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GEOGRAPHICAL HANDBOOK SERIES

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NETHERLANDS EAST INDIES

VOLUME I

April 1944

NAVAL INTELLIGENCE DIVISION

This volume was produced and printed for official purposes during the war 1939/45

PREFACE

IN 1915 a Geographical Section was formed in the Naval Intelligence Division of the Admiralty to write Geographical Handbooks on various parts of the world. The purpose of these handbooks was to supply, by scientific research and skilled arrangement, material for the discussion of naval, military, and political problems, as distinct from the examination of the problems themselves. Many distinguished collaborators assisted in their production, and by the end of 1918 upwards of fifty volumes had been produced in Handbook and Manual form, as well as numerous short-term geographical reports. The demand for these books increased rapidly with each new issue, and they acquired a high reputation for accuracy and impartiality. They are now to be found in Service Establishments and Embassies throughout the world, and in the early years after the last war were much used by the League of Nations.

The old Handbooks have been extensively used in the present war, and experience has disclosed both their value and their limitations. On the one hand they have proved, beyond all question, how greatly the work of the fighting services and of Government Departments is facilitated if countries of strategic or political importance are covered by handbooks which deal, in a convenient and easily digested form, with their geography, ethnology, administration, and resources. On the other hand, it has become apparent that something more is needed to meet present-day requirements. The old series does not cover many of the countries closely affected by the present war (e.g. Germany, France, Poland, Spain, Portugal, to name only a few); its books are somewhat uneven in quality, and they are inadequately equipped with maps, diagrams, and photographic illustrations.

The present series of Handbooks, while owing its inspiration largely to the former series, is in no sense an attempt to revise or re-edit that series. It is an entirely new set of books, produced in the Naval Intelligence Division by trained geographers drawn largely from the Universities, and working at sub-centres established at Oxford and Cambridge. The books follow, in general, a uniform scheme, though minor modifications will be found in particular cases; and they are illustrated by numerous maps and photographs.

The purpose of the books is primarily naval. They are designed first to provide, for the use of Commanding Officers, information in a

comprehensive and convenient form about countries which they may be called upon to visit, not only in war but in peace-time; secondly, to maintain the high standard of education in the Navy and, by supplying officers with material for lectures to naval personnel ashore and afloat, to ensure for all ranks that visits to a new country shall be both interesting and profitable.

Their contents are, however, by no means confined to matters of purely naval interest. For many purposes (e.g. history, administration, resources, communications, etc.) countries must necessarily be treated as a whole, and no attempt is made to limit their treatment exclusively to coastal zones. It is hoped therefore that the Army, the Royal Air Force and other Government Departments (many of whom have given great assistance in the production of the series) will find these Handbooks even more valuable than their predecessors proved to be both during and after the last war.

J. H. GODFREY,
Director of Naval Intelligence
1942

The foregoing preface has appeared from the beginning of this series of Geographical Handbooks. It describes so effectively their origin and purpose that I have decided to retain it in its original form.

This volume has been prepared for the Naval Intelligence Division at the Cambridge sub-centre (General Editor, Dr. H. C. Darby). It has been largely written by Mr. S. H. Beaver with contributions by Professor A. A. Miller, Mr. F. J. Monkhouse, Mr. P. O'Driscoll, Dr. P. W. Richards, Mr. J. C. Stuttard, Mr. T. G. Tutin, and Dr. Charles Wilcocks. The maps and diagrams have been drawn by Miss Margaret Alexander, Miss K. S. A. Froggatt, Miss M. Garside, Mrs. Gwen Raverat and Miss J. D. I. Tyson. The volume has been edited by Mr. S. H. Beaver and Mr. T. G. Tutin.

E. G. N. RUSHBROOKE,
Director of Naval Intelligence

April, 1944

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INTRODUCTION

Netherlands-India, the Netherlands Indies and the Dutch East Indies are names alternatively applied to the Dutch possessions in the Malay Archipelago, which the Dutch call Nederlandsch Oost-Indië. The whole Malay Archipelago, variously known as Malaysia, the East Indies, Indonesia, etc., is the vast congeries of islands—numbering over 2,000—which lie between south-eastern Asia and northern Australia. Some parts of the area belong to other powers, e.g. north-west Borneo and eastern New Guinea are parts of the British Empire, the Philippines belong to U.S.A., and Portugal possesses the eastern half of Timor. Dutch territory extends from 95° E, at the north-western corner of Sumatra, to 141° E on the frontier of British New Guinea, a greater longitudinal extent than that of the continent of Europe, representing a distance of some 5,000 km., and from latitude 6° N at We island, north of Sumatra, to 11° S at Roti island, south-west of Timor, a latitudinal distance of almost 2,000 km., roughly equivalent to that from Edinburgh to Madrid. (Fig. 1). Considerably more land lies to the south than to the north of the equator, which passes through the middle of Sumatra and Borneo, through the northern peninsula of Celebes and just north of the 'Bird's Head' peninsula of New Guinea. (Fig. 2.)

Fig. 1. The East Indies and Europe compared

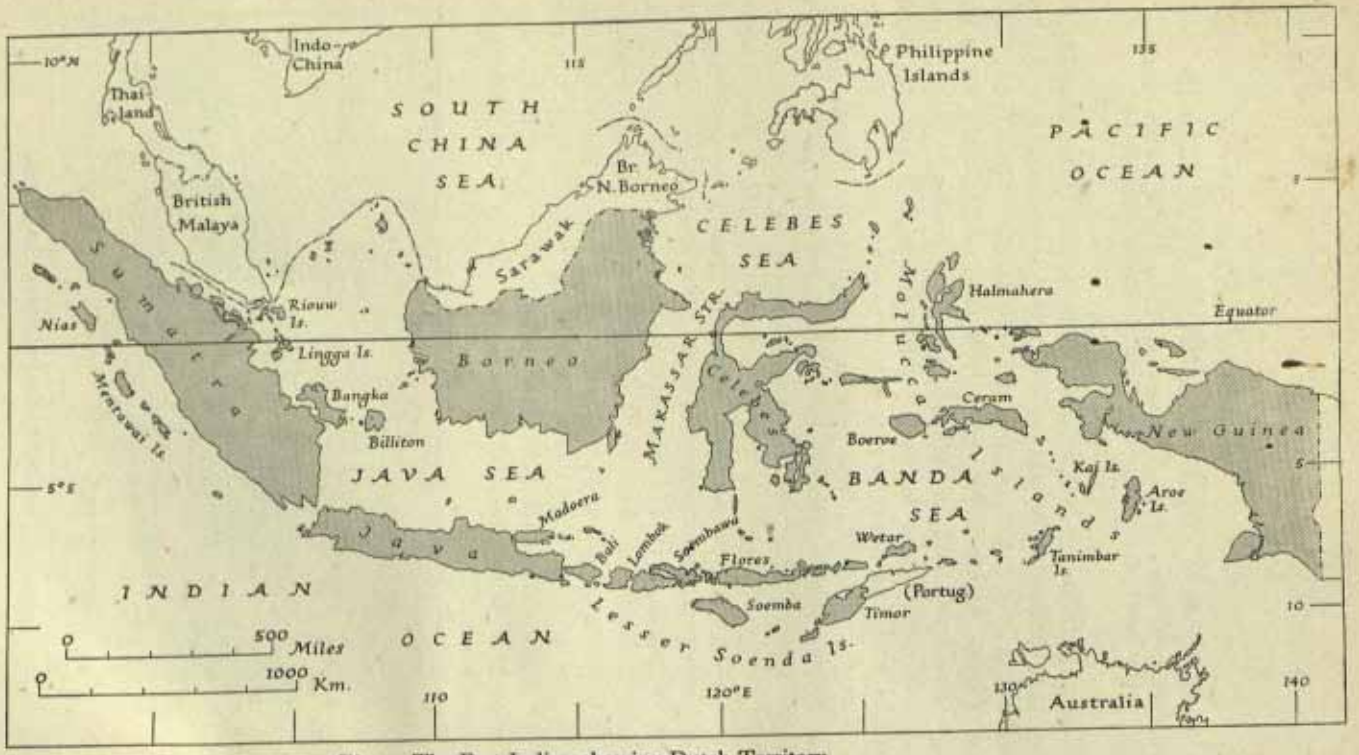

Fig. 2. The East Indies, showing Dutch Territory

Source: *Atlas van Tropisch Nederland*, plate 2 (Batavia, 1938).

The largest islands are Sumatra, Java (with Madoera), Borneo and Celebes—together known as the Great Soenda islands—and New Guinea. Between these are situated groups or lines of smaller islands: the Lesser Soenda islands extending from Java to Timor, the Moluccas, between Celebes and New Guinea, and many others located for the most part between and around the shores of the larger islands. The total area amounts to almost two million sq. km., fifty-six times the area of the mother country, Holland.

The following table presents a statistical summary of the chief territorial divisions and their populations:

Division	Area (thous. sq. km.)	Roughly equivalent to	Popul. 1930 (thous.)	Pop. per sq. km.
Java and Madoera	132·2	Greece	41,718	316
Sumatra	425·1	} Sweden	7,678	18
Bangka, Billiton	16·8		279	17
Riouw-Lingga Arch.	31·7	Belgium	298	9
Borneo	539·5	France	2,169	4
Celebes	189·0		4,232	22
Molucca Is.	83·7	Scotland	579	7
New Guinea	412·8	Romania and Bulgaria	314	0·8
Timor Arch.	63·3	Eire	1,657	26
Bali and Lombok	10·3		1,802	175
Total N-I	1,904·3		60,727	32

Java, though by no means the largest island, is by far the most densely peopled, and is economically the most important. Moreover, it contains Batavia, capital and administrative centre of the Indies. As a result, the Dutch make a broad division of their territories into (*a*) Java (with the contiguous island of Madoera), and (*b*) the Outer Provinces (Buitengewesten).

The Indonesian Archipelago

The islands of the archipelago vary in size from Borneo, Sumatra and New Guinea, which are amongst the world's largest islands, to uninhabited islets, barren rocks and coral-reefs that are only exposed at low tide. They can be divided into three natural groups:

(1) Extending a long way from Indo-China, Siam (Thailand) and Lower Burma towards the south and south-east is a submerged platform known as the Soenda Shelf, on which stands the long peninsula of Malaya (known to the Dutch as Malaka). Towards the outer edge of this platform the large islands of Sumatra, Java and

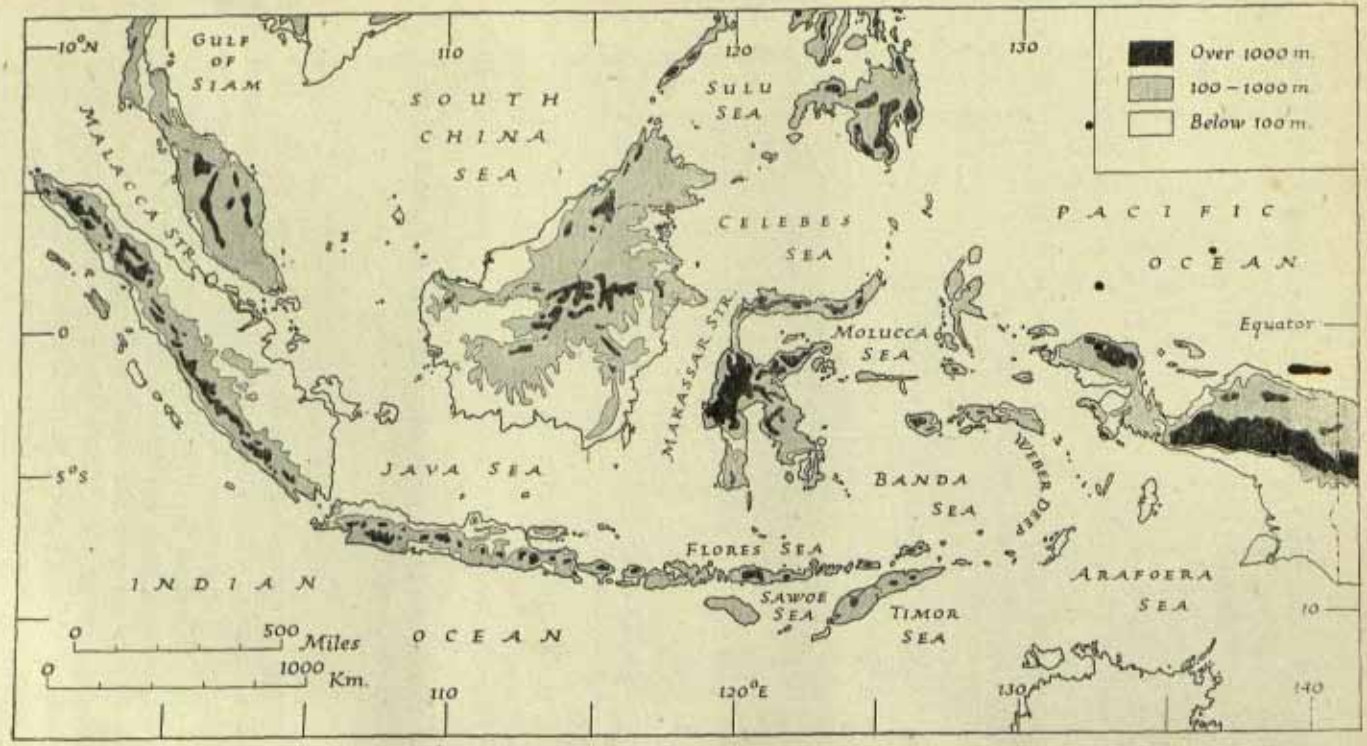

Fig. 3. The East Indies: Orographical

Source: *Atlas van Tropisch Nederland*, plate 3 (Batavia, 1938).

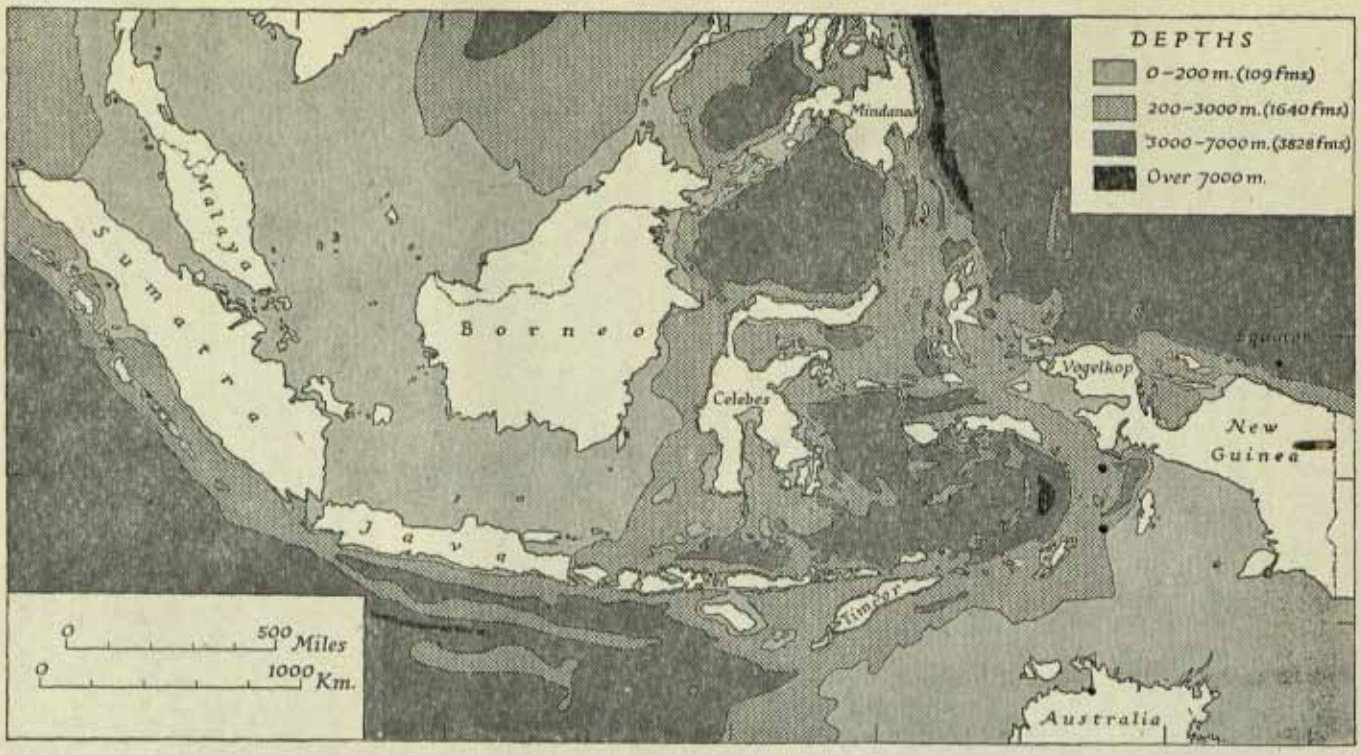

Fig. 4. The East Indies: Sea Depths
Source: *Atlas van Tropisch Nederland*, plate 3 (Batavia, 1938).

Borneo rise from a shallow and island-studded sea, the depth of which seldom exceeds 100 m. (50 fm.). This sea comprises the Malacca strait between Sumatra and Malaya, the South China Sea between the Asiatic mainland and Borneo, and the Java Sea between Java and Borneo. The greatest concentration of smaller islands is at the meeting place of these three seas, between Sumatra, Malaya and Borneo. The Riouw and Lingga archipelagoes and the 'tin islands' of Bangka and Billiton are the chief; they may perhaps be regarded as remnants of a former south-eastward extension of Malaya. Beyond the edge of the shelf the sea floor drops rapidly to great depths. The edge lies off the west coast of Sumatra and off the south coast of Java. Sumatra however has a fringe of islands—the Mentawai islands and others—separated from the mainland by a deep trough; beyond the islands the Indian Ocean floor descends quickly to abyssal depths of more than 5,000 m. (2,700 fm.). Java has no such fringe, but a submarine ridge takes its place. The eastern edge of the shelf, marked by coral islands and reefs, runs from the eastern end of Java north-eastwards into the Makassar strait, turning northwards to the middle east coast of Borneo. The northern edge is outside Dutch territory; it runs north-westwards from Brunei, in north-western Borneo, towards Cochin China.

(2) Northern Australia and New Guinea rise from another platform, the Sahoel Shelf, which is submerged beneath the shallow Arafoera Sea. The north-western peninsula of New Guinea projects like a spear-head from the main platform. Known as the Vogelkop (Bird's Head), it has a number of adjacent islands, such as Misoöl, Waigeo and Japen. Further south, on the edge of the shelf, is the low-lying Aroe group. The ocean floor, which is generally less than 100 m. (50 fm.) below sea level on the shelf, drops suddenly to considerable depths beyond the edge, in the Timor Sea and between the Aroe islands and the Tanimbar and Kai groups, and also to the Pacific Ocean north of New Guinea.

(3) Between these two relatively stable areas, with their shallow seas, lies a large unstable area in which land and sea alternate sharply, and the ocean bed descends to abyssal depths. The islands within this area fall into several groups or lines.

(*a*) The Kleine (Lesser) Soenda islands are a continuation of the arc formed by Sumatra and Java. The axis of Java is continued eastwards through Bali, Lombok, Soembawa, Flores and smaller islands to Alor and Wetar; a subsidiary arc, possibly a continuation of the Sumatran fringe and the Javanese submarine ridge, comprises

Soemba, Sawoe, Roti and Timor, separated from the main island by the Sawoe Sea.

(*b*) These two lines of islands are continued in boldly curving arcs, the Outer Banda arc stretching from Timor through Babar, the Tanimbar and Kai groups to Ceram and Boeroe, and the Inner Banda arc, comprising a number of much smaller islands which continue the Bali-Wetar line through Romang, Damar, Nila and Manoek to the Banda group. Between the two arcs at their point of greatest curvature in the east the ocean floor descends in the Weber Deep to the greatest depth known in the East Indian region, over 7,000 m. (3,800 fm.) Within the curve of the inner arc lies the Banda Sea, also of great depth.

(*c*) Separated from Borneo by the deep trough of Makassar strait, and from the Lesser Soenda islands by the still deeper Flores Sea, is the large and irregularly shaped island of Celebes, consisting of four peninsulas, each of which is prolonged by groups of small islands. The north-eastern or Manado peninsula is connected by a submarine ridge, on which stand the Sangihe islands and others, with Mindanao in the Philippine group.

(*d*) Eastward of northern Celebes is another island of curiously similar shape though smaller dimensions. This is Halmahera, which also has numerous outlying islands, the largest of which are Morotai in the north and Obi in the south. The Halmahera group is surrounded by deep water on almost all sides—the Pacific Ocean to the north-east, the Molucca Passage to the west, the Ceram Sea to the south. There are also deep troughs on the south-east, but the continuity of the deep ocean floor is considerably interrupted on this side by submarine ridges and groups of islands which act as stepping stones to the 'Bird's Head' of New Guinea.

General Sketch of Geological Background

The existence of an unstable area between the ancient and relatively stable regions of south-eastern Asia and northern Australia, has been a feature of the earth's crust for several hundred million years. The oldest rocks found in the East Indies are of Palaeozoic age, and the history of the area since Devonian times is a record of alternate submergence and emergence, with folding and fracturing, in various regions and at various periods (Fig. 5). Crustal disturbances have been more or less continuous in one part of the region or another, though four periods of more intense uplift and crumpling can be distinguished—the Carbo-Permian, roughly contemporaneous with the

'Hercynian' or 'Altaid' folding of Eurasia, the late Triassic, the end of the Cretaceous and the middle Tertiary. The last two correspond to the prolonged epoch of mountain-building which in other parts of the world produced the Alps, Himalayas, Rockies and Andes. Whereas however the Cretaceo-Tertiary earthstorm in Europe and Asia has died down after producing lofty ranges of mountains, in the Indies the process of mountain-building has not advanced so far, and is still in progress, as is evidenced by the frequency of volcanic eruptions and earthquakes, and by the uplifting of recently-formed coral reefs.

Palaeozoic. The late Palaeozoic rocks comprise sedimentary rocks—sandstones, shales and limestones; volcanic rocks—lavas and tuffs (solidified fragments and ashes) poured out during the eruptions which accompanied mountain-building; and metamorphic rocks—slates and crystalline schists—formed from the other rocks by great heat and pressure during subsequent folding movements. These old rocks are found in the mountains of western Sumatra and of western and central Borneo, in parts of the mountainous areas of Celebes and New Guinea, and in the islands of the Timor—Ceram, or Outer Banda, arc.

Earth movements towards the end of the Palaeozoic era raised the New Guinea–Northern Australia area above the sea and initiated a great crustal sag or 'geosyncline' in the region now occupied by the Timor–Ceram–Celebes island arc and its neighbouring seas. Meanwhile the western part of the area—Malaya, the Riouw islands, and western Borneo, were the scene of considerably outpourings of volcanic material, which ended in late Triassic times with earth movements which upheaved this region into a mountainous and stable block which has probably never since sunk beneath sea level. Granite batholiths rose up in the core of the mountains, cooling and crystallizing slowly, and in the fissures and cracks then produced were deposited the metallic minerals—especially tin—which are so valuable to-day.

Mesozoic. During the greater part of the Mesozoic era most of the area lying between Malaya and northern Australia was beneath the sea, either continuously or for long periods. It was not just a simple trough; the deposits which accumulated on the sea-bed varied considerably from region to region, some being formed at great depths and others in quite shallow water. Deposits probably formed at abyssal depths—resembling modern deep-sea oozes—accumulated in parts of Borneo and New Guinea. Other areas lay adjacent to the

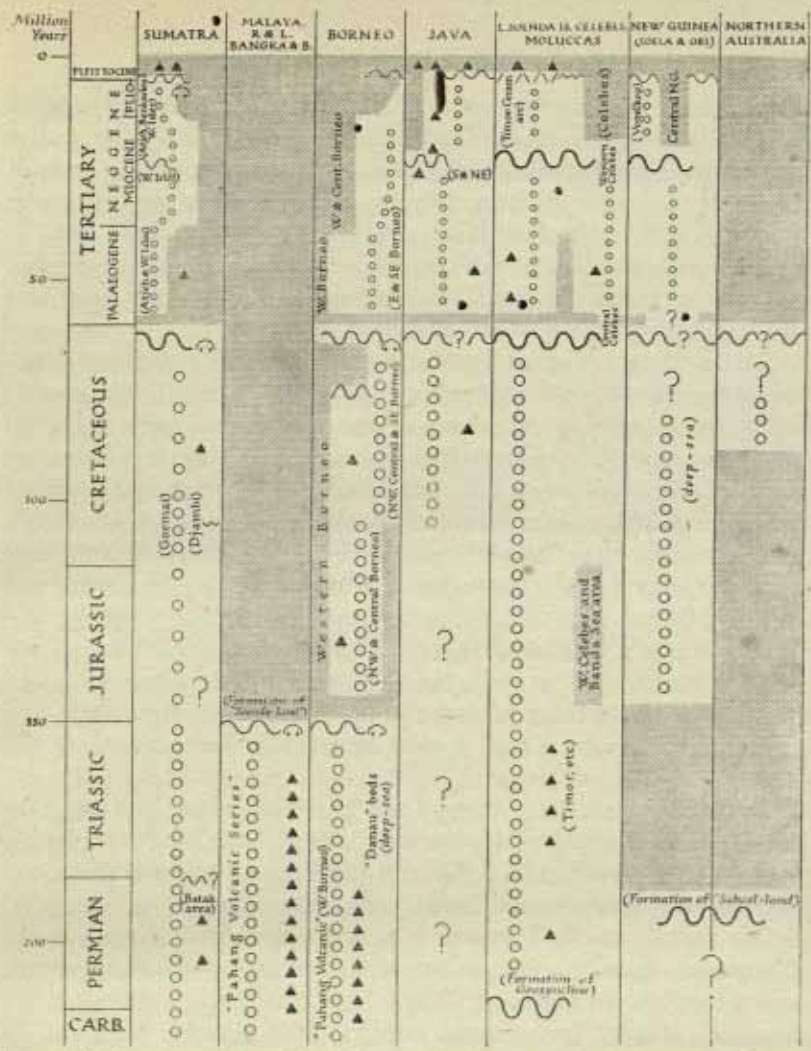

Fig. 5. A diagrammatic geological history of the East Indies and neighbouring regions

The vertical columns represent the territories named at the top, working from west to east. The left hand column indicates the geological time-periods and their approximate duration. Stipple indicates that the area in question was land; circles represent sedimentation. Black triangles show volcanic activity; wavy lines represent earth movements (folding and uplift), with an indication of relative intensity. The broken wavy line at the top of the Lesser Soenda islands column, represents uplift with fracturing instead of folding. Inverted semi-circles with crosses indicate granite intrusions, accompanying folding and uplift. Questions marks indicate uncertainty.

This diagram expresses in concise form the geological history summarized on pp. 8–12. It is not possible to trace the history much further back than 200 million years, though in other parts of the world, including Britain, a fairly complete record is available for some 600 million years, since life first appeared on the earth, and a further 600 million years can be traced in a fragmentary way.

Compiled from the work of J. H. F. Umbgrove and others (especially Umbgrove in *Bulletin of the American Association of Petroleum Geologists*, vol. XXII, pp. 1–70, Chicago, 1938).

wasting land masses; in such localities great thicknesses of conglomerates, sandstones, shales and limestones were laid down. Yet other areas lay in between the lands and the deeps, and here beds of limestone accumulated, formed largely of corals and of the calcareous skeletons of other dead sea creatures. There were periods of volcanic activity; volcanic islands and submarine volcanoes must have existed, and lavas and tuffs of Triassic, Jurassic and Cretaceous ages are found in Borneo, southern Sumatra, Timor and elsewhere.

The enormous thicknesses of comparatively soft sediments which had accumulated in the geosyncline between the stable blocks of Asia and Australia during the Mesozoic era were more easily crumpled and thrust by the compressional forces than the hard and ancient rocks of the latter areas, and in consequence when the earth-storm began, in the late Cretaceous period, about sixty million years ago, incipient mountain ranges began to appear in the belt extending from Sumatra through Java and the Soenda islands to Ceram and Celebes. There were strong folding and thrusting movements, and in Sumatra granites and other intrusive rocks were formed deep down beneath the surface, in the core of the folds. The intense heat and pressure converted many of the sedimentary rocks into slates and schists, which subsequent erosion and uplift has exposed at the surface.

Tertiary. A very large part of the East Indian region must have been converted into land by these movements, but by the beginning of the Tertiary era much of this land had been worn down again, and shallow seas were formed, which gradually extended in area until by the middle of the Tertiary—a period probably equivalent to the Miocene in Europe—the greater part of the area was under water, except for 'Soenda-land' (Malaya, the 'tin-islands', south-eastern Sumatra, western and central Borneo) and northern Australia. In the western part of the area, considerable sagging took place around the edges of Soenda-land—in eastern Sumatra, northern Java and eastern Borneo. Great thicknesses of sediments accumulated—amounting to between 4,000 m. and 9,000 m. in eastern Sumatra—but the rate of deposition kept pace with the sagging of the geosyncline, and so the nature of the deposits remained characteristic of shallow water conditions. Sands and clays predominate, and the large quantities of plant debris which accumulated have led to the richness of these areas in lignite and petroleum. Similar conditions occurred on the borders of Sahoel-land, and thick series of oil-bearing sediments accumulated in the 'Bird's Head' and other areas of New

Guinea. In the intervening area, open sea prevailed and the deposits were for the most part limestones. Volcanic eruptions were frequent, both on land and under the sea, as the earth-storm worked up towards a new climax in the middle of the Miocene period.

This mid-Miocene folding mainly affected a belt extending from Nias through Java and the Soenda islands to Ceram and eastern Celebes, and was especially intense in the outermost parts of this belt, i.e. the Mentawai islands, Timor and the arc stretching thence through Ceram to eastern Celebes. The weathering of the newly-formed mountains was rapid, however, and the late Tertiary ('Neogene') seas transgressed once more on to southern Java and the Soenda islands, and on to the western fringe of Sumatra and its adjacent islands.

The Tertiary era came to a close with renewed folding of a non-intensive character. The chief areas affected were quite naturally the Neogene geosynclinals previously referred to, where the gentle folding into anticlines and synclines produced the necessary physical conditions for the concentration of the petroleum deposits. At the same time the already existing mountain axes of Sumatra and Java were further elevated, and this phenomenon was accompanied by the rise to the surface of magma (rock-liquid) which in some areas, e.g., southern Sumatra, appears as granite batholiths, and in most parts initiated a new period of intense volcanic activity.

Thus by the end of the Tertiary era the main outlines of the East Indian Archipelago were formed, and in fact land occupied a greater area than at present, since the low plains of Soenda-land and Sahoel-land were still above sea level.

Pleistocene. The Pleistocene history of the region has two aspects. In the tectonic field, the chief events were faulting and subsidence rather than folding. In brief, the outer arc of islands (especially Timor-Ceram) would appear to have been considerably uplifted, as is indeed shown in Timor by the existence of coral reefs at elevations up to 1,300 m. (4,265 ft.) above the present sea level, whilst the areas behind subsided to form the present deep-sea basins. The fracturing in the volcanic regions of Java and Sumatra increased the outpouring of volcanic debris, and helped further to build up the great cones which still exist to-day.

The other aspect concerns the effects of the Great Ice Age. This scarcely affected the East Indies directly, for only the central mountain range of New Guinea (sometimes called the Snow Mountains) stood high enough to allow of the accumulation of snow and

ice. Indirectly however it exercised a most important influence, by reason of the considerable fluctuations in sea level to which it gave rise. At the end of the ice-age the return of the enormous volume of water which had been locked up in the polar ice-caps and the great ice-sheets and glaciers of lower latitudes caused a rise in the sea level sufficient to drown low-lying areas. Thus the Java Sea and the

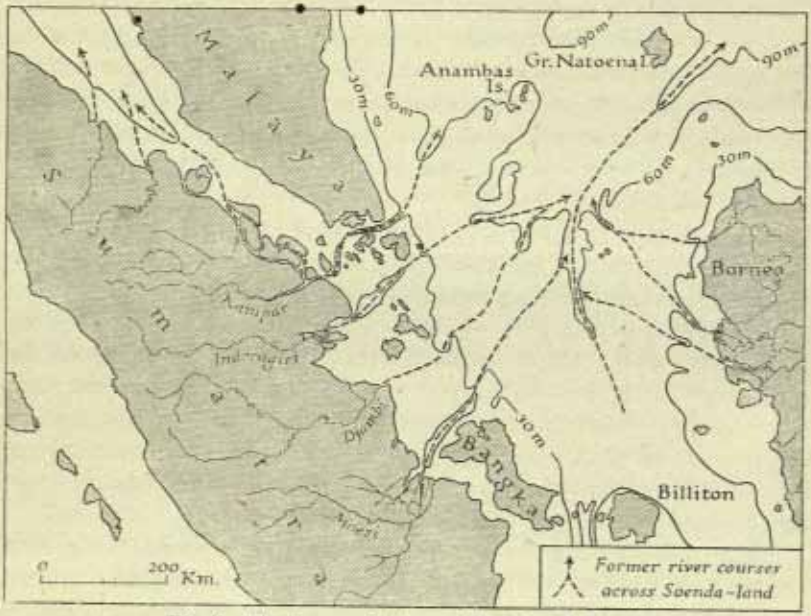

Fig. 6. The drowned rivers of the Soenda Shelf
Submarine contours enable the pre-Pleistocene courses of the great rivers of Sumatra and Borneo to be easily traced. For the present condition of the coastlands of Sumatra and Borneo, see Figs. 27, 44 and 86.
Source: *De Zeeën van Nederlandsch Oost-Indië*, plate 11 (Leiden, 1922).

southern part of the South China Sea spread over the low plain of Soenda-land, which became a shelf at a shallow depth, fringed by low coasts with drowned river mouths (Fig. 6), and bordered on its eastern edge by a barrier reef of coral, which was built up on the edge of the shelf as the sea level gradually rose (Fig. 7). Similarly the centre of Sahoel-land became the Arafoera Sea, bordered by the swampy shores of south-western New Guinea.

Structure of the archipelago

The form and disposition of the islands of the East Indian Archipelago have given rise to much speculation. The following brief

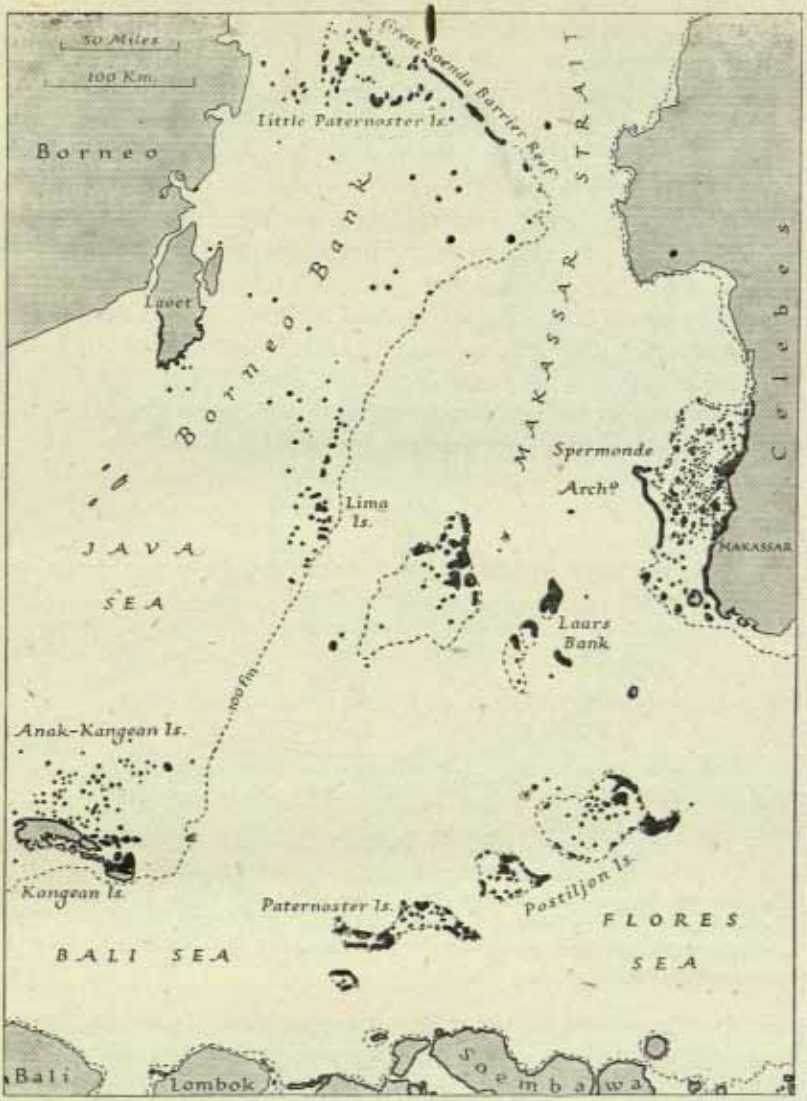

Fig. 7. Coral reefs and islands between Borneo, Celebes, and the Lesser Soenda islands

Coral reefs and islands shown in black. The 100-fathom line off south-eastern Borneo marks the edge of the stable block or 'shelf' of Soenda-land. The upward growth of coral kept pace with the late Pleistocene flooding of the shelf—resulting in the Great Soenda Barrier Reef, the Lima islands, and the Kangean islands. For a note on the Spermonde archipelago, see p. 243.

Sources: *De Zeeën van Nederlandsch Oost-Indië*, plate 4 and p. 324 (Leiden, 1922); also British Admiralty Chart 941B.

summary is based on the work of Dutch geologists. A much larger body of evidence must be accumulated, however, before anything like a complete picture can be obtained.

The whole process of mountain building in the East Indian region may be looked upon as a crumpling of the earth's crust in the area between the Soenda stable block on the one hand, and the floor of the Indian Ocean and the Sahoel stable block on the other, with the pressure apparently coming from the former towards the latter. So far, two main 'waves' have been generated. The second, rearward or northern wave, is an upfold of the crust—a 'geanticline'—three thousand miles in length, running through Sumatra, Java, the Lesser Soenda islands and the Inner Banda arc. Along the crest of this fold are over fifty active volcanoes—roughly one every 50 miles—and in addition there are many extinct cones (Figs. 8 and 9).

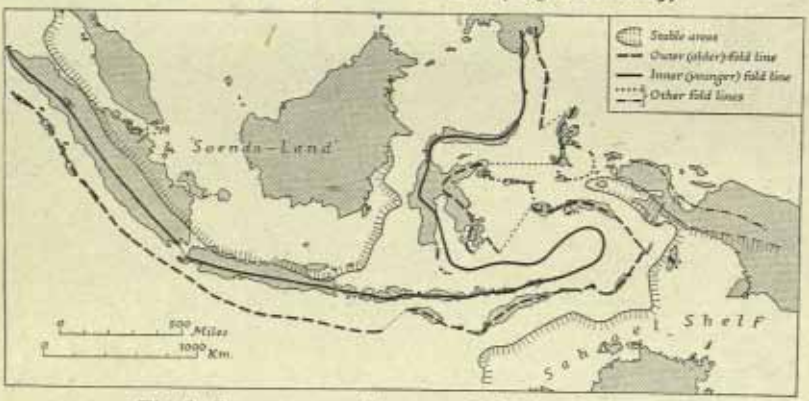

Fig. 8. Some structural features of the East Indies—I
This shows the stable blocks and the fold belts. Based on H. A. Brouwer, *Geology of the Netherlands East Indies* (London and New York, 1925) and Smit Sibinga, *Proceedings Koninklijke Nederlandsche Akademie van Wetenschappen*, vol. XXXVI (Amsterdam, 1933).

The first or forward wave, the more southerly of the two, has had a longer history; it dates from the Miocene period (Fig. 5) and consequently it is more complex, consisting probably of two waves in close proximity. The simple upfold has been pushed over, or overfolded, and large masses have been overthrust towards the south. The Timor-Ceram arc, and its westward representative in the islands off western Sumatra, thus consists of a very thick mass of piled-up and compressed sedimentary rocks, a phenomenon which has two results. In the first place there are no volcanic vents, and secondly the downward folding of the crust into the heavier sub-surface layers,

with the overthrusting of the surface masses, causes a slight reduction in the force of gravity in this zone, below the expected calculated value (Fig. 9). This last interesting discovery was made in the 1920's as a result of a scientific expedition in a submarine through the waters

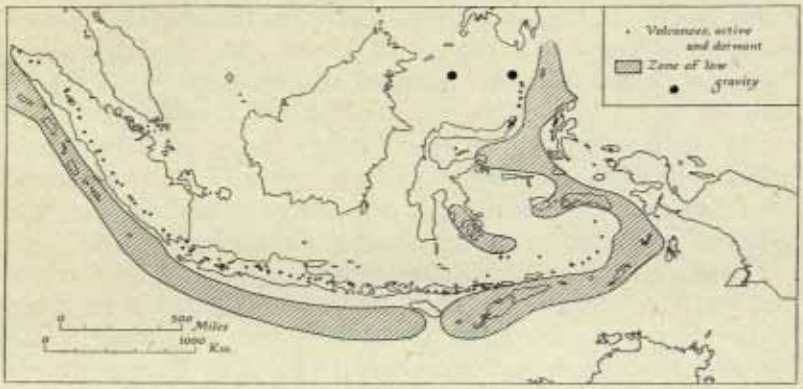

Fig. 9. Some structural features of the East Indies—II

This shows that the outer (older) fold belt corresponds to a zone of negative gravity anomaly, whilst the inner fold belt coincides with a long chain of volcanoes. Based on *Atlas van Tropisch Nederland*, plate 5 (Batavia, 1938).

of the Archipelago. At the same time it was noted that a gravitational force slightly greater than expected occurs especially in the region of the abyssal troughs in the Banda and Flores seas, and to a less extent in the volcanic arc, in both of which areas the heavier sub-crustal material is covered with a relatively thin crust of lighter material.

It is noteworthy that where the second fold-arc approaches most closely to the first—in the islands of Alor and Wetar—it has some of the characteristics of the older fold, and the volcanoes are extinct.

The arcuate form of the folds on the earth's surface is perhaps the result of movement up a gently inclined 'thrust-plane' which dips towards the north; the outcrop of such a thrust-plane on the spherical surface of the globe is an arc of a circle, convex towards the south. That the East Indian arcs are imperfect is obvious from the map, but it is equally clear that the imperfections are due to the way in which the folds have accommodated themselves to the form of the stable Sahoel massif towards which they have been pressed. The 'spear-head' of western New Guinea has notably affected the curvature of the two Banda arcs and their possible continuations in the islands of Celebes and Halmahera.

As the fold-waves spread outwards, lateral tension caused breaks to occur, with differential horizontal movement, and hence the folds appear not as a continuous ridge, but as a series of elongated islands, separated by deep channels which obviously cannot have been excavated by rivers. Thus the channel between Bali and Lombok, in the inner fold, reaches a depth of over 300 fathoms, that between Soemba and Sawoe, in the outer fold, is more than 700 fathoms deep. Moreover, it has been demonstrated that the fold-axis of western Java has moved forward (i.e. southward) nearly three miles relatively to its continuation in southern Sumatra—a fact with which the existence of the famous volcano Krakatau, in the middle of the Soenda Strait, may not be unconnected. A similar shift has been proven in the Manipa Strait between the islands of Ceram and Boeroe.

Continuing Movement. The movement of the fold belts is continuing. The uplifted coral reefs of Timor which must have been formed just below sea level, have already been mentioned; similar occurrences at 300 m.–500 m. altitude are found in the nearby islands of Roti and Sawoe. Further north, in the Toekang Besi islands, off Celebes, and elsewhere, downfolds are accompanied by upward-growing coral reefs, in which the upward growth of coral has kept pace with the slow sagging along a synclinal axis (Fig. 11). Further evidence of continuing disturbance is provided by the frequency of volcanic eruptions in the inner arc, and of earthquakes.

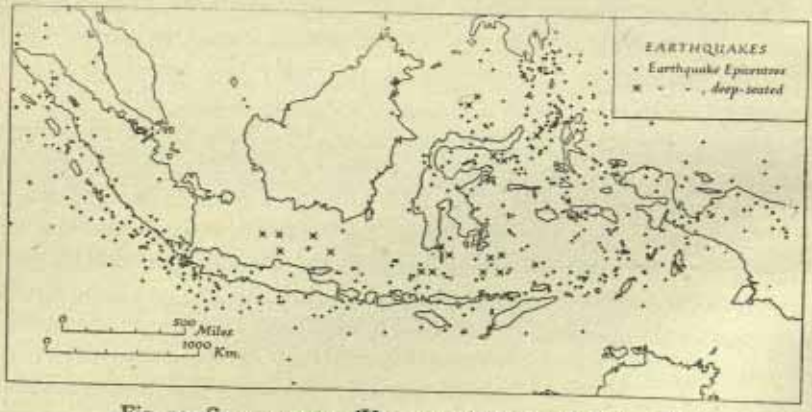

Fig. 10. Some structural features of the East Indies—III

This shows the distribution of earthquake epicentres recorded since the establishment of the first seismograph at Batavia in 1898. There are more earthquakes in the outer fold belt than along the volcanic zone, whilst deep-seated shocks are located in the area behind both belts. Based on *Atlas van Tropisch Nederland*, plate 5 (Batavia, 1938).

Earthquakes are associated with thrusting and faulting movements rather than with volcanicity, and although small shocks are of frequent occurrence in the volcanic belt, especially at the time of eruptive activity, the main zone of large earthquakes is the outer fold-arc,

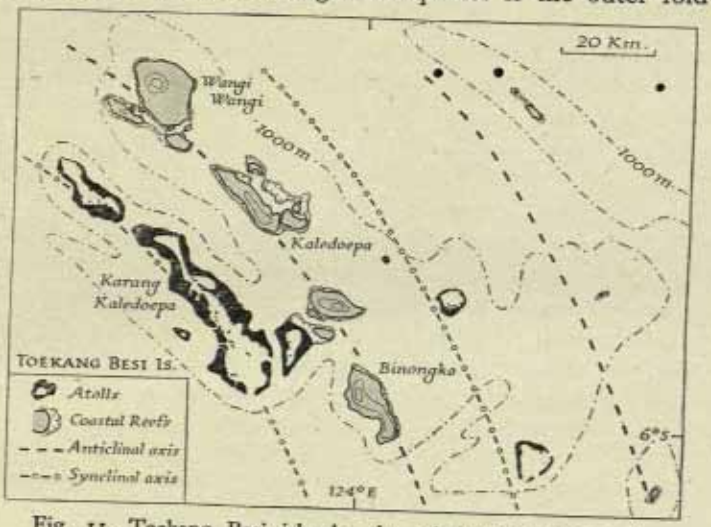

Fig. 11. Toekang Besi islands: the relation of structure to coral formation

This belt of parallel folds lies south-east of Celebes (see Fig. 8). The anticlines (upfolds) bear 'solid' islands with fringing reefs; the synclines (downfolds) carry atolls (*karang* = coral reef). Coral can only live near the sea surface, and consequently the slow formation of the downfold has been accompanied by the upward growth of the coral colonies. On the islands, form-lines have been drawn at roughly 100 m. intervals.

Source: *De Zeeën van Nederlandsch Oost-Indië*, plate v (Leiden, 1922).

where active deformation of the crust is in progress. It is noteworthy, too, that the majority of the shocks originate beneath the sea bed, especially in the abyssal depths. Really deep-seated shocks (originating more than 100 km. (60 miles) beneath the surface) occur for the most part in the area behind (i.e. north or north-west of) the second or volcanic fold-arc (Fig. 10)—a fact which is in accordance with the idea of a northward-dipping plane along which thrusting movements occur. It is likewise very noticeable that earthquakes are virtually absent from the stable areas of Soenda and Sahoel.

Earthquakes of extreme violence are rare in the East Indies, and within the last few hundred years, at any rate, there have been no shocks to compare with those, for example, which were experienced in California in 1906 or at Yokohama in 1923. Minor earthquake

damage to flimsily-built native dwellings is not uncommon, and one omnipresent danger in many of the islands is that of great sea-waves due to submarine earthquakes, a danger which is aggravated by the frequent siting of villages close to the shore and to sea level. These waves—often erroneously called 'tidal waves'—are generally known by their Japanese name, *tunami*. They approach the coast as a long unbroken swell, the height increasing as the water gets shallower. The first movement observed at the shore is a slow withdrawal of the water, after which the wave advances and sweeps over the low-lying country. Similar phenomena often accompany submarine volcanic eruptions. The most disastrous ever known, perhaps in the world's history, was the wave which followed the cataclysmal eruption of Krakatau in 1883, referred to on p. 25.

In recent years on an average over 500 earth-tremors have been recorded annually in the East Indies, about one-third of which occurred in Sumatra. The most serious earthquakes during the last fifty years were in the island of Ceram in 1899, and at Benkoelen, on the west coast of Sumatra, in 1914 (Plate 2).

The Volcanoes

The existence of over seventy active volcanoes in the East Indian region is in itself a justification for a more elaborate treatment of the phenomena of volcanicity; but the subject is far from being one of academic interest only, for to a large extent human life in Java and in parts of other islands is dependent on the presence of these volcanoes. The weathering of volcanic debris under conditions of equatorial climate produces soils of unparalleled richness that support a dense agricultural population. But the volcanoes are not merely beneficent in their influence; they can also be dangerous enemies of mankind, and for this reason their behaviour is more closely studied in Java than in any other volcanic region in the world.

The Netherlands Indies Volcanological Survey, which is a division of the Government Geological Survey, is engaged in two branches of work. In the first place it is concerned with the exploration and survey of volcanoes, both active and extinct, and with morphological and geological studies relating thereto, and secondly it organizes the collection of reliable scientific data about present volcanic activity with a view to predicting eruptions and as far as possible guarding against their evil effects. Most of the Survey's work is done in Java, where the agricultural population is in closest proximity to the

volcanoes and the dangers are therefore greatest. Here, permanently-staffed observation posts are maintained on seven active volcanoes. At these stations daily records of the state of activity within the craters, and measurements of the temperature of steam and gas emanations and other phenomena are made, and the population of the surrounding regions is warned of impending danger. The other ten active volcanoes in Java, which are less dangerous, are visited and reported on several times a year. Outside Java, the surroundings of the active volcanoes are usually far less densely peopled, and consequently only intermittent watch is kept.

Volcanicity

Volcanicity comprises all phenomena associated with the rise of hot rock liquid, known as magma (temperature about 1,000° C or more), to the proximity of the earth's surface. The liquid stiffens into stone on cooling, and the term 'lava' is applied both to the liquid and the solid rock. Cracks or weaknesses in the earth's crust in regions where the magma is near the surface are liable to allow some of the liquid lava to be poured forth, forming lava-flows. With explosive activity at the place of emission, the lava is blown skywards and fragmented. The finest material is known as ash, larger fragments are called lapilli ('little stones'), and compact masses more than a few centimetres in diameter are called bombs. The ash may form such dense and extensive clouds that daylight may be excluded over wide areas. Most of the material, however, falls down around the explosion-vent, forming a cone with a wide funnel-shaped crater. A single eruption is capable of forming such a cone, but the East Indian volcanoes are the result of many eruptions extending over perhaps scores or even hundreds of thousands of years, and often combining lava-flows as well, so that the resulting cones are gigantic structures, often reaching elevations of over 3,000 m. (10,000 ft.) and sometimes having several active or extinct eruption points. Sometimes the cones are grouped in more or less circular form around the edge of a large plateau, itself probably a gigantic crater, with a smaller cone or cones in the middle, and the whole formation is then known as a 'caldera'.

Volcanicity includes more than just eruptions of ash and lava, however. Even though most of the subterranean magma has crystallized, the very existence of the hot mass not far from the surface may cause emanations of gases, steam and hot water long after active eruption has ceased. In the classification of the N.I. Volcanological

Survey, all volcanoes which are known to have had eruptions of ash or lava since A.D. 1600 are reckoned as 'active', whilst those in which the activity has been confined to steam and gas are regarded as 'dormant', or, to use the scientific term, 'in the fumarolic stage'. Volcanic cones which have neither eruptions nor fumaroles to their credit are regarded as extinct. *Fumaroles* are steam- and gas-vents. The cooling and crystallizing magma contains steam and other gases in solution, and these accumulate and boil off as crystallization proceeds, blowing off through fissures. The gases are mainly carbon dioxide (CO_2) and sulphuretted hydrogen (H_2S). Sometimes the activity may take the form of boiling mud or hot springs of sulphur-laden water—known as *solfataras*. The temperature of fumaroles may be anything from mere warmth to 600° C. (1,100° F.), whilst the high pressure to which the vapours are subjected underground may raise the boiling point of the water very much above normal.

Some aspects of fumarolic activity are useful to man. Sulphur is frequently deposited, and the hot springs may be used for bathing and for medicinal waters. But the concentration of heavy suffocating gases is sometimes dangerous, and there are numerous examples in Java of 'death-valleys' (in Dutch, *doodendal* or *stikvallei*) where lethal gases may flow down and accumulate to a depth of many feet, killing off first the ground fauna, then small animals, and lastly human beings (see, for example, Figs. 15 and 16).

Most of the eruptive activity in the East Indies takes the form of ash-eruptions, lava flows being comparatively rare and of limited extent. The magma is generally of an intermediate or basic composition, producing the rocks which are known as andesite and basalt. The lava usually solidifies so quickly after reaching the surface that long and extensive flows, such as occur in the Hawaiian islands, for example, are rare or non-existent. In several cases the last eruptions have produced lava which solidified as a great plug inside the crater. Flows of hot water, mud, stones, steam and burning gases, however, are characteristic of some of the volcanoes, and it is these flows which have been responsible for much of the destruction and loss of life which has occurred within historic times.

The extremely heavy rainfall on the mountain slopes frequently gives rise to severe erosion and land-slipping in the soft and unconsolidated ash of which most of the volcanoes are composed (Plate 8). It is for this reason that a rain-gauge always constitutes an important item in the equipment of volcano observation posts. Mud-avalanches, usually canalized in gorges on the slopes, but

sprawling over the plains at the foot, are known as *lahars*. They may be either hot or cold according to the nature and origin of the material of which they are composed. The hot lahars of the Keloed volcano, for example, were due to the ejection of water from a crater lake during eruptive activity. Of a different character, and more destructive, are the *ladoes;* these are dry streams of hot volcanic dust, sand and boulders, intimately mixed with superheated steam and other gases, and levitated and carried by the latter. Associated with ladoes are *nuées ardentes* or 'scorching clouds', which accompany eruptive activity on some of the Javanese volcanoes. Blocks of glowing lava which, owing to their viscosity, have not crumbled into ash, tumble down into ravines, carrying with them dust and stones, and causing repeated explosions of steam and gases; the burning avalanche rushes down the valley and spreads death and destruction over the plain beneath.

List of Volcanoes

On p. 22 is a complete list (so far as present knowledge goes) of the 'active' volcanoes, compiled from the Bulletin of the Netherlands Indies Volcanological Survey.* The date of the most recent eruption is given in brackets, but no details are available of any activity which may have occurred since 1939. Volcanoes numbered 1 to 11 will be found on Fig. 28; numbers 12 to 28 on Fig. 64; numbers 29 to 56 on Fig. 12 and numbers 57 to 71 on Fig. 13.

The Volcanic Belt

A great arcuate belt of volcanic activity extends from Burma through the East Indies to the Philippines and Japan. Within the Netherlands Indies, the belt commences at the north-western end of Sumatra (Fig. 9, see also Fig. 28 on p. 51) and runs through the whole length of the island, though with wide gaps between active centres, especially in the north. There are ten active eruption points, most of which have been operative during the present century, and at least fifteen dormant volcanoes, together with scores of extinct cones in various stages of decay. On the whole the Sumatran volcanoes are less violently active than those of the remainder of the belt—but their activity is also less well known owing to their comparative remoteness from densely populated regions.

In the Soenda strait lies Krakatau, described in some detail on p. 25. The volcanic belt continues through the mountain backbone

* Bulletin No. 75, 1936, with supplementary information from Nos. 76–88.

VOLCANOES IN THE NETHERLANDS INDIES

(Date of most recent eruption in brackets)

SUMATRA

1. Peuëtsagoë (1919–20)
2. Boer ni Telong (1856?)
3. Sorikmarapi (1917)
4. Tandikat (1924)
5. Marapi (Fort de Kock) (1927)
6. Talang (1845)
7. Kerintji (Peak of Indrapoera) (1936)
8. Soembing (1926 ?)
9. Kaba (1918)
10. Dempo (1939)
11. Krakatau (1939)

JAVA

12. Gede (1886)
13. Tangkoebanprahoe (1929)
14. Papandajan (1924–5)
15. Goentoer (1843)
16. Galoenggoeng (1918)
17. Tjareme (1937)
18. Slamet (1939)
19. Boetak Petarangan (1928)
20. Diëng (Pakoewodjo) (1826)
21. Soendoro (1906)
22. Merapi (1935)
23. Keloed (1919–20)
24. Bromo (1939)
25. Semeroe (1913)
26. Lamongan (1898)
27. Raoeng (1939)
28. Kawah Idjen (1917)

LESSER SOENDA ISLANDS

Bali

29. Batoer (1926)
30. Agoeng (1843)

Lombok

31. Rindjani (1915)

Soembawa

32. Tambora (1815)
33. Sangeang Api (1911)

Flores

34. Inië Lika (1915)
35. Ineri (1911)
36. Amboerombo (1855)
37. Ija (Endeh Api) (1882)
38. Keli Moetoe (1860's ?)
39. Poei (Medja) (1871)
40. Egon (1907 ?)
41. Lewotobi
    (Perampoean (1935)
    (Lakilaki) (1932–4)
42. Leweno (1881)
43. Paloeweh (1928)

Between Flores and Wetar

44. Ili Boleng (Adonara) (1885)
45. Ili Weroeng (Lomblen) (1928)
46. Wariran (Lomblen) (1931–2)
47. Batoe Tara (P. Komba) (1849–52)
48. Siroeng (Pantar) (1934)

BANDA SEA

49. Api (N. of Wetar) (1699)
50. Damar (1892 ?)
51. Teon (1693)
52. Nila (1932)
53. Seroea (1921)
54. Banda-Api (1901)
55. Emperor of China (submarine)
56. Nieuwerkerk (submarine) (1927?)

CELEBES

57. Oena–Oena (1898)
58. Sopoetan (1924–5)
59. Lokon (1930)
60. Mahawoe (1904)
61. Tongkoko (1821)

SANGIHE ISLANDS

62. Roeang (1914)
63. Api Siaoe (1935)
64. Banoewa Woehoe (1918)
65. Awoe (1931)

HALMAHERA

66. Doekono (1939)
67. Iboe (1911)
68. Gamkonora (1926)
69. Peak of Ternate (1933)
70. Motir (1744)
71. Makian (1890)

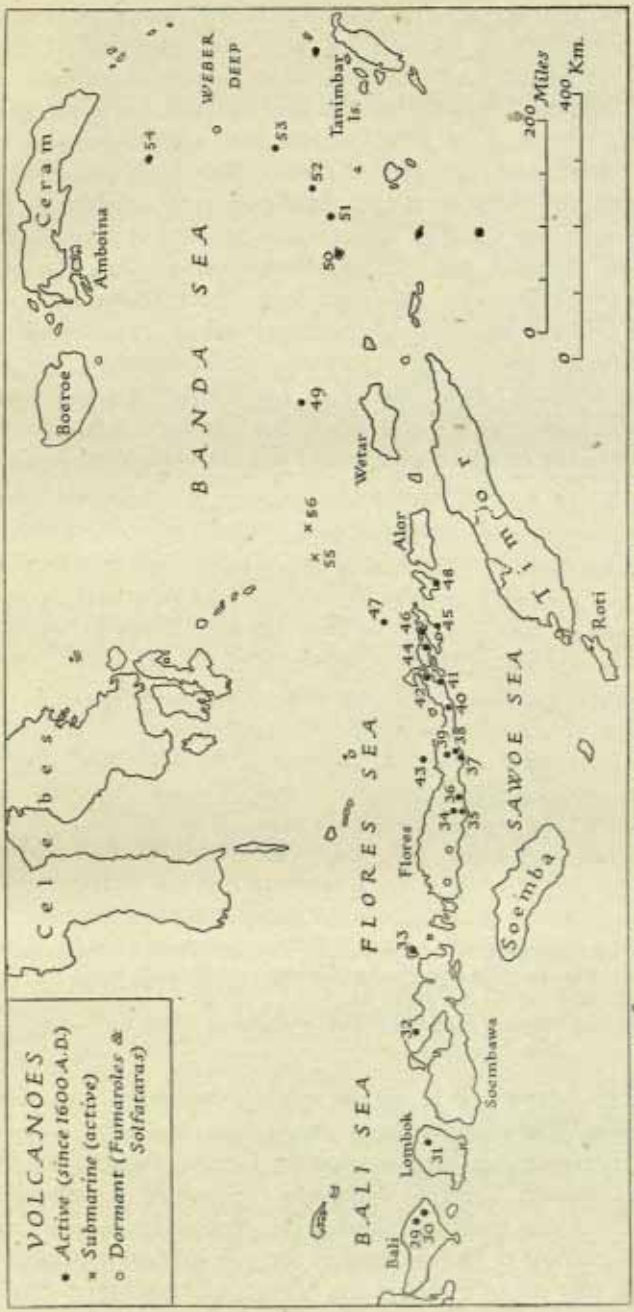

Fig. 12. The volcanoes of the Lesser Soenda islands and the Banda arc. For key numbers see the list on p. 22.

Source: *Atlas van Tropisch Nederland*, plate 5 (Batavia, 1938).

of Java (Fig. 64), where there are seventeen active eruption points, at least eighteen more in the solfatara stage, and many extinct centres. It is here that volcanic activity reaches its maximum intensity; and the density of population makes the study of the volcanoes of vital importance. Several of the Javanese volcanoes are described below.

The belt continues through the Lesser Soenda islands (Fig. 12). Bali, Lombok and Soembawa each have one major volcano, but the activity becomes more intense again in Flores, where nine active and a number of dormant and extinct centres are known. The belt is rather broader in Flores and its adjacent islands of Adonara, Lomblen and Pantar, and two small islands north of the main chain—Paloeweh and Komba—are also active volcanoes. Then, however, the main island chain ceases to be volcanic (cf. p. 15). Alor, Wetar and Romang have no volcanoes, and the active belt lies further north, evidenced by two submarine eruption points and the tiny island of Api.

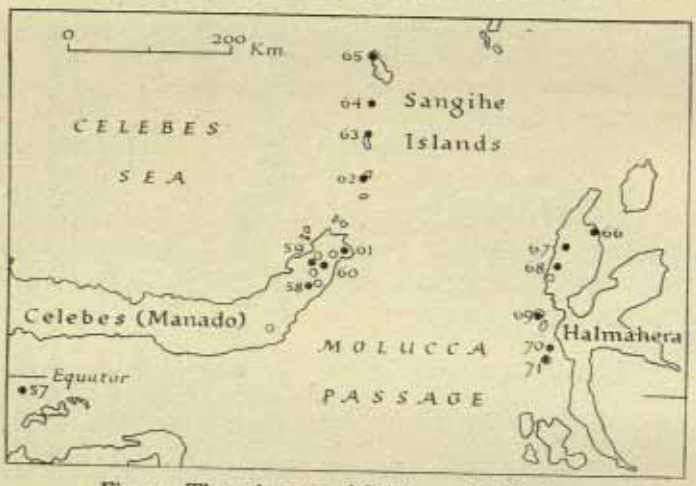

Fig. 13. The volcanoes of Celebes and Halmahera
For key to numbers see the list on p. 22.
Source: *Atlas van Tropisch Nederland*, plate 5 (Batavia, 1938).

The Banda island arc is almost entirely volcanic, from Damar through Teon, Nila and Seroea to Banda Api.

A large non-volcanic area—including Ceram, Boeroe, the Soela islands and eastern Celebes—separates the last of the Banda Sea volcanoes from the Celebes–Halmahera volcanic belts. Apart from the isolated outpost of Oena-Oena, in the gulf of Tomini, these belts run parallel, one on each side of the Molucca Passage (Fig. 13). The

western belt extends from the Minahasa peninsula of Celebes (Fig. 26) to the Philippines, and the eastern belt through the north-western part of Halmahera and the offshore islands of Ternate, Motir and Makian.

Descriptions of Volcanoes

The following notes on individual volcanoes are intended to give some idea of the variety of form and phenomena amongst the seventy-one active centres, and to indicate some of the measures which the Dutch authorities have taken in order to minimize the risk of disasters.

Krakatau (Fig. 14). Krakatau, in the middle of the Soenda strait, is one of the world's most famous—or infamous—volcanoes. In 1883, after a period of quiescence lasting for 200 years, it burst into violent activity, which culminated in the paroxysmal eruption of August 26–27, probably the greatest disaster of its kind in human history. A large part of the main island disappeared, either engulfed by the sea or blown into the sky. Steam and ash rose to a height of 20 km. (12 miles), and a rain of ashes fell all over southern Sumatra, as far north as Singapore, as far east as Batavia, and southwards to the Cocos islands; the finer particles of dust floated round the earth in the upper atmosphere for many months, causing brilliant sunsets. The sound of the explosion was heard at Perth in Western Australia, in New Guinea, in Ceylon and in Mauritius. The sea in the Soenda strait was covered with pumice—but the disaster came not so much from the shower of ashes as from the waves which the explosion created. The shores of the strait were devastated by inundations, which in places reached a height of 36 m. (118 ft.) above normal sea level, and penetrated inland for distances up to 10 km. Scores of villages were obliterated, and the town of Teloekbetoeng, at the head of Lampoeng bay in southern Sumatra, was destroyed. A small steamer was washed 3 km. inland near here, and its boiler was still lying in a river bed in 1929. Altogether some 36,000 people perished.

For 44 years after this catastrophe, Krakatau remained quiet. Vegetation, which was completely destroyed during the eruption, reappeared, and the three islands, after suffering considerable erosion of their soft and unprotected shores, assumed a fairly stable outline. Then, at the end of 1927, glowing bombs emerged from the sea at a point about midway between the islands, and shortly afterwards a new island—christened Anak Krakatau ('the child of Krakatau')—appeared above the waves. Erosion by surf soon removed this, but

after rising and disappearing several more times the Anak—the fourth in the series—became firmly established in August 1930, since when, though its height and size have fluctuated considerably, it has never completely disappeared. Eruptions have been frequent, and by August 1939 the island had attained an elevation of 113 m. (Plate 1). Its

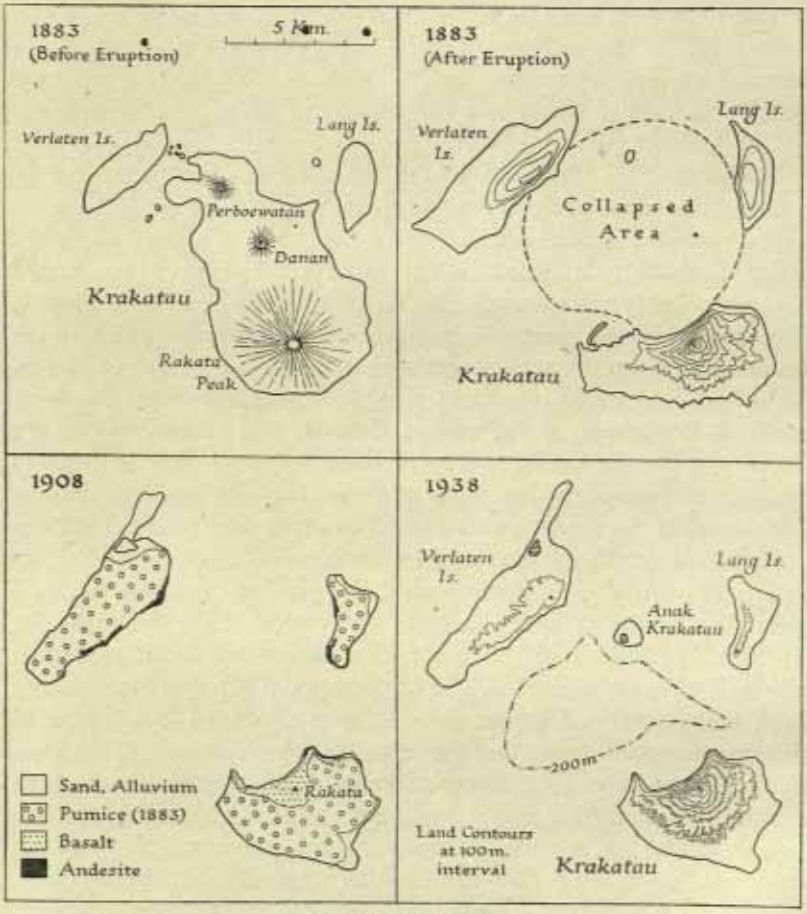

Fig. 14. Krakatau

This series of maps summarizes the recent history, geological constitution and physical form of the volcanic island group known as Krakatau.
Sources: 1883 maps from Verbeek's Krakatau Atlas; 1908 outline from G.S.G.S. series 4278, sheet 1, geology from Backer's *Problem of Krakatau*, plate III (Weltevreden, 1929); 1938 from 'Krakatau' (Handbook for *Fourth Pacific Science Congress, Java*, 1929) and *Bulletin Netherlands Indies Volcanological Survey*, No. 86 (Bandoeng, 1939).

Plate 1. Anak Krakatau

Photographed from the air on June 27th, 1939. The breach in the crater rim is clearly visible. At this date the island was a little over 100 m. high; the gently-shelving ash slopes are rapidly eroded by equatorial rain and the Indian Ocean.

Plate 2. Earthquake damage at Benkoelen (Sumatra)
Damage to the Chinese quarter of Benkoelen in 1914, resulting from one of the comparatively rare severe earthquakes.

Plate 3. The summit of Tangkoebanprahoe (Java)
Aerial view, looking southwards across the plain of Bandoeng. In the centre is Kawah Oepas, with Kawah Baroe on its right and the much larger Kawah Ratoe on its left. The volcano is forested to its 2,076 m. summit, except for the crater. See also Fig. 15.

crater contains a lake, and an inrush of sea-water over the broken rim into this lake is always liable to cause the young volcano to spew up its contents in protest.

An observation post is maintained on Lang-eiland.

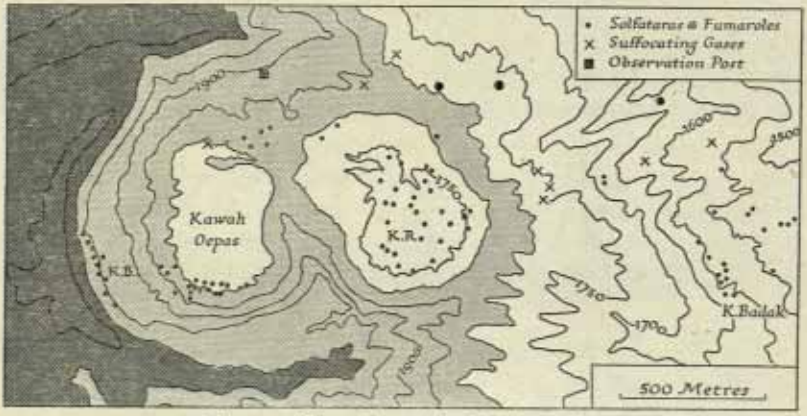

Fig. 15. The volcano Tangkoebanprahoe
Land over 1,800 m. stippled; over 2,000 m. cross-hatched; contour interval 50 m. Only the western half of an ancient crater rim remains, with two crater-like depressions, and a number of active centres of gas, steam and hot water eruptions. K.B. is Kawah Baroe, K.R. is Kawah Ratoe. See also Plate 3.
Source: *Bulletin Netherlands Indies Volcanological Survey*, No. 75 (Bandoeng, 1936).

Tangkoebanprahoe (Fig. 15). Rising from the northern side of the plain of Bandoeng in western Java, to a height of 2,076 m. (6,800 ft.), this volcano has an ancient crater rim, lower on the east than on the west, enclosing two smaller craters, known as Kawah Oepas and Kawah Ratoe (*Kawah* is a Malay word meaning crater). Within and outside these craters and on the eastern slopes of the volcano there are several scores of eruption points—fumaroles, solfataras, mud wells and hot springs—including a number of places where suffocating gases accumulate. The observation post is equipped with a subterranean refuge room which has two outlet tunnels, each with a gas-proof door. The flanks of the volcano are covered with dense jungle up to the crater rim, which is approachable by motor road from Bandoeng (Plate 3).

Papandajan (Fig. 16). Papandajan is the most easily accessible of all the Javanese volcanoes, and the most visited by tourists. It can be reached from Bandoeng by a motor road which was opened in 1935. There is a large horse-shoe shaped crater rim, open towards the north, enclosing several smaller crater remnants, the youngest of

which dates from an eruption in 1772. This outer rim, which reaches a height of 2,622 m. (8,600 ft.) is forested all over. Within the craters there are many fumaroles, solfataras, mud wells and hot springs. In Kawah Mas, the youngest crater, the temperatures are still very high —300–400° C. (570–750° F.)—but the others are much cooler (40–80° C.). There are several places where suffocating gases accumulate; these are naturally made inaccessible to tourists, as far as possible (Plates 4 and 5).

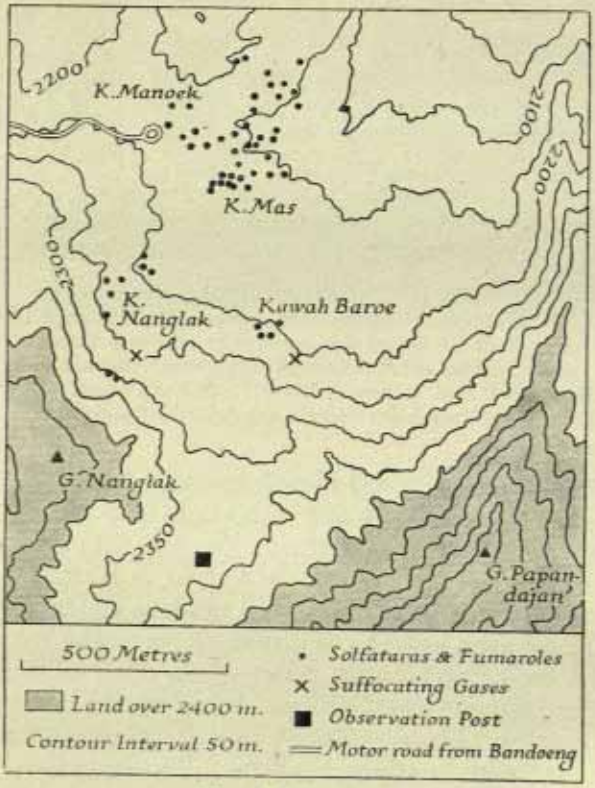

Fig. 16. Papandajan

Source: *Bulletin Netherlands Indies Volcanological Survey*, No. 86 (Bandoeng, 1939).

Galoenggoeng. The complex volcano Galoenggoeng-Telagabodas rises up between the plains of Garoet and Tasikmalaja in western Java (Figs. 68, 69); there are several summits of over 2,000 m. Telagabodas is the more northerly of the two; it has a large horse-shoe shaped crater rim, open on the northern side, with a lake in the

bottom. It is this lake which gives the volcano its name (*telaga bodas* means 'white lake'). There are suffocating gas emanations on the eastern shores of the lake, and several other fumaroles.

The horse-shoe shaped crater rim of Galoenggoeng is open to the south-east. The summit of the rim is known as Goenoeng Goentoer (a common name, meaning 'thunder hill'). The enormous quantities of debris derived from the bursting of the south-eastern side of the volcano are largely distributed over the area beneath, as far as Tasikmalaja. This gently sloping area has an irregular surface with numerous lakes and some 3,600 hillocks. Galoenggoeng erupted with disastrous effect in 1822, when the rising lava caused the ejection of the crater lake, thus flooding a huge area with boiling mud; eighty-five villages were destroyed over an area extending for 20 km. to

Fig. 17. Merapi (Central Java)

Viewed from the west, December 1930, showing the cleft near the summit made by the 1930 eruption.

The destruction wrought by the *Ladoes* and scorching clouds in the midst of the richly-cultivated plain, with its terraced rice-fields and tree-screened villages, is clearly seen.

Drawn from a photograph in *Vulkanologische Mededeelingen*, No. 12 (Weltevreden, 1933).

the south-east. There were several other eruptions during the nineteenth century, and the last was in 1918, when a large dome of lava arose in the crater. The lake, now largely filled with debris, rests against this lava plug—so that potential danger is still present, though all has been quiet and cool since 1918.

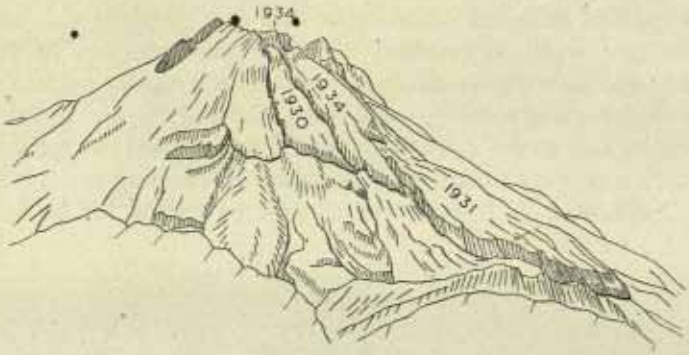

Fig. 18. The summit of Merapi

The summit region, with its lava streams, in January 1936. The steep edges of the tongues of lava are the result of weathering; the breaking off of large blocks generates avalanches. The 2 km. long flow of 1931 is clearly seen.
Source: *Bulletin Netherlands Indies Volcanological Survey*, No. 75 (Bandoeng, 1936).

Merapi (*Central Java*) (Figs. 17 and 18). *Api* is a Malay word meaning 'fire', and Goenoeng Api or G. Merapi (or Marapi) is therefore a common name for volcanoes in the East Indies. This particular Merapi is Java's most active and dangerous volcano. During the nineteenth century it was continuously active for long periods, from 1822 to 1873 and from 1883 to 1915, and within the last twenty-five years there have been several lava eruptions, accompanied by ladoes and scorching clouds, which have sometimes been destructive of life and property, as in the disaster of 1930. Continuous scientific study of the summit region has been carried out since 1920, and much valuable data recorded. In fact Merapi is the only volcano where a big eruption has been preceded by years of study of the summit.

Merapi is the south-eastern outpost of volcanic activity in the 'waist' of Java. It has a neighbour—Goenoeng Merbaboe—on the north, but on the other three sides its slopes lead down to fertile plains teeming with people—Magelang on the west, Jogjakarta on the south and Soerakarta on the east. To the life of these plains Merapi has contributed much, for its ash has constantly renewed their soil,

Plate 4. The summit of Papandajan (Java)
Aerial view from the south, showing the 2,622 m. summit on the right, forested all over, and the crater in the centre. See Fig. 16.

Plate 5. Papandajan, Kawah Mas
Kawah Mas is the youngest eruption point on Papandajan, with superheated steam and gases, and boiling mud, constantly escaping.

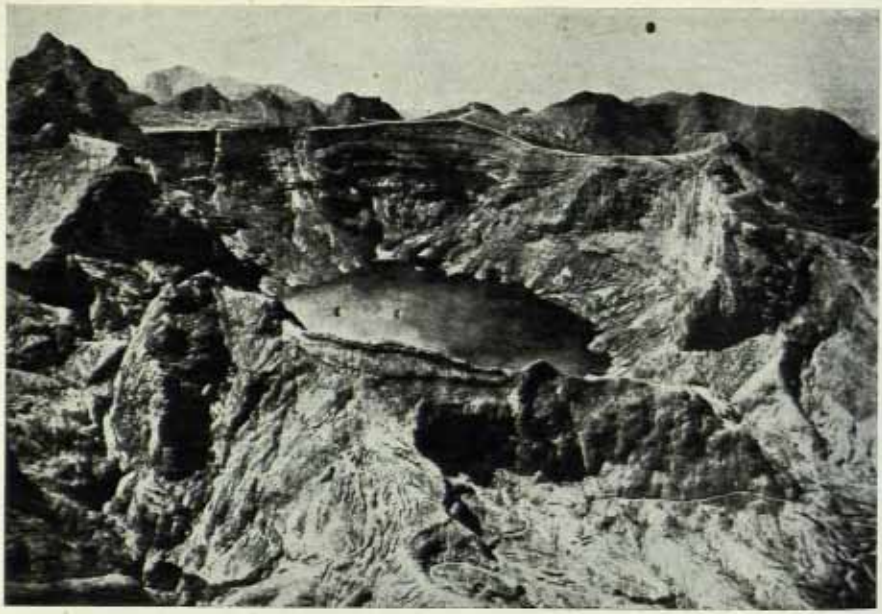

Plate 6. Keloed crater lake, Java
Viewed from the north-west in 1922, before the partial draining of the crater lake. The andesite peak of Keloed is in the top left; the Lahar Badak in the bottom right. The columnar-jointed lava in the precipitous wall of Goenoeng Soembing is clearly seen to the right of the lake. See Fig. 20.

Plate 7. Twin volcanoes, Lamongan and Taroeb
Starting probably as a parasitic cone, Lamongan has almost equalled its parent Taroeb in size. Taroeb, on the left, reaches 1,670 m.; it is extinct and is vegetated all over. Lamongan attains 1,647 m., and has a 150 m. deep crater; it is on the 'active' list but has been quiet for nearly half a century; its slopes are steep and bare. See also Fig. 22.

and the rapid erosion of its flanks by torrential streams has caused much fluvial deposition. To some of the localities within 15 km. (10 miles) of the crater, however, the volcano has brought much destruction.

The 'scorching clouds' had been observed on several occasions, but they were first scientifically studied in 1920–21, and the 1930 eruption provided more grand but catastrophic examples. The greatest avalanche rushed down the Blongkeng ravine and spread out over the land below, extending for 12 km. and destroying 20 sq. km. of country, including thirteen villages (with twenty-three more partly destroyed) and annihilating 1,369 people and 2,100 animals. The ash clouds were so thick that the ground was covered for depths of up to 40 cm. (15 inches). This eruption left a great cleft, 850 m. long and 250 m. deep, near the top of the mountain; as a result the old lava plugs in the crater collapsed. The following year a new lava stream spread slowly down the side for a distance of 2 km., accompanied by scorching clouds and rains of ash. Further big eruptions of lava in 1934 spread ash as far west as Bandoeng, 320 km. (200 miles) distant, and produced a new lava flow which generated ladoes and scorching clouds.

Merapi is carefully watched. In 1931 an electric rain-gauge was set up to give warning of excessive falls which might cause lahars; a warning given by this means in 1932 probably saved some loss of life, though it could not of course prevent the damage to ricefields and villages. In 1937 a siren was installed at one observation post to warn certain of the more vulnerable villages.

Keloed (Figs. 19 and 20). Keloed rivals Merapi in destructiveness, despite its comparative insignificance amongst the Javanese volcanic giants. Its summit rises to a mere 1,731 m. (5,676 ft.), but the crater contains a lake which has several times overflowed during periods of activity. Since 1811 there have been six eruptions, each accompanied to a greater or less extent by lahars resulting from the ejection of the lake water, and by scorching clouds.

The peak of Keloed is an andesite mass, possibly the lava plug of an ancient volcano. On the south-west side of the crater, Goenoeng Soembing (1,530 m.) is a lava-dome, partly destroyed so that the columnar structure of its interior is now visible. The northern wall of the crater is solid lava. The crater rim is broken on the south-western side; this breach is largely the result of the 1848 eruption; the col is at just over 1,200 m. (3,900 ft.), and it is this which allows the lake to overflow down the Lahar Badak gorge (Plate 6).

As far back as 1905 a dam was built across this gorge to protect the fertile and densely peopled plain of the Brantas river, with the towns of Blitar and Srengat and scores of villages; in 1907–8 another dam was built in the crater-rim col. Both were destroyed, however,

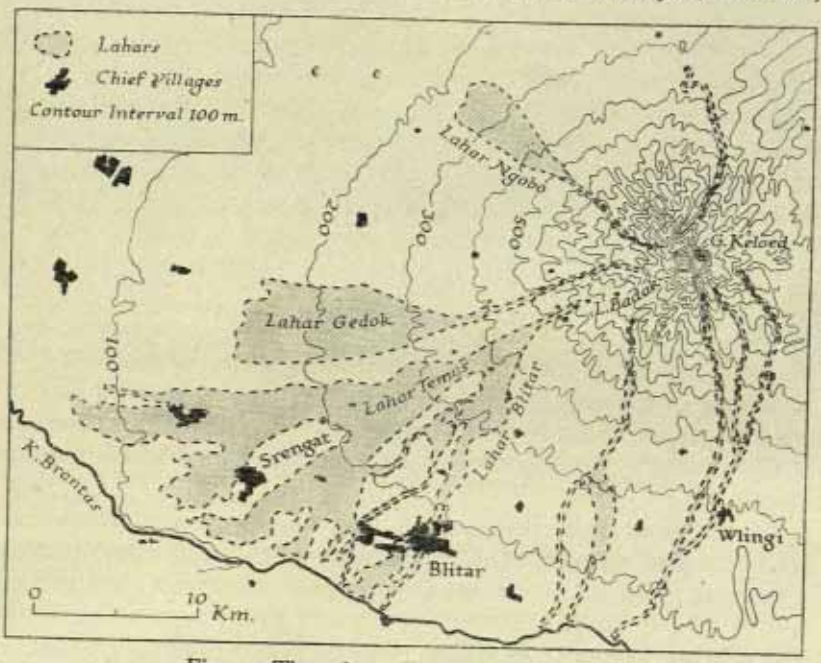

Fig. 19. The volcano Keloed and its lahars

Lahar Gedok carried the overflow of the lake until 1848, when Lahar Badak was formed. All the stippled areas except Lahar Gedok were covered by the 1919 flows. The deposits of the lahars yield variable soils, coarser and more irregular in the middle, finer and richer, though more liable to erosion, at the sides. In the intervals between eruptions, much re-deposition of the material by streams and heavy rain has taken place.

Source: C. E. Stehn & J. H. Coert, 'Keloet' (Handbook issued for *Fourth Pacific Science Congress, Java*, 1929).

in the eruption of 1919, which was one of the greatest volcanic disasters of recent times. The ejection of the lake—38 million cu. m. of water—caused enormous lahars of cold water to pour down Lahar Badak, followed by hot water, scorching clouds and ash. In forty-five minutes, 131 sq. km. (50 sq. miles) of land were covered, over 5,000 people perished and 104 villages were destroyed. The deposit was up to 2·5 m. (8 ft.) thick in Blitar, and in places it did not cool down completely for six years. Considerable damage outside the destroyed

area was caused to coffee and sisal estates by hot air streams and rains of ash.

To limit the possibilities of a recurrence of such a catastrophe, work was begun in 1919 to drain the lake. A series of tunnels was

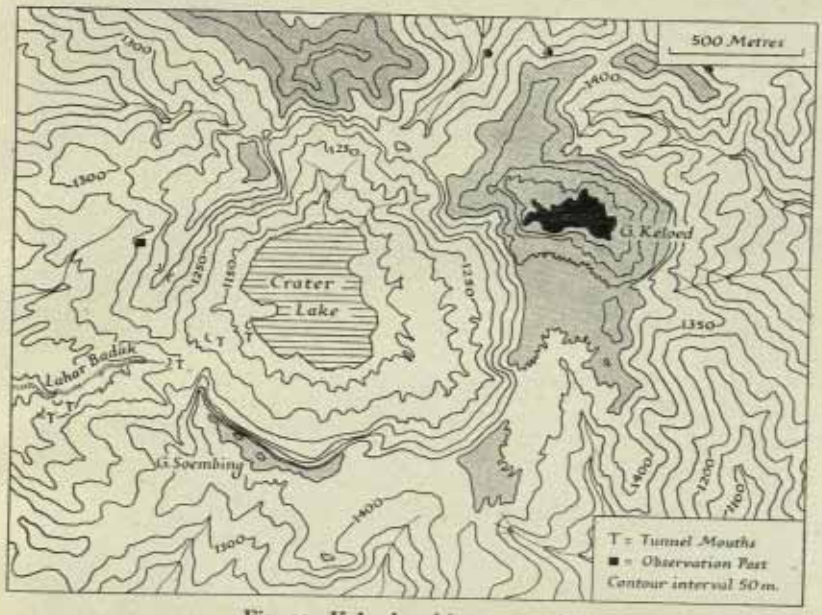

Fig. 20. Keloed and its crater lake

Land over 1,450 m. stippled; over 1,650 m. black. The map shows the tunnels which were constructed under the south-western col in 1919–28 to drain the lake, and also the tunnel serving the observation post.

Source: *Bulletin Netherlands Indies Volcanological Survey*, No. 76 (Bandoeng, 1936).

constructed under the crater-rim col (Fig. 20) and the water siphoned out, and by 1928, when the scheme was complete, the volume of the lake had been reduced from 40 million cu. m. to under 1·9 million cu. m. A new observation post was established in 1935–6 on the outer edge of the crater rim, with a tunnel cut through to the inner side. Measurements of the temperature of the lake water and of the fumaroles in the crater are made; a telephone system, with underground cables, links the post with the villages of the plain, so that due warning can be given of any signs of activity within the crater.

The Tengger Caldera. The Tengger-gebergte, in East Java, provide the finest example of a caldera, the conjectured history of which is as follows: The original volcano complex may have consisted of a

gigantic cone perhaps 4,500 m. (14,800 ft.) high, with subsidiary eruption points all round. The first catastrophic eruption blew off the top of the cone and created a large breach on the north-eastern side—the Sapikerep valley. New cones arose in the big pit, and the whole area was covered with new debris. A second catastrophic eruption caused another great collapse, this time in the west, and the last event, which is still in progress, is the building up of new cones on the floor of the collapsed area. The present caldera rim is mostly over 2,400 m. (7,900 ft.) and reaches 2,770 m.; the pit is 8 km. (5 miles) across, and its floor—known as the Dasar or 'sand-sea'—lies at about 2,100 m. From it rise several cones, of which Bromo is active and fairly frequently gives out flames and ash (Plate 8).

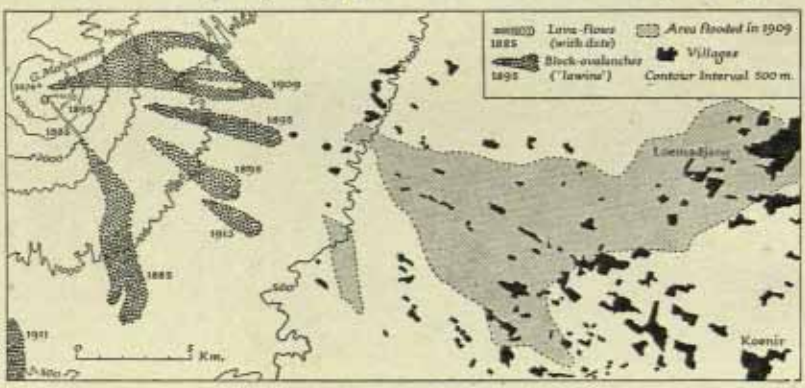

Fig. 21. The volcano Semeroe
Showing recent lava streams, avalanche-tracks, and the area of the great 1909 mud-flow. For the regional setting of the area, see Figs. 71 and 78.
Source: *Vulkanologische Mededeelingen*, No. 4 (Weltevreden, 1922).

Semeroe (Fig. 21). This lofty volcano in eastern Java has spread its destructive avalanches and floods south-eastwards, over the plains of Loemadjang. The summit is called Goenoeng Mohomeroe (3,676 m.—12,000 ft.); about half a kilometre to the south-east is the 200 m. deep crater. Semeroe erupted thirty-two times between 1818 and 1913; its activity was more or less continuous from 1885 to 1913, since when there have been no further disturbances. Small lava eruptions have occurred from time to time, with avalanches of mud and stones flowing down the ravines towards the plain. The most disastrous event of recent years, however, was the eruption of 1909, one of the effects of which was an enormous flood which spread over an area 20 km. long and 5 km. broad, extending as far as the town of Loemadjang.

Plate 8. Bromo, in the Tengger 'Sand-sea' (east Java)

In the centre is the active crater of Bromo; on the right is the finely-sculptured ash-cone of Batok (see also p. 34 and Plate 105).

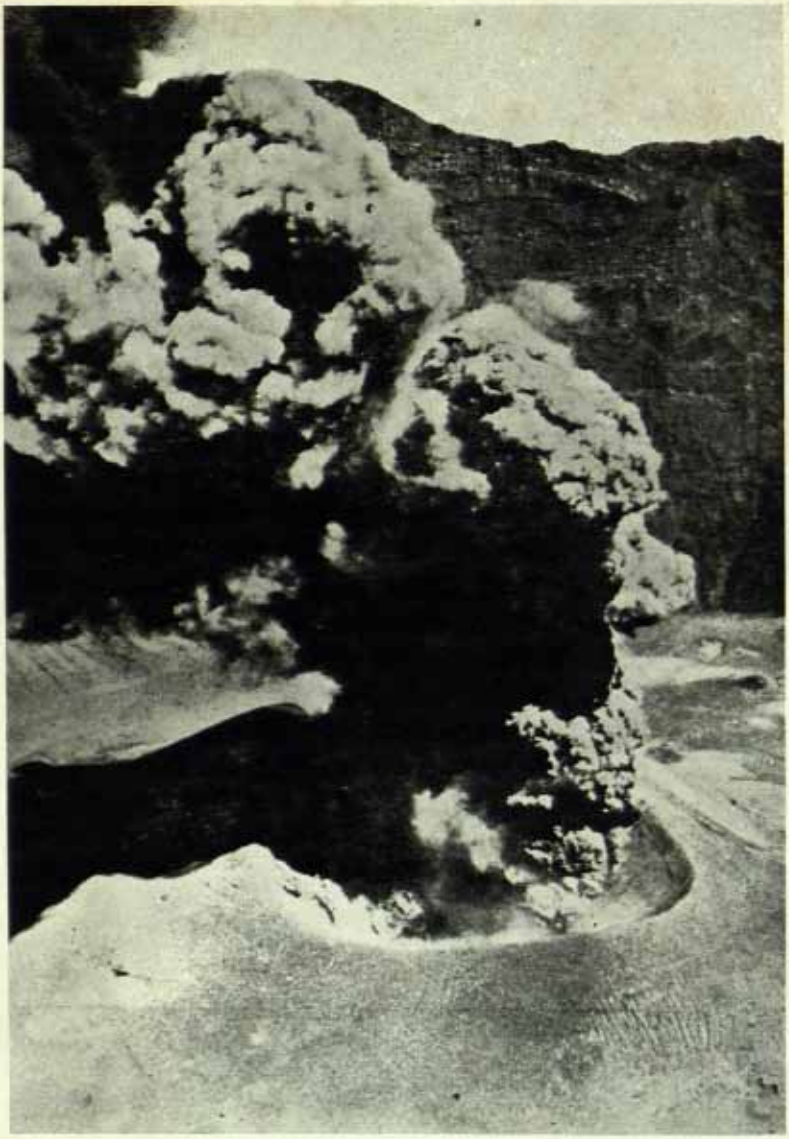

Plate 9. Ash-eruption of Raoeng (east Java)

Raoeng lies on the south-western side of the Idjen volcanic group, at the eastern end of Java (Fig. 23). This eruption, in August 1936, was photographed from the northern rim of the Raoeng caldera; the picture gives a vivid impression of the size of this huge volcano.

Lamongan (Fig. 22). Lamongan-Taroeb is a twin volcano, of relatively small dimensions, on the outer western flanks of the great Ijang mountain mass in eastern Java. Its summit scarcely reaches 1,670 m. (5,500 ft.), but it is interesting on account of its

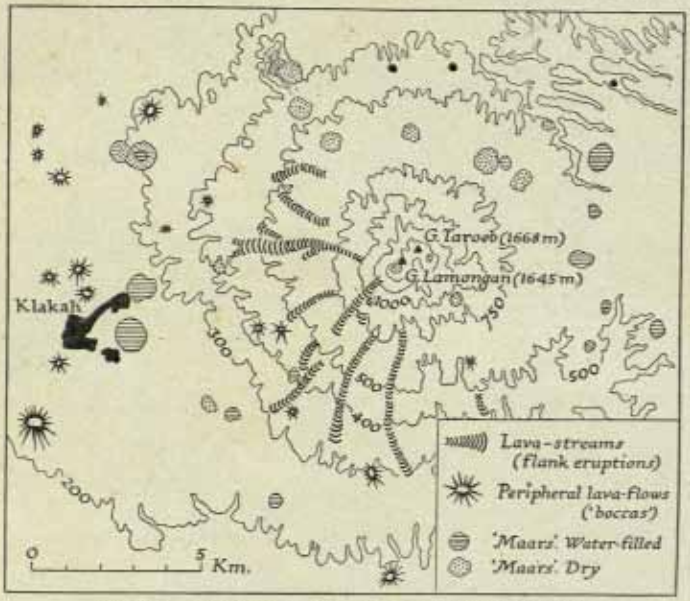

Fig. 22. Lamongan, with its 'maars' and 'boccas'
For the regional setting of the area, see Figs. 71 and 76; see also Plate 7.
Source: *Vulkanologische Mededeelingen*, No. 4 (Weltevreden, 1922).

peculiar features. It erupted thirty-two times between 1806 and 1898, but has since been quiet. Taroeb is old and quiet, vegetated all over, and with but a tiny crater, but Lamongan is active and bare, with a crater 150 m. (500 ft.) deep (Plate 7). Eruptions however have been largely from fissures in the lower flanks of the volcano, on the western and south-western sides; here numerous lava-flows have occurred. Allied phenomena are the *boccas*, small lava cones, of which twenty-nine exist; these are from 20 m. to 150 m. high and up to 1 km. in diameter. Lastly, a series of small depressions known as *maars*, up to 1 km. or more in diameter, clusters all round the lower flanks of the volcano; thirteen of these are water-filled, and eleven are dry. Temperature and water-level observations are made on several of them.

Kawah Idjen (Figs. 23 and 24). Kawah Idjen is a crater lake adjacent to the volcano Merapi in the Idjen-gebergte of eastern Java. Merapi

itself (summit 2,800 m.) has four sand-filled craters, but apart from these it is forested all over. The crater lake is 200 m. deep, and its water, which is turbid green, has a high percentage of free sulphuric acid and hydrochloric acid. Any overflow, therefore, can do great

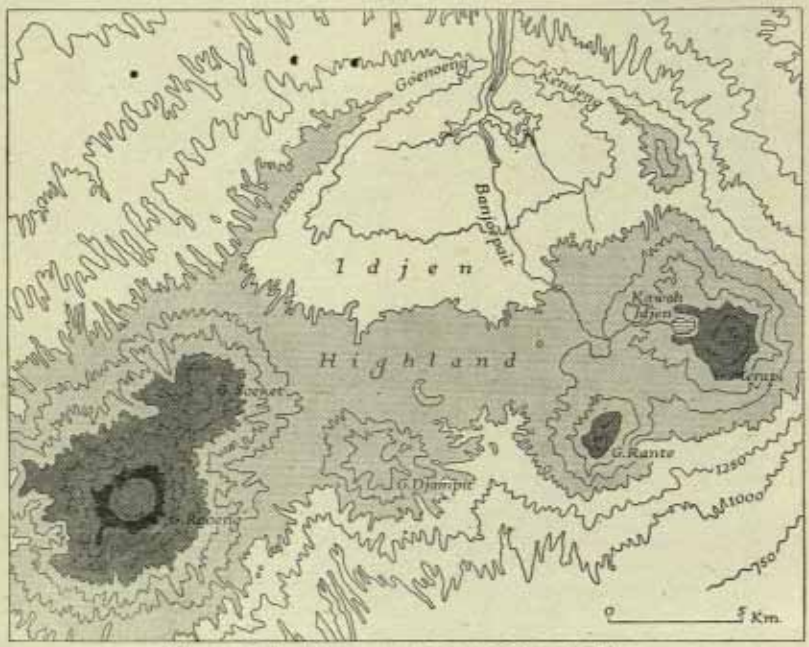

Fig. 23. The Idjen mountains and Kawah Idjen

Contour interval 250 m. Land over 1,500 m. stippled; over 2,250 m. cross-hatched, over 3,000 m. black.

The Idjen mountains and highlands are the remains of a stupendous volcanic complex, the northern rim of which has been reduced to small proportions, whilst the southern rim is studded with large cones—Merapi 2,799 m., Rante 2,644 m., Djampit 2,209 m., Soeket 2,950 m., and lastly Raoeng 3,332 m., itself a caldera 2 km. in diameter (Plates 9 and 41). The floor of the main caldera has several worn-down cones; it slopes northwards, and the Banjoepait river cuts a 500 m. deep gorge through the northern rim. The crater lake Kawah Idjen forms the subject of Fig. 24.

Source: *Atlas van Tropisch Nederland*, plate 6a (Batavia, 1938).

damage to the cultivated valleys and plains below. There is no regular outflow from the lake, though it may discharge underground to the Banjoepait (meaning 'acid water') valley. Excessive rainfall or eruptive activity may cause the level to rise, however, and accordingly a dam has been constructed at the outflow col. When the level of the water rises to within 100 cm. (3 ft.) of the zero point, the flood gates

are opened—but only after the intakes of the irrigation systems on the coastal plain have been closed; the acid water then flows down the Banjoepait and discharges by a single channel to the sea. The level, temperature and colour of the lake water are kept under constant

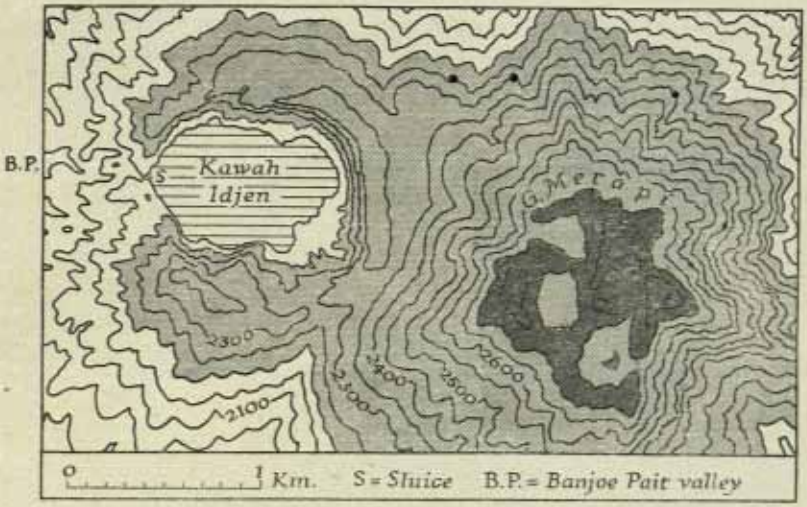

Fig. 24. Merapi (East Java) and Kawah Idjen

Land over 2,200 m., stippled; over 2,700 m., cross-hatched; contour interval 50 m. The summit of the ancient volcano Merapi (marked by a triangle) is 2,800 m. The lake lies in an oval crater, broken on the western side by a col leading to the Banjoepait valley (see also Fig. 23).
Source: *Bulletin Netherlands Indies Volcanological Survey*, No. 78 (Bandoeng, 1936).

observation, as are the solfataras within the crater. A new observation post was built in 1939.

Batoer (*Bali*) (Fig. 25). The volcano Batoer, on the island of Bali, is one of the largest closed calderas in any volcanic region of the world; its oval outer rim measures 13·8 km. from NW–SE and 10 km. from SW–NE. Within this is a second caldera, 7 km. in diameter. The highest point of the outer rim is Goenoeng Abang (2,152 m.) in the south-east, an old volcano cut in half by the formation of the cauldron subsidence. At its foot is the large lake, Danau Batoer, about 90 m. deep, formed by subsidence. In the middle of the oval is the present active centre, Goenoeng Batoer (1,717 m.), with a twin summit and several groups of craters, including many parasitic craters at the foot of the cone. Seven lava flows have been recorded during the past hundred years; the last was in 1926, when in the space of seven weeks 21 million cu. m. of lava poured out, and one branch of the flow

engulfed the Hindu village of Batoer, which five years previously had been closely approached by another flow (Plate 72).

Paloeweh. There are several small island volcanoes in the Lesser Soenda and Banda chains, and Paloeweh may be taken as an example.

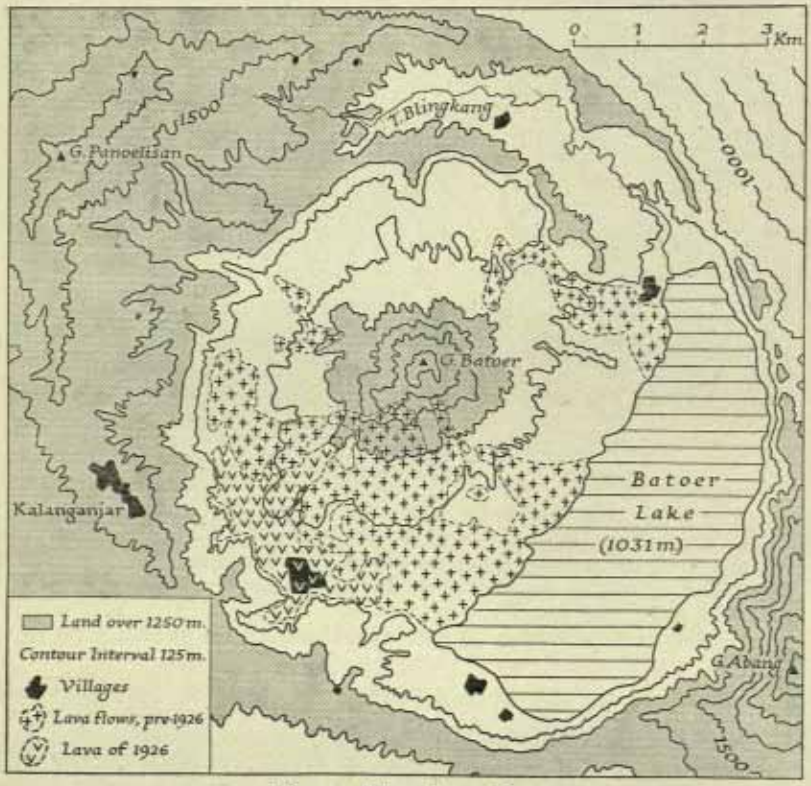

Fig. 25. The volcano Batoer

The map shows the 1926 lava flow which obliterated the village of Batoer.
Source: *Vulkanologische Mededeelingen*, No. 9 (Weltevreden, 1928).

The island, off the north-east coast of Flores, culminates in the young cone of Ili (875 m.) which has grown within the 900 m.-wide crater of an older cone. There is fumarolic activity over the whole island, and the southern flank of the mountain has been disrupted by collapses. Several craters and lava plugs exist. There was an eruption of the Rokatinda crater in 1928, when nearly 20 million cu. m. of debris were ejected—pumice, ash and blocks of lava. The whole south-western part of the island was set ablaze, and ash fell as far west as

Bali and eastern Java. Over 200 people were killed, half of them by three sea-waves (see p. 18), between 5 and 10 m. high, which flooded the shores as a result of landslides at or near shore level.

Keli Moetoe. The water in crater lakes is often coloured by chemicals, in solution or suspension—e.g. Telagabodas, Kawah Idjen; but in this volcano, in the island of Flores, three distinct colours are found in close proximity. The Tiwoe Ata Polo ('lake of the bewitched people') is dark red, due to iron salts in solution and a layer of red

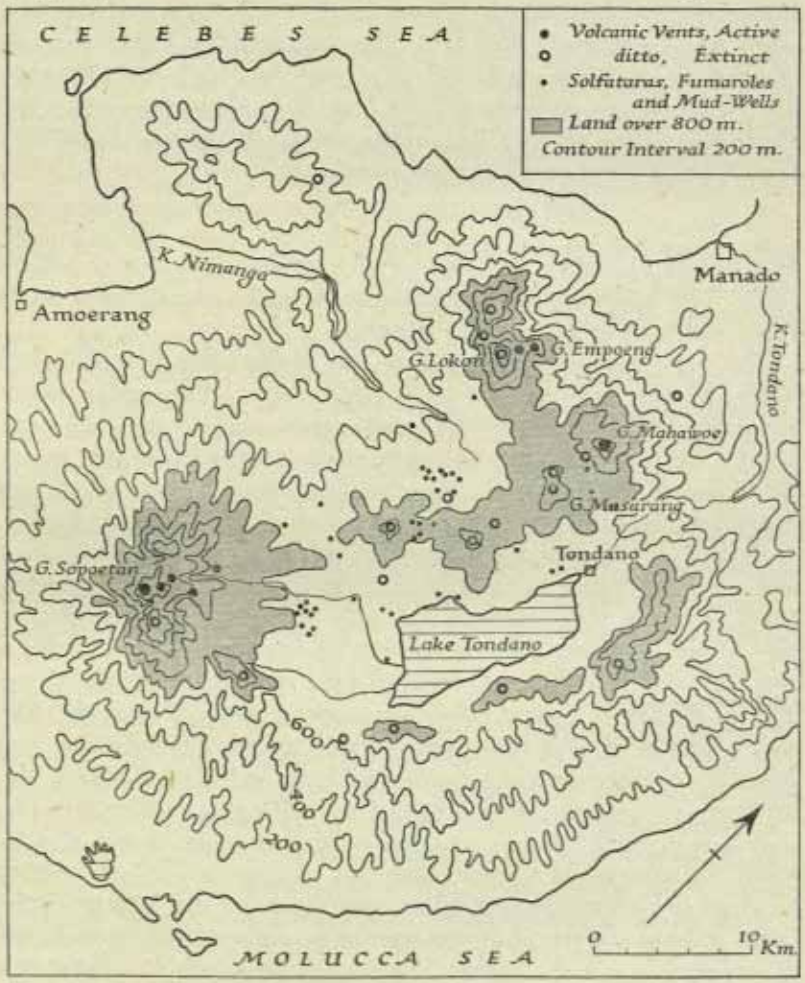

Fig. 26. Volcanoes of the Manado region, Celebes

Source: *Vulkanologische Mededeelingen*, No. 5, plate 13 (Weltevreden, 1923).

sediment on the bottom; the Tiwoe Noea Moeri Koöh Fai ('lake of the young men and virgins') is turbid green, due to free sulphuric and hydrochloric acid (cf. Kawah Idjen); the last lake, Tiwoe Ata Mboepoe, is a more transparent green, but the chemicals are the same as in the previous one (Plate 81).

Sopoetan (*Manado, Celebes*) (Fig. 26). The Minahasa peninsula of Celebes contains numerous volcanoes, including several on the active list (Fig. 13). Sopoetan is noteworthy for its numerous lava streams, almost every one of which has emanated from a different eruption point (cf. Lamongan, Fig. 22). The main summit crater (highest point of rim 1,784 m.) is 200 m. deep, but has only a few sölfataras. Recent eruptions—there have been four since 1905—have emanated from two points about 1 km. north-east of the summit, and have flowed either north-west or south-south-east.

Coasts

In later chapters details of the coast-line of the major islands will be given. The following is a general account only, intended to convey some idea of the main characteristics.

The very extensive coast-line of the Netherlands East Indies is estimated at 25,000 nautical miles (46,000 km.). This figure, which is considerably in excess of the equatorial circumference of the earth (40,000 km.) results from the very large number of islands in the Archipelago and from the complexity of their coasts, which are frequently indented by wide bays and narrow, penetrating inlets.

Below high tide mark fringing and barrier coral reefs often occur and are a hindrance to navigation in any but the smallest sea-going boats. The sea water inshore is usually wonderfully clear, enabling one to see in bright sunlight objects on the sea-bed at a depth of five fathoms. Exceptions to this clarity occur at the mouths of rivers, and on mangrove coasts, where the water is generally muddy. The water inshore is also very warm, about 27° C. (80° F.), and it is possible to bathe for long periods without bad results. There are, however, crocodiles, biting fish, and fish with poisonous spines that may give trouble, while certain jelly-fish can inflict a very painful sting. An affection of the ear, known as 'Singapore Ear', also has to be guarded against. Bathing off an open shore may be indulged in for years without accident, but it is safer to be protected by an enclosure of stakes, which keep out the larger marauders such as sharks, rays and crocodiles. Any numerous body of men landing from the sea, however, would scare away all such nuisances into deeper water.

The following types of coast-line are found:

i. Mangrove swamps.
ii. Coral shores.
iii. Sandy beaches.
iv. Rocky shores and headlands.
v. Precipitous cliffs with no beaches.
vi. Beaches formed of volcanic rocks.

i. Mangrove swamps occupy a large proportion of the coast-line on the inner or 'continental' side of Sumatra, Borneo and New Guinea, where river-borne silt accumulates in vast quantities on the shores of the shallow waters of the Soenda and Sahoel shelves. They form the most unattractive sea-shores that can be found anywhere: mud and monotonous vegetation are their two chief characteristics. The commonest animal life usually visible comprises the goggle-eyed mud-skippers, little fish with large heads and protruding eyes that slither over the mud at low tide and climb up onto the aerial tree-roots, and 'calling crabs' or 'fiddlers', little crabs with one large claw coloured bright blue or red with which they seem to beckon before they scurry down into their holes in the mud.

The vegetation composing mangrove-forest consists of a few species only, compared with the many species of the inland forests, and although it thrives under very wet conditions the principal species exhibit certain characters found in plants adapted to withstand drought, the leaves being thick and somewhat fleshy.

Mangrove-forests flourish best where the sea is quiet and a liberal supply of rich silt from the rivers is necessary for extensive growth. The first condition required is the formation of mudbanks. On these the pioneer mangrove species, *Avicennia* and *Sonneratia*, begin their life, sending out long rootlets into the mud from which pneumatophores rise like asparagus shoots. These plants can stand submersion in seawater to a wonderful extent, the young trees being completely covered at high tide, but the neap high tide-mark is the limit, there being a few days in every month above that when the trees are not covered; in other words, the trees cannot stand complete submersion every tide. After growth is established the *Rhizophoraceae* become the most abundant trees, and the forests, which hold up more mud brought down by the rivers, show the characteristic aerial roots, forming slender flying buttresses and protruding from the ground as loops like extended croquet-hoops (p. 379 and Fig. 132).

On coasts where there is strong and sustained wave-action mangrove-forest can only establish itself at the mouths of rivers

where fine silt and mud can collect inside the sandy bars that commonly block the entrances. Where prolonged scouring by waves takes place sandy or rocky beaches are formed, but it sometimes happens that mangrove is found immediately behind them.

Except in the river channels—which are often hard to find, for the mangrove coast is very monotonous and featureless—access by water may be possible only in the smallest boats, as the mud on which the mangrove thrives extends far out to sea, and off some coasts, e.g. western Borneo and south-western New Guinea, may cause ships to run aground before land is sighted.

Creeks and channels in mangrove-forest are sometimes inhabited by fishermen and woodcutters who earn a living by procuring firewood. They live in roughly built houses on piles, and it is stated on good authority that mangrove-swamps, though generally swarming day and night with mosquitoes and sandflies, are surprisingly healthy. This may be due to the absence of anopheline mosquitoes, but is more likely due to the thin population and the small opportunity that anopheline mosquitoes have of becoming infected with malaria by biting a human carrier of the disease. At night swarms of fire-flies frequently illuminate the tops of certain species of trees in these swamps. A poisonous snake (*Lachesis*) with dark green and yellow bands is common; its bite produces severe results but is not fatal. Crocodiles (*Crocodylus porosus*, the only salt-water species) are very numerous and may be seen far out at sea, especially off river mouths. When passing along a mangrove channel one sees these creatures slide down from the mud into the water as they take alarm. A crocodile will often attack small boats and upset them with its tail.

Mangrove-swamp coasts are constantly growing seaward with occasional checks caused by erosion, but at the same time the inland forest constantly encroaches on the landward side as the soil consolidates. The mangrove-forests are intersected by numerous channels along which boats can pass from one river-system to another or from one branch of a delta to another. Such channels are called *tĕrusan* or *pinta* by Malays, (*troessan* in Dutch orthography) both words being equivalent to our 'short cut'. These channels sometimes, as in the case of the Palembang river in Sumatra, form a complicated network in the mangrove-forest and without an experienced guide losing one's way is an easy matter and very unpleasant.

Some say that mangrove-swamps as residential areas are by no means as black as they are painted, but others who know them well fail to see anything attractive apart from some special mission, such

as obtaining firewood or other forest products, or scientific investigation. Walking in them is far from pleasant. One may sink in the mud knee-deep or more, or only ankle-deep. Aerial roots may be some help as steps but on the other hand the loops protruding from the mud trip up the unwary and the pneumatophores sticking up out of the mud are also a hindrance. Mangrove mud is evil-smelling and the only good thing to be said for it is that it is warm.

ii. Coral. The next most characteristic shores are those where coral grows. Corals require clear water but, as has been proved in Batavia bay, they can sometimes grow on a muddy sea-floor. The coral polyps cannot live below 25 fathoms, and in consequence the great thicknesses of coral rock sometimes found in the East Indies can only have accumulated through a sinking of the land or a rise in the sea level. Coral-reefs do not consist entirely of coral; calcareous algae play a very important part in their formation, and sand composed of the shells of foraminifera is also found. Reefs occur in three forms, fringing reefs, barrier reefs and atolls.

Fringing reefs are flats at sea level, up to half a mile in width with a wall on the seaward side that dips into deep water. The inner or landward side is composed largely of dead coral with spiny sea-urchins, shells ranging from the smallest to the giant clam weighing up to 500 lbs. and calcareous algae.

Barrier reefs are separated from the shore by a belt of sea which may be many miles in width. The sea-bottom between the barrier reefs and the land is composed of fine calcareous matter. Good examples of barrier-reefs occur off the west coast of Sumatra, off the east coast of Borneo (where the reef marks the eastern edge of the Soenda Shelf, see p. 12 and Fig. 7) and off the coasts of Celebes.

Atolls are not so common in the East Indies as in the Pacific archipelagoes. They consist of a central lagoon, usually shallow and coral-filled, with a fringing reef, circular or oval in form and seldom completely above water for the whole of its circumference. A few palms may grow on the parts permanently above sea level. Good examples of atolls occur in the Toekang Besi islands, to the south-east of Celebes (Fig. 11) and elsewhere.

Beaches overlooking coral reefs are formed largely of broken coral ranging in grade from fine sand to coarse detritus that can be used for building. At the head of the beach a cliff of consolidated coral-rock is often found, generally strongly undercut by the sea. This coral-rock may extend inland and reach considerable elevations, due in some measure to a slight fall in the sea level which is believed to

have followed on the much greater rise after the Pleistocene glaciation, but mainly to the uplift of the land (cf. pp. 11, 16).

Coral-reefs have very rough and hard surfaces that make progress on foot at low tide difficult. The coral-rock also is difficult to walk over, being hard and having irregular, jagged and honey-combed surfaces.

iii. Sandy beaches are formed where wave action, tides and currents are sufficiently strong to prevent the formation of mud-flats and mangrove swamps. They are a marked contrast to the latter type of shore. In some cases they extend for miles, giving a firm surface over which one can walk or bicycle freely and with enjoyment. Sometimes they are bordered by cliffs, or they may rise gently to the inland surface. Immediately above high tide mark vegetation begins. Short grass, bushes, among them being a conspicuous *Hibiscus* with yellow and purple flowers, and an *Ipomea* with violet-coloured flowers, are found. The *Ipomea* spreads over the ground and to some extent prevents the sand from being blown inland. A fringe of graceful casuarina trees often lines the beach for many miles and affords a welcome shelter from the hot sun. Coconut-palms thrive well along such beaches and native settlements are therefore found close to the shore. Brilliant sunlight and cool sea-breezes make these sandy beaches very pleasant resorts, but if they are near villages anyone camping on them risks being infected with malaria. It should be added that turtles' eggs are found buried in the sand; they are excellent eating.

Shingle is rare and is only found where such rocks as the Triassic conglomerate (composed of pebbles) are exposed, as for instance on Samboe, a small island in the Riouw archipelago just south of Singapore.

Sandhills are sometimes found, for instance on Madoera, where also, as in many other places, the screw-pine (*Pandanus*) grows close to the sea. Parts of the south coast of Java, exposed to the swell of the Indian Ocean, are formed of parallel belts of sand dunes, which sometimes rise to a height of 20 m. (66 ft.).

On some sandy beaches where the sand is derived from granite the action of the waves concentrates the heavier mineral grains to form a strip of black sand a few inches thick. In Malaya such black sand has been found to be rich in cassiterite (tin-ore), and the same may be the case in the tin-bearing islands of the Archipelago. The chief minerals in this black sand, however, are ilmenite (titaniferous iron-oxide) and tourmaline. Other beaches of black sand, derived

from volcanic rocks, are found on the south coast of Java and elsewhere.

iv. Rocky shores and headlands are found where mountain spurs extend down to the sea and where isolated masses of rock are situated on the shore-line. The surface of rocky shores varies with the nature of the rock, and the same applies to headlands. Granite and similar rocks produce numerous boulders of large size with patches of sand. Bedded rocks such as shale and schists are planed down by the sea to sloping platforms exposed at low tide and sometimes hardened by the deposition of black or brown iron-oxide. Bedded rocks on headlands show minute details of structure, such as folding.

An important negative feature of rocky shores and headlands in East Indian waters is that where the sea is calm thick growths of seaweed on the rocks, such as occur on some parts of the English coast, are absent. There is no slippery surface of weed to fall on, and in fact an encrustation of small but palatable oysters helps to give a firm foothold in many places. The reason for the comparative scarcity of seaweeds is that they require well aerated water, which calm and warm equatorial seas cannot provide. Seaweeds certainly occur in places, however, especially in the Moluccas, where they may be used as human food; of the three types, brown, green and red, the red are the commonest.

In addition to seaweeds, sea-grass occurs. *Enhalus*, known to the Javanese as jelamoen, and in Sumatra as jari ambun, is a marine plant found in the sea about and below low water mark. It is believed to be one of the chief foods of the sea-cow or dugong. This plant resembles the British *Zostera* (sea grass).

Tropical vegetation in full luxuriance crowns the rocky headlands and overhangs the rocks. Plants take every opportunity of establishing themselves until they are stopped by the bare rocks and inhospitable sand, so that one can climb from a headland straight into the densest forest (Plate 52).

v. Precipitous cliffs plunging into the sea with no beach are sometimes found, particularly where quartzite or limestone forms the coast. In the case of limestone, which is found as isolated islets with vertical and even overhanging cliffs, the rock is frequently so strongly undercut by the sea, limestone being a soluble rock, that a small boat can shelter under the overhanging mass. In general, however, cliffs such as are characteristic of so much of the British coast are comparatively rare in the Netherlands Indies. One of the main reasons, no doubt, is the much greater rapidity of weathering in an equatorial

climate, and a correspondingly greater speed of vegetative growth. What in Britain would be bare cliffs thus become crumbled, rocky headlands covered with scrub, wood or even forest.

vi. Volcanic beaches. A special type of rocky and sandy shores is afforded by volcanoes when near enough to the sea. The sand of such beaches, derived from ashes and lava, is generally dark in colour, but when composed of broken-up pumice it is light-coloured. Blocks of lava and consolidated ashes are piled up on some shores and high volcanic cliffs are found. Very good examples of these shores are exhibited on the three islands of the Krakatau group. On the main island, Rakata (813 m.—2,667 ft.), the 1883 eruption has left a tremendous precipice that is a section of an old volcano showing its inner structure very clearly. Lang island, nearby, shows low cliffs of pumice derived from the same eruption and a beach of the same material (Fig. 14).

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Chapter II

SUMATRA*

Introduction: Physical Features: Regional Description: Coasts: Bibliographical Note

INTRODUCTION

Sumatra is an elongated island, covering 425,000 sq. km. (164,000 sq. miles) an area approximating to that of Sweden. It is narrower in the north than in the south, and its axis runs from north-west to south-east. It straddles the equator from 6° N to 6° S, and in length is about 1,720 km. (1,060 miles); the greatest width, roughly athwart the equator, is about 400 km. (250 miles). Superimposed on the map of Europe, it would stretch from London to Brindisi (Fig. 1); it is one of the world's largest islands, and its area is thirty times that of the mother-country of Holland.

For administrative purposes Sumatra is divided into the following Residencies: in the extreme north is Atjeh (better known perhaps as Achin—the English form of the name); next on the east is the Oostkust (East Coast) Residency, followed by Riouw (including the Riouw and Lingga islands), Djambi, Palembang and Lampoeng. On the west coast Atjeh is succeeded by Tapanoeli, the Westkust (West Coast) Residency and Benkoelen.

Off the west coast, at a distance of 130 km. in the north and 90 km. in the south, is a line of large islands extending from 3° N to 5° 30′ S. These islands, separated from the mainland by a deep channel—mostly deeper than 1,000 m. (550 fm.)—and from each other by channels of moderate depth, generally over 200 m. (110 fm.), form part of the outer fold arc described above (p. 14). Starting from the north they are Simeuloeë, Nias, the Batoe islands, Siberoet, Sipora, the Pagaï or Nassau islands, and Enggano. Siberoet, Sipora and the Pagaï islands are together sometimes known as the Mentawai islands. Between Simeuloeë and Nias, but some distance to the east, and

* For Sumatra and Java, and also to a large extent for Borneo, Celebes and New Guinea (chap. IV, V, VI, and IX), the descriptions given in this volume relate almost entirely to matters of geology and physical geography, since other aspects of the land and life of these territories are dealt with in the chapters on Agriculture, Mining, etc. in vol. II of this Handbook. For the smaller islands additional descriptive details are added relating to vegetation, agriculture, mining, distribution of population, etc., in order to present a more complete geographical picture of each island.

linked to the mainland by a submarine shelf, are the Banjak islands, the easternmost of which is little more than 30 km. from the mainland.

On the east Sumatra is bounded by the shallow waters of Malacca strait, the South China Sea and the Java Sea. Between 3° N and the equator there are many large, jungle-clad and mangrove-fringed islands lying immediately off the shore; they are very low and flat and are simply a continuation of the equally flat and swampy mainland, the whole forming an 'amphibious' belt liable to be half drowned at every high tide. Further out in the South China Sea are the Riouw and Lingga Archipelagoes—the East Indian *Cassiterides* or tin-islands—of quite different physical form. Off the coast of the Palembang Residency are the larger tin-bearing islands of Bangka and Billiton.

In the extreme north, We island is separated from Sumatra by the Malaka Passage. Two other islands—Breuëh or Lam Poejang and Peunasoë—lie further to the south-west, separated from We by the Bengalen Passage and from Sumatra by the Ceder Passage; they are a continuation of the main axial range of Sumatra. In the south Sumatra is separated from Java by the Soenda strait. It terminates in three large capes separated by Semangka and Lampoeng bays.

PHYSICAL FEATURES

The physical features of Sumatra are clearly defined. Three parallel belts may be distinguished. In the west is a chain of mountains. The whole range is sometimes referred to as Boekit Barisan (meaning 'a line of hills') but this name is perhaps more properly ascribed only to the southern two-thirds of the range, the northern one-third, where the mountains are broader and more centrally placed, being known as the Batak and Atjeh Highlands. The range drops steeply to the west coast, leaving only occasional low lying plains up to 30 km. (*c.* 20 miles) wide; to the east the descent is more gradual, and the rolling hills of volcanic and sedimentary rocks which occupy the centre of the island form the second belt. The third zone is the flat alluvial lowland, swampy and jungle-covered, which merges beyond a fringe of mangroves into the shallow waters of the Soenda Shelf.

The drainage of the island flows either westwards to the Indian Ocean or eastwards to Malacca strait and the Java Sea, but the watershed occupies a distinctly asymmetric position except in the Atjeh and Batak Highlands of the north, where it lies almost exactly halfway between the two coasts (Fig. 27). South of lake Toba the

Barisan ranges lie close to the west coast, and the crest line which forms the watershed is seldom more than 60 km. (37 miles) from the ocean; it runs out into Soenda strait in the middle of the three capes. As a result the westward-flowing streams are short and swift, and are

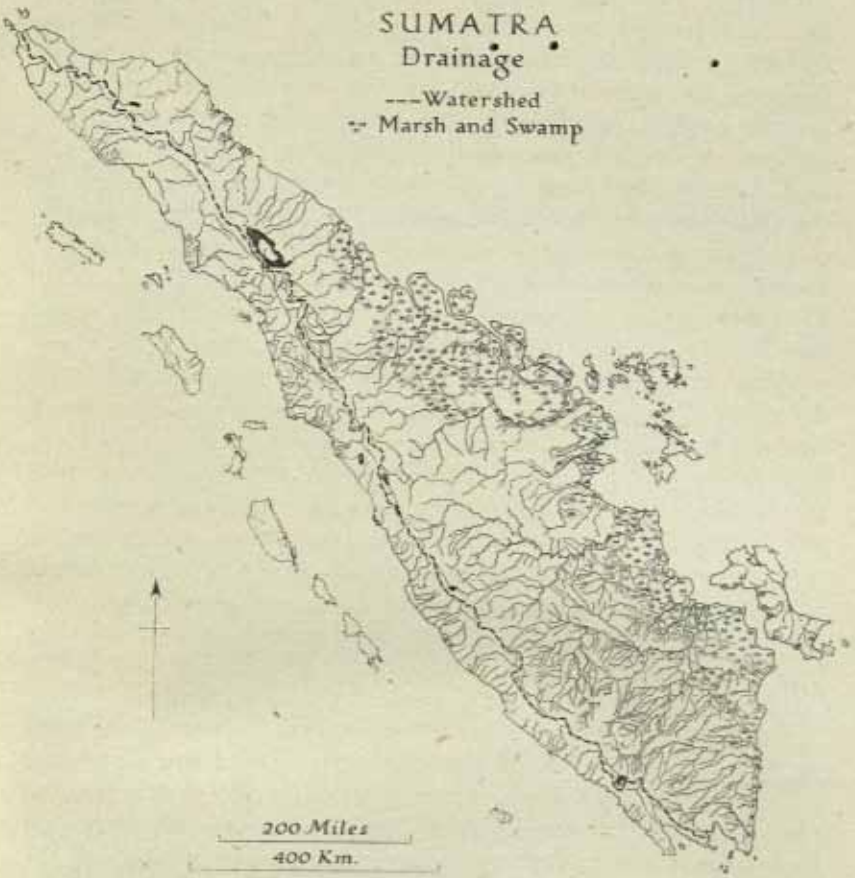


Fig. 27. Sumatra: Drainage pattern
Source: *Atlas van Tropisch Nederland*, plates 12, 13, 14 (Batavia, 1938).

rapidly eroding the steep mountain wall which experiences the full force of the south-west monsoon. Flowing eastwards are the head-streams of a large number of much longer rivers which when they reach the alluvial plain meander slowly amidst the swamps and deposit their load of silt in sandbanks and deltaic mud-flats.

In the physical history of Sumatra the most prominent event was the Cretaceo-Tertiary folding which produced the great mountain ranges (Fig. 5). Rocks of various ages between Carbo-Permian and Lower Tertiary (or Palaeogene) were involved in the most intense crumpling; the Upper Tertiary (or Neogene) rocks however must have been formed after the period of greatest folding, for they are flanking in their disposition and are for the most part but gently puckered into the anticlines and synclines of small amplitude which provide excellent conditions for the accumulation of mineral oil deposits. After the Tertiary folding, considerable modification of the land forms resulted from the changes of level which occurred during the Quaternary or Pleistocene period. The relief of the mountains was already mature when a considerable uplift—or more probably a lowering of sea level—rejuvenated the drainage system, and caused increased erosion which eventually reduced the eastern part of the island to a peneplain. The latest earth movements seem to have been a tilting, up on the west, down on the east, which resulted in the drowning of the lower parts of the east coast and the accentuation of the westward-facing mountain wall, with the upraising of coral reefs. This tilting, and the movements which preceded it, was accompanied by faulting, which produced, in the mountain area, deep troughs and rift valleys dividing the maturely-dissected mountain ranges. A discontinuous longitudinal trough lying between two main ranges is characteristic of the greater part of the mountainous region, from the basins of Goja and Alas in the Atjeh Highlands to Semangka bay in the extreme south. Several lakes occur in these troughs, including Toba, the largest body of inland water in the East Indies.

Much volcanic activity also accompanied the Tertiary–Quaternary earth movements. Considerable quantities of andesitic lava were poured out during the mid-Tertiary period; much of this lava has been removed by erosion or covered by subsequent outpourings, but large areas remain in the south, and occasional outcrops occur on the western side of the mountains. In the latter location especially their relative hardness and resistance to erosion gives rise to distinctive relief and coastal features. Of the more recent volcanic activity, there was least in the Atjeh region of the north, but the Batak country around lake Toba is entirely composed of a very thick mass of volcanic tuff, whilst much of the Barisan range further south is made of young volcanic lavas and ashes, with a long line of active, dormant and extinct cones (Fig. 28). The eastern lowlands, too, in the southern part of the island, are largely underlain by volcanic rocks, but in this

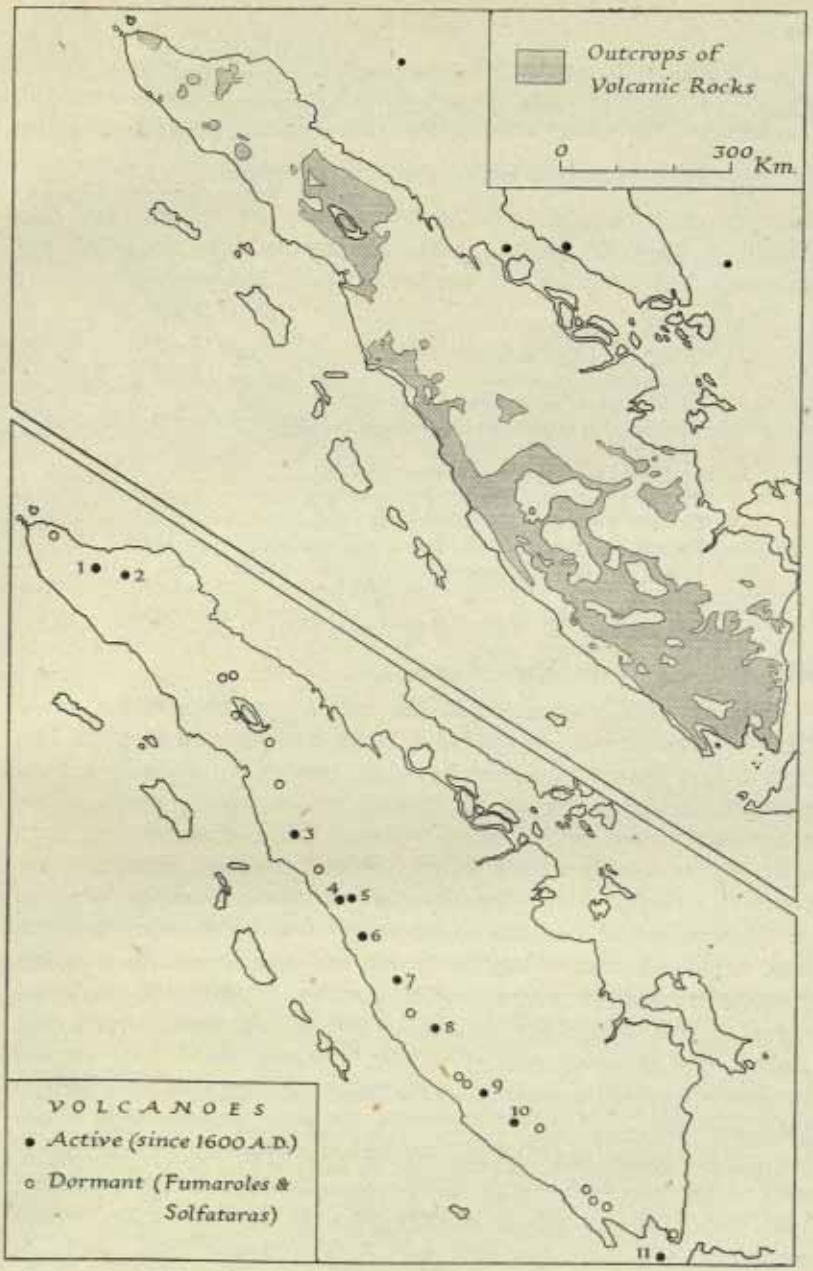


Fig. 28. Sumatra: Volcanoes and Volcanic Rocks

Based on *Atlas van Tropisch Nederland*, plates 5 and 11 (Batavia, 1938). For key to numbers of active volcanoes, see p. 22.

case the rocks are not lavas but ashes and cinders—tuffs and pumice—which have generally been re-deposited by water.

REGIONAL DESCRIPTION

For purposes of description Sumatra may be divided into the following physical regions, grouped broadly into those of the mountain belt and those of the eastern hills and plains:

A. The Mountain Belt:
- The Atjeh Highlands
- The Batak Highlands
- The Tapanoeli and Padang Highlands
- The volcanic highlands of southern Sumatra:

B. The Hills and Plains of Eastern Sumatra
- Soengai Asahan to Soengai Inderagiri
- Soengai Inderagiri to Batang Hari
- Batang Hari to Air Moesi (and Air Komering)
- Palembang and Air Komering to south-east coast.

A. The Mountain Belt

The Atjeh Highlands (Figs. 30 and 31)

This physical division, extending from the north-western end of the island to the volcanic region of Batak, a distance of over 400 km. (250 miles), is distinguished from the rest of Sumatra in several respects. In the first place the mountains are mainly composed of sedimentary and metamorphic rocks of Carbo-Permian age with only a few comparatively small volcanic masses. Secondly, the complex structure and relief, especially in the Gajo region, are due to the meeting of two sets of structural trend-lines, the WNW–ESE lines which dominate western Atjeh and the NW–SE lines which characterize Malaya and the rest of Sumatra. Thirdly, the bordering strips of Upper Tertiary sediments and recent alluvium are only narrow and discontinuous. Fourthly, although there is a marked tendency in Atjeh, as elsewhere, for two main ranges to be separated by a discontinuous longitudinal valley, the major crestline and water-parting are more centrally disposed in this region than in any other part of the island (Fig. 27), and there is hardly a westward facing 'wall' such as that which characterizes the Barisan range further south.

The rocks which compose the Atjeh Highlands are for the most part schists, slates and limestones of Carbo-Permian age, with occasional masses of granite in the core of the upfolds. The softer

slaty rocks have weathered comparatively easily under conditions of heavy rainfall into a mature or intricately dissected landscape; the limestones, harder and more porous, frequently stand out as prominent ridges with cliff-like escarpments, cut through in deep and

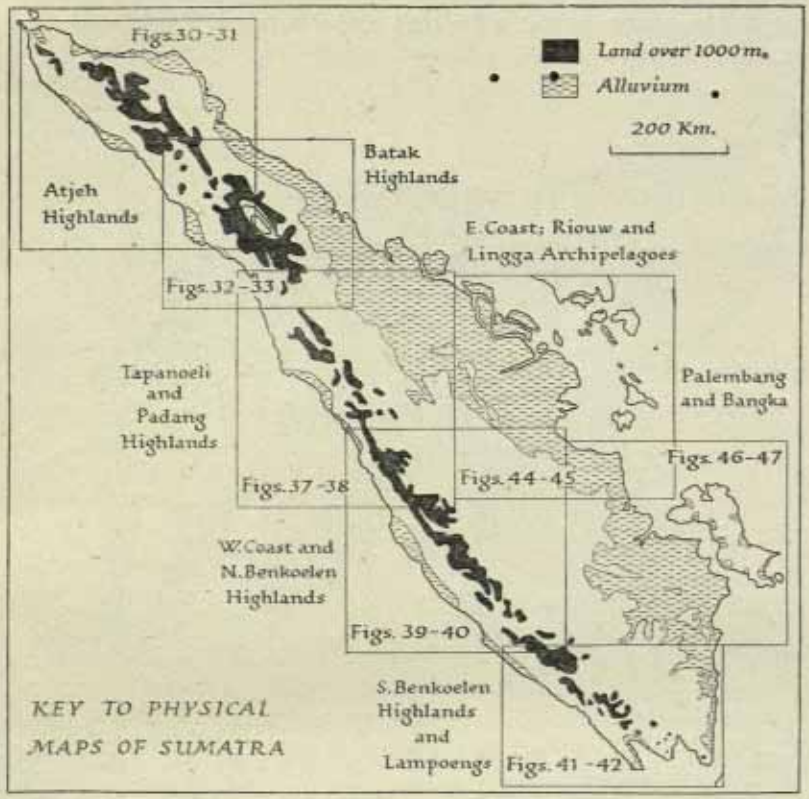


Fig. 29. Key to Physical maps of Sumatra

General Note on detailed maps of Sumatra, Figs. 30–33, 37–42, 44–47.

In these maps an effort is made to show the essential elements of the physical environment.

The first of each pair of maps shows the geology, much simplified from the Dutch 1 : 1 M geological series, and a contour selected to show the highest parts of the mountain system; in addition, the extent of swamp areas is shown, drawn from the International 1/1 M series (G.S.G.S. 4204), and the volcanoes are classified in accordance with the geological maps and the lists of the Netherlands Indies Volcanological Survey.

The second map in each pair repeats the essential geological lines of the first, has one or more lower contours designed to give a broad indication of the extent of the highland area and the inland limit of coastal lowlands; it also provides a key to the more important names of physical features and towns.

impressive gorges by the rivers which flow westwards across the axis of the folds. On the eastern flanks of the highlands are folded rocks, also in part limestone, of Lower Tertiary age, while similar rocks also occur in downfolded or faulted basins in the heart of the highland mass, as in the Goja or Djamat basin and the nearby trough of Laoet (lake) Tawar, also in the upper part of the Kroeëng Tripa basin, and

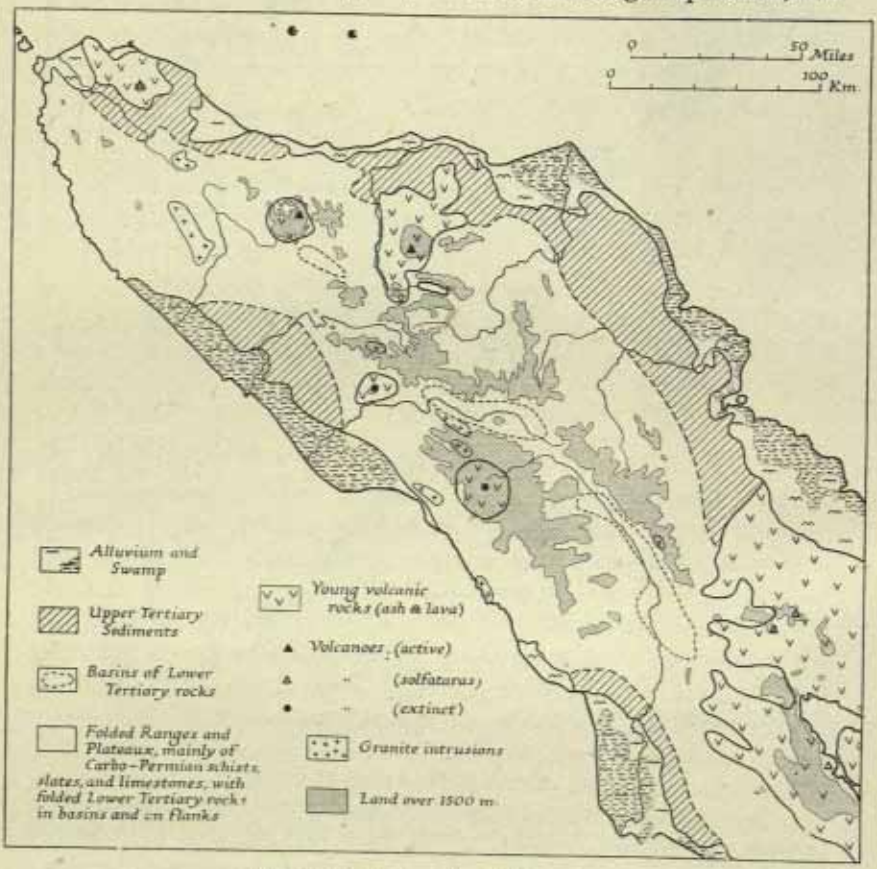


Fig. 30. Sumatra: the Atjeh region

Simplified geological map showing mountain ranges and coastal swamps. For sources see Fig. 29.

in the longitudinal trough of the Lae Alas. Superimposed upon the landscape of folded mountain ranges, though not necessarily forming the highest summits, are five masses of volcanic rocks, two of which contain active eruption centres.

The axial range of Sumatra starts in the limestone promontory of Atjeh Hoofd (Achin Head). The 'W' gebergte—as it is called for want of a recognized native name—is also made of limestone, and trends south-eastwards for about 50 km. (30 miles), reaching an altitude of 2,140 m. (6,900 ft.) in Bateë Meutjitja. The range drops eastwards to the trough of the Kroeëng Atjeh, formed of soft Upper Tertiary

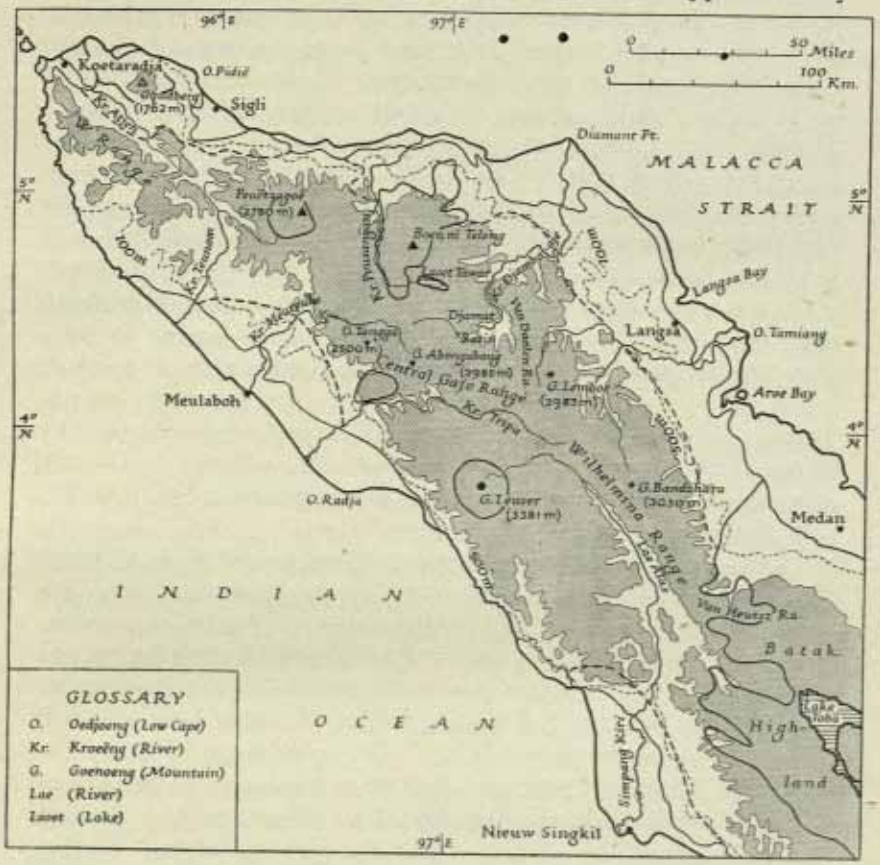


Fig. 31. Sumatra: the Atjeh region
Key map to Fig. 30, showing relief and chief towns. Mountain peaks shown by asterisks are non-volcanic. 100 m. contour shown as pecked line; land over 500 m. stippled. For sources see Fig. 29.

sediments with the alluvial plain of Koetaradja at its lower northern end. The Atjeh valley communicates eastwards by an easy route round the southern side of the dormant volcanic mass of Seulawai-hagam or Goudberg (1,762 m.—5,577 ft.) with the coastal plain of

Sigli. The forested western flanks of the 'W' range drop steeply to the sea in rocky headlands separated by sandy bays. South-eastwards the relief becomes much more broken and confused and the range is discontinuous. The headwaters of the Kroeëng Teunom lie in a continuation of the longitudinal trough of the Atjeh valley, and they provide a useful routeway across the mountains from Sigli to Meulaboh. The south-westward flanks of the ranges are very broken, and a considerable lowland intervenes between them and the sea. Undulating Upper Tertiary hills fall gently to the flat alluvial swamps of Meulaboh, which extend for about 170 km. (100 miles) from Tjalang in the north to Soesoh in the south-east, with a width of 15–25 km. (10–16 miles). This marshy plain, which has been built up by the deposits of the many streams flowing down from the highlands, projects seawards in the low, sandy headland known as Oedjoeng Radja.

On the north-eastern side of the ranges which back the Meulaboh plain rise two volcanic cones, Peuëtsagoë (2,780 m.—9,000 ft.) with the active eruption point of Bateëkeubeuë, and Boer ni Geureudong (2,900 m.—9,500 ft.) with a similar active crater known as Boer ni Telong. The northern flanks of these two masses, wrapped round by Tertiary sediments, drop fairly steeply to the narrow coastal plain of northern Atjeh, where the alluvial belt is under 10 km. (6 miles) wide and there is scarcely any swamp.

The Gajo region of central Atjeh is characterized by bold relief. The picturesque lake Tawar (Laoet Tawar='fresh sea'), with the small town of Takingeun on its western shore, lies at about 1,200 m. (4,000 ft.) above sea level, bordered by rice fields and almost surrounded by wild, pine-clad limestone mountains, the summits of which rise to between 2,400 and 2,800 m. (8,000 and 9,000 ft.). It owes its origin to the damming of a valley by volcanic debris, and its outlet, the Kroeëng Peusangan, follows in a deep gorge the line of weakness which marks the junction of the volcanic rocks of Boer ni Geureudong with the folded Carbo-Permian sediments. Further south lies the enclosed basin or plateau which is the centre of the Gajo country—the Gajo or Djamat basin, floored and bordered by Lower Tertiary rocks; owing to its sheltered aspect it is much more sparsely vegetated than the richly jungle-clad mountains. The basin is bordered on the east by the north–south Van Daalen range, and on the south by the imposing wall of the Central Gajo range (Gajosche Centraal-gebergte). The latter, which attains summits of 2,500 m. (8,200 ft.) in the granite dome of Goenoeng Tangga, which overlooks

the limestone gorge of the Kr. Meureubo, and 2,985 m. (9,800 ft.) in the limestone peak of Goenoëng Abongabong, drops steeply in its turn to the upper valley of the Kroeëng Tripa, another down-warped Lower Tertiary basin, so sheltered from the monsoon rains as to be almost semi-arid steppeland. The headwaters of the Kr. Tripa are separated by only a low divide from the elongated depression which is the centre of the Alas country—the valley of the Lae Alas (='jungle river'), a narrow trough over 100 km. (60 miles) in length. The slopes of the Alas valley are distinctly asymmetrical. On the east rises the steep wall of the Wilhelmina range, with summits reaching over 2,500 m. (Goenoeng Bandahara 3,030 m.—9,850 ft.); to the west the ascent is more gentle, and numerous tributaries run down from wild and nameless ranges which contain several peaks reaching more than 3,000 m. The Lae Alas itself rises in the extinct volcanic cone of Goenoeng Leuser (3,381 m.—11,100 ft.) which dominates the northern end of these ranges. From G. Leuser and its neighbouring limestone and slate mountains to the coast the drop is steep, and the coast is rocky, with prominent cliffs of limestone, and of granite and other igneous rocks.

The Lae Alas breaks through from its interior valley to the coastal plain in a gorge. Its vast quantities of silt have built up an extensive alluvial plain—the Troemon marshes—some 75 km. (50 miles) long and 30 km. (20 miles) wide. The lower course of the river is known as the Simpang Kiri; after much meandering across the marshes it enters the sea near Nieuw Singkil.

The eastern flanks of the Atjeh Highlands drop steeply to about 200 m. (650 ft.), a level which marks roughly the outcrop of the gently folded Upper Tertiary oil-bearing strata. The surface then declines by easy stages to the coastal alluvial belt, which is of variable width, broadening in the swamp of the lower Kroeëng Djamboaje to more than 20 km. (12 miles), and in the region of the lower Soengai Tamiang, east of Langsa, to a width only slightly less.

The Batak Highlands (Figs. 32 and 33)

The Batak Highlands, like the Atjeh Highlands, form a well-marked physical division, but in this case the distinctive feature is a high plateau formed by a great thickness of comparatively recent volcanic debris. The volcanic tuff covers an area of some 35,000 sq. km.—an area larger than the whole of Holland—and the deposit averages 600 m. (2,000 ft.) in thickness; it has submerged almost all the pre-existing relief. The underlying Carbo-Permian rocks come to the

surface only in one region within the volcanic area, in a range on the eastern side of lake Toba which culminates in the twin peaks of Dolok Pangoeloebao and Dolok Simanoek-manoek, each over 2,100 m. (7,000 ft.).

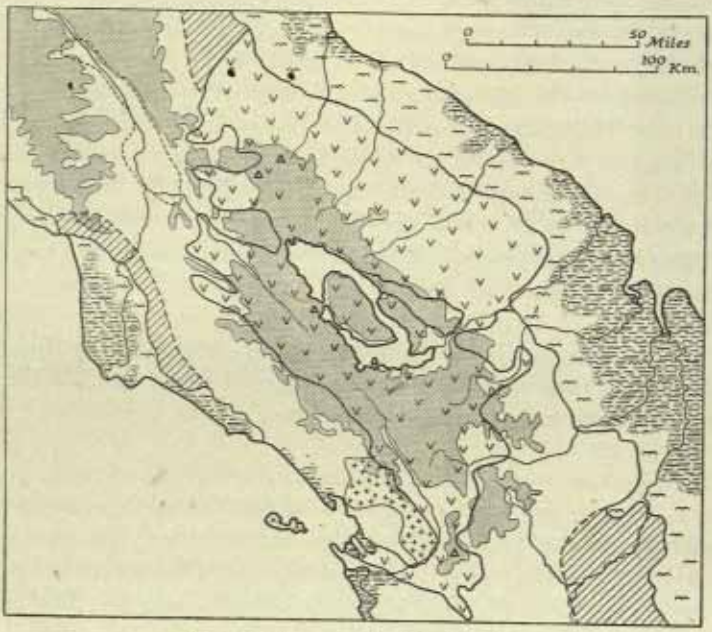


Fig. 32. Sumatra: the Batak region

Simplified geological map, showing land over 1,000 m. (stippled). For key to symbols see Fig. 30; for sources see Fig. 29.

In the north-west, the volcanic plateau interdigitates with the last offshoots of the Atjeh Highlands, the Van Heutsz range and the range which culminates in Dolok Siboeatan (2,451 m.), towering over the north-western end of lake Toba. The plateau itself averages 1,000–1,400 m. (3,000–4,500 ft.) above sea level, but the piled-up volcanic tuffs rise to higher altitudes on the rim of lake Toba—e.g. the dormant volcano Poesoek-boekit ('navel hill') (1,982 m.)—and in the dormant cones of Dolok Sinaboen (2,451 m.) and Deleng Sibajak (2,094 m.), in the north (Plate 10 and Fig. 34).

On the western side of the plateau the underlying Carbo-Permian rocks come to the surface once more, forming a rough and very broken rim rising several hundred metres above the plateau level—e.g. Dolok Pinapan, 2,037 m., and the limestone range of Pak Pak.

From this rim, the southern part of which is formed by an intrusion of granite which rises behind Sibolga, the surface plunges steeply through a very difficult and dissected terrain of folded Lower Tertiary rocks, to the narrow coastal plain which borders the shore from the

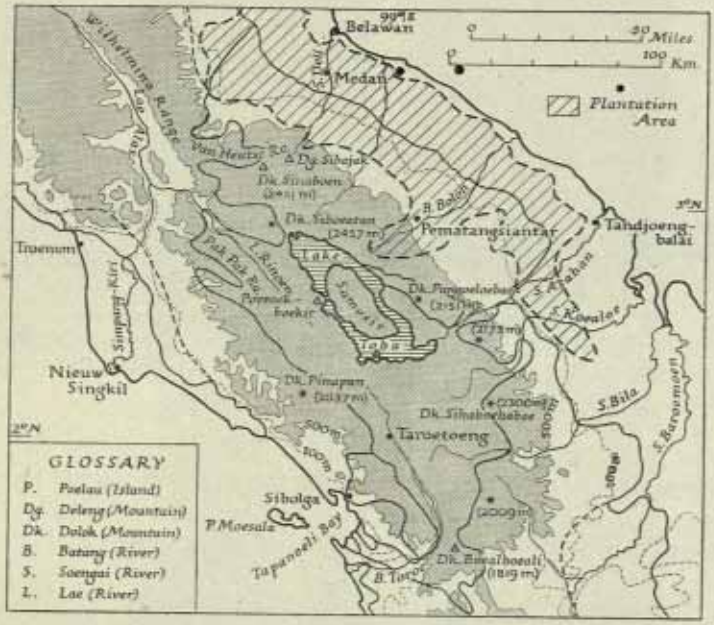


Fig. 33. Sumatra: the Batak region
Key map to Fig. 32, showing relief, chief towns, and the location of the 'Cultuurgebied' (Plantation area). Note the relation of the latter to the coastal lowland and to the volcanic rocks (see p. 61). 100 m. contour shown as pecked line; land over 500 m. stippled.
For sources see Fig. 29.

Troemon marshes to Tapanoeli bay. This western wall, which has many deep valleys and gorges but no major routeway, renders the Batak plateau almost inaccessible from this direction. The only avenue of approach is the Batang Toroe valley, which leads through gorges round the southern end of the granite ridge, and then northwards to Taroetoeng and the plateau south of lake Toba.

The south-eastern part of the Batak plateau also has a broken rim of Carbo-Permian rocks, the superior resistance of which enables them to stand out boldly in a series of highly dissected mountains such as Dolok Soeroengan (2,173 m.), Dolok Sihaboehaboe (2,300 m.) and Dolok Tampoelonandjang (2,009 m.). The rim is deeply gouged

by river valleys, and it descends steeply on the south-eastern side to the lowlands of the Soengai Baroemoen.

On the eastern side of the plateau there is no rim of old rocks, and although there is a fairly steep drop at first, especially from the Karo

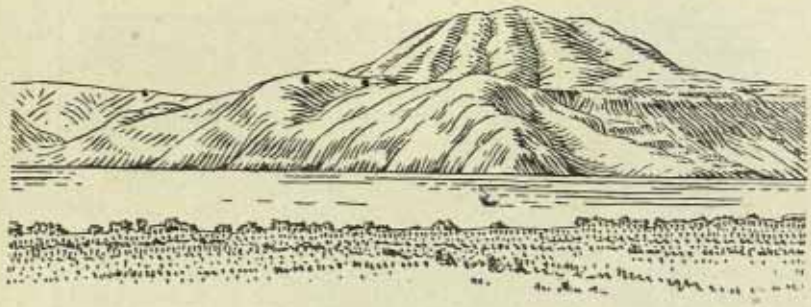


Fig. 34. Lake Toba and Poesoek-boekit volcano
View from Samosir island across lake Toba to the dormant volcano Poesoek-boekit (='Navel hill'). The volcano rises from the surface of the Batak plateau. Drawn from a photograph.

plateau north of lake Toba and on the flanks of the two dormant volcanoes, the slope flattens out gradually towards the coastal lowland. Many steeply graded rivers have cut deep gorges in the plateau edge, and the enormous quantity of easily-eroded volcanic debris which

Fig. 35. Tobacco plantation in the Deli region
Drawn from a photograph.

Plate 10. Berastagi and the Sibajak volcano

Berastagi, in the Batak highlands at 1,600 m. (5,250 ft.), is a popular health resort for Dutch planters from the Medan region. In the background is Deleng Sibajak, 2,094 m. (6,870 ft.) a dormant volcano with deeply-eroded sides.

Plate 11. Lake Toba
South-eastward view across Bandarsamboe bay, on the northern shores of the lake. This is one of the few places where a metalled road reaches the lake-shore. In the distance on the right is the steep eastern side of Samosir.

Plate 12. Lake Toba and Samosir
View from near Prapat, on the eastern shore of the lake, looking westwards to the steep eastern face of Samosir. Prapat is a small market centre, frequently visited by people from Samosir, who cross the lake in large canoes.

they have transported has built up an extensive alluvial plain averaging about 30 km. (20 miles) in width. It is on the fertile soils of the volcanic and alluvial deposits, mostly at elevations of below 200 m. (650 ft.), that the economically important 'plantation area' (*cultuurgebied*) of eastern Sumatra has been developed (Figs. 33 and 35).

The greater part of the volcanic rocks of the Batak Highlands is of a rather acid character which is not very common in the East Indies as a whole. The parent rock from which the debris is derived is described as liparite, the chemical composition of which is not unlike that of granite. Only the recent effusiva emanating from the two dormant cones in the north are of the more normal intermediate or basic character—a fact which, through its influence on the resultant soils, has a vital controlling influence over the distribution of the tobacco plantations of the Medan region (see vol. II, ch. VI and Fig. 35). The widespread distribution of acid volcanic cinders of a rather spongy character has an important influence on the natural vegetation and agriculture of the Batak plateau. Only the high rims of non-volcanic rocks, such as the Pak Pak range, are jungle-clad. For the rest the vegetation is a rather dry savanna, almost semi-arid

Fig. 36. The gorge of the Soengai Asahan

South-westward view up the Soengai Asahan valley, in the gorges by which it descends from the level of Toba lake to the coastal plain. On the right is the Sampoeranharimau waterfall.
Drawn from a photograph.

in appearance, with giant ferns and *alang-alang*, a tall coarse grass. Much of the area may formerly have been forested, but the porosity of the soil, the relatively light rainfall and the evaporating power of the strong winds which sweep across the plateau make the regeneration of forest far more difficult here than in most other areas of Sumatra.

The central feature of the whole Batak country is lake Toba (Toba-meer), which has a water surface of over 1,300 sq. km. and a length of 85 km. (50 miles). Lying at an altitude of just over 900 m. (*c.* 3,000 ft.) above sea level, it is almost completely surrounded by wall-like scarps up to 600 m. (2,000 ft.) in height (Plate 11 and Fig. 34). Innumerable silt-laden streams flow down these walls into the lake; they have built up a narrow belt of irrigable alluvial land which can be used for rice-growing. Only in the south-eastern corner is there any outlet. The Soengai Asahan, almost immediately after leaving the lake, plunges through deep gorges for about 30 km., traversing in its torrential course two of the most spectacular waterfalls in Sumatra, one of which is 135 m. (443 ft.) high (Fig. 36).

In the middle of the lake is a large peninsula, Samosir by name, covering over 700 sq. km. It is connected to the mainland on the north-west by a low and floodable isthmus only 200 m. (215 yd.) wide, but is actually converted into an island by an artificial channel cut through the isthmus. The maximum elevation on Samosir is 1,685 m. (5,250 ft.), and the relief is asymmetrical, with a steep drop on the east and a more gentle slope to the west (Plate 12).

The Tapanoeli and Padang Highlands (Figs. 37 and 38).

The last southerly outpost of the Batak volcanic plateau is Boealboeali (1,819 m.) a dormant volcano with solfataras and mud-wells on its flanks. For the next 400 km. (250 miles) the mountains of Sumatra, trending NW–SE and known generally as Boekit Barisan, take on a quite different aspect. The main characteristics may be summarized as follows:

(i) The mountain belt varies in width from under 40 km. (25 miles) at the northern end to about 80 km. (50 miles) in the centre.

(ii) There is a more marked tendency in this region than in the rest of the Sumatran backbone for two ranges to be separated by a line of tectonic depressions. There are five such elongated valleys, with damp, swampy or partially lake-filled bottoms; all are drained either westwards or eastwards by streams which break through the border ranges in gorges.

(iii) In general, except at the northern end, the western range is composed of recent volcanic material, and is crowned at intervals by active or dormant cones which rise to summit levels of well over 2,000 m. (6,500 ft.). The eastern range, on the other hand, is for the most part composed of Carbo-Permian schists, slates and limestones, as in the mountains of Atjeh. Elevations of over 2,000 m. are rare except for an occasional volcanic cone.

(iv) The western flanks of the highlands, more exposed to the westerly monsoon and composed of less resistant volcanic rocks, present a steep, highly dissected and jungle-clad face to the ocean; there are swampy coastal plains at intervals, separated by cliffs and headlands formed of harder rocks, such as the andesites which form a magnificent stretch of coastal scenery south of Padang.

(v) The eastern flanks, made for the most part of folded Carbo-Permian rocks, descend more gently, but there are several subsidiary ridges, following the main NW–SE trend, formed by outcrops of the harder formations, amongst which are certain beds of Lower Tertiary age, and several depressions, notably the basin of the Batang Oembilin which contains Sumatra's chief coalfield.

The belt of country which intervenes between the Batak plateau and the main mass of the Padang Highlands (Padangsche Bovenlanden) forms the 'waist' of Sumatra's highland trunk. The great breadth of the Batak plateau and its non-volcanic rim is suddenly reduced, about latitude 1° 30′ N, and Boekit Barisan begins as two low and narrow ranges of Carbo-Permian rocks. At its narrowest point the width of the highland between the 200 m. (656 ft.) contours on either side is only 30 km. (20 miles), and it is possible to cross from the west coast plain to the Baroemoen lowland, through Padangsidimpoean, without rising much above 600 m. (2,000 ft.). The two ranges increase in height and width to the south, enclosing between them a long, narrow, flat-bottomed trough, 75 km. long and less than 10 km. wide, the floor of which is little more than 200 m. above sea level. The northern two-thirds of the trough is traversed by the Batang Angkola; the town of Padangsidimpoean lies at its northern end. The southern section forms part of the valley of the Batang Gadis, which after being joined by the Angkola turns sharply westwards and breaks through the western range in an impressive gorge, descending thence across the folds of Lower Tertiary rocks to the narrow belt of coastal swamp, where it is navigable for some 30 km. (20 miles) from the sea.

Beyond the southern end of the Angkola–Gadis trough the western

range becomes volcanic, and the sharp cone of Sorikmarapi rises to 2,145 m. (6,890 ft.). The Gadis valley continues south-eastwards in a less trough-like form, and eventually a col not much over 500 m. leads the main highland road across to the next longitudinal furrow,

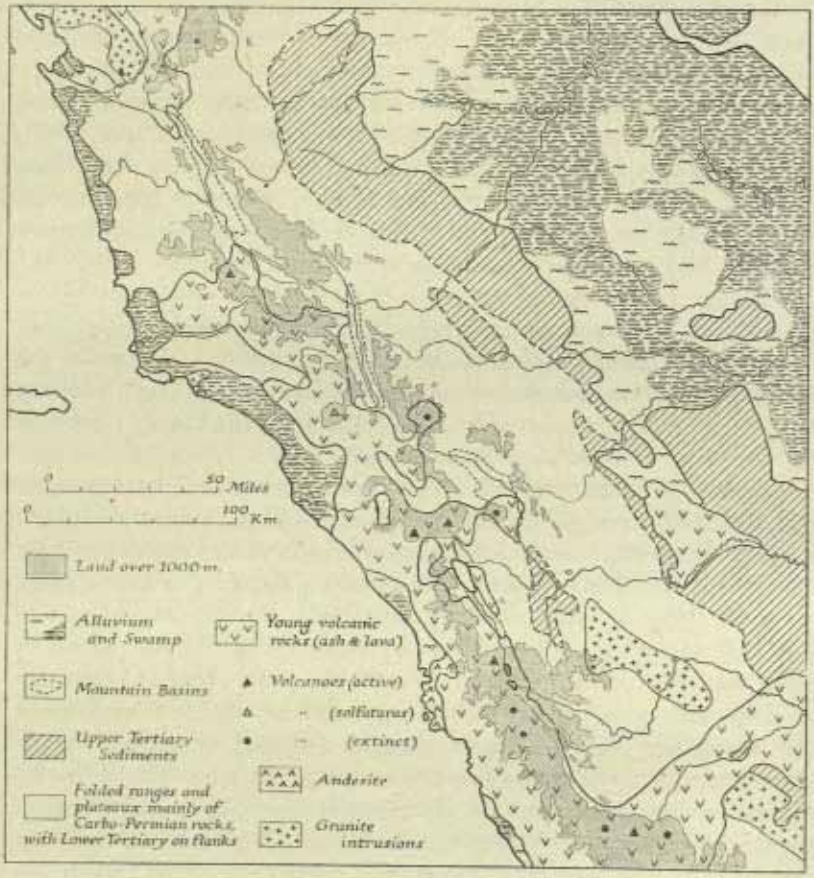


Fig. 37. Sumatra: the mountains of Tapanoeli and Padang
Simplified geological map, showing mountain ranges and lowland swamps. For sources see Fig. 29.

that which contains the Batang Soempoer, one of the headstreams of the great Rokan river. The Soempoer trough is 60 km. long, and narrower than the Angkola–Gadis depression, but it lies at roughly the same altitude, 200–250 m. Like the Gadis, the Soempoer breaks through one of the border ranges, but in this case the direction is eastwards to the Soengai Rokan Kiri. South of the Soempoer trough,

at the southern end of which lies the town of Loeboeksikaping, the volcanic rocks sprawl right across the highlands, from the elegant and regular cone of Goenoeng Talakmau, 2,912 m.—the 'Mount Ophir' of the early Portuguese navigators—on the west to the extinct mass

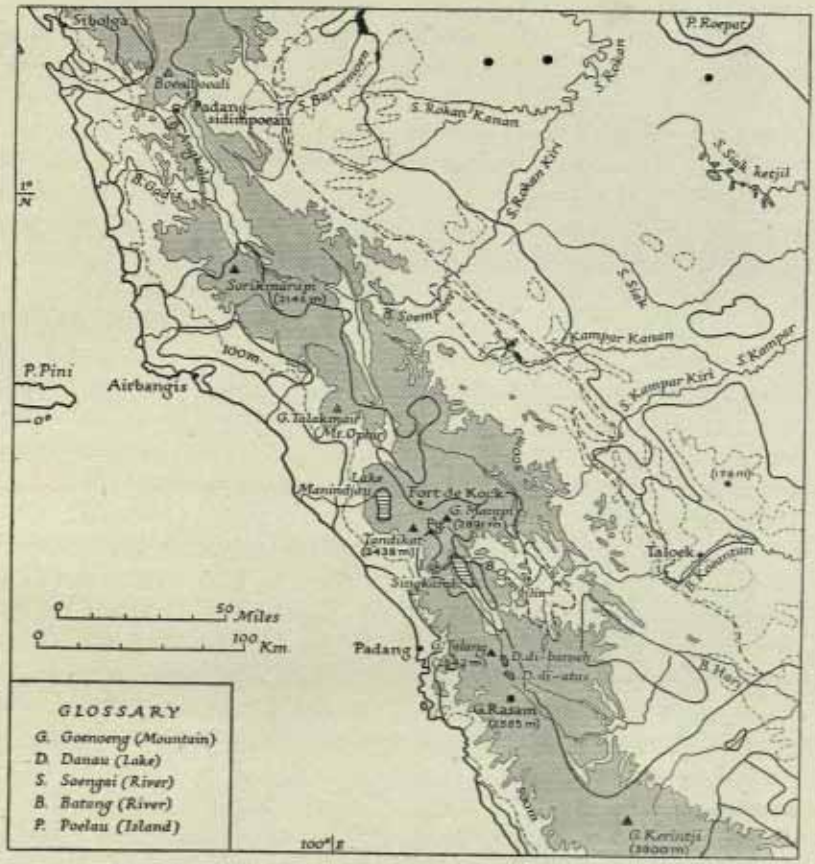


Fig. 38. Sumatra: the mountains of Tapanoeli and Padang

Key map to Fig. 37, showing relief and chief towns. 100 m. contour shown as pecked line, land over 500 m. stippled.
For sources see Fig. 29.

of G. Amas, 2,271 m., on the east. The highland road, however, threads a fairly easy way southwards, following headstreams of the Batang Masang, to the upland basin of Fort de Kock, which lies just over 900 m. (3,000 ft.) above sea level and is floored by Quaternary sediments (Plate 15). Another somewhat similar basin, at a lower

level—about 500 m.—lies to the east of Fort de Kock; Pajakoemboeh is its centre.

South of these two basins the volcanic rocks again spread right across the highlands and there is an impressive array of volcanic phenomena. In the west is lake Manindjau, 100 sq. km. in area, occupying all that remains of an enormous crater. It is almost surrounded by vertical walls, but the western rim is broken, allowing the water to drain by the Batang Antokan to the Indian Ocean (Plate 16). Then there are the twin cones of Singgalang and Tandikat, the latter still active. Further east is the huge truncated cone of Marapi (the name, which is a common one, means 'angry fire') reaching nearly 2,900 m. (9,500 ft.) with a crater 500 m. (550 yd.) in diameter and numerous fumaroles on its flanks. Finally, there is the extinct cone of G. Malintang, rising to 2,262 m. (7,415 ft.).

The highland road, accompanied by a railway, makes its way southwards from Fort de Kock over the 1,100 m. (3,600 ft.) col between the Tandikat and Marapi volcanoes, and at Padangpandjang (='long plain') both road and railway fork. One branch of each turns westwards to pass through the 'Anaikloof', a deep and sinuous gorge cut into relatively soft volcanic debris by the Batang Anai (Plate 14); the route then turns south to descend to the coastal plain and the port of Padang. The other branch strikes south-eastwards and descends rapidly to the next longitudinal trough, the Singkarak–Solok depression. In the bottom of this trough, at 362 m. (1,180 ft.) above the sea, is lake Singkarak, an elongated oval, 21 km. (12½ miles) long with a maximum width of 7·7 km. (5 miles). The banks of its longer sides rise steeply, scarcely leaving room for road and railway. The effluent of the lake is Batang Oembilin, which breaks through the bounding wall on the north-eastern side and subsequently flows south-eastwards to the Tertiary basin in which lies the coalfield of Sawahloento. Lake Singkarak is the shrunken remnant of a much longer (though very little wider) body of water which formerly extended south-eastwards to the region of Solok. The Solok plain is now drained northwards to lake Singkarak by a stream which originates in Danau di-baroeh, a small lake lying in a faulted trough at the foot of the Talang volcano, about 1,462 m. above sea level.

A low col at about 1,550 m. (5,050 ft.) separates Danau di-baroeh ('lower lake') from Danau di-atas ('upper or summit lake'), which lies at the northern end of the last longitudinal trough of the Padang Highlands, with the small town of Alahanpandjang near its low eastern shore (Alahanpandjang='long, dried-up river bed'). Danau

Plate 13. Karbouwengat (Fort de Kock)

The Karbouw gorge, close to Fort de Kock, is excavated in soft volcanic debris; owing to the porosity of these deposits, lateral erosion does not keep pace with downward erosion, and the gorge has precipitous sides.

Plate 14. Anaikloof, near Padangpandjang
The gorge of the Anai is excavated in soft volcanic debris (cf. Plate 13). It carries the main road and railway from Fort de Kock to Padang (see Fig. 56).

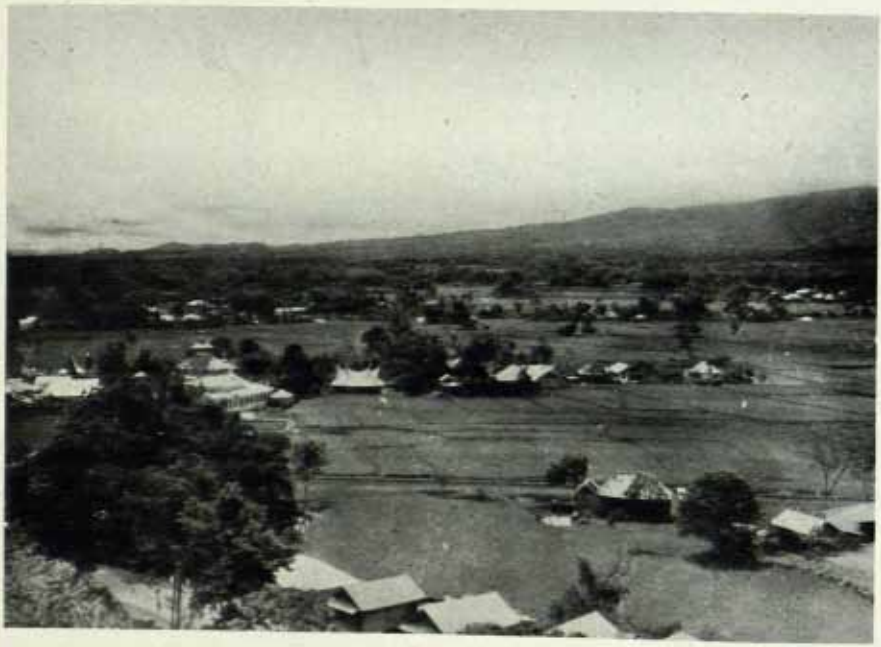


Plate 15. The Fort de Kock basin
This mountain basin, at about 900 m. altitude, is probably the floor of ancient lake; it is sometimes known as the Agam plateau, and is drained eastwards by the Batang Agam and its tributaries. The basin is well cultivated and Fort de Kock (originating in 1825 as a fortress) is an important market centre.

di-atas owes its origin to the accumulation of volcanic debris, a low mound of which separates its southern shore from the source of the Batang Hari, a stream which flows south-eastwards for 25 km. before breaking through the eastern range and descending to the lowlands to become one of the greatest rivers of eastern Sumatra. Several imposing but extinct volcanic peaks rise on the western side of the B. Hari valley, such as G. Rasam (2,585 m.) and G. Pantaitjarmin (2,690 m.), completely dwarfing the eastern range, which sinks and disappears entirely at about latitude 1° 35′ s, beyond which point the Carbo-Permian schists and slates cease to play any significant part in the structure of the mountain backbone, and the young volcanic rocks almost completely dominate the relief. West of the lakes and of the Batang Hari valley the western range, for about 70 km., drops not to a coastal plain but to foothills which run out to sea in a rocky coast of capes and bays, most imposing in the 40 km. south of Padang, where they are formed of Tertiary andesites.

The volcanic highlands of southern Sumatra (Figs. 39–42)

Immediately to the south of the line—clearly marked by the valley of the Batang Liki, a tributary of the B. Hari—along which the Carbo-Permian rocks disappear from view, rises the great volcano of Kerintji, called by the Dutch Piek van Indrapoera. The native name means 'home of the gods' or 'celestial abode' and is most appropriate for a 3,800 m. (12,470 ft.) summit which is the highest point in Sumatra. Its height and the continuous activity within its 300 m.-deep crater render its upper part the most naked of all the Sumatran volcanoes. With two extinct satellites—Goenoeng Patahsambilan (2,591 m.) on the west, and G. Toedjoeh (2,604 m.) which has a large crater lake, on the east, it sits astride the highland axis, creating a large vacant space in the patterns of settlement and communications, and forming a fitting introduction to the mountains of southern Sumatra.

These mountains extend over a distance of more than 600 km. (370 miles), with a width varying from about 85 km. (50 miles) in the north to about 35 km. (20 miles) in the region north of lake Ranau. They differ from the three previously described regions in consisting mainly of volcanic rocks, which form, however, not a plateau as around lake Toba, but two parallel ranges, fluctuating in height and width and separated by a discontinuous line of small depressions and valleys. The main highland ranges are almost entirely composed of recent volcanic ejectamenta, with some active and many extinct cones,

or of somewhat older andesitic rocks of Tertiary age; but occasional granite bosses protrude from beneath the volcanic debris, and in the area south-east of Benkoelen the western range is for a time composed of granite and Palaeozoic rocks. The eastern flanks of the mountains

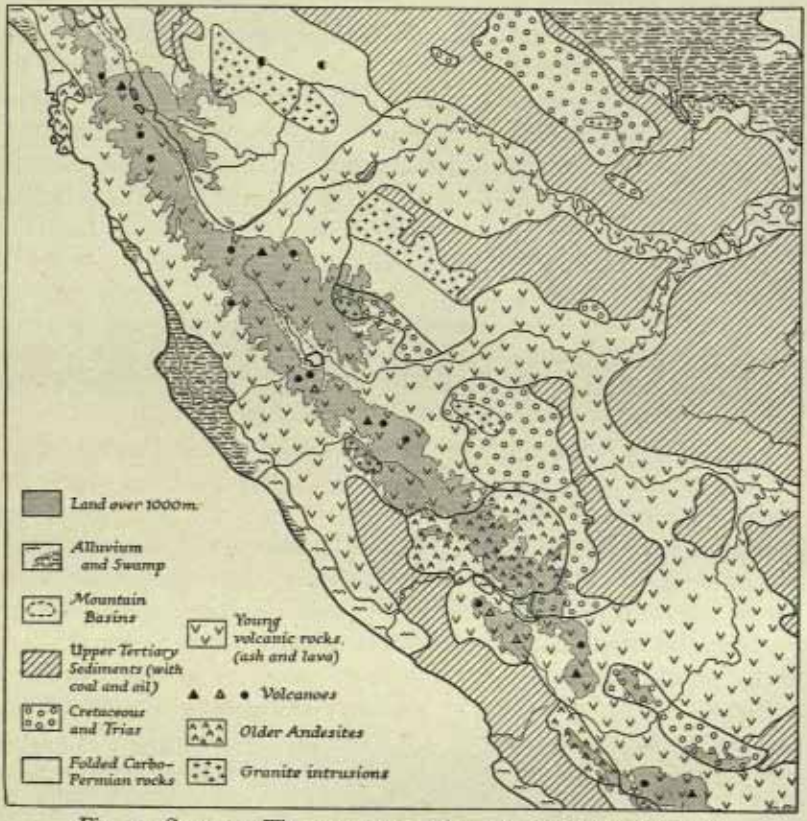


Fig. 39. Sumatra: The west coast and north Benkoelen mountains Simplified geological map, showing mountain ranges and coastal swamps. For sources see Fig. 29.

are more complex in their structure and morphology in the Residencies of Djambi and Palembang than elsewhere; in the north is a large area of old rocks which have suffered considerable thrusting, and further south, sharply-folded Triassic and Cretaceous rocks play a major part in the relief, as in the Garba- and Goemai-gebergte.

At the southern foot of Kerintji the longitudinal valley reappears, followed by the Soengai Sioelak, which flows into lake Kerintji. The plain is studded with rice-fields, bamboo thickets and woods,

and there are numerous villages, of which the chief is Soengaipenoeh, which is linked to the coast by a road running across the western range at about 1,300 m. (4,000 ft.). The lake (the native name for which is Danau Gadang) lies at 783 m. (2,570 ft.) above sea level.

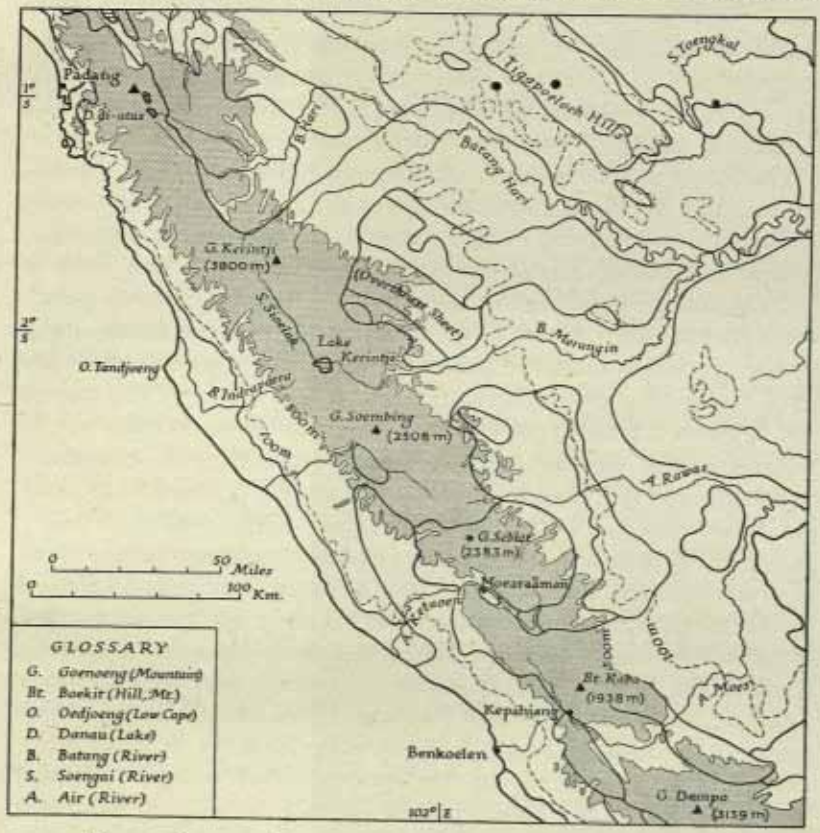


Fig. 40. Sumatra: the west coast and north Benkoelen mountains
Key map to Fig. 39, showing relief and chief towns. 100 m. contour shown as pecked line; land over 500 m. stippled.
For sources see Fig. 29.

Both ranges which overlook the plain are volcanic, though devoid of recent cones. The western range is comparatively narrow, and drops in a steep and intricately dissected slope to one of the few broad coastal plains of western Sumatra, about 25 km. wide, composed of alluvium and extending seawards in the 'amphibious', mangrove-fringed headland of Oedjoeng Tandjoeng (in Dutch, Hoek van Indrapoera). The eastern range is much broader, and the eastward

descent is interrupted by several peaks (e.g. G. Roentjing, 1,835 m., and Boekit Temiang, 1,754 m.) rising to between 1,700 m. and 1,900 m. and formed of Carbo-Permian volcanic rocks. The latter, which greatly resemble the Pahang Volcanic Series of Malaya, and with which are associated considerable bodies of granite, especially on the eastern side, rest nearly horizontally on the almost vertically upturned edges of Triassic rocks, and must thus clearly have been thrust from somewhere, perhaps even from Malaya during the late Cretaceous period of intensive earth-movements.

The outlet of lake Kerintji—the Batang Merangin, a large tributary of the B. Hari—flows south-eastwards and then eastwards, round the southern end of this thrust mass, making a considerable breach in the continuity of the eastern range. South of lake Kerintji volcanic cones—including the dormant G. Koenjit (2,151 m.)—again interrupt the valley, which however soon reappears in a trough about 45 km. (30 miles) long, and 900–1,500 m. (3,000–5,000 ft.) above sea level, formed by certain headstreams of the Air Dikit. This trough lies between a granite ridge on the west and an imposing array of volcanic cones on the east, including the active G. Soembing (2,508 m.) and the extinct G. Masoerai (2,935 m.). Then once more the recent volcanic debris obliterates the valley, with G. Gedang (2,446 m.) dominating the mountain belt. Beyond here, however, the structure becomes more complex, and a longitudinal valley, followed by several streams in turn, is traceable for some 170 km. (100 miles) as far as the volcano Dempo. The eastern range for some distance is made of Tertiary andesite; it carries a number of peaks rising to over 2,000 m., including G. Seblat (2,383 m.) The western range, which contains the most important gold-bearing localities in Sumatra is lower and is breached by the Air Ketaoen, which occupies a trough 35 km. in length, the lowest part of which is a dried-up lake basin around Mouaraäman, little more than 350 m. above sea level.

The highland road which starts at Mouaraäman climbs over a col in the longitudinal valley, at the eastern foot of the volcano Boekit Daoen, and drops to the headwaters of the great Air Moesi, which occupies the valley for some 50 km., during which it falls from about 1,000 m. to under 300 m. This part of the valley is not a steep-sided, flat-bottomed trough like its counterparts elsewhere; it is broad, shallow and with gently sloping sides, and the ranges which border it are comparatively low, the volcano Boekit Kaba (1,938 m.), on the east, being the only summit to rise much above 1,000 m. From Kepahiang (alt. 517 m.) the road to Benkoelen, on the west coast,

rises to no more than 750 m. (2,460 ft.) (Plate 26). The western range, in fact, almost ceases to exist, for soft Upper Tertiary sediments, which form the western flanks of the mountains all down the Benkoelen district, here almost reach the longitudinal valley. South of Kepahiang a strong western range resumes, with summits 1,500–1,600 m., formed at first of andesite and then of Carbo-Permian rocks and granite. The enormous erosion of the Air Moesi and its many tributaries has almost destroyed whatever may once have existed of an eastern range, however, and the river has also carved its way through an important offshoot of the Barisan mountains, the Goemai-gebergte. This range, the summit level of which is 1,300–1,700 m., has a steep and highly dissected north-eastward slope, an escarpment of Cretaceous and Lower Tertiary volcanic sediments (tuffs), and a gentler though still undulating southerly dip slope which drops to the Moesi, to its tributary the Air Lintang and to the Air Selangis, a tributary of the Air Lematang.

The upper Moesi valley is continued southwards by its tributary the Air Keroh, which rises at the foot of a volcanic mass which includes G. Dempo (3,159 m.). For some distance south-eastwards there is only one main volcanic range, with a string of extinct cones, trending ESE and rising to well over 2,000 m. (G. Patah, 2,817 m.). The western flanks are made of Palaeozoic rocks and granite, with Upper Tertiary sediments at lower levels dropping down to the narrow and alluvial coastal plain. The eastern flanks are broader, owing to the existence of a number of volcanic cones situated, as it were, off the main line. The trend of this volcanic range is slightly inland, and the next range has a more westerly position and a more normal NW–SE direction. It is all volcanic, with a number of extinct cones rising to over 1,500 m. East of it lies a further portion of the longitudinal valley, utilized by two headstreams of the Wai Silaboeng, a tributary of the Air Komering, which meet in the middle at about 400 m. and break through the low eastern range, which is here not a range at all, but just hills rising to between 700 m. and 1,000 m. At the southern end of this section of the longitudinal valley is lake Ranau, the last of the mountain lakes of Sumatra. It lies at 540 m. (1,770 ft.) above sea level, and is over 100 sq. km. in area. It probably occupies the site of a huge crater; there are steep volcanic walls on the west, and the large extinct cone of G. Seminoeng on the south. The water is warm in places owing to the existence of hot springs. The outflowing stream, on the northern side, flows across a flat expanse of volcanic tuff.

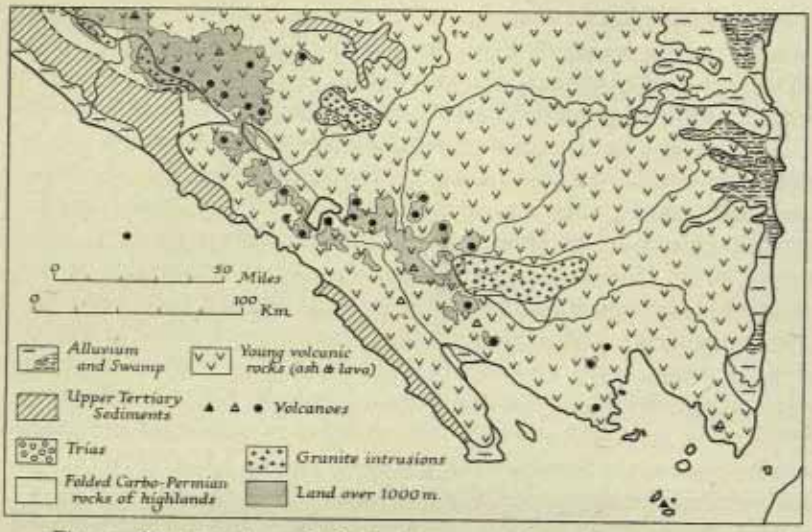


Fig. 41. Sumatra: the south Benkoelen mountains and Lampoeng region

Simplified geological map, showing mountain ranges and coastal swamps.
For sources see Fig. 29.

Fig. 42. Sumatra: the south Benkoelen mountains and Lampoeng region

Key map to Fig. 41, showing relief and chief towns. 100 m. contour shown as pecked line; land over 500 m. stippled.
For sources see Fig. 29.

The hills which lie east of this section of the longitudinal valley drop eastwards in a great embayment excavated in the mountains by the Air Komering and its tributaries from young and soft volcanic sediments. In the middle of this embayment, just north of the plain of Moearadoea, rise Boekit Garba and other hills, reaching nearly 800 m. These hills are a complex group with a general NW–SE orientation, largely composed of granite flanked by folded Triassic volcanic rocks.

About 12 km. south-east of lake Ranau, a col at about 900 m. leads to the last section of the longitudinal valley, occupied by the Wai Semangka, which flows into Semangka bay. The valley consists of three plains of tectonic origin, at successively lower levels, separated by narrower and steeper sections. The Liwa hoogvlakte (plateau) in the north lies at 800–900 m., the Soeoh vlakte (plain) in the centre, at about 250 m., and a triangular lowland at the head of the bay is little above sea level. These plains are all well populated, but the Liwa, highest and best drained, has the greatest number of villages. The western side of the valley, especially from the Soeoh plain southwards, is strongly faulted, as is evidenced by its straightness and steepness (it averages 1 in 3). Lavas derived from fissure eruptions are known to exist, and the Pematang Bata eruption of 1933, in the Soeoh plain, was a catastrophe of similar nature, being an outpouring of hot mud from a series of aligned explosion-vents (Fig. 43).

Fig. 43. The Pematang Bata volcanic mud eruption

In July 1933, a violent earthquake was followed by gas explosions and an outpouring of boiling mud. The explosions were heard in western Java, and some 35 sq. km. of a hitherto fertile plain were covered with mud which did immense damage to forests, cultivated land and villages. The Soeoh plain is a fault-bounded trough, and movements along a fault may have allowed river water to penetrate to the heated layers of rock beneath, so precipitating the explosions.
Drawn from a photograph taken before the activity had died down, showing steam clouds still rising.

The western range, known in the north by the usual name of Barisan and further south, in the Benkoelen peninsula, as Pematang Sawah, is composed mainly of andesitic rocks, with a fringe of Upper Tertiary sediments along the coastal belt and a granite boss at the root of the peninsula. The eastern range—known as Rebang-gebergte—is wider and more broken, and is studded with extinct cones, of which the highest are G. Pesagi (2,232 m.) in the north, and G. Tanggamoes (2,102 m.) in the south, overlooking the head of Semangka bay. This range continues through the western part of the Semangka peninsula. Its eastern flanks are varied and complex. A belt of structurally disturbed country lies immediately east of the range. In the north, there is the Gedongsoerian depression—so named after its principal village—a tectonic trough at about 800–900 m. altitude. Further south, at a much lower level and occupying a broad embayment open to the east, is the Wailima vlakte, a swampy alluvial plain about 100 m. above sea level, crossed by tributaries of the Wai Sekampoeng. Finally, a zone along which considerable thrusting from the north-east has taken place extends from the western side of the Wailima plain to Ratai bay.

East of this zone of disturbance are more highlands: in the north there are several extinct volcanoes, including Tangkit Tebak (2,115 m.); further south is the granite mass of the Hoeloewaisamang-gebergte, while beyond the Wailima plain are two more extinct cones, G. Betoeng (1,256 m.) and G. Ratai (1,632 m.), overlooking Lampoeng bay. Further outposts of both the main volcanic range and its eastern extension are to be found—of the former in Krakatau, in the middle of Soenda strait, and of the latter in G. Radjabasa, a solitary double-peaked mass which rises in the south-eastern extremity of the island.

B. The Hills and Plains of Eastern Sumatra

More than one-half of Sumatra lies east of the Barisan mountains, at an elevation of less than 100 m. (330 ft.) above the sea (Fig. 29). This vast plain is of variable width. On the eastern flanks of the Atjeh and Batak mountains it averages 10–30 km. South of the lower Asahan river, however, it broadens considerably, reaching a maximum width of some 250 km. (150 miles) in Palembang Residency. In a general way three types of country may be distinguished, occurring in parallel, though not even and continuous, belts.

The western belt comprises the eastern foothills of the Barisan ranges and the undulating hill-country which spreads east thereof.

Plate 16. Lake Manindjau

Westward view across this vast crater-lake, showing the broken rim through which the water escapes by the Batang Antokan to the west coast (see Fig. 37). The water level is 459 m. (1,506 ft.) above the Indian Ocean.

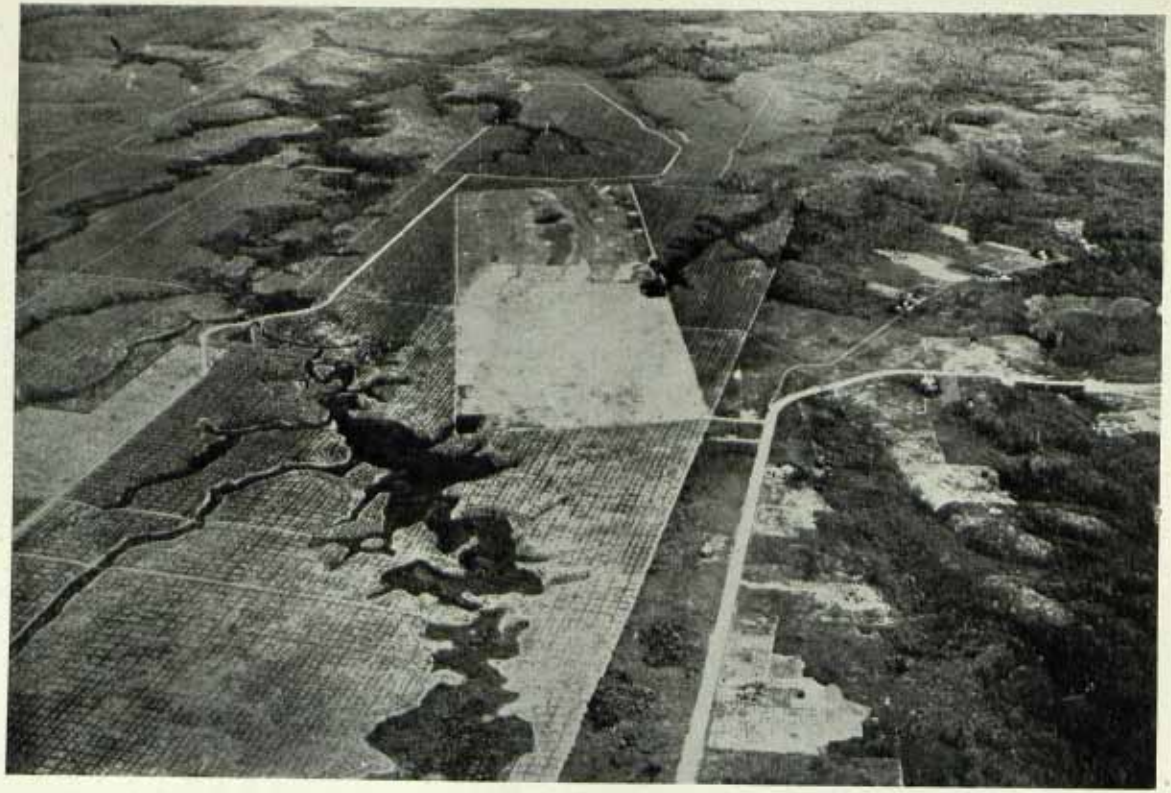


Plate 17. Rantauparapat

Rantauparapat, on the Soengai Bila, lies in a south-westward extension of the Medan 'plantation area'. This air view shows an area of plantations surrounded by smaller plots and uncultivated land. The lower parts and the stream courses are left with their natural vegetation cover. Set amid the plantations is a landing ground. For location see Fig. 52.

A large part of this area is underlain by gently folded Upper Tertiary rocks, in which coal and oil are of not infrequent occurrence. Occasionally, as in the Tigapoeloeh-gebergte, older rocks—in this case Triassic—come to the surface, forming, by reason of their greater resistance to erosion, areas of sharper relief. In the south, volcanic debris has largely obliterated the pre-existing relief and structure.

The remainder of the area comprises the real plain, built up of recent alluvium derived from the rapid erosion of the volcanic highlands and overlying, for the most part, the underground continuation of the belt of Upper Tertiary folds. The area is not much above sea level and is almost devoid of relief, but such minor differences in elevation as do exist enable a two-fold division of the landscape to be made, the 'dry' areas, of relatively small extent, and the vast region of swampy jungle which ends in a coastal belt of mangroves. The former lie furthest inland, and generally on the interfluves between the major rivers; the latter extends inwards from the coast, and commonly stretches unbroken for distances up to 100 km., and even further in the neighbourhood of the great rivers. The rivers, heavily laden with mud, decaying vegetation and even tree-trunks, meander interminably, and their courses are constantly changing. Abandoned channels, known as 'troessan', develop thick masses of aquatic vegetation until a great flood fills them again. In the rainy season hundreds of square miles are inundated, and an area extending perhaps 20 km. (12 miles) inland from the coast is 'amphibious', being swamped by the tides twice daily. All the rivers have large mouths, often deltaic and obstructed by shifting mud-banks. Between the main channels is an inextricable network of waterways and false arms ('soengai mati'=dead rivers) meandering aimlessly.

Through these swampy jungles the rivers form the only means of communication. Many of them are navigable for scores of kilometres for sea-going vessels, and for native craft for several hundred kilometres, up to the Barisan mountains. Their courses are punctuated at long intervals by native villages, built on piles or consisting of boats anchored to the muddy banks, and with cultivated clearings behind them (Plates 18 and 22). It is only on the higher and drier western edge of the swamp-forest that movement on land becomes relatively easy; roads and an occasional railway have a general NW–SE trend, linking the heads of river navigation.

The comparatively narrow fringe of Upper Tertiary rocks in Atjeh—oil-bearing in the area behind Langsa and Aroe bays—and

the narrow alluvial plains of Atjeh and the 'plantation area', have already been briefly described. The remainder of the lowland area falls into four sections, each differing slightly from the others.

(i) From the Soengai Asahan to the Soengai Inderagiri: a broad swampy plain, averaging 150 km. (100 miles) wide, with numerous 'dry' areas, backed by Upper Tertiary hills.

(ii) From the S. Inderagiri to the Batang Hari (Djambi): the alluvial plain is much reduced, to a minimum of 40 km. (25 miles), by a considerable area of hill-country, largely composed of Upper Tertiary rocks but with the Triassic Tigapoeloeh-gebergte forming the central and highest part (reaching 700 m.).

(iii) From the Batang Hari to the Air Moesi (Palembang): the swampy alluvial belt remains restricted to about 75 km. in width, and is backed by a low and gently undulating area of Upper Tertiary rocks, in the folds of which occurs the Palembang–Djambi oilfield.

(iv) From the Air Moesi to the Soenda strait: the alluvial plain decreases in width from about 130 km. to under 10 km., but behind it lies a vast expanse of low and undulating terrain built up of volcanic sediments, with several areas of Upper Tertiary rocks containing coal and oil.

(i) *Soengai Asahan to Soengai Inderagiri*

The cultivated and almost swampless alluvial plain of the 'plantation area' broadens suddenly, beyond the Soengai Asahan, from 30 km. (20 miles) to between 50 and 60 km. in width, and about two-thirds of this width is occupied by swampy jungle, which occurs especially around the lower courses of the rivers Koealo, Bila and Baroemoen. The inner edge of the plain is drier, and here, in a belt some 20 km. wide, and 20–60 m. (65–195 ft.) above sea level, are concentrated plantations and people, with a road and railway. This belt, passing through Rantauparapat on the S. Bila and ending at Kotapinang on the S. Baroemoen, is a southward extension of the main 'plantation area' (Plate 17). Behind it, a region of dissected hills, carved from Lower Tertiary and Triassic rocks, leads to the mountainous south-eastern rim of the Batak highland.

A line drawn from Kotapinang to Goenoengtoea, 65 km. to the south-west, marks roughly the southern edge of these foothills, along the course of the Batang Galoga, a tributary of the Baroemoen. South of this line the eastern Sumatran lowland broadens to twice its previous width, partly through the westward recession of the

mountainous zone and partly through the extension of the muddy swamp-forest into the Malacca strait.

The alluvial zone averages 150 km. (*c.* 95 miles) in width, and by far the greater part of it is swamp-forest. It is continued eastwards in a series of flat, jungle covered and mangrove-fringed islands, which are separated from the mainland by channels a few kilometres wide. There is an interrupted belt of 'dry' alluvium on the west, and several 'islands', floored by Upper Tertiary rocks and rising in places to about 100 m., within the main swamp area. Such 'islands' occur to the north and south-east of Pakanbaroe, on the Soengai Siak, and in a long NW–SE belt between the Kampar and Inderagiri rivers. The Soengai Siak is one of the few large and navigable rivers of Sumatra which does not rise in the Barisan mountains. With its tributaries the S. Tapoengkiri and S. Tapoeng-kanan, it takes its source in the belt of Upper Tertiary rocks west of the alluvial plain, at an elevation of less than 100 m. above the sea. One of its lower tributaries, the S. Siak-ketjil, is peculiar for the string of 'broads' (called *tasik*) along its course. These are shallow, water-filled depressions of variable size, covered with aquatic vegetation and bordered by reeds and an impenetrable, muddy jungle; they have a fauna of fish, otters and crocodiles.

The Siak itself is navigable for sea-going vessels below Pakanbaroe; the other major waterway in this region is the Inderagiri (or Koeantan), which is navigable below Taloek. Taloek lies in the centre of the island, 230 km. (140 miles) from the sea in a straight line (and 320 km.—200 miles by river), yet its altitude is no more than 22 m. (72 ft.). The other large rivers and many of their tributaries are navigable for small native craft only.

The western foothill belt between the Baroemoen and the Inderagiri is of variable width, averaging about 50 km. The northernmost section, comprising the basin of the S. Baroemoen, is of low relief and from 50–500 m. in elevation; it is floored by Tertiary rocks and is peculiar in having a vegetation cover of savanna type. Further south, the foothill belt is characterized by parallel ridges or hilly zones, oriented NW–SE. The ridges are due partly to folding and partly to the differential erosion of hard and soft beds of rock; they are formed sometimes by Lower Tertiary beds, sometimes by Carbo-Permian rocks with small granite cores. Between the S. Kampar-kiri and the S. Inderagiri the hilly zone is wider, and consists of a higher western belt of Carbo-Permian sandstones, with summit levels of over 500 m., a lower central belt of volcanic tuff, north-west of Taloek, rising to

just over 100 m., and separated from the eastern belt of Upper Tertiary hills by an alluvial depression. The Tertiary hills reach 197 m. in Boekit Sitoegal.

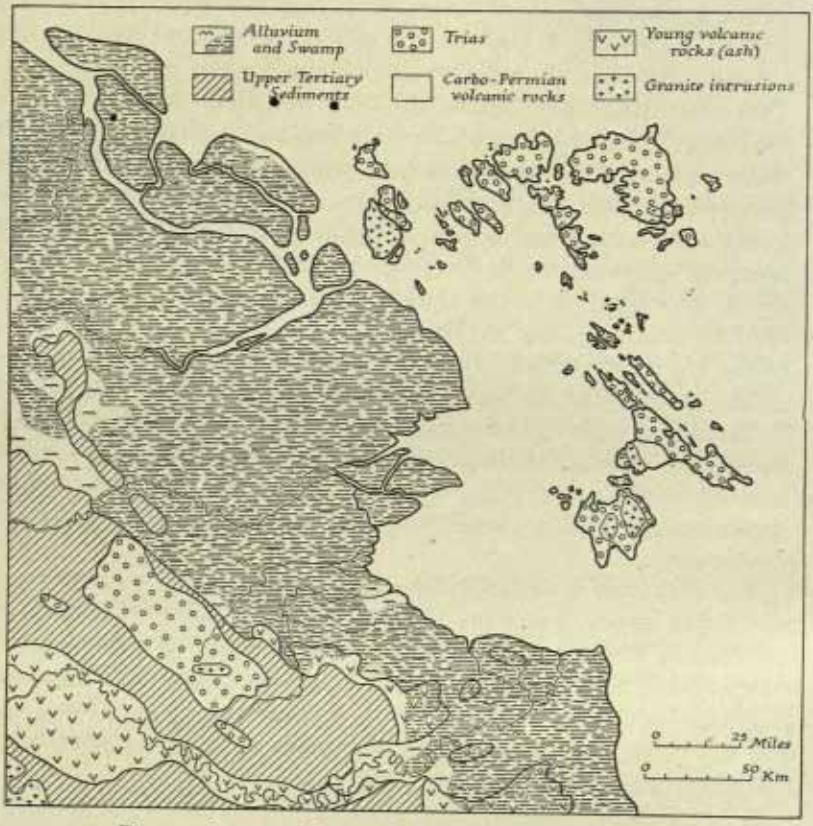


Fig. 44. Sumatra: East coast, Riouw and Lingga islands
Simplified geological map, showing lowland swamps.
For sources see Fig. 29.

(ii) *Soengai Inderagiri to Batang Hari*

Between the lower course of the Inderagiri and the mouths of the Batang Hari the coastal lowland, which is almost entirely covered by swamp-forest, is reduced to between 40 and 80 km. in width. Extending in a NW–SE direction for over 200 km. (125 miles) from Taloek, on the Inderagiri, to the neighbourhood of Djambi, on the Hari, is a belt of hill-country, about 50 km. wide, with the middle course of the Batang Hari on its western edge. Much of the surface

is composed of gently folded Upper Tertiary strata, with elevations fluctuating around 100 m. and some slightly higher areas in the north-west, but in the centre is a roughly rectangular tract, about

Fig. 45. Sumatra: East coast, Riouw and Lingga islands
Key map to Fig. 44. Land over 200 m. stippled. For further details of island groups see Figs. 60 and 61.
For sources see Fig. 29.

80 km. by 30 km., of intricately dissected hills of greater elevation, reaching a maximum altitude of just over 700 m. This region is known as the Tigapoeloeh-gebergte ('thirty hills'); it is composed of sharply-folded shales of Triassic age, with an intrusion of granite forming the rounded eminence of Boekit Rinting (709 m.—2,296 ft.) near the southern end. Two isolated outposts of these Triassic hills are Boekit Limau (492 m.) to the north-west, and Boekit Bakar (437 m.) to the south-east.

The middle course of the Batang Hari is a broad, flat plain, some 50–80 m. above sea level, and marshy in parts, formed of volcanic debris derived from the Barisan mountains and deposited during scores of thousands of years by the river and its tributaries. At the north-western end of the plain is Tandjoeng, head of navigation for small sea-going vessels on the B. Hari, and on the western edge is Moearaboengo, a similar point on the tributary Batang Tebo. These localities are more than 450 km. from the mouth of the Batang Hari, but they lie scarcely 50 m. above sea level. Joining the Hari at Moearatembesi is a large tributary, the Batang Tembesi, flowing from the south-west. This river, with its tributary the Batang

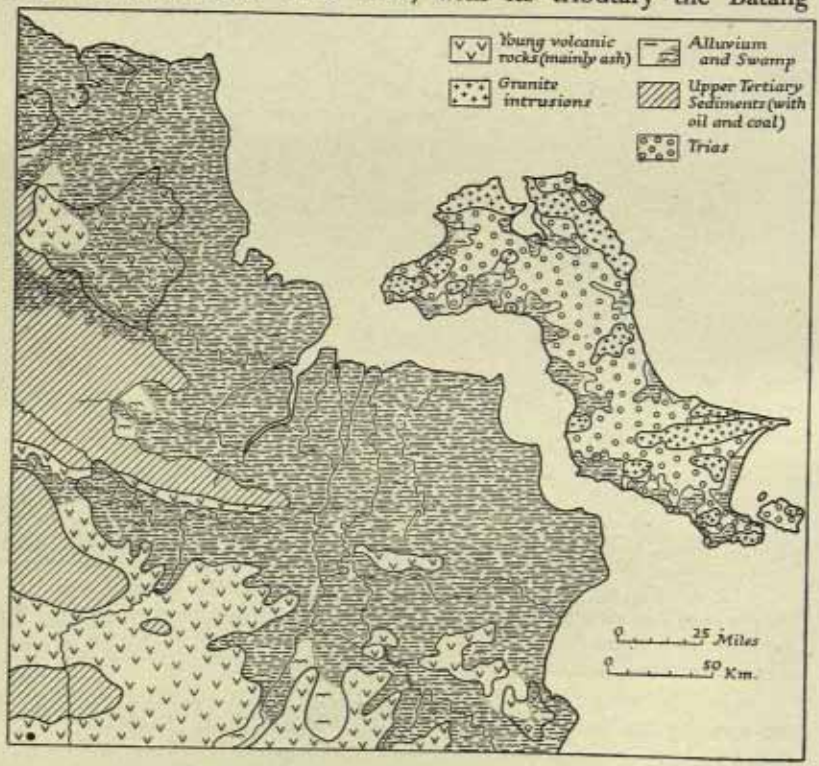


Fig. 46. Sumatra: Palembang region and Bangka
Simplified geological map, showing lowland swamps.
For sources see Fig. 29.

Merangin, which rises far away to the west in lake Kerintji, also flows across a low (30–50 m.), flat and somewhat marshy plain, floored by similar volcanic tuff. The Tembesi is navigable below Sarolangoen, and the Merangin below Pamenang.

The Merangin, Tembesi and Hari rivers form three sides of a rectangle, the interior of which is a low plain averaging 50–100 m., and made of the same gently folded Upper Tertiary rocks as occur in the area north of the Hari. To make the similarity more complete, an inlier of Triassic rocks forms a small group of hills, the Doeabelas-gebergte ('twelve hills'), on the southern side, rising to over 400 m. The Tertiary rocks spread westwards into the easternmost foothills of the mountains, and here, lying on the edges of the great thrust mass of granite, referred to above, are several small coal basins, as for example at Rantaupandan (='screw-pine reach') on the Batang Boengo, a tributary of the B. Tebo.

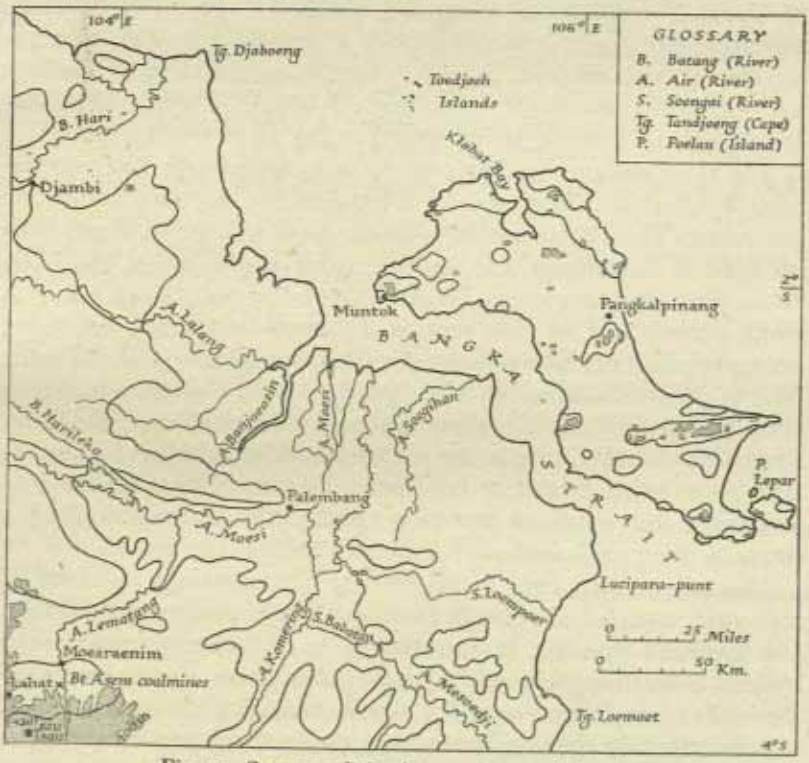


Fig. 47. Sumatra: Palembang region and Bangka
Key map to Fig. 46. Land over 100 m. stippled. For further details of Bangka see Fig. 62.
For sources see Fig. 29.

(iii) *Batang Hari to Air Moesi (and Air Komering)*

Between Djambi and Palembang the swampy belt is roughly 80 km.

in width, but it spreads further inland in the neighbourhood of the Air Lalang and Air Teloektenggoeleng, and especially along the Air Moesi, which carries a tongue of marshy land 25 km. wide far inland to Sekajoe, over 200 km. from the mouth of the river but still only 9 m. above sea level. Behind the alluvial plain is a broad expanse of slightly higher ground, still densely forested but less liable to floods. This vast area, extending back to the foothills of the mountains, comprises three types of country. In the east, occupying the major part of the region, are gently undulating plains, with low, flat hills, underlain by folded Upper Tertiary rocks which contain oil. In the west, on the edge of the Barisan foothills, are several more outcrops of Upper Tertiary strata, containing coal and some oil. In between, forming what might almost be termed a 'sub-Barisan depression', is an area of soft volcanic deposits—also in part of Upper Tertiary age—generally at a lower level than the eastern Tertiary hills, and sometimes, around the larger rivers, so low as to be swampy.

The main eastern Tertiary outcrop is separated into four unequal parts by the Air Moesi and its tributaries the Air Rawas and Air Lematang. The largest section is an elongated triangle in shape, with its apex at Palembang and its base along the Tembesi and Hari rivers from Sarolangoen to Djambi, about 130 km. (80 miles). The south-eastern end of this area is a narrow interfluve, averaging 10–30 m. altitude, between the Air Teloektenggoelang and the Air Moesi. Above Sekajoe, on the Moesi, this low plateau broadens considerably, and the elevation increases to a maximum of 150 m. in an area of flattish hills in the north-west. The whole area is underlain by a great thickness of Upper Tertiary rocks, folded into anticlines and synclines trending roughly NW–SE, and at least a dozen of the anticlines have been bored successfully for oil.

The other three areas of oil-bearing Tertiary rocks lie south of this main area. The largest lies between the big curve of the Moesi and the Air Lematang. It is mostly 30–80 m. in altitude, but in the middle a smaller inlier of Triassic rocks makes the eminence of Boekit Pandapo (159m.—520 ft.). Another area lies between the Moesi and its tributary the Air Rawas, and the last and smallest is in the Praboemoelih region south of the Air Lematang. These three areas are also crossed by NW–SE folds which have yielded oil, and the Praboemoelih area has lignite as well.

There are three main areas of Upper Tertiary rocks at the eastern foot of the mountains. The first extends in a fairly narrow belt from the Tembesi river, west of Sarolangoen, nearly to the Air Klinggi at

Loeboeklinggan. The Tertiary strata dip eastwards from off the Triassic rocks which underlie them, and their western edge does not rise much above 200 m.

Fig. 48. The Serelo hills
One of a series of angular peaks of andesite projecting from the lignite-bearing plain between the Lematang and Enim rivers.
Drawn from a photograph.

The foothills on the north-eastern side of the Goemai-gebergte are encumbered with volcanic debris. The next area of Tertiary rocks is an economically important region in the Lematang and Enim valleys, east of the Goemai range, focussing upon the towns of Lahat and Moearaenim. Here, in an area about 70 km. from east to west and 30 km. from north to south, is located a valuable oil and coal field. The anticlines in which the oil occurs are here oriented almost east-west, having been influenced no doubt by the WNW–ESE trend of the Goemai axis. East of Lahat, between the Lematang and Enim rivers, are the Serelo hills, a series of sharp andesite peaks, with summits of 600 m. or so, probably representing the necks or plugs of old volcanoes (Fig. 48). The heat developed during the volcanic activity associated with these plugs has converted some of the lignite seams into coal of much higher calorific value. South of the Serelo hills is the ruined volcano Isau Isau, which rears its broken cone to 1,431 m. (4,600 ft.).

A short distance to the south-east of the Lematang–Enim area lies the Batoeradja basin, in the Air Ogan valley, at roughly 50–100 m. above sea level. Here the folds are WNW–ESE.

The Upper Tertiary rocks of these areas in the provinces of Djambi and Palembang attain a thickness of between 4,000 and 6,000 m. They may be summarized as follows (with the youngest at the top):

Upper Palembang formation	: volcanic tuffs deposited by rivers;
Middle Palembang formation	: contains many lignite and coal seams;
Lower Palembang formation	: marine clays and sandstones;
Goemai (or Telisa) series	: marls and clays;
Batoeradja series	: limestone.

The succession demonstrates that the sag or geosyncline in which the beds were laid down subsided at a slow rate, so that sedimentation more than kept pace with it and it gradually filled up, the water becoming shallower until deltaic and estuarine swamps were formed, the vegetation of which became converted into lignite.

(iv) *Palembang and the Air Komering to the south-east coast*

Between Palembang and Bangka Strait lies a huge area of almost uninhabited swamp-forest, very little above sea-level; aside from the main waterways it is almost unsurveyed. South of a line joining Palembang and Lucipara-punt, at the southern end of the Strait, 'dry' patches, floored by Upper Tertiary volcanic sediments, begin to appear, and south of the Air Mesoedji the belt of alluvium and swamp narrows considerably, being reduced to a coastal strip averaging 10 km. in width with a series of tentacles spreading up the major rivers, the Air Toelangbawang, the Wai Sepoetih and its tributaries, and the Wai Sekampoeng.

In effect the swampy area between Palembang and Bangka Strait is an island, for a continuous water channel links the Air Komering with the Soengai Loempoer, through a series of swamp-lakes, of which the largest is Lebak Deling. Another similar interconnecting channel lies further south, joining the Air Komering via the Soengai Babatan and Air Padang to the great northerly bend of the Air Mesoedji.

The vast plain which extends inland from the coastal and riverine swamps to the foothills of the Barisan mountains, occupying a large part of the Lampoeng province, is for the most part between 20 m. and 50 m. above sea level, almost flat or very gently undulating, and largely covered with virgin tropical rain forest or with the secondary growth (*bloekar*) that follows from clearance and shifting cultivation. It is underlain by a varied series of Upper Tertiary and Quaternary rocks, consisting almost entirely of volcanic debris re-deposited by water—tuffs and pumice alternating with clays and mudstones.

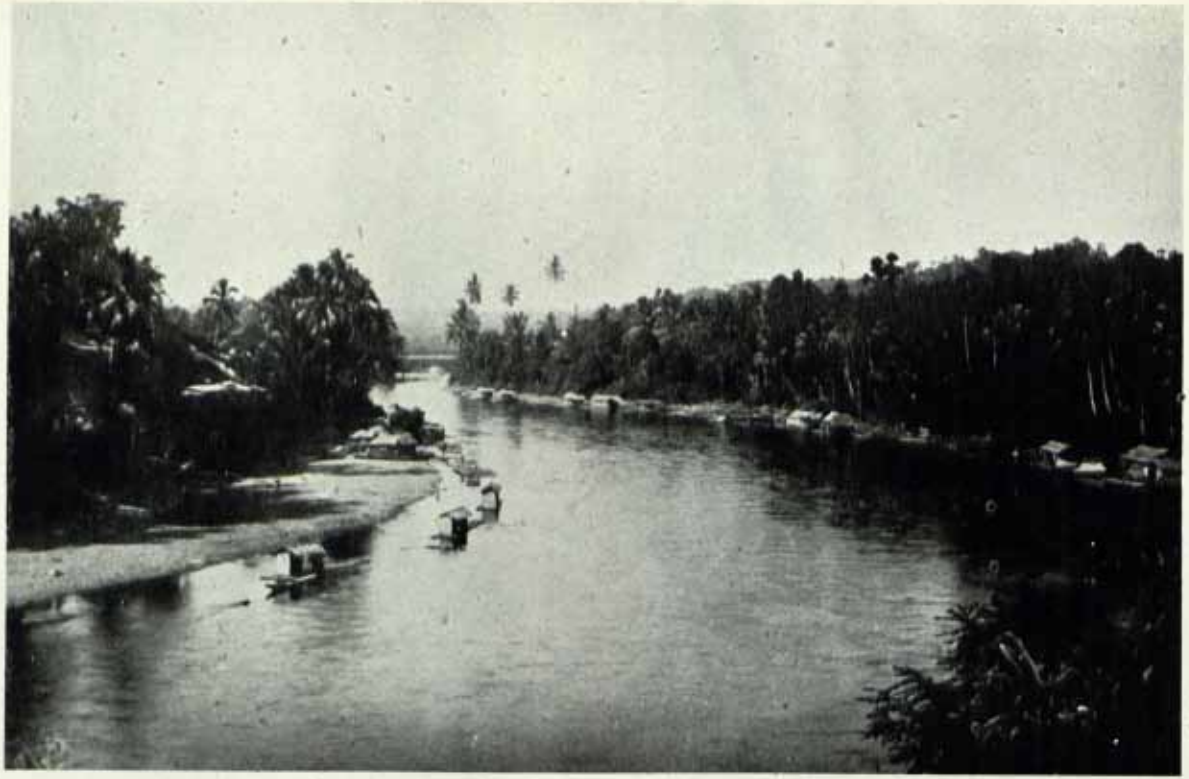


Plate 18. Batoeradja on the Air Ogan

Batoeradja is about 44 m. above sea-level and 320 km. from the sea. The river is navigable during the west monsoon season for vessels drawing 0·9 m. (3 ft.). The view is typical of many of the eastern Sumatran rivers, with densely vegetated banks and 'amphibious' dwellings strung out along each side of the navigable stream. For location see Fig. 42.

Plate 19. Oeleëlheuë

Oeleëlheuë is the most northerly port in Sumatra. It lies on a sand spit at the mouth of the Kroeëng Atjeh. There is anchorage in 4 to 5 fm. off the piers. In the centre is a road bridge crossing the river; on the right another bridge carries the Atjeh railway (see Figs. 51 and 59).

Plate 20. Belawan-Deli

The port of Belawan, on an island at the mouth of the Belawan river, is the outlet for the 'plantation area' centring on Medan. It has been created out of the swampy jungle which still surrounds it. In the foreground is the Ocean quay (depth 7·9 m.—26 ft.) on the northern side of the island; the western side, in the background, has more quays with a slightly smaller depth. For location see Figs. 33 and 52.

Lignite is known to occur over large areas, especially in the region of the Air Mesoedji; in places there are several seams within 30 m. or 40 m. from the surface. In the south-west, in the basin of the Wai Sepoetih, just north of the Holoewaisamang granite hills, is a small coal basin. In the south-east, between Soekadana and the lower Sekampoeng, is an area of distinctly hillier country, rising to over 100 m. and in isolated hills to over 200 m. This region is underlain by a sheet of basaltic lava.

The rivers of the Lampoeng plain are for the most part slightly incised in the soft volcanic sediments, flowing in the dry season between banks 4–6 m. high. The wet season flooding spreads water and mud over wide areas, especially along the Air Mesoedji, providing a natural annual renewal of the top soil. Villages are scattered along the river banks. Towards the western edge of the plain is the state-owned railway line, running from Oosthaven and Teloekbetoeng, at the head of Lampoeng bay, through Koetaboemi and Martapoera to Batoeradja and Palembang.

COASTS

The physical history of Sumatra has resulted in the development of several different types of coast, and there is naturally, owing to the asymmetric disposition of the mountain backbone, a strong contrast between the western and eastern shores of the island. In general, however, it may be said that for the most part both coasts are growing. That the west coast is emergent is evidenced by frequent marine terraces and uplifted coral reefs; the land on this side is also increasing in extent in places by the accumulation of river-borne silt. The east coast, despite its tendency to sink in accordance with the regional tilting of the whole island, is also growing, rapidly in some parts, as a result of the seaward growth of mangrove-anchored mudbanks.

For convenience of description the coast, which totals some 6,000 km. in length, may be divided into four unequal parts, the eastern and western coasts of considerable length, and the northern and southern sections much shorter:

Northern Coast (Koningspunt to Diamantpunt)

Eastern Coast:

(i) Western shore of Malacca strait
(ii) South-western shore of China Sea
(iii) Western shore of the Java Sea

Southern Coast (Soenda strait):
- (i) Lampoeng bay
- (ii) Semangka bay

Western Coast:
- (i) Vlakke Hoek–Benkoelen
- (ii) Benkoelen–Indrapoera roads
- (iii) Indrapoera–Padang
- (iv) Padang–Airbangis bay
- (v) Airbangis bay–Baroes
- (vi) Baroes–Troemon
- (vii) Troemon–Soesoh
- (viii) Soesoh–Tjalang
- (ix) Tjalang–Koningspunt

Northern coast (Koningspunt to Diamantpunt)

The northern coast of Sumatra, about 225 km. (140 miles) in length, is varied in aspect. The greatest contrast is between precipitous cliffs crowned by dense forest, and sandy beaches backed now by marshy lagoons, now by low cultivated plains studded with native villages (kampoeng).

The main mountain backbone of the island ends in a high and rocky shore which extends for 6 km. between the two promontories of Koningspunt (Oedjoeng Radja) and Atjeh Hoofd (Oedjoeng Masam Moeka or Achin Head). The peninsula of which these two headlands form the corners rises rapidly to a height of over 600 m. (*c.* 2,000 ft.). Between Atjeh Hoofd and Pedropunt the longitudinal valley, here represented by the trough of the Kroeëng Atjeh, runs out to sea, and the coast for 25 km. is low and sandy, with dunes backed by lagoons and marshes. There is a sand-spit at the mouth of the river, which is navigable only by boats. Oeleëlheuë, the outport of Koetaradja, has lost much of its importance since the development of Sabang on Poelau We, but it has a narrow-gauge railway which runs to Koetaradja and thence round the north-east coast to Aroe bay (Plate 19).

Pedropunt is a low headland; from here to Oedjoeng Pidië, a distance of some 47 km. (29 miles), high ground, dropping northwards from the volcanic mass of the Goudberg, again reaches the coast. There are some sheer headlands, such as the white limestone cliff of Batoe Poetih, the sandstone cliff of Batoe Kapal, and Oedjoeng Pidië itself, but most of the section consists of sloping wooded terrain, and the only flat and swampy stretch of any extent is on the west and south sides of Kroeëngradja bay.

Eastwards of Og. Pidië, the shore of the Sigli plain is low and sandy; a narrow strip of thinly wooded dunes is backed by marshes

or by coconut groves, but behind these is a cultivated and densely peopled lowland. Sigli is a government station and military post, on the Atjeh railway, and the terminus of a road which runs right across the Atjeh mountains to Meulaboh on the west coast. Hills of Tertiary rock reach the coast for a few kilometres eastwards of Koeala Ndjong, but the sandy beach then resumes, and is continuous, backed by a narrow coastal plain along which runs the railway, as far as

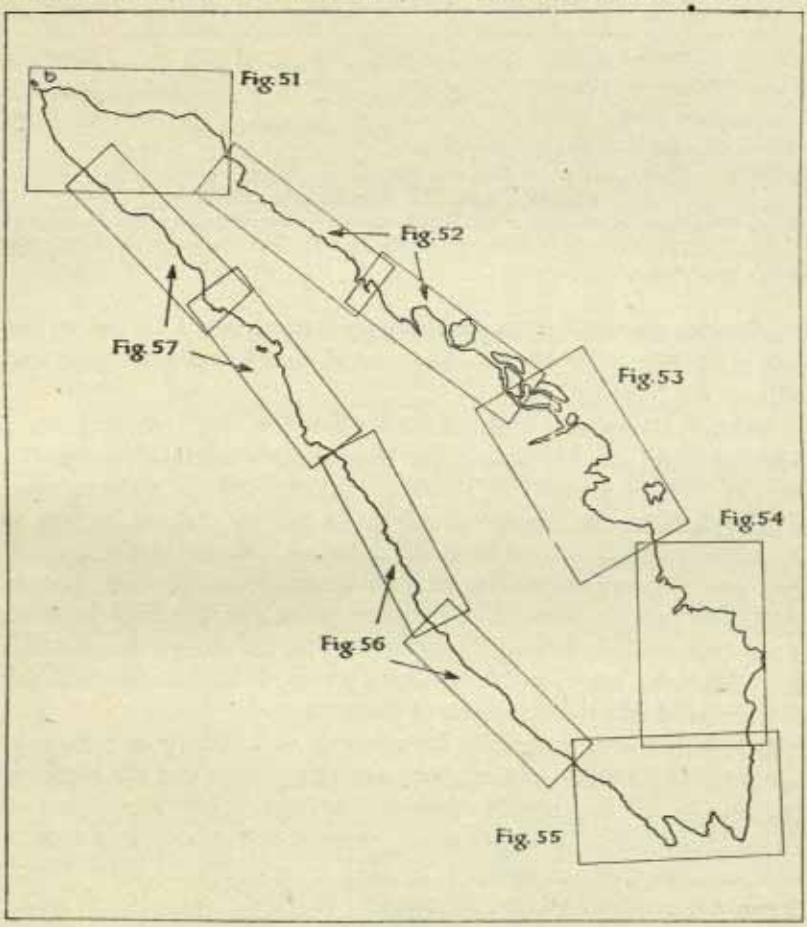


Fig. 49. Sumatra: Key to coast maps

The information in these maps has been compiled from many sources, mainly the *Eastern Archipelago Pilot*, vols. ii and iv (London, 1934 and 1939); *Malacca Strait Pilot* (London, 1934); *De Zeeën van Nederlandsch Oost-Indië* (Leiden, 1922); British Admiralty charts and Dutch topographical maps (copied as G.S.G.S. series 4184 and 4197).

Lhokseumawe, some 86 km. (50 miles) further east. This long east-west stretch is little interrupted save by the low, sandy promontories of Oedjoeng Radja and Oedjoeng Peusangan. Numerous small streams enter the sea, but the only considerable river is the Kroeëng

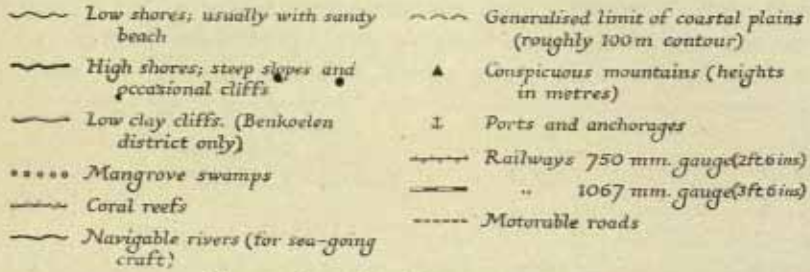


Fig. 50. Legend for Sumatra coast maps

Note.—The symbol for ports and anchorages is normally placed in its correct position, in the sea or on a river; where for any reason it cannot be so placed, it is shown in brackets.

Peusangan, the shallow and shifting mouths of which lie just to the east of Oedjoeng Peusangan. The coastal strip is well populated and villages are frequent.

Between the mouth of the Kroeëng Koekoes and Diamantpunt, a distance of 43 km. (27 miles), the coast forms a bight. The western part of this is known as Teloek Seumawe; on its western side, separated from the mainland only by a narrow channel known as Koeala Mamplam, is Seumawe island, flat and marshy, with the small port and government station of Lhokseumawe on its south-eastern side. The port is connected by a short branch to the Atjeh railway. There are low hills behind the island, but they trend south-eastwards away from the coast, and here begins the great lowland plain which extends all down the east coast of Sumatra.

Diamantpunt (Tandjoeng Djamboaje) is a sandy promontory, just above high water, about 1 km. east of the mouth of the Kroeëng Djamboaje, a considerable river which rises in the mountains of Gajo. The mouth of the river is low, swampy and not easily navigable, and its fringe of mangroves heralds a new coastal type which dominates much of eastern Sumatra.

Eastern Coast

The eastern coast of Sumatra is alluvial throughout, and in aspect is very monotonous. Broadly speaking there are only two types, the shore fringed with mangroves and the sandy beach covered with

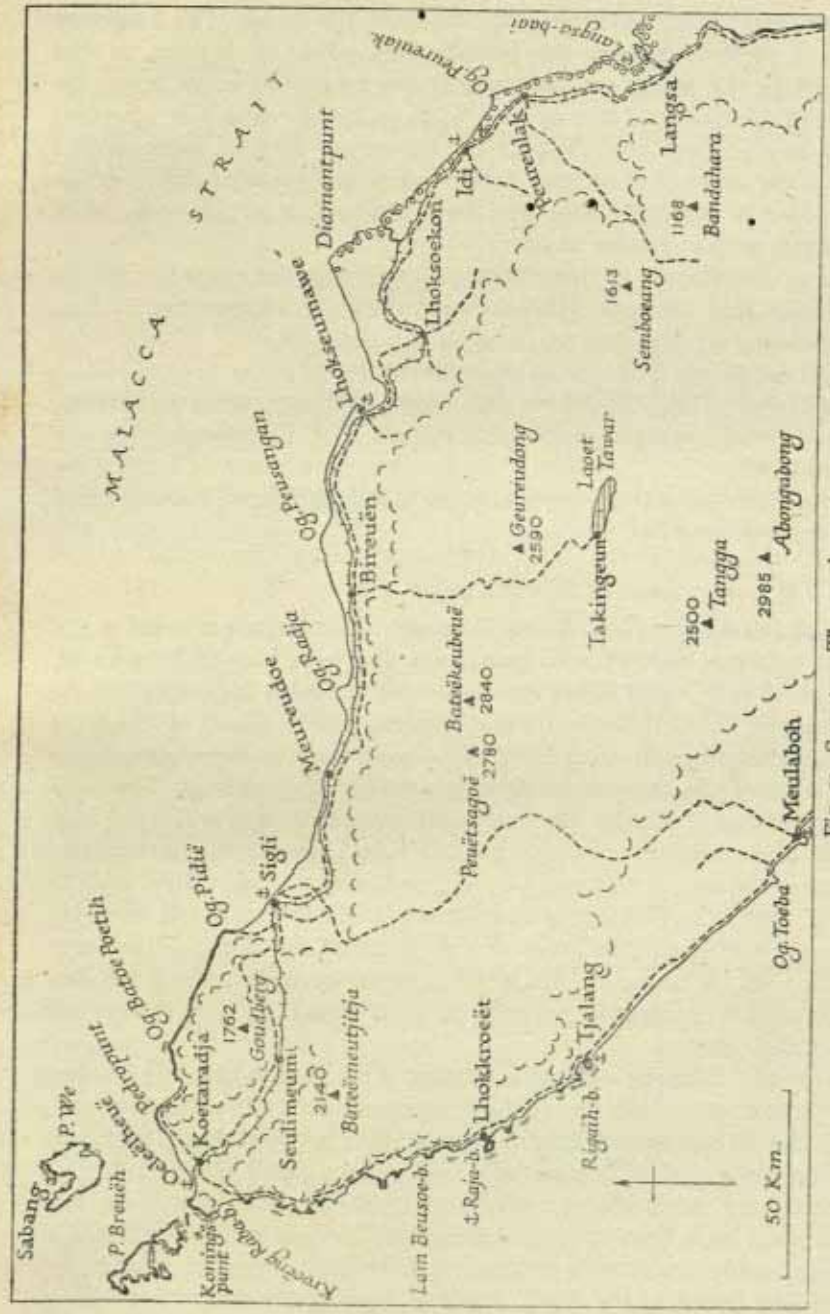


Fig. 51. Sumatra: The north coast

For location, sources and key see Figs. 49 and 50.

casuarinas; both are backed by dense swamp-forest. The height of the forest trees is frequently considerable, 30–40 m. or more, so that although the actual ground surface may be almost at sea level, the line of the tree-tops may be seen from 30 km. or more (say 20 miles) out at sea. Even at a distance the casuarinas may be distinguished from the mangroves by their darker colour and greater height; within the mainly mangrove zone they frequently occur on the more sandy patches at the mouths of rivers.

For convenience of description and reference the east coast will be divided into sections. Three major divisions suggest themselves, depending on the general trend of the coast-line:

(i) bordering Malacca strait, oriented NW–SE;

(ii) bordering the China Sea, from Malacca strait to Bangka strait, with several deep embayments but a general NNW–SSE direction;

(iii) bordering the Java Sea, from Bangka strait to Soenda strait, running almost due N–S.

(i) *The western shore of Malacca strait*

(*a*) *Diamantpunt—Oedjoeng Tamiang*. This stretch of coast is low and uniform, fringed with mangroves and back by high rain-forest. A number of small rivers enter the sea; the most important are the Simpang Olim, Kroeëng Idi and Kroeëng Peureulak, all of which are navigable, though with difficulty owing to shifting channels, to villages of the same name situated on the Atjeh railway. The large indentation of Langsa bay is shallow and silted, and is fringed with mangrove swamps; the tiny port of Koealalangsa, on the southern side of the bay, is connected by a branch with the main Atjeh railway line. Oedjoeng Tamiang is conspicuous by the groups of tall casuarina trees growing on sandbanks at the mouth of the Soengai Tamiang; this river is navigable for small craft to Seroewai, about 16 km. (10 miles) upstream, whence a road leads to the railway at Koealasimpang.

(*b*) *Og. Tamiang—Soengai Asahan*. This section of coast borders what is economically one of the most important parts of Sumatra, the plantation region centering on Medan. It is low, thickly covered with vegetation, and is intersected by numerous small rivers, a few of which are navigable for small craft. Mangrove swamps are less common here than anywhere else along the east coast, and there is more sandy beach with casuarinas. None of the coast is suitable for landing owing to the swell, which is particularly dangerous during

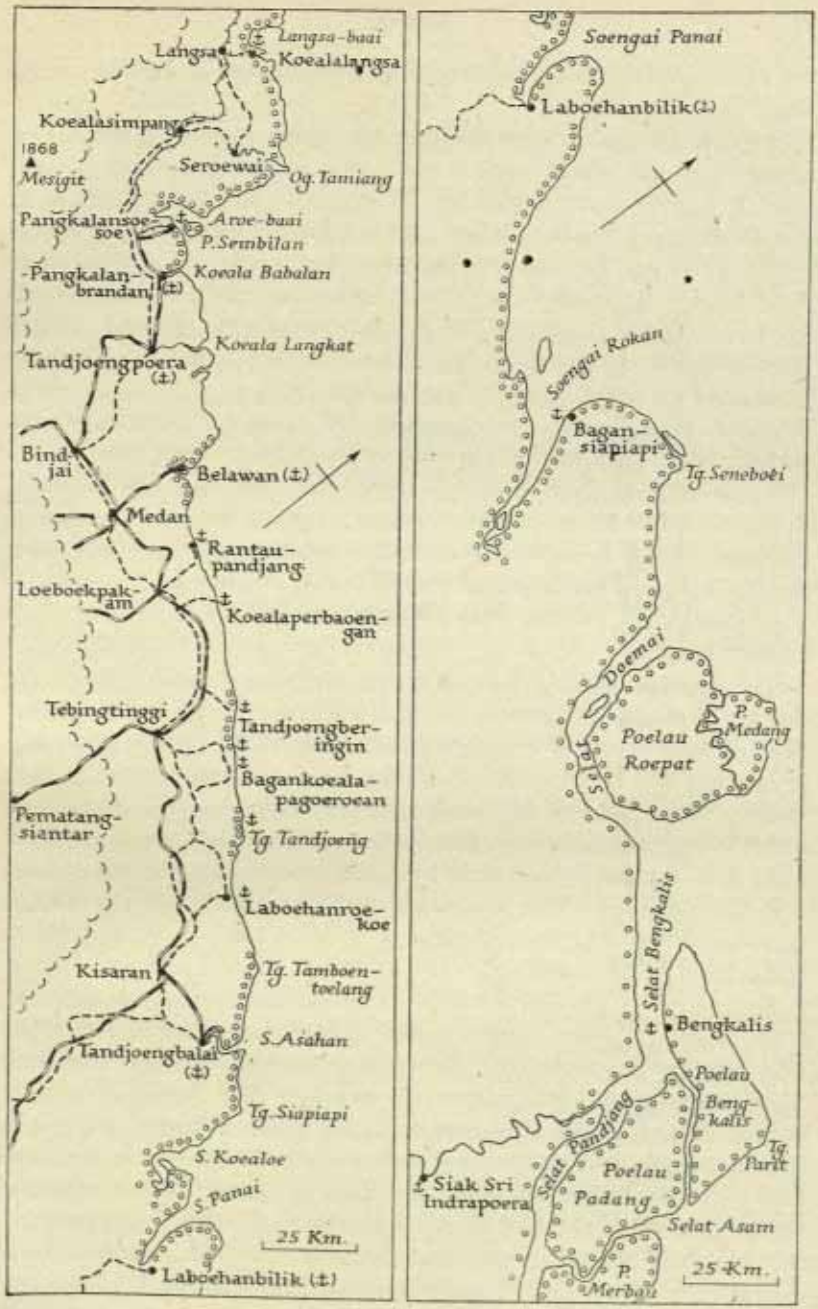


Fig. 52. Sumatra: the east coast, bordering Malacca strait
For location, sources and key see Figs. 49 and 50.

the north-east monsoon. Nevertheless the section contains Sumatra's chief port, Belawan.

A broad embayment lies between Og. Tamiang and the estuary of Koeala Langkat; at its head is Aroe bay, sheltered by two forested islands, Poelau Sembilan and P. Koempai, both mangrove-fringed. About 10 km. behind Aroe bay rises an isolated hill, 155 m. (508 ft.) high—the only near-shore elevation on the whole of the east coast. Aroe bay is very shallow, but the channel south of P. Sembilan leads to the small petroleum port of Pangkalansoesoe (pangkalan = 'small port'), which is also a railway transhipment station linking the southern end of the 750 mm. gauge Atjeh railway with the northern terminus of the 1,067 mm. gauge Deli railway which leads south-eastwards to Medan and beyond.

South-east of Aroe bay, the estuary of the Soengai Babalan, navigable for small craft, leads to the petroleum depot of Pangkalan-brandan, some 6 km. inland. Still further south-east, the wide Koeala Langkat leads inland for 20 km. (12 miles) to the town of Tandjoengpoera, which, like Pangkalanbrandan, is on the Deli railway line.

The Soengai Deli, or Deli river, rising in the volcano Sibajak and flowing northwards through Medan, is joined at its mouth by the Soengai Belawan. The southern mouth, that of the Deli, is silted and unnavigable, but the mouth of the Belawan provides a channel leading to the port of Belawan, or Belawan-Deli as it is sometimes called (Plate 20). This port, which is largely artificial, having replaced mud and mangroves, can only be maintained by constant dredging; it is the terminus of the main line of the Deli railway from Medan and owes its importance entirely to the growth of plantation agriculture in its hinterland.

Between Belawan-Deli and the mouth of the Soengai Asahan the coast is low, covered with vegetation and almost featureless. The only low promontories are Tandjoeng Tandjoeng and Tandjoeng Tamboentoelang, both sandy and wooded. The beach is mainly sandy, though there are occasional mangrove swamps, especially between Tg. Tamboentoelang and the mouth of the S. Asahan. Many rivers enter the sea, but none of any great size. There are a few settlements on or near the shore, especially at the river mouths, some of which act as small ports, and are linked by roads leading back through the plantations to stations on the Deli railway.

The mouth of the S. Asahan is nearly 1 km. wide between mangrove-fringed shores; its channel leads inland for 11 km. to the

small port of Tandjoengbalai, the eastern terminus of the Deli railway main line.

(*c*) *Soengai Asahan—Soengai Rokan.* About 13 km. (8 miles) beyond the mouth of the S. Asahan is the low point of Tandjoeng Siapiapi, fringed with mangroves ('api-api' is a generic name for trees of the mangrove variety). The coast here turns sharply south, opening into a broad shallow bay 32 km. (20 miles) across, which forms the combined mouth of the Soengai Koealoe and the Soengai Panai. About 20 km. above the mouth of the latter, which is navigable for small craft, is the small town of Laboehanbilik; from here a road leads inland for a considerable distance to Rantauparapat, the southern terminus of the Deli railway.

The next great embayment of the coast is formed by the estuary of the Soengai Rokan. The shores are mangrove-fringed and the estuary is shallow and much encumbered; a tidal bore (a wave about 1 m. high, known as the *bena*, which travels 50 km. upstream) is experienced for three days on either side of both full and new moon. The only important settlement is Bagan-siapiapi ('the quay in the mangroves') (Plate 21), on the eastern side of the mouth; it has no road into the interior, which is densely forested and swampy.

(*d*) *Soengai Rokan—Soengai Kampar.* A low peninsula, the north-eastern corner of which is known as Tandjoeng Seneboei, separates the Rokan mouth from Malacca strait. Between Tg. Seneboei and the mouth of the Soengai Kampar, some 300 km. (190 miles) to the south-east, the coast is almost uniformly flat, mangrove-fringed and backed by almost uninhabited rain-forest. In front of the main coastline, and separated from it by channels averaging about 5 km. (3 miles) in width, is a series of equally low, flat and densely forested islands. Poelau Roepat is separated from the mainland by Selat Doemai (or Selat Roepat); with Poelau Medang, from which it is separated only by a sinuous channel about 200 m. (215 yd.) wide, it forms a compact and almost circular mass just over 40 km. in diameter. Further to the south-east lies a whole group of similar islands, separated from the mainland by a navigable channel known at its northern end as Selat Bengkalis or Brouwers strait, and for the greater part of its length as Selat Pandjang ('the long strait'). The islands themselves are separated from each other by narrower channels which average about 2 km. wide. All these channels are of somewhat surprising depth—between 5 and 20 fathoms—a feature which may in part be due to their being river channels which have been submerged by the regional tilting before referred to (cf. Fig. 6), but is also a

result of the strong tidal scour. It is in this region that the tidal stream of the Malacca strait meets that from the China Sea, and the amplitude at springs is about 3 m. (10 ft.) (compared with an average of only 1 m. (3 ft.) on the western coast which faces the Indian Ocean). Moreover, the Rokan and Kampar are the only two rivers on the east coast which experience a tidal bore. The high tides are 'absorbed' by the mangroves and swamp-forests of the islands and mainland, and the land fully deserves the epithet 'amphibious'. Whilst most of the shores are mangrove-fringed, the outer, northern shores of Poelau Bengkalis and Poelau Rangsang are sandy and wooded, and are perhaps receding rather than growing, owing to the strength and direction of the tidal currents.

The only important settlements on the islands, apart from a few coastal villages, are Bengkalis, on the south-western side of P. Bengkalis, and Selatpandjang, on the southern shore of Selat Air-hitan, the strait which separates P. Rangsang from P. Tebingtinggi.

Into the Selat Pandjang flows the Soengai Siak, one of the most important navigable rivers in Sumatra. It is navigable for small sea-going craft as far as Pakanbaroe, 146 km. (90 miles) upstream, where the channel—in which tidal influences are felt—is still 80 m. (87 yd.) wide and 25 m. (13½ fm.) deep. From Pakanbaroe a road leads southwards to Taratakboeloeh on the upper Soengai Kampar-kanan, which is navigable for small craft to the foothills of the Barisan ranges. The same road, forking near Parit, leads westwards, also following the Kampar-kanan valley, across the Padang Highlands to the west coast. Thus the Siak river is part of one of the few trans-Sumatran routeways. About 63 km. (40 miles) from the Siak mouth is the town of Siak Sri Indrapoera, an administrative centre set in the middle of the forest, through which there are no roads.

At the southern end of the group of islands is the large estuary of the Soengai Kampar. The Kampar is one of the largest rivers in Sumatra, but the density of the rain-forest around its lower course is such as to discourage human settlement, and the tidal currents—including a fortnightly bore—and shifting channel make navigation difficult.

(ii) *The south-western shore of the China Sea*

The Malacca strait ends at the extensive archipelago which lies off the southern end of the Malay Peninsula. The westernmost members of this archipelago are the Karimoen and Koendoer islands, which lie opposite the mouth of the Soengai Kampar, leaving a strait

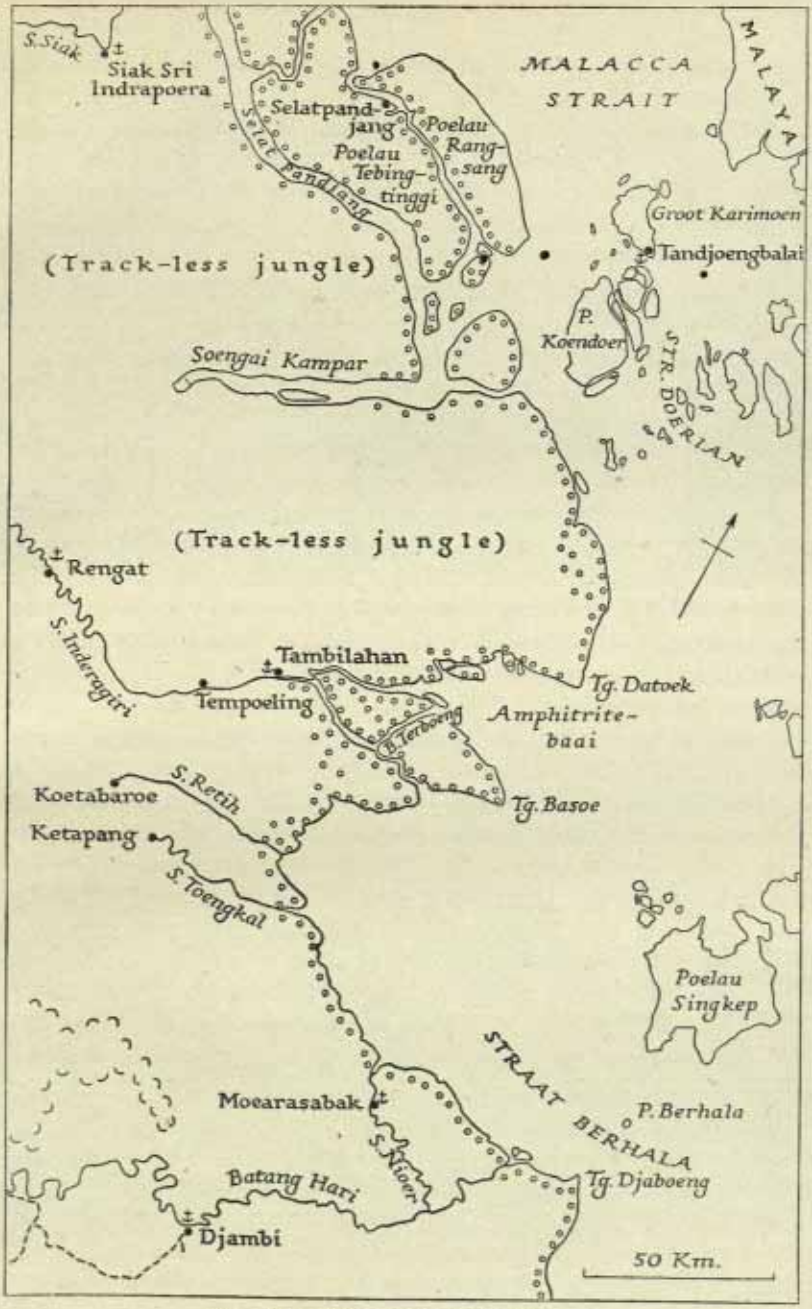


Fig. 53. Sumatra: the middle east coast
For location, sources and key see Figs. 49 and 50.

only about 12 km. (7 miles) wide between Koendoer and the mainland of Sumatra.

Between the Kampar and Lucipara-punt, some 500 km. (300 miles) to the south-east, Sumatra is washed by the South China Sea, but a fringe of islands, large and small, representing the relics of a former south-eastward continuation of the Malay Peninsula, intervenes before the main open waters of that sea are reached. The whole of the coast is low, flat, mangrove-fringed and backed by high rain-forest. It is intersected by the mouths of Sumatra's greatest rivers, and is accordingly extending rapidly in parts owing to the deposition of silt and the growth of mangrove swamp. The bays are all shallow and silt-filled, but the currents tend to sweep the low headlands clear, and deep water is found quite close, for example, to Tg. Datoek and Tg. Djaboeng.

From the Soengai Kampar the coast swings round south-eastwards to Tandjoeng Datoek, beyond which lies the largest embayment on the whole Sumatran coast, 130 km. (80 miles) across between Tg. Datoek and Tg. Djaboeng. Into this bay flow two very large rivers, the Inderagiri or Batang Koeantan and the Batang Hari, both of which bring down enormous quantities of silt. The bay is accordingly shallow (mostly under 10 fm.) and the Inderagiri has built up an extensive delta, ending in Tandjoeng Basoe, which divides it into two unequal parts, the smaller northern section being known as Amphitrite bay, the southern part apparently having no native or Dutch name but called Jambie (i.e. Djambi) bay on British charts. The entire shore is low and flat, fringed with mangroves and backed by high rain-forest. The main channel of the Inderagiri, which has four navigable distributaries, is the Batang Terboeng, which leads inland from the head of Amphitrite bay. The river itself is navigable for quite large vessels as far as Tempoeling Soengai Salak, 48 km. (30 miles) upstream, for smaller vessels a further 43 km. to Tjenako, and for small craft to Rengat, 127 km. (75 miles) from the mouth. From Rengat a road follows the Inderagiri westwards to Airmolek airfield and the Padang Highlands.

At the head of 'Jambie bay' are the mouth of the Soengai Toengkal and the delta of the Retih river. The former has a deep navigable channel for at least 63 km., but the villages served are unimportant and have no road communication through the dense jungle. The Retih is navigable to Koetabaroe, 56 km. upstream, but there are no roads from here either.

The southern shore of 'Jambie bay', from Soengai Toengkal to

Plate 21. Bagansiapiapi
The wooden pier or 'bagan' is typical of many of the small ports on the east coast of Sumatra, which can only be used by praus. Bagansiapiapi lies on the estuary of the Soengai Kampar (see Fig. 52).

Plate 22. Native dwellings on the Air Moesi at Palembang
The environment of the swampy jungle and wide tidal rivers in eastern Sumatra renders pile-dwellings more or less essential.

Plate 23. The river port of Palembang

Palembang is the second port of Sumatra, after Belawan. The town is built along the river banks and has practically no width. In the foreground, on the northern bank of the river, is the government wharf, which can take vessels drawing up to 7 m. (23 ft.) at all times.

Plate 24. Pladjoe oil refinery, near Palembang

For location see Fig. 54. The Pladjoe refinery, owned by the *Nederlandsche Koloniale Petroleum Maatschappij*, is set in the midst of the jungle, on the Moesi river at its junction with the Air Komering. It refines oil from the fields in the Moesi and Lematang basins above Palembang. The refineries and shipping stations are in three sections, at Soengai Gerong (pictured above) on the eastern side of the Air Komering mouth, at Pladjoe, on the western side, and at Bagoeskoening, on the Moesi just above Pladjoe. All three can take vessels of 7 m. (23 ft.) draught at all times.

Fig. 54. Sumatra: the Palembang coast and waterways
For location, sources and key see Figs. 49 and 50.

Tg. Djaboeng, is low and forested, and fronted by a shallow and shelving mud-bank. It is intersected by the mouths of the Batang Hari or Djambi river, the largest river in the country. The main navigable channel of the delta is Koeala Nioer. Djambi, an important administrative centre (capital of Djambi Residency), is situated about 130 km. (80 miles) from the sea, and is reached by sea-going steamers; the river is here about 300 m. (330 yd.) wide. Smaller vessels can reach Moearatebo, some 240 km. above Djambi, and native craft can penetrate several hundred kilometres further up the main stream and several of its tributaries, as far as the foothills of the Barisan mountains. From Djambi a road follows the Batang Hari valley right across to the Padang Highlands; there are several other roads radiating from Djambi. At Tg. Djaboeng the coast turns sharply southwards, and makes a broad sweep of 100 km. (60 miles) to Batakarang-punt at the entrance of Bangka strait. It is low and mangrove-fringed, fronted by a broad mud-bank, backed by high forest, and uninhabited.

The Sumatran shore of Bangka strait comprises three broad embayments, of which the most northerly is the largest. The greater part is uninhabited mangrove swamp backed by high forest, but there is one highly important means of access to the interior. Into the north-western end of Bangka strait flow several large rivers, the broad channel of the Air Banjoeasin and the three main mouths of the Palembang river or Air Moesi. The former is navigable though shoaly; one of its tributaries, the Air Lalang, is navigable for small vessels for some 160 km. (100 miles) to Moeara Bahar. The Palembang river proper is the western of the three mouths; it leads almost due southwards to the town of Palembang, nearly 100 km. (60 miles) upstream. Palembang (Plates 22, 23) is the principal town in eastern Sumatra, with roads leading north-westwards to Djambi and south-westwards to Lahat, Batoeradja and the west coast. The suburb of Kertapati, on the right bank of the river opposite the upper end of the town, is the northern terminus of the state-owned railway of southern Sumatra. It is the focus and port of the rich oilfields and the Lematang coalfield (Plate 24).

The Moesi and its tributaries provide an extensive system of inland waterways serving economically important areas, but navigation is hampered by lack of water during the season of the east monsoon (June–September). The Moesi itself is navigable for small craft for 300 km. to Moearaklingi during the west monsoon season; the Air Lematang is navigable during this season for 170 km. above its

confluence with the Moesi to the coal-mining centre of Moearaenim, on the Lahat branch of the railway; the Air Ogan is navigable throughout the year from Palembang to Tandjoengradja, 56 km. (35 miles) upstream, and during the west monsoon to Batoeradja, 225 km. (140 miles) upstream, an important centre on the Lampoeng section of the railway line. The Air Komering is navigable for some 90 km. to its junction with the curious interconnecting channel known as Soengai Babatan, which is also navigable and provides a water link with the Air Mesoedji.

(iii) *The western shore of the Java Sea*

From Lucipara-punt, at the southern end of Bangka strait, the Sumatran coast, washed by the Java Sea, runs almost due north-south to the Soenda strait. The whole stretch, some 300 km. (*c.* 180 miles) in length, is low and flat, and consists of broad shallow embayments separated by low headlands. Mangrove swamps dominate much of the shore, but towards the south, sandy beaches become more common. The neighbourhood of the coast is almost uninhabited, but there are several fairly large rivers which give access to the interior.

The broadest embayment is the first one, about 70 km. (40 miles) across, between Lucipara-punt and Tandjoeng Loemoet (Tg. Mendjangan). Into this bay flows the Soengai Loempoer, which is navigable for small craft and provides a waterway to the Air Komering and so to Palembang. The next bay, between Tg. Loemoet and Tg. Serdang, contains the mouths of the Air Mesoedji and the Wai Toelangbawang. The former river provides another navigable waterway to Palembang, via the Soengai Babatan mentioned above. The Toelangbawang is navigable for 110 km. to Menggala, whence roads lead westwards to Batoeradja and southwards to Teloekbetoeng.

The third embayment is relatively small, between Tg. Serdang and Tg. Kenam. Just beyond the latter is the mouth of the Wai Sepoetih, but this river is unnavigable except for small native craft owing to a bar. Tandjoeng Poelausekopong separates the fourth and fifth bays; the latter ends in the rounded point of Tg. Penet, beyond which sandy beaches take the place of mangroves. The last navigable river is the Wai Sekampoeng, which is passable for small craft to Djaboeng, whence a road leads into the interior.

In the south-eastern corner of Sumatra is the double-peaked volcano Radjabasa. The foothills of this mountain do not quite reach

the east coast, but leave a narrow plain extending from the light-coloured cliff of volcanic rock called Batoe Poetih to the headland of Varkenshoek. Near Batoe Poetih is the village of Ketapang which has a road running inland to Teloekbetoeng. Off this section of coast are the Zutphen islands, four in number, all densely wooded and rising to elevations of between 100 m. and 200 m.

Southern Coast (Soenda Strait)

In sharp contrast to the east coast, the south coast of Sumatra is for the most part high and rocky. It comprises two large bays, separated by Semangka peninsula, a mountainous mass of volcanic rock, with several extinct cones, which forms the southern extremity of the axial range of the island. Lampoeng bay, the eastern of the two, is comparatively shallow (under 20 fm.), and several groups of high, steep-sided islands lie across its broad mouth, extending into Soenda Strait; the chief of these are Lagoendi, Seboekoe, Sebesi and the Krakatau group. Semangka bay, on the west, is a much deeper trough, almost certainly of tectonic origin, and representing the southern end of the longitudinal valley of the Barisan mountains. In the centre of its broad mouth is Taboean island, high and steep, with a peak reaching nearly 700 m. (2,300 ft.).

(i) *Lampoeng bay*. The south-eastern extremity of Sumatra is Varkenshoek (or Tandjoeng Toeal), a high, promontory, rocky and forested. North of this point the coast, still high and steep, swings round the southern and western sides of the Radjabasa volcanic mass. At Kalianda, whence a road runs north-westwards to Teloekbetoeng, it suddenly becomes flat, with a beach of sand and stones. The rest of the eastern coast of Lampoeng bay is hilly, though the shore itself is usually flat, and the beach is subject to considerable swell, especially during the west monsoon. Near the head of the bay is the port of Oosthaven, sheltered by a coral reef; this port is the southern terminus of the state railway which runs round the head of the bay to Teloekbetoeng and then north-westwards to Palembang. The construction of Oosthaven has relieved Teloekbetoeng, the approach to which is shallow and much encumbered with reefs and islets.

The western shore of Lampoeng bay is rugged and much indented by bays, most of which are sheltered by islands. The mountains descend almost to the shore, leaving only here and there a small strip of beach, with swamps at the stream mouths and an occasional fringing coral reef. The principal bay is Ratai, with Poelau Kelagian

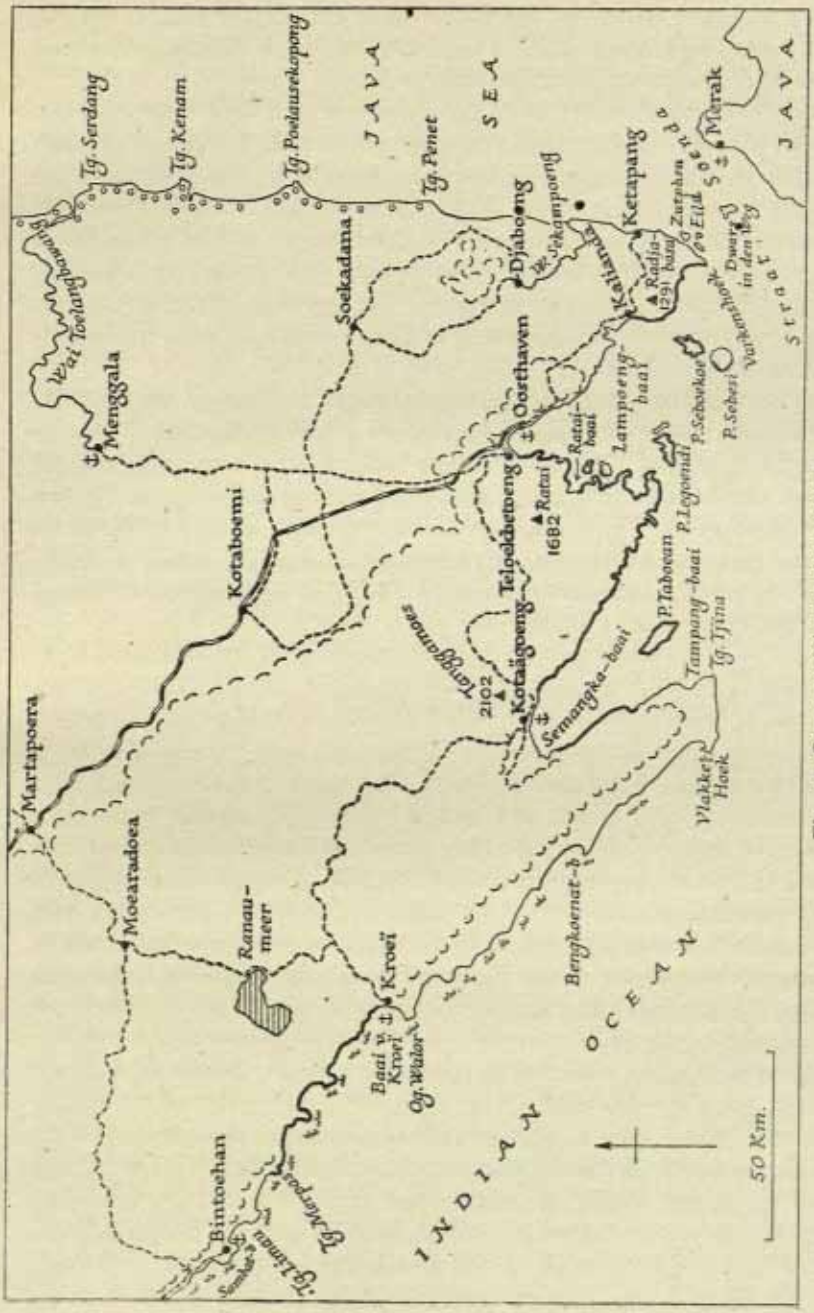


Fig. 55. Sumatra: The southern coasts

For location, sources and key see Figs. 49 and 50.

(282 m.—918 ft.) at its entrance; there are several villages on the northern shore, from which a road runs up the Wai Ratai valley and also northwards to Teloekbetoeng.

(ii) *Semangka bay*. The eastern shore of this bay resembles the shore just described, but the bays are smaller. It is steep, rocky and mostly inaccessible; a strong swell also hinders approach. At the head of the bay the valley of the Wai Semangka runs out to sea, and the shore is flat, swampy and wooded. The small town of Kotaagoeng lies at the eastern end of this flat stretch, and at the south-western foot of the prominent extinct volcano Tanggamoes (2,102 m.). Roads lead eastwards to Teloekbetoeng and northwards into the mountains of the Ranau area.

The western shore of the bay is steep and almost without indentations; it would appear to owe its origin to faulting. Towards the southern end the landward slope becomes less steep, and the small open bay of Tampang has a sandy beach. The bay ends at the low promontory of Tg. Tjina (or Tjoekoe Redak), at which the coast turns abruptly westwards, extending for 20 km. (12 miles) as a flat, sandy beach, sometimes swampy, to the appropriately named Vlakke Hoek (Flat Cape).

Western Coast

The west coast is far more varied than the east. There are only a few stretches of mangrove swamp, but sand dunes, covered with coconuts and casuarinas, and backed by swampy lagoons or marshes, are more common. There are long stretches of wooded sandy beaches, backed by a narrow coastal plain or by hills. Despite the nearness of the mountain backbone to the coast the shore is only rocky and precipitous in a few places, as in the extreme north and just south of Padang. The peaks of the Barisan ranges can usually only be seen from the sea just after sunrise; during the rest of the day they are concealed by cloud. The whole coast is very exposed to the swell of the Indian Ocean, which is increased by the west monsoon, and as a result ports are few and far between. The difficulties of navigation are accentuated over a great part of the coast by the existence of coral reefs, especially in the middle section between Hoek van Indrapoera and Oedjoeng Radja. A 'continental shelf', covered by less than 100 fm. of water and with a submerged barrier reef along its edge, runs for some distance along this part of the coast, and twice extends to the island fringe, in the Batoe and Banjak groups.

(i) *Vlakke Hoek to Benkoelen*

Although of varied character, the whole of this 350 km. (220 miles) stretch of coast has one common characteristic: it is almost entirely without shelter. There are only three useful anchorages, in Sambat, Kroeï and Bengkoenat bays, but even these are unsafe during the westerly monsoon, and the whole coast is dangerous for landing owing to the heavy surf.

(*a*) *Vlakke Hoek to Kroeï bay*. From the flat sandy promontory of Vlakke Hoek to Kroeï bay the shore is low, and either densely overgrown with vegetation or with a broad beach of sand and coral grit. A narrow coastal plain, floored by soft Neogene sediments and varying in width from 2 to 6 km., rises gradually to the Pematang Sawah plateau which forms the axis of the Benkoelen peninsula, and its northward continuation known by the general name of Barisan range. There are several broad but shallow embayments separated by low headlands; the largest is Bengkoenat bay. Settlement is not dense, and the few groups of villages are situated for the most part away from the actual shore.

Beyond the low promontory Oedjoeng Walor is Kroeï bay, with the town of Kroeï at the mouth of a small river on its eastern side. The little plain of Kroeï is quite densely peopled, and the town has a road leading inland across the Barisan range, and so to Teloekbetoeng on the one hand or via lake Ranau to Batoeradja and Palembang on the other.

(*b*) *Kroeï bay to Sambat bay*. For the next 60 km. (37 miles) the coast is different. Erosion has presumably removed the covering of Upper Tertiary sediments for the greater part of this distance, and the volcanic foothills of the Barisan range come right down to the sea. There are several sandy-shored bays, behind which the ground rises steeply, and some rocky headlands. A few small villages exist along the coast, but there is no means of access to the interior.

At Tandjoeng Merpas the fringe of Neogene rocks resumes, and Sambat bay is partially protected—though it remains open to the south-west monsoon—by two low, flattish headlands, Tandjoeng Limau on the south and Tg. Bandar on the north. On the north-western side of the bay is the town of Bintoehan, from which a road runs along the coast north-westwards to Benkoelen.

(*c*) *Sambat bay to Benkoelen*. This stretch of coast is low, and the shore is generally sandy and covered with casuarina trees. It is backed by the dissected foothills of the Barisan range, with a narrow coastal plain which broadens and becomes alluvial about 30 km. (19 miles)

beyond Bintoehan, at which point also the fringe of coral which has been more or less continuous along the shore all the way from Vlakke Hoek, ceases to exist owing to the alluvial, and therefore muddy character of the shore deposits. The coast for 125 km. (77 miles) from here to Buffelpunt is almost straight, and the width of the alluvial plain remains very constant at about 10 km. (6 miles). It is dotted with villages, most of which lie inland. Apart from a short stretch of mangrove-swamp beyond Mana, the actual shore consists of sand dunes covered with casuarinas. The longshore drift is northwards, and in consequence the streams entering the sea have their mouths blocked, and frequently run for several kilometres in a north-westerly direction behind the dunes before breaking through. The road from Mana to Benkoelen follows the coast, behind the dunes, as far as Pasarseloema, where it turns inland to Tais and then follows the inner edge of the plain, for the seaward side tends to be marshy.

Beyond Buffelpunt there is a bay, on the southern side of which is a large lagoon (Poelau bay) protected by a long sand-spit. On the low headland which bounds this bay on the north is the town of Benkoelen, a provincial capital and small port. It is actually only a roadstead, and the tiny harbour, which is sheltered from the south-east monsoon, is used only by boats. The western Barisan range behind Benkoelen is lower than usual, and an easy road passage is obtained leading to Kepahiang, in the longitudinal valley, whence further roads lead northwards to the Moearaäman goldfields and eastwards to Lahat and Palembang (Plate 25).

(ii) *Benkoelen to Indrapoera roads*

This section of coast, about 270 km. (170 miles) in length, is low and uniform, with no conspicuous points or indentations. It is backed by a wide alluvial plain composed of debris brought down by rivers from the volcanic mountains. This debris is reddish in colour, and the numerous streams which cross the plain are very muddy, especially during the rainy seasons. Occasionally, low cliffs of red clay occur, as near the mouths of the Air Teramang and Air Ipoeh, and from Seblat southwards, nearly to Benkoelen. Here especially, as so often elsewhere in regions of tropical rain-forest, the tallness of the trees makes the coast look much higher than it actually is.

In the south the coastal plain is about 10 km. wide. It is well populated, and a coastal road runs from Benkoelen through Lais to Ketaoen, a distance of some 70 km. Ketaoen is at the mouth of the Air Ketaoen, which is navigable for native craft to Napalpoetih,

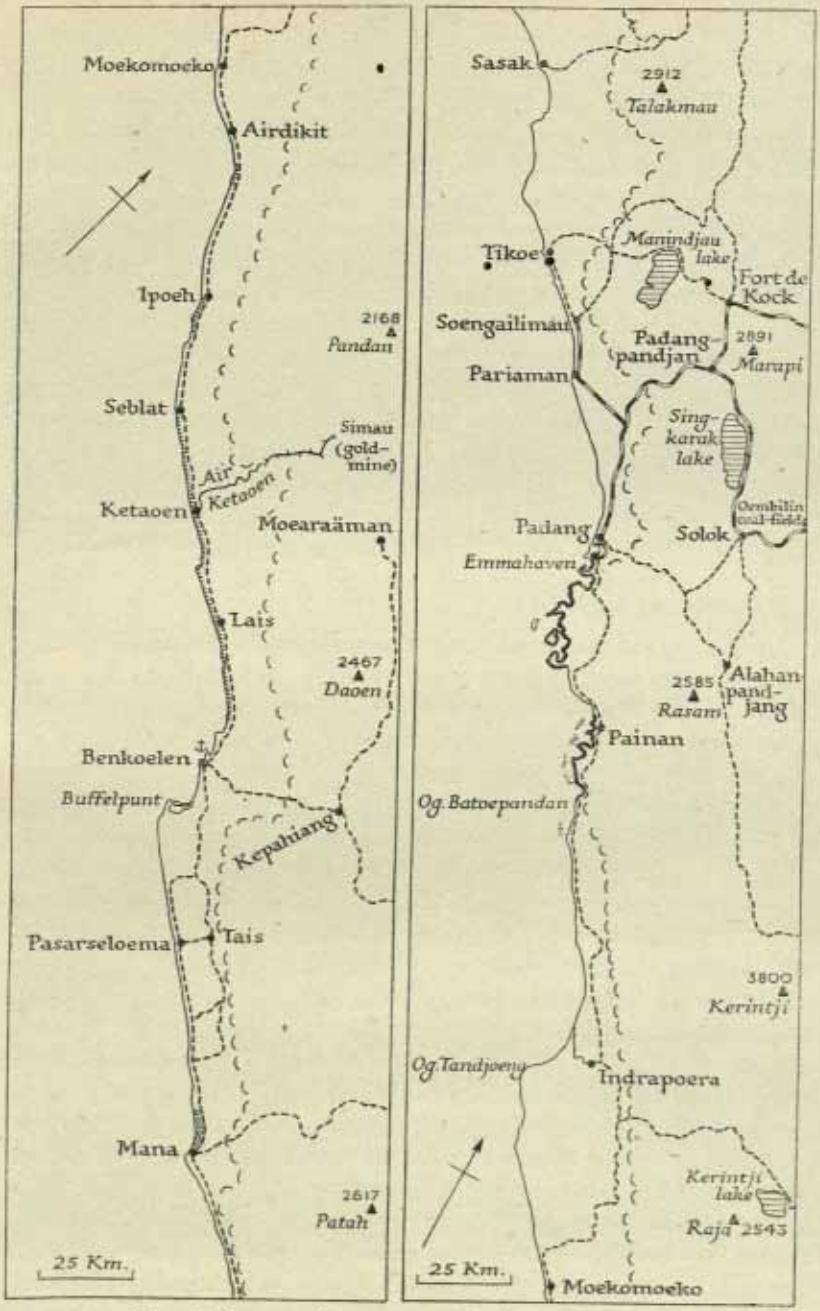


Fig. 56. Sumatra: the west coast, Benkoelen and Padang
For location, sources and key see Figs. 49 and 50.

whence a tramway leads to the Simau gold-mines, about 50 km. inland on the flanks of the Barisan range. The road continues, in a poorer condition, through Seblat, Ipoeh and Airdikit to Moekomoeko, crossing the mouths of the larger streams by bridges, and fording or ferrying the rest (Plate 26).

In the vicinity of Moekomoeko the country changes somewhat. The alluvial plain doubles in width, to 20–25 km., and the greater part of it becomes swampy and uninhabited. The shore line is sandy and densely wooded, and there are some mangroves. The plain projects seawards in the low, wooded Oedjoeng Tandjoeng, or Hoek van Indrapoera. The road turns inland, and keeps to the inner edge of the plain, following a line of villages to Indrapoera. This small town lies about 12 km. from the sea, on the Air Betang, a tributary of the Air Indrapoera. These rivers, together with the lower part of another tributary, the Air Tapan, are navigable for native craft. There is an open roadstead off the mouth of the river.

(iii) *Indrapoera to Padang*

In this section the Barisan mountains approach the sea once more, giving rise to some striking coastal scenery, especially to the south of Padang. Coastal coral reefs again become common, and a 'continental shelf' about 20–25 km. wide extends offshore, with a 'barrier reef' on its seaward edge.

Northwards from the Air Indrapoera, the coastal plain narrows to 2–6 km., and the foothills of the volcanic mountains approach the shore. Casuarina-covered dunes, often with coconuts, continue to form the shore-line, behind which are occasional swamps and blocked stream-mouths. There are numerous villages on drier sites, and the main Benkoelen–Padang road connects them.

Beyond Oedjoeng Batoepandan the alluvial plain ceases to exist, and the coast becomes increasingly wild and rocky, and more sparsely populated. There are numerous bays, separated by rocky and reef-fringed headlands; the bays offer little shelter as they are exposed to the westerly monsoon. There are two groups of bays. In the more southerly group the chief is Painan bay, with the small town of Painan near its north-eastern shore. The main road runs here sometimes near the shore, sometimes inland to avoid the headlands. Between Painan bay and Taroesan bay is a lower stretch of coast, with sand dunes, but then an outcrop of hard volcanic rock extends to Padang, and the coast is extremely indented, forming the second group of bays and headlands. There are few villages, and the main road runs

Plate 25. The Kepahiang-Benkoelen road
For location see Fig. 56. The road is here crossing one of the lowest and narrowest parts of the western Barisan range.

Plate 26. A ferry on the Benkoelen coast road
There are many ferries like this across the streams which flow from the Barisan ranges to the Indian Ocean. The steep river banks are often a great hindrance, as in this case of the Silaoet ferry, about 30 km. north of Moekomoeko (Fig. 56).

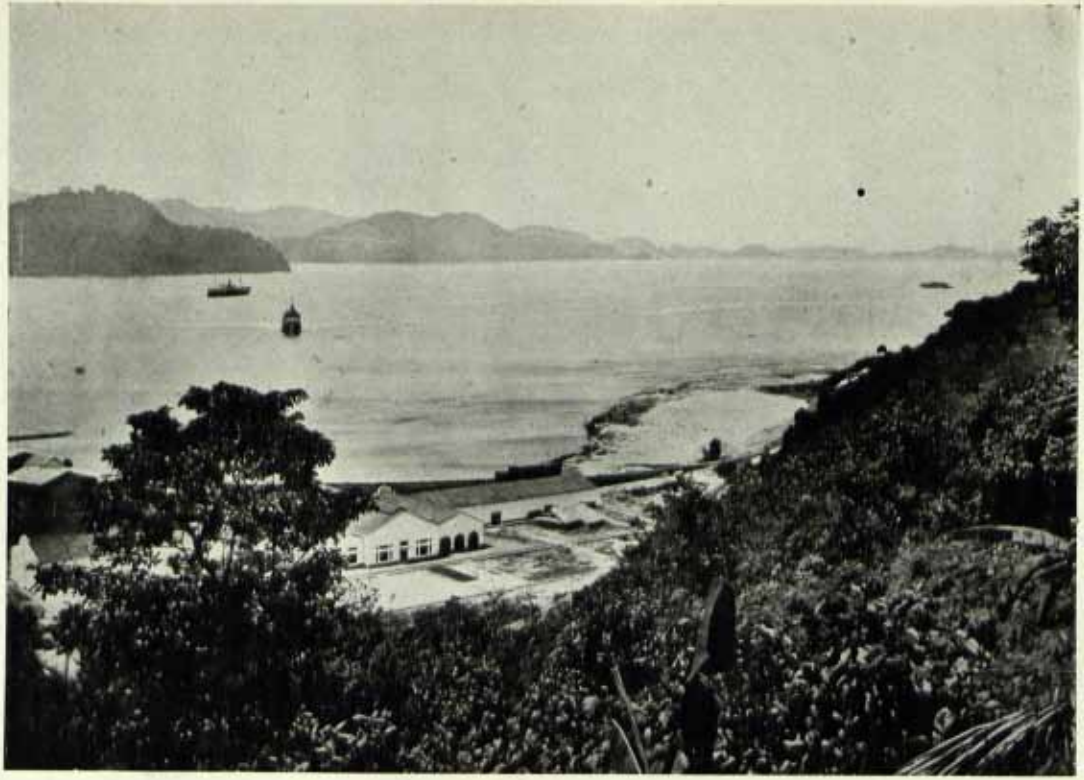


Plate 27. Emmahaven and Koninginne bay

Looking south from Emmahaven, the harbours and quays of which lie beyond the left hand edge of the picture. In the middle distance is Oedjoeng Batoemandi, the end of a long promontory which separates Koninginne and Boengoes bays. Emmahaven is the fourth port of Sumatra, after Belawan, Palembang and Teloekbetoeng; its wharves can accommodate vessels of 7 to 11 m. (23–36 ft.) draught. For location see Fig. 56.

well inland. The chief bay in the southern part of this section is Taroesan bay, protected by Poelau Tjoebadak, an island rising to 230 m. (755 ft.); and there are other rocky and reef-fringed islands off the coast.

At the northern end of this rocky stretch are two other important bays, Boengoes bay, with several villages on its shores, connected by the main road, and Koninginne bay. The latter contains one of the few important harbours in western Sumatra, Emmahaven, the port of Padang. The bay has steep, forested and reef-fringed shores (Plate 27), and the port lies on its north-western side, thus sheltered from the westerly monsoon by the headland of Oedjoeng Joengoet Batoe Pati; the shelter is increased by a breakwater. The quays have railway connection to Padang and to the Padangsche Bovenlanden (highlands), which are the source of agricultural and forest produce and of coal from the state-owned Oembilin mines.

The last outpost of the volcanic rocks which make this rugged coastline is Goenoeng Padang (322 m.) with its offshoot Apenberg or 'monkey mountain', (108 m.) below which sprawls the town of Padang. The Batang Arau, navigable for small craft, flows at the foot of these two hills; along it extends the old quarter of the town; the European quarter lies further north. Padang is the capital of the West Coast Residency, and the chief town in western Sumatra. The railway and a main road run northwards into the highlands; another road runs eastwards across the Soebang pass (*c.* 1,500 m.) to the longitudinal valley at Solok and thence to the eastern side of the country.

(iv) *Padang to Airbangis bay*

At Padang the coast changes abruptly, and for the next 170 km. is generally low and flat, sandy and covered with casuarinas and coconuts, and backed by an alluvial plain of variable width. There are a number of small coral islets, overgrown with coconuts, off the coast, and the 'barrier reef' which roughly follows the 100 fm. line curves westwards to the Batoe islands, 120 km. (75 miles) WSW of Airbangis.

Between Padang and Pariaman, 45 km. (28 miles) to the northwest, there is a coastal plain, populated and cultivated. Pariaman is on a branch of the railway; the main line runs inland to the Anai valley and Padangpandjang. From Pariaman to Tikoe, there is really no plain. A succession of hill-spurs from the volcanic mountains around lake Manindjau comes down to the shore; the spurs are

separated by small stream valleys. The Pariaman branch railway continues along the shore to Soengailimau, and a road parallels it, continuing, through a number of small coastal villages, to Tikoe, where it turns inland to the highlands.

At Tikoe the flat alluvial plain reappears, for the most part densely forested and swampy, and almost uninhabited. It extends in a great embayment up the Batang Masang, and then maintains a fairly constant width of about 12–15 km. Several large streams cross the plain, coming from the mountains around Goenoeng Talakmau ('Mt Ophir'); all have deltas which form slight projections on an otherwise smooth coast. The only road across the plain runs inland from Sasak; it crosses the western range to the longitudinal valley, where it meets the main highland road which runs from Sibolga to Fort de Kock.

(v) *Airbangis bay to Baroes*

This section of coast contains two large bays, and for the rest consists of a low shore backed by hills with only a very narrow coastal plain. Coastal coral reefs are of frequent occurrence, especially bordering the headlands; the 'barrier reef' previously mentioned, after its excursion across to the Batoe islands, lies between 50 and 65 km. (30 and 40 miles) offshore. It contains numerous islets and drying rocks; about the latitude of Baroes it swings westwards again to the Banjak islands.

Airbangis and Tapanoeli bays owe their origin and striking scenery to the existence of offshoots or detached portions of the main Barisan ranges which have been invaded by the sea. Airbangis bay is a broad, south-facing indentation, with high and rocky headlands on the west and east, and a low, sandy beach at the head. The town of Airbangis lies at the mouth of the Air Bangis, on the eastern side of the bay between two hills. A road runs inland across the plain, joining the road from Sasak before crossing the highlands.

Beyond Airbangis bay the coast continues rocky and indented, maintaining a general westerly direction as far as the twin headlands of Oedjoeng Biang and Oedjoeng Toean, where it turns sharply northwards. For the next 65 km. (40 miles), as far as Taboejoeng, it comprises a succession of broad, shallow, sandy bays separated by headlands. The headlands, which are reef-fringed, are due to the existence of a number of isolated hills, rising to heights of 100–300 m., just behind the coast, which interrupt the continuity of the marshy

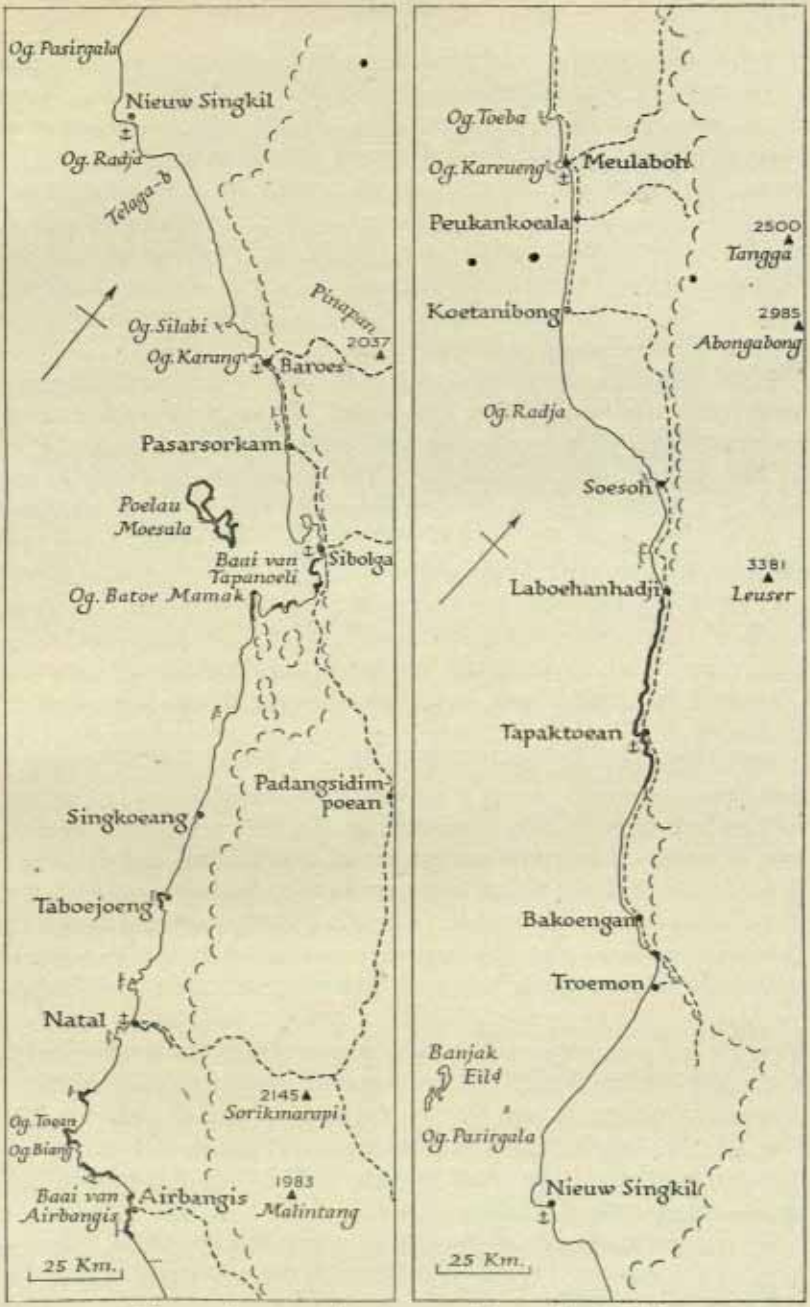


Fig. 57. Sumatra: the west coast, Tapanoeli and Atjeh
For location, sources and key see Figs. 49 and 50.

alluvial plain. The bays are all exposed to the westerly monsoon and swell, and offer little in the way of shelter or landing facilities. There are numerous settlements on the shores of the bays, though few on the plain behind; some of the river mouths are navigable for native craft. The chief town is Natal, at the mouth of the Batang Natal, which is navigable for about 33 km. to Tapoes. It is a small administrative centre, and has a road running inland, crossing the western Barisan range at the foot of Sorikmarapi volcano, to the main highland road in the longitudinal valley. Natal roadstead is a very poor anchorage, shoaly and exposed.

North of Taboejoeng, which lies at the foot of the headland of the same name, the coastal plain narrows, and although there are no more coastal hills forming headlands, the foothills of the mountains begin to rise within a few kilometres of the shore, receding only in the vicinity of a few of the larger streams, such as the Batang Singkoeang (which is navigable for boats). The shore is sandy, and frequently there are tree-covered dunes backed by marsh. There are few villages, and no means of access inland. Eventually, some 85 km. (53 miles) north of Taboejoeng, one of the foothill ranges runs out to sea in the high cape known as Oedjoeng Batoe Mamak. Beyond this cape lies Tapanoeli bay, the largest indentation on the whole west coast of Sumatra.

Tapanoeli bay has been compared to Rio de Janeiro in scenic grandeur. It owes its variety of scenery to the variable character of the rocks which form its hilly surroundings. Tertiary sediments, volcanic tuff, Palaeozoic slates, and granite are all to be found, and where the harder rocks run out to sea there are headlands, separated by bays. The entrance to the bay is 16 km. (10 miles) across, between Oedjoeng Batoe Mamak and Og. Kariang; it broadens to 24 km. (15 miles) behind these two capes. The whole bay is sheltered by Poelau Moesala (or Mansalar), a rugged island lying about 13 km. (8 miles) offshore. Moesala has precipitous cliffs, fringed by reefs; in the interior, peaks rise to 400–500 m. Within the bay there are numerous reefs and islets. The surroundings of the bay are high, hilly and densely wooded (Fig. 58); the beach itself is frequently low and sandy, with occasional mangrove swamps; the most notable cliff is Og. Kaboen on the south-eastern side of the bay.

On the northern side of the bay is a further indentation, Sibolga bay, on the eastern shore of which stands the administrative centre and small port of Sibolga. Two main roads lead inland: one crosses the granite highlands to the Batak plateau at Taroetoeng, leading

thence via the shore of lake Toba to Medan in the east coast plantation area; the other runs south-eastwards, skirting the shores of the bay and then running inland to Padangsidimpoean, where the highland road begins which follows the longitudinal valley in the Barisan mountains to Fort de Kock.

Fig. 58. Tapanoeli bay
View looking southwards across the bay from above Sibolga. The road from Taroetoeng can be seen winding down the hillside to Sibolga, which lies just off the picture to the right. Two islands appear on the right, and in the distance is the south-western extremity of the bay, Oedjoeng Batoe Mamak (Fig. 57).
Drawn from a photograph.

Beyond Og. Kariang the coast resumes its general SE–NW direction. The shore is low, wooded and shelving, and the coastal plain is narrow and sparsely populated. From Pasarsorkam to Baroes a road runs along the coast; it arrives at the former locality from Sibolga, and at the latter place turns inland, climbing steeply up the forested mountain range which borders the Batak plateau. Baroes roadstead is sheltered by a long spit, Og. Karang, which sticks out like a jetty; the small town lies at the mouth of a river, where landing can be effected.

(vi) *Baroes to Troemon*

For about 140 km. (87 miles) beyond Baroes the coast is low, featureless, densely wooded, mainly by casuarinas, and backed by a wide and swampy alluvial plain. Between Baroes and Telaga bay this plain is under 10 km. wide, but thereafter it broadens to about 30 km. closing in again to nothing just beyond Troemon.

About 10 km. (6 miles) west of Baroes is Tapoes roadstead, similar in character, protected by another spit, Og. Silabi; here also are anchorage and landing facilities, but no means of access to the interior. From Og. Silabi to Telaga bay the shore is almost straight, featureless and uninhabited; there are numerous coconut-covered islets lying offshore. Westwards of Telaga bay lies a large area of swamp, built up by the enormous deposits of silt brought down by the Simpang river, the only really large river on the western side of Sumatra, one branch of which (the Simpang-kiri—or left-hand branch, looking upstream) originates in the Alas country, far to the north, the other (the Simpang-kanan—or right-hand branch) in the Batak highlands to the east. The river is of no use to shipping, but is navigable for some distance inland by native boats. Just east of the mouth, on the northern side of a lagoon which is fronted by an extending mud-bank, is the small town of Nieuw Singkil. There is no road to the interior.

West of the Simpang mouth, the coast, still low and overgrown, turns northwards. A string of islets and shoals extends westwards to the Banjak islands from Oedjoeng Pasir Gala, beyond which the coast extends, sandy, featureless and covered with casuarinas, to Troemon.

(vii) *Troemon to Soesoh*

A few kilometres beyond Troemon the foothills of the mountains reach the coast, which then resumes its normal SE–NW direction for some 130 km. (80 miles) to Soesoh. Along the whole stretch, though at a varying distance from the shore, is a road, which links Troemon with Soesoh and so with Meulaboh and Koetaradja. The mountains behind the foothills are wild and almost uninhabited.

From the bend in the coast to Soeakbakoeng, at the mouth of the Kroeëng Kloeët, there is a narrow coastal plain, on which the chief village is Bakoengan. Thenceforward the plain almost fades out, and from just beyond Koetaseuneuboh the coast becomes steep and rocky, with frequent high cliffs separated by small bays, and many offshore reefs, as far as Laboehanhadji. The northern and southern portions of this section are mostly of limestone, but in the middle, from Tapaktoean to Sawang, the headlands are of granite. Tapaktoean bay, surrounded by high, rocky and wooded shores, offers anchorage; the small town is an administrative centre on the coastal road.

At Laboehanhadji the coast once more becomes low, as the hills recede leaving a narrow plain, which extends northwards to Soesoh.

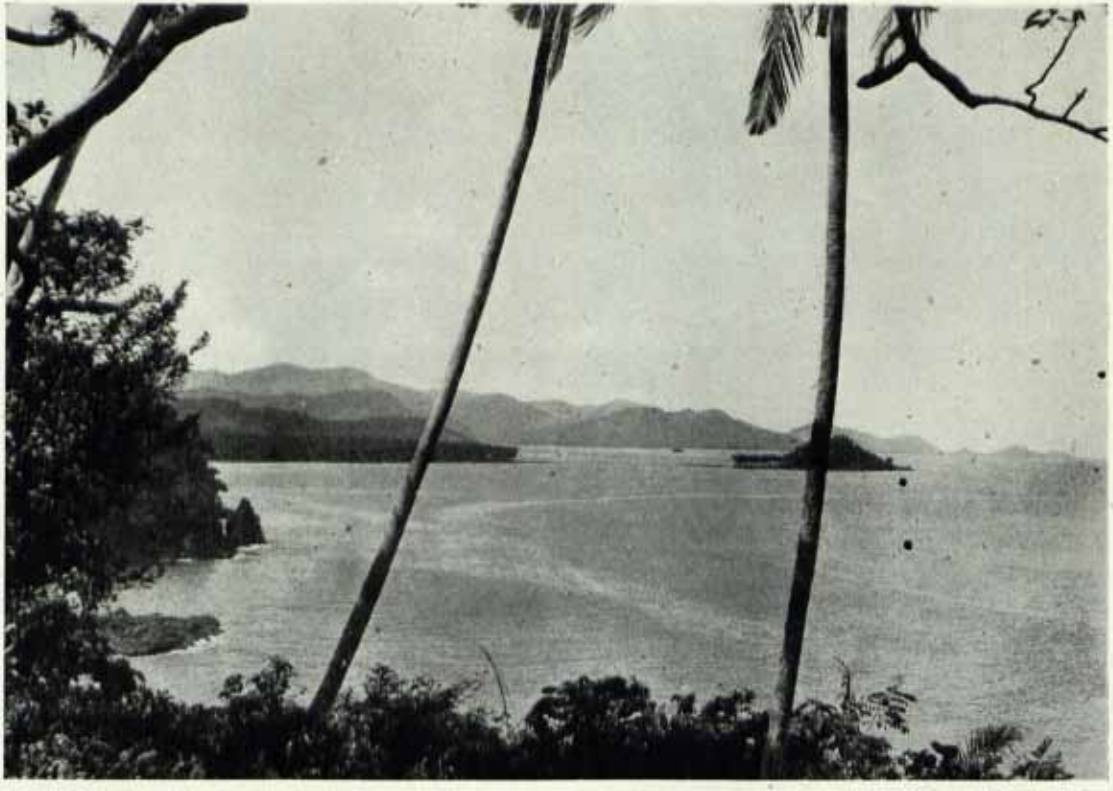


Plate 28. Padang bay

Padang bay lies between Emmahaven and Padang. This view looks south-eastwards across the bay to the hills which border Koninginne and Boengoes bays.

Plate 29. Sabang, Poelau We
General view of the port, looking south-westwards across Sabang bay and Lhok Perialakot to the north-western peninsula of We island. Sabang is an important re-fuelling port, with an annual shipping tonnage as great as that of Palembang. The coaling quays and a floating dock can be seen in the photograph.

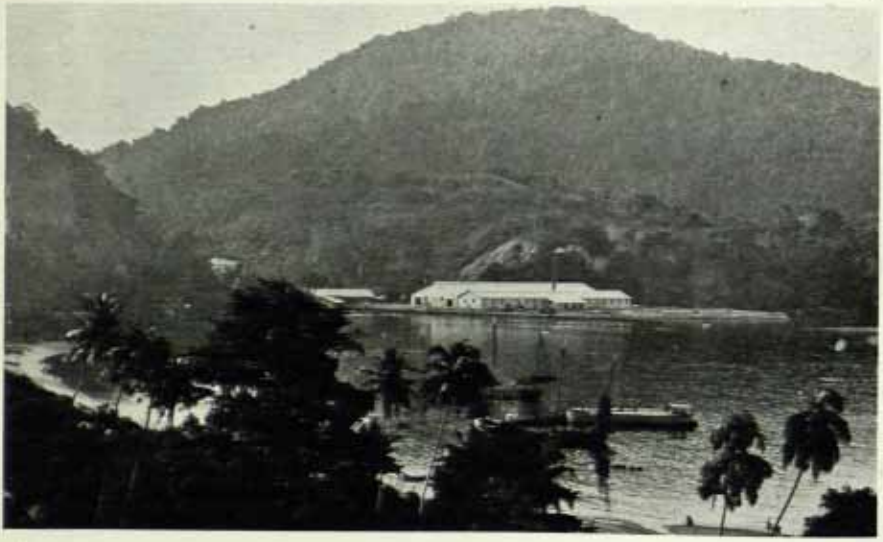


Plate 30. Tea-chest factory at Sabang
The factory is situated at the eastern end of Sabang bay.

This village has road connection with the main coastal road of western Atjeh. West of the village is a roadstead which affords protection from north-westerly winds. There are some reefs and shoals off the shore around the great bight in the vicinity of Soesoh and further west.

(viii) *Soesoh to Tjalang*

The wide alluvial plain which extends behind the coast from Soesoh to Tjalang, a distance of 170 km. (105 miles), resembles the Troemon–Singkil plain. It is low and swampy, rather sparsely populated except for a number of coastal villages, and varies in width between 15 and 25 km. Instead of having one main river, however, it has numerous streams, some of considerable size, which flow south-westwards from the tangled ranges of the Atjeh mountains. Some of these, e.g. the Kroeëng Meureubo, Kr. Tripa and Kr. Kloeët, are navigable for native boats right across the plain, but the bars at their mouths prevent easy access from the sea, and the danger is increased during the south-west monsoon. The shore for most of the distance is sandy, and covered with casuarinas.

At Soesoh the coast turns westwards to Oedjoeng Radja, a low, sandy point, and then resumes its normal SE–NW trend, with very few recognizable features except the muddy river mouths. The main road runs inland at Soesoh, avoiding the extensive swamp behind Og. Radja; it returns to the shore at Koetanibong, near the northern of the two mouths of the Kroeëng Tripa, one of the largest rivers in Atjeh, and then follows the shore closely all the way to Tjalang. At the mouth of the Kr. Seunagan is the village of Peukankoeala, from which a road leads inland, following the river across the plain to the foothills. The chief town and administrative centre on this part of the coast is Meulaboh, situated on the western side of a small bay near the mouth of the Kr. Meureubo, and slightly protected by a low, reef-fringed headland called Oedjoeng Kareueng. Apart from the coastal road, Meulaboh is the terminus of the only motor road which crosses the Atjeh mountains; this runs across the plain, following the Kr. Meureubo, and then strikes northwards, reaching the north coast at Sigli.

Between Meulaboh and Lhokboeboen, 14 km. (9 miles) to the north-west, the coast is swampy, and a dense, low scrub replaces the fringe of casuarinas. The village and anchorage of Lhokboeboen closely resemble Meulaboh; a small bay, with the village on its western

side, is protected by a low, reef-fringed headland, covered with coconuts, called Oedjoeng Toeba. Beyond Og. Toeba the coast is almost straight to Tjalang; it is low, with a sandy beach covered with casuarinas and backed by denser forest. The road runs along the coast linking the villages which mostly lie at or near the river-mouths.

(ix) *Tjalang to Koningspunt.*

In this section, the north-western extremity of Sumatra, the mountains of Atjeh reach the sea and provide the boldest and most rugged stretch of coastline in the whole island, covering a distance of about 110 km. (70 miles). The structure-lines of the mountains are not quite parallel with the general direction of the coast, and as a result there are many imposing headlands where the more resistant rocks run out to sea, separated by sandy bays. These bays offer little security however; they are exposed to the south-westerly monsoon and to the heavy ocean swell, which also makes landing difficult; coral reefs are also frequently present. From Tjalang to Lam Beusoe bay the coastal hills are made of Tertiary rocks, mostly sandstones, and only rarely are elevations of more than 200 m. (650 ft.) found close to the shore. The northern section, however, is composed of Palaeozoic rocks, mainly hard and resistant limestones, and in consequence the coastal scenery is bolder. A road runs the whole way along the coast, keeping close to the shore as far as this is physically possible.

Tjalang bay is protected from the west by a hilly peninsula which ends in Oedjoeng Tjalang and is projected out to sea in a series of reefs and wooded islets known as the Pasi islands. The village and tiny port lie on the western side of the bay, in the shelter of the hills. Immediately north of the peninsula is Rigaih bay, much larger but rather shallow, having several islands, and exposed to the south-west. From here to Lam Beusoe bay there is a succession of small bays, sometimes backed by coastal plains and by the swampy lower courses of torrential rivers, separated by rocky and wooded headlands. There are numerous coastal villages, from some of which roads lead inland into the foothills; the chief is Lhokkroeët, on the south-eastern side of Raja bay. This bay, sheltered from the south-west by Poelau Raja, a wooded island about 100 m. high, is the best anchorage on this part of the coast.

Lam Beusoe lies at the mouth of the Kroeëng Lam Beusoe, on the northern side of the bay of the same name; the river mouth, which is navigable for boats for a short distance, forms a convenient landing-place. Northwards from here the coast becomes higher and the bays

generally smaller, as far as Kroeëng Raba bay, behind which the mountains, now reduced to one narrow range, are temporarily broken, thus giving a passage to the coastal road from the village of Lhoknga across to Koetaradja. Between Kroeëng Raba bay and Koningspunt, the north-western corner of Sumatra, the mountain range drops steeply to the shore.

BIBLIOGRAPHICAL NOTE

There is virtually nothing in the English language on the physical geography of Sumatra, and very little on any other aspects of the island and its people. A rapidly increasing amount of geological literature is becoming available in Dutch, especially on the southern part, whilst there are several substantial works in Dutch and German on cultural anthropology, particularly on the Atjeh region and the western islands (for details of the latter see vol. II of this Handbook).

A useful general source in French, is O. J. A. Collet, *Terres et peuples de Sumatra* (Amsterdam, 1925).

Chapter III

ISLANDS ADJACENT TO SUMATRA*

Islands off the north-west coast: Islands off the west coast: Islands off the east coast

ISLANDS OFF THE NORTH-WEST COAST

The structural features of north-western Atjeh are continued beyond the mainland. The longitudinal valley of the Kroeëng Atjeh is continued seawards as Bengalen Passage. The main axial range which ends in the cliffs of Koningspunt and Atjeh Hoofd is continued in a series of islands, of which the largest are Poelau Breuëh and Poelau Peunasoë. The Goudberg volcanic range reappears beyond Malaka Passage in Poelau We (Fig. 59).

The islands of the western group are for the most part rugged, and built of old rocks similar to those of the adjacent mainland.

Poelau Breuëh (also known as Lam Poejang after its chief village) has a hilly interior, rising to 700 m. (2,297 ft.) in Goenoeng Tjoemo; its shores are generally steep and rocky, except for a strip along the south coast and a few sandy bays on the west. There is a line of villages, with rice-fields, coconut and other plantations (including pepper) on the southern coastal strip, and a few hamlets at the head of the bays.

Poelau Peunasoë (or *P. Deudab*) is somewhat similar, but its highlands are peripheral rather than central, rising to 320 m. (1,050 ft.) in the south-west and to 228 m. in a ridge running NW–SE, parallel to the east coast, which is generally steep and rocky. In the centre is a long flat alluvial plain, clearly a silted-up arm of the sea, covered with rice-fields and pepper plantations, and ending against the sand dunes of Lhok Aloeë Rieëung in a swamp-edged lagoon. Apart from the villages on this plain the chief settlements are on the narrow west coast plain and in the south-east.

The other islands of the western group are much smaller and are uninhabited.

* In these descriptions altitudes of summits are given as on Dutch maps. British Admiralty Chart figures are almost always greater than these, since they represent tree-top heights as seen from the sea, whereas Dutch maps quote ground level. Differences may be as much as 50 m. or more in some cases where high rainforest is present.

Poelau We

Poelau We is 17 km. (11 miles) from the mainland of Sumatra at its nearest point, across Malaka Passage. It is composed of volcanic rock, and volcanic activity is not entirely extinct; there is a solfatara and some sulphur deposits. It is shaped rather like a reversed N, with

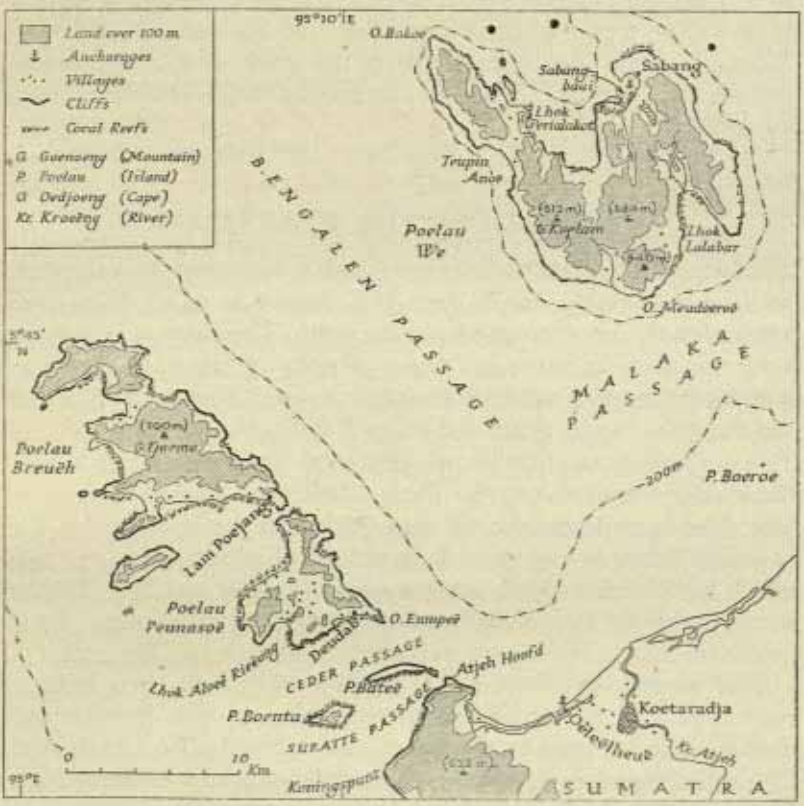


Fig. 59. Islands off north-western Sumatra

Based on Admiralty Chart No. 3869; North Sumatra 1 : 40,000, sheets iii B, and iv A (G.S.G.S. series 4293) and *Atlas van Tropisch Nederland*, plate 12 b. (Batavia, 1938).

parallel east and west coasts running NW–SE and two large bays, one in the north and another in the south-east. There are several bold highlands, the highest summit reaching 615 m. (2,018 ft.) in Goenoeng Koelam, in the south-west; apart from the cultivated areas at low level round the villages, which are mainly on or near the coast, the whole island is richly forested. The north-western peninsula is steep and

rocky as is the whole of the west coast except for the sandy bay of Teupin Anoë. Beyond the high southern point of the island, Oedjoeng Meudoeroë, is a deep and reef-fringed bay, Lhok Lalabar, with a plain at its head on which stands Blangkoeala and other villages, from which a road runs northwards to Sabang. The east coast also rises steeply behind a narrow coastal strip. The great northern bay is known in its southern part as Lhok Perialakot, and the eastern extension as Sabang bay. On the northern side of the latter, sheltered from wind and sea at all seasons, is the port and coaling station of Sabang (Plates 29 and 30).

ISLANDS OFF THE WEST COAST

The long line of islands off the west coast is separated from the mainland by a channel, usually deep and varying in width from about 130 km. in the north to 90 km. in the south. The channel is well over 1,000 m. deep in parts, but the continuity of the deep sections is interrupted by two submarine platforms, each covered by less than 100 fm. (200 m.) of water and fringed with a 'barrier reef' of coral. The northernmost of these two platforms bears the Banjak islands; the southern runs out to the Batoe islands and carries Poelau Pini. The islands and groups are separated from each other by deep channels. Little is known of their geological affinities, but the areas which have been mapped would appear to consist mainly of Tertiary strata, including some volcanics and a great deal of limestone. Earthquake shocks are of frequent occurrence (cf. p 18 and Fig. 10).

The islands are all of rather rugged relief, and their indented coast-lines are reef-fringed and, especially on the western side, continuously battered by the heavy surf of the Indian Ocean swell. The difficulty of navigating these tempestuous seas in flimsy boats has accentuated the isolation of the islands; this isolation has rendered the native peoples of exceptional anthropological interest (see vol. II, chap. I).

SIMEULOEË

Simeuloeë, which covers 1,783 sq. km., has its longer axis, 100 km. (62 miles) in length, running NW–SE; its breadth varies between 15 and 30 km. (9 and 19 miles). It has a hilly and densely forested interior, and a very broken and indented coastline, the greater part of

which is fringed with coconut groves and bordered by coral reefs, with numerous off-lying islets. The hills reach the coast in the rocky north-western end of the island, from which a ridge of varying altitude, rising in places to more than 300 m. extends south-eastwards for some 50 km. (30 miles), with occasional lateral spurs stretching coastwards. This ridge then expands into a hill-mass stretching from coast to coast and culminating in the summits of Delok Sibau, 576 m. (1,890 ft.), near the north-east coast, and Delok Sialoe, 486 m., in the centre. The south-eastern end of the island is also hilly, but lower. Narrow plains occur along much of the coast, running inland for short distances up the small river valleys, the largest of which is the Lajambaoeng, in the north-east. Some of the plains are marshy and have a coastal fringe of mangroves; the largest is in the Salang district, in the north-west, about 17 km. long and averaging 5 km. in width.

The west coast is for the most part low, with a sandy beach backed by dunes covered with coconuts, but the swell renders access difficult. The east coast is more readily approachable, and is indented by three large bays, each with a comparatively narrow entrance and a large expanse of sheltered water behind. The northernmost is Loegoe Sibigoe, with the village of Sibigo on its south-eastern shore. Almost exactly in the centre of the coastline is Telok (or Lhok) Dalam, the largest of the three, with an irregular marshy shore and the village of Oeroeng at the south-western end. The southern bay is Sinabang bay, a very fine harbour, the entrance to which is well sheltered by low coral-fringed islands; on its western shore is the village of Sinabang, the largest settlement and chief port on the island.

The abundant rainfall produces a dense forest cover in which huge specimens of *Shorea*, a large dipterocarp, commonly reach 50–60 m. (160–200 ft.) high. An attempt was made a few decades ago to work the timber commercially, and sawmills, fed with tree-trunks by aerial ropeways or by tramways, were established, as at Sinabang for example, but the venture failed. The forests shelter herds of buffalo and wild boar—the English sailors' name for Simeuloeë is 'hog-island'. The human population numbers about 4,000.

Simeuloeë rests on a platform, broadest off the western shore and extending also to the north-west and south-east, which carries a number of small islands, mostly coral-fringed and covered with coconuts. To the north-west is the Sa Laoet (or Kokos) group, one of which is inhabited and cultivated. To the south-east, lying half-way between Simeuloeë and the Banjak islands, are Babi and Lassia, both low, sandy, coral-fringed and covered with coconuts.

The Banjak Islands

The native name means 'many' or 'numerous'; actually there are sixty-seven islands and islets, most of which are very small. The three largest are Toeangkoe, Bangkaroe and Oedjoeng Batoe, all hilly and forested, with a few native villages. The remainder, many of which are simply reefs only just awash and supporting perhaps a tree or two, are for the most part low, built of sand and coral and covered with coconuts or low scrub.

The largest and centrally placed island is Toeangkoe, which is high in the north—reaching 313 m. (1,027 ft.) in Tioesa—and lower in the south. Its shore is low for the most part, and overgrown, except for one or two headlands in the north and at the southern extremity; it is fringed almost the whole way round with coral reefs. South-west of Toeangkoe is Bangkaroe, which is hilly in the north and south and lower in the centre. The coast is generally steeper than on Toeangkoe, but the shore of Telok Brassi (Chameleon bay) on the east coast, is fringed with mangroves. This island too is ringed by an almost unbroken coral reef. North-east of Toeangkoe is a complex group of islets and shoals and reefs, beyond which lies the long hilly island Oedjoeng Batoe. The submarine platform on which the Banjak islands rest is joined on the north-east to the shelf which fringes Sumatra.

Nias

Nias is the largest of the west Sumatran islands; it covers nearly 4,200 sq. km., and supports a population of 200,000. Like other islands in the series, it is roughly rectangular in shape, with a length of 125 km. (75 miles) and a width averaging nearly 40 km. (25 miles). Geologically the greater part of the island is composed of marly slates and crystalline limestones, mostly of Upper Tertiary age, but there is a narrow central core of Lower Tertiary rocks, mainly volcanic. The whole island is of rather rugged relief, and the hills, which reach a maximum elevation of 886 m. (2,907 ft.) in Goenoeng Lelematsjoea, are orderless, with narrow marshy valleys and tabular limestone plateaux. The hydrographic pattern is also complex and apart from a few major streams which follow devious courses to the sea there is a labyrinth of small streams dissecting the periphery of the hill-mass.

The hill slopes are forested, where not cultivated, and native shifting cultivation has produced considerable expanses of secondary forest and bush in which a few large trees remain. The chief wild animals are large herds of deer.

Although Nias is predominantly hilly, the hills only reach the coast at the southern end and in the north-western and north-eastern corners whilst the large eastern bulge of the island is low, alluvial and marshy, as also is the shore in the north-west on either side of the mouth of the Ië Moezoj. For the most part the shore consists of sandy beaches, sometimes covered with casuarinas and nearly always backed by miles and miles of coconut groves, especially in the east and south. There are many small bays round the coast, but no large indentations like those on Simeuloeë. The largest is Lagoendi bay on the south coast, but the most important is the roadstead of Goenoengsitoli. The anchorage here is indifferent, but the town is the headquarters of a Dutch official and the port is regularly visited by K.P.M. vessels.

Batoe Islands

The Batoe islands are about fifty in number, lying about half-way between Nias and Siberoet and on the edge of a shelf which projects westwards from the Sumatran coast. The main group consists of two large islands and several dozen small ones. Tanahmasa rises to 204 m. (669 ft.) and Tanahbala to 270 m. (886 ft.). The whole group is hilly, covered with verdant forest, surrounded by coral reefs and fringed with coconuts. The islands are sparsely populated and only Sigata and Telo—two of the smaller ones—have any commercial significance. The small port of Poelautelo deals in coconut products and timber.

North-east of the main group is Poelau Pini, densely wooded and with few inhabitants.

The Mentawai Islands

Siberoet, Sipora, Noord-Pagai and Zuid-Pagai, with about a hundred smaller islands, are collectively known as the Mentawai islands. Only the four large islands and a few of the smaller ones are inhabited. The population, which is autochthonous and quite unlike the Sumatran mainland people in language, customs and appearance, is primitive and scattered in small villages. It probably numbers some 15,000.

The islands are hilly, with maximum elevations of 300–400 m. (1,000–1,300 ft.), but the shores are generally low. The western coasts have sandy beaches and a fringe of coral reefs; they are battered by heavy swell and surf and are almost unapproachable. The eastern shores are less exposed to the ocean and the west monsoon, but are open to the east monsoon; they are generally unhealthy with frequent mangrove swamps, and river mouths fringed with sago palms.

The islands are densely forested; the fauna includes herds of deer and monkeys, also crocodiles and many kinds of snakes. The coastal peoples reap rich harvests of crabs at certain times of the year.

The administrative centre of the group, which belongs to the Sumatra's Westkust Residency, is Moearasiberoet, on a bay in south-eastern Siberoet.

Enggano

Some 300 km. (180 miles) to the south-east of Zuid-Pagai lies the lonely outpost of Enggano, or Talandjang, about 50 sq. km. in area. The western part of the island is fairly low, with hills of marl and clay; the centre and east is higher, rising to 280 m. (922 ft.), with limestone hills and some caves. The whole island is densely forested and somewhat unhealthy; there are many wild pigs. The coast is for the most part clad in vegetation, with frequent coconut palms, but there are some sandy beaches. Coral reefs and the ocean swell make landing impossible except at a very few places.

The people are ethnographically distinct, and very primitive; they live for the most part in the more sheltered eastern part of the island. The administrative centre is the tiny islet of Doea, one of three which lie at the entrance to Enggano bay, on the eastern side of the island.

ISLANDS OFF THE EAST COAST

The low 'amphibious' islands bordering the middle east coast of Sumatra have been dealt with as part of the mainland (p. 93). The other islands lying east of Sumatra, in the South China Sea, belong geologically to Malaya rather than to Sumatra, consisting as they do for the most part of Triassic sandstone with granite intrusions and deposits of tin. The Riouw and Lingga archipelagoes are the drowned remnants of a former southward continuation of the Malay Peninsula. Further to the south-east, resting on the shelf which links Sumatra and Borneo and separates the South China and Java Seas, are the much larger islands of Bangka and Billiton—commonly known as the 'tin islands'.

Riouw Archipelago

The Riouw archipelago (Fig. 60, also Figs. 44 and 45) lies south of Singapore and east of the mouth of the Sumatran river Kampar. It comprises the large islands Bintan and Batam, between which is Riouw strait, and a large number of smaller islands, islets and reefs.

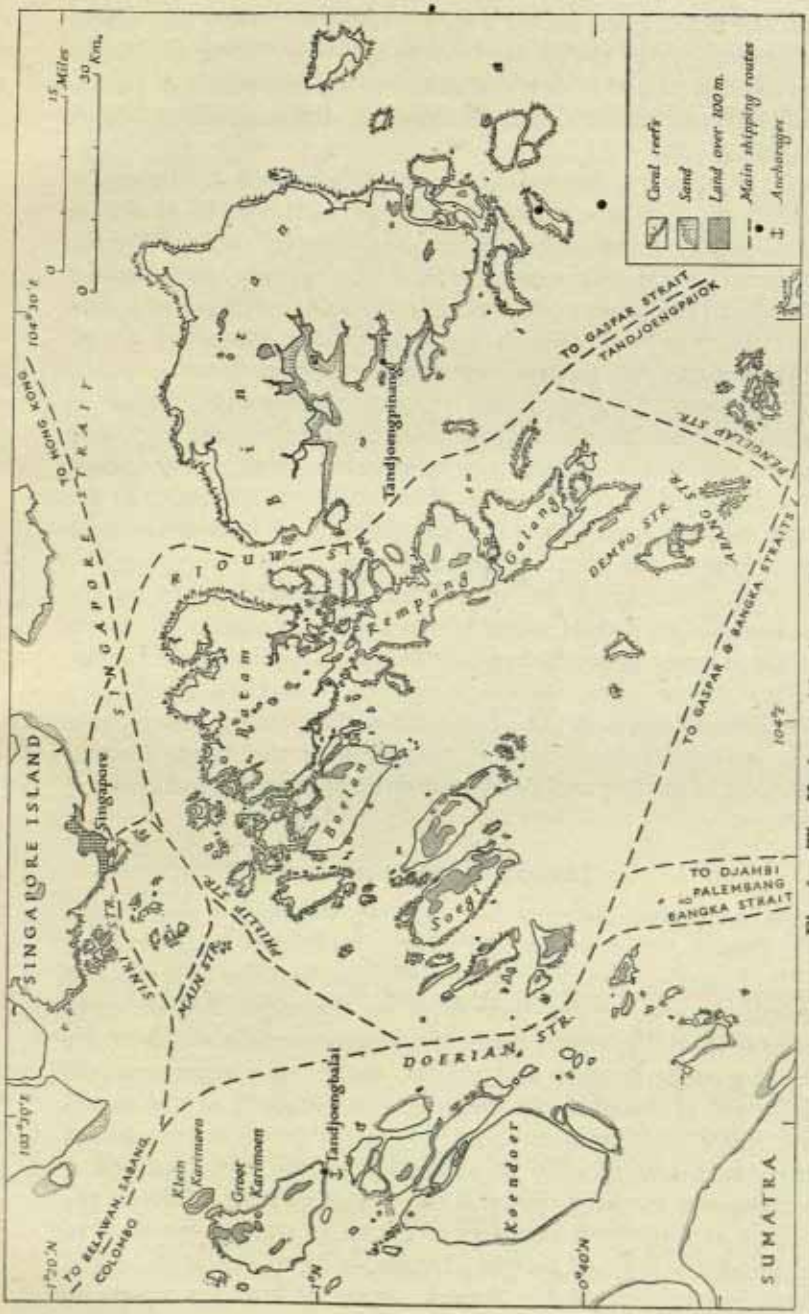


Fig. 60. The Karimoen islands and Riouw archipelago

The map shows the multitude of reef-fringed and sand-fringed islands, and the main shipping routes through them, comprising the approaches to Singapore and the main routes between Malacca strait, the Far East and Java. Based on Sumatra 1:250,000 sheet 13 (G.S.G.S. series 4197) and Admiralty Chart No. 2757; and on information in the *Eastern Archipelago Pilot*, vol. 4 (London, 1939).

On the whole the relief is undulating, though only in a few places are elevations of over 150 m. (500 ft.) to be found. Groot Karimoen has a summit of 580 m. (1,900 ft.), however, and Bintan one of 360 m. (1,180 ft.) The coasts are extremely irregular, and most of the islands have fringing reefs.

Riouw strait forms the main channel of approach to Singapore from the south. It is safe, sheltered and easily navigable by all classes of vessels. On its eastern shore, on the south-western coast of Bintan, is the port of Tandjoengpinang (population *c.* 4,300), the capital of the Residency of Riouw en Onderhoorigheden (Riouw and Dependencies). The roadstead is used by vessels exceeding 3·7 m. (12 ft.) in draught; the pierhead has a depth of 2·7 m. (9 ft.).

Further west, Doerian strait, between the granite island of Koendoer and the Doerian islands, offers another passage leading to Singapore, also available for all classes of vessels. North of Koendoer island and its satellites is Groot Karimoen, low and swampy at the southern end and mountainous in the north. Near its south-eastern extremity is the small port of Tandjoengbalai.

The Riouw islands are well populated. The total in 1930 for the Riouw and Lingga groups together was 135,000, a density of twelve per sq. km. The inhabitants are mainly Malays, Boeginese and Chinese, with a few natives. The Chinese are mostly cultivators, the Malays and Boeginese fishermen. The chief cultivation product for export is gambir, an extract derived from the leaves of the shrub *Uncaria gambir*, used in tanning and the manufacture of dyestuffs and chewing mixture.

Lingga Archipelago

There is no natural dividing line between the Riouw and Lingga islands, though for convenience, Pengelap strait may be regarded as one. The Lingga group (Fig. 61, also Figs. 44, 45) lies to the east of the deltaic mouths of the Inderagiri; on the south Berhala strait separates it from Tg. Djaboeng on the Sumatra mainland. There are two large islands, Singkep and Lingga, and many smaller ones, all of which are surrounded by offshore reefs. Singkep, at the south-western end of the group, is about 32 km. (20 miles) in both length and breadth, though it is by no means square, for large bays indent its northern and southern coasts. It has a range of granite hills on the east, rising in Goenoeng Landjoet to 475 m. (1,558 ft.) but most of the remainder is low and marshy. Lingga, lying to the north-east of Singkep, is very irregularly shaped, about 56 km. (35 miles) in

length from north-west to south-east. The eastern part of the island, formed of Triassic sandstone, is mostly low lying, with several large coastal indentations, but there are hills in the north, and the western

Fig. 61. The Lingga archipelago

The uplands and mountains are of old volcanic rock and granite (see Fig. 44). Based on Sumatra 1 : 250,000 (G.S.G.S. 4197), sheets 13 and 17; and Admiralty Chart 2757.

bulge is mountainous, due to the resistance of a large mass of Carbo-Permian volcanic rocks with an intrusion of granite on its western side. Goenoeng Daik (Piek van Lingga) rises with a sharp double peak to 1,163 m. (3,816 ft.). The other islands of the archipelago, of which the largest are Sebangka, Bakoeng, Temiang and Selajar, are also hilly, though elevations of more than 150 m. (500 ft.) are few.

The coasts of the Lingga islands are deeply indented by many shallow bays, bordered by rocky headlands. The seaward approach to the coast is difficult owing to the extensive shoals and coral reefs. The main shipping routes to and from Singapore pass to the east of the archipelago (the outer route), or else through Berhala strait (the inner route), but Temiang and Pengelap straits are also used.

The principal ports in the archipelago are Penoeba and Kotadabok. Penoeba lies on the island of Selajar, between Singkep and Lingga, sheltered by Penoeba islet. It has a small pier and is the administrative centre of the group. Kotadabok (or Dabo) is on the eastern side of Singkep. It has a long pier fitted with railway tracks, which serves for the transport of the tin ore which is obtained from the edges of the granite hills referred to above.

Apart from this tin mining the main activities on the islands, which are less densely peopled than the Riouw group, are agriculture and forestry. As in the Riouw islands, the Chinese are the cultivators of pepper, gambir and sago, and are also traders; the Malays and Boeginese are fishermen and boatbuilders. There are some sawmills and a small export of timber and charcoal.

Bangka

The island of Bangka (Fig. 62, also Figs. 46, 47) is separated from Sumatra by Bangka strait which is the main shipping route for vessels proceeding from Soenda strait to Singapore. It is one of the most important of the smaller islands of the Netherlands Indies on account of its rich tin resources. It is about 185 km. (115 miles) long from north-west to south-east and has an area of about 11,340 sq. km. (4,430 sq. miles). It is largely composed of undulating hilly country rising to a maximum elevation of 692 m. (2,270 ft.) in the north. A large part of the island is covered with tropical jungle, though the original forest covering has almost entirely disappeared as a result of mining and agricultural operations. Geologically, Bangka resembles Malaya, being built of Triassic sandstones and slate, with granite intrusions; the granite outcrops form most of the high ground,

making irregular groups of small hills and short ridges. Most of the rivers, the chief of which are the Antan, Lajang, Djering and Bangkakola, flow through deeply cut valleys in their upper courses and form extensive marshes near their mouths. This peculiarity is clearly connected with the Pleistocene history of the Soenda Shelf (see p. 12 and Fig. 6). The steep upper courses were initiated when the shelf was dry land; the flooding of the shelf at the end of the Ice Age raised the base-level of the rivers and so caused extensive alluviation in their lower courses.

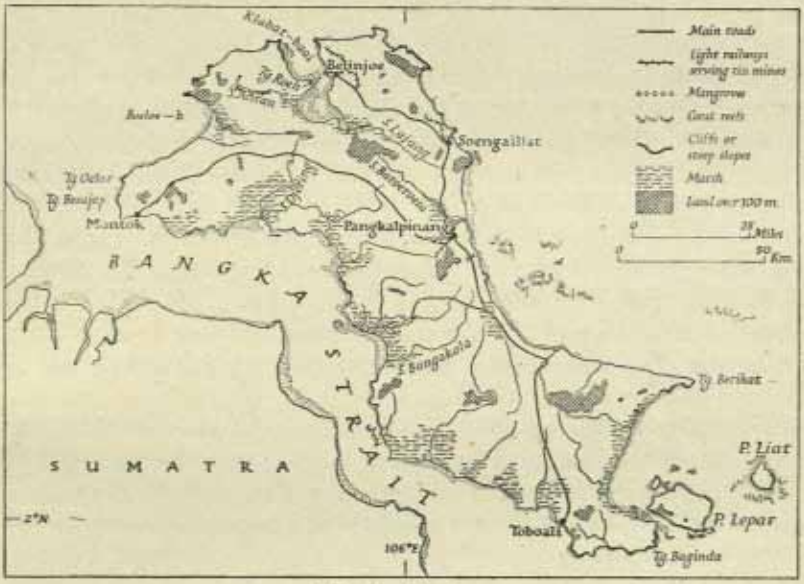


Fig. 62. Bangka

The hills are mostly of granite or Triassic rocks (Fig. 46).
Source: Sumatra 1 : 250,000 (G.S.G.S. 4197), sheet 22; Bangka 1 : 150,000 (in 4 sheets); and Admiralty Chart 2149.

The coasts of Bangka are low-lying and frequently marshy, though there are several high rocky points where the hills reach the sea. Reefs and shoals lie offshore in many places. Tg. Besajap and Tg. Oelar, both of which rise to over 50 m. (150 ft.) above sea level, form the most westerly point of the island and mark the northern entrance to Bangka strait. North-east of these headlands are the two large bays of Kampa (Boeloe) and Klabat. Kampa bay is nearly 30 km. (20 miles) wide and has a smooth shoreline broken only by the mouths of several streams of which the Soengai Kampa is the largest. Anchorage may

be obtained off the mouth of this river in a depth of 9·1 m. (5 fm.). Klabat bay is a large inlet extending in a north-south direction for about 32 km., and divided into an outer and inner section by the low, granite promontory of Tg. Roeh. Sandy beaches with blocks of granite are found near the entrance to the bay while at its head are low, muddy shores covered with mangroves. The outer bay is very shallow except in its eastern part where there is a channel with a minimum depth of 5·9 m. (3¼ fm.). This channel leads to the sheltered roadstead near the mining settlement of Belinjoe at the entrance to the inner bay; anchorage may be obtained here in depths of from 5·5–11 m. (3–5 fm.). Several rivers flow into the head of the bay, the largest being the Soengai Lajang. Along the eastern coasts of Bangka there are no deep indentations and the shores are difficult to approach owing to the numerous rocky islets, banks and reefs a short distance out to sea. Off the village of Soengailiat a channel through the reef gives access to an anchorage in a depth of 6·9 m. (3¾ fm.). Further south three channels lead through these dangerous waters to the roadstead at the mouth of Soengai Marawang (Soengai Batoeroesa) close to the important settlement of Pangkalpinang, the capital of the island. This roadstead has the disadvantage of being open to both monsoons. The west coast of the island, bordering Bangka strait, is low and considerable stretches are marshy, like the shores of Sumatra which they face; the two chief settlements are at Tobiali and Muntok. The latter is the chief port for communication with the mainland.

The population of Bangka numbers about 115,000 of whom some 43,000 are Chinese and the remainder mostly natives (derived mainly from the Palembang district of Sumatra) and immigrant Malays. The Chinese in this case are mostly engaged in the tin mining, which is the most important economic activity. The open-cast tin workings are situated round the edges of some of the granite outcrops; several of them are served by light railways running to the nearest port. Agriculture on Bangka is relatively poor, for the sandstone and granite do not yield very productive soils; there is some cultivation of pepper and gambir.

Apart from the light railways Bangka has several fairly good roads, the best ones linking the three principal towns of Pangkalpinang, Muntok and Belinjoe.

Billiton

Billiton (Fig. 63) lies about 90 km. (55 miles) east of Bangka across the island-studded Gaspar strait. It is roughly square in shape,

about 90 km. (55 miles) long and 70 km. (43 miles) wide and covering an area of 4,595 sq. km. (1,160 sq. miles). In its relief and geology it resembles Bangka. It is mostly either flat or gently undulating, with several summits rising to over 300 m. (1,000 ft.), and a maximum elevation of 510 m. (1,673 ft.) in the double-peaked Tadjam. The rocks are Triassic sandstone and slate, with granite intrusions, the latter occupying a large area in the north-west with smaller patches in the south-west, south-east and north-east corners of the island. As on Bangka, secondary forest covers much of the surface, but there are treeless plains in the centre, covered with *alang-alang* grass. The rivers mostly radiate from the centre of the island; they generally have sand bars at the mouth and are of little use for navigation. In the

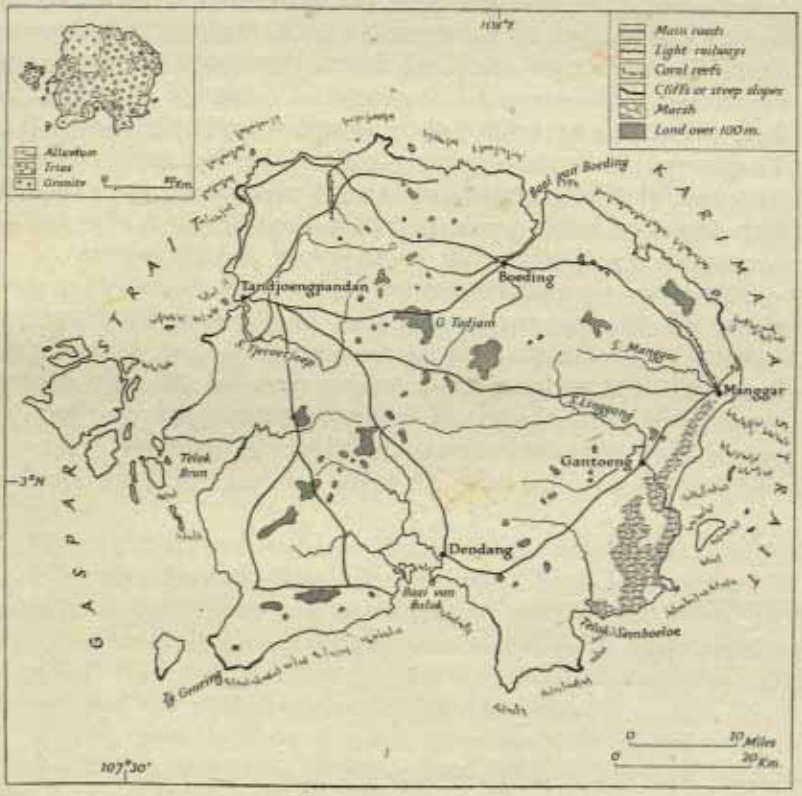


Fig. 63. Billiton

General map to show relief, geology, coasts and communications.
Source: Billiton 1 : 200,000 (copied as G.S.G.S. 4264); Admiralty Chart 2137, 2160; geological inset from *Atlas van Tropisch Nederland*, plate 11 (Batavia, 1938).

south-eastern part of the island, between Manggar and Telok Semboeloe, is a large area of swampy lowland, separated from the sea by a belt of sand dunes.

The coasts of Billiton are generally low and densely wooded, with innumerable rocky islets and coral reefs offshore. There are steep slopes in the stretches where the granite outcrops approach the coast, notably in the south-west and north-west. The only large bays are clearly drowned river mouths; thus Balok bay on the south coast somewhat resembles Klabat bay in Bangka. On the north coast is Boeding bay, the mouth of the Soengai Boeding, and on the west coast is Telok Bran, the funnel shaped mouth of the Soengai Sapal. Boeding and Balok bays offer anchorage in a depth of about 7·3 m. (4 fm.). On the eastern side are open roadsteads with anchorages in about 5·4 m. (3 fm.), off the entrances to the Manggar and Linggang rivers. Small craft can reach the tin mining centres of Manggar on the Soengai Manggar and Gantoeng on the Soengai Linggang. On the western side of Billiton there is anchorage in the roadstead of Tandjoengpandan, close to the mouth of the Soengai Tjeroetjoep. The port of Tandjoengpandan (12,000 inhabitants) has two piers with depths of about 3·7 m. (2 fm.) at their heads; it is in regular steamer communication with Java, Borneo and Singapore.

Billiton has a population numbering about 58,000, of whom some 20,000 are Chinese, the latter mainly employed in the tin mining industry. As in Bangka, and for the same reason, agriculture is not important. The working of tin ore has provided the main impetus towards the establishment of internal communications. There are several fairly good roads and a number of light railways.

Chapter IV

JAVA AND MADOERA

Introduction: Physical Features: Regional Description: Coasts: Animal Life: Madoera: Bibliographical Note.

INTRODUCTION

The island of Java, with its satellite Madoera, forms the economic and administrative core of the Netherlands Indies. It is smaller than Sumatra, and its geographical make-up is simpler, but a combination of three factors—a volcanic soil, a tropical monsoon climate, and the beneficient influence of the Dutch—has been responsible for a seven-fold multiplication of its population in little more than a century, from 6 millions in 1813 to 42 millions in 1930.

Java covers an area of 125,625 sq. km. It is 1,000 km. (620 miles) in length, with its longer axis running slightly south of east, so that its north-western corner, St. Nicolaaspunt, is in latitude 5° 52′ s, and its south-eastern corner, Tandjoeng Bantenan, is 8° 49′ s. Its breadth varies between 88 km. and 195 km., and it is divisible roughly into four rectangular sections, the first from Soenda strait to Cheribon, roughly 320 km. × 150 km., the second—the 'waist'—from Cheribon to Semarang, roughly 220 km. × 100 km., the third from Semarang to Madoera strait, roughly 270 km. × 180 km., and the fourth at the eastern end, roughly 180 km. × 90 km. The fourth division once probably resembled the third, but the formation of Madoera strait severed it into two parts, of which the northern is now the island of Madoera.

For administrative purposes Java is divided into three provinces and two native principalities. The province of West-Java corresponds almost exactly with the western rectangular section; that of Oost-Java is almost coincident with the two eastern divisions, while Midden-Java and the native states of Jogjakarta and Soerakarta occupy the 'waist' and the western part of the third rectangle.

Broadly speaking there are only three elements in the relief of Java: first the volcanoes, covering about 28% of the land surface, secondly the Neogene (Upper Tertiary) sediments, covering 38% of the surface, and lastly the Quaternary and Recent deposits—composed very largely of volcanic debris—occupying 33%. The volcanoes form the island's backbone, and in the eastern two-thirds there is on an

average one 'vertebra'—in the shape of a volcanic cone or caldera—every 50 km.; in the west the volcanic belt is broader and the cones are even more closely spaced.

PHYSICAL FEATURES

Geological History

It is impossible to reconstruct the geological history of Java as far back as that of Sumatra, for example, for almost the entire island is composed of rocks of Tertiary and Quaternary ages, and there is no evidence to show what conditions prevailed in times previous to the Cretaceous period.

Only three small areas are known to be formed of pre-Tertiary rocks, and in each of these the rocks are highly folded and metamorphosed, so that their exact age is difficult to determine. In the Loekolo region, east of Banjoemas, there are schists and gneisses, slates and limestones; other occurrences of schist are in the Djiwo hills, east of Jogjakarta, and on the southern side of Wijnkoops bay, in the south-west. In all three areas the metamorphic rocks are bordered by small outcrops of folded sediments—sands, marls and limestones—which can be proved by their fossil content to be of Palaeogene (Lower Tertiary) age. The metamorphosis of the older rocks is possibly of late Cretaceous age, but the folding of the Palaeogene rocks must obviously have occurred during one or other of the two great Tertiary periods of mountain-building and volcanicity (cf. p. 11 and Fig. 5). Of the latter there is far more abundant evidence.

The first great episode of folding and volcanic activity took place probably during what in Europe would be called the Miocene period, i.e. Middle Tertiary. Huge volcanic piles must have been built up, but then as now erosion was very powerful, and the debris was dissipated into the surrounding seas, so that little evidence remains of the site of the craters. Considerable thicknesses of sedimentary rocks accumulated during the late Tertiary (Neogene) period. In the south these sediments were largely derived from volcanic lavas and ashes; they comprise tuffs and volcanic sands, with occasional lavas; locally, but especially in the eastern half of Java, limestones are well developed. In northern Java the lower part of the Neogene formations contains no volcanic material at all, and the limestones and marls, with local lignites and oil deposits, were derived from the continental land to the north. The higher beds however contain an increasing proportion

of volcanic debris. The renewed attachment of Java to the continent of Asia during this period permitted the migration of vertebrate animals, including prehistoric man, into the region; evidence of the latter has been provided by the discovery of fossil bones—the famous 'Java man' (*Homo soloensis*)—in the Solo valley of East Java, in fluviatile deposits of late Pliocene age.

At the end of the Tertiary era, or at the beginning of the Pleistocene, the volcanic activity, which had never completely died down, burst forth again with renewed vigour, accompanied by strong folding movements. The present line of volcanoes was initiated at this time, and the relatively soft Neogene sediments were bent up into folds and sometimes fractured. In the north the folding was not intense, and gentle upfolds and downfolds occur, oriented east-west; in the centre the folding is sharper, and trends more north-west to south-east, while the present south coast of Java is in effect a gigantic faultline scarp, a great fracture line with a subsidence on its southern side.

The rapid erosion of the growing volcanoes soon produced a considerable fringe of muddy deposits, especially on the northern side of the line of cones, where the land of the Soenda Shelf had been flooded once more as a result of the melting of the Pleistocene polar ice-caps. Renewed uplift of Java however converted this fringe into dry land, and the increased erosion which this uplift entailed initiated the formation of a second fringe. The present northern plains of Java thus consist of two roughly parallel belts, an older one, sometimes referred to as 'Quaternary terraces', at higher elevation, on the south, nearest the mountains, and a more recent one, little above sea level, and still extending rapidly in places, nearest the coast. In the interior, the accumulation of volcanic debris sometimes dammed the drainage of large areas, and lake basins resulted, such as those which now form the upland plains of Bandoeng, Garoet and Banjoemas.

Physical Characteristics

The three main geological formations give rise to more than three main types of landscape, for the Neogene rocks are of varying lithology, the volcanoes are in various stages of growth and decrepitude, and the Quaternary deposits are at varying levels.

Neogene rocks are found at elevations varying from sea level to just over 1,300 m. (4,400 ft.). There is a strong contrast between the maturely-dissected landscape of the rocks (mainly marls) derived from volcanic debris and the 'karst' of the limestone areas. 'Karst' is a

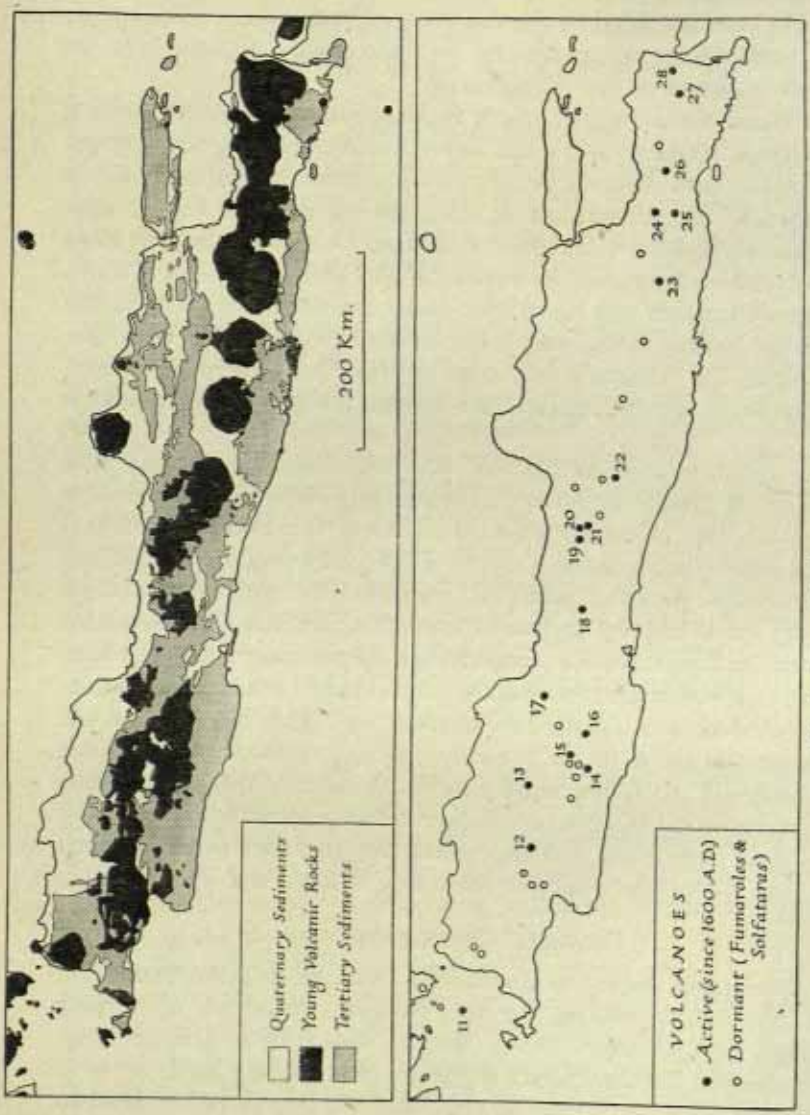


Fig. 64. Java: Geology and volcanoes

Isolated areas of volcanic rocks in areas without active or dormant volcanoes are for the most part relics of pre-Quaternary eruptions. For key to numbers of active cones see p. 22. The tiny areas of pre-Tertiary rocks have been omitted; see Figs. 67 and 70.
Based on *Atlas van Tropisch Nederland*, plates 5 and 15 (Batavia, 1938).

general name given to the almost waterless land surface which develops on thick, porous limestone formations. Despite the heavy rainfall, there is little surface water, for the drainage is mostly by underground channels. The surface is often pot-holed with large and small sinks, down which the water drains. The barrenness of the landscape is accentuated in eastern Java by the drought of the east monsoon season. The best example of karst landscape is in the Duizend-gebergte (thousand hills) or Goenoeng Sewoe, in southern Jogjakarta; but there are other occurrences further east, in the Blambangan peninsula and in Madoera. The mature landscape developed on the marls, with abundant surface water and rapid erosion, is exemplified especially in southern Preanger, south of the volcanic mountains.

The scenery of the volcanic rocks dominates Java. It is seldom possible to obtain a long distance view which does not include at least one volcanic cone. The volcanic phenomena of several of the active ones have already been described in Chapter 1 (pp. 27–37 and Figs. 15–24) and further general details are given in the physical description which follows, so that little else needs to be added here. It may be useful however to convey some idea of the form and size of the volcanic mountains.

A relief of extreme youth characterizes most of the volcanic region, though some of the older parts—the relics of the Late Tertiary cones and the extinct Quaternary ones—have a more maturely-dissected appearance. Whereas the Tertiary remains now attain no greater elevation than 1,900 m. (6,200 ft.), there are forty-five recent cones attaining summit levels of between 2,000 and 3,000 m. (roughly 6,500 to 10,000 ft.), and fourteen rising to more than 3,000 m. The highest of all are those that have preserved their original slender ash cone, with a small central crater—such as Semeroe (Mohomeroe) 3,676 m. (12,060 ft.) and Slamet 3,432 m. (11,260 ft.). Other lofty but less perfect cones are Tjareme, Soembing and Merapi. On the whole the single slender ash cone is a rarity; more frequently the top has been truncated by explosive eruptions, and commonly the volcano has two or more cones grown together—e.g. Gede–Pangrango, Lamongan–Taroeb (Plate 7) Ardjoeno–Welirang, Goentoer (near Garoet), and Lawoe. A further variety is provided by the gigantic caldera of eastern Java—Tengger, Ijang and Idjen.

Considering the narrow width of the island, it is clear that the slopes up to such heights must be very steep. Mohomeroe, in fact, is only 25 km. (15 miles) from the Indian Ocean; even at a regular slope

this would mean a gradient of 1 : 7, and the concavity of the actual slope means of course that a much steeper gradient is in fact found on the higher parts of the mountain. In general, the upper slopes of all the active volcanoes, particularly those which are devoid of vegetation, are as steep as the unconsolidated character of their ash and lava surfaces will permit. Such bare, steep slopes are very easily eroded by torrential rains, and ash cones especially are often highly sculptured by deep gullies (see Plate 8).

Each steep-sided cone stands on a very broad base, and the angle of slope decreases considerably towards the outer edge. Thus the larger cones and caldera have bases 30–50 km. in diameter, and the ratio of the height of the cone to its base is roughly 1 : 10 to 1 : 15 (e.g. Tjareme 1 : 9; Semeroe 1 : 10; Slamet 1 : 11½; Merapi 1 : 14; Lawoe 1 : 15). The older extinct masses are of course more worn down and less perfectly conical, and the ratio is thus lower; Moerjo, for example, is only 1,600 m. high on a 35 km. base—a ratio of 1 : 22.

Fig. 65. Java: rice-fields

This map should be compared with Figs. 64, 67 and 70.
Based on *Atlas van Tropisch Nederland*, plate 17 (Batavia, 1938).

A last essential element of the Javanese landscape, this time man-made, is the rice-field (Plates 31, 33, 36, 38, 42). Sawah (rice-fields) cover the greater part of all the lowlands, and spread in terraces up the slopes of the volcanic mountains (Fig. 65). The Tertiary rocks do not provide a rich enough soil to make elaborate terracing worth while, and these mountain and upland areas therefore create the major gaps in the map of rice-fields, together with the higher parts of the volcanoes.

Rivers

The drainage pattern and the position of the main watershed are shown on Fig. 66. It is noteworthy that in the two broad sections of

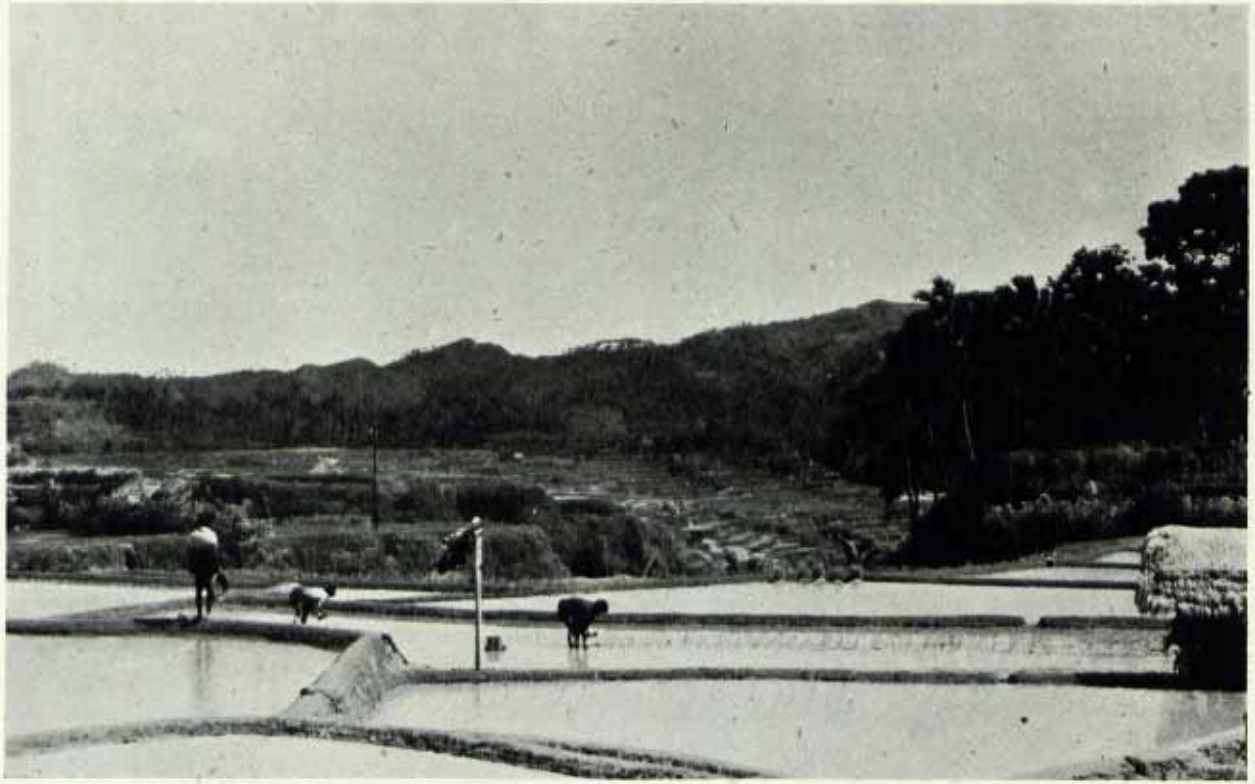


Plate 31. Rice-planting in the Garoet basin

These are 'sawah'—wet rice-fields, arranged in terraces constructed and maintained with infinite care, partly to enable the flooding to be carried out and partly to prevent the soil erosion which would otherwise inevitably occur on cultivated slopes under conditions of equatorial rainfall. For further examples of 'sawah' see Plates 33, 36, 38 and 42.

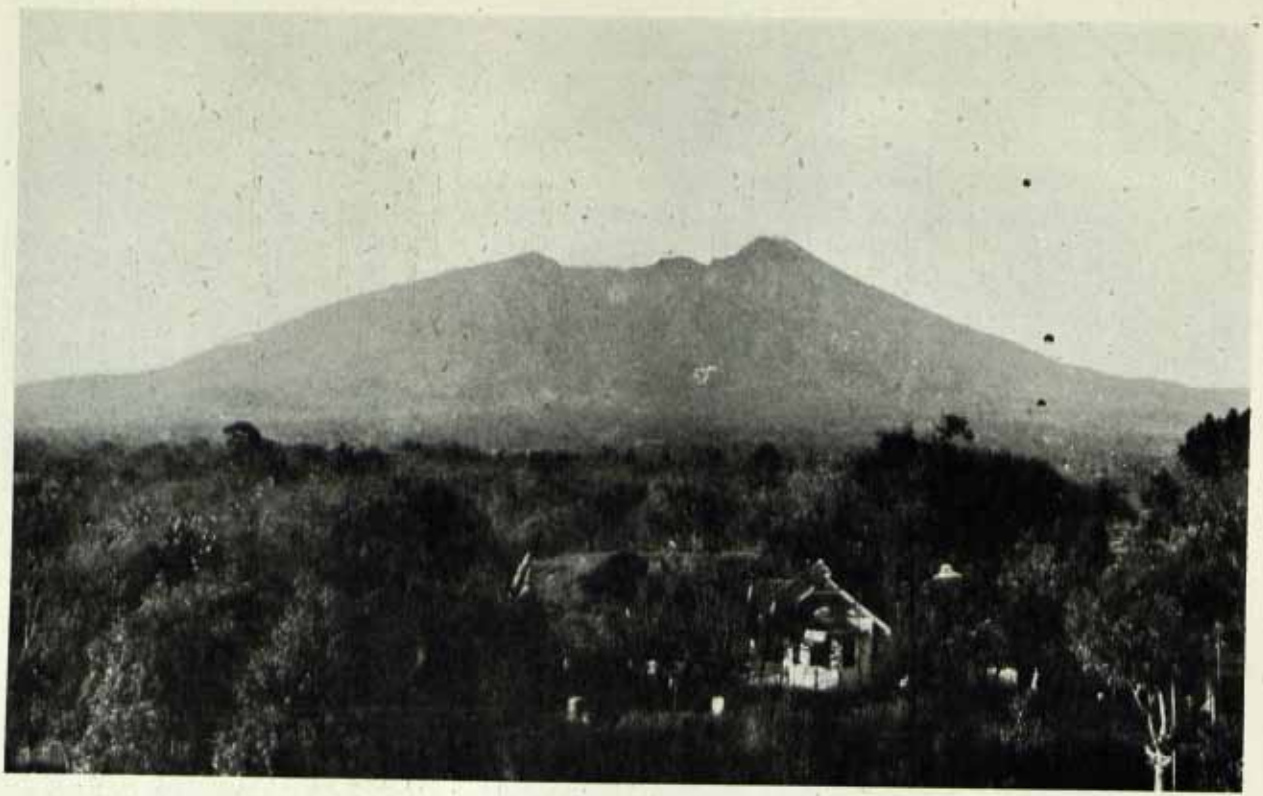


Plate 32. Goenoeng Salak

Salak (summit 2,211 m.—7,254 ft.) is a dormant volcano lying 15 km. S.SW of Buitenzorg. It is probably older than the active ash-cones; its summit has collapsed or been blown off, and its sides are more dissected and less steep than those for example of Slamet or Semeroe.

Fig. 66. Java: Drainage pattern
Based on *Atlas van Tropisch Nederland*, plates 20, 21, 22 (Batavia, 1938).

the island the divide between Java Sea and Indian Ocean drainage is much nearer to the latter than to the former, whereas in the two narrow portions it is more or less centrally placed. Actually about 63% of the land surface drains to the Java Sea, and 32% to the Indian Ocean, the remainder comprising the basins of small rivers entering Soenda and Bali straits.

The simplicity of the drainage pattern is interrupted by three main features. In the first place, the great volcanoes and caldera are characterized by innumerable streams which drain radially before being caught up into major rivers. Secondly, the existence of old Quaternary lake basins interferes with the symmetrical arrangement of streams flowing north and south; and thirdly the east–west orientation of the Tertiary fold-ranges of the north-east imparts a similar direction to the major rivers in that area.

In West-Java the largest rivers are the Tjitaroem and Tjimanoek (the prefix Tji means river). They both rise in the great volcanic group of which Papandajan is the centre, and both in their upper courses drain an old Quaternary lake basin, the Tjitaroem flowing across the Bandoeng basin and the Tjimanoek across the basin of Garoet. Both rivers are building extensive deltas. Each is useful for irrigation, and is also navigable for small native boats.

In the 'waist' of Midden-Java the major streams are naturally smaller. The largest in the north is the Kali Pemali, but there are several substantial rivers draining to the Indian Ocean, notably the Tjitandoej, which flows across one of the few swampy lowlands of southern Java, the Kali Serajoe which drains the Quaternary lake basin of Banjoemas, and the Kali Progo. The Tjitandoej is the only one which is navigable, and that only for a few kilometres from its mouth.

It is in the broader section of middle-east Java that rivers attain their maximum length and volume. The Bengawan (or Kali) Solo rises in the southern Tertiary range and has a course of well over 500 km., with a drainage basin covering 15,500 sq. km. It flows northwards across the Quaternary basin of Soerakarta, and then turns east, meandering considerably. Beyond Trinil (where the fossil man was found) it breaks through one of the east–west Tertiary ranges and then resumes its meandering easterly course, finally entering the Java Sea by an artificial channel which ends in the rapidly extending muddy projection of Oedjoeng Pangkah (Fig. 77). The Solo is navigable for small praus from its mouth to Soerakarta. The Kali Brantas has a peculiar course, only slightly shorter than the Solo. It rises in

the volcanic mountains north of Malang, flows southwards across the Quaternary basin of Malang, and then turns westwards between the southern limestone range and the foothills of the volcanic mass of Keloed and Boetak; it then turns north to follow the Quaternary basin of Kediri, and lastly curves eastwards to Madoera strait, which it enters by two widely separated mouths. It is thus perhaps unique in the world in following in turn each of the cardinal compass directions.

In the eastern rectangle of Java there are no large rivers, owing to the central position of the volcanic backbone and the well-marked dry season.

The volume of the Javanese rivers varies considerably according to the season. During the westerly monsoon, roughly from October to May, the rainfall is heavy, both in total amount and in individual storms, and this is especially so in the west. During this season therefore the rate of discharge is high, and floods are frequent, occasionally causing damage to engineering structures, irrigation works and agricultural land. In the period of the easterly monsoon, from May to September, when the rainfall, especially in eastern Java, is less, the rivers are naturally low. Most of the rivers are of a deep brown colour, owing to their mud content. The larger ones have a strong tendency to form relatively high strips, or natural levees, along their banks in their lower courses.

The erosive power of the rivers is considerable, as a result of the heavy rainfall and the predominantly soft and unconsolidated character of the volcanic debris in the mountain areas. The Solo, for example, has a length of only 560 km. compared with the 1,300 km. of the European river Rhine, yet its annual water discharge is eight times greater, and its mud content is sixty times greater than that of the Rhine. Rivers in many parts of the world discharge eroded debris equivalent to a lowering of the land surface over their catchment basins by under 0·05 mm. per annum, e.g. Thames 0·02 mm., Mississippi 0·06 mm. In Java however these figures are greatly exceeded: the Brantas records 0·31 mm., the Tjimanoek 0·4 mm., the Loesi 0·87 mm., and the Serajoe 1·6 mm., whilst in the case of some small torrential streams the rate of erosion may reach 2 mm. or even 3 mm. per annum. One small Javanese stream has recorded a denudation equal to 1 mm. in a single day—the equivalent of the work done by the French river Marne in 200 years!

The combination of soft rocks and heavy tropical rainfall thus produces a state of affairs which makes the land-forms of Java

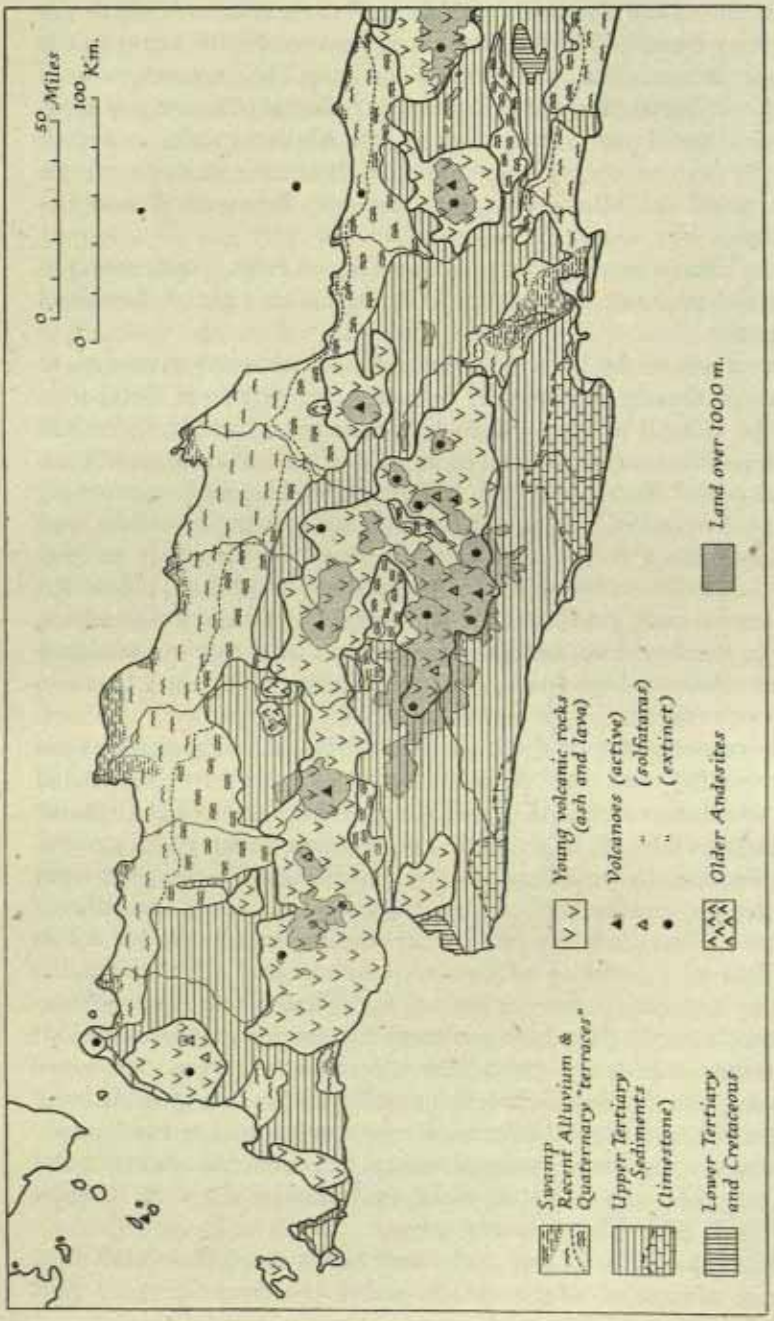


Fig. 67. Java: Western half

Simplified geological map, showing mountains over 1,000 m. and coastal swamps.
Based on Dutch 1 : M geological maps, International 1 : M series (G.S.G.S. 4204), and *Atlas van Tropisch Nederland*, plates 20 and 21 (Batavia, 1938).
See underline to Fig. 29 for further explanatory note.

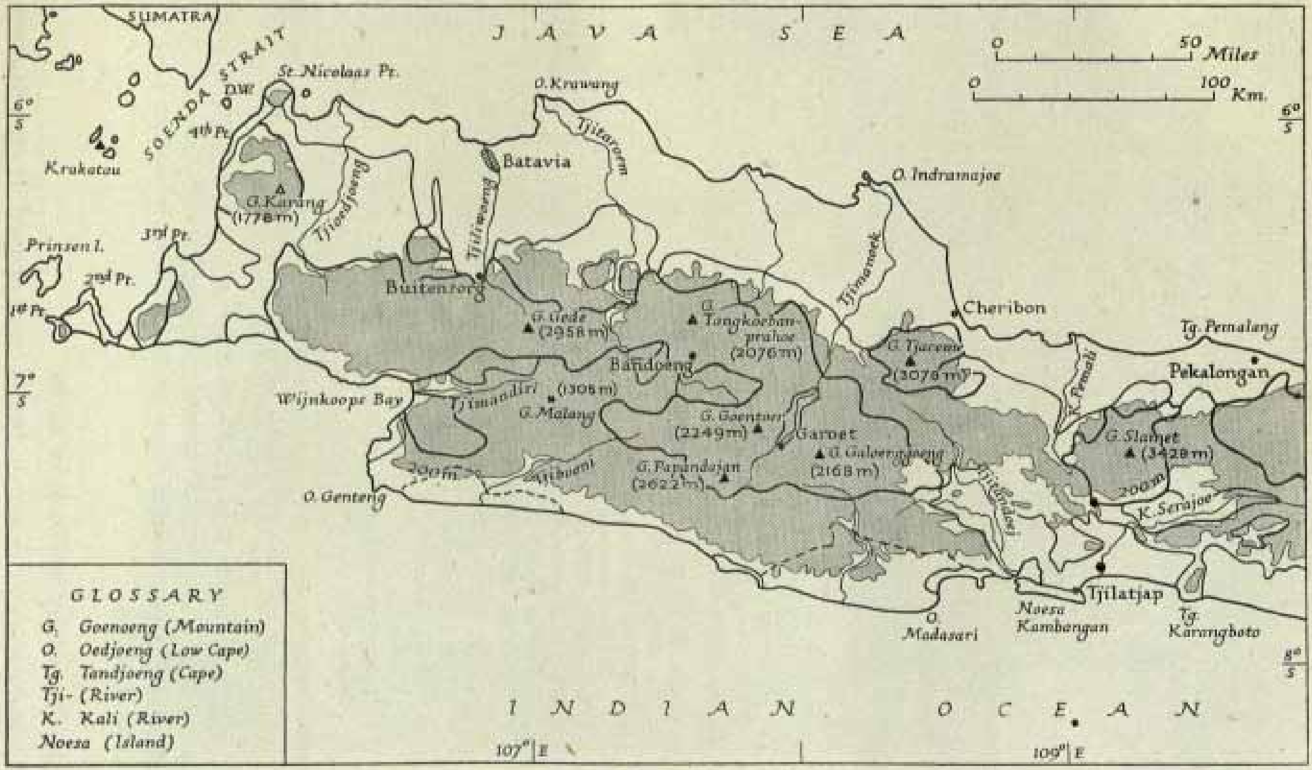


Fig. 68. Java: Western half

Key map to Fig. 66, showing land over 200 m. and chief physical features and towns. Mountain peaks shown by asterisks are non-volcanic.

amongst the least stable of the whole world. The Tertiary volcanoes have almost completely disappeared; the early Quaternary cones are mostly in ruins; some of the most recent ones are already badly cut up by erosion—and meanwhile the northern plains go on extending rapidly, perhaps by as much as 1 km. in ten years in the vicinity of the larger deltas (see p. 169, Fig. 75 and Plate 47).

* * *

REGIONAL DESCRIPTION

For purposes of description Java may be divided into the following sections:

West-Java:
- Volcanic mountains and included basins
- Neogene mountains and flanking uplands
- Coastal plains

Midden-Java:
- Tertiary mountains and volcanoes
- Banjoemas basin
- Northern coastal plain
- Southern coastal plain

Middle-East Java:
- Goenoeng Moerjo
- Northern limestone range
- Loesi-Solo depression
- Central Tertiary range
- Central Quaternary depression and inter-volcanic basins
- Volcanoes
- Southern Tertiary ranges and plateaux

Oost-Java:
- North coast plains
- Volcanic masses
- South coast plains
- Tertiary mountains
- Blambangan peninsula

West Java

All the major elements in Javanese relief are to be found in this western division—volcanic mountains, flanking highlands and plateaux of Neogene sedimentary rocks, Quaternary upland basins, and coastal plains.

Volcanic mountains and included basins

The main volcanic mountain belt is crook-shaped. It extends from

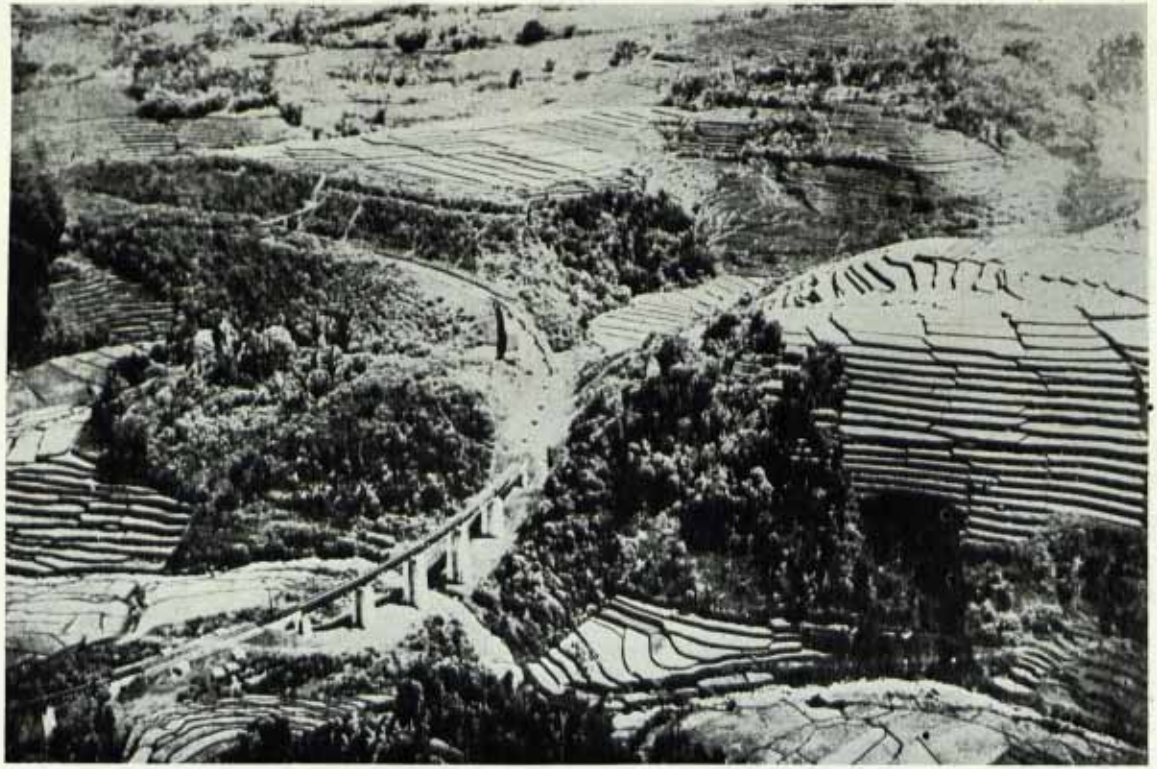


Plate 33. Railway and sawah near Padalarang

The railway is the Batavia–Bandoeng line, at the north-western end of the Bandoeng basin (see Fig. 69). The picture gives a good idea of the intensity of rice cultivation in Java; every possible patch, excluding only the steepest slopes, is utilized, where the fertility of the volcanic soils warrants the expenditure of such effort.

Plate 34. Tjibogo near Bandoeng

This photo shows the countryside near Lembang, at about 1,200 m., in the south-eastern foothills of Tangkoebanprahoe, 11 km. north of Bandoeng. The soft volcanic debris has been much cut into by streams rejuvenated as a result of the drainage of the Bandoeng lake basin. For location see Fig. 69.

the Bantam lowlands on the west to the head of the Tjitandoej lowland in the east, a distance of almost 300 km., and then curves back westwards for 100 km. as far as the extinct cone of Kendeng. Within the crook lie the upland basins of Garoet and Bandoeng. There are also several outlying portions of volcanic highland—individual cones or mountain masses—lying east and west of the main belt. To the east lies the almost perfect cone of Tjareme (3,078 m.), an active volcano which overlooks the plain of Cheribon from the south-west. To the west, several outposts of past and present volcanicity link the main Javanese volcanic belt with that of Sumatra. In Soenda strait are Prinsen-eiland (Poelau Panaitan) (summit 320 m.), and the Krakatau group (summit of Rakata 813 m.). On the mainland of Java there are four separate areas. In the south-west corner is Goenoeng Pajoeng (480 m.); on the eastern side of Welkomst bay rises a ridge, presenting a steep face to the west and culminating in G. Hondje (620 m.); this ridge continues northwards as a low swelling, ending in Batoe Hidoeng (275 m.). In western Bantam is a group of volcanic mountains, lying between Peper bay and Serang; the two highest summits, Karang (1,778 m.) and Peolasari (1,346 m.) are both dormant volcanoes. Finally, the north-western corner of Java is composed of a small volcanic mass, rising between Merak and Bantam bay; it has several peaks, the highest of which is G. Gede (595 m.). (Gede is a common mountain name, meaning simply 'great' or 'big'). The gap between the mountains of western Bantam and the Gede group gives passage to road and rail between Serang and the small ports of Merak and Anjer Lor on the coast of Soenda strait.

The main volcanic mountain belt presents more contrasts than any other part of Java. In the southern Bantam or Lebak mountains in the west it contains some of the wildest and most sparsely populated country, but further east there are several easily accessible 'tourist' volcanoes, and a dense population clusters about the richly cultivated lower slopes and over the enclosed basins. The mountains of the Lebak region are mainly built of volcanic brecchias; there are some extinct cones, the highest of which is Halimoen (1,929 m.) roughly in the centre of the mountain mass. Most of the higher parts are densely forested, and means of communication are scarce. There are tea and other plantations at lower altitudes. The mountains act as a watershed between southward drainage by short and swift streams to Wijnkoops bay, and northward drainage by longer rivers which cross the plains to the Java Sea. The eastern outpost of this

mountain region is Goenoeng Salak (2,211 m.), a dormant volcano (Plate 32).

Between the cones of Salak and Tangkoebanprahoe, about 95 km. to the east, the volcanic belt has been very severely eroded by the headstreams of three rivers, and its continuity has been broken by two 'gaps', the eastern of which is some 50 km. wide. Between the two breaches is a large double-peaked volcano; the higher of the two summits is Pangrango (3,019 m.—9,905 ft.), the other is Gede, only slightly lower, with a crater still on the 'active' list (see p. 22 and Fig. 64). Lying between Salak and the Gede–Pangrango mass is the Benda gap, only 530 m. (1,740 ft.) above sea level. The northern approach to this gap is formed by the head of the Tjisadane, the southern side by the Tjitjatih, a tributary of the Tjimandiri which flows into Wijnkoops bay. The gap carries the Buitenzorg–Bandoeng railway and a main road.

Eastwards of Gede, the headstreams of the Tjitaroem have completely broken down the volcanic belt. The erosive power of the river was no doubt considerably enhanced in the past by the drainage of the former lake in the basin of Bandoeng. Several tributaries from the west, rising on the flanks of Gede, drain the large Tjiandjoer trough, roughly 250–500 m. above sea level, which provides a routeway for the Buitenzorg–Bandoeng railway. The Tjitaroem itself rises in the volcano Kendang and flows SE–NW across the almost flat floor of the Bandoeng basin, 650–750 m. (*c.* 2,100–2,500 ft.) above sea level, before turning northwards and following a sinuous course through the volcanic belt and its flanking Neogene uplands to the northern plain. The main Batavia–Bandoeng railway does not follow the river, which is winding and often deeply incised; it takes a more easterly course via Poerwakarta, and joins the line from Buitenzorg at the north-western end of the Bandoeng plain (Plate 33).

The Bandoeng plain (Plate 34) is overlooked from the north by a caldera, the rim of which, broken on the southern side, is crowned by three cones, the highest being Tangkoebanprahoe (2,076 m.) (Fig. 15 and Plate 3). The volcanic mountain belt extending south-eastwards from this caldera to Goenoeng Sawal comprises a succession of large and imperfect extinct cones separated by wide gaps. Between Tangkoebanprahoe and Goenoeng Boekit Toenggoel (2,209 m.), the road from Bandoeng to Soebang crosses the range at about 1,500 m. The next gap is that of Tandjoengsari, only 859 m., which carries the Bandoeng–Cheribon road. The third gap is the large and deep valley of the Tjimanoek, the erosive power of which was increased in the

Plate 35. Leles lake, in the Garoet basin

Leles lake is one of the remnants of the sheet of water which formerly occupied the Garoet basin. The basin ends sharply against the volcanic mountains which surround it.

Plate 36. Rice-fields in the Garoet basin
The level surface of the old lake bed has been cut into by river erosion since the drainage of the lake, and the resulting slopes are now terraced.

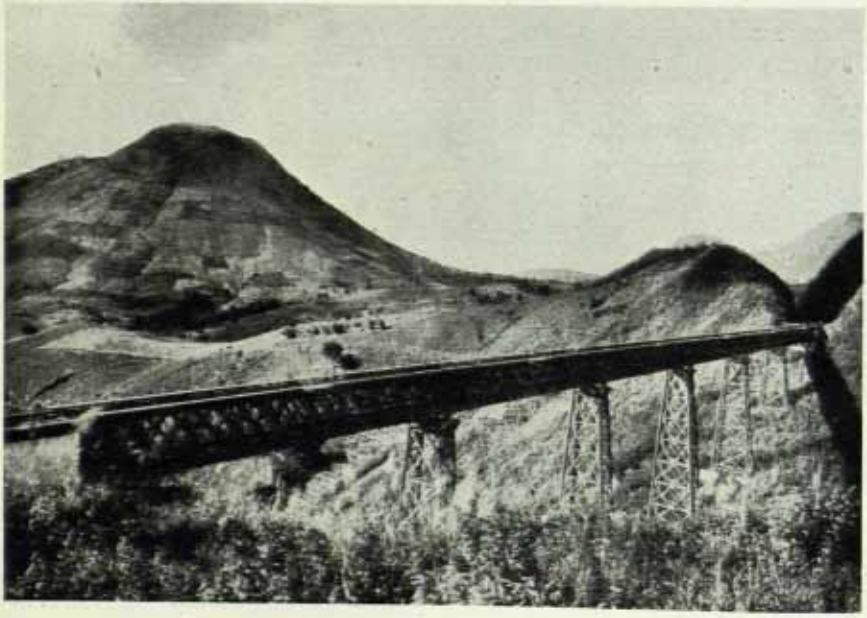


Plate 37. Railway bridge near Nagreg.
The railway linking the Bandoeng and Garoet basins crosses the intervening watershed near Nagreg, about 900 m. (3,000 ft.) above sea-level. The slopes are cultivated, except where too steep.

past by the lake-waters of the Garoet basin. This basin lies at 600–700 m. (2,000–2,300 ft.) above sea level, with the town of Garoet near its upper end. The surface is still lake-studded (Plate 35); some of the lakes, as near Trogong, have been converted into fish-ponds.

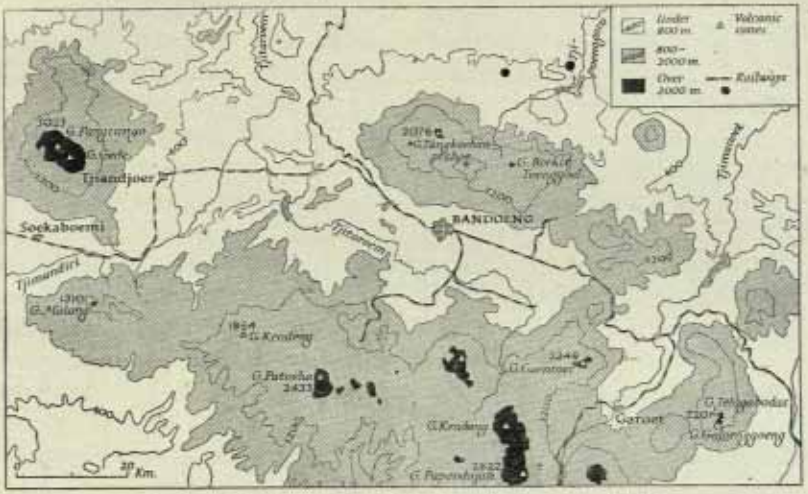


Fig. 69. The basins of Bandoeng and Garoet, and their surrounding mountains

The map shows the physical setting of the ancient lake basins surrounded by volcanoes. Note the gorges by which the rivers leave the basins, cutting through the dam of volcanic debris which formerly ponded back the lake waters. G. Malang, in the west, is non-volcanic. For further details of some of the active volcanoes of this region, see pp. 27 and 28, Figs. 15 and 16; also Plates 34 to 37.
Based on Java 1 : 250,000, sheet 2 (copied by G.S.G.S. as series 4200).

The main railway line enters the basin from the west, crossing the Nagreg col at about 900 m. from the Bandoeng plain (Plate 37). Like the Tjitaroem, the Tjimanoek valley is not followed by either rail or road, owing to its incised character on leaving the Garoet basin; the railway to central and east Java crosses the Tjipeundeuj col at little over 700 m. and descends south-eastwards to the Tjitandoej plain.

The Garoet basin is more or less surrounded by imposing volcanoes, including the active Galoenggoeng-Telagabodas, Papandajan and Goentoer (cf. p. 28 and Fig. 16). West of the basin, the broad belt of the volcanic mountains of Preanger, with several extinct and dormant cones, extends westwards, forming the southern ramparts of the Bandoeng basin; on the slopes of these mountains there are numerous tea and cinchona estates. The last volcanic cone is Kendeng

(1,854 m.) beyond which the trend of the mountains is continued, though with decreasing altitudes, by Neogene sedimentary formations.

Neogene mountains and flanking uplands

The Neogene rocks in western Java give rise to landscapes which are on the whole more repellent to human settlement and agriculture than in any other part of the island. The marls, sandstones, brecchias and occasional limestones yield less fertile soils than are to be found on the slopes of the volcanoes and in the alluvial lowlands. This is especially true of the broad and dissected southward-facing slope of the Preanger mountains, which receives the full force of the westerly monsoon and has in consequence an extensive forest cover. It is also true however of the low-lying terrain of southern Bantam, between Peper bay and the southern coast. North of the volcanic backbone the Neogene fringe is narrower and less continuous, being completely absent in the vicinity of Buitenzorg. In northern Bantam, between the Lebak mountains and the coastal plain of Serang, is a large area of low relief and altitude, crossed by the Tjioedjoeng and Tjidoerian, and floored by Neogene sediments largely made of acid volcanic debris. Most of this area is geographically more allied to the coastal plains than to the highland flanks (cf. Figs. 64 and 65).

Coastal Plains

The northern plains of West-Java average some 35 km. in width, and consist of two parallel belts. The coastal belt of recent alluvium is narrowest in the west, behind Bantam bay, where it extends inland for some 10 km. to Serang; it broadens eastwards, and occupies almost the full width of the plain in the regions of the Tjitaroem and Tjimanoek. In general it is very flat and is less than 15–20 m. above sea level. Rice-fields occupy a very large part of the surface (Plate 38,) and the dense population is for the most part strung out in villages aligned along the roads, or along the large rivers, the meandering courses of which are navigable for small boats (Plate 46). These larger rivers, e.g. Tjioedjoeng, Tjitaroem, Tjipoenagara and Tjimanoek, have built, and are still building, extensive deltas, the seaward ends of which are still marshy; these are more fully described in the section on coasts (see p. 169 and Figs. 74, 75).

The 'Quaternary terrace' belt lies between this coastal plain and the edge of the mountains. Its width fluctuates considerably, and it is occasionally almost sandwiched out. The surface offers considerable contrasts with the coastal rice-belt; it is at higher elevation, generally

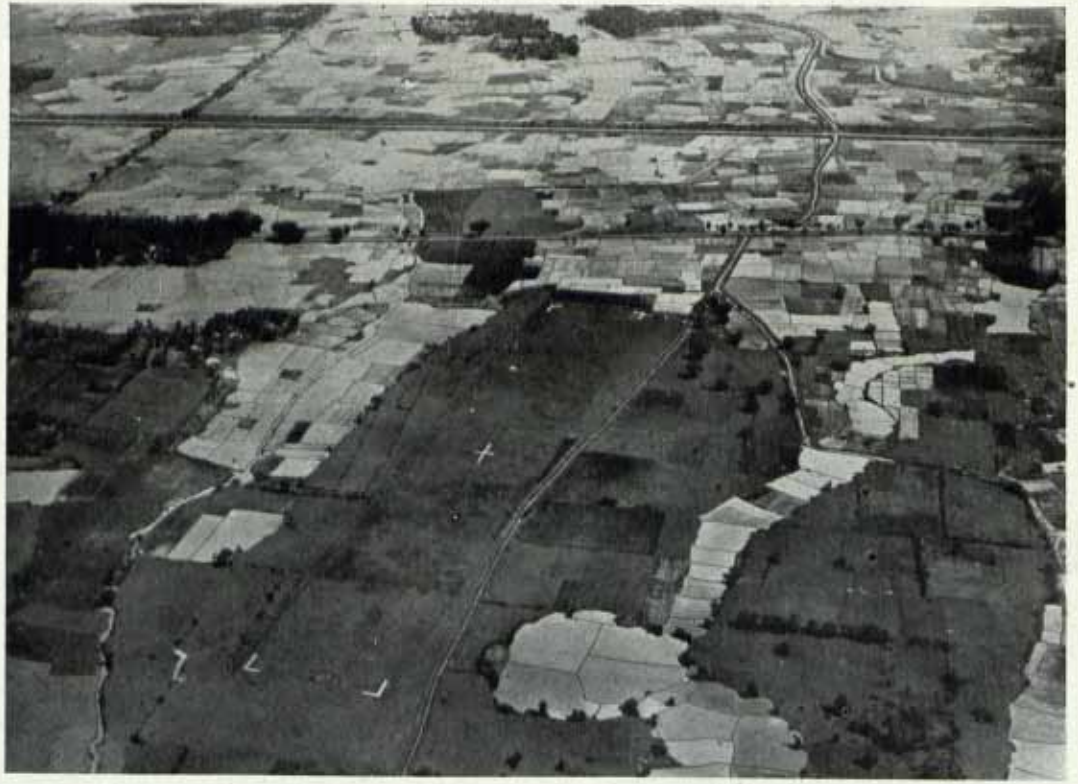


Plate 38. Typical north Java landscape near Serang

A large part of the plain is covered with sawah.

Plate 39. Irrigation works on the Tjitaroem
Careful control of the major rivers of northern Java is necessary not only to prevent flooding, but to make adequate water available for sawah. These works are at Walahar, near Krawang.

20–50 m. though occasionally rising to 100 m., and is much more diversified. It is less flat, being crossed by innumerable watercourses, which are often quite sharply incised into the soft volcanic debris of which the 'terrace' is built. Rice-fields cover a much smaller proportion of the surface; they are terraced, and are for the most part confined to the immediate vicinity of the streams; large areas are covered with plantations of various kinds. The population is more scattered and settlements are generally smaller.

The dividing line between the two parts of the plain is sometimes quite sharp; it may take the form of a terrace or break of slope a metre or two in height; elsewhere the transition is accomplished within a few kilometres. There is a marked tendency for a concentration of settlement along the junction zone; villages are closely spaced, with small towns at frequent intervals. Towns located on or near the line include (from west to east) Serang, Tangerang, Meester Cornelis, Bekasi, Tjikerang, Pagaden, Bangadoea and Ardjawinangoen. At times too the Batavia–Cheribon railway line follows the same zone.

Midden-Java

The relief of this section of Java is rather more symmetrical than in the regions to the west and east; the watershed is more or less centrally placed, and there are plains behind both north and south coasts. This apparent simplicity however conceals a somewhat complex structure of Tertiary folds with large superimposed volcanic masses.

At the western end of the 'waist' the Tertiary folds have already taken on a NW–SE trend, and this is maintained over the broad belt of country which intervenes between the volcanoes of Tjareme and Sawal on the west and the huge cone of Slamet on the east. The central range reaches 1,347 m. (4,429 ft.) in Goenoeng Podjoktiga, the highest elevation attained anywhere in Java by mountains of other than volcanic origin. Only a few kilometres to the south-east however the range is so reduced in height and width that a narrow col only just over 300 m. above sea level separates a tributary of the Tjitandoej from a headstream of the Kali Pemali. A more southerly and broken range flanks the Tjitandoej lowland on its north-eastern side. The NW–SE trend of the structure is apparent in the direction of this Tjitandoej trough and also in the line followed by the Cheribon–Jogjakarta railway line between the central range and the foothills of Slamet, crossing the main watershed at Kranggan (*c.* 325 m.).

Beyond the gorge of the Kali Serajoe, by which the former lake basin of Banjoemas is drained to the southern coastal plain, the main range, here reduced in altitude to 300–400 m., curves eastwards, and broadens out into a belt of low mountains, reaching summits of 1,000–1,100 m., separating the Banjoemas basin from the coastal plain. It is in the heart of this region, in the Loekolo valley, that some of the pre-Tertiary metamorphic rocks are exposed. The Tertiary belt swings south-eastwards again, south of the volcano Soembing, and ends on the flanks of the Kali Progo valley.

The corresponding Tertiary belt on the northern side of the 'waist' is less continuous, being interrupted by the northward sprawling of the volcanic debris of Slamet (south of Tegal), of the Dijëng plateau (south-east of Pekalongan), and of the dormant cone of Oengarang (south of Semarang). The areas lying between these three volcanic masses, in the centre of the island, are characterized by Tertiary folds, again oriented NW–SE. Between Slamet and the Dijëng plateau, summit levels of over 1,200 m. are attained, and the watershed range has a steep southern face overlooking the Banjoemas basin; between Soendoro and Oengarang, the same trend is observable in the ridge which forms the watershed between the Magelang trough (Kali Progo valley) on the south and the Kali Bodri on the north.

The volcanoes of this region form an impressive array. The most westerly is the slender active cone of Slamet (3,428 m.). Further east is a NW–SE zone of volcanicity, with the confused region known as the Dieng (or Dijëng) plateau (summit Goenoeng Praoe, 2,565 m.) in the north, the active cone Soendoro (3,135 m.) in the centre, and the dormant Soembing (3,371 m.) in the south. Beyond the wide and deep trough of Magelang is a north–south volcanic belt, with the dormant Oengarang (2,050 m.) in the north, and the two giants Merbaboe (3,142 m.) and Merapi (2,911 m.) in the south (Plate 40) (see p. 29 and Fig. 17). Half-way between Oengarang and Merbaboe is the small Quaternary lake basin of Ambarawa, at 460–470 m. (*c.* 1,530 ft.) above sea level, now drained by the Kali Toentang which has cut a gorge through the dam of volcanic debris. The floor of the basin, swampy in the centre, is almost completely covered with rice-fields, and there is a line of settlement round the edge.

The Banjoemas or Kali Serajoe basin is floored by Quaternary sediments. At its lower western end it is drained through a gorge 4 km. in length and over 150 m. (500 ft.) deep, cut in the Tertiary ridge referred to above. The floor of the basin at this end is only 12–20 m.

Plate 40. Goenoeng Merapi (central Java)
A view of the volcano from the north, in the col (about 1,500 m.) which separates Merapi from Merbaboe. See also Figs. 17 and 18.

Plate 41. Goenoeng Raoeng
A view of the crater of the volcano showing the degree of activity in 1922. See also plate 9.

Plate 42. The north coast plain of Midden-Java
Air view, looking south near Songgum, about 24 km. south-west of Tegal. In the centre is a main road; on the left the Cheribon–Poerwakerta railway line and in the top right the Kali Pemali. Sawah dominate the landscape here as elsewhere in the Javanese plains.

above sea level, but it rises to 200–300 m. at the eastern end. Much of the surface is covered with terraced rice-fields. Communication outwards is severely limited by the volcanoes and the Tertiary ridges. The railway north-westwards to Cheribon has already been mentioned; this continues southwards through the Serajoe gorge to the coastal plain. Neither rail nor good road crosses the mountains north and south of the basin, and the only eastern exit is via the head of the Serajoe valley to Wonosobo, a route followed by road and light railway. Thence the road crosses the high col (1,390 m.—4,560 ft.) between the volcanoes Soendoro and Soembing to reach the upper Progo valley.

The northern coastal plain (Plate 48) is narrower and of more variable width than in western Java. East of Pekalongan it is actually sandwiched out completely by a northward projection of Tertiary hill-country which culminates in Goenoeng Prikso (367 m.). In general, and except in the vicinity of the few comparatively small deltas, the recent alluvium occupies a smaller proportion of the plain than the older terraces. Both parts of the plain are usually covered with rice-fields, swamp-rice on the coastal section and terraced on the areas further inland, where also sugar is important. Owing to the narrowness of the whole plain, the differentiation between the older and newer parts of the plain is less apparent than the striking orographical change which occurs as soon as the Quaternary alluvia give way to 'solid' Tertiary rocks. This change takes place at a lower altitude than in West-Java, and in the western part of the plain, for example, it is to be found at 25–30 m. (*c.* 80–100 ft.); the towns of Tjiledoej and Bandjarardja are members of a family of settlements situated along this geological junction.

A number of small northward-flowing rivers have built up deltas, e.g. the Kali Pemali and Kali Tjomal, but their extent is much less than those of West-Java.

The southern coastal plain falls into four sections. At the western end is the Tjitandoej lowland, trending NW–SE and crossed from north to south by the meandering Tjitandoej, which is bordered by broad areas of forested swamp. This river flows into the mangrove-bordered lagoon, Segara Anakan; the lagoon and the swampy eastern end of the lowland are protected from the ocean by a long island, Noesa Kambangan. The second section is the plain behind Schildpadden bay, with the port of Tjilatjap at its south-western end. This plain is crossed by the lower Kali Serajoe. The actual shore line consists of a belt of high sand dunes, behind which, for almost the

whole width of the plain, the dense population (averaging upwards of 550 per sq. km.) is strung out in east–west lines, with rice-fields in between. There is also an almost continuous line of settlement at the inner edge of the plain, at the foot of the Tertiary ranges. The third section is separated from the second by a mass of forested Tertiary hills, the highest summit of which is Goenoeng Doewoer (476 m.). The east–west railway line tunnels through the neck of high ground connecting this hill mass with the main Tertiary ranges. For some 60 km. east of the Doewoer hills the coastal plain continues, characterized as before. Then another group of Tertiary hills intervenes. This group culminates in Goenoeng Gepak (859 m.) but unlike the Doewoer group does not quite reach the coast. Beyond the hills is the last section of the plain, crossed by the lower Kali Progo; the eastern part of this plain runs inland, rising gently to the broad expanse of Quaternary alluvium on which the town of Jogjakarta is built. The Jogjakarta plain (Plate 43) is probably the most densely populated part of Java; the density approaches 800 per sq. km. It is a land of rice and sugar, with a highly fertile volcanic soil which has been frequently renewed by deposits of ash from the eruptions of Merapi.

Middle-East Java

This portion of Java comprises six parallel belts of country, each running more or less east–west; the regularity of this arrangement is interrupted only by the ancient volcanic mass of Moerjo, which forms a great northward bulge in the north-western corner. The belts are as follows:

(i) the northern Neogene limestone range, with teak forests and some oilfields;

(ii) a Quaternary depression, occupied by the lower Loesi in the west and the lower Solo in the east;

(iii) the central Tertiary range, again with teak forests;

(iv) a discontinuous Quaternary depression, comprising the upper Solo and lower Brantas lowlands;

(v) a broad belt containing several large volcanic masses, including Lawoe, Wilis and the large group of Keloed, Ardjoeno–Welirang and Boetak, separated by the Quaternary plains of Soerakarta, Madioen and Kediri;

(vi) the southern Tertiary ranges, comprising several strikingly different types of relief, with limestones in the west and east and other

sedimentary and igneous rocks in the centre, and dropping sharply to the south coast.

Goenoeng Moerjo, rising to 1,602 m. (5,250 ft.), is the greatest of the pre-Quaternary volcanic ruins, forming an almost circular mountain mass 35 km. in diameter. The whole mass is conical in form; the lower slopes rise at about 1 : 25, a gradient which steepens to about 1 : 3 at higher levels; the summit region is irregular, and there are three peaks of over 1,400 m. The drainage is radial, but there are especially deep gulches on the northern and southern sides. The higher parts and the northern flanks are forested. There is a narrow coastal plain west and east of the mountain mass, and a less continuous one to the north; the broad base of the peninsula, in the south comprises two large alluvial plains, that of the Djoewana on the south-east, with a considerably swampy area in its upper part, and that of the lower Kali Serang on the south-west. The watershed between these two plains is little more than 10 m. (33 ft.) above sea level.

(i) *The northern limestone range*

The plain of the Djoewana continues eastwards as a coastal plain behind the bay of Rembang, but further east there is only a narrow and intermittent plain, for first the old volcanic mass of Goenoeng Lasem and then the limestone hills approach the coast closely.

The northern hill range, which extends from the Djoewana–Kali Serang waterparting in the west to the mouth of the Solo river in the east, is composed for the most part of gently folded sediments, mainly limestone. Much of it is covered with teak forests, and on the southern flanks, south of Rembang, there are oilfields (cf. p. 132). The range has a general east–west trend, and is broadest in its middle portion, where a southward bulge forms the watershed between tributaries of the Loesi and Solo rivers. In the west, it rises abruptly, from the alluvial plains of the Djoewana and Loesi, and reaches its highest elevations; there are considerable areas over 300 m., and the highest point is Goenoeng Gadang, 535 m. (1,755 ft.). The broad middle portion attains a maximum elevation of just over 200 m., while the eastern section of the range, reaching over 400 m. at first, in the region north of Bodjanegara, declines eastwards. East of Toeban there are only a few summits of over 100 m.; the range narrows considerably, averaging only about 8 km. and being reduced to a mere 3 km. wide near Brondang; it also runs quite close to the coast.

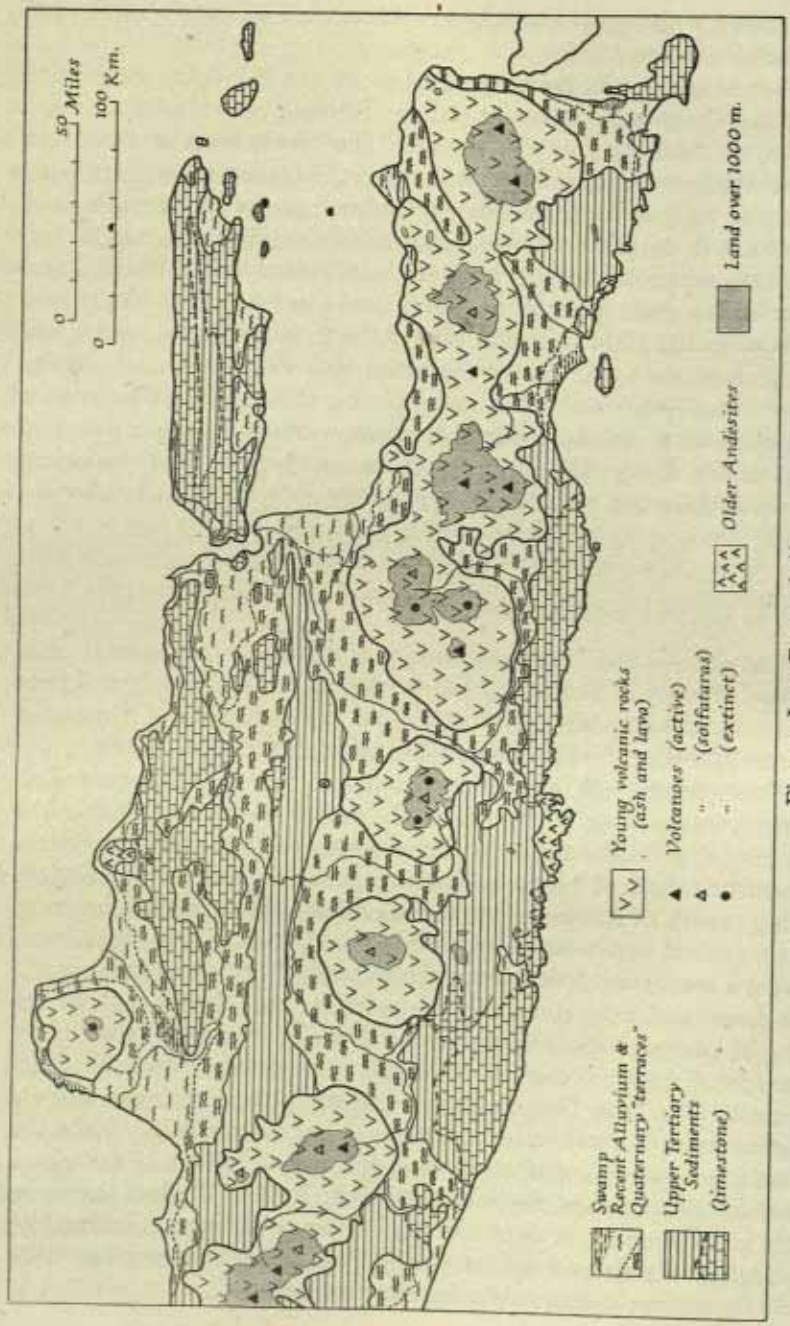


Fig. 70. Java: Eastern half

Simplified geological map, showing mountains and coastal swamps. For further explanation, see Fig. 67.

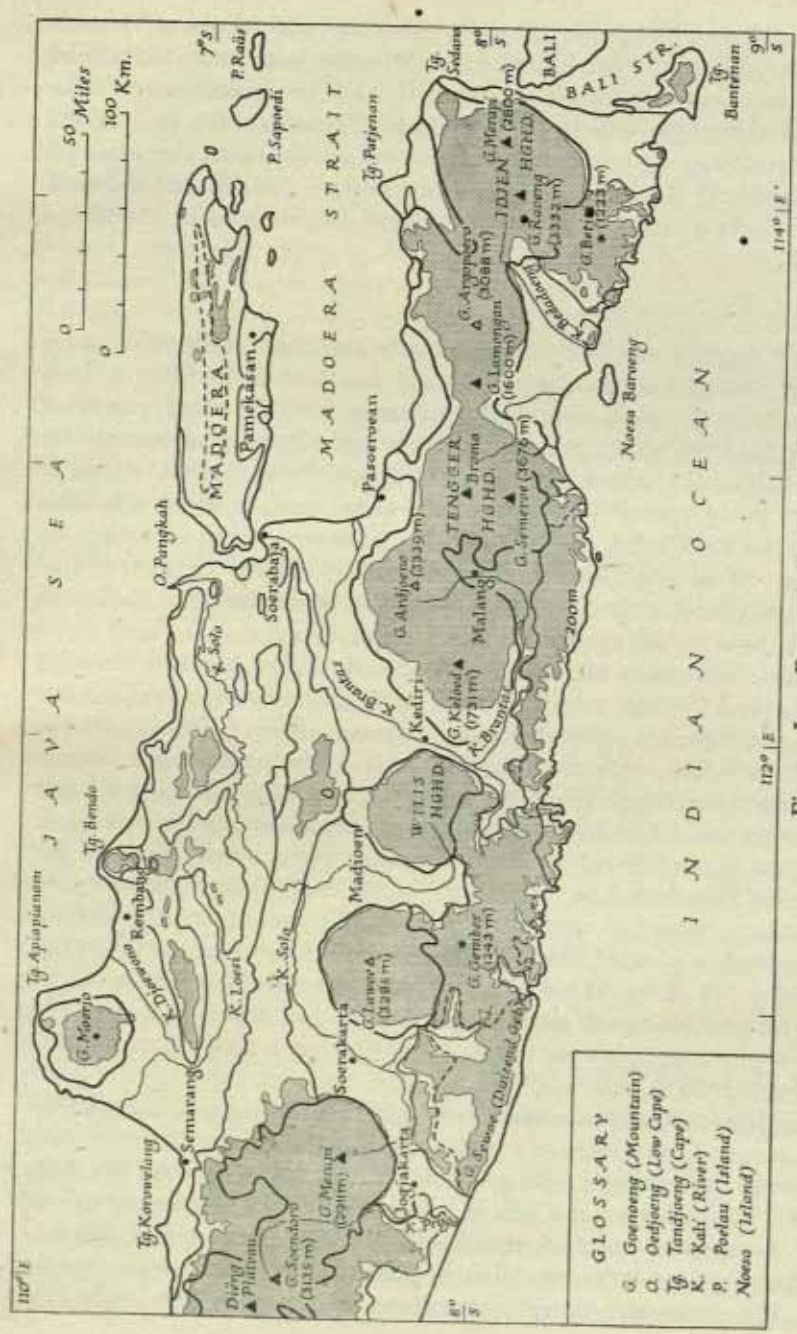


Fig. 71. Java: Eastern half

GLOSSARY

G. Goenoeng (Mountain)
O. Oedjoeng (Low Cape)
Tg. Tandjoeng (Cape)
K. Kali (River)
P. Poelau (Island)
Noesa (Island)

Key map to Fig. 70, showing land over 200 m. and chief physical features and towns. Mountains marked by an asterisk are non-volcanic. For further details of Madoera, see Figs. 82, 83.

The range is comparatively easily crossed in several places by roads and light railways. The line which follows the Loesi plain to its head at Blora rises to no more than 150 m. (500 ft.) in crossing the southward bulge of the hills between Blora and Tjepol, in the Solo valley. The Rembang–Bodjanegara line rises to about the same altitude, and the Rembang–Blora line a little higher. Further east, the rail and road from Toeban to the Solo valley at Babad do not have to rise above 60 m.

(ii) *The Loesi–Solo depression*

The western end of this depression is the plain of Demak, nearly 50 km. broad between Semarang and the foothills of Moerjo. It is crossed by the Kali Serang (as the lower Loesi is called); its level never rises above 10 m., and it is covered almost continuously by rice-fields. The Loesi plain narrows gradually eastwards, rising to about 90 m. (300 ft.) above sea level at its head, at Blora. The link with the Solo valley is further south, however, where a continuous trough of alluvial land stretches eastwards across an almost imperceptible watershed at Gaboesan, about 80 m. (260 ft.) above sea level. This trough carries road and light railway.

The Solo enters the east–west depression after breaking through the central Tertiary range from the south. Its course is very meandering, and there are many abandoned channels. East of Bodjanegara the plain broadens, with the river following a winding course nearer to the northern edge. There are broad areas of rice-fields, and many swamps and small lakes. Several large limestone 'islands', rising to 50–150 m. and largely covered with teak forest, protrude from the 'sea' of alluvium. The seaward end of the Solo plain is swampy, and there are extensive areas of fish-ponds. The mouth of the river is described on p. 175. The population of the plain is scattered in fair density, but along the banks of the Solo river the villages extend in an almost uninterrupted succession.

(iii) *The central Tertiary range*

Unlike its northern counterpart, this Tertiary range is not made of limestone. The rocks are mostly marls, and the range is more continuous and uniform, though it is severed completely by the Solo river. Commencing as a belt of hills behind Semarang, at the foot of the Oengarang volcano, the Tertiary rocks first begin to form a definite range north of the plain of Soerakarta, where they are crossed by the Semarang–Soerakarta railway at about 122 m. (400 ft.).

Between this point and the Solo valley, 65 km. further east, the maximum altitude reached is 184 m. (604 ft.). The floor of the Solo valley, where it breaks through the range, is scarcely 10 m. above sea level, though the distance from the mouth, even without counting the meanders, is at least 165 km. (100 miles).

East of the Solo the range is generally higher, and the relief is complicated by the existence of an old volcanic stump, Goenoeng Pandan, which rises to 897 m. (2,943 ft.). Eastwards of this eminence it declines, narrows to about 5 km. and peters out beneath the alluvium, north-east of Modjokerto. Almost the entire range is forested with teak, and the surface, weathered in marls, is generally more intricately dissected than that of the northern limestone range. The central range is rather more of a barrier, too; there is no crossing between the Soerakarta railway at the western end and a road just east of the Solo gap; 80 km. east of the latter a road and light railway cross from Babad to Djombang, rising to just over 100 m.

(iv) *The central Quaternary depression and intra-volcanic basins*

The east–west portion of this region comprises a section of the middle Solo valley and the lower part of the Brantas valley, separated by the northern foothills of the Wilis-gebergte. The four intra-volcanic basins of Soerakarta, Madioen, Kediri and Malang are oriented NNE–SSW, that is at right angles to the general WNW–ESE trend of middle-east Java.

(*a*) *The Soerakarta basin* is linked south-westwards across a 147 m. col at Prambanan with the basin of Jogjakarta and the south coast plain; the col is followed by road and main railway line. The basin is a portion of the great Solo valley, formed by the union of the Solo itself from the south-east and the Dengkeng from the south-west. It lies between the volcanic masses of Merapi–Merbaboe on the west and Lawoe on the east. At Soerakarta, the plain is 35 km. (22 miles) wide, and its alluvial floor varies in altitude from about 80 m. (260 ft.) by the river to about 200 m. (650 ft.) where alluvium gives place to volcanic debris and the slope increases. A large part of the plain is covered with terraced rice-fields, and there is much sugar cane also. The soil, as in the Jogjakarta basin (p. 150) has been frequently renewed by ash deposits from Merapi, and the very high productivity results in a dense population.

(*b*) *The west–east part of the Solo valley* lies between the central Tertiary range and the foothills of Lawoe. The river hugs the foot of the forested range, its course having been pushed northwards, no

doubt, by the many strong and mud-laden torrents which descend from the volcano. At Ngawi the river turns suddenly northwards and meanders through a wide gap in the central range.

(*c*) *The Madioen basin*, the broad valley of the Bengawan Madioen and its tributaries, lies between Lawoe and the Wilis-gebergte. It is narrower than the Soerakarta basin, and its floor is 60–100 m. above sea-level. Its surface is well covered by permanently irrigated rice-fields, which also extend in terraces far up the sides of Lawoe to over 1,000 m. The basin ends sharply in the south against the scarp of the southern Tertiary range—a sinuous wall 600 m. (nearly 2,000 ft.) high, surmounted by only one road which wriggles its way across to the south coast at Patjitan. In the north the basin merges with the Solo trough, for the Madioen river joins the Solo just as the latter turns northwards.

(*d*) *The Kediri basin*. The continuity of the east–west depression is broken between the Wilis-gebergte and the volcanic outpost of the central range, G. Pandan. The main road and railway have to rise to about 110 m. (330 ft.) to cross from the Madioen basin to that of Kediri. The Kediri basin carries the south–north section of the Kali Brantas, and there are really two basins, separated by a 'bottle-neck' above the town of Kediri. The upper basin—the plain of Toeloeng-agoeng—spreads out in an east–west direction at the foot of the southern Tertiary range, and the latter is so narrow here that the watershed is only 1·3 km. (1,400 yds.) from the south coast at the head of Popoh bay. The eastern extension of this basin is the plain of Blitar, at the foot of the destructive volcano Keloed (see p. 32 and Fig. 19). The lower plain—plain of Kediri proper—broadens rapidly below the town; it lies at 40–100 m. above sea level. Both upper and lower plains have much rice and sugar cultivation, the terraces extending far up the volcanic slopes on either side. The alluvial soil has been frequently enriched by ash eruptions.

(*e*) *The lower Brantas plain*. The Kali Brantas curves eastwards below Kertosono, where the Jogjakarta–Soerabaja railway crosses it, and flows through a plain 20–25 km. wide. The floor of the plain varies from sea-level to 40 m. (130 ft.); alluvial soil spreads upwards to about 100 m. on the southern (i.e. volcanic) side, but the plain terminates more sharply on the north against the central range. Below Modjokerto the Brantas river splits into two channels; the Kali Mas flows north-eastwards and curves north through the port of Soerabaja, whilst the Kali Porong flows east-south-east and traverses an extensive area of fishponds before entering Madoera strait. The

whole plain has large areas of rice-fields, and the population is very dense; villages are almost continuous along the main rivers. There is a marked line of settlement at the foot of the central range, but no such line at the junction of the alluvium and volcanic rocks, for both these are fertile and there is no marked break of slope; the junction of rice-fields and forest on the volcanic slopes is a very fluctuating edge.

(*f*) *The Malang plain.* Unlike all the previous plains the Malang plain opens southwards, and lies at a considerable elevation. It is formed by the north–south section of the upper Kali Brantas. It communicates with the coastal plain of Madoera strait only by a col at 543 m. (1,781 ft.), at Bedali, between the great volcanic masses of Ardjoeno on the west and the Tengger-gebergte on the east; the col is followed by rail and road. The plain is probably an old lake basin (cf. the plain of Bandoeng), and its floor, which is basin-like rather than dead flat, varies from 300–500 m. above sea level. At the southern end of the plain the Brantas curves westwards, and soon after, its course steepens and the valley deepens for several kilometres, through what is presumably the overflow channel of the old lake, until the lower level of the plain of Blitar is reached. There is no communication across the southern range to the south coast.

(v) *The volcanoes*

The three volcanic masses in middle-east Java differ widely from each other, increasing in complexity from west to east. Lawoe (3,265 m., dormant) is a fairly symmetrical single cone covered right over the summit with vegetation except on the steepest and stoniest slopes; the Wilis-gebergte (summit Goenoeng Liman, 2,563 m.) is a caldera with several subsidiary cones, while the third group is more complex, with four main centres. The highest, reaching 3,339 m. (10,954 ft.), is Ardjoeno-Welirang, twin cones, in the east; then come Kawi and Boetak (2,868 m.) in the south, Argowajang (2,198 m.) in the north-west, and lastly Keloed (1,731 m.) with its crater lake (see p. 31, Fig. 20 and Plate 6), in the south-west.

On these volcanic mountains, population, terraced rice-fields and tree plantations extend far up the sides, notably, for example, coffee and rubber plantations on the southern side of the Keloed–Boetak mountains.

(vi) *The southern Tertiary ranges and plateaux*

This region falls into four quite distinct subdivisions, in which

geological differences are responsible for marked differences in landscape.

(*a*) *The Duizend-gebergte*, or Goenoeng Sewoe, is a limestone plateau stretching from the lower Kali Opak to Patjitan bay, and extending inland for between 13 and 30 km. The rise from the coast is steep, and a maximum elevation of about 400 m. is attained. Inland, the peculiar limestone landscape ends at roughly 200 m. (650 ft.) above sea level. It is a land of hills and hollows, with little or no surface drainage—a veritable 'karst' landscape. There is very little forest, and in consequence, with little possibility of agriculture, the population is very sparse—a great contrast with the fertile alluvial basin and volcanic slopes which border the region on the north.

(*b*) *The central Tertiary mountains* are built of sandstones and marls, and the region stands in sharp contrast to the limestone plateau. There are several summits of over 1,000 m., the maximum being Goenoeng Gembes, 1,243 m. (4,078 ft.); the surface is highly dissected with an abundance of surface drainage. A sharp and sinuous northward-facing scarp overlooks the gentle lowermost slopes of the Lawoe volcano, in the north-west, and the upper part of the Madioen plain, in the north-east. The coastal belt is again steep and rugged, with limestones forming headlands and the bays eroded in softer marls. This mountain area, too, is sparsely populated, and it lacks forests except at the eastern end, where it wraps round the south-western slopes of the Wilis-gebergte.

(*c*) *The volcanic belt*. Between Panggoel and Popoh bays the coast and immediate hinterland are composed of volcanic rock of greater age than the existing cones. The coast is very rugged and the relief considerable, but the soils are more fertile than those derived from the Tertiary sediments, so there is a forest cover and patches of rice cultivation and settlement.

(*d*) *The eastern limestone plateau* extends along the coast from Popoh bay to Sipelot bay, and inland for some 12–25 km. The general surface level is 200–600 m., highest in the east. There is some 'karst' landscape, but not in such large measure as in the Duizend-gebergte, and the coastal slope is forested. Prominent though discontinuous scarps overlook the Brantas valley in the north. Population is sparse, and there are no communications across the plateau.

Oost-Java

Certain elements of the relief of middle-east Java continue into the eastern end of the island, but the central depressions of the former

have become submerged beneath Madoera strait, and Madoera island represents the northern limestone ranges. This eastern rectangle contains five major relief elements:

(*a*) the northern coastal plains, interrupted by volcanic hills;
(*b*) the volcanic masses—three huge calderas;
(*c*) the southern coastal plains, two in number;
(*d*) the Tertiary mountains;
(*e*) the Blambangan peninsula.

(*a*) *The north coast plains* (see also coastal description, pp. 176-8).

There are four small plains, separated by volcanic hills which project northwards from the great central volcanic piles. The plain of Pasoeroean is actually a continuation of the plain of the lower Brantas. Like the latter, it has a belt of fish-ponds behind the shore, and a dense agricultural population, with rice and sugar cultivation. The Probolinggo plain, about 50 km. long and stretching 10 km. inland, has only a narrow belt of recent alluvium, the bulk of the surface being on the so-called Quaternary terrace (cf. p. 133), which rises inland to 100 m. or so and is covered with terraced rice-fields and sugar plantations.

The Besoeki plain is small, and mainly consists of the deltaic deposits of the Kali Deloewang. The last plain, of Sitoebondo, is also deltaic, comprising a large and richly cultivated alluvial area built up and later abandoned by the Kali Sampoean. Rice and sugar are again dominant.

(*b*) *The volcanic masses.*

The westernmost of these is the Tengger-gebergte, a gigantic caldera, the volcanic phenomena of which are more fully described on p. 33. The outer rim—nearly 10 km. in diameter—is mostly over 2,500 m. except where breached on the western and eastern sides. From the floor of the enclosed 'sand-sea' rises the active cone of Bromo (Plate 8). The outer slopes of the mountain mass drop steeply towards the north, with an average gradient of about 1 : 3½, which decreases below about 1,200 m. and gradually flattens out as the coastal plain is approached. On the north-western side cultivation and villages extend up to about 2,000 m. Tongues of volcanic highland extend east and west, and to the south a 2,000 m. ridge links the Tengger-gebergte with the smaller but loftier Semeroe-gebergte. The latter (see also p. 34 and Fig. 21) culminates in the 3,676 m. (12,060 ft.) summit of Goenoeng Mohomeroe, an active volcano with

a considerable record of eruptions during the last century. The upper slopes of Mohomeroe are very steep; on the eastern side the gradient flattens considerably below 800 m., and the surface drops more gently, at about 1 : 30, to the plain of Loemadjang. On the south-western flanks, plantations extend to about 1,400 m. (4,600 ft.); on the south-east, the downward slope is sharply interrupted at about 700 m. by the northward-facing scarp of the southern Tertiary range.

The next volcanic mass is the Ijang-gebergte, another gigantic caldera, higher and less symmetrical in form than the Tengger, and culminating in Goenoeng Argopoero, 3,088 m. (10,131 ft.). This huge mountain mass makes a much larger gap in the population map than does the Tengger-gebergte; there is very little settlement on its steep slopes above 1,000 m., and the area above this level is over 25 km. in diameter.

The third and last mountain area is the complex Idjen-gebergte (see p. 36 and Fig. 23), which comprises the ruins of an enormous caldera, dominated at the western end by the active crater of Raoeng (3,332 m.), itself a small caldera 2 km. in diameter (Plates 9 and 41), and at the eastern end by Goenoeng Merapi (2,800 m.) which overlooks the Kawah Idjen crater lake (see Fig. 24). The outer slopes of this mountain mass are less deeply gullied than most of the Javanese mountains, and the northern and southern sides present a contrasting appearance, the northern slopes being dissected by innumerable small ravines which are dry for much of the year, while the southern slopes, more exposed to the westerly monsoon, have fewer but more constantly watered valleys.

In the north-eastern corner of Java is an offshoot of the Idjen mountains, Goenoeng Baloeran (1,247 m.), with a horse-shoe shaped crater, 3 km. in diameter, breached on the eastern rim.

Generally speaking all these east-Java volcanic mountains are forested to their summits, except where the slopes are too steep and rocky, and where eruptive activity prevails.

Between the three great mountain areas there are no Quaternary plains as in middle-east Java, but broad saddles of volcanic debris. These saddles are the obvious routeways, and each is followed by road and rail. The more westerly, between Tengger and Ijang, links Probolinggo and Loemadjang. The summit is 275 m. above sea level, and the broad surface of the saddle is studded with the 'maars' and 'boccas' of the Lamongan volcano (see p. 35 and Fig. 22); it is neither well cultivated nor densely peopled. The eastern saddle links Bondowoso with Djember, and has a summit level of 350 m.; it is

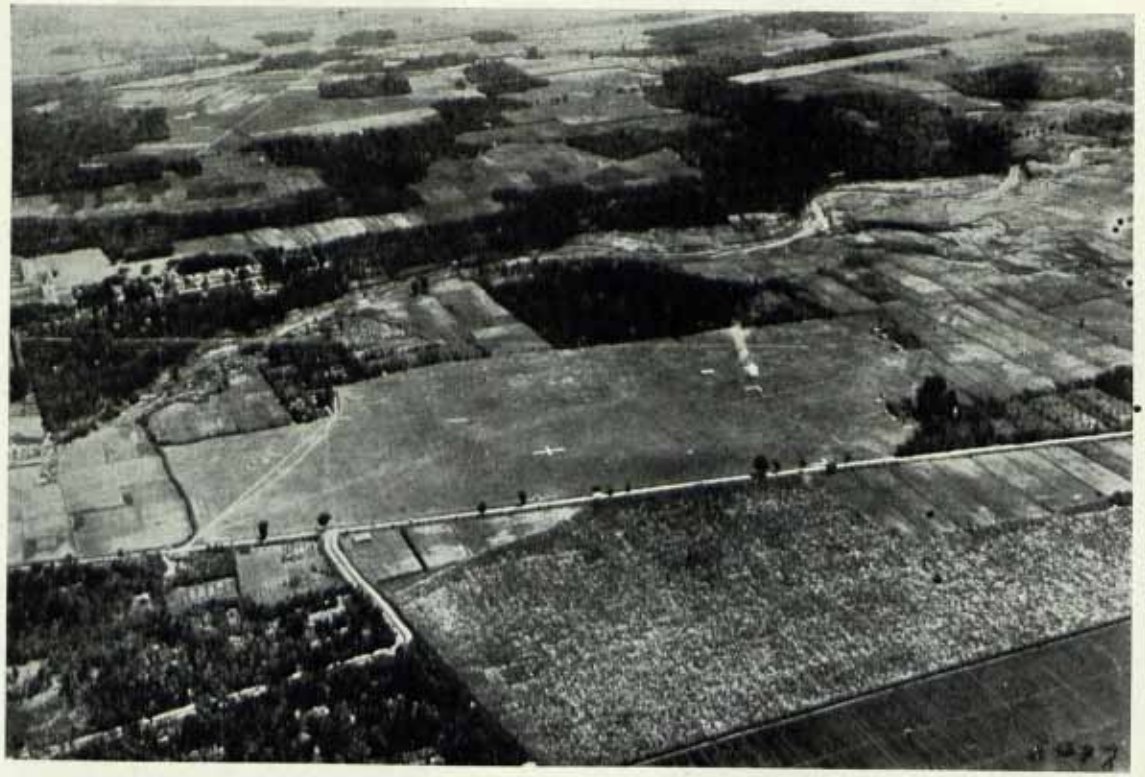


Plate 43. The plain of Jogjakarta

In the foreground is an airfield, set in the midst of an intensively cultivated plain with rice-fields and plantations.

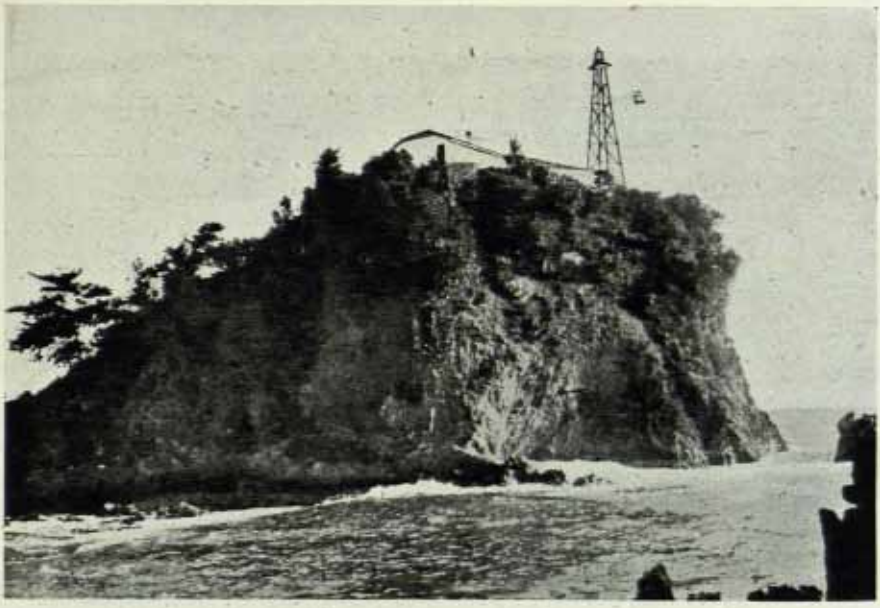


Plate 44. Java's Eerste Punt
The cliff of Tandjoeng Lajar, or Java's Eerste Punt, is the western extremity of the island; it is composed of volcanic rock.

Plate 45. Islands in Batavia bay
These two low, wooded coral islets lie in the north-western part of Batavia bay (see Fig. 74). In the background is Onrust, with a quarantine station; in the centre is Kuiper, with a hospital for non-infectious cases. The latter has a small pier and several mooring buoys. The view is looking slightly east of north.

more cultivated and populated, for its surface is largely composed of fresh volcanic ash. Plantations of coffee, rubber, etc., extend up the slopes.

(*c*) *The south coast plains*

The first of these is the plain of Loemadjang and Djember, floored for the most part by Quaternary alluvium and fresh volcanic ash, with recent alluvium along the swampy, dune-fringed coastal belt. There is much rice cultivation, and the population is fairly dense. The second plain stretches from Gradjagan bay to Banjoewangi. The recent alluvium of the southern and eastern shores is swampy; the Quaternary alluvium extends inland to the edge of the volcanic deposits, at about 150 m. above sea level. The population is relatively sparse, especially in the south, where there is some teak forest.

(*d*) *The Tertiary mountains*

These occupy a semicircular area, with its base on the rugged coast, and extending inland to the two plains on the north-west and east, and lapping up against the foot of the Idjen-gebergte in the north. The mountains are mostly built of sandstone and marl, and in consequence are highly dissected. The maximum elevation reaches 1,223 m. (4,013 ft.) in Goenoeng Betiri, and the surface is for the most part forested. The mountains rise abruptly, and with a highly sinuous face, from the plains. An offshoot projects northwards, overlooking by a 200–400 m. scarp the south-western flanks of the Raoeng volcano; the existence of this ridge creates difficulty for the East Java railway line, which has to tunnel twice in crossing it.

(*e*) *The Blambangan peninsula*

This is a karstic limestone plateau, tilted towards the south. It is bush-covered, presenting a definitely 'east monsoon' aspect, and is almost unpeopled.

COASTS

The coastline of Java approaches 3,000 km. (1,600 miles) in length, of which some 2,600 km. (1,400 miles) are represented by the northern and southern coasts, facing the Java Sea and Indian Ocean respectively. These two longer coasts are in striking contrast with each other. The former is generally low and flat, muddy and extending rapidly in the vicinity of the large deltas; it borders the comparatively shallow Java Sea and is almost completely devoid of

coral reefs. Its hinterland is a highly cultivated and densely peopled plain, and there are several large ports. The south coast, especially in its eastern half, presents a bold front to the Indian Ocean, with very few indentations of any size; it drops steeply offshore to oceanic depths, and is exposed to a heavy, surf-creating swell which at all seasons, but especially during the westerly monsoon, makes anchorage or landing impossible. Only in the middle section of the south coast is there any extensive area of lowland, but the plains are bordered by a high and wide belt of sand dunes. In this middle section, too, occurs the only port of any size—Tjilatjap.

In short, the characteristics of the two opposite coasts may be pithily summed up as follows: the north coast has plain, ports, people, paddy-fields and petroleum; the south coast, swell, surf, sand dunes and solitude.

The backbone of volcanic mountains provides a useful series of landmarks, from the sea, the height of the cones—many rising to over 3,000 m.—rendering them visible for great distances, sometimes well over 100 km. Visibility, however, depends on the season and the time of day. At all seasons it is least during the afternoon, when thunder-clouds gather, but during the east monsoon the volcanoes can only be seen in the early morning. At night some of the more active ones may provide natural beacons through the glow of molten lava within their craters.

The coasts of Java may be conveniently divided into the following sections:

West Coast:
- (i) First–Second Points
- (ii) Second–Third Points
- (iii) Third–Fourth Points
- (iv) Fourth Point–St Nicolaaspunt

North Coast:
- (i) St Nicolaaspunt–Cheribon
- (ii) Cheribon–Djapara
- (iii) Djapara–Soerabaja
- (iv) Soerabaja–Bali strait

East Coast

South Coast:
- (i) Blambangan peninsula–Kali Opak
- (ii) Kali Opak–Oedjoeng Madasari
- (iii) Og. Madasari–Og. Genteng
- (iv) Og. Genteng–Javahoofd

The West Coast

The west coast of Java, forming the south-eastern shore of Soenda strait, is a little over 200 km. in length. It cuts across the general east–west trend-lines of the island, and is in consequence broken up into short stretches of different character, separated by headlands

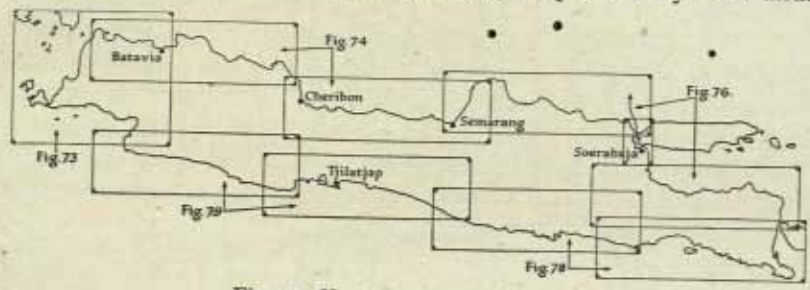


Fig. 72. Key to coast maps of Java

The information on these maps has been compiled from many sources, mainly the *Eastern Archipelago Pilot*, vol. II (London, 1934); *De Zeeën van Nederlandsch Oost-Indië* (Leiden, 1922); British Admiralty Charts and Dutch topographical maps (copied as G.S.G.S. series 4200 and 4202).

which are known as Java's First, Second, Third and Fourth Points. The immediate hinterland is in general, but especially in the southern part, not densely populated; it is composed mainly of volcanic hills separated by alluvial plains, but there is one section where Neogene sedimentary rocks form the coastal slope.

(i) *From First to Second Points*

The angular Oedjoengkoelon peninsula is densely wooded and almost uninhabited; there are no roads or tracks. About 1,300 m. north of Javahoofd is Java's Eerste punt (First Point or Tandjoeng Lajar) (Plate 44). From here to Tweede (Second) punt, 20 km. to the north-east, the shore of Meeuwen bay has a sandy but surf-beaten beach. Facing the shore, across Prinsen-straat (or Behouden Passage) is Prinsen (Prince's) island (also known by its native name Poelau Panaitan), densely wooded except on its south-western prong, and rising to 320 m. (1,050 ft.); it, too, is uninhabited, but the bays on the north-eastern side are used by Javanese fishermen.

(ii) *From Second to Third Points*

Tweede punt (or Tandjoeng Alang Alang) is a low, sandy, wooded headland, beyond which the coast turns at right angles, south-eastwards, to form the western side of a great bight, the head of which is

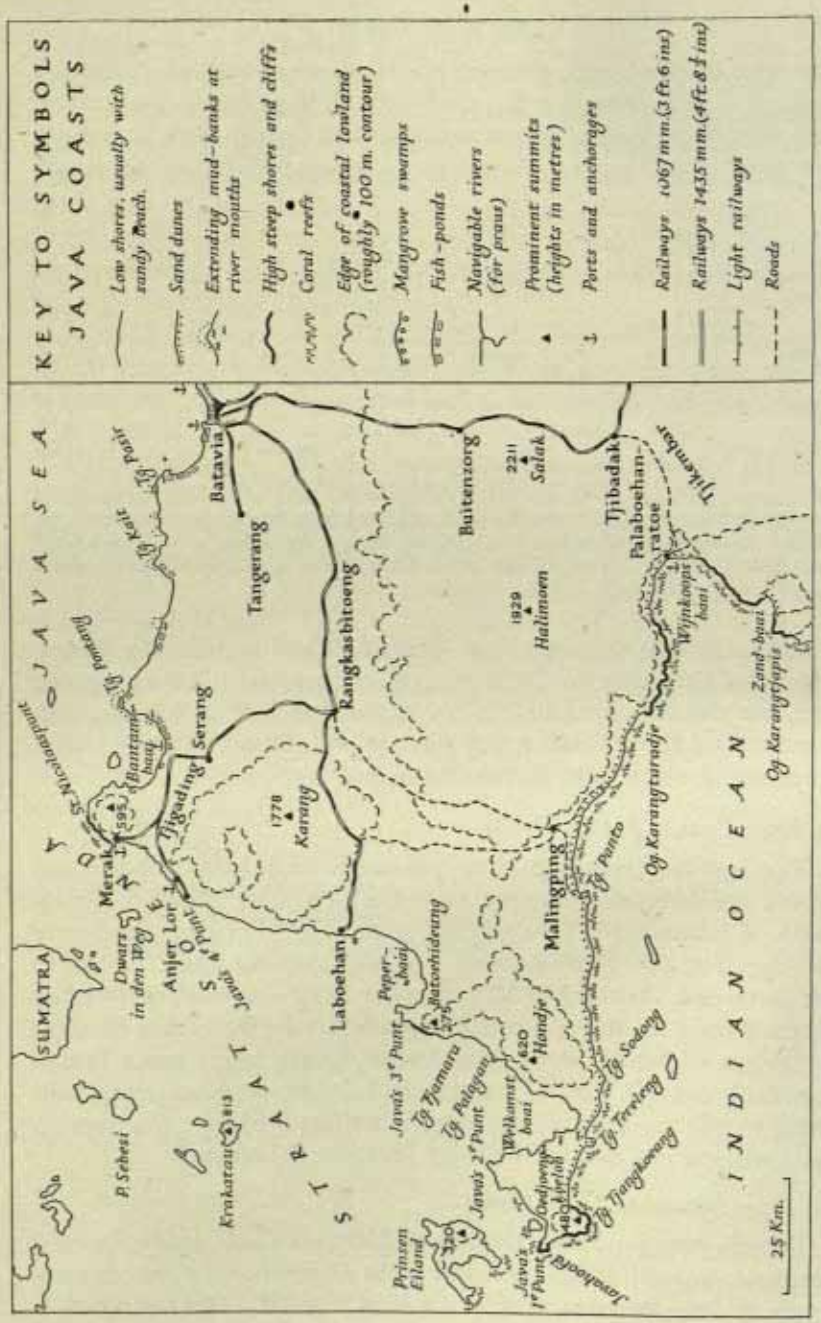


Fig. 73. Java: west coast; and legend to coast map series (Figs. 73, 74, 76, 78 and 79).

For location and sources, see Fig. 72.

known as Welkomst bay. This western shore, forming the north-eastern side of the Oedjoengkoelon peninsula, is low, alluvial and marshy; at the head of the bay is a narrow sandy isthmus which connects the peninsula with the mainland and separates the Soenda strait from the Indian Ocean. The eastern shore has a sandy beach, backed by wooded volcanic hills, as far as Tandjoeng Palagan, beyond which, as far as Tandjoeng Tjamara, is an alluvial plain, with a few coastal villages and a track connecting them along the shore, with occasional branches into the interior. Between Tg. Tjamara and Derde (Third) punt (or Tandjoeng Lesoeng), Neogene sedimentary rocks form the Batoehideung hills which drop fairly steeply to a shore which is occasionally rocky.

(iii) *From Third to Fourth Points*

Derde punt is low and sandy. Beyond it the coast turns sharply south again to form another bight, known as Peper bay, almost semi-circular in form, and 19 km. (10 miles) across from Derde punt to the vicinity of Laboehan. Except on the western side the shore is low and muddy, and a broad alluvial plain extends inland for distances up to 20 km. Several fair-sized rivers cross this plain, notably the Tjiliman and Tjiboengoer. The plain is not densely peopled; there are a few coastal villages—e.g. Tjiteureup—connected by a poor road, but most of the settlement is towards the inner edge of the plain. This was one of the worst devastated areas in the Krakatau disaster of 1883, when a great sea-wave swept 10 km. inland (p. 25).

At the north-eastern end of Peper bay is the anchorage and small port of Laboehan, at the mouth of a small creek, the Tjipoetanagoeng. The creek itself is navigable by praus at high water only. The village is the terminus of a main road and railway leading inland, eastwards, to give connexion with Serang and Batavia. Just north of Laboehan the coastal plain ends, and the wooded foothills of volcanic mountains approach the shore, which is sometimes rocky, sometimes with high sandy beaches. There are a few coastal villages, connected by a road running along the shore.

(iv) *From Fourth Point to St Nicolaaspunt*

Vierde (Fourth) punt (or Tandjoeng Tjikoneng) is low and wooded. On its northern side is Anjer Kidoel, a small village which is the terminus of a branch railway line leading to Serang. About 4 km. further to the north-east is Anjer Lor, a small port offering anchorage with some shelter from the east monsoon; this town is also on the

branch railway, and is the terminus of a main road which leads eastwards to Serang and Batavia.

The coast between Vierde punt and Merak roadstead comprises two stretches of lowland separated by a spur of volcanic hills which reaches the sea in Tandjoeng Leneng. The first plain is that of Anjer Lor; the second has a rather more swampy coast and is uninhabited. Just before Merak, the volcanic hills, which form the north-western corner of Java, reach the coast.

The roadstead and port of Merak are protected by an island, Poelau Merak; the port offers the only completely sheltered anchorage on the western coast of Java. The port comprises a pier and landing jetty regularly visited by steamers from Oosthaven in Sumatra, and the terminus of a railway line leading inland to Serang, Batavia and the rest of the island.

Beyond Merak, the coast is bold and is fringed with coral reefs. St Nicolaaspunt (Tandjoeng Poedjoet) is the most northerly point of Java; behind it rises an extinct volcanic mass which has several summits, the highest of which is Goenoeng Gede, 595 m. (1,952 ft.).

The North Coast

The north coast of Java, about 1,200 km. (650 miles) in length, falls naturally into four sections, two stretches projecting northwards alternating with wide embayments.

(i) From Soenda strait to Cheribon: backed by a wide alluvial plain, and extending rapidly in several deltas.

(ii) From Cheribon to Djapara: a great embayment, backed by a narrower plain.

(iii) From Djapara to Soerabaja: the second northward-projecting stretch, in which high ground several times approaches the coast, as on the northern slopes of Moerjo and Lasem.

(iv) From Soerabaja to Bali strait: on the southern side of Madoera strait, backed by a narrow and discontinuous plain.

(i) *St Nicolaaspunt to Cheribon*

The greater part of this section, from Bantam bay to Cheribon, is backed by a coastal plain averaging 35 km. in width, which has been built up by the deposits of the numerous rivers which flow northwards from the easily-eroded volcanic mountains. The shore is entirely low, often marshy and almost always densely overgrown with a vegetation of scrub and low trees, with taller coconut palms around the villages. Nearly all the rivers, and especially the larger ones, Tjitaroem and

Tjimanoek, flow out to sea between low mudbanks which are continually extending.

From St Nicolaaspunt, the north-western corner of the island, the coast, low and fringed with coral reefs and islets, curves southwards round the extinct volcanic mass of Gede, forming the western shore of Bantam bay. The southern shore of this bay is low and marshy, and is fronted by a wide mudbank. There are many fish-ponds (*tambak*) behind the shore-line, especially on the south-eastern side. Within the bay there are several low, wooded islets and coral reefs; the largest is Poelau Pandjang. On the southern shore is the small prau harbour of Karangantoe, on the canalized mouth of the Kali Bantam; this is the port for Serang, with which it is connected by the State Railways' Merak–Batavia line (gauge 1,067 mm. or 3 ft. 6 ins.). The eastern shore of the bay ends in the northward-projecting deltaic headland Tandjoeng Pontang, at the mouth of the Tjioedjoeng.

Between Tg. Pontang and Tg. Kait, 26 km. (14 miles) to the east, the coast forms a shallow bight. Several small streams cross the coast-line, and the large river Tjidoerian sends a mudbank several kilometres out into the bay. There are several coastal villages, with roads and tracks leading inland to a densely peopled plain which is crossed by the Serang–Batavia road and railway.

Between Tg. Kait and Batavia bay the coast is deltaic, formed by the new and old mouths of the Tjisadane. For a few kilometres south-east of Tg. Kait, sawah (rice-fields) reach the beach; there follows a swampy area with five shallow mouths of the Tjisadane, and some fish-ponds. The chief mouth is Koeala Tiangsampan, 5 km. east of which is Tandjoeng Pasir, low and muddy and prolonged seawards by a mudbank; south-east of Tg. Pasir is the old delta of the Tjisadane. Offshore lies a small group of wooded islets, on one of which, Onrust, is the Batavia quarantine station (Plate 45).

Batavia bay is 35 km. (22 miles) across, from Tg. Pasir to Oedjoeng Krawang. The whole shore is low and wooded; it is often backed, especially on the south-western side, by a belt of fish-ponds. At the head of the bay lies Batavia, formerly on the sea shore, but now, owing to silting, nearly 2 km. inland behind the fishpond belt. A canal (actually the canalized mouth of the Tjiliwoeng), the entrance to which is protected by two long moles, leads from the roadstead to the old port. It can be used by small coasting vessels and by native boats and barges. Eight kilometres east of the canal mouth is the newer artificial port of Tandjoengpriok, built during the decade 1877–87. The outer harbour is enclosed by two long breakwaters

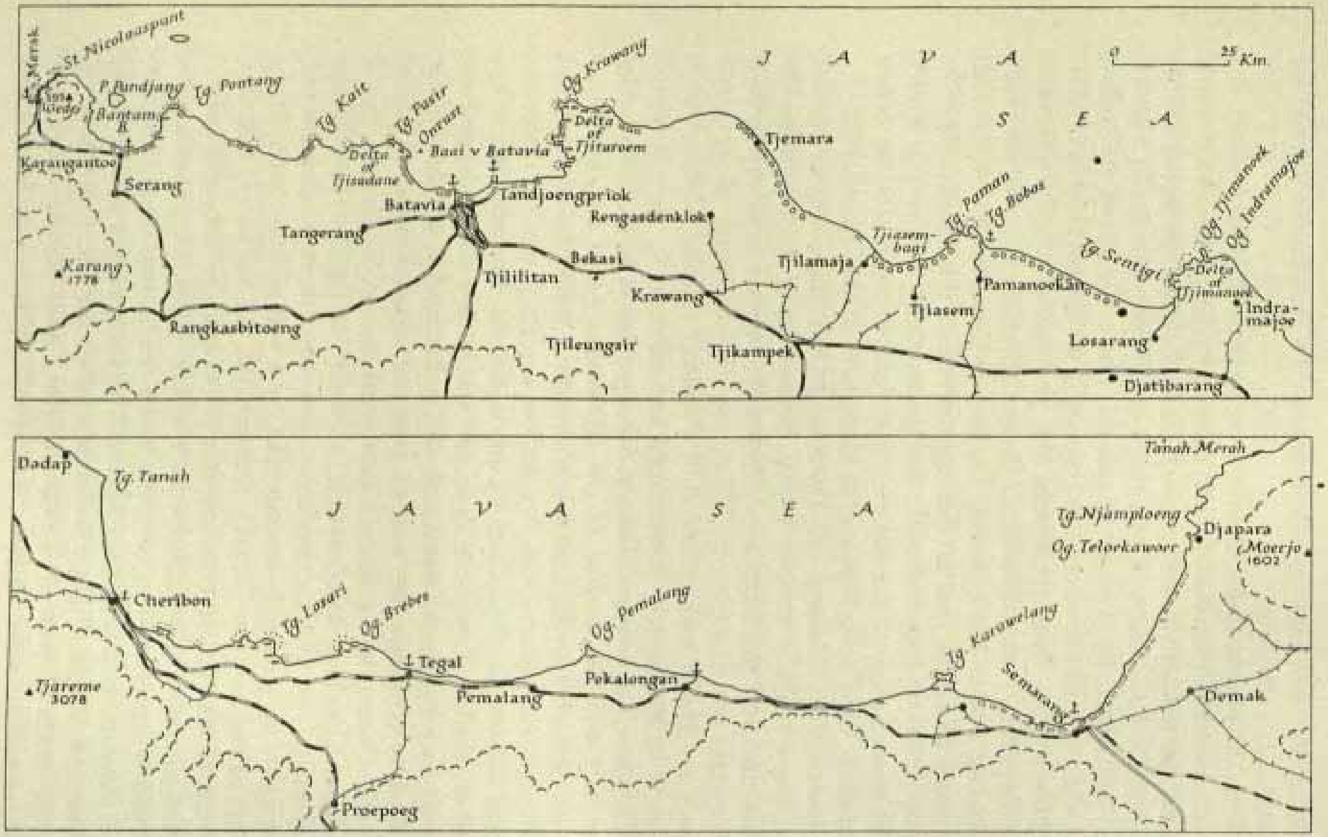


Fig. 74: Java: North-west coast

For location, sources and key see Figs. 72 and 73.

which project about 1,700 m. (1,860 yds.) from the edge of the docks.

About 15 km. (9 miles) east of Tandjoengpriok, beyond a further stretch of low shore backed by fish-ponds, there commences the huge northward protrusion of the coast, 50 km. (30 miles) across, which has been built up by the Tjitaroem. The older part of the delta, in the east, has been abandoned by the river and the shore-line has been smoothed off by the longshore drift. The western side of the delta is actively extending, at the north-eastern corner of Batavia bay, in the low muddy promontory known as Oedjoeng Krawang. The coast of this deltaic region is low, flat and wooded, and devoid of recognizable objects. On the smoother eastern side a few coastal villages exist, but then as the shore-line swings eastwards again, there is a narrow belt of mangroves, backed by swamp forest, and habitations are rare. The only village of note is Tjemara, which has a road leading inland to Rengasdenklok, whence a light railway runs southwards to the main State Railway line from Batavia to Cheribon.

Tjiasem bay has low shores with mangroves, backed by swamp forest; there is no coastal population, but praus can navigate some of the river mouths, e.g. those of the Tjilamaja and Tjiasem, which lead inland to villages of the same name which have light railway connexion with the State line.

East of Tandjoeng Pamanoekan (the eastern point of Tjiasem bay), lies the delta of the Tjipoenagara, which has extended rapidly during the last half-century, forming the low promontory Tandjoeng Bobos. Just east of the latter is Pamanoekan roadstead; the canalized mouth of the distributary Kali Bobos, protected by piers, can be ascended to Pamanoekan village, about 10 km. upstream, whence a light railway connects with the main line.

Between Tg. Bobos and Tg. Sentigi is another bay, with a smooth, mangrove-fringed south-western shore and a rapidly extending delta on the eastern side. In the south-eastern corner is the canalized mouth of the Kali Tjemara, which is navigable for praus to Losarang, whence a road leads to the railway line. East of this bay is another large deltaic area, with Oedjoeng Tjimanoek as its most northerly point. It is the delta of the Tjimanoek, one of the largest rivers in western Java, which rises in Papandajan volcano, 150 km. to the south. The delta is not unlike that of the Tjitaroem, already mentioned. Its eastern side has been abandoned and is being smoothed off (Oedjoeng Indramajoe); the western side is building out rapidly, and has actually extended about 5 km. (3 miles) in the last fifty years (Fig. 69), so that

Og. Tjimanoek, and not Og. Indramajoe, is now the most northerly point. The town of Indramajoe is now 16 km. from the main mouth of the Tjimanoek; it can be reached by small craft only. There is a light railway to the main line at Djatibaran, and a main road to Cheribon.

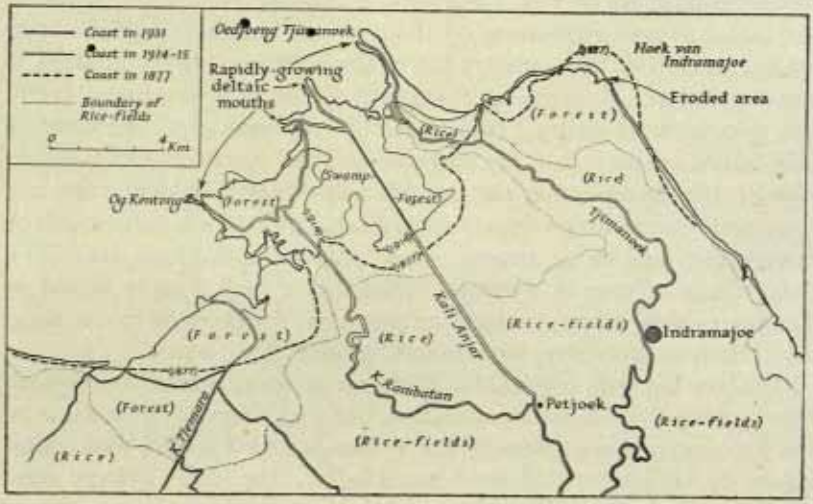


Fig. 75. Coastal changes in the Tjimanoek delta

The delta is growing north-westwards; the Hoek van Indramajoe is being slowly eroded. The area on either side of the 1877 coastline, extending in the more stable portions to the present shore, is covered with forest or jungle ('wildhoutbosch'). The newer (post-1914) area is swamp forest ('vloedbosch'). The oldest river channel is the eastern arm of the Tjimanoek, on which the town of Indramajoe stands; rice-fields follow its course almost to the sea. The outgrowth of land is not without its significance for human life; the population of Indramajoe Regency increased 166% between 1895 and 1920, largely as a result of the draining of the new deltaic land and the consequent improvement of sanitary conditions and availability of more paddy fields.

Based on *Jaarboek van het Mijnwezen*, p. 44 (Buitenzorg, 1929), and on 1/50,000 map (copied from Dutch originals by G.S.G.S. series 4202), sheets 41/XXXVII, C. and D, dated 1931.

From Og. Indramajoe a smooth coast, with a beach of firm black sand, runs south-eastwards for 38 km. (24 miles) to Tandjoeng Tanah (or Tg. Oedjoeng). Rice-fields reach the beach over much of this section, and there are several villages, the chief of which is Dadap. A large bank—Tanah reef—extends eastwards from Tg. Tanah. Beyond the point the coast swings southwards to Cheribon, still with a sandy beach; a long line of settlement follows the road which runs almost parallel to the shore, about 2–3 km. inland.

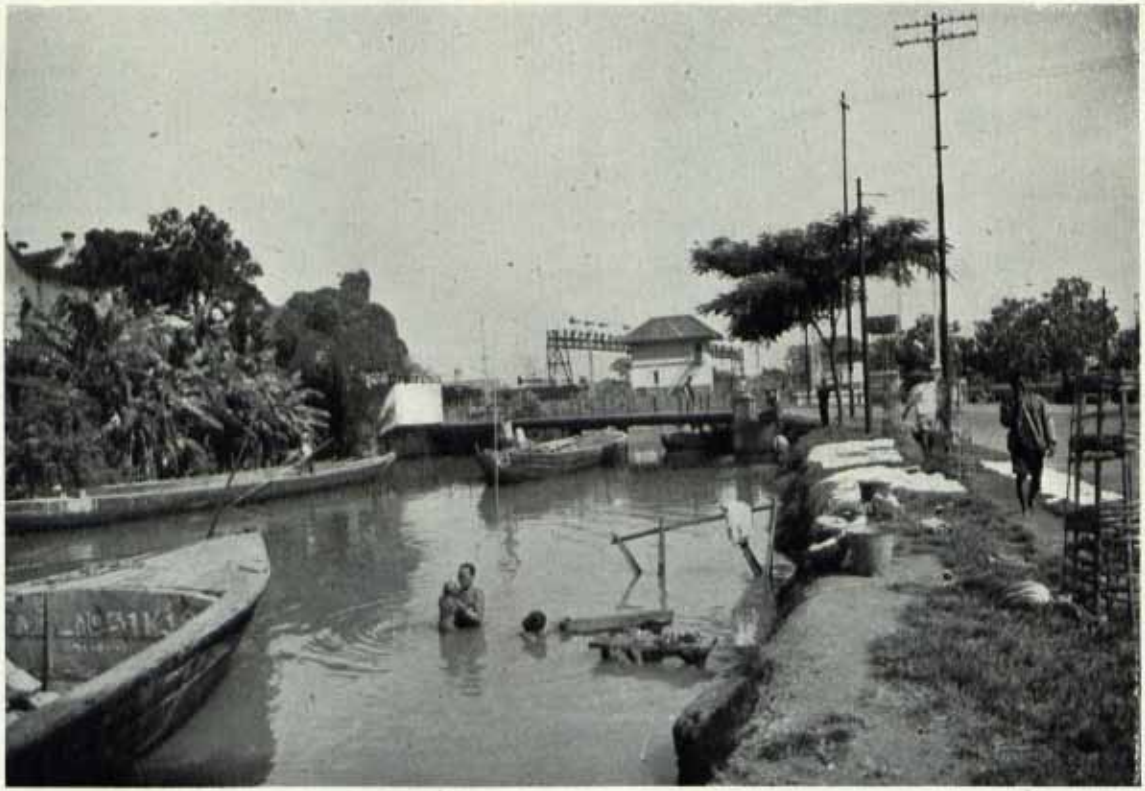


Plate 46. The canal, Batavia

The waterway is the canalized mouth of the Tjiliwoeng. It is used for navigation, bathing and laundry. The bridge in the background carries the electric railway.

Plate 47. Oedjoeng Brebes
This deltaic headland, some 15 km. west-north-west of Tegal, is the mouth of the Kali Pemali. Sedimentation at the side of the main stream and distributaries causes rapid extension of the delta into the sea. Cf. similar phenomena shown in Figs. 75 and 77.

Plate 48. North coast of Java, near Tegal
The airfield, on the north-eastern outskirts of Tegal, lies immediately behind the narrow beach. In the background the main road and the Cheribon-Semarang railway run parallel, crossing the Kali Goeng on bridges.

Cheribon roadstead is a good anchorage in the west monsoon. The harbour, entered between two long piers, will take only small vessels. Cheribon is a focus of main roads, and has State railway connexion westwards to Batavia and south-eastwards to Jogjakarta; an important privately-owned line (gauge 1,067 mm.) runs eastwards to Semarang, and a light railway runs westwards to Kadipaten.

(ii) *Cheribon to Djapara*

This section is the northern shore of Java's 'waist'. Not only is the island here much narrower than further west or east, but the line of volcanic mountains is more centrally disposed, so that the coastal plain is much narrower—averaging only 15 km. in width—and more variable, in one part completely disappearing. There are many rivers, but naturally few large ones, and so few extensive deltas. There are no large ports, and the three small ones—Tegal, Pekalongan and Semarang—are poor, being exposed to both monsoons. The coastal plain is densely peopled and well cultivated with rice, sugar, etc.; it is traversed from end to end by a main road and the Cheribon–Semarang railway; road and rail run for the most part parallel, close to or within 10 km. of the shore.

Between Cheribon and Tegal the coast is low, with a fringe of coconuts, and rice-fields almost reaching the beach except at three small deltaic headlands, which are covered with swamp forest (Plate 47). The main road and railway are fairly near the shore, the former almost reaching it at the village of Gebang; there are also occasional Decauville lines (light narrow-gauge tramways) serving sugar estates and factories. Tegal harbour is only available for small vessels; the roadstead is 2–3 km. offshore. Tegal is on the main east–west road and railway (Plate 48), and also has a road and light railway running inland to Proepoeg junction on the State Railways' Cheribon–Jogjakarta line.

East of Tegal the shore is smooth and wooded; road and rail run parallel behind the beach to Pemalang (Plate 49), beyond which is a deltaic headland, Oedjoeng Pemalang, formed by the mouth of the Kali Tjamal, which is extending seawards. Some 24 km. (15 miles) beyond Og. Pemalang is the small port of Pekalongan, at the mouth of a river of the same name. The town, which was on the coast when its fort was built, in 1753, is now 3 km. inland, reached by a dredged channel. Main road and railway pass through the town.

About 11 km. east of Pekalongan, the coastal plain is sandwiched out by the approach of hills. The hills, which are of Upper Tertiary

(Neogene) rocks, form the northern foothills of the Dijëng volcanic plateau. They rise to about 300 m. within 4 km. of the shore, which is hilly but without cliffs. There is a narrow sandy beach, and the railway line runs behind it at the foot of the densely wooded hills. The hilly section is about 13 km. (8 miles) in length; beyond, the coast is low and alluvial again, with the deltaic headland of Tandjoeng Karawelang formed by the mouth of the Kali Bodri.

Beyond Tg. Karawelang the coast sweeps round in a big bight, Semarang bay, curving northwards on the eastern side to round the volcanic mass of Goenoeng Moerjo. The shore of the bay is low and marshy, and is bordered by a belt of fish-ponds up to 2 km. in width for the greater part of the distance between Kendal and Djapara. The roadstead and port of Semarang lies at the head of the bay. The roadstead is between 1 and 5 km. (1,100 yds. to 3 miles) offshore; the harbour is protected by two moles. The old town of Semarang lies on a small stream, one of the mouths of which has been dredged to form the harbour entrance. It is very low-lying and rather unhealthy, but is an important focus of rail and road communications. It is the terminus of several private railways, the 1,067 mm. line to Cheribon, another on the same gauge to Soerabaja, and a standard gauge (1,435 mm.) line to Jogjakarta, as well as a light railway to Djoewana and other parts of the Moerjo district. Main roads run to the east, west and south.

Beyond Semarang for 40 km. (25 miles) the coast, now trending north-eastwards, continues low, with a belt of fish-ponds, and backed by an alluvial plain which extends eastwards round the southern side of the Moerjo mountain. Many small streams cross the coast-line, and each has a long narrow village stretching inland along it. The smooth, swampy shore comes to an end at Oedjoeng Teloekawoer, a low and crumbled headland, wooded and fringed with coconuts. Beyond the next sandy bay lies the town of Djapara.

(iii) *Djapara to Soerabaja*

This is the most varied section of the whole northern coast, backed now by alluvial plains, now by volcanic hills, and in one section by a limestone ridge; there is only one large delta, near the eastern end.

The bay of Djapara (Teloek Kesemboe) lies between the low, wooded headlands of the Kelor peninsula and Tandjoeng Njamploeng. Djapara town lies in the south-eastern corner, nearly 1 km. up the mouth of the Kali Pengkol, which is navigable by praus. The town is unimportant; it is the only place of any size on the north coast

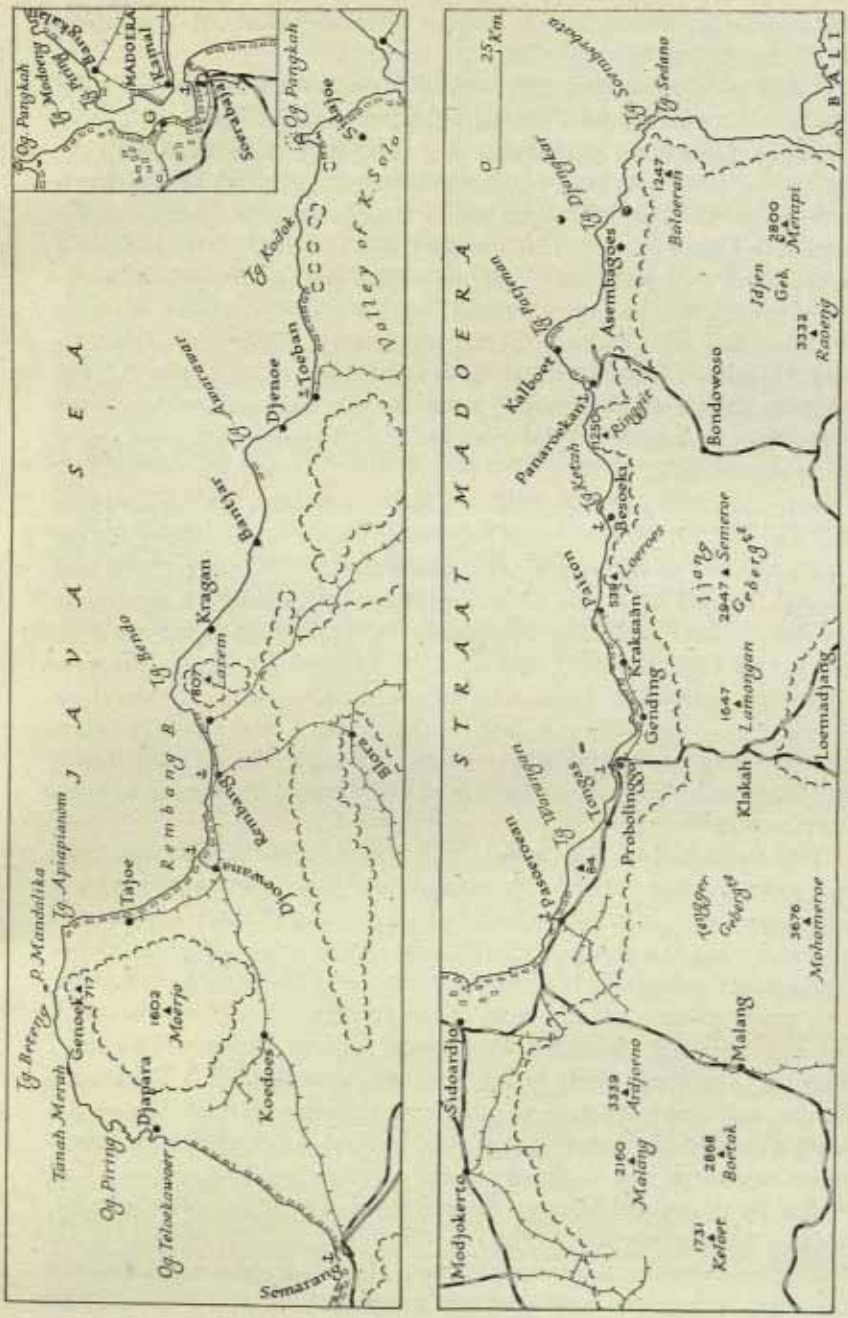


Fig. 76. Java: North-east coast

For location, sources and key see Figs. 72 and 73.

which has no railway, and despite a densely-peopled immediate hinterland it has no first-class road either.

North of Djapara there are several bays, each with a white sand beach, separated by low, reef-fringed headlands. The coast curves gradually eastwards, continuing low and with a rocky foreshore; behind the land rises gradually to teak forests, to which several roads and Decauville lines lead. The most conspicuous point is the reddish headland Tanah Merah. This northern front of the Moerjo peninsula is the least accessible and least populated part of the whole north coast. It ends in Tandjoeng Beteng (Tg. Blenderan), in front of which is Mandalika islet, 74 m. (243 ft.) high, and behind which rise the volcanic hills of Genoek, the summit of which, 717 m. (2,352 ft.), lies 5 km. to the south. Continuing eastwards, the hills peter out, and the north-eastern corner of the peninsula, Tandjoeng Apiapianom, is low and wooded.

Here the coast turns sharply south, and between Tg. Apiapianom and Tg. Bendo, 55 km. (34 miles) to the south-east, there is a large bight, the bay of Rembang. The entire shore of the bay is low and alluvial, backed by a belt of fish-ponds and fronted by a mud-bank 6–8 km. wide. Behind the fish-ponds on the western shore are rice-fields, and then the road and light railway running from Tajoe to Djoewana. Djoewana is a tiny haven, about 4 km. up the Kali Djoewana; it has light railways to Semarang, Tajoe and Rembang. East of Djoewana, the southern shore of the bay has a sandy beach, still frequently backed by fish-ponds, and fronted by several wooded islets and reefs.

The roadstead of Rembang offers some shelter during the west monsoon, but the port has no harbour, and praus carry cargo ashore. The town has light railways leading to Semarang and to two junctions with the main Semarang–Soerabaja line; there is also a good motor-road along the coastal plain. About 10 km. east of Rembang is Lasem, on a small stream; beyond here, the coast projects northwards round the old volcanic mountain Goenoeng Lasem, 806 m. (2,644 ft.). The northernmost point is the low and bare headland Tandjoeng Bendo, and there are several other rocky points. A road follows the coast all round the Lasem projection, beyond which the coast swings south-eastwards and becomes smooth again, fringed by coconuts and dotted by occasional fishing villages. A main road follows the coast, linking these villages.

Beyond the alluvial projection which ends in Tandjoeng Awarawar the coast resumes its south-easterly trend for 16 km. (10 miles), past

Djenoe, which is about 10 km. from Toeban. Toeban is a small port, with a pier; it is not very sheltered in either monsoon. A light railway runs inland to Babad, on the Semarang–Soerabaja line, and main roads also lead southwards to the Solo valley and to the native states of Soerakarta and Jogjakarta.

The coast now trends eastwards, and a belt of wooded limestone hills, rising to summits of 100–150 m., intervenes between the shore and the Solo valley. Between Palang and Brondang the sandy beach is backed by fish-ponds; beyond the latter place the shore-line is more irregular, with almost no coastal plain, several rocky points—e.g. Tandjoeng Pakis and Tg. Kodok—and sometimes a foreshore fringe of coral. A main road follows the coast fairly closely, and a few poor roads and tracks cross the hills southwards to the Solo valley.

At the end of this section of coast is the northward-projecting headland of Oedjoeng Pangkah, formed by the present mouth of the Solo river. This river is the largest in Java, and the enormous quantities of silt brought down by it have created this large new delta within the last half-century (Fig. 77).

Fig. 77. Coastal changes at the mouth of the Solo river
The last two decades have no doubt witnessed further considerable changes in the coastal outline, but no later maps are available.
Source: *Jaarboek van het Mijnwezen*, p. 46 (Buitenzorg, 1929).

Beyond Og. Pangkah the coast turns south, forming the western shore of the funnel-shaped entrance to Soerabaja roadstead. The shore is low and swampy, with a belt of fish-ponds up to 4 km. in width. The entrance to the Westervaarwater—the channel separating Java from Madoera—is only 2·4 km. (2,900 yds.) in width at its narrowest part, between the former island of Mertani and the western end of Madoera. South of these narrows the Javanese shore recedes a little, and is again low and backed by a wide belt of fish-ponds. Then follows a slightly more solid section (a low limestone hill) on which the small town of Grissee is built, after which another belt of swamp and fish-ponds swings round eastwards to Soerabaja. The main road in these parts is well inland except at Grissee which is connected by light railway with the main line to Soerabaja.

Soerabaja is a considerable port, lying astride the lower reaches of the Kali Mas. The whole town is about 13 km. long from north to south; the lowest section is the modern port, Tandjoengperak; about 5 km. from the river mouth is the old town, whilst the European town extends for a further 8 km. up the river to Wanakrama. Soerabaja is an important railway focus. State Railway lines run south-westwards (for Jogjakarta and Batavia), south and south-east (for East Java generally); there is a privately-owned line to Semarang and several light railways or steam-trams.

(iv) *Soerabaja to Bali strait*

This section of coast forms the southern shore of Madoera strait. It is backed by a coastal plain of variable width; there are actually four small plains, averaging perhaps 10 km. in width, separated by northward projections of the volcanic mountains. The latter lie generally nearer to the north coast than to the south, but they are less continuous than further west and thus there are several significant routeways across them. The greater part of the shore-line has a beach of black sand derived from the volcanic rocks.

East of Soerabaja the coast turns south, forming the western shore of Madoera strait. It is low, flat, with a sandy beach overgrown with brushwood, and backed by a belt of fish-ponds between 2 and 5 km. in width. After 50 km. (31 miles) in this direction it runs east, and its trend remains unchanged to the end of the island.

The first of the four coastal plains is that of Pasoeroean. The small port of the same name is sheltered in the west monsoon; there is a prau harbour at the mouth of the Kali Gembong, and the town lies 1 km. upstream, but the proximity of Soerabaja detracts from its

importance. The State Railways' Soerabaja–Banjoewangi line passes through the town; several light railways run inland and there are Decauville lines serving sugar factories. East of Pasoeroean a belt of fish-ponds extends behind the shore to Lekok, 9 km. to the east.

This plain is separated from the plain of Probolinggo by a low coastal swelling of volcanic rock, the northern slope of Goenoeng Semongkrong (84 m.—275 ft.), which ends in the rounded, rocky point of Tandjoeng Warangan, covered with high trees. The coast and hills are wooded, and the main road and railway run inland, behind them.

The coast of the Probolinggo plain extends from the mouth of the Kali Lawejan, just west of Tongas, to a little east of Paiton, a distance of about 53 km. (33 miles). The plain is about 10 km. wide, densely peopled and richly cultivated with rice and sugar. It is crossed by many small streams, some of which have caused small deltaic projections of the shore-line. In general the sandy beach is wooded; it is sometimes backed by a narrow belt of fish-ponds. Probolinggo is a small port, with a prau harbour at the mouth of the Bangor stream, protected by two moles. The State Railways' East Java line turns inland here, to pass through the Klakah gap between Lamongan volcano and the eastern foothills of the Tengger mountains. A light railway follows the coastal road eastwards, about 2–4 km. from the shore, and there are several Decauville lines serving sugar factories, both behind Probolinggo and in the vicinity of Gending, Kraksaän and Paiton, further east.

East of Paiton, the foothills of Goenoeng Loeroes, a northward spur of the Ijang mountains, approach the coast, and for about 5 km. there is only a narrow strip of beach, backed by hill-slopes, and followed by the main road.

The small plain of Besoeki fronts the sea for little more than 12 km. (7 miles); in the middle of this stretch is the deltaic headland Tandjoeng Ketah, formed by the mouth of the Kali Deloewang. The small port of Besoeki lies on the western side of this delta, up the mouth of a small stream. The coastal road cuts across the head of the delta, and sends a branch inland to Bondowoso.

The northern slopes of Goenoeng Ringgit (1,250 m.) again interrupt the coastal plain. The beach is low and sandy, and is closely followed by the road; it is backed by steep hills. There is some coral on the foreshore, as at the headland Tandjoeng Pasir Poetih (='white sand'). This section of coast is about 10 km. (6 miles) in length.

The next plain begins a few kilometres west of Panaroekan, and

extends eastwards to the foothills of the Baloeran mountain. The western part of the plain contains the large but old deltaic projection built up by the Kali Sampoean. This ends in the low, sandy point Tandjoeng Patjenan. It is richly cultivated with rice and sugar. The present mouth of the Kali Sampoean is much further west, near Panaroekan, a small port with a pier, offering some shelter in the east monsoon, but difficult of approach between January and March. Panaroekan is the terminus of one of the State Railway branches in East Java; paralleled by a road, this runs inland to Bondowoso and through the wide gap between the volcanic mountains of Ijang and Idjen. Further along the old delta, which has a fringe of coconuts all the way round, is the small sugar port—only a roadstead—of Kalboet. East of the deltaic area the plain continues but with a changed aspect; cultivation almost ceases, and a dry-looking savanna takes its place, except at the old and overgrown deltaic headland Tandjoeng Djangkar, behind which lies the cultivated area around Asembagoes.

The north-eastern corner of East Java is made of spurs from the extinct volcano Baloeran. The plain disappears entirely between Tandjoeng Soemberbata and Tg. Sedano, and a line of islets and coral reefs fringes the shore. The main road takes an inland course, behind the volcano.

The East Coast

The east coast of Java is short and of no great importance outside the small port of Banjoewangi. The northern section is backed by the foothills of Baloeran and the Idjen highlands; the southern part is formed by the semi-arid Blambangan peninsula; in the middle is an alluvial plain.

From Tandjoeng Sedano to the entrance of Bali strait the coast is in general low and densely wooded. The main road gradually approaches the shore, reaching it at the entrance to the strait, where the Idjen foothills are in closest proximity. The strait is narrowest at its northern entrance, just under 2 km. (about 2,000 yds.) of sea separating Java and Bali.

Banjoewangi (the name means 'fragrant water') has a small pier and a prau harbour. It is the eastern terminus of the State Railway; rail and road run inland, south-westwards. South of the port the coast, trending north–south, is low and marshy for a time, subsequently becoming densely wooded.

Pangpang bay is a long sheltered haven, protected on the east by the

limestone peninsula which ends in Tandjoeng Semboeloengan. Its eastern shore, on the peninsula, has a sandy beach and a coral reef; the low and swampy mainland shore has a fringe of mangroves.

The rest of the east coast comprises the north-eastern shore of the Blambangan peninsula, a dry limestone plateau, devoid of population. The eastern extremity is Tandjoeng Slokah.

The South Coast

The south coast of Java presents a fundamental contrast with the north coast. It is backed for the most part not by alluvial plains but by hills and mountains; it is often bold and rugged, and drops steeply off-shore to oceanic depths. It is exposed to the swell of the Indian Ocean, which is accentuated during the westerly monsoon. Broadly speaking there are only two coastal types, both equally inhospitable—steep rugged slopes and cliffs on the one hand, and belts of high, steep-fronted sand dunes (up to 20 m. or more in height) on the other. The greater part of the coast is fringed with a narrow belt of coral reefs, which adds to the difficulties of approach from the sea. There is only one harbour of any significance, Tjilatjap, situated nearly half-way between the two ends, and a few anchorages which are generally only available during one monsoon but not both. Except in the lower parts the coast is almost unpopulated, in striking contrast with the great density of population over most of the island; communications with the interior are almost non-existent for considerable distances. The rivers which intersect the coast are of no importance; most of those along the lower stretches of coast are blocked at the mouth by sand banks.

The volcanic mountains of Java being more or less centrally disposed, rocks of volcanic origin reach the south coast in only a few places. The greater part of this coast is made of Neogene (Upper Tertiary) sedimentary rocks, amongst which limestone plays a very conspicuous part, especially in the east, where rugged cliffs with caves are a characteristic coastal type. The ocean south of Java is not a much-utilized sea lane like the Java Sea, but as from the latter the volcanoes provide useful landmarks for such shipping as there is. Visibility is poorest during the afternoons, and especially during the east monsoon. The foreshore is also liable to bad visibility, but in this case the sea spray which results from the heavy surf is the cause.

For purposes of description the south coast may be divided into four sections, each with slightly different characteristics and with several subdivisions.

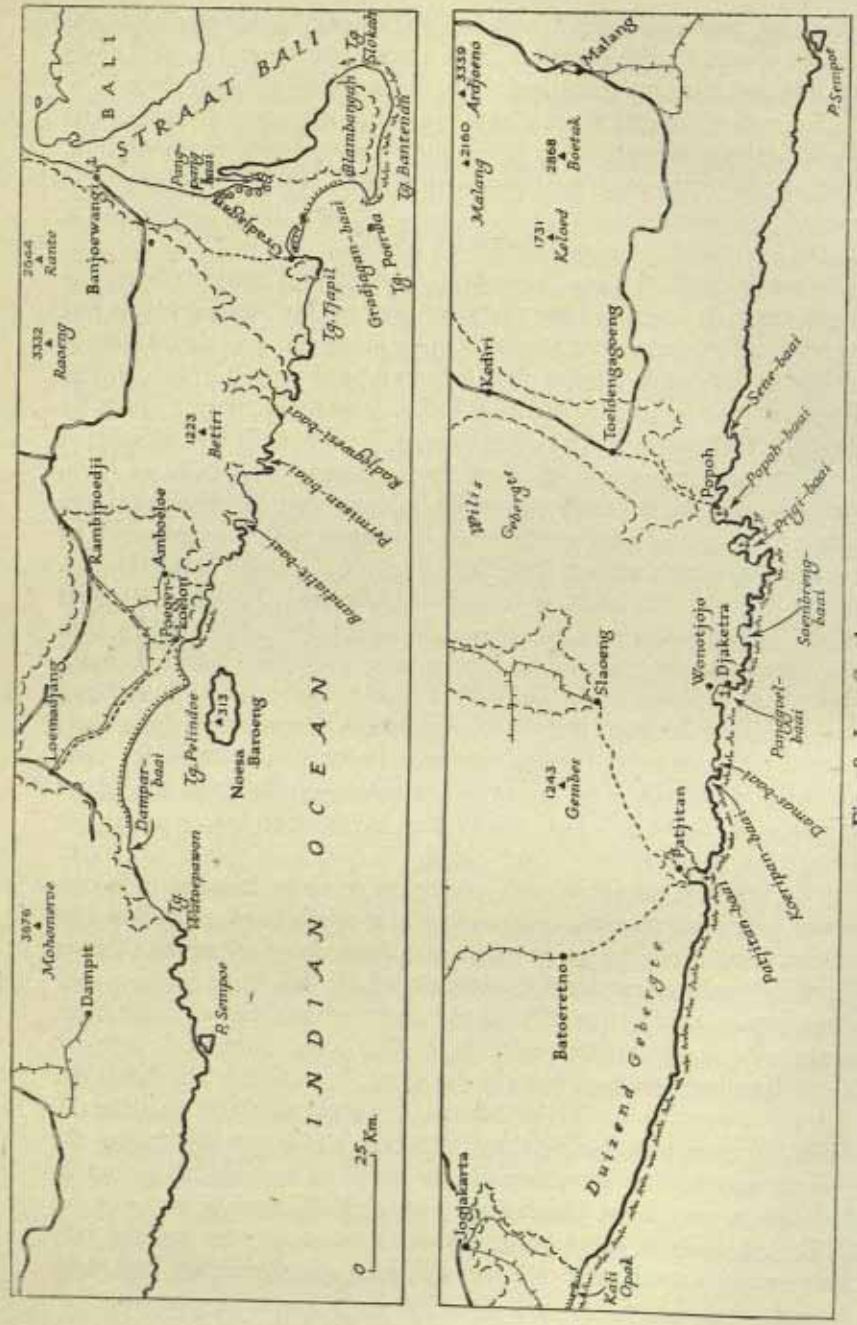


Fig. 78. Java: South-east coast

For location, sources and key see Figs. 72 and 73.

(i) From the Blambangan peninsula to the Kali Opak (south of Jogjakarta)—characterized, apart from two flat-shored bays in the east, by rugged limestone cliffs with but few indentations; the most rugged and indented section occurs where an outcrop of old volcanic rock forms the coast.

(ii) From the Kali Opak to Oedjoeng Madasari—generally of lower and smoother character, sandy and backed by alluvial plains; in this section lies Tjilatjap.

(iii) From Og. Madasari to Oedjoeng Genteng—a generally low shore but backed by high hills and mountains.

(iv) From Og. Genteng to the Soenda strait—the most irregular section, the steep shores of Wijnkoops bay contrasting with low sandy beaches further west.

(i) *Blambangan peninsula to Kali Opak*

(*a*) *The Blambangan peninsula.* This limestone plateau, rising to over 300 m., is almost an island, being joined to the mainland only by a flat alluvial isthmus which extends from Pangpang bay, in Bali strait, to Gradjagan bay on the south coast. It slopes fairly steeply to the north, but more gently, with a rather waterless surface, covered with deciduous wood and scrub, towards the south. The southern shore is low, but landing is not easy owing to the surf, which is accentuated by the presence of a narrow coral reef. The whole peninsula is uninhabited, and has no roads.

(*b*) *Gradjagan bay.* This bay, which is open to the south-west, but provides anchorage during the east monsoon, has a broad sweep of sandy shore extending from Tandjoeng Poerwa, the western extremity of the Blambangan peninsula, to the Segara Anak, the broad lagoon-like mouth of a stream which runs for the greater part of its course parallel to the coast, forming a swampy area behind coastal sand dunes. The only village is Gradjagan, in the extreme north-west; from here a poor road runs northwards to the terminus of a light railway at Bentjoeloek, which leads to Banjoewangi on Bali strait.

The western side of Gradjagan bay runs north–south and ends in the sandstone headland of Tandjoeng Tjapil.

(*c*) *Tg. Tjapil to Poeger-koelon.* Most of this section consists of sandstone headlands, fringed by numerous rocks and islets (though no coral reefs) alternating with small bays, at the head of which are sandy beaches. The coast and the immediate hinterland of wooded hills and low mountains, rising to several summits over 1,000 m., are almost

uninhabited, and there is naturally therefore a complete absence of means of access into the interior.

The cliffs of Tg. Tjapil soon give way to another sandy beach backed by an alluvial plain, the lowest part of which, behind the mouth of the Kali Baroe, is marshy. Then follows a succession of capes and bays for over 50 km. Of the five main bays, only three—Radjegwesi, Permisan and Bandialit—have possible anchorages and landing places, from which tracks run to neighbouring plantations. Beyond Bandialit bay are some high cliffs of volcanic rock, with several offshore islets, and then another stretch of sandy beach with the plain of the lower Kali Majang behind. The village of Tjoerahredjo lies near the mouth of this river; a poor road runs inland to the light railway terminus at Amboeloe. Between this little plain and Poeger-koelon is an isolated limestone ridge (Goenoeng Watangan, 480 m.) which drops steeply to the coast for nearly 10 km.

The island of Noesa Baroeng is a large detached mass of the limestone hills of south-eastern Java. About 15 km. long and 5 km. wide, it lies about 5 km. from the nearest point on the mainland. It has a rough surface and steep sides, and is uninhabited. The south coast has a narrow sand beach.

(*d*) *Poeger-koelon to Tandjoeng Watoepawon.* For some 60 km. west of Poeger-koelon the coast forms a bight, the smoothness of which is only interrupted by the southward projecting sandspit known as Tandjoeng Pelindoe. The eastern two-thirds of this bight present a low sandy shore, behind which is the extensive plain of Loemadjang, one of the few large plains in southern Java. Dunes fringe the shore, and the longshore drift is presumably eastwards, for the rivers, of which the largest is the Kali Bandajoeda, run for long distances in an easterly direction behind the dunes before entering the sea. There is no coastal population, though some villages exist on the rivers behind the dunes, and the plain itself is densely peopled. The only town near the coast is Poeger-koelon, at the eastern extremity of the plain and bight, and near the mouth of the Kali Bedadoeng; from here motorable roads run inland, north-westwards to Loemadjang and north-eastwards to Rambipoedji, both of which places have railway connexion with the rest of Java.

The western shore of the bight, beyond the slight embayment known as Dampar bay, is backed by hills, though it remains a sandy beach, as far as Tandjoeng Watoepawon.

(*e*) *Tg. Watoepawon to Popoh bay.* This is a long and monotonous stretch of coast, 130 km. (80 miles) in length, little indented and for

the most part high and steep, composed from end to end of Tertiary limestone. The first section, as far as Poelau Sempoe, contains three small bays, but little is known of them and they have no villages or communications. Poelau Sempoe is a high, rocky island (260 m.), uninhabited and inaccessible. The entire coast for the next 80 km. (50 miles) is also inaccessible, almost without indentations, covered with deciduous woodland except where slopes are too steep, and quite uninhabited. At the end of this long stretch are three bays, Sene bay, Boemboen bay and Popoh (or Gemah) bay, separated by high, rocky headlands. The last of these is the largest and most sheltered, and on its eastern side, off Popoh village, is anchorage which is reasonably safe except during the worst storms of the east monsoon. The limestone plateau is reduced to its narrowest width behind this bay, and a road runs across the narrow watershed at little more than 200 m. to the southern end of the Kediri plain, which it follows to the main railway line at Toeloengagoeng.

(*f*) *Popoh bay to Patjitan bay*. This section is more rugged and indented than the last, and contains several bays where anchorage is possible. The eastern half, as far as Panggoel bay, is more rugged than the western owing to its being formed of hard volcanic rock; it has also a number of small off-lying islets. Prigi (or Segoro Wedi) bay, separated from Popoh bay by a high and steep-sided peninsula, is the largest sheltered anchorage on the whole south coast; its sides are very steep, but at the head is a flat sandy beach, behind which stands the village of Tasikmadoe. There is scarcely any plain, however, and the hills behind are only crossed by tracks.

A rocky and indented stretch of about 20 km. (12 miles) separates Prigi bay from Soembreng bay, which is rather similar, with steep sides and a sandy beach at the head, but without good anchorage. On the small plain behind this beach is the village of Moedjoengan, with several hamlets, but there is no road into the interior.

The next large indentation is Panggoel bay, which opens to the south-west and accordingly only gives shelter during the east monsoon. The sides of the bay are steep, but at the head, in the north-eastern part, is a flat sandy beach with two river mouths. The anchorage is in Djaketra bay, a small inlet between two hills on the eastern side. There are several hamlets round the bay, including Djaketra which has a small pier for boats, and in the plain at the head is the village of Wonotjojo. There are however no roads leading inland, and the mountains separating the coast from the Madioen plain are crossed only by tracks.

Between Panggoel and Patjitan bays the coast is rugged and almost inaccessible, forming cliffs all the way except at the heads of two small bays, Damas and Koeripan. From the shore of the former a track leads inland for a short distance, to Ngadirodjo and other villages.

Patjitan bay resembles others on this coast in having high, steep and rocky east and west shores, with a wide sweep of sandy beach at the head. This beach is subject to very heavy surf and landing is impracticable. The anchorage is on the western side, where the village of Temperan has a small beach and landing pier. From here a road zigzags over the dry limestone uplands north-westwards, striking a light railway terminus at Batoeretno and proceeding with the railway to Soerakarta. Another road runs round the head of the bay and across the small plain formed by the Kali Grindoeloe to Patjitan, threading its way thence across the hills to the plain of Madioen.

(*g*) *Patjitan bay to the mouth of Kali Opak.* This stretch of coast, 90 km. (56 miles) in length, borders the limestone plateau known as Goenoeng Sewoe or Duizend-gebergte ('thousand hills'). The plateau averaging about 300 m. (1,000 ft.) above sea-level, is pot-holed and almost waterless, and very sparsely populated. The coast is high, steep, almost unindented and of desolate appearance; there are occasional beaches and frequent caves, but the shore is quite unapproachable from the sea owing to the heavy swell and surf.

Suddenly the limestone hills cease, giving place to an alluvial plain bordered by sand dunes.

(ii) *From the Kali Opak to Oedjoeng Madasari*

(*a*) *Kali Opak to Tandjoeng Karangboto.* For 95 km. (60 miles) westwards from the end of the Duizend-gebergte the shore is an almost continuous belt of sand dunes, of considerable dimensions, between 1 and 2 km. wide and between 8 and 20 m. high. The dunes are broken only at infrequent intervals by rivers which have in many cases wandered through marshes for some distance parallel to the dunes before finding an exit to the sea. The shore is shelving and has a narrow fringe of coral reef, and is quite unapproachable from the sea owing to the heavy surf. There are no villages on the coast or on the dunes, but the alluvial plain behind is densely peopled and covered with rice-fields; there are many roads, and the main Batavia–Jogjakarta line of the State Railway runs in an east–west direction, between 5 and 15 km. inland.

(*b*) *The shore of the Doewoer hills.* Separating the flat shore just

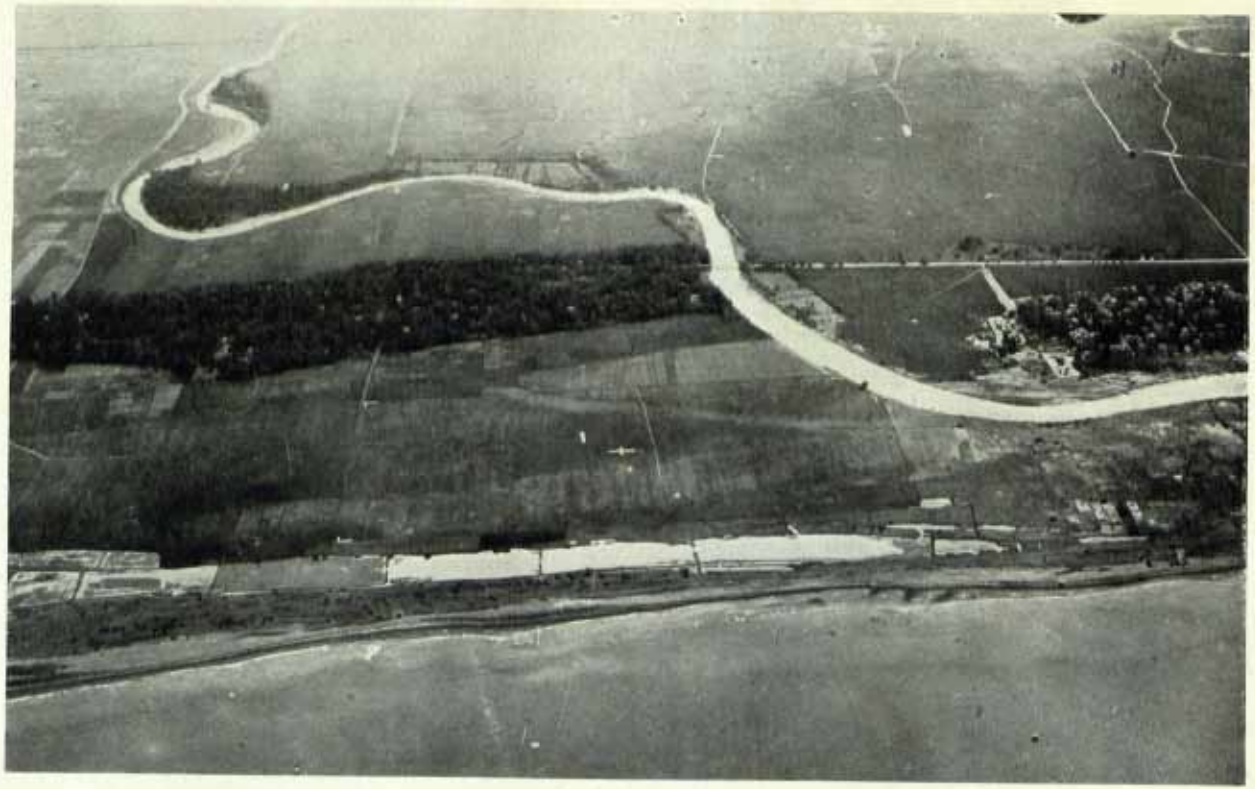
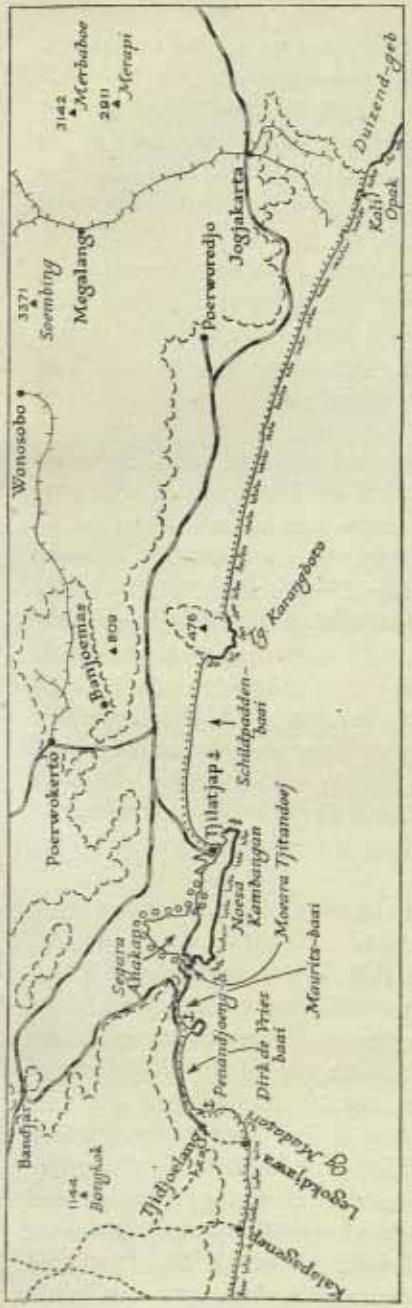


Plate 49. North coast of Java, near Pemalang

The river is the Kali Ramboet. Between the airfield and the narrow beach is a belt of fish-ponds. The main coastal road crosses the river on a bridge; the parallel railway is here just too far inland to be visible.

Plate 50. Tjilatjap harbour, eastern entrance
Tjilatjap is well sheltered by the eastern end of Noesa Kambangan, with limestone cliffs and rocks (see also Plate 52).

Plate 51. Tjilatjap harbour, western entrance
At the western end of Noesa Kambangan this shallow mangrove-fringed channel gives an alternative access to Tjilatjap for native craft.



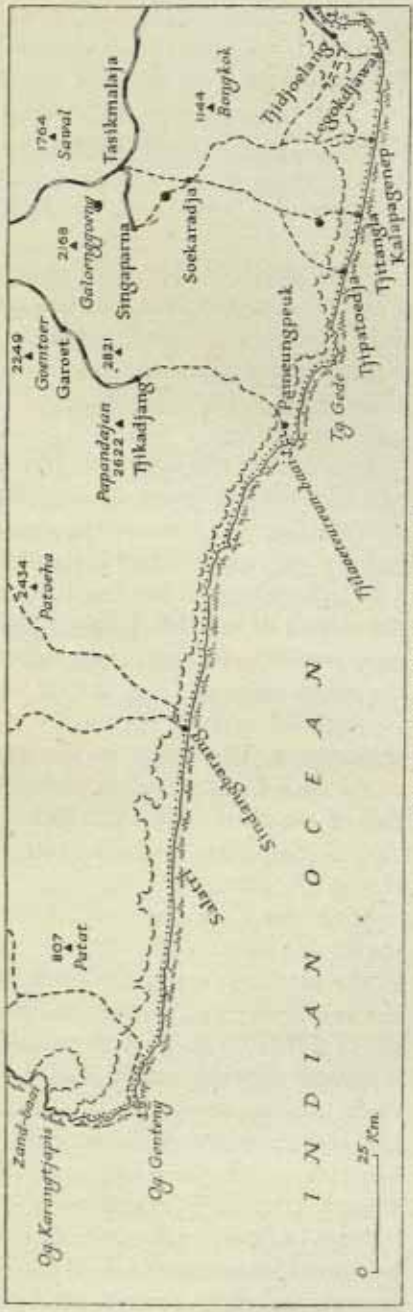


Fig. 79. Java: South-west coast

For location, sources and key see Figs. 72 and 73.

described from Schildpadden bay is a mass of hills formed of Tertiary limestone, the summit of which rises to 476 m. (1,562 ft.). These hills protrude in most conspicuous fashion from an otherwise low and smooth coast, in a series of cliffs, the most prominent of which is Tandjoeng Karangboto. There are numerous caves at the foot of the cliffs, which are quite unapproachable from the sea owing to the heavy surf, which is accentuated by the fringing coral reef.

(*c*) *Schildpadden bay*. The sand dune coast resumes as suddenly as it ended, extending for a further 40 km. (25 miles) to Tjilatjap. Only one large river crosses the dune belt, the Kali Serajoe, but its mouth is inaccessible as indeed is the whole of the bay, owing to surf. The plain behind is densely peopled, as before, and well supplied with communications.

At the western end of the bay, sheltered from the south and west by a long narrow limestone island called Noesa Kambangan, is the port of Tjilatjap. The town is situated on a low peninsula, washed on the east by the waters of Schildpadden bay, on the south by Tjilatjap inlet, which separates it from Noesa Kambangan, and on the west by the mouth of the Kali Donan. The inlet and river mouth provide the only perfectly safe anchorage during both monsoons on the whole of the south coast of Java, and as the entrance channel varies in depth between 6·8 m. (22½ ft.) and 8·8 m. (29 ft.), the port is of considerable importance. The quays, on the western side of the town at the mouth of the Kali Donan, are connected by railway with the main east–west line of the State Railway, which is joined about 20 km. to the north-east. A first-class road also runs inland to Banjoemas and so to the rest of the country.

(*d*) *Noesa Kambangan*. This island is nearly 30 km. long and has a maximum width of about 5 km.; it reaches a height of 200 m. (650 ft.) in the east, but is mostly lower than this. It is densely wooded, and the southern coast is steep and rocky, with several caves and a fringe of coral (Plate 52). Its eastern half is separated from the mainland by a narrow channel, called Kali Pasoeroehan, navigable only by native craft, and swampy on its northern side. At the eastern end this channel runs into Tjilatjap inlet (Plate 50); at its western end is a large lagoon, Segara Anakan, very shallow, and bordered by mangrove swamp (the only example on the south coast) and with several villages built on piles on the eastern shore. A swampy plain, traversed by the sinuous course of the Tjitandoej, extends inland from this lagoon. Its south-western exit is a tortuous channel, again navigable

only by native boats, known as Moeara Tjitandoej, which completes the separation of Noesa Kambangan from the mainland (Plate 51).

(*e*) *Penandjoeng bay*. Between the western end of Noesa Kambangan and Oedjoeng Madasari is Penandjoeng bay, 32 km. (20 miles) across and divided into two unequal parts by a limestone promontory, which is almost an island, called Pasir Panindjoan (Plate 53), the summit of which is 148 m. (485 ft.). The eastern part, Maurits bay, is hilly with low cliffs on the north-eastern side, and has a sandy beach on the north-western side. The western and larger part is Dirk de Vries bay, also bordered by a narrow belt of sand dunes, but backed by a wider plain. A branch of the State Railway, paralleled by a road, runs behind the shore of both parts of the bay, about 1 km. from the sea; the railway, which terminates at Tjidjoelang, inland from the western shore of Dirk de Vries bay, joins the main east–west line at Bandjar, at the head of the Tjitandoej plain. On the narrow isthmus (only 300 m. wide) which joins Pasir Panindjoan to the mainland is the town of Pangandaran. Both parts of Penandjoeng bay have anchorages protected from the west though not from the east monsoon. One lies in Maurits bay off the town of Pangandaran, the other at the western end of Dirk de Vries bay.

At the south-western end of Penandjoeng bay the dunes cease and the shore becomes more broken, and with a fringe of rocks, round the low point of Oedjoeng Madasari.

(iii) *Oedjoeng Madasari to Oedjoeng Genteng*

For 240 km. (150 miles) the coast, trending slightly north of west and almost without inlets, is low, monotonous, and wooded, with cultivated patches around the villages. The dissected slopes which rise behind the narrow coastal plain continue to be formed of Tertiary rocks, with limestones forming softer country in the east; sandstones and tuffs give areas of sharper relief in the centre and west. The whole shoreline has a fringing coral reef and a narrow belt of sand dunes. Of the innumerable streams which enter the sea only a few of the smaller ones proceed directly; the larger ones, more silt-laden, have deposited much of the material which now forms the sand banks, and their lower courses usually run parallel to the dunes for some distance before breaking through. The coast is not thickly populated; there are few villages actually on the shore, but many are situated behind the dune belt, on the lower courses of the rivers. Owing to the nature of the hinterland there are few means of communication with the

interior, and only one motor road leads inland in the whole distance from Penandjoeng bay to Og. Genteng.

(*a*) *Og. Madasari to Tandjoeng Gede.* The landward slope behind this stretch of coast is gentle. Cart-tracks run inland, eventually joining motorable roads, from several villages situated behind the dune belt, e.g. from Legokdjawa, Kalapagenep, Tjitangla and Tjipatoedja (in order from east to west).

(*b*) *Tg. Gede to Tjilaoeteureun bay.* This short section is backed by a narrow alluvial plain, and the belt of dunes broadens in the low headland of Tg. Gede and in the similar promontory (Tandjoeng Bodjong Kerentjeng) which marks the southern end of Tjilaoeteureun bay. This bay offers the only anchorage between Penandjoeng bay and Oedjoeng Genteng, and even this is not very safe (Fig. 80). From the landing place in the south-east corner of the bay the only motorable road in this part of Java runs inland to Pameungpeuk, and thence across the mountains skirting Papandajan volcano, to the upland plain of Garoet, which is on a branch of the main east-west State Railway line.

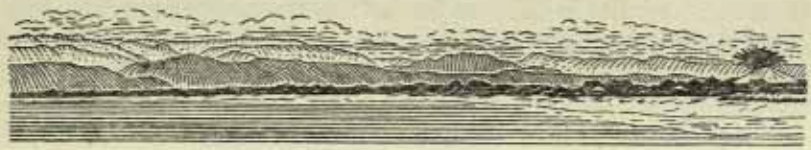


Fig. 80. Tjilaoeteureun bay
Surf-beaten beach, exposed to the west monsoon. View near the landing place, looking inland towards Pameungpeuk.
Drawn from a photograph.

(*c*) *Tjilaoeteureun bay to Oedjoeng Genteng.* This section repeats for a further 150 km. (nearly 100 miles) the features previously described —a fringe of coral, a belt of dunes with interrupted river-mouths, a narrow coastal plain with villages, dissected slopes rising steeply behind; and a paucity of communications except tracks connecting one village with another. The only small town having road communication with the regions beyond the mountains is Sindangbarang, situated behind the dune belt on the Tjisadea. On reaching the inner edge of the coastal lowland, some 4 km. from the shore, this road forks. One branch runs due north and climbs to over 1,000 m. before dropping to Tjibeber on the Batavia–Bandoeng railway line; the other strikes north-eastwards and winds round the foot of the Patoeha volcano, rising to about 1,800 m. before dropping to the plain of Bandoeng.

Plate 52. Noesa Kambangan, eastern end
A rocky and coral-fringed shore is backed by steep, wooded slopes. Bare cliffs are uncommon in the East Indies, owing to the rapidity of weathering and vegetative growth.

Plate 53. Penandjoeng peninsula (Pasir Panindjoan)
The limestone peninsula has a rough and wooded surface. The isthmus, only 300 m. wide, carries the town of Pangandaran, concealed by trees. There is anchorage in Maurits bay (on the left). For location see Fig. 79.

Plate 54. Wijnkoops bay, mouth of Tjimandiri
Like most rivers on the south coast of Java the Tjimandiri has a sand bar across its mouth. Beyond the airfield is the conspicuous hill referred to on p. 190 and illustrated in Fig. 81.

The coastal plain gets broader, and the hills behind lower, as the western end of this section of coast is approached, and a slight embayment ends in the low, wooded peninsula of Oedjoeng Genteng which, projecting in a southward direction, gives shelter on both sides at different times. There is anchorage off the western side during the east monsoon, and off the eastern side during the west monsoon when the wind direction is north-westerly; the former is far the more important of the two, and on this side there is a pier. From the village of Genteng a road leads along the coastal plain in an easterly direction and thence northwards over the hills to the Tjimandiri valley, Wijnkoops bay and the Batavia–Bandoeng railway.

(iv) *Oedjoeng Genteng to Javahoofd*

The shore line and immediate hinterland of this section is varied in character, due to the greater variety of rocks which build the landscape. There is one consistent feature, however, and that is the existence all the way round of a narrow, fringing coral reef.

(*a*) *Og. Genteng to Og. Karangtaradje*. The coast between Og. Genteng and the western extremity of Java forms a large bight, the eastern end of Wijnkoops bay which owes its origin to faulting. At Og. Genteng the coastal direction changes suddenly to S–N, and swings round past Zand bay to SW–NE on the south-eastern shore of Wijnkoops bay. For the first few kilometres from Og. Genteng the shore continues low, but then, approaching Oedjoeng Karangtjapis it becomes steep and eventually rocky, as some of the oldest rocks in

Fig. 81. Wijnkoops bay

View looking north-westwards across the mouth of the Tjimandiri to the northern shore of the bay; showing on the right the conspicuous hill mentioned on p. 190. See also Plate 54.
Drawn from a photograph.

Java—resistant metamorphic rocks probably of Cretaceous age—compose the shore for several kilometres in the vicinity of Zand bay. Zand bay, which lies between Og. Karangtjapis and Og. Karangragoek, has steep and rocky north and south shores, and a sandy beach backed by marshes at the eastern end; the Tjiletoen which flows into it is navigable for native craft for several kilometres.

The coast continues high, steep and forested on the south-eastern side of Wijnkoops bay, but at the head of the bay is a flat north–south stretch, about 7 km. in length, with a conspicuous hill (138 m.) in the middle, just behind the shore (Plate 54 and Fig. 81). South of this hill is the mouth of the Tjimandiri, blocked by a shoal and inaccessible owing to heavy surf. North of it, in the north-eastern corner of the bay, is the anchorage and tiny port of Palaboehanratoe, which has a pier. The anchorage is safe except at stormy periods during the west monsoon. A good road runs inland, climbing the slopes above the Tjimandiri valley to the Batavia–Bandoeng railway at Tjibadak, with a branch southwards across the hills to Genteng.

The northern shore of the bay is backed by high, forested, volcanic hills; the shore is low in the eastern part, but becomes higher, steeper and more rocky at the mouth of the bay, between Oedjoeng Tjikembang and Og. Karangtaradje.

(*b*) *Og. Karangtaradje to Javahoofd.* In this section the 'normal' direction, slightly north of west, is resumed. The coast is entirely low and sandy, and continues to be fringed by a narrow coral reef. A narrow coastal plain widens rapidly into a broad alluvial expanse which ends at Tandjoeng Panto, a low promontory just east of the mouth of the Tjibinoeangeun. There are a few villages on this plain, connected by a road which runs inland to Malingping and thence across the island to Serang. The easiest means of access to this road from the sea is by native boat up the mouth of the Tjibinoeangeun to the village of Moearabinoeangeun.

Westwards of Tg. Panto the coast continues smooth, sandy and reef-fringed, but the plain behind, densely wooded and almost unpeopled, is not alluvial and lies at an elevation of 20–50 m. (70–160 ft.). Towards Tg. Sodong there is a backing of volcanic hills rising to 300–600 m.

Between Tg. Panggorak and Tg. Terelang, both low, sandy and wooded promontories, lies a swampy stretch which forms an isthmus only 2 km. wide, on the northern side of which is Welkomst bay, on the Soenda strait.

The southern shore of the Oedjoengkoelon peninsula, the western

extremity of Java, is low, but in the south-west corner is the forested volcanic eminence Goenoeng Pajoeng, 480 m. (1,575 ft.) high, which drops precipitously southwards to the sea in Tandjoeng Tjangkoeang, and more gradually westwards to the rocky headland Javahoofd.

ANIMAL LIFE

In both Java and Sumatra animal life is extremely rich and varied. Though the larger mammals are diminishing in numbers and, especially in Java, becoming restricted to the remoter and less civilized districts, the abundance of the smaller forms of animal life is amazing. By day the brilliantly coloured birds and butterflies are a constant delight to the European visitor. By night the geckos or tjitjacks on the ceiling and the unceasing chorus of frogs and cicadas out of doors bear witness to the exuberance of animal life in the tropics.

Generally speaking the fauna of Java and Sumatra is like that of India and Burma. In both islands, for instance, there are tigers and the Indian elephant is found in Sumatra. In many cases, however, the animals of Java and Sumatra, though similar to those of India, are not of identical species. The resemblance between the faunas of Java, Sumatra, Borneo and the Malay peninsula is even closer than that between those of Java and Sumatra on the one hand and India on the other. This close similarity of fauna clearly indicates that the three great western islands of the Malay archipelago, all of which are separated by very shallow seas, were once joined to each other and to the mainland of Asia. The fauna of Java stands a little apart from that of Sumatra and Borneo and lacks a number of animals found in the latter islands. For instance, the tapir is found in Sumatra, Borneo and the Malay peninsula, but not in Java; the orang utan is found only in Sumatra and Borneo. Facts like these suggest that Java became an island earlier than Sumatra or Borneo.

Monkeys of many kinds are found in Java and Sumatra; apart from the orang utan, the most interesting of them is the graceful and agile gibbon. These animals are common in Sumatra, but in Java they are now practically extinct except where protected; in the famous forest reserve of the botanical garden at Tjibodas their call may be frequently heard, though they are seldom seen. Besides the true monkeys there are several lemur-like animals, including the quaint *Tarsius spectrum*.

The largest of the carnivores is the tiger which is still numerous

and often claims human victims in both Java and Sumatra. Tigers are hunted, but not systematically, as they help to keep down the numbers of wild pigs which would otherwise be a menace to the crops. Other cats include the leopard and panther as well as several smaller species.

The elephant was at one time found all over Sumatra, but now it is restricted to a number of isolated areas. In former times the sultans of Atjeh domesticated it and up to 1929 the Dutch army in the Netherlands Indies used elephants for transport. The one-horned rhinoceros is still common in Sumatra; the two-horned species was abundant in the forests of Java a century ago, but is now nearly extinct. Besides the elephant and rhinoceros the hoofed animals include the banteng, a kind of large wild ox, deer, and a goat-like antelope, found in Sumatra.

Other interesting mammals are the Malay bear, a harmless creature which eats coconuts, and the mydaus, an evil-smelling badger-like animal found in the high mountains of Java.

Among the birds of Java are crows, orioles, pigeons, cuckoos, hornbills and honey birds. Rice birds and weaver birds do much damage to the rice. The green jungle fowl, a relative of the domestic hen, is found in Java; this, the peacock and various other Javanese birds do not occur in Sumatra. Several very fine birds, including the argus pheasant and the great helmeted hornbill live in Sumatra and Borneo, but not in Java.

Snakes are common in both Java and Sumatra, not infrequently making their way into the houses; the poisonous species are not very dangerous as their fangs are mainly used in self-defence. The commonest snakes of Java are the ular ribu (*Cylindrophis rufa*), which is about 2½ ft. long and has a red ring round its neck, the ular tanah, a kind of adder, and the ular balang, which can be virulent when aroused. Pythons and hat snakes are found and the hooded cobra sometimes reaches a length of 10 ft. Sea snakes up to 6 ft. long are found in the Indian Ocean.

Among the insects, ants and termites ('white ants') are omnipresent. Though many of the ants bite fiercely, they do much good by clearing away garbage and refuse. In houses elaborate precautions are necessary to protect food from them. As in other tropical countries, termites are a constant danger to woodwork and do an enormous amount of damage. Mosquitoes, sand-flies, bees, wasps, centipedes and scorpions are common nearly everywhere.

For an account of the vegetation of Java and Sumatra see chap. XII.

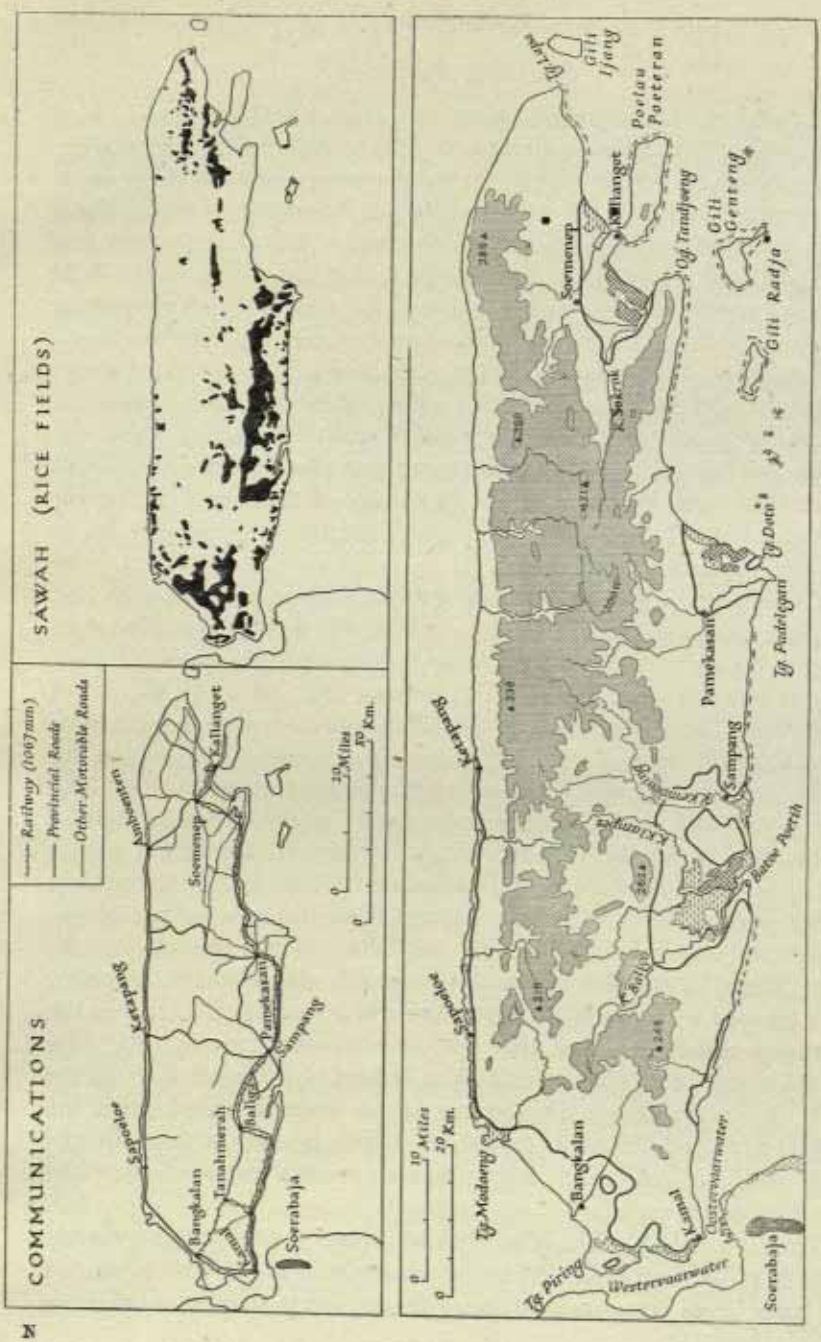


Fig. 82. Madoera

Key to large map: land over 100 m. stippled; salt-pans, cross-hatched; fish-ponds, broken horizontal lines; coral reefs are shown, and the thick black lines are the boundaries of the coastal plains.
Based on Dutch 1 : 500,000 map; G.S.G.S. 1 : 250,000 (series 4200), sheets 4 and 5; G.S.G.S. 1 : 50,000 (series 4202) and *Atlas van Tropisch Nederland*, plate 22 (Batavia, 1938).

MADOERA

Physical Features

The island of Madoera is about 160 km. (100 miles) long and 37 km. (23 miles) broad, covering an area of 4,486 sq. km. It is a continuation of the Neogene limestone hills of north-eastern Java, from which it is separated only by the narrow strait of Soerabaja. Its structural lines run east–west, and its northern coast is almost a straight line along latitude 6° 55′ s. In the southern part the trend of the hills diverges very slightly towards the south-east, so that the south-eastern coasts consists of several limestone promontories separated by bays.

There are only two geological formations present, the gently-folded Neogene (Upper Tertiary) rocks, mainly limestones, and the alluvial deposits of Quaternary and Recent age which floor the occasional lowlands, at the western end and along parts of the south coast. The only evidence of the proximity of the island to a great volcanic region is provided by the occurrence of occasional warm springs, especially in the west.

The whole island is of undulating relief. The most continuous belt of high ground lies in the north, parallel to the coast; here there is an extensive area of over 100 m., with maximum elevations of 215 m. (705 ft.) in the west, 238 m. in the centre and 398 m. (1,306 ft.) in Goenoeng Merangan towards the east. Many small streams flow northwards from this belt, which is also several times broken by rivers which cut right across it from south to north—e.g. Kali Boengbedi and Kali Pasongsongan. South of this northern belt or ridge, the island falls into two divisions, west and east. In the west, a central depression is followed by a further broken belt of hill-country, rising in places to over 200 m., beyond which there is a gentle slope, sometimes interrupted by further low hills, towards the south coast. The central depression is not continuous in an east–west direction; it is crossed from north to south by several rivers which rise in the northern ridge and break through the southern ridge in wide gaps on their way to Madoera strait. The largest of these are Kali Baliga and Kali Kemoening. The former in its lower course crosses the largest area of lowland in the island, which is also traversed by the Kali Bahbatah and Kali Klampes, two tributaries which join the Baliga near its mouth.

The eastern half of the island has no central depression, but several belts of hill-country, parallel to the north coast or nearly so, separated by lower areas sometimes followed by east–west streams, sometimes

crossed by them. The largest east–west valley is that of the Kali Sokrok, over 30 km. long, which empties into Soemenep bay. The central ridge, north of the upper Sokrok, is steep sided, with gradients reaching 1 : 2½ on both sides; it contains the highest summit in the island, Goenoeng Tamboekoe, 471 m. (1,545 ft.). It runs eastwards, becoming lower and less steep, as far as Soemenep, and is probably structurally continuous with the island of Poeteran, to the south-east. South of the Sokrok valley is another ridge, several times reaching 300 m., and presenting a steeper face to the south than to the north. This ridge runs out to sea in Oedjoeng Tandjoeng, on the south side of Soemenep bay.

A second lowland area lies at the head of Boender bay; it contains Pamekasan, the chief town of the island, and is crossed by several rivers which join to form the Kali Semadjid, now entering the sea in a deltaic flat on the south-western side of the bay. A belt of low hills (50–80 m.) separates Pamekasan from the south coast.

The limestone foundation of Madoera and the easterly aspect of the island make for a rather barren landscape. Bare white limestone is frequently exposed (the name Batoepoetih—white rock—is of frequent occurrence), and the vegetation is mostly deciduous owing to the drought of the east monsoon season. The population is more scattered than in Java, and small patches of cultivation are found in hollows and in the stream valleys. The greatest concentration, naturally, is on the three southern lowlands and on the narrow plain bordering Soerabaja strait. In addition to the usual rice cultivation, with maize and tobacco, the wealth of Madoera is largely derived from the salt-pans and fish-ponds which cover large areas at the seaward end of the three lowlands—Soemenep bay, Boender bay and the mouth of the Kali Baliga.

Coasts

North coast

The north coast is almost a straight east–west line. It is accessible anywhere at high water, though rocks may hinder landing at low tide. There is almost no coastal plain, and the land rises to elevations of 100–200 m. (300–650 ft.) in about 5 km. (3 miles) from the shore. A main road runs fairly close to the shore almost from end to end; tracks and an occasional road lead southwards across the hills.

The north-west corner of the island is Tandjoeng Modoeng, low and swampy, and backed by fish-ponds. Between Sapoeloe and

Ketapang there are frequent villages, patches of cultivation and occasional fish-ponds along the coast, and from Ketapang a road runs southwards to Sampang on the south coast. East of Ketapang, the coastal slope is steeper, the aspect is more barren, and villages are fewer. Main roads lead southwards from Pasian to Pamekasan and from Amboenten–Timoer to Soemenep. Between Amboenten and Sergang there are belts of sand dunes. Beyond the latter locality, from which a road runs south to Soemenep, the coast curves gradually south-eastwards. It is low, flat and of barren aspect; the eastern extremity of the island is Tandjoeng Lapa, a low, wooded promontory.

South coast

The south coast is more variable, reef-fringed shores and low limestone capes alternating with swampy stretches and occasional

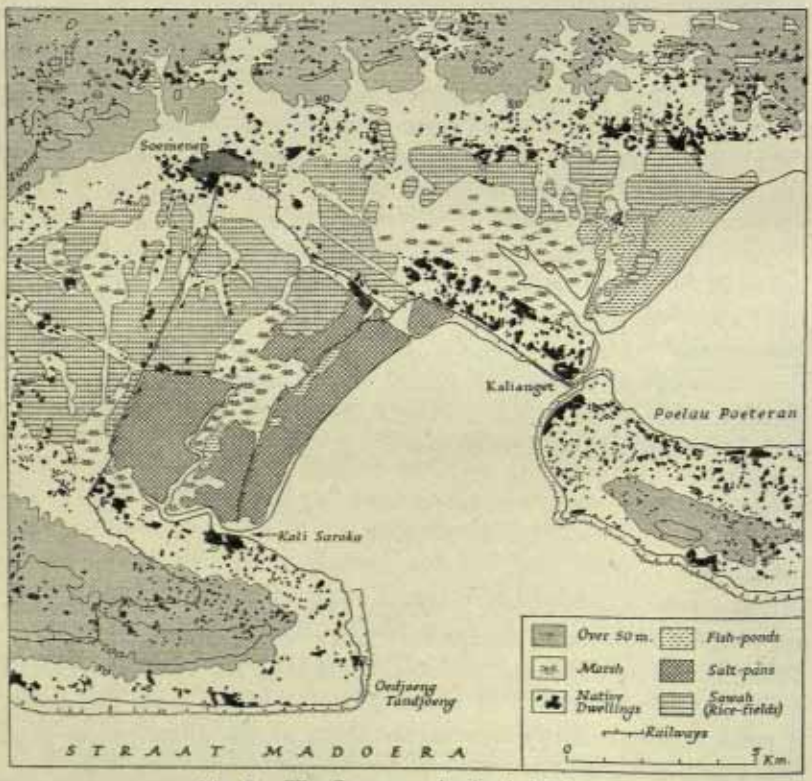


Fig. 83. The Soemenep lowland, Madoera
Based on 1 : 50,000 map (G.S.G.S. series 4202), sheet 58/XL–A and adjoining sheets.

small deltaic projections. From Tandjoeng Lapa a coral reef fringes the beach for about 14 km. (9 miles) and then, as the hills recede and the Soemenep lowland begins, a sandy foreshore takes its place and the beach is backed by fish-ponds. The lowland is interrupted by a low limestone ridge which runs from Soemenep across Kalianget channel to Poeteran island. The channel is only about 350 m. wide; on its northern side is the small port of Kalianget, with a pontoon pier. Kalianget is the terminus of the Madoera light railway; there is a large factory which deals with the product of the salt-pans. Road and rail run north-westwards to Soemenep. The shore of Soemenep bay is low, and is backed by an extensive area of salt-pans (Fig. 83). Beyond the mouth of the Kali Saroka (known upstream as Kali Sokrok), is an eastward-projecting limestone promontory which ends in the low cape, rocky and wooded, known as Oedjoeng Tandjoeng.

Beyond here the coast turns westwards; it is straight and reef-fringed, followed by a road and later by the railway as well, to just beyond Kapedi, where the sand and mud of Boender bay commence. The mouth of the Kali Pekamban causes a low, wooded, deltaic headland, and then the coast sweeps round south-westwards, past Talang, where it becomes even lower, flatter and more marshy, with fish-ponds and salt-pans. The railway goes well inland to avoid this low-lying area, but it sends branches to the salt factories on the banks of the Kali Boender. The Boender bay roadstead offers some shelter during the west monsoon. Beyond the swamps, Tandjoeng Doto is the rocky, wooded end of a low limestone ridge, beyond which lies the deltaic headland produced by the former and present mouths of the Kali Semadjid.

The coast now resumes its westerly direction, and beyond Brantapaseser, hills approach the coast, the coral reef resumes and road and railway once more run close behind the beach, as far as the Kali Sampang delta. This deltaic swamp is covered with marsh and fish-ponds; the mouth of the river leads up to Sampang, a small salt port. About 5 km. west of this delta begins the large and swampy lowland formed by the lower part of the Kali Baliga and several tributaries. The lowland is mostly covered with salt-pans (especially on the eastern side), fish-ponds and sawah (rice-fields). At the mouth of the Kali Baliga is Tandjoeng Batoepoetih, a light-coloured limestone cliff about 12 m. (40 ft.) high, beyond which the coast resumes its westerly direction and its coral fringe. The main road and railway which have run inland round the Baliga lowland, reach the shore again at Kedoengdoeng. Beyond Tandjoeng Goemoeng, a small

deltaic headland, the coral reef ceases, and the coast is low and wooded; road, railway and villages are invisible behind the fringe of woods. Beyond Kebanjar–Timoer, where a branch of the railway runs inland to Tanahmerah and Bangkalan, hills approach the shore again.

At the south-western end of Madoera is the small ferry port of Kamal, opposite Soerabaja on the northern side of the Oostervaarwater. Here the coastal railway turns northwards to Bangkalan.

West coast

The west coast of Madoera forms the eastern shore of Soerabaja strait, i.e. of the Westervaarwater and its funnel-shaped entrance. It is low and marshy, backed by fish-ponds in the southern part. The western extremity of the island is Tandjoeng Boeloe, low and densely wooded. Between here and the equally well-wooded Tandjoeng Piring, the strait is at its narrowest; there are two piers along this stretch.

Beyond Tg. Piring the coast turns north-east, low and wooded, to Tandjoeng Modoeng. In the middle of this section is a small deltaic headland, the mouth of the Soember Poetjang, up which lies the town of Bangkalan, served by the railway.

BIBLIOGRAPHICAL NOTE

The geological literature of Java is mainly in languages other than English. The most important source is the encyclopædic, *Description géologique de Java et Madoera*, by R. D. M. Verbeek and R. Fennema, 2 vols. (Amsterdam, 1896). Subsequent researches are to be found in the *Jaarboek van het Mijnwezen* (Batavia, annually), and in Dutch scientific journals, notably the *Tijdscrift van het Koninklijk Nederlandsch Aardrijkskundig Genootschap* (Amsterdam) and *Leidsche Geologische Mededeelingen* (Leiden).

The volcanoes are treated in several monographs in the series *Vulkanologische en Seismologische Mededeelingen* (Batavia, published at irregular intervals): No. 2, Keloet's eruption of 1919 (1921); No. 3, Merapi, 1920–21 (1921); No. 4, Semeroe, Bromo and Lamongan (1922); No. 6, Galoenggoeng and Telagabodas (1924); No. 7, Vulkaanstudien op Java (1926); No. 12, Merapi (1933).

A useful work in German on the physiography of Java is H. Lehmann, 'Morphologische Studien auf Java', *Geografische Abhandlungen*, 3 Reihe, Heft 9 (Stuttgart, 1936).

All general works on the East Indies naturally devote much attention to Java; for these, see the bibliographical note to chap. 1.

Chapter V

BORNEO

Introduction: Physical Features: Coasts: Adjacent Islands: Plant and Animal Life: Bibliographical Note

INTRODUCTION

The word Borneo is a corruption of Brunei or Burni, the name of the town and Malay sultanate on the north-west coast of the island. The modern inhabitants, both Dyak and Malay, have no term in general use for the whole of Borneo, though the Malays are said to speak of it occasionally as *Tanah* or *Poelau Kalamuntan* (Land or Island of the kalamuntan) from a fanciful resemblance in its shape to the fruit of the kalamuntan (*Cerbera odollam*).

Borneo is the third largest island in the world and, after New Guinea, the largest in the Malay Archipelago; it is roughly triangular in shape, tapering to the NNE. It is nearly bisected by the equator and lies between 108° 50′ and 119° 20′ E long. The total area is about 736,000 sq. km. (284,000 sq. miles) or more than three times the size of Great Britain. On the west, Borneo is separated from Sumatra and the Malay peninsula by the South China Sea, the narrow Karimata strait dividing it from Bangka and Billiton. To the south, across the Java Sea, lies Java. Both the South China Sea and the Java Sea are mostly less than 35 fm. deep and could nowhere cover St Paul's Cathedral; the three great islands, Borneo, Java and Sumatra, thus stand up from a vast submarine plateau, the Soenda Shelf (Fig. 8). To the east, the Makassar strait, between Borneo and Celebes, is much deeper than the seas to west and south, while towards the Celebes Sea, to the north-east, the sea bed slopes rapidly down to depths of over 4,000 m. (2,200 fm.). The many islands off the Bornean coast will be considered at the end of this chapter. Most of them are small and of very little importance, excepting Labuan on the north-west coast, Poelau Laoet (99 × 34 km.), which is divided by a narrow channel from the south-east coast, and Seboekoe (Seboekoet) (32 × 10 km.) adjoining Poelau Laoet.

Unlike Java and Sumatra, Borneo does not form a single political unit, but is divided into no less than four separate states, one forming part of the Netherlands Indies, the others of the British Empire (Fig. 84). The northern part of the island constitutes British North

Borneo, a protectorate administered by a chartered company, the British North Borneo Company. The north-west of Borneo, from Tandjoeng Datoek north-eastwards to Brunei bay and inland as far as the main central watershed, forms the independent state of

Fig. 84. Political boundaries in Borneo

Based on *Times Atlas*, plate 61 (London, 1920).

Sarawak, ruled by a hereditary rajah of British nationality; this too is a British protectorate. The native state of Brunei, consisting of the town of Brunei and two small tracts of country, forms an enclave in the north of Sarawak; it has been under British protection since 1888 and is ruled by a sultan with the advice of a British Resident. The small island of Labuan, situated close to the west coast of British North Borneo, is a British Crown Colony and forms one of the Straits Settlements. Dutch Borneo includes the whole of the south and east of the island. It has an area of 539,460 sq. km., about equal to that of France, and is divided into two Residencies, West Borneo, extending from the frontier of Sarawak south to the mouth of the Soengai Djelai, and South and East Borneo, comprising all the rest of the Dutch territory.

Besides being politically divided, Borneo contrasts in nearly every other respect with its neighbours Java and Sumatra. Though it is traversed by mountain ranges, much of it is hilly rather than mountainous and the rivers are longer and larger. There are no active volcanoes and severe earthquakes are an uncommon event. It is however less in its physical features than in its economic development that Borneo differs so strikingly from Java and Sumatra. Borneo is still a land of the primæval jungle; the coasts are fringed with endless mangrove swamps and over nine-tenths of the interior is covered with thick evergreen forests (Fig. 138). Agriculture is mostly carried on for subsistence only and under the most primitive system of shifting cultivation. The population is sparse; that of the whole island is estimated at rather more than 2¾ millions, that of Dutch Borneo at 2,168,661 (1930 census) and, apart from the Malays and Chinese who live mainly in the coastal districts, consists of a varied collection of aboriginal races (often, but incorrectly, spoken of collectively as Dyaks), most of whom have only quite recently given up their time-honoured practice of head-hunting. In the whole island there are less than a dozen settlements large enough to be called towns, and there are no railways and very few roads; communication is mainly by water or by narrow jungle paths often consisting of tree trunks laid end to end.

The backwardness of Borneo, in spite of its apparently favourable central position, is due to more than one cause. The compact shape of the island, by giving it a comparatively short coastline in relation to its great area, has helped to make the interior inaccessible, as has the lack of good natural harbours and of easily navigable rivers. A more fundamental cause than any of these, perhaps, is that the soil, contrary to what is often stated, is not very fertile, chiefly because of the excessive rainfall and lack of active volcanoes (see chap. I and XI).

Much of the country is unexplored or very inadequately known. In Dutch Borneo only the West Borneo Residency has been completely surveyed (Fig. 142); many districts, such as the frontier of Sarawak and East Borneo and the Apo-Kajan region on the Boeloengan (Kajan) river in East Borneo are more remote and unknown than anywhere in the East Indies, excepting parts of Celebes and the interior of New Guinea. In attempting to describe the physical geography of the island the incompleteness and inequality of the data is a serious handicap.

Geologically Borneo is still very incompletely known, though a

geological sketch-map by Th. Posewitz was published as long ago as 1892, and the discovery of gold, diamonds, coal and oil has given an impetus to a considerable amount of survey work. The structural relationship of Borneo to the rest of the Archipelago is dealt with in Chap. 1 (Figs. 6 to 10), and a diagrammatic representation of its geological history is given in Fig. 5.

In the lowlands Quaternary deposits cover enormous areas; there are also extensive outcrops of Mesozoic rocks (Triassic, Jurassic and Cretaceous). The so-called 'Old Slates', which are probably of Palæozoic age, contribute largely to the building of the great mountain ranges. The presence of Carboniferous rocks has not been proved, but is not unlikely. Eruptive and plutonic rocks are important in some districts—especially in the west—and in some places there are remains of extinct volcanic cones. The latter are probably mainly of Miocene age, and thus belong to an earlier period than the volcanoes of Java and Sumatra; there are no signs of recent volcanic activity. Goenoeng Kelam in West Borneo, a mountain with a steep face of bare rock, is an immense dyke of quartz-porphyry, now standing out owing to the removal of the surrounding rocks by denudation. Near Goenoeng Nioet (1,701 m.) in the Landak district of West Borneo there are two large streams of basalt.

Borneo is a country of considerable mineral wealth. In the last century it promised well as a source of gold and diamonds, the latter being found at Landak and on the Sekajan river in West Borneo and about Martapoera in the extreme south of the island. Gold in small quantities is generally distributed and is still worked on a small scale in the neighbourhood of Montrado and Sambas in West Borneo, near Tampang on the Kahajan and near Martapoera and Pengaron in the south-east. Gold and diamonds have long since become of small significance and the minerals of most importance at the present day are coal and oil. Coal, of Tertiary age, is mined chiefly on Poelau Laoet, where the proximity of the mines to the sea is a great advantage. The oil fields of Borneo have now become of about equal importance to those of Sumatra. The fields which have been developed are situated at Miri in Sarawak and at several points on the east coast of Dutch Borneo. Balikpapan, the outlet of the oilfield near the mouth of the Mahakam river, has in recent years become the most important port in Borneo. Iron ore is mined on Seboekoe island off the south-east coast and the neighbouring mainland. Platinum, mercury, antimony and other minerals occur in quantities too small to be profitably exploited.

PHYSICAL FEATURES

Relief

In Borneo there are no very extensive plains, but though ranges of mountains run through the length and breadth of the island, the greater part of the area would be better described as hilly rather than mountainous. Even the so-called mountain ranges consist of broken lines of short high ranges and isolated peaks, crossed by many low passes, rather than of continuous high ridges extending for great distances. Summits over 2,000 m. (6,100 ft.) are few, but the highest mountain in the whole island, the huge flat-topped granite peak of Kinabalu in British North Borneo reaches a height of 4,175 m. (13,681 ft.).

The appearance of the Bornean mountains is very varied, depending on whether they are composed of hard igneous rocks or of sandstone, shale or slate; many are flat-topped with steep or precipitous sides. Like most mountains of the wet tropics, they are not difficult to climb. Except for occasional sheer faces of bare rock, they are tree-covered to the top and trunks and tree roots provide handholds on slopes which would otherwise be too steep to climb. In the hill country many of the ridges are steep-sided; often the tops are knife-edges just wide enough to walk along. Very striking scenery is found where there are limestone hills, as, for instance, in the Boelit valley. The sides of these hills consist of bold vertical or even overhanging cliffs, often eroded into fantastic pinnacles; underground they are honeycombed with caves. Practically all land in Borneo above 250 m. (800 ft.) is uninhabited (Plate 55).

The statement has been often repeated that if Borneo were partially submerged its shape would be like that of Celebes and it was formerly supposed that the main mountain ranges radiated from a central massif somewhere in the neighbourhood of G. Batoe Tibang on the frontier of Dutch Borneo and Sarawak. This view was held at a time when the interior of Borneo was much less known than it has since become. Though the interior mountain ranges, owing to their extreme remoteness and inaccessibility, are still very imperfectly mapped, it is already clear that the idea of ranges radiating from a central point has to be abandoned. The structure of the island, according to the modern view, is governed by folds and faults mostly running nearly from east to west. In the southern half of Borneo it is only in the extreme east that folds are found running SSW–NNE; the line dividing the two regions of folding demarcates the mountain

system of the western part from that of the eastern part of the archipelago. Diverging from this east–west fold, near the point where the frontiers of Sarawak, West Borneo and South and East Borneo meet, is the watershed which continues to form the boundary

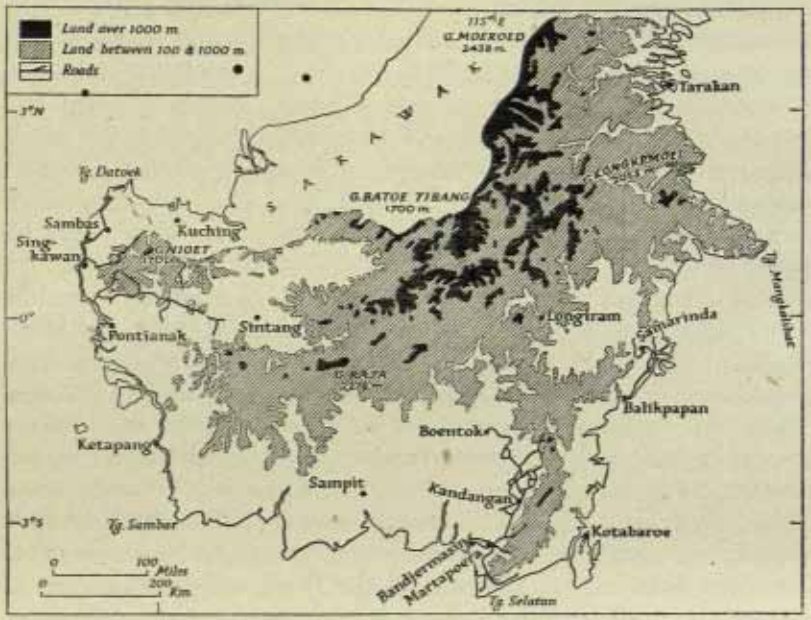


Fig. 85. Borneo: Relief and principal roads

The small road system radiates from Pontianak and Bandjermasin. Elsewhere communication is by river or forest track.
Source: *Atlas van Tropisch Nederland*, plate 25 (Batavia, 1938).

between Sarawak and Dutch Borneo as far north as British North Borneo. This watershed, on which lie G. Batoe Tibang 1,700 m. (5,590 ft.) and G. Moeroed 2,150 m. (7,084 ft.), has been very little explored, but the International Boundary Commission reported that it appeared to be an uninterrupted mountain chain.

The main east–west fold-belt crosses the island from Tg. Datoek in the west to Tg. Mangkalihat in the east and forms an immense mountain chain of very varying height. Near the west end it forms the Bawang range, culminating in G. Nioet 1,704 m. (5,580 ft.). The central part is called the Upper Kapoeas range (Boven-Kapoeas-gebergte); further east it is called the Bawoei range. The Upper Kapoeas mountains consist of numerous parallel chains, separated by longitudinal valleys; they are largely formed of strongly folded strata

of 'Old Slate'. The highest points are over 1,800 m. (6,000 ft.) high, but the majority of the summits are under 1,200 m. (4,000 ft.). Nearly 200 km. (120 miles) to the south of this range lies a mountain district of a very different character, to which Molengraaff, who contributed so much to the exploration of the Bornean mountains, gave the name of Schwaner-gebergte. It runs westwards towards the South China Sea, eastwards as far as the Kahajan river; to the south it merges gradually into the hill country of south-west Borneo. The centre of these mountains consists of granite and other igneous rocks, the flanks mostly of sandstone; their height is not in general very great, but G. Raja, 2,278 m. (7,472 ft.), the highest peak, is believed to be the highest summit in Dutch Borneo. Between the Schwaner mountains and the Upper Kapoeas range lies the Madi plateau, formed of shale and sandstone and falling away on the south side in sheer precipices, and further eastwards the Muller-gebergte, a volcanic range with many summits between 1,200m. and 1,500 m. (4,000 and 5,000 ft.). Sandstone like that of the Madi plateau gives a characteristic relief to a great part of the landscape of west and central Borneo; the rivers have hollowed out deep, narrow ravines, dividing the plateaux into sharply separated sections. In western Borneo, this sandstone slopes down gently northwards, and there are only a few remnants of it north of the Kapoeas river. East of Sintang, on the Kapoeas, the sandstone is broken in several places by old volcanic cones, some of which rise to over 1,000 m. (3,300 ft.).

From the region of the Schwaner and Muller mountains, there are ranges with a general east–west direction running towards the east coast, where they join on to the mountains of Pasir and the Meratoes range, which have a SSW–NNE direction. The mountains to the north of the great east–west fold-belt (i.e. north of the line Tg. Datoek–Tg. Mangkalihat) are very inadequately known. In addition to the main watershed between the rivers of Sarawak and those of the northern part of Dutch Borneo which, as already mentioned, is thought to be a continuous range, there are numerous lateral ranges, mostly following a general east–west direction, which separate the river valleys of East Borneo. It is certain that between the rivers there are mountain tops of over 1,000 m. (3,300 ft.), at distances of 60–100 km. (40–60 miles) from the coast, but it cannot be assumed that all the watersheds are mountain ranges, because most travellers in this part of the country have limited themselves to noting the course of the rivers and only occasionally mapping a striking mountain summit.

Fringing the south and east coast of Borneo, there is a belt of low-lying, largely swampy land, which narrows at the projecting west, south-west, south-east and east extremities of the island (the capes of Datoek, Sambar, Selatan and Mangkalihat) and widens to 160 km. (100 miles) or more in between. Offshoots from the coastal plains run up the larger river valleys. The chief plain of the interior is the remarkable valley of the upper Kapoeas, lying at a height of 30–45 m. (100–150 ft.), above sea-level. This plain, which is almost completely encircled by mountains, is sprinkled with lakes and crossed by a complicated system of waterways; at times almost the whole of it is flooded. According to Molengraaff, it is a partly filled-up lake basin originally formed by subsidence. The plain of the lower Mahakam, though much nearer the sea, resembles that of the upper Kapoeas in many respects.

Rivers

The vast number of rivers in Borneo is a consequence of the uniformly high rainfall and for several reasons they are of far greater geographical importance than the mountains. In a country which is still largely forest-covered, the rivers form the chief, in many districts the only, means of communication. The importance of the mountain ranges as barriers is due much less to their height and steepness than to their forming a break in the continuity of the river communications. By means of the rivers, explorers, fortune-seekers, and invaders, have penetrated into the interior; whether the rivers are easily navigable or not, has decided the speed and intensity of the penetration of these foreign cultural influences. Almost all the towns and villages, even the smallest, are situated on the river banks, generally near the mouth or at the confluence of a tributary with the main stream (Fig. 87).

Most of the rivers can be entered only at high tide by vessels of shallow draught. Even the huge Soengai Barito has a bar on which the minimum depth of water is only 1·7 m. (5½ ft.), and the maximum 3·7 m. (12 ft.). Several of the larger rivers form deltas consisting of islands covered with mangroves and nipah palms, intersected by a maze of channels. After the difficulties of entering the rivers have been surmounted, navigation is still far from straight-forward. Most Bornean rivers are subject to great and sudden changes of water level; rapids and other obstacles are constantly encountered. On the Kapoeas as far down as Sintang, the variation of water level may amount to 10 m.; after heavy rain a rise of 5 m. in an hour is not unusual. The traveller is often delayed for days on end, either because

the water is too low, or because it is too high and the current too strong. Even a large river such as the Kapoeas is occasionally, perhaps once in three years, navigable only by the smallest native canoes, so that trade is brought practically to a standstill. Almost nothing has been done to regulate the courses of the rivers or to make them more navigable. In addition to sandbanks, mudbanks, and rapids, tree trunks lodged in the river bed are often met with and endanger navigation in the more difficult channels.

Where they cross the coastal plains, the rivers wind between high banks of mud overgrown with reeds and other vegetation. All the rivers are very liable to flooding, and on the alluvial flats, one can often wander for miles in a small boat through quiet flooded jungle. After a big flood, a new channel is often formed cutting across a meander; such new channels may be only temporary or subsequent floods may enlarge them so that they become a permanent part of the river course. Most of the *danau* or lakes which are characteristic of many of the river valleys of Borneo, are ox-bows, or old parts of river courses, short-circuited in this way. A new channel cutting across a meander is called a *pintas* or *pintassan* (from the Malay verb meaning to make a short-cut), or an *antassan* or *troessan* (meaning the short or straight way). When travelling by river, it is important to ascertain whether the *pintassan* are at the moment navigable, and can be used to shorten the journey. The many *danau*, *pintassan* and connecting creeks make both sides of a river in the lowlands a chaotic wilderness of channels, pools and flooded forests in which the raised banks of the main stream are the only habitable ground.

Above the coastal plains the river banks often become rocky and constant rapids and gravel banks may make navigation impossible, except for native praus and canoes. Many of the smaller rivers of the hill country, especially those draining sandstone areas, as well as the waterways in the peaty swamp forests of the coastal plain, have clear coffee-coloured water, like an English moorland stream.

The chief features of the river system follow from the description of the mountain ranges, which has already been given. Immediately to the south of the main east–west fold, are the S. Kapoeas, flowing to the west, and the S. Mahakam flowing to the east. From the southern slopes of the Schwaner and Muller mountains and the ridges forming the southern watershed of the S. Mahakam, a large number of rivers follow roughly parallel courses south to the Java Sea. As the coast tends towards the south-east, and the mountains slightly towards the north-east, the eastern of these rivers are longer than the western.

Much the most important of this group is the S. Barito, the basin of which is divided from the strait of Makassar only by the more or less meridional Meratoes mountains and the narrow coastal strip beyond. In the following survey we can thus conveniently divide the rivers

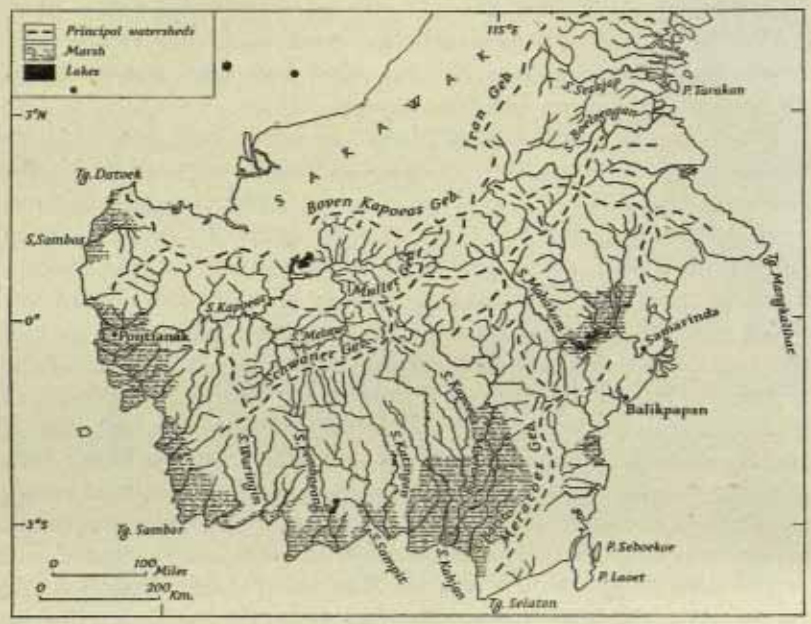


Fig. 86. Borneo: Drainage pattern

Source: *Atlas van Tropisch Nederland*, plate 25 (Batavia, 1938).

of Dutch Borneo into three groups: (i) the S. Kapoeas and the much smaller rivers draining to the west coast between Tg. Datoek and Tg. Sambar; (ii) those flowing to the south coast between Tg. Sambar and the south-east extremity of the island (Tg. Selatan); (iii) the S. Mahakam and the rivers between it and the frontier of British North Borneo.

Since almost all the inhabitants of Borneo live on, or very close to, the river banks, *Koeala* (*Kuala*) (a Malay word, meaning the mouth of a river or tributary), and *Long* (a 'Dyak' word with the same signification) are constantly recurring elements in place names. With the exception of Balikpapan, the important oil port on the east coast, almost the only settlements deserving the name of town are situated at river mouths where sea and river traffic meet. These towns are of Malay origin, and the present population contains the usual admixture

of Chinese and other alien orientals met with in all trade centres in the archipelago. Up every large river Malay settlements are found at the mouth of each important tributary; these settlements control traffic and hence trade and politics. The smaller ones have a mixed Malay–Dyak population. In general the aboriginal races ('Dyaks') have been pushed back towards the upper reaches and tributaries of the princpal rivers, except in the thinly populated regions of the north and south-west. Their villages are not fixed in position, but change from time to time. Usually the aboriginal people live in 'long houses'—communal houses raised on piles in which the separate dwellings open on to a common gallery. A Dyak village may consist of one or several such 'long houses', each of which may be inhabited by over a hundred people (Fig. 87).

(1) *Rivers of the west coast*

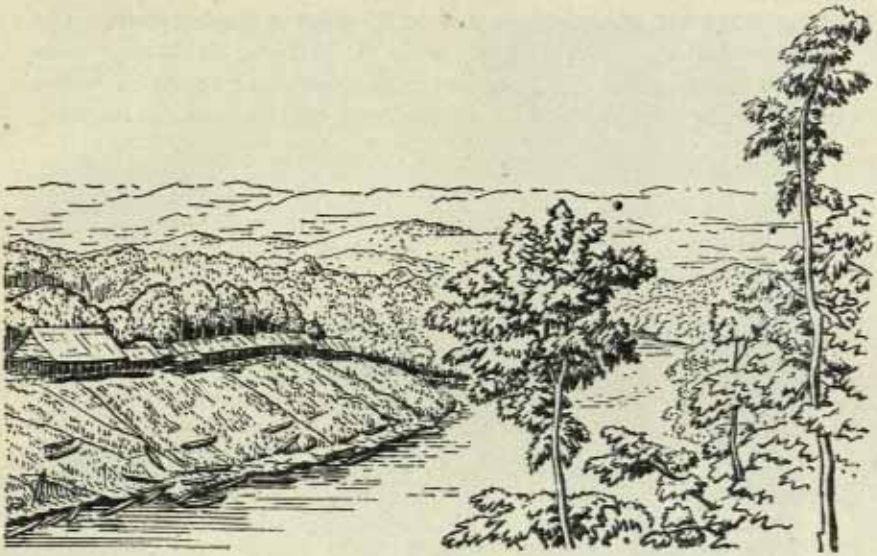
By far the most important river in this sector is the S. Kapoeas. Of the various small rivers reaching the sea to the north of the Kapoeas, the chief is the S. Sambas, which has a wide navigable estuary. Sambas, a small town of poverty-stricken appearance, is the capital of a Malay sultanate, and lies on a small tributary of the left bank, the Sambas-ketjil (Plate 57). From Singkawang, a small port on the coast about 30 km. (20 miles) south of the mouth of the Sambas, a road runs inland through Bengkajang on one of its small tributaries. A branch from this road runs to Montrado, once an important mining centre, on the very small river Raja.

The main stream of the S. Kapoeas rises in the Upper Kapoeas mountains near the point at which the frontiers of West Borneo, South and East Borneo and Sarawak meet; it is 1,143 km. long (a little shorter than the Rhine) and its basin has an estimated area of 102,000 sq. km. (39,000 sq. miles). At Poetoes Sibau, where it enters the Upper Kapoeas plain, it is already 208 m. wide and at Tajan the width has increased to 1,600 m. The course can be divided into four sections. From the source to Poetoes Sibau, the Kapoeas flows between mountains in a general south-westerly direction (Plate 56). In its second section, it crosses the swampy Upper Kapoeas plain from east to west. Near Semitau, it leaves the plain and breaks through the hill country, again flowing south-west. The fourth and last section, from Tajan to the sea, is again more nearly east–west. Above Pangkalan Djemoeti (164 km. above Poetoes Sibau) the Kapoeas is merely a wild mountain stream; between this point and where it enters the Upper Kapoeas plain it is navigable by Dyak canoes, but the many

Fig. 87. 'Dyak' village on the bank of the
Each 'long house', which is inhabited by numerous families, has a number of river bank to the water. Note the many small praus in the river. Source: Drawn (Leiden, 1904).

rapids make the journey difficult. The second section of the course, that across the plain, has endless meanders and *antassan*, and resembles the lower course of most Bornean rivers. Poetoes Sibau is 50 m. (164 ft.) above sea-level, and the drop from there to Semitau is slight; in the 93 km. from Djongkong to Semitau the fall is only 1 in 77,666, about one third the fall in the true lower course west of Tajan. Launches with a draught of 3 ft. can navigate the river to Boenoet at low water level, or to Poetoes Sibau under average conditions; at high water even steamers drawing 6 ft. can reach Poetoes Sibau. The extensive marshes and lakes of the Upper Kapoeas plain play an important part in regulating the water level; the course from Boenoet to Semitau remains navigable in droughts for a much longer time than the reach below Semitau. The many small settlements in the Upper Kapoeas plain are mostly situated on the high sedimentation banks.

From Semitau to Tajan the Kapoeas keeps to a well-defined bed, and the windings are mainly dictated by the position of the high ground; there are few meanders or *antassan*. The lower course below Tajan is very short as the river soon enters its extensive delta region.



Soengai Bloeoë, a tributary of the Mahakam
rooms opening onto a common gallery. Paths of tree trunks run down the steep
from a photograph in A. W. Nieuwenhuis, *Quer duch Borneo*, vol. 1, p. 268

The main tributaries along the first section of the course are the Boengan and the Kerijau; from a small tributary of the former, the Boelit, a path leads to the Penaneh, belonging to the river system of the S. Mahakam. Another path leads from the Kerijau to the basin of the S. Barito. The first tributary of any size in the Upper Kapoeas plain, is the Sibau. This forms one of the routes to the Rejang basin in Sarawak. Poetoes Sibau, the highest settlement of any importance on the Kapoeas, lies at the junction of the Sibau with the main stream. Of the remaining tributaries above Semitau (several of which are larger than the Sibau), the Boenoet deserves mention because the Malay settlement of Boenoet, a fairly important trade centre, lies at its mouth. Between Boenoet and Semitau are the settlements of Djongkong, and Salimbau, both of which are small district centres. Semitau lies on a very unimportant tributary; it was chosen as a Government centre chiefly because the main river narrows at this point to a single channel, making it easy to control the traffic. The first important tributary below Semitau is the Ketoengau, on the right bank; this is navigable nearly to its source and forms a natural route from Sintang to Sarawak, which has been much used by opium

and gunpowder smugglers as well as by more reputable traffic. The largest tributary of the Kapoeas is the S. Melawi, which joins it on the left bank; it has itself not less than twenty-one navigable tributaries. At the confluence of the Melawi with the Kapoeas lies Sintang,

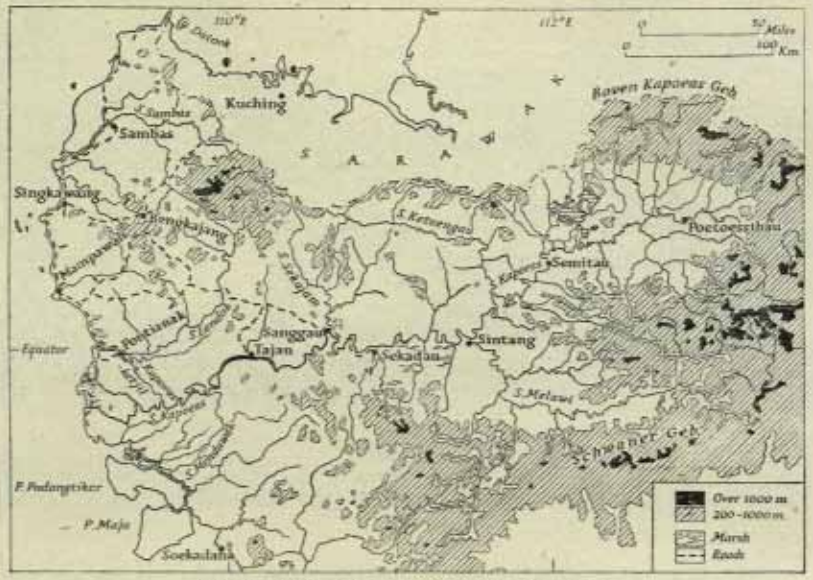


Fig. 88. The basin of the Soengai Kapoeas
Source: 1 : 1 M, sheets N.A. 49 and S.A. 49 (G.S.G.S. 4204).

a place with a prosperous Chinese population, and the seat of an Assistant Resident. The chief tributaries below the Melawi are the Sekadau, the Sekajam, and the Tajan. The Sekajam is of some importance because of the many settlements along its course, and because a path from the Upper Sekajam to Sarawak is a recognized route; at its mouth lies Sanggau (3,233 inhabitants) which like Sekadau (3,446 inhabitants) and Tajan (all situated at the mouths of the similarly named rivers), is the capital of a Malay principality.

The Kapoeas delta has an area of 8,000 sq. km., and consists of swamp forest and mangrove, except in a few parts where it has been drained and planted with coconut palms. The many arms of the delta and the numerous secondary creeks make a veritable maze of waterways. Most of the delta arms are not navigable, chiefly because of the bars at their mouths; only those which are navigable will be named here. The first branch from the Kapoeas is the Mendawak; this has a subsidiary branch called the Djenoe, which runs into the medley of

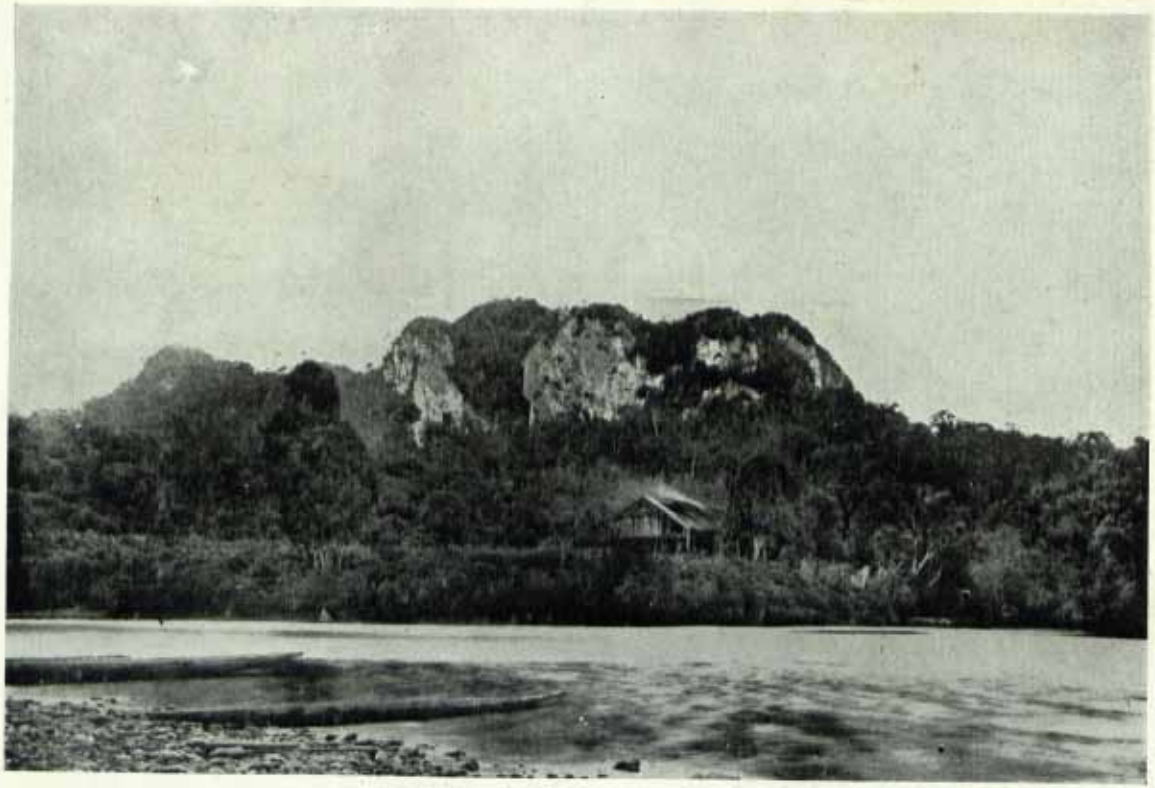


Plate 55. Liang Kasing at the mouth of the Soengai Tjehan
The hill with its bare precipices is typical of limestone scenery in the interior of Borneo.

Plate 56. View on the upper Soengai Kapoeas (West Borneo)

channels opening into Padang Tikar bay. After the Djenoe leaves it the Mendawak is called the Lida and runs into the sea by two channels, one on either side of Poelau Maja. The main stream of the Kapoeas continues westwards after losing the Mendawak and near Soeka Lanting it gives off the Kleine Kapoeas (Kapoeas-ketjil), which is joined on the north by the Landak, which can be regarded either as an independent river or as a tributary of the Kapoeas. On the Landak lies Ngabang, through which runs a road from the coast near Mampawa to Sanggau, and Sekadan on the Kapoeas. The Mandor, a tributary of the Landak, drains the district of the same name. At the junction of the Landak and the Kleine Kapoeas lies the largest town of West Borneo, Pontianak, with a population of 45,196 (1930 census) including 541 Europeans and 15,275 Chinese. The houses are built on piles and though the town is flooded at every high tide, it is one of the healthiest places in the Netherlands Indies. The European quarter has broad streets lit by electric light. As the main gateway to the Kapoeas basin, Pontianak is a busy trade centre; in addition it has sawmills and factories.

Below Soeka Lanting the main stream is called the Poengoer Besar. After throwing off the Koeboe, which gives off another arm in its turn, and runs into Padang Tikar bay, the Poengoer Besar finally discharges into the sea by a large number of channels which are navigable only by fishing canoes; thus the main stream of the Kapoeas is the least important of the delta arms from the point of view of navigation. Besides Pontianak, the only place of the slightest importance in the delta is Koeala Kakap, a short distance to the south.

Of the numerous rivers between the Kapoeas and Tg. Sambar, none is of much importance. One of the largest is the S. Pawan, at the mouth of which lies Ketapang. Soekadana, where the first Dutch trading factory in Borneo was established in 1608, lies on the coast between the mouth of the S. Pawan and the Kapoeas delta.

(2) *Rivers of the south coast*

All the rivers in this group are much alike, except for the S. Barito, which is longer than the others, and rises further east. They rise in the Schwaner mountains, or their southern foothills, and generally speaking first follow a south-south-east course, gradually turning south, and running into wide estuaries; none, except perhaps the S. Katingan, has much indication of delta development. The catchment areas are small and the tributaries are long only when they run more or less parallel with the main stream. After short turbulent

courses between mountains these rivers have much longer stretches where they cross low-lying flat country; the lowest parts, where the tides are felt, are obstructed by islands of sedimentation. None of these rivers can be entered by large ships except at high tide. The western rivers of the group have no settlements of any size except at their mouths; the eastern rivers are longer and have a larger population.

The first river of some size to the east of Tg. Sambar, is the S. Waringin, which is formed by the junction, some 24 km. (15 miles) from the sea, of the Lamandaoe and the Aroet. On the latter lies Pangkalanboeoen (4,544 inhabitants). Of greater importance, is the long Pemboeang, which has a wide but shallow mouth. The main settlement is Koealapemboeang or Koemai, the seat of the district chief; ships of not more than 6 ft. draught can reach this point. The Sampit or Mentaja rises to the south of the Schwaner mountains, and runs into a broad, fairly well protected bay. The lower reaches are easily navigable, but the population is small. The chief place is Sampit, with about 5,892 inhabitants.

The S. Mendawai or Katingan is a long river which after rising in the Schwaner mountains, runs at first due east. The upper reaches have many rapids, but below the large village of Toembang Samba, at the mouth of one of the chief tributaries, the Samba, the Mendawai is navigable by small steamers. Kasoengan, on the lower course of the river is the residence of the district chief, but Pegatan at the mouth is the main export centre. The S. Kahajan, like the Mendawai, rises in the Schwaner mountains, and at first runs in an easterly direction. In the upper part there are many rapids of which the chief is the Labeho Tampang, which often holds up the traveller for weeks and is the main barrier to traffic upstream (Plate 58). The chief tributary is the Roengan, which runs nearly parallel with the main stream and joins it on the right bank. A short distance above the confluence of the Roengan, lies Rawi, a village which exports forest produce, and can be reached by vessels drawing not more than 5 ft. Pahandoet, a short distance below the Roengan mouth, can be reached by vessels drawing up to 9 ft. Near the mouth of the Kahajan, is the village of Pangkoeh, the residence of the district chief. A partly artificial canal, useable by native canoes, links the Kahajan near Poelau Pisau with the next large river to the east, the S. Kapoeas Moeroeng. This, though shorter than the Kahajan, is a much more important river. At high water it is navigable by small steamers up to Djangkang, at average level up to Toembang Hiang, the point where the river turns south. During

the east monsoon, navigation is possible only up to the mouth of the Maroeöei, the largest tributary. The *antassan* connecting the Kahajan and the Kapoeas Moeroeng opens into the latter near the large village of Mandoemai. There is also a natural link between the Kapoeas Moeroeng and the Barito, the Poeloepetak; at its mouth lies Koeala Kapoeas (5,248 inhabitants) the seat of an Assistant Resident. The surrounding district, though flooded at every high tide, is one of the most densely populated areas of Borneo. The wide estuary of the Kapoeas Moeroeng is shallow and can be entered by vessels drawing 12 ft. only when the tide is high.

The longest of the south coast rivers, and one of the largest rivers of Borneo, is the Barito, which rises north of the mountains which form the eastward continuation of the Schwaner mountains, not far from Long Deho on the Mahakam. After the usual wild upper course, the Barito, the upper part of which is known to the Dyaks as the Moeroeng, is joined by the equally large Djoeloi. Below the village of Toembang Toean the rapids cease to be dangerous. For a time the Barito still flows between mountains, but after a number of changes of direction, it makes a great bend to the south and after reaching Moeara Tewe, it finally leaves the hills behind. From now onwards, the banks are swampy and for the rest of its course the river is accompanied by *antassan* and *danau*; no other river in Borneo has as many of these as the Barito. A vast area near the lower course is daily flooded by the tide, and during the wet season, it is estimated that one third of the entire river basin is under water.

The wide mouth of the S. Barito is too shallow for most ships; those of 12 ft. draught and more can enter only at high tides. Above the mouth, however, navigation is fairly good till the great rapids are reached, except in the dry season when shallows make it impossible at many places. During the west monsoon, vessels drawing 7½ ft. can ascend the river beyond Moeara Tewe.

Except in the upper reaches, all the larger tributaries are on the left bank, as the watershed between the Barito and the Kapoeas Moeroeng mostly lies much nearer the former than the latter. In addition to the Djoeloi, which has already been mentioned, the chief tributary in the upper, mainly eastward, course is the S. Laoeng. Along the upper Barito there are only Dyak villages; the first Malay settlements are not met with till below the main rapids. At the village of Batoe Poetih, coal is mined by the natives in a primitive way. Poeroek Tjahoe is a Government centre. The next large tributary is the S. Tewe, which joins the main river on the left bank at Moeara

Tewe; it is of importance because, owing to the lower part of its course running due west, it forms a route between Pasir and the Upper Barito. The Barito is joined in the middle part of its course, below the Tewe, by the Montalat and the Ajoeh. A little to the south of the mouth of the latter is Boentok (21,925 inhabitants), the residence of a Controller. A road connects Boentok with Amoentai on the Negara and thence with Martapoera and Bandjermasin. At the small village of Mengkatip, a branch of the same name leaves the Barito and runs into the Poeloepetak, the *antassan* between the Barito and the Kapoeas Moeroeng. In the lowest part of its course, the Barito receives several tributaries, of which the largest is the S. Negara; opposite the mouth stands Marabahan. The Negara, which itself has several navigable tributaries, is navigable in its lower part by sea-going vessels; it drains a district, the Hoeloe or Oeloe Soengai, which is prosperous and densely populated; it enjoys amenities such as good roads and well-built houses almost unknown elsewhere in Dutch Borneo. The chief settlements in the basin of the Negara are Kandangan (6,592 inhabitants), the headquarters of an Assistant Resident, Margasari (14,649 inhabitants), a trade centre, Amoentai (population about 6,500) and Barabai, which is connected to Bandjermasin by a daily bus service. Another large tributary joining the Barito near its mouth, is the Martapoera, which is formed by the junction of the Riam Kiwa, and the Riam Kanan. The town of Martapoera, situated just below the confluence, is a prosperous place with a busy market; it is the centre of the diamond trade, and of fruit growing for the Bandjermasin market. On the Martapoera, 10 km. above the point where it joins the Barito, is Bandjermasin, the largest town in South and East Borneo, with a population of 65,698 (1923 census), including 947 Europeans and 5,014 Chinese. Like Pontianak, the town is built on marshy ground, and the houses are raised on piles; it is traversed by broad ditches, and the inhabitants move about mainly by water, using boats called *tambangan*. As in other places in Borneo, many of the houses are built on rafts. Bandjermasin is important to-day chiefly as the outlet of the trade of the Barito, and the economically well developed Hoeloe Soengai; formerly it was the seat of a powerful sultan (Plates 58 and 59).

The Barito has no delta, but flows into the sea through a broad estuary.

(3) *Rivers of the east coast*

Along the southern part of the east coast, the mountains are close

Plate 57. Sambas (West Borneo)
A typical small Malay town in Borneo

Plate 58. Sand-bar at low water. Soengai Kahajan (South Borneo)

Plate 59. Bandjermasin (South Borneo)

The commercial section of the town, on the low right bank of the Soengai Martapoera a few kilometres above the latter's confluence with the Soengai Barito estuary.

to the sea, and run in a mainly north–south direction, leaving no room for extensive river basins. The only stream worth noting here, is the S. Pasir, on the banks of which are the settlement of Pasir, and the Government centre Tanah Grogot (5,000 inhabitants). The very important oil port of Balikpapan, with a population of 29,843 (1930 census), including 988 Europeans and 4,327 Chinese, is situated a the mouth of a deep inlet, but only very small rivers flow into it, so that there are no communications by water with the hinterland (Plate 60). The oilfield it serves is situated to the north, near the Mahakam delta.

North of Balikpapan, the mountain ranges resume their general east–west trend, and big rivers are again met with. The southernmost of these is the huge S. Mahakam, second only to the Kapoeas in importance and considerably greater in length. Rising far back in the interior, at the foot of G. Batoe Tibang, it runs in a mainly easterly direction, and flows into the strait of Makassar, some 80 km. (50 miles) north of Balikpapan. Its valley has some resemblance to that of the Kapoeas, as before reaching the sea, it forms an extensive swampy plain, partly cut off from the coast by a range of hills running approximately north–south. This plain, like that of the upper Kapoeas, has a network of lakes and waterways (Fig. 89).

The S. Mahakam, known in its highest part as the Selirong, flows first of all south-west till it reaches the mouth of the Howong; here it turns south and then east. This part of the course is gentle; from the Dyak village of Long Bloeoë to Long Tapai, there is a drop of only 20 m. Below Long Tapai the river, which higher up was as much as 200 m. wide, narrows down and forms a series of formidable rapids, the Kepala Kiham, the Kiham Oedang, and the Kiham Halo; in some places the river becomes only 20–30 m. wide. Below Long Bagoeng the rapids are passed, but the river bed is still obstructed by gravel banks. The Mahakam emerges from the hills and crosses the alluvial lake-strewn plain, already described; finally between Moeara Kaman and Samarinda, it breaks through a low range of hills to the sea, forming an elegantly fan-shaped delta.

Most of the tributaries of the upper Mahakam are of no great size. The previously mentioned Howong, the Kaso, and the Penaneh, are of interest as routes to the Kapoeas basin. The largest of the upper tributaries is the S. Boh, which flows in a southerly direction, and forms a route to the remote Apo-Kajan district. Along the west–east section of the upper Mahakam, there are numerous native villages, mostly situated at the mouths of tributaries. The largest tributary

on the middle course is the Rata, on the right bank. Longiram (1,200) on this part of the river, has grown into an important trade centre (Plate 62). Below Longiram the river is joined by the

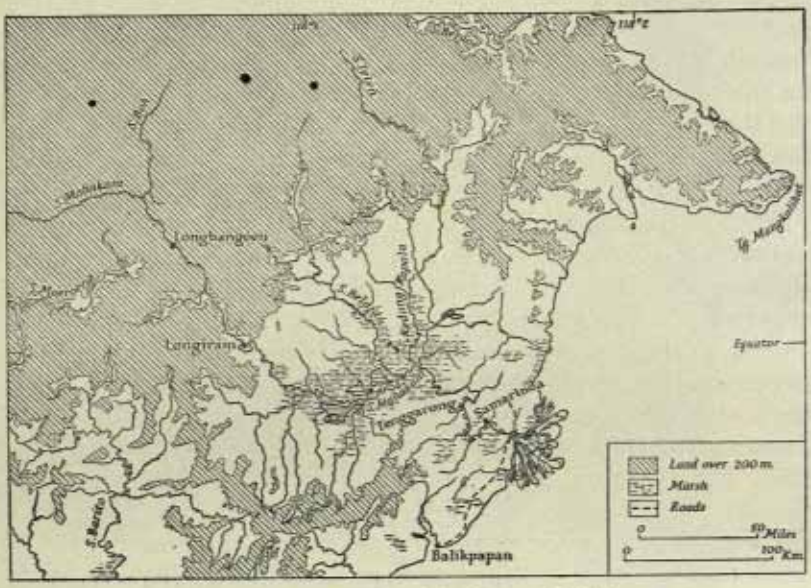


Fig. 89. The lower part of the Soengai Mahakam
Source: 1 : 1 M, sheets N.A. 50 and S.A. 50 (G.S.G.S. 4204).

Kedang Pahoe on the right bank, with Moeara Pahoe at its mouth. In the region of the lakes, the Mahakam receives several large tributaries from the north, first the S. Belajan, then the S. Kedang Kepala, which itself has a tributary called the Antjalong or Kelindjau; a branch from the latter, the Kedang Rantau, reaches the Mahakam as a separate tributary. All the tributaries just named, are navigable for a long distance, and their valleys are well populated. The chief settlement on the Mahakam in the region of the lakes, is Kota Bangoen, a Malay village of 3,000 inhabitants. On the lower course of the river are Tengarong (population, 6,000), the seat of the Sultan of Koetai, and a few hours lower by steamer, Samarinda, a small town with about 5,000 inhabitants.

The rivers north of the Mahakam drain wild, little known country, and have been explored only in recent years. In their lower courses, they flow more or less parallel in an eastward direction, and reach the sea through extensive marshy deltas. The first of some size is the

Plate 60. Houses built on rafts, Bandjermasin (South Borneo)

Plate 61. The oil port of Balikpapan (East Borneo)
Showing the wharves and oil storage tanks.

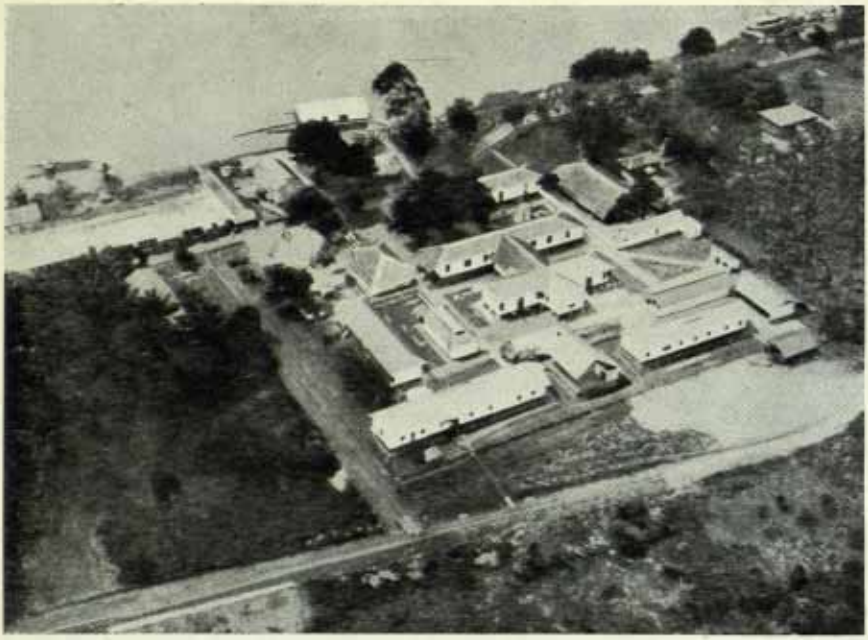


Plate 62. Longiram, a settlement on the Soengai Mahakam (East Borneo)

Plate 63. Coast of Tarakan island (East Borneo)

Beraoe, formed by the junction 30 km. above the delta of two streams, the Kelei, and the Segah or Makam. At the junction lies the Government centre Tandjoengredeb (1,700 inhabitants) and the Malay sultanates of Goenoengtaboer and Samabalioeng. The Kelei is navigable to small steamers up to the Dyak settlement Tanah Merah. The Makam is navigable by vessels drawing 6 ft. A few miles above Tandjoengredeb is a tributary, the Birang, famous for its edible bird's nest caves. In the delta the northernmost and southernmost arms are the most important; the former, the Moera Tidoeng, can be used at high tides by vessels drawing up to 15 ft.

The largest of the north-eastern rivers is the Boeloengan or Kajan. It rises in the Bawoei mountains, flowing at first north, then, after several changes of direction, east. The many large rapids in the central part of the course, where the Boeloengan runs north-east are the largest in Borneo and have a total length of 19 km. The presence of these rapids isolates the upper part of the Boeloengan basin, the Apo-Kajan, whose population is virtually cut off from the outer world. A route from the Boeloengan to the Apo-Kajan runs up its principal tributary, the Bahau and then overland to a small tributary of the upper Boeloengan. Near the head of the Boeloengan delta is the small port of Tandjoengselor (Boeloengan). Of the rivers to the north of the Boeloengan only the Sesajap (called the Melinau in its upper part), the Sembakoeng and the Seboekoe need be mentioned. The S. Sesajap follows a course rather like that of the Boeloengan. Its chief tributary is the S. Mentarang, which flows down from the north. It has a very large delta with three main mouths, called respectively the south, central and north Sesajap mouths. One of the many islands near the mouth of the Sesajap is Poelau Tarakan on which is the town of the Tarakan (also called Linkas), the port of an oilfield of some importance. The Sembakoeng rises in British North Borneo; small steamers can ascend it beyond the village of Peladjoe Baroe. The Seboekoe follows a similar course and also rises in British territory; the village of Pembeliangan is situated at its mouth.

COASTS

The shores of the Netherlands territory in Borneo are with few exceptions, low, often marshy and densely overgrown with mangroves for long stretches, with patches of nipah palms near the river mouths, giving a monotonous appearance (Fig. 90). Only at a few points do

spurs from the mountains of the interior approach the coast, which has few deep indentations although there are a number of wide shallow bays at the many river mouths.

For the purpose of a more detailed description the coastline of Borneo may be divided into three sections:

The west coast from Tandjoeng Datoek, at the Sarawak boundary, to Tandjoeng Sambar at the south-west corner.

The south coast from Tandjoeng Sambar to Laoet strait.

The east coast from Laoet strait to the boundary with British North Borneo at Poelau Sibatik.

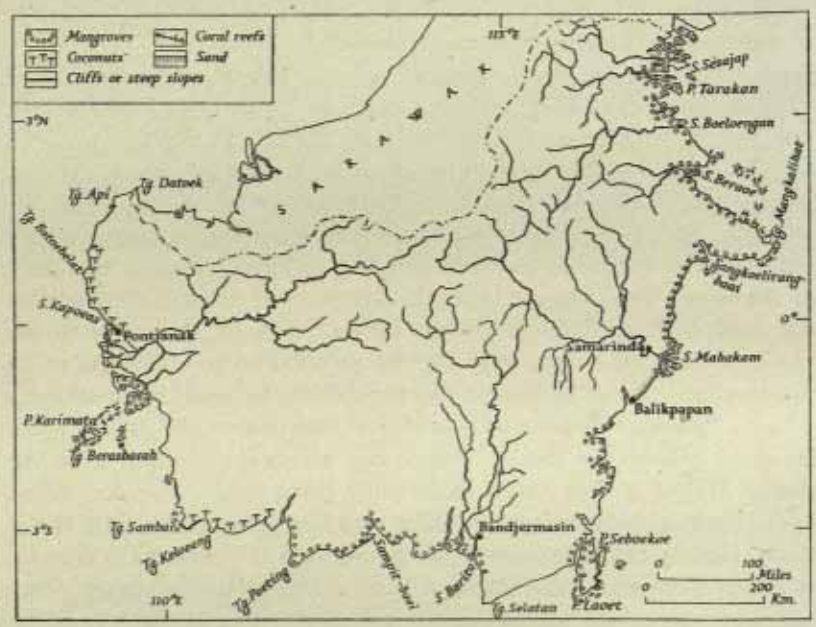


Fig. 90. Borneo: Coastal features

Source: *Atlas van Tropisch Nederland*, plates 23 and 25 (Batavia, 1938), and *Eastern Archipelago Pilot*, vols. 1, 2 and 4 (London, 1935, 1934 and 1939).

The West Coast

This is about 700 km. (440 miles) long. Tandjoeng Datoek, the north-west point of Borneo is the rocky precipitous end of a mountainous peninsula; from here to Tg. Api, 40 km. (25 miles) west-south-west, the coast gradually becomes low and sandy, backed by dense forest. 20 km. (12·5 miles) south of Tg. Api is the Soengai Paloh, the mouth of which is closed by a bar with a least depth of 2·5 m. (8 ft.) and

hence of minor importance; from here to the mouth of the more important Soengai Sambas is another 60 km. (37·5 miles) of low flat coast with occasional small hills. Sambas, a small port, lies a short distance up the river, which is obstructed by a bar with 2·5 m. (8 ft.) least depth; small native vessels can ascend a further 40 km. (25 miles) upstream. From the Sambas to Tg. Bangkai some 55 km. (35 miles) in a southerly direction the shore continues mainly low and densely overgrown; good anchorages are available at several points especially in Sinkawang bay. The densely wooded Boeroeng islands lie offshore along this stretch of the coast. From Tg. Bangkai to the Kapoeas delta 40 km. (25 miles) away the coast continues low and marshy with occasional patches of coconuts a little distance inland; a coastal bank is found well offshore and there are anchorages in 5–8 fathoms. The delta of the Kapoeas, a marshy forest plain traversed by many distributaries, extends for some 200 km. (125 miles) along the coast to the deltaic island of Poelau Maja. Vessels drawing 10 ft. can ascend to Sintang about 400 km. (250 miles) upstream while small native vessels can travel a further 480 km. (300 miles) up this important waterway. Some 16 km. (10 miles) up the Kleine Kapoeas is the chief port of West Borneo, Pontianak. The Kleine Kapoeas entrance has a mud bar of 2·1 m. (7 ft.) least depth; inside the bar there is a least depth of 6·1 m. (20 ft.) in the channel to Pontianak. The other channels through the delta are obstructed by bars and shoals, but offer safe routes for small craft in bad weather. Farther south, there are two large deltaic islands, P. Padang Tikar, and P. Maja, both low and marshy with patches of high ground and largely fringed with mangroves. To the south-west of the Kapoeas delta are the Karimata islands, which consist of the high rocky island of Karimata, a number of small islands, mostly lofty and wooded, and numerous coral reefs.

South of the Kapoeas delta is Soekadana bay, the shores of which are generally low and densely covered with vegetation, but have occasional higher rocky patches. This bay is of little importance except for native craft engaged in local traffic. From Tg. Berasbasah, the southern point of Soekadana bay, the coast runs south for 120 km. (75 miles) to Tg. Sambar, the rocky south-west point of Borneo. This stretch of coast is low and marshy, and the rivers reaching it are small and much obstructed by bars. Rocky headlands with sand beaches are found north and south of the mouth of the Soengai Kendawanga. Ketapang, at the mouth of the S. Pawan which is obstructed by shallow bars, is a minor port and trading centre.

The South Coast

The south coast, about 1,000 km. (526 miles) long, is even more monotonous in aspect than the west coast. Numerous rivers which increase in size to the east, debouch on the coastal lowland, which is generally swampy and mangrove-fringed, with occasional sandy beaches. These rivers usually have bars at their mouths and many of the smaller ones have large funnel-shaped entrances. During the rainy season there is a considerable discharge from the rivers which may discolour the sea up to 65 km. (40 miles) from the shore.

From Tg. Sambar eastwards along the coast to Tg. Keloeang is a shallow bay into which the Air Hitam Besar discharges; the western side of the bay is rocky with sand beaches, but it becomes low and densely wooded to the east. East of Tg. Keloeang the Soengai Djelai enters the sea, and still further east is a 32 km. (20 miles) stretch of sandy beach extending nearly to the mouth of the Soengai Waringin, where mud and mangroves occur. From here to Tg. Pengoedjan a series of low sandy hillocks run along the shore. The west side of Koemai bay is also low and sandy backed by forest, but the east side is mostly of mud. Anchorages of 4–6 fm. may be found in the broad mouths both of the Soengai Waringin and the Soengai Koemai. Between Tg. Poeting and Tg. Siamok, about 70 km. (45 miles) eastward is a shallow bay with a muddy mangrove-lined shore; from Tg. Siamok the coast becomes sandy, backed by a dense forest cover for 55 km. (35 miles) north-eastwards to Sampit bay. The Soengai Sampit with a bar of least depth of 7 ft., is navigable up to Sampit, a village 55 km. (35 miles) upstream; fair anchorages are available in the outer part of the bay.

Immediately east of Sampit bay is the broad mouth of the Soengai Mendawai which is navigable for small craft 270 km. (170 miles) inland. The coast here is predominantly low, muddy and covered with mangroves, and continues so the whole way to the mouth of the Barito, passing the mouths of the S. Kahajan and the S. Kapoeas Moeroeng, both of which are navigable for some distance upstream for vessels of 3·7 m. (12 ft.) draught.

The Soengai Barito is the most important river of the south coast; vessels drawing 3·7 m. can cross the bar at high tide and proceed to the important port of Bandjermasin, 55 km. (35 miles) upstream on the Soengai Martapoera, a tributary of the Barito.

From Tg. Boeroeng, near the Barito mouth, to Tg. Selantan the coast runs in a southerly direction for about 65 km. (40 miles)

continuing low and wooded. At Tg. Selantan, which is higher, it turns north-east for another 135 km. (85 miles) to Laoet strait and is again low and flat with a dense forest cover.

The East Coast

This stretch is about 1,200 km. (750 miles) long. At the south-east corner of Borneo, to the east of the very narrow Laoet strait, is the large mountainous island of Poelau Laoet 99 km. (61 miles) long by 34 km. (21 miles) broad; it is densely wooded throughout, with a rocky coast to the south-east, elsewhere generally low, muddy and covered with mangroves. A broad coral reef makes landing difficult in most of the southern part of the island. At the north end of the island is the port of Kota Baroe, which affords good anchorage in 9 m. (5 fm.). Immediately east of Laoet is Poelau Seboekoe, an island with rocky shores and sand beaches on the east side, the west side being low and sandy.

North of Laoet strait, which affords many good anchorages, the coast of Borneo is low, marshy and forest covered, with shallow dangerous seas outside. There are several large indentations, Kloempang bay, Pamoekar bay, Apar bay and Adang bay, formed by the estuaries of a series of rivers. For the first 200 km. (125 miles) to Tg. Sapoenang, there are occasional sandy patches with coconut trees. North-east of Tg. Sapoenang is Balikpapan bay, the wide estuary of several rivers. The land surrounding the bay is low and swampy with a few hilly ridges, some of which approach the shore. The important oil port of Balikpapan is built on one of these ridges to the east of the bay. From Balikpapan the coast trends north-east to the Mahakam delta, becoming higher with sandy beaches backed by wooded coastal hills.

The Soengai Mahakam is the most important river of the east coast and flows into the sea through a low swampy wooded delta with many channels. The Moeara Pegah channel, with a bar of 3·3 m. (11 ft.) least depth, offers the best entrance and is most used by shipping. At the delta head is the port of Samarinda, and the river is navigable by praus for over 240 km. (150 miles) upstream.

North of the Mahakam, the coast continues low and flat, with mangroves, for some 20 km. (12 miles) to Sangkoelirang bay. The 180 m. (100 fm.) line runs closer to the shore than usual here and there are a considerable number of reefs offshore; anchorages in 15–22 m. (8–12 fm.) are available at various points in this section.

Sangkoelirang bay is another wide estuary, its west shore being low and forested, its east shore hilly; the bay has many reefs, banks and islets and is difficult to navigate.

From Sangkoelirang the coast runs east and then north-east about 120 km. (75 miles) to Tg. Mangkalihat. It is generally low and covered with mangroves, but rocky at a few points where the hill country comes near the coast. At Tg. Mangkalihat the coast runs north-west for 145 km. (90 miles) to the Beraoe delta; here it is mainly low, flat and marshy, and overgrown with mangroves, with an occasional rocky headland. A coral reef fringes most of the eastern part of the peninsula which juts out towards Celebes. There is a well sheltered anchorage in 18–22 m. (10–12 fm.) between the mainland and Poelau Tandjoengboeajaboeaja, a low thickly wooded island close to the shore, but it is difficult to approach.

The estuary of the Soengai Beraoe is filled with numerous low wooded islands separated by the many distributaries of the river. Vessels drawing 4·8 m. (16 ft.) can reach the small port of Tandjoengredeb 24 km. (15 miles) up the river, which is navigable for small craft for about 65 km. (40 miles). From Tg. Batoe, immediately east of the Beraoe delta, the coast continues low and covered by casuarina trees to the delta of the Soengai Boeloengan.

The last 160 km. (100 miles) of the Dutch Borneo coast to the boundary with British North Borneo is made up of the deltas of the Boeloengan, Sesajap, Sambakoeng, and Seboekoe rivers, with numerous low, densely forested islands often fringed with mangroves. Several of the larger islands, however, notably Tarakan, Boenjoe, Mandoel, Oost Noenoekan and Sibatik, are hilly. The Boeloengan is navigable for vessels of 3·3 m. (11 ft.) draught up to the district centre of Tandjoengselor, the Sesajap for native craft up to Malinau, but the Sembakoeng and Seboekoe are of minor importance. On Tarakan island is the oil port of Tarakan which offers a safe anchorage in 18–22 m. (10–12 fm.). The whole deltaic area has numerous bars, banks and shoals which are often hidden by the muddy discharge from the rivers (Plate 63).

ADJACENT ISLANDS

Between Borneo and the neighbouring land masses there are several groups of small islands, most of which are of little importance. The two large islands, Poelau Laoet and P. Seboekoe (or Seboekoet) adjoining the south-eastern corner of Borneo have already been

mentioned; they contain deposits of coal and iron ore of some significance and also export pepper and other products. On the former is the small port of Kota Baroe, at which vessels call on the voyage between Java, Celebes and the east coast of Borneo.

In the South China Sea between Borneo and the Malay Peninsula lie the Anambas islands, the Natoena islands, the South Natoena islands and the Tambelan islands, all of which form part of the Netherlands East Indies. All these islands are very small, except Groot-Natoena island, in the Natoena group, which rises in the peak of G. Ranai to a height of 959 m. In the Karimata strait between West Borneo and Billiton is the small Karimata archipelago, already mentioned.

In the strait of Makassar and the Celebes Sea are the Laoët islands (lying immediately to the south of the much larger P. Laoet), the Kleine Paternoster or Balabalagan islands and a number of other unimportant groups (Fig. 7). In addition, there are various islands close to the coast of Borneo; Tarakan, the most important of these, has already been referred to.

PLANT AND ANIMAL LIFE

The lowlands are hot and moist, the temperature varying very little from a mean of about 27° C. (80° F.) at any time of year. Rainfall is everywhere high; though it is lower on the east coast than elsewhere, there are probably few places with less than 2,500 mm. (100 in.) per annum and in some localities it approaches double this amount. There is no true dry season, though the rainfall is generally greater at some periods of the year than at others, the season of the greatest rainfall varying in different parts of the island. In many places thunderstorms accompanied by torrential downpours are an almost daily event.

A consequence of the high rainfall is that the natural vegetation of practically the whole island is tall evergreen rain forest; it has been said that an orang-utan could travel through Borneo from end to end without once touching the ground. On the coasts and estuaries and in the many swampy areas inland tall rain forests give place to mangrove swamps, palm swamps and other types of vegetation, but these too consist mainly of evergreen trees. In the forests of the well drained land the taller trees reach a height of 45–60 m. (150–200 ft.) and climbing plants grow in profusion. Much of the life of the native peoples is taken up with an unending struggle with the jungle which

rapidly invades cleared land as soon as it is given the chance. The jungle is however not entirely an enemy to man. It provides him with building material—many of the forest trees, especially the bilian or ironwood (*Eusideroxylon Zwageri*) provide excellent timbers, hard and durable—and palm leaves for thatch. Some of the minor forest products, e.g. jelutong gum, camphor and dammar, are valuable and are collected by the natives to trade for salt, cloth and other necessities. The small quantities of nuts and other edible plant foods found in the forest are useful to the natives when the harvests are poor. The climbing palms called rattans (rotangs) with long, often thorny stems up to 60 m. (200 ft.) or more in length are plentiful nearly everywhere in the Bornean forest and are an indispensable material for tying, plaiting and basket work.

Travelling through the forest is not easy. The absence of good paths and easily visible landmarks make it difficult to find one's way, even with the help of a compass, though the natives are skilful in noting and remembering small marks on trees. The saturated sultry atmosphere and the innumerable streams and rivers which have to be forded, not to mention the land leeches which no clothing will keep out, combine to make overland travel far from comfortable.

The lowland forest is, at least to the non-botanical eye, very monotonous and uniform, but at a height of about 1,000 m. (3,000 ft.) the tall rain-forest gives way to dwarf or crooked trees covered with a thick blanket of sodden moss, a consequence of the drizzling rain and driving mist which prevail at these heights. In parts of the lowlands of South and East Borneo there are considerable stretches where the forest opens out to make way for savannas of *alang-alang* grass, sometimes thinly covered with scattered trees. This is probably not a natural type of vegetation, but owes its existence to clearing and recurrent fires; left to themselves these savannas would probably soon become, like the rest of the country, covered with forest.

Cultivated land occupies only a very small area. The chief food plant is rice, which is generally grown without irrigation (*ladang* cultivation), but though a large proportion of the population is engaged in rice production, the native method of cultivation is so inefficient that large quantities have to be imported. Maize, tapioca, sago and most of the other crops of the East Indies are grown on a smaller scale. The area of the coconut plantations increases yearly. Pepper is grown on a fairly large scale, mainly in the 'Chinese Districts' of the south, as well as small amounts of plantation rubber, tobacco, coffee, etc.

Borneo has a rich and varied animal life, which is much more like that of Sumatra than that of Java, and differs considerably from that of Celebes and other islands to the east of 'Wallace's Line'. There are no tigers or panthers and elephants are found only in British North Borneo where they were originally introduced by man, but wild pigs, monkeys of many kinds and deer are abundant everywhere. The rhinoceros and tapir are found, but are rarely seen by the white man. The bubbling call of the gibbon is one of the most characteristic and delightful sounds of the early morning in the Bornean forest. The most interesting of all the mammals is the orang-utan, which elsewhere is known only in Sumatra; it is fairly common in south Borneo in the districts of Bandjermasin, Pontianak and Sambas and on some of the rivers of Sarawak. Of the animals peculiar to Borneo the quaint proboscis monkey is one of the most remarkable. Apart from dogs and cats, the natives have few domestic animals except pigs; there are a few cattle. The birds of the island include some of the most splendid in the world, such as the Argus pheasant. The ungainly hornbill is common. The swift which makes the edible bird's nests so much relished by the Chinese occurs in caves in the limestone hills in various parts of Borneo. These nests and the wax and honey of wild bees are some of the few animal products of any economic importance. The rivers of Borneo abound with crocodiles, as well as fish, which the natives catch by netting and often by poisoning the water with tuba, the root of the *Derris* creeper. Fresh-water fishing is of some importance as a source of food.

Birds and mammals play a large part in Dyak myth and superstition. This is of great practical importance to the traveller in the interior, as nothing will induce a native to embark on a long journey or any other important enterprise without first obtaining a favourable omen; to do this it may be necessary to examine the liver of a freshly killed pig or to observe the flight of certain birds.

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Chapter VI

CELEBES

Introduction: Physical Features: Coasts: Adjacent Islands: Plant and Animal Life: Bibliographical Note

INTRODUCTION

Celebes, one of the four Greater Soenda islands, is situated in the eastern portion of the Indonesian Archipelago, between latitudes 1° 45′ N, and 5° 37′ S, and between longitudes 118° 50′ and 125° 5′ E of Greenwich. The strait of Makassar separates it from its neighbour Borneo, some 300 km. (200 miles) to the west, while the Flores Sea and the Lesser Soenda islands lie to the south. East of Celebes is the Banda Sea, and the scattered group of islands known as the Moluccas, and to the north the Celebes Sea which separates it from the Philippine Islands.

From the tip of the northern peninsula to the end of the southern, Celebes measures some 1,050 km. (650 miles), while its greatest width from Tomori bay westward, is about 240 km. (150 miles); the northern peninsula in parts is less than 20 km. (12·5 miles) across. Owing to its peculiar configuration, no part of Celebes is more than 115 km. (70 miles) from the sea, while its extensive coastline is almost 3,000 miles long. The island has an area of 189,000 sq. km. (73,000 sq. miles), including certain neighbouring islands which are part of the two administrative units—the Residency of Manado, and the Government of Celebes and Dependencies.

Celebes, though surpassing Java in extent, is the least familiar of the large islands of the archipelago; in fact, much of what is known about it has only been discovered in the last half-century. As a result partly of its location and partly of its mountainous and densely forested terrain, not only did it remain perfectly free of European influence of any kind later than any of the other important islands, but pre-European colonists too, seem to have left it alone. The Hindu influence which had so profound an effect on south Sumatra, Java and Bali, hardly touched Celebes, while the earliest travellers mention no other religion than animisim, indicating that Moslem missionaries had not reached Celebes at that time.

The Portuguese were the first Europeans to land in Celebes, but discovering neither gold nor the even more precious spices, they

turned their attention to the Moluccas further east. In 1540, they established a settlement at Makassar, to serve as a stopping place on the route to the Moluccas. Since then only at the extremities of the peninsulas of Makassar and Minahasa has European civilization and culture made itself felt. Central Celebes remained completely unknown until the travels of Adriani and Kruijt, Dutch missionaries, and of the Sarasin brothers, Swiss naturalists, early in this century. The Dutch geologist Abendanon, the German Grabauer, and others, afterwards followed in the tracks of these pioneers. The highest mountains, the Latimodjong mountains, the largest lake, Towoeti, the longest river, Soengai Lariang, have all been discovered comparatively recently. Thus Celebes is gradually becoming better known, though much still remains to be done before an accurate knowledge of its geography can be gained.

There are no railways and few highways, except in the Minahasa and Makassar regions, where roads radiate from the two cities of Manado and Makassar. Elsewhere, short stretches of road have been built, but lack interconnexion. As navigable rivers are absent, travel in the interior must be on foot or on horseback over difficult mountain tracks.

The population in 1930 (the details of the 1940 census are not available, owing to the Japanese occupation) was 4,231,906, of which 3,093,251, were in the Government of Celebes and Dependencies, and 1,138,655, in the Residency of Manado. Of these, 7,683 were Europeans, 41,402 Chinese, and 9,218 other Asiatic peoples, the vast majority thus being of native origin. The density of population varies from less than twenty persons per square mile, over large tracts of the centre and east, to seventy-five in Minahasa, and 325 in the Makassar region. In general, the majority of the population is found on the coast, and at the northern and southern extremities; the interior is thinly peopled with settlements confined to isolated valleys and basins, specially favourable to the primitive economy of the Toradjas and other native tribes.

Of the native peoples, by far the most numerous and important are the Boeginese and Makassarese of the southern peninsula, who number a little over 2,000,000. They are Mohammedans and their rulers once dominated most of the island. Formerly pirates and slave-dealers of evil reputation, they have now become the chief trading people, and are also found along the east coast of Borneo.

In the centre of the island are the Toradjas, and related tribes numbering over 500,000: they are a primitive people, largely pagan

animists, and worshippers of the dead. They were formerly head-hunters, but are now beginning to change their ways, owing to the civilizing effect of Dutch traders and missionaries. In the northern peninsula, there are 250,000 Mohammedan Gorontalese, and an equal number of Minahassese, who are akin to the Filipinos of Mindanao. These latter are the most advanced people of Celebes, and have almost all been converted to Christianity in the last hundred years.

Though full details of the mineral resources of Celebes are still unknown, the available evidence suggests that they are not of great extent.

In the northern peninsula gold has been worked in several localities, notably at Paleleh and Totok, but the workings were closed by 1937 owing to the poor yield. Nickel ore exists to the west of lake Towoeti and near Kolaka, but awaits further development; the Towoeti region also possesses some iron-ore of good quality and traces of chromium. Small amounts of silver, copper and iodine are also found in the northern peninsula, a little silver in the central mountains, and poor quality coal north of Latimodjong. There are slight indications of petroleum, and asphalt is worked in the island of Boetoeng for use on the roads of Java.

PHYSICAL FEATURES

Relief

The peculiar tentacled shape of Celebes, which is repeated further east in the island of Halmahera, has in the past given rise to many hypotheses. The island lies in the unstable area between the Soenda Shelf to the west, and the Sahoel Shelf to the east, and has been subject to three different periods of folding, the earliest in late Cretaceous times, a second in the Miocene period, and a third in the early Pleistocene (see Fig. 5). The folding was accompanied by widespread faulting and fracturing, and in the case of the latest folding, by much volcanic activity which is still proceeding in the Minahasa region, and has not very long ceased in the south, where there is the extinct volcano of Lompobatang.

The peculiar shape of the island and its precipitous shores, running steeply into deep water, are due mainly to faulting, which is also responsible for an extensive development of *horsts* (upstanding blocks) and *graben* (rift valleys) through the island.

Accordingly Celebes is not maturely eroded like its near neighbour, Borneo, but displays the landscape features associated with a juvenile stage in the erosion cycle; deep valleys incised by streams, rejuvenated by uplift, separate blocks whose flat tops have been reduced to narrow ridges. There are numerous tectonic basins, generally running NNW–SSE in the centre of the island, often filled by lakes or by the alluvium of former lakes (Fig. 91).

Fig. 91. Celebes: Physical features

Source: *Atlas van Tropisch Nederland*, plate 26 (Batavia, 1938).

For the purpose of a more detailed description, Celebes may be sub-divided into five regions; the four peninsulas, and central Celebes. There are no clear-cut natural boundaries between the peninsulas and the central mass, hence the lines of division are largely arbitrary.

The Northern Peninsula

This region is separated from central Celebes by a line running from Parigi on the gulf of Tomini to Paloe at the head of the gulf of the same name. From the Parigi–Paloe line northwards, runs a narrow isthmus for a distance of about 200 km. (125 miles). This isthmus, which at its narrowest, north of the Manimbaja peninsula, is but 17 km. (10·5 miles) across, has a mountainous core of granite and schists, rising to 2,199 m. (7,215 ft.) in Boeloe Sidole near its southern end, and to 2,565 m. (8,415 ft.) in the Ogoamas, south-west of Dondo bay. Many of the loftier ranges of this isthmus are bare, but the lower slopes are generally densely covered by forest. There are few routes across the isthmus, the lowest running west from Kasimbar, over a pass 350 m. (1,150 ft.) high, but the most important from Toboli west to Tawaeli on Paloe bay, climbs to 1,067 m. (3,500 ft.). The peculiarly shaped Manimbaja peninsula which juts out into the strait of Makassar, is a mountainous mass of metamorphic rock.

From Tolitoli bay east to the Minahasa, two almost parallel mountain chains run for some 400 km. (250 miles). The one near the north coast has a core of schists often covered by either sedimentary or eruptive formations, and rises to 2,432 m. (7,980 ft.) in B. Kalangkangan, near Tolitoli bay, while G. Tentolomatinan, some distance to the east, reaches 2,175 m. (7,140 ft.). The range nearer the south coast, which appears to be a continuation of the isthmus range, touches 2,707 m. (8,881 ft.) in B. Silonböoe at its western extremity, but becomes lower to the east where G. Mataboelawa, a peak of 1,907 m. (6,260 ft.) some distance east of Gorontalo, is the highest point. Between the two ranges is a fault line with several tectonic depressions, of which that containing lake Limboto is the largest.

From the Poigar river to Bangka strait is the Minahasa region, which geologically does not belong to the rest of the island, but to the Manado–Sangihe volcanic arc (see Fig. 13), which can be traced across the Celebes Sea to the Philippine Islands. The region is composed mainly of late Tertiary and Quaternary volcanic rocks, with some sedimentaries in the depressions: about a dozen volcanoes are found, some of which are in the fumarole stage, but one, G.

Sapoetan, 1,827 m. (5,990 ft.) high, erupted as recently as 1925 (see p. 40 and Fig. 26). The region is conveniently divided into three by the Manado-Kema and Amoerang-Belang depressions; the sub-region south-west of the latter depression, consists of the two recent volcanic massifs of Lolomboelan to the north and the Manebo mountains further south, separated by the Ranaipo valley. Central Minahasa, containing lake Tondano, is a plateau rising steeply to 700 m. (2,300 ft.) on the south side; north-east Minahasa is a mountainous region, dominated by the extinct volcano G. Klabat, 1,995 m. (6,543 ft.) high.

The Eastern Peninsula

This region is separated from central Celebes by the line Oeikoeli–Tomori bay, which crosses a low watershed of 800 m. (2,600 ft.); it measures some 260 km. (160 miles) from this line to Tg. Pangkalaseang, its most easterly point. The peninsula widens considerably east of Tomori bay, then narrows gradually, terminating in the mushroom-shaped Boealemo sub-peninsula. Except for parts of the coastal fringe, and a few tranverse routes, this part of Celebes is unknown. The eastern peninsula as well as the south-eastern peninsula, appears to have been formed by the earlier or Miocene folding to which the area was subjected, but there is a remarkable difference between the direction of the peninsula, and the strike of the rocks which is NW–SE. Much faulting of a complicated type has taken place in both peninsulas, and this increases the complexity of the problems of their geology and structure.

Two mountain chains which eventually merge to the east, run through the peninsula, with a dissected plateau between. The southern chain, which includes the Tokala and Batoei ranges, rises to peaks of 2,628 m. (8,600 ft.) to the west, and 2,400 m. further east. The northern chain has G. Katopasa, 2,808 m. high, and G. Loemoet 2,280 m. high. Across the Boealemo peninsula run the Balantak mountains, a range of basic igneous rocks, which seldom exceeds 1,500 m. (4,900 ft.) in altitude.

There are large exposures of limestone in the eastern part of the interior, where there is irregular surface drainage, and other usual features of the 'karst' landscape.

The South-eastern Peninsula

This peninsula is only slightly better known than the eastern one. The boundary between central Celebes, and the south-east peninsula

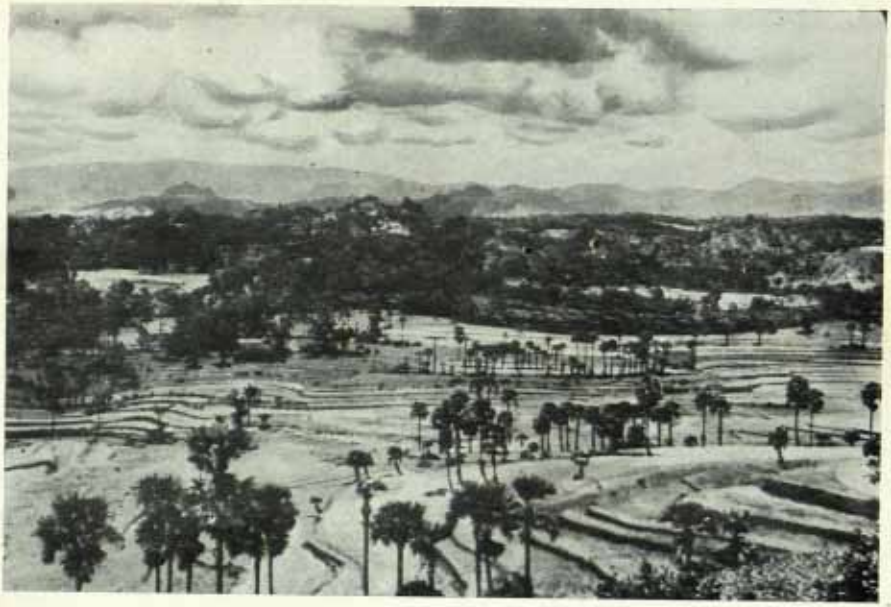

Plate 64. Country near Bonthain, at the tip of the southern peninsula

In the foreground terraced rice-fields and scattered coconut palms: in the background the rugged foothills of the Lompobatang massif which can be dimly seen in the distance.

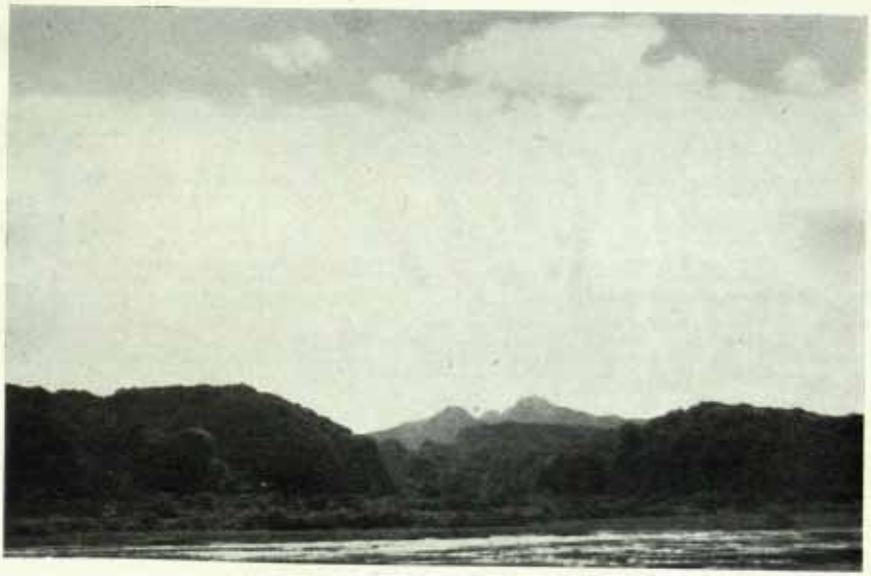

Plate 65. Bantimoeroeng, near Makassar

The densely wooded limestone hills are typical of the Maros region north-east of Makassar

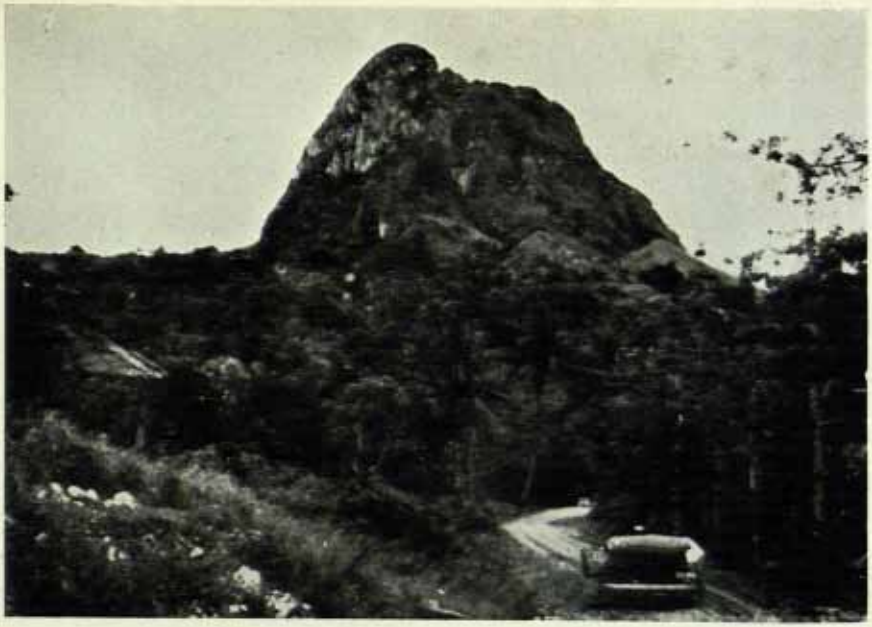

Plate 66. Road from Parepare to Makale
Typical hill country in the south of central Celebes.

Plate 67. Amoerang bay
Amoerang bay offers some of the best anchorages of the north coast of Celebes; it is backed by low wooded hills, which are here shown in the background. In the foreground is a native canoe with double outrigger and bifid prow.

may be taken to run from Lingkoboe on Tomori bay up the S. Sokita, across the Verbeek mountains to the headwaters of the S. Tjenrekang, and thence to Oesoe bay. From this line to the end of the peninsula on Boetoeng strait, is approximately 320 km. (200 miles).

At the neck of the peninsula, is a series of depressions containing the deep lakes, Matana, Mahalona, and Towoeti. South of these lakes is a broken mountainous country, with a series of parallel ranges, of which the Mekongga on the west side is the most important rising to 2,790 m. (9,150 ft.) in G. Mekongga. North-east of the Mekongga mountains is the extensive valley of the Konaweha. At the tip of the peninsula, the highland runs in a curve around Tioro strait, reaching 1,000 m. (3,000 ft.) in a few points. The core of the mountains is generally of resistant igneous and metamorphic rocks, chiefly granite, schists, and gabbro; softer shales, marls, and limestones are found in the valleys and the lower ranges.

The Southern Peninsula

The line of demarcation between central and southern Celebes is particularly difficult to draw, as the mountain system of the centre penetrates some distance southwards. The boundary may well be taken as running from the Sadang mouth south-east to a point north of Singkang, where the spurs from the mountains further north reach their most southerly extension, and thence to the coast of the gulf of Boni.

South of this line is the tectonic depression of lake Sidenreng—lake Tempe extending from Parepare bay east to the mouth of the Tjenrana. This depression, from which another depression forming the Walannae valley runs southward between parallel faults, and the volcanic cluster of Lompobatang at the southern tip, indicate that the region has been subjected to much volcanic and tectonic disturbance. In parts limestones of late Tertiary age have been raised as much as 1,000 m. (3,000 ft.) but the area is now relatively stable. The presence of the reefs of the Spermonde archipelago on the coastal shelf west of Makassar, suggests a positive change in sea-level, drowning the western part of the peninsula (cf. p. 12 and Fig. 7).

From the lake depression already mentioned, two ranges run south on either side of the Walannae trough, meeting in the Lompobatang massif which rises to 2,871 m. (9,416 ft.). This ancient and extinct volcano, with one main crater, and several parasitic cones, has been subject to heavy stream erosion. The area surrounding consists chiefly of late Tertiary and Quaternary volcanic rocks, but the ranges to the north are mainly of limestone, which outcrops all the way to

the west coast in the vicinity of Maros. There is a greater extension of coastal plain, mostly alluvial, on the borders of the southern peninsula than elsewhere in the island. This is particularly noticeable in the Makassar region, which as a whole is less mountainous than the other parts.

Central Celebes

As previously indicated, central Celebes was until recently entirely unknown; as yet the geological map shows large blank spaces and the structure still awaits thorough scientific investigation. It is an extremely mountainous area; its highlands are the denuded fragments of a shattered and uplifted peneplane, its valleys deeply cut by torrential rivers, or formed from tectonic depressions.

The region may be subdivided into three sections—the western, the central, and the eastern. Between the western and the central sections runs the Fossa Sarasina, a series of tectonic troughs, bounded by parallel faults running SSE from Paloe bay to Masamba on the Loewoe plain at the head of the gulf of Boni. The irregular Poso depression separates the central from the eastern subdivision.

The western section, which is by far the largest, contains three lofty mountain ranges. The Molengraaf mountains, running from the west side of Paloe bay to the Loewoe plain, have two high peaks: Boeloe Waoekara, 3,127 m. (10,260 ft.), in the north, and B. Kamboeno, 2,950 m. (9,678 ft.) at the southern extremity. Further southwest is the Quarles range which rises to 2,963 m. (9,720 ft.) in B. Kalando, and to 3,074 m. (10,086 ft.) in B. Gandiwata. Projecting into the southern peninsula is the Latimodjong range with B. Rantemario, 3,440 m. (11,286 ft.) high. The upper parts of these ranges are often heavily eroded and bare, but in general there is a dense cover of virgin forest. The Molengraaf range consists of resistant igneous and metamorphic rocks, with much granite and gneiss outcropping. The Quarles mountains display a great thickness of tuffs, while the Latimodjong block is composed mainly of granite, schists, and other resistant rocks. At the southern end of the Molengraaf mountains is the Loewoe plain built up of alluvium brought down to the gulf of Boni by the rivers draining the mountain country inland.

Through the central area, in a north–south direction, runs the Fennema group of mountains, which are composed mainly of schists and other metamorphic rocks; G. Nokilalaki, 3,311 m. (10,860 ft.), and G. Balease, 3,016 m. (9,896 ft.), are the highest points of this rugged mountainous area.

The eastern region is considerably lower than either the western or central, the highest peak being G. Kajoga, 2,563 m. (8,408 ft.) in the Pompangeo mountains south of the gulf of Poso. The mountain ridges here are mainly of schists, limestone and other sedimentaries occupying the lower parts. There has been much complex faulting and numerous tectonic depressions occur. The Poso depression itself is floored with limestones, soft clays and other sedimentary rocks.

Rivers

The rivers of Celebes are neither of great length, nor of much importance. Many of them flow through narrow gorges, and are much obstructed by waterfalls and rapids, while the presence of numerous lakes testifies to the youth of the drainage system. The longest rivers are those few which run longitudinally, draining tectonic basins between lofty mountain ranges. The majority have short courses from the uplands to the sea; they are therefore of little use as waterways, and even the small native praus cannot ascend them for many miles. Bars off the deltas of the larger streams further hinder navigation.

The Northern Peninsula

The rivers of the northern peninsula are almost all very short, flowing in torrential fashion from the mountainous backbone to the coast nearby. As the watershed lies nearer the north coast, the longer rivers flow south. These include the S. Randangan, which reaches the sea in a marshy delta west of Marisa, and the Soengai Pagoejama, which breaks through a coastal range in a narrow valley to enter the sea at Bilatoe. From the middle Pagoejama eastwards, runs a depression, once an arm of the sea, but now largely filled in; this contains lake Limboto, a shallow lake, some 2 m. (6 ft.) deep, and 11 km. (7 miles) by 6·5 km. (4 miles) in extent, but larger during the rainy season. The Malango drains lake Limboto, breaking through a range of hills near the coast in a gorge to enter the sea at Gorontalo. Though the river mouth is deep, it shoals rapidly, and vessels cannot proceed inland any distance. Further east is the small lake Moöat, probably of volcanic origin, drained by the S. Poigar which flows north-west across a plateau, before reaching the coastal plain south of Amoerang bay. Into the latter bay flows the Kali Ranaipo draining the volcanic mountain area east of lake Moöat. In the plateau of central Minahasa, some 700 m. (2,300 ft.) above sea-level, is an ancient caldera blocked by lava flows and volcanic debris, now filled by lake Tondano, nearly

17 km. (10 miles) long, bordered by low ground at the north end, and by a steep 400 m. (1,300 ft.) scarp, to the south-east. The Kali Tondano draining the lake to the north-west, plunges over a waterfall more than 150 m. (500 ft.) high and through a deep gorge to reach the Manado plain and the sea (Fig. 26).

The Eastern Peninsula

None of the rivers draining this area is of any great significance. They are mostly very short streams, many of which run dry in the dry season, particularly where they flow through the limestone country. The most important are the Soemara, which drains the swampy lowland at the head of Tomori bay, and the S. Bongkoe, which is by far the longest, rising in the Tokala mountains, near the south coast, and draining with its tributaries, a large area of broken country, eventually reaches the sea south-west of Tg. Api. None of the rivers of this peninsula is navigable.

The South-eastern Peninsula

At the base of this peninsula is a series of lake-filled depressions, containing Towoeti, the largest lake in Celebes, the very deep lake Matana, lake Mahalona, and several smaller ones. Towoeti is drained by the La Rona, which flows from its western end through a valley 85 m. (280 ft.) deep, to enter the sea at the head of the gulf of Boni. In its lower reaches, where it is called the Malili, it flows in a drowned valley, and consequently it is navigable by small native vessels for 16 km. (10 miles) from its mouth. South-east of lake Towoeti, is a much broken country drained by the La Solo and its tributaries; this stream is navigable for some 25 km. (16 miles) from its mouth in Lasolo bay. The Konaweha, which is named Sampara in its lower course, drains with its many tributaries, a very large extent of the unknown mountain country north-west of the Mekongga mountains. In its middle course, there is a large depression, probably a former lake, filled by swamps, which become extensive in the wet season. The river which reaches the coastal plain through a gorge and enters the sea in a sandy delta, is of little use for navigation.

The Southern Peninsula

In the south, the drainage pattern radiates from G. Lompobatang; many small streams of a torrential nature during the rainy season flow from the craters of parasitic cones on the south side of this ancient volcano, entering the sea near the southern tip of the island. From the

main crater further north, runs a larger river, the Beerang, which has created, at the foot of the mountain, a fan of debris brought down by the rushing torrents of the rainy season. The last fall on the Beerang, is but 2 m. (6 ft.) above sea-level so it completes its journey to the sea over a plain which is often flooded. The river can be navigated by canoe up to Boetakang, where it is 120 m. (390 ft.) wide.

The largest river of the southern peninsula is the Walannae, which flows due north to the lake Sidenreng–lake Tempe depression, into which many other streams flow from the north. These lakes are at their largest extent in the wet season, and shrink considerably during the dry season. They are drained eastwards by the Tjenrana, which reaches the sea 40 km. (25 miles) away, over a low plain forming a marshy delta, with numerous mouths. The Tjenrana, is navigable for small craft some 30 km. (20 miles) from its mouth to Pampanoe.

The Walannae for 25 km. (15 miles) above Singkang, can be navigated by small praus; higher up it becomes a mountain stream torrential during the wet season. The only other river worth noting is the Maros, which flows first in a deep gorge through the limestone country north of G. Lompobatang, and then through a broad alluvial plain, before reaching the sea. Praus can get a short distance upstream from the Maros delta.

Central Celebes

From the Latimodjong massif, a number of small rivers flow south into the lake Tempe depression, as already mentioned. The east side of these mountains is drained by the S. Djenemedja or Maroro which rises west-south-west of Palopo, flows south through a deep cleft to break across the coastal ridge at right angles and reaches the gulf of Boni. East of the Latimodjong range is the capacious basin of the Sadang, which rises west of Palopo, and soon reaches the fertile basin of Rantepao, which was formerly occupied by a lake. The river breaks through a limestone ridge at the south of this basin, to enter the similar basin of Makale, from which it continues in a south-westerly direction, and is joined by several tributaries. The Masoepoe, and the Mamasa, are the most important of these, and drain basins in the Quarles mountains further to the north-west. At Melaling, the Sadang turns sharply to the west, breaking through a tongue of basalt; it reaches the sea in a swampy delta with four mouths. West of the Sadang drainage basin, in the Mandar peninsula, are a number of unimportant rivers.

The north side of the Quarles range is drained by the Karama,

which flows west into the strait of Makassar; it is navigable for a short distance upstream by native canoes.

The longest river of Celebes, the Lariang, called Koro in its upper reaches, drains a large area of central Celebes. The main source stream, the Tawaelia, rises in a little lake at the southern end of the Fennema mountains, and flows northwards through a number of depressions along the Fossa Sarasina to the Grimpoe basin, collecting the waters of numerous tributaries. Here it turns at right angles towards the west in a deep valley through the mountains to reach the strait of Makassar at Lariang.

The upper part of the Fossa Sarasina is drained by the Soengai Paloe, which rising in the lake, Danau Lindoe, to the west of B. Nokilalaki, flows first south-west and then north to reach Paloe bay.

In the centre of central Celebes, is lake Poso, which occupies the deepest part of yet another depression. This lake is nearly 1,500 m. (4,900 ft.) deep, and is drained northwards by the Soengai Poso, which pursues a much obstructed course to the gulf of Tomini.

The country east of the Poso depression is drained by the La, which in its middle course has cut a 100 m. (330 ft.) deep valley through a former lake-bed, and breaks through a ridge of mountains before reaching the sea at Tomori bay; the river is navigable for praus for some 20 km. (12 miles) upstream.

The mountain country north of the gulf of Boni, with the Loewoe plain, is drained by a number of small rivers of which the Rongkong, Kebo, and Kalaena, are the chief.

COASTS

Celebes, owing to its peculiar shape has an enormously long coastline, of almost 3,000 miles, in proportion to its area (Fig. 92). Unlike Java, Sumatra, and Borneo, which stand on the shallow Soenda Shelf, Celebes is surrounded on all sides by deep seas. Accordingly the 180 m. (100 fm.) line generally runs close to the shore, and the coastal shelf bordering the island does not reach any considerable width, except to the west of Makassar, where lies the Spermonde archipelago, a group of coral islands and reefs.

The faulting and fracturing which has contributed mainly to the peculiar shape of the island, also accounts for its rectilinear coasts and for the absence of both coastal shelf and coastal plain. The coasts of Celebes in contrast to those of Java, Sumatra, and Borneo, generally rise steeply from the sea, and do not present to the coastwise traveller

the monotonous panorama of a low, densely forested coastal plain so commonly observed in the other islands. Only in the Loewoe region, at the head of the gulf of Boni, does the coastal lowland penetrate beyond 30 km. (18·5 miles); in several localities, however, the mountains do recede further from the shore than usual. Low-lying areas occur in the Makassar region, to the north of Parepare and at the mouth of the Lariang, on the west coast; to the north of Tomori

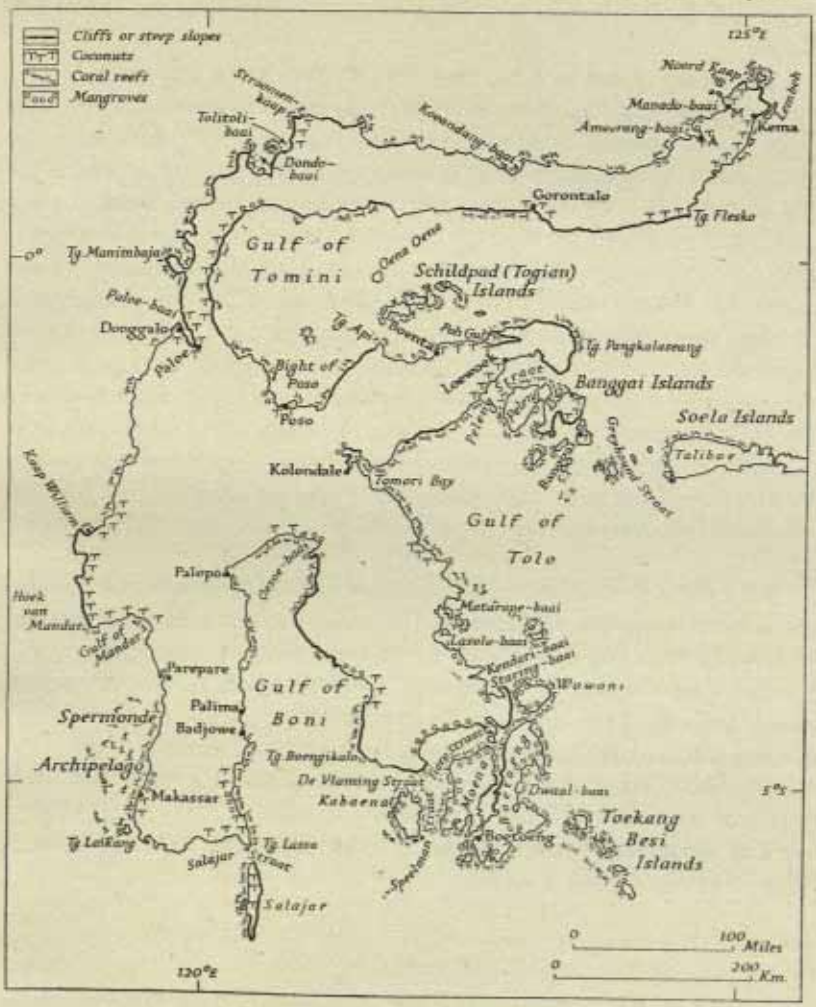

Fig. 92. Celebes: Coastal features

Source: *Atlas van Tropisch Nederland*, plates 23 and 26 (Batavia, 1938), and *Eastern Archipelago Pilot*, vol. 2 (London, 1934).

bay in the gulf of Tolo, and also at the mouth of the Tjenrana and in the north of the gulf of Boni.

Steep cliffs surmounted by a luxuriant growth of vegetation and rocky headlands with small stretches of sandy beach are characteristic of most of the indented coast of Celebes. There are, as might be expected, few stretches of the mangrove-covered swampy type so characteristic of the east coast of Sumatra, and of the south and east coasts of Borneo; these are most extensive on the shores of Tioro strait.

At varying distances from the rocky shores over a very considerable extent of the coast is a line of coral reefs, many in the south and west forming vegetation-covered islets, but the majority under water or just awash. These make coastal navigation difficult, and access to the shore possible only to small craft. Penetration inland from the sea is further hindered by the mountainous nature of the island interior; the only railway, a light one from Makassar south to Takalar, closed down in August 1930. The road system is still quite inadequate, though the Colonial Government has had in hand for some time a considerable road-building programme for the more thickly-peopled Makassar and Minahasa regions. Hence in spite of the dangers caused by the numerous coral reefs, banks and shoals, most of the trade of Celebes moves along the coast in the twenty or thirty-ton sailing craft of the Boeginese and other native traders supplemented by the steamers of the ubiquitous *Koninklijke Paketvaart Maatschappij* (K.P.M.).

Though information on the geology and hydrography of Celebes is neither complete nor accurate, the coast may be divided into the following four major sections for the purpose of description:

The west coast from Tandjoeng Laikang north to the Stroomen-kaap, including the Spermonde archipelago.

The north coast from Stroomen-kaap east to Lembeh strait.

The east coast from Lembeh strait south through the deep gulfs of Tomini and Tolo to Wowoni strait.

The south coast from Wowoni strait west through the gulf of Boni to Tandjoeng Laikang.

The West Coast

The west coast is about 1,100 km. (680 miles) long. The southern portion from Tg. Laikang to Hoek van Mandar, about 300 km. (185 miles) in length, is generally low with numerous sandy beaches

backed by dense vegetation further inland. From Makassar north to the Soengai Sigeri there are at intervals marshy areas with mangroves, some quite extensive, while in the Makassar, Maros and Tanette districts where patches of savanna occur there are many cleared areas which are cultivated.

The rivers debouching on to the coast plain are of minor importance, most of them having a shallow bar at their mouths. There is but one bay of some importance, Parepare bay, which is divided into two parts both of which offer good anchorages in depths of 9–18 m. (5–10 fm.). The town of Parepare on the east side of the bay, is a small port of some trading importance, but cannot of course be placed in the same category as Makassar, one of the major ports of the Netherlands Indies. North of Parepare the Soengai Sadang, and Soengai Alita reach the sea in a low wide coastal plain, running 40 km. (25 miles) north to the gulf of Mandar, where the coast turns at right angles westwards, and the central mountain mass approaches the sea. Here the 180 m. (100 fm.) line runs close to the shore and encloses a number of reefs, but anchorages in 9–27 m. (5–15 fm.) are available at Polewali, Balangnipa, and Majene, all of which have considerable native trade.

From Tg. Laikang to Parepare, a sandy shoal runs close to the shore, broken in many places north of Makassar. On the seaward side of this is a continuous series of coral reefs and submerged banks of varying width rising steeply from the sea. From Batoe northwards the coral is of less significance, but becomes dangerous once more east of Hoek van Mandar. In consequence, navigation in this section of the coast is rendered particularly difficult.

About 60 km. (35 miles) off the coast of the Makassar region, lies the Spermonde archipelago, a series of coral islands, rocks and banks, standing on the coastal shelf, here extending some distance into the strait of Makassar (see Fig. 7). Tanakeke, the largest islands of the archipelago, is a low island, thickly wooded and surrounded by a brushwood-covered coral reef. The other islets are similar, many being planted with coconuts. The whole Spermonde area is dangerous to navigation, hence passing vessels do not venture outside the three usually frequented channels through the group.

The northern portion of the west coast stretches about 800 km. (almost 500 miles) to Stroomen-kaap (Tg. Besar). In this section the coast quite changes its aspect, rising precipitously from the water's edge, and being densely overgrown with forest.

In the stretch of 120 km. (75 miles) from Hoek van Mandar to

Kaap William (Tg. Rangas) a rocky tableland can be seen to join the coastal heights with the craggy crests of the mountain mass further inland. Here and there, between the wooded headlands, are found small bays with sandy beaches, which offer anchorages for small craft and are frequently used by native traders. At Kaap William the coast runs north-east for 40 km. (25 miles) to Belangbelang, continuing bold and high with few anchorages. In the stretch of 130 km. (80 miles) from Belangbelang to Pasangkajoe, it becomes low, sandy, and wooded, with occasional hilly patches covered with the distinctive light green *alang-alang*. The mountains recede from the shore, and the coast plains widen considerably, especially where the Soengai Lariang flows into the sea, through a patch of swampy country. Further along the coast, deep water runs close in-shore, and few anchorages are found, the best being in Pasangkajoe bay in 10 fm. From here north to Paloe bay, some 65 km. (40 miles), the coast gradually rises to Tg. Karang, at the mouth of Paloe bay.

Paloe bay, which is 5 to 7 km. (3 to 4 miles) in width, penetrates about 27 km. (17 miles) inland in a south-easterly direction; its waters are very deep and on both sides hills run up steeply from the sea. Anchorages in about 30 m. (17 fm.) are available at Donggalo, at the mouth of the bay, which is the trade centre for the area, and at Paloe itself, at the head of the bay.

From Paloe northwards to Tg. Babandji, runs the narrow isthmus 225 km. (140 miles) long, connecting the northern peninsula with central Celebes. This isthmus has two prominent landmarks, the high peaks of Sidole, 2,199 m. (7,215 ft.) and Soljolo, 2,656 m. (8,714 ft.) at its south and north ends respectively. Ridges descend from the mountainous core towards the sea, terminating in lofty wooded headlands between which there are small sandy bays; these give the coastline a very jagged appearance. There is practically no coastal plain and no coastal shelf. Anchorages are few, but in Tamboe bay, bounded on the south by the peculiarly shaped mountainous peninsula of Manimbaja, and in Dampelas bay immediately to the north, vessels can anchor in depths varying from 12–25 fm.; the bays are regularly used by native craft and K.P.M. steamers.

The whole section from Kaap William northward, has no more than a few scattered islands of little importance, nor are the coral reefs offshore as continuous as in the Makassar section; the reefs are of greatest extent, and most dangerous in the vicinity of Tamboe bay.

Between Tg. Babandji and Stroomen-kaap is a prominent bight containing the two large bays of Dondo and Tolitoli. Dondo bay,

which penetrates some 12 miles inland, has a steep rocky western side, but to the south and east there are stretches of sandy beach with coconut plantations. Offshore there are many islands and numerous reefs. Between Dondo bay and Tolitoli bay, the coast is lofty and densely wooded with numerous islets and deep creeks which are blocked for the greater part by dry coral reefs. Tolitoli bay, 2½ km. (1½ miles) across, has a black sandy beach and affords secure anchorage (18 fm.) at all seasons. The remaining 30 km. (18 miles) of the west coast to the rocky headland of Stroomen-kaap continues precipitous with a few sandy bays.

The North Coast

The north coast is about 600 km. (275 miles) long. Like the sections of the west coast, just described, it is in general steep and indented, broken by numerous small bays and three larger ones—Koeandang bay, Amoerang bay, and Manado bay. Behind the coastal plain, which is usually very narrow, rises the mountainous forested backbone of the northern peninsula from which spurs descend to the shore in many places, forming steep capes with small sandy stretches of low-lying shore between.

From Stroomen-kaap, 80 km. (50 miles) east to the coral limestone headland of Tg. Kandi, the coast is steep with occasional lower sections where streams reach the shore. There are numerous patches of coral reef, but sheltered anchorages in 18–46 m. (10–25 fm.) are to be found inside the reefs at many points, e.g. Boesak bay, Pindjang bay and off Lingdang. From Tg. Kandi the coast runs south for 15 km. (10 miles) before running east again another 120 km. (75 miles) to Koeandang bay. It continues to be precipitous, but there are no extensive reefs offshore, and good anchorages in 18–55 m. (10–30 fm.) are available at Boeol, Paleleh, and Soemalata.

Koeandang bay, some 35 km. (20 miles) wide, contains many wooded islets and coral reefs, but offers safe anchorages at all seasons of the year. From the village of Koeandang, on the south shore of the bay, a road leads across the peninsula to the port of Gorontalo on the gulf of Tomini.

Immediately east of Koeandang is a rugged stretch of 20 km. (12 miles) fringed with dangerous and little known coral reefs. The coast continues bold, high and densely overgrown for another 120 km. (75 miles) to the Soengai Poigar. From here to Amoerang bay, 30 km. (18½ miles), there is a narrow low coast plain, fringed by mangroves

and backed by hilly country. A line of coral reefs is found at varying distances from the shore, but does not present many dangers. Bolaängoeki bay offers good shelter in 18–27 m. (10–15 fm.) for a large number of vessels at all seasons, and there are many smaller anchorages.

Amoerang bay, about 13 km. (8 miles) wide, penetrates an equal distance eastwards; its shores are backed by low wooded hills, and many patches of cultivation. The bay itself is very deep, and steep-sided, but several anchorages are available which are quite safe at all seasons. Amoerang, a small town at the head of the bay, is connected by good roads with Manado further north, and Kema across the peninsula.

From Amoerang bay to Manado bay is a short hilly stretch of coast bordered by an extensive reef. Manado bay, about 11 km. (7 miles) wide at its mouth, and extending some 6·5 km. (4 miles) eastwards, is very deep with little hindrance to navigation. Manado, an open roadstead of spacious extent, offers insecure anchorages during the west monsoon.

Manado, the capital and chief route centre of Minahasa, is the second port of Celebes, and a regular port of call on a main K.P.M. route.

From Manado bay north-east to the rugged Noord-kaap, the most northerly point of the island, the coast is backed by lower land with many coconut plantations. The south shore of Bangka strait is low and wooded, fringed by a shelving coral reef. Further east to Lembeh strait, the coast continues low with several prominent rocky headlands; this section of the coast affords a few anchorages, none of much importance.

The East Coast

On the east coast, which is about 2,000 km. (1,250 miles) long, between the three great peninsulas, are two deep and extensive bays, of which the northern, the gulf of Tomini, runs very much further west than the southern, the gulf of Tolo. On the north shore of the gulf of Tomini, the stretch of 150 km. (90 miles) from Lembeh strait to Tg. Flesko, is wooded, steep, and rugged, with many bays and sandy beaches (Fig. 93). Around Kema, and near Roembia further south, are small coastal plains. Except off Kema, coral reefs are practically absent, and numerous anchorages can be used; the chief of these are in Tolok bay, in Belang bay, and Kema bay. Between

Plate 68. The north coast of Celebes, between Amoerang and Manado
In the distance is the truncated volcanic cone of Manadotoea island with the low island of Boemakeng to the right. The small rocky beach in the foreground is typical of many on the north-coast.

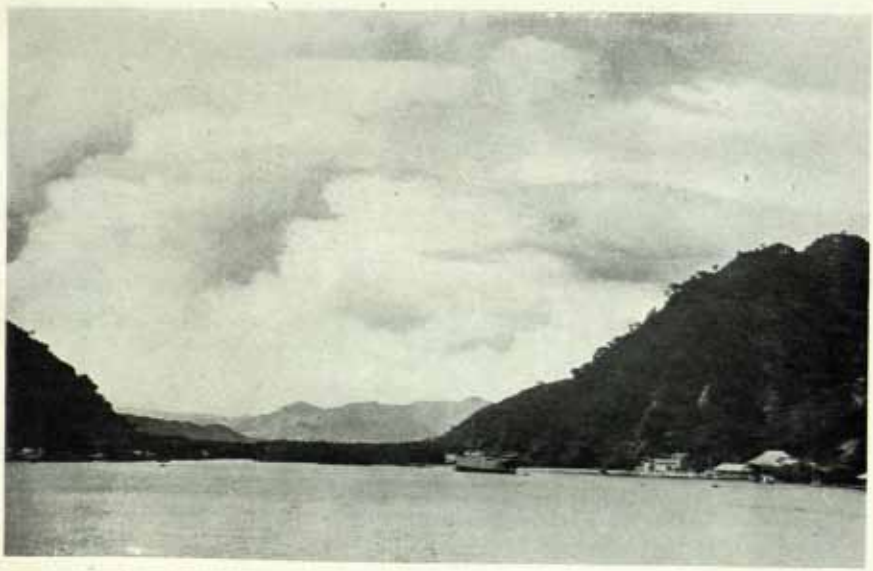

Plate 69. Gorontalo, Gulf of Tomini
Here the lofty northern shores of the gulf of Tomini are broken by the river draining the Limboto depression some miles inland. Hills rise steeply from each side of the deep bay, which is regularly visited by K.P.M. steamers.

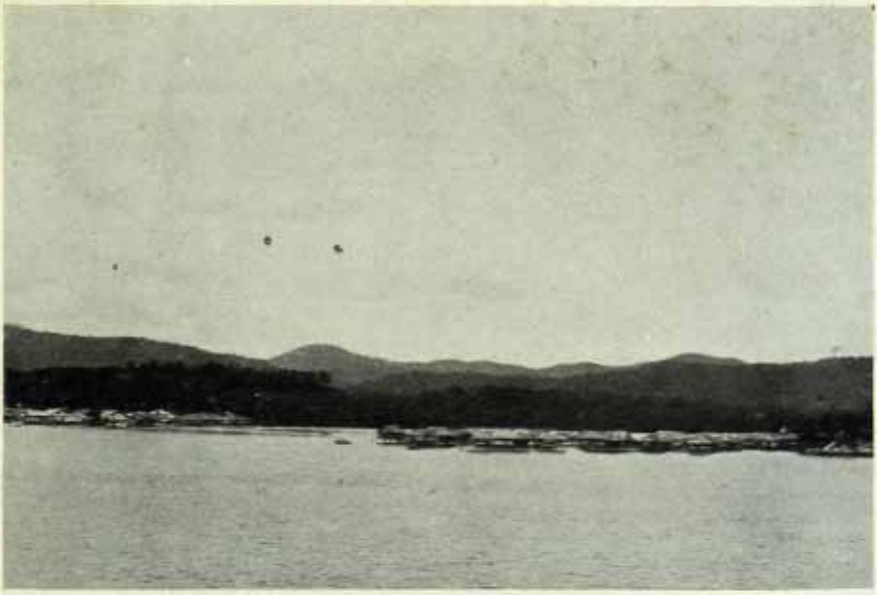

Plate 70. Pagimana, Gulf of Tomini
The thickly wooded hilly coastlands of this part of the island are clearly seen: the fishing village on piles in the centre is characteristic of many in Celebes: the trading post appears on the left.

Plate 71. Manado
At the head of Manado bay a stretch of lowland extends south-eastwards. On the right is a spur from the central Minahasa plateau. The warehouses of the port line the water's edge, but the town is hidden by the coconut trees further inland.

the thickly wooded, uninhabited and rocky Lembeh island, and the mainland, is Lembeh strait, a narrow and difficult passage for shipping.

Fig. 93. Moëtong, on the north shore of the gulf of Tomini (drawn from a photograph).

From Tg. Flesko to Gorontalo, a distance of 150 km. (90 miles) the coast is very steep with deep water close to the shore. Hence, though there is an absence of reefs, anchorages are few and rarely used. At Gorontalo, on both sides of the river mouth, hills rise steeply. Though the river is deep at its mouth, the anchorages available are not secure during the east monsoon; nevertheless, Gorontalo has become the chief port of the gulf of Tomini.

The coast continues to be high from Gorontalo to Pagoejamah bay, but further west there is a narrow coastal plain, often marshy and mangrove covered. This plain reaches its greatest width in the swampy delta of the Soengai Randangan. Some distance offshore in this section runs a barrier of coral islets and reefs but anchorages in 10–60 m. (5–30 fm.) are easily found in the broad channel, though Tilamoeta bay is the only one of much importance.

The coast from the Randangan delta west to Toeladenggi resumes its normal mountainous aspect, with spurs from the high interior closely approaching the coast, leaving stretches of sandy beach and marshy woodland between. West of Toeladenggi as far as Tomini, 70 km. (45 miles) away, the coast is flat and wooded with occasional patches of coconuts; at Tg. Santigi, and just to the west, there are a series of prominent hills close to the coast. A broad line of reefs and numerous islets near the 180 m. (100 fm.) line in this gulf make navigation difficult. Anchorages in 22–33 m. (12–18 fm.) can be found off Papajato, at Moëtong, off Magogondo and at Tomini itself.

The western shore of the gulf of Tomini is backed by ranges of mountains, but in most of the 200 km. (125 miles) section from Tomini to Tg. Pondindilisa there is a narrow coastal plain. As elsewhere in the gulf the shore is steep-to, and from Kaboe Kaboe south there is a more or less continuous barrier reef. Anchorages are available at a few points, the best known of which is off the large village of Parigi.

South of Tg. Pondindilisa the coast is high, but where the Soengai

Saoesoe reaches the sea is a broad strip of lowland, drained by the Saoesoe and other smaller streams. A narrow coastal plain, backed by hills, continues south for 40 km. (25 miles) to Mapane, where the coast, mostly high and rocky, runs due east another 40 km. (25 miles) to Oeikoeli. There are numerous reefs off the coast in this section, including the Haarlemermeer reef far out in the bight of Poso, the name given to the wide bay between Saoesoe and Tg. Api.

Few anchorages are available along this largely uninhabited section of the coast. The safest are at Tamboe, Mapane, and off Poso, a large village situated at the mouth of the Soengai Poso.

At Oeikoeli the coast turns north-east, for about 90 km. (55 miles), becoming precipitous once more as the mountains approach the sea; there is a narrow stretch of lowland at Tongkoe, and another nearer Tg. Api, where the Bongka river reaches the gulf; both have many coconut groves.

East of Tg. Api, the immediate hinterland becomes hilly rather than mountainous, and coconut plantations may be seen here and there on patches of coastal plain. Poh gulf, which runs 32 km. (20 miles) inland and is surrounded by high land on all sides, lies 120 km. (75 miles) east of Tg. Api. From Poh gulf to the entrance to the gulf of Tomini at Tg. Pangkalaseang, hills rise steeply from the sea. As elsewhere around the shores of the gulf of Tomini, the highlands are densely forested, while small patches of cultivation and coconut plantations are limited to the coastal fringe. Numerous reefs extend all along the coast from Oeikoeli eastwards and safe anchorages are few. Worth mention are Todjo (22 fm.), Laboean Blanda (30 fm.), Pagimana (14 fm.) in the Poh gulf, and Boenta (30 fm.), the most important trading centre on the southern shore of the gulf of Tomini.

The gulf of Tolo is also usually bordered by high wooded coasts, with many bays the chief of which is Tomori bay; only in this bay, and in Lasolo bay far to the south, are there rivers of any size. South of Tg. Pangkalaseang the coast continues high, but as it turns westward to Peleng strait it becomes lower with may coconut plantations, especially in the large bay of Telok Lamala. Loewoek, an important copra trading centre is 30 km. (18·5 miles) further west, where there is a good anchorage in 46 m. (25 fm.). From Loewoek the coast runs south-west for 180 km. (110 miles) to the entrance of Tomini bay, and is mostly high and rocky, backed by hill country rising gently to the interior, but very flat and marshy for the last 25 km. (15 miles). Except in Peleng strait, it is generally bordered by a barrier reef and has few anchorages.

Tomori bay, 8 km. (5 miles) wide at its entrance, penetrates about 30 km. (18·5 miles) north-east. At the entrance and the head, where the Soengai Soemara has its mouth, the shores are low; elsewhere they are high and rocky. The bay contains many wooded islets and a number of reefs at the entrance. The main anchorage (6–7 fm.) is at Kolondale on the west side; to the south-east of Kolondale the Soengai La, one of the largest rivers of central Celebes, enters the sea. Much of the region around Tomori bay is uninhabited.

From Tomori bay the coast runs south-east for 90 km. (55 miles) to Tg. Losoni, with alternate patches of lowland and high rocky shore; this section, which has the usual barrier reef offshore, includes but one settlement of any size—Boenkoe, with anchorages in 29–46 m. (16–25 fm.). South of the rocky Tg. Losoni is a wide bight with a narrow fringe of coastal plain, but as the high steep headland of Hoek Nederburgh is approached the shore becomes high and indented.

The section from Hoek Nederburgh south to Tg. Nipanipa, 120 km. (75 miles) away, is deeply indented in Salabangka strait, Matarape, Dalem, and Lasolo bays, all of which have high, rugged shores. Opposite the island of Bahoeloe debouches the large river La Solo with a low swampy delta, bordered by a sandy shoal on the seaward side. The whole coastline, and the many islands offshore, are fringed with numerous reefs, rendering navigation difficult. Here there are but few anchorages.

Between Tg. Nipanipa and Wowoni strait, are two well marked indentations, Kendari and Staring bays. The northern shore of Kendari bay is steep, the southern, low and densely wooded. It has numerous reefs at its mouth, but good anchorage may be found everywhere inside. Staring bay, though sheltered and offering good anchorages everywhere, is of little importance since it is surrounded by a steep shore, backed by a thinly peopled mountainous region.

The South Coast

This section is about 1,000 km. (621 miles) long. From Staring bay the coast curves widely, first south and then west to Tioro strait, and is high, rocky and covered by a thick growth of woodland. This is broken by Kolono bay running 16 km. (10 miles) inland, is deep and clear, but of little importance.

Tioro strait runs south-west for about 80 km. (50 miles), and has numerous reef-fringed islets. The shore, except for isolated rocky points, is low, swampy, and largely overgrown with mangroves.

From Tioro strait to the entrance of the gulf of Boni the coast is backed by hills, and the shore is rocky except near Boengikalo, where there is a considerable stretch of low, swampy land.

The gulf of Boni, like the gulf of Tomini, penetrates far inland. The eastern side is in general high, backed by hilly country, and with few indentations. From Tg. Boengikala, at the entrance to the gulf, the coast runs in a northerly direction to Tg. Pakar, a distance of about 80 km. (50 miles). It is fringed with reefs and has no important anchorages. North of Tg. Pakar is Bingkoka bay containing the peculiar star shaped island of Padamarang. Numerous reefs exist in the bay, but there is safe anchorage in 29 m. (16 fm.) off the trading village of Kolaka in the north-west corner.

From Bingkoka bay the coast runs some 180 km. (110 miles), first north-west and then north-east, to Oesoe bay at the head of the gulf. The shore continues high and steep-to, but since there are numerous dangerous reefs the coastal area is sparsely settled, and this part of the gulf is generally avoided by shipping.

The north shore of the gulf of Boni, about 100 km. (62 miles) long, is backed by a broad coastal plain running 30 km. (18·5 miles) inland in the centre. Many reefs lie offshore, navigation is difficult and there are no anchorages worth mention.

At the north-west corner of the gulf is the large trading settlement of Palopo, which offers a good anchorage in 11 m. (6 fm.). From Palopo the west side of the gulf runs due south for 310 km. (190 miles) to Tg. Lassa. The coast is on the whole much lower than is usual in Celebes. From Palopo south to Tg. Siwa there is a very narrow coast plain, swampy in parts. From here to the rocky tip of the southern peninsula the coastal lowlands are much wider, generally swampy by the shore, and often lined by mangroves. Of the numerous rivers which cross the plain the most important is the Tjenrana, which reaches the sea in a marshy delta. North of the Tjenrana mouth there are numerous reefs close to the shore, while to the south the reefs stand further out to sea. Anchorages may be found at Palima (5–6 fm.), at Bajowe (5 fm.), which is linked by road with the district centre of Watampone, and at Sindjai (5–11 fm.) another district centre.

The stretch of coast running 120 km. (75 miles) west from Tg. Lassa to Tg. Laikang has the Lompobatang (Peak of Bonthain) volcanic massif as a majestic background. As far as Djeneponto, the coast is low with a narrow plain; sawah and fish-ponds can be seen, backed by low cultivated hills, with coffee and coconut plantations, especially near Bonthain. Bonthain is a large village with a fair

anchorage in 10 m. (5 fm.), but Boeloekoembas further east is a safer roadstead. To the west the coast becomes hilly and rocky, and includes the bays of Malasoro and Laikang, with steep wooded shores, where good secure anchorages are found at all seasons.

ADJACENT ISLANDS

Salajar

Salajar, which is separated from the south-east tip of the southern peninsula by the 16 km. (10 miles) wide Salajar strait, measures 71 km. (44 miles) long, with a greatest breadth of 11 km. (7 miles). The island is traversed throughout by a terraced mountain chain, descending steeply to a rocky coral-fringed coast on the east side but more gradually to the west. The low west coast is thickly peopled and has many coconut plantations; there is much native coastal traffic. Off the centre of the west coast is the small hilly Poelau Pasi; though there are numerous reefs between it and Salajar, there is a safe anchorage in 11–13 m. (6–7 fm.) in the channel. Salajar, the chief settlement of the island, is a copra market of some importance.

South-east of Salajar are the Tijger islands, a group of conspicuous rocky islands and numerous coral reefs covered with dense forest. Anchorages in 28–31 m. (15–17 fm.) are available at various points amongst the islands.

Kabaena

Kabaena is a steep mountainous island 49 km. (31 miles) long by 29 km. (18 miles) broad, with one peak 1,650 m. (5,414 ft.) in height. It is separated from the mainland by De Vlaming strait, 20 km. (12·5 miles) wide, and has a rocky coast except in the north-west. There is an almost continuous reef round the island.

Moena

Moena, just east of Kabaena, is separated from Celebes by Tioro strait, and measures 100 km. (62 miles) by 45 km. (28 miles). It is a low lying island, mainly of limestone like Kabaena and Boetoeng. The north coast is fringed by mangroves while in the south there are two capacious bays affording many safe anchorages.

Boetoeng

Between Boetoeng and Moena is the very narrow Boetoeng strait. Boetoeng, 155 km. (95 miles) long, is narrow, wooded, and mountainous, and its coasts are generally steep and rocky with outlying coral reefs. Excellent anchorages in 13–42 m. (7–23 fm.) are available off the chief settlement of the island. This is also named Boetoeng and is situated in the south-west of the island. The capacious Dwaal bay on the east side is obstructed by many reefs, but affords some safe anchorages.

Wowoni

Wowoni, a circular island separated by the Wowoni strait from Celebes, is hilly with rocky shores and affords few anchorages.

Toekang Besi Islands

To the south-east of Boetoeng, is the Toekang Besi group, a series of coral islets and reefs of which P. Wangiwangi and P. Benongko are the largest (Fig. 11).

Banggai Islands

Separated by Peleng strait from the eastern peninsula, are the Banggai Islands. The peculiarly shaped P. Peleng is the largest, and P. Banggai the most important. P. Bangkoeloe and P. Labobo are the only others of the group of any size. Peleng is irregular, mountainous and thickly wooded; it has several large bays, the chief of which is Mesamati. All the bays are much obstructed by reefs, those on the north side affording the best anchorages. Banggai contains the trading centre of Banggai, chief settlement of the group. The remaining islands are steep and densely forested.

Schildpad (Togian) Islands

These islands lie in the gulf of Tomini the three largest, P. Batoedaka, P. Togian, and P. Talatakoh, being separated by extremely narrow and dangerous channels. The whole group, which is composed mainly of volcanic rocks, is densely wooded and surrounded by dangerous barrier reefs. Some distance to the north-west lies P. Oenaoena, a circular island containing an active volcano (see p. 22 and Fig. 13).

Islands adjacent to Minahasa

Of the series of islands grouped around the north-east part of Celebes, the most important are Bangka and Talisei. Bangka is a hilly, tree-covered island, with many coconuts at the back of sandy beaches, and surrounded by a coral reef. Talisei to the north-west of Bangka, is a ridge-like, thickly wooded island with extensive patches of coconuts. Stretches of its southern coast are lined with mangroves and fronted by a coral reef. There is a good anchorage off the south-eastern point of the island.

North of Manado bay, is a group of five islands: Nain and the truncated volcanic cone of Manadotoea are lofty, Manterawoe, Boemakeng, and Siladeng being low. They are all thickly planted with coconut palms, and have dangerous coral reefs.

Sangihe Islands

The volcanic Minahasa-Sangihe arc continues northwards in the direction of the Philippines with its highest summits, which include a number of active volcanoes, above water level in the Sangihe islands (Fig. 94). Nearly all these islands are mountainous and densely overgrown, rising steeply out of the sea. P. Sangihe, easily recognized by the flat summit of the volcano Awoe, has a rocky irregular coast with some low marshy sections in the south. The most important of the others is P. Siaoe, with the active volcano Api. Many of these islands are well cultivated, and have numerous coconut groves and nutmeg plantations.

Talaud Islands

Of the Talaud group, north-east of the Sangihe islands, the largest is P. Karakeleng which is hilly and forested with a rocky shore surrounded by a coral reef.

PLANT AND ANIMAL LIFE

To the naturalist Celebes is one of the most interesting islands of the Malay Archipelago. Because of its central situation and its nearness to the other large islands, it might be expected that there would be little of special interest in its fauna and flora, but quite the contrary is true. Though it has many animals and plants in common with Borneo, Java and Sumatra, Celebes has a very high

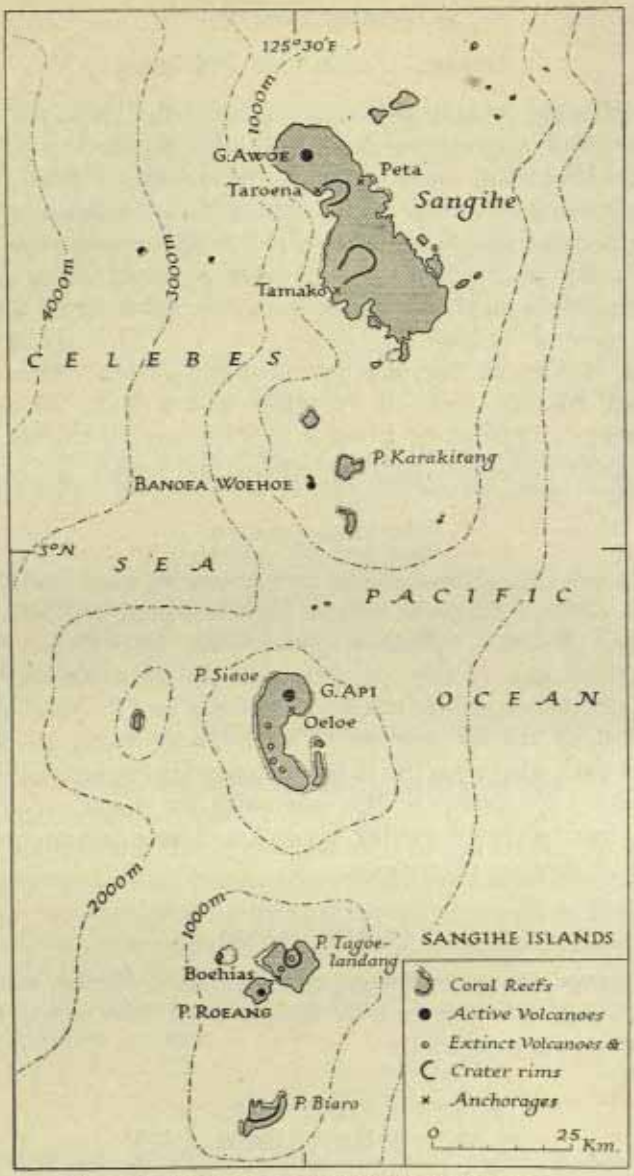

Fig. 94. The Sangihe islands and their volcanoes

There are four active volcanoes (see p. 22 and Fig. 13) all of which have been in eruption during the last thirty years. Roeang and Awoe each have a lava plug and a crater lake, and so are potential sources of danger. Api (summit 1,784 m.) has two old craters, one with a lake, and a third, active centre on the western flank. Banoea Woehoe is a submarine volcano: its eruption of 1918 produced an island, which was rapidly eroded and had disappeared completely by 1934.

Source: *Vulkanologische Mededeelingen*, vol 5 (Weltevreden, 1923).

proportion of species which are endemic, that is, not found elsewhere. Some of these peculiar species have no near relatives anywhere or only in very distant parts of the world. Equally remarkable is the number of plants and animals which are found in most of the neighbouring islands, but not in Celebes.

The difference between the fauna and flora of Celebes on the one hand and Borneo and Java on the other, is partly due to a difference of climate; in much of Celebes there is a much more marked seasonal drought than in most of the neighbouring islands, excepting east Java and the Lesser Soenda islands. There is no doubt, however, that the peculiarities of Celebes are largely due to its geological history. It lies to the east of Wallace's Line (which divides the fauna and flora of the archipelago into an eastern and a western half), and many of its plants and animals have reached it by westward migration from Australasia. Celebes forms the western outpost of several Australian forms of life, e.g. the pouched opossums among animals, the eucalyptus among trees.

In spite of its large size, Celebes has only about fourteen land mammals (excluding bats), less than half the number found in Java, and of this number a large proportion are not known elsewhere. The most interesting of the mammals are the sapi-utan or anoa, an animal resembling an antelope or small cow, and the babirusa, a pig-like animal with four immense upward curving tusks; the latter is also found in Boeroe and the Soela islands. Many of the birds of Celebes are as beautiful as they are remarkable. The Celebes roller has no close relatives anywhere in the Malayan region. The maleo is a very odd mound-building bird related to the brush turkeys of Australia and New Guinea.

Celebes is not as uniformly forested as, for instance, Borneo. Particularly in the south arm of the island much of the forest has been destroyed and replaced by wildernesses of scrub and grass. In places there are savannas sometimes covered with prickly pears and other thorny plants. The forests are mostly evergreen and can be classified under the heading of tropical rain forest, but many of them are less luxuriant than most rain forests and the trees tend to lose their leaves in the dry season. Probably they are intermediate in type between rain forest and the deciduous monsoon forests of the Lesser Soenda islands. In some parts of Celebes, notably about Malili, in the Latimodjong mountains and north of the Lompobatang mountains, the forests contain large numbers of dammar or copal trees (*Agathis alba*), a conifer nearly related to the kauri pine

of New Zealand and like it producing a valuable resin. The tree grows to a great height and to a diameter of over 6 ft; in some places it forms over 50% of the larger trees. In some parts of Celebes, especially in the Poso district, ebony trees (*Diospyros*) are plentiful; the beautiful and valuable wood is exported under the name of Macassar ebony. Sandalwood is common in some parts of the island. In the mountains tall rain forest gives place to dwarf mountain forest often containing many coniferous trees.

A fair proportion of the land, particularly in the Makassar and Minahasa districts, is cultivated and the crops include most of those grown elsewhere in the Netherlands Indies. In addition to rice, coconuts, coffee, kapok and nutmegs are important. The chief centre of coconut and nutmeg cultivation is the Minahasa.

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Less serious in character are *East Monsoon* (London, 1936), and *Makassar Sailing* (London, 1937), both by G. E. P. Collins.

Chapter VII

THE LESSER SOENDA ISLANDS

Introduction: Bali: Lombok: Soembawa: Flores: Solor and Alor Islands: Soemba: Timor: Plant and Animal Life: Bibliographical Note

INTRODUCTION

The chain of islands known in Dutch as the Kleine Soenda-eilanden lies between long. 114° 25′ and 125° 10′ E and lat. 8° and 11° S.

Soemba and Timor belong to the outer fold arc (see p. 14 and Fig. 8) and are not volcanic; they are separated from the rest of the islands by the Sawoe Sea and the Soemba and Ombai straits. The remainder of the islands form part of the inner fold arc and stretch in a long line from Bali in the west to Alor in the east. Nearly all the islands in this arc have one or more active volcanoes (see p. 24 and Fig. 12).

Although the whole group is mountainous, nearly all the islands having summits exceeding 1,000 m., the climate is on the whole drier than that of the large islands to the west and north. A consequence of this is that forests are generally thin and open, and there is a considerable amount of savanna (Fig. 137).

Bali and Lombok, at the western end of the group, are densely populated and have been fairly thoroughly studied; the remainder of the islands have a scanty population and large parts are little known and incompletely mapped (Fig. 142).

BALI

Bali is the most densely populated and by far the best known of the Lesser Soenda islands. Separated from Java by a strait which is little more than 2 km. wide at its narrowest point, it naturally repeats some of the major physical regions of that island, namely the volcanic mountains, the central plain and the southern limestone plateau (see p. 159). Bali has a long east–west axis of 140 km. (87 miles), a north–south axis of 88 km. (55 miles) and an area which amounts to 5,561 sq. km. The population numbers over a million, which represents a density of almost 200 per sq. km. (500 per sq. mile), but the latter is a misleading figure in view of the concentration of the people on the fertile volcanic plains. At least one-fifth of the island is

uninhabited, and seeing that the great density long antedates the arrival of the Dutch, this portion must be considered uninhabitable, consisting as it does of steep-sided volcanic mountains clad in jungle, or bare limestone 'karst'.

Volcanic mountains

The axial range of volcanic mountains lies in the north; it forms a sickle-shaped belt, the handle being in the west. The slope to the north is generally steeper than that to the south. The belt falls into four well-marked sections:

(i) The western range, from Bali strait to the transverse road from Pengastoelan to the south-west coast. This is the least inhabited, though not the highest part of the volcanic belt. Its summits rise to over 1,200 m., and the greater part of the range is forest-clad—rain forest at higher levels, and monsoon forest on the northern slopes.

(ii) The central group, a complex volcanic massif comprising the Piek van Tabanan (2,176 m.), Goenoeng Tjatoer (2,098 m.) and a number of lesser summits, with several large calderas and crater lakes. One of the lakes, Danau Tamblingan, has a deep blue colour. The outside flanks of this mountain mass are covered with coffee plantations of considerable antiquity—often more or less wild and sub-spontaneous, forming veritable woods—which have replaced the natural jungle up to a level of some 1,500 m. (about 5,000 ft.). Virgin rain forest remains in the interior of the mountains.

(iii) The volcanoes Batoer and Agoeng. These two large volcanic mountain masses occupy the north-eastern portion of Bali. The shapely cone of Goenoeng Agoeng (Piek van Bali, 3,142 m.—10,309 ft.) is almost extinct (Plate 76). North-westwards of Agoeng lies the active Batoer, with its lake, Danau Batoer, and recent lava flows (see p. 37, Fig. 25 and Plate 72).

(iv) The eastern extremity of the island is the eroded mass of Goenoeng Seraja (1,174 m.) which is separated from Agoeng by a low col and slopes steeply to the coast on the north and east.

The lower slopes and plains

That part of Bali in which population and rice-fields are concentrated is not strictly a plain. There are, it is true, several small coastal plains—those of Pengastoelan and Singaradja in the north, and that of Djembrana in the west—but the main area is a diamond-shaped region stretching from the flanks of the Tjatoer massif on the north to the Tafelhoek peninsula, and bounded by the sea on the west

Plate 72. The Batoer Caldera

Viewed from the main road near Kintamani. In the background is Goenoeng Batoer, with several parasitic cones on its flanks. On the right is the precipitous eastern wall of the caldera, at the foot of which lies the lake, Danau Batoer.

The fine figures of the Balinese women are largely due to their habit of carrying loads balanced on their heads—a feat which needs strength and poise.

Plate 73. Rice terraces, Kintamani

In high fertility of the volcanic soils and the advanced culture of the Balinese combine to produce a more elaborate system of rice cultivation than in most other parts of the East Indies. In the background is Goenoeng Abang, on the south-eastern edge of the Batoer caldera.

and east. Dense settlement and rice-fields extend inland to an altitude of about 600 m. (about 2,000 ft.), but there are many villages above this level, up to the 1,500 m. (5,000 ft.) of Kintamani, on the western rim of the Batoer caldera. The 'plain' is thus tilted, from 600 m. down to sea-level, in a southerly direction. It is crossed by innumerable streams, which in their upper courses are quite sharply incised; they are all torrential in character, flowing in spate during the west monsoon, and drying up during the east monsoon (May to November). The whole area is floored by re-deposited material of volcanic origin, and the soil has an almost incredible fertility; its productivity even exceeds the rich plains of Java, a fact which helps to explain the high density of population. Terracing and irrigation were practised long before the advent of the Dutch (Plate 73). The settlement pattern takes on a north–south trend, following the direction of the rivers and roads (Figs. 95 and 96). The principal east–west road is that which, by a somewhat roundabout route, connects the main towns of the plain—Tambanan, Denpasar, Gianjar and Kloengkoeng. Denpasar—called Badoeng by the Balinese—is the principal township of southern Bali, with nearly 16,000 inhabitants; Gianjar is a market town, and Kloengkoeng a centre of wood-carving and precious metal working.

The continuity of the 'plain' is interrupted in the east by an upstanding mass of Neogene limestone which rises to over 700 m. This hill district almost isolates the small plain of Karangasem, which lies sandwiched between it and the volcanic foothills of Agoeng and Seraja.

The limestone plateau

The curious Tafelhoek peninsula is linked to the mainland only by a low, sandy isthmus, 1–2½ km. in width. It consists of a Neogene limestone plateau, rising to 200 m. and sloping steeply on all sides, but especially to the south. It has an almost bare karstic surface, with very few villages (Plate 77).

The limestone plateau reappears some 25 km. further east in Noesa Penida, a steep-sided island, with several smaller satellites. The main island rises to 529 m. (1,736 ft.), and is largely scrub-covered. The population is small and scattered.

The coasts

The Balinese coast presents some striking variety. The north coast apart from the two plains, is mostly steep, with a beach of black sand,

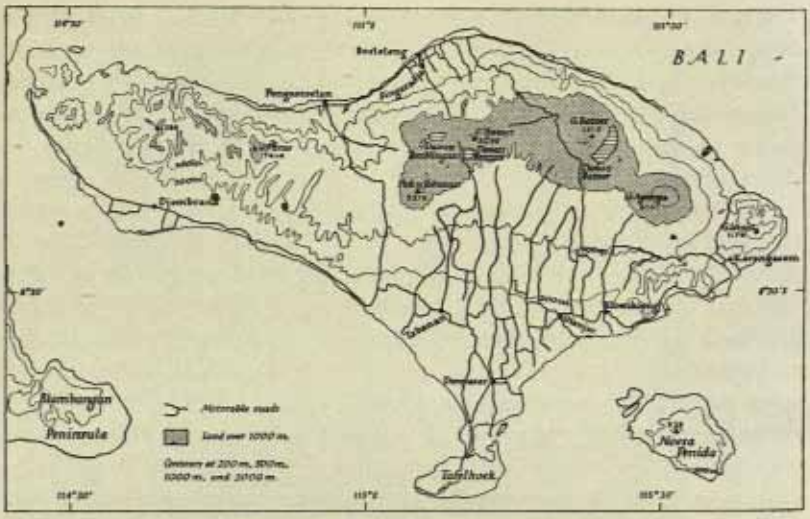

Fig. 95. Bali: Relief and communications

This map and Figs. 96–98 demonstrate the essential features of the geography of Bali, with its uninhabited volcanic mountains and with human life concentrated in one main area and a few small areas of fertile and well-watered slopes and lowland.

Figs. 95–98 based on Dutch 1 : 200,000 topographical map (copied as G.S.G.S. 4266).

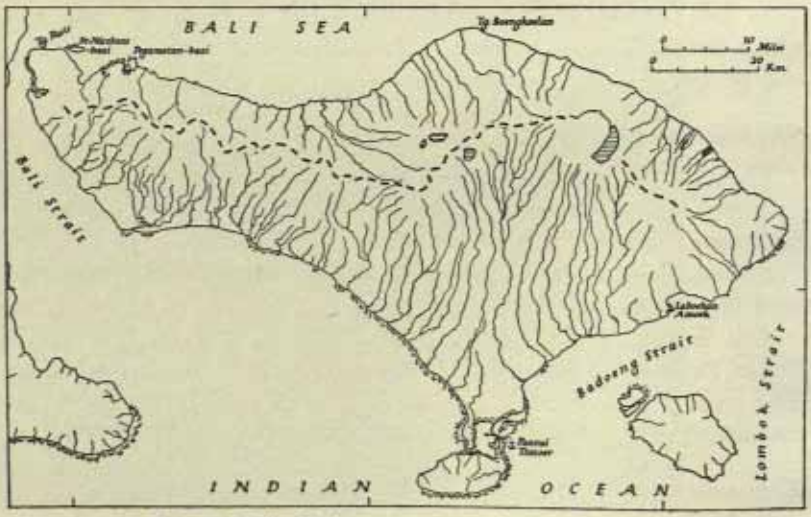

Fig. 96. Bali: Drainage pattern and coastal features

The main watershed is shown by a pecked line.

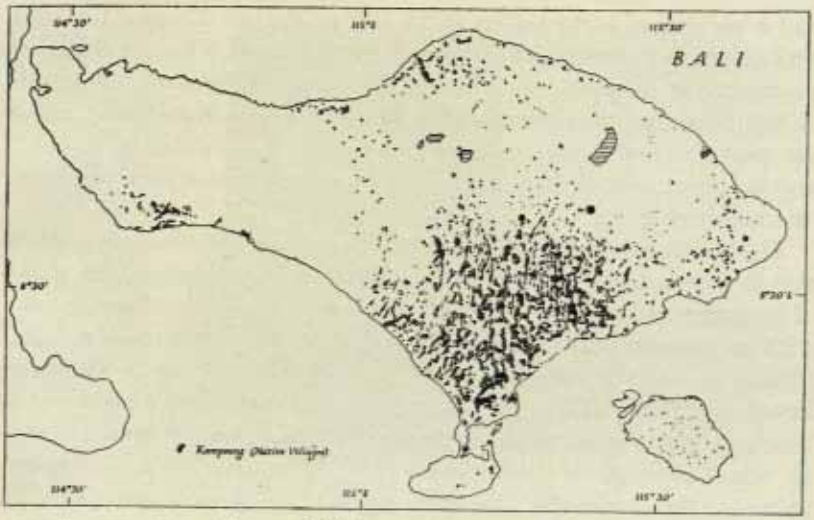

Fig. 97. Bali: Settlement pattern

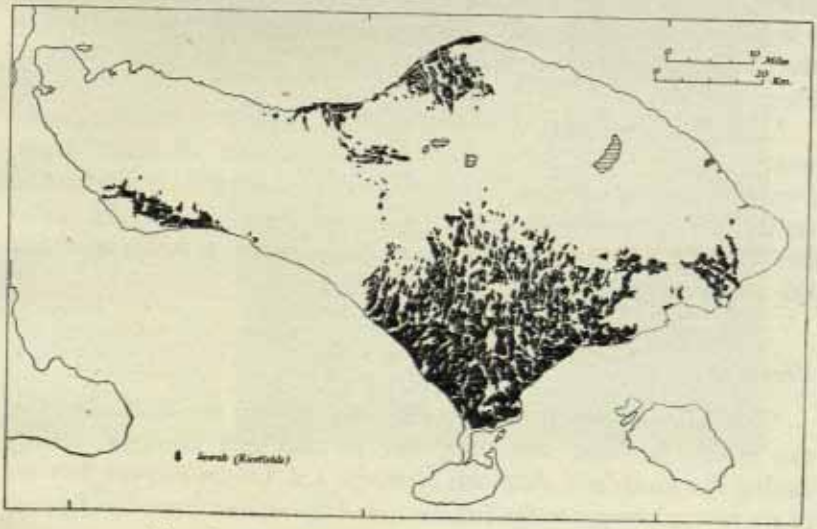

Fig. 98. Bali: Areas covered by irrigated rice-fields

and a number of rocky points at the foot of Batoer. There is no coral reef except at Pegametan bay near the western end. There is only one roadstead, at Boeleleng, but this is unsafe during the west monsoon. It has, nevertheless, a considerable annual tonnage of shipping, being the port for the Residency capital, Singaradja (population 10,000), and the chief port of entry for tourists—most of whom arrive in large or small liners.

The south-east coast is varied; at the eastern end there is a steep rise to Goenoeng Seraja, then follows the sandy beach of the plain of Karangasem, and the large bay Laboehan Amoek (or Padang bay) with a narrow coastal plain behind it, rising to limestone hills. (Plates 74 and 76). At the south-western end of this bay is the small haven of Padang (Plate 75). The shore of the southern plain has a beach of black sand, which turns to white at the south-western end as the Tafelhoek is approached. The large bay Pantai Timoer, between the mainland and Tafelhoek, has marshy shores with mangroves, and is mainly filled with coral. Large vessels anchor outside, beyond the 10-fm. line, owing to the difficulty of the tortuous entrance passage, which is known as Benoa channel; there is a heavy swell during the south-east monsoon, but anchorage within the bay is safe for small ships at all seasons. The port of Benoa, which is the most important in Bali, is in two parts, one on each side of the channel; Benoa Tandjoeng, on the southern side, accommodates only praus, but Benoa Oedjoeng, on the northern side, has wharves with 7 m. (23 ft.) depth alongside, and is connected to the mainland across the drying coral by a causeway, 3 km. in length, which leads to Denpasar.

A fringe of coral runs all round the Tafelhoek. It continues on the western side of the isthmus, in the bay known as Pantai Barat ('western beach'—Pantai Timoer being the 'eastern beach'). The south-west coast has an almost continuous coral fringe; the plains have black sandy beaches, and where the mountain foothills approach the shore the beach is littered with large rocks.

People

The Balinese practise the Hindu religion, and are descendants of the Hindu-Javanese who emigrated to Bali and Lombok, mainly during the ninth and sixteenth centuries A.D. On an average they are of superior physique to the Javanese, and the women have fine figures. For further details see vol. II of this Handbook.

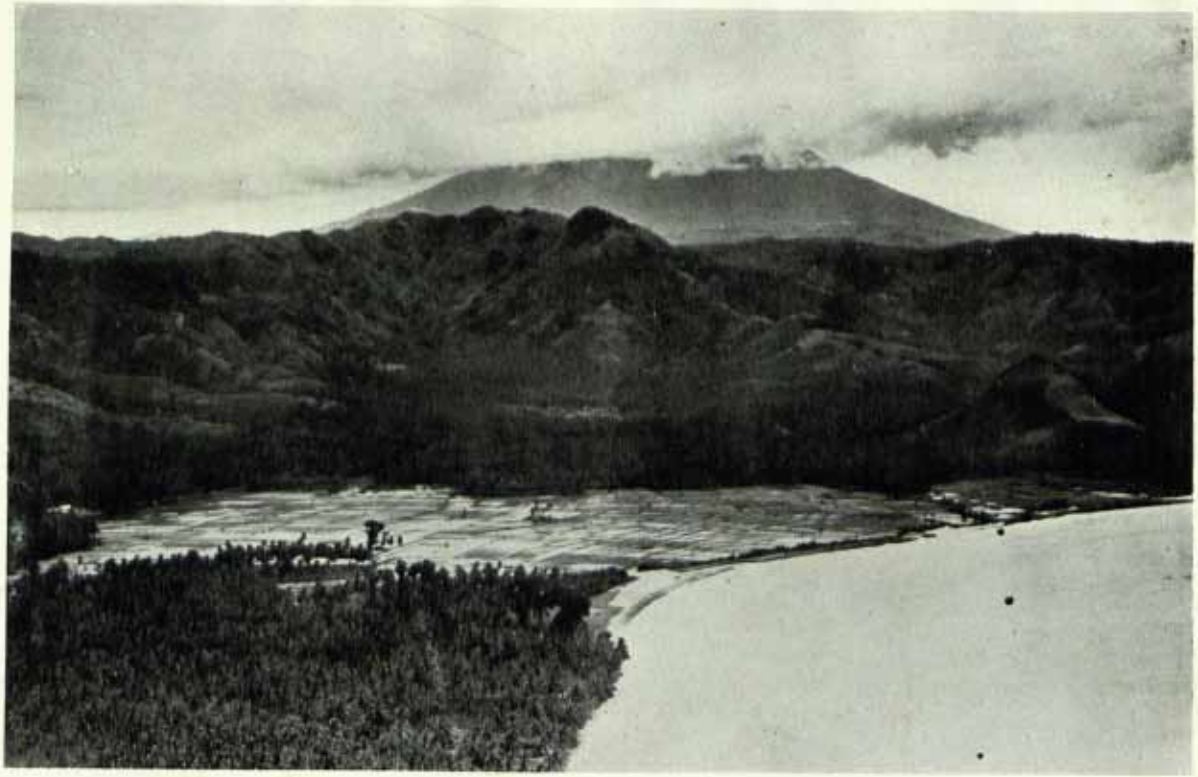

Plate 74. Laboehan Amoek, Bali

Looking due north across the bay to Goenoeng Agoeng, the summit of which is obscured by cloud. The small plain is largely covered with sawah; behind it rise rough limestone hills with scrubby vegetation.

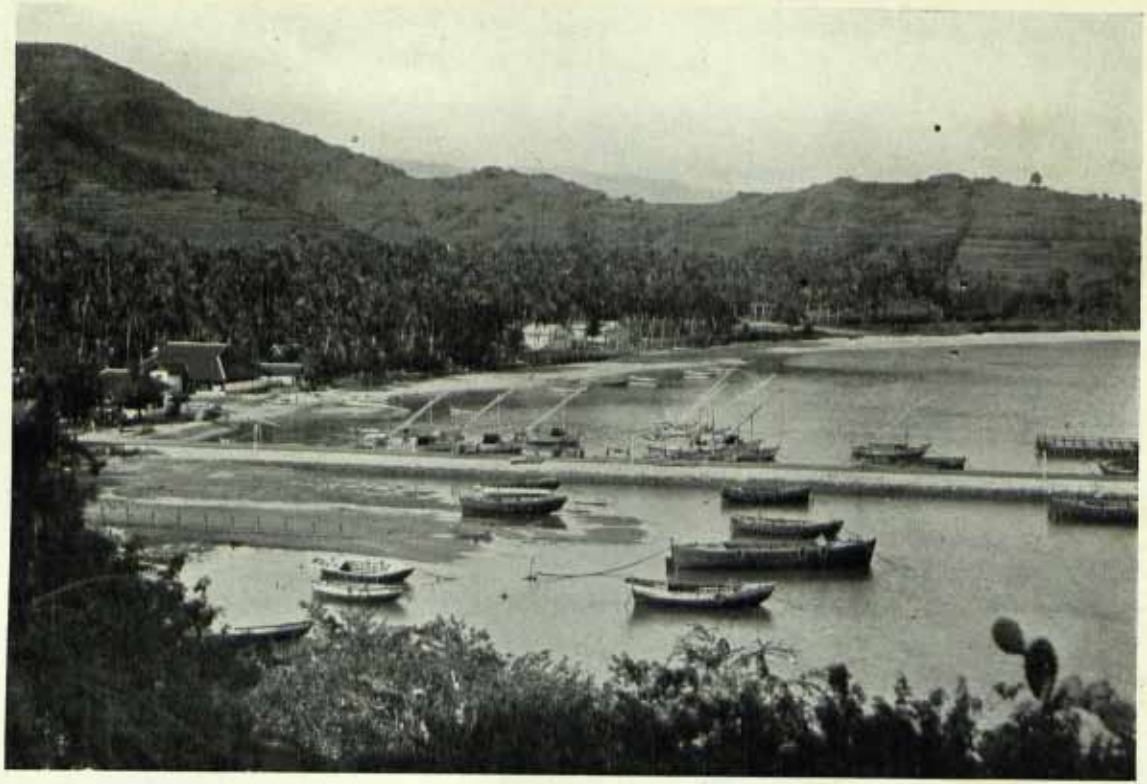

Plate 75. Padang bay, Bali

A small bay at the south-western end of Laboehan Amoek (Plate 74) with a prau harbour, a landing pier, and a road running inland. Behind the fringe of coconuts rise terraced hill slopes. Looking north-east.

Agriculture and industry

Rice is the principal crop (Fig. 98), and in its cultivation and irrigation the Balinese are perhaps more advanced than any other peoples of the East Indies (Plate 73). Coconuts, coffee, maize, tobacco, kapok, indigo, onions and a variety of fruits are also grown. The breeding of cattle and pigs takes a prominent place in Balinese life, and the raising of poultry—including fighting cocks—is also important.

Industry, apart from brick-making, salt-panning and boat-building, is mainly of an artistic character—stone-sculpture, wood-carving, pottery, gold and silversmith's work, and silk weaving.

Despite the frequency of earthquakes, domestic and temple architecture is of a high standard; walls are often richly ornamented with sculptures. The chief building material is a volcanic tuff, easy to carve yet reasonably resistant to weathering and earthquake damage. Apart from this stone, sun-dried mud brick is the principal building material.

LOMBOK

Lombok and Bali are separated by Lombok strait, which is the main passage-way for shipping from Singapore and Makassar strait to Australia. Lombok is 4,668 sq. km. in area (1,802 sq. miles), and its geography repeats in striking fashion that of Bali. The same three elements—northern volcanic mountains, fertile and densely populated central lowland, and southern limestone plateau, are present; the main difference is in the greater extent of the bush-covered limestone plateau in Lombok.

Physical features

The northern part of the island is dominated by the Rindjani volcano, one of the loftiest cones in the East Indies. The summit—with an active crater last in eruption in 1915—rises to 3,726 m. (12,225 ft.), towering far above its surroundings. Rindjani lies on the eastern rim of an elliptical caldera, in the western part of which lies a large horse-shoe shaped lake. The volcanic range is prolonged in an east–west direction, but the western part is much lower than the eastern, which ends in the peak of Goenoeng Nangi (2,330 m.—7,645 ft.) only 15 km. from the east coast. The range, which is thickly wooded, slopes steeply, with deeply-scored flanks, to the north and south.

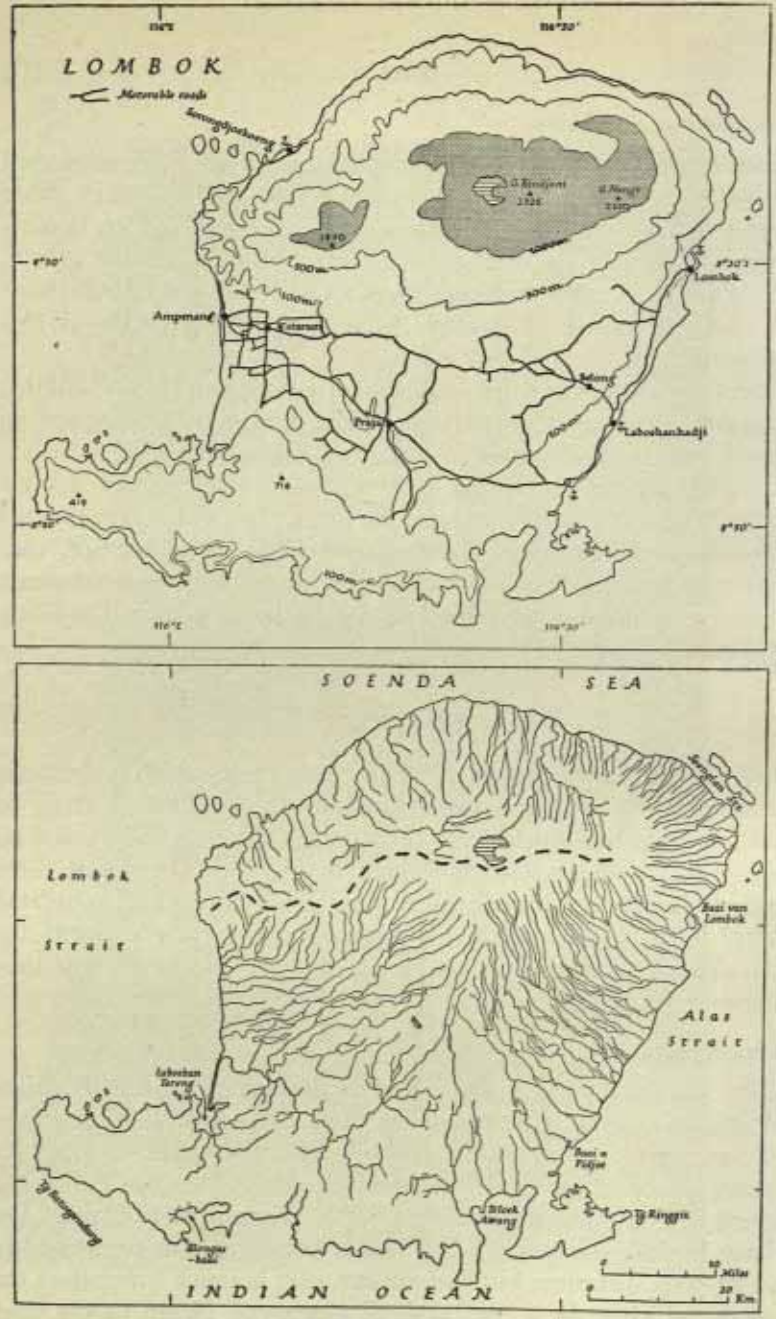

Fig. 99. Lombok

Above: relief, communications and ports (anchors indicate anchorages); Below: drainage pattern (main watershed shown by pecked line). These maps and those forming Fig. 100 demonstrate the essential features of the geography of Lombok, with its striking concentration of human activity in the central lowland belt between the volcanic mountains of the north and the limestone plateau of the south.

Figs. 99 and 100 based on Dutch 1 : 200,000 topographical map (copied as G.S.G.S. 4266).

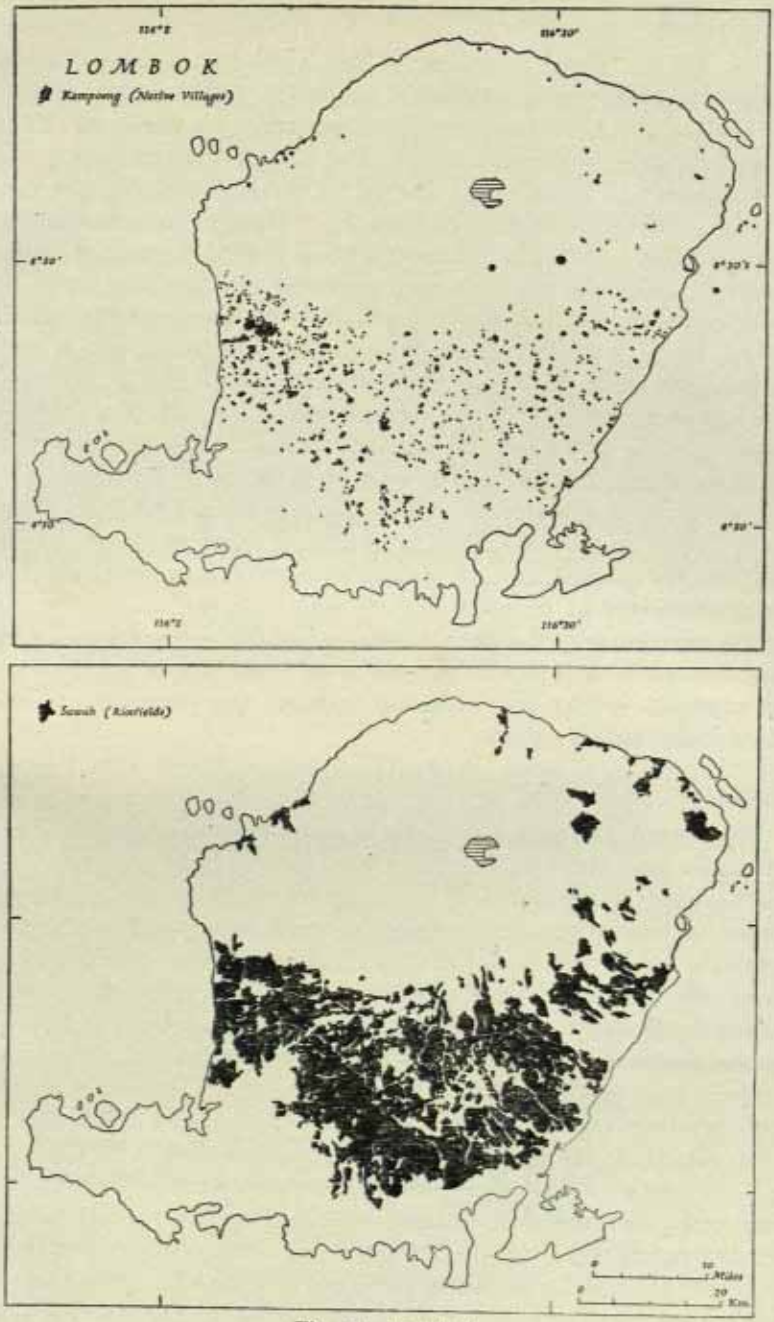

Fig. 100. Lombok
Above: settlement pattern; Below: irrigated rice-fields.

The central 'plain' stretches the full width of the island, about 55 km. (34 miles), and extends for 20–30 km. between the volcanic foothills on the north and the limestone range on the south. It is formed entirely of volcanic debris, and is well watered during the west monsoon. The streams, most of which dry up during the east monsoon, are almost all derived from the volcanic mountains, and the water-parting, on the plain, between those flowing westwards to the Lombok strait and those flowing eastwards to the Alas strait or south-eastwards to Teloek Awang, is almost imperceptible, about 100 m. above sea-level. The whole area is undulating, and is well covered with rice-fields, but these are less continuous in the east, which is much drier. Thus the western half of the plain has a denser population than the eastern half, and contains the large town of Mataram, 6 km. inland from its port of Ampenan.

The southern limestone range is almost waterless, and is largely covered with bamboo thicket. At one point an elevation of 716 m. (2,350 ft.) is reached, but the greater part of the range does not rise much above 350 m. (*c.* 1,100 ft.),

The vegetation of Lombok shows, especially in its drier eastern part, distinct Australian affinities; there are large areas of prickly pear, for example—whilst the cockatoos indicate the proximity to the Australasian faunal region.

Coasts

The north coast is on the whole steep, and in places rocky; there are some low, flat, uninhabited islands off the north-western and north-eastern extremities. The middle part of both east and west coasts, i.e. where the plain reaches the sea, is low and sandy, and generally overgrown with brushwood. The coast of the limestone range offers a third quite distinct aspect. It is steep and highly indented, the largest bay being Teloek Awang (or Baai van Ekas). There are limestone cliffs at many points, including the south-western and south-eastern extremities of the island—Tandjoeng Batoegendang and Tandjoeng Ringgit.

On the whole the coast of Lombok is more hospitable than that of Bali. Ampenan roadstead is suitable for large vessels, though surf may make landing difficult, especially during the west monsoon. Further south is Laboehan Tereng, more sheltered but obstructed by a reef. The north coast has possible anchorages at Sorongdjoekoeng in the north-west and Soengkian in the north-east. On the east coast there are three anchorages; Pidjoe bay offers good shelter for large

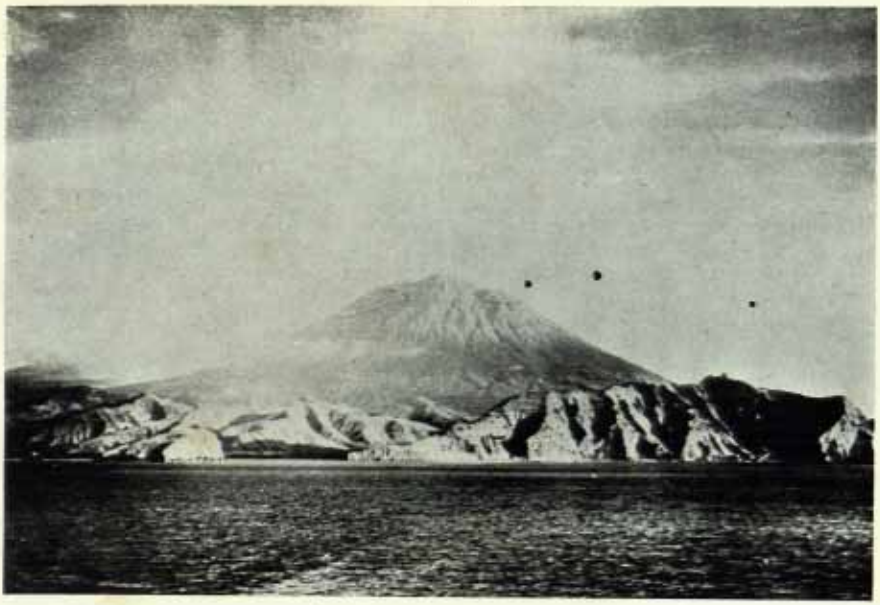

Plate 76. Goenoeng Agoeng (Piek van Bali)
View from Lombok strait across the eastern end of Bali to Goenoeng Agoeng. Relatively soft volcanic rocks, and a markedly seasonal rainfall result in strong dissection and barren surfaces.

Plate 77. Tafelhoek peninsula (Bali)
Tandjoeng Meboeloe, precipitous limestone cliffs on the coast of Tafelhoek peninsula.

Plate 78. Bima bay, Soembawa
The landlocked harbour of Bima bay in northern Soembawa is surrounded by hills. Vegetation is sparse because of the pronounced dry season, but there is cultivation on the lower and flatter ground.

Plate 79. A bay in Komodo island
Komodo, off the west coast of Flores, is the home of the Komodo dragon; it is almost uninhabited.

vessels, but the other two—Laboehanhadji and Lombok bay—are not completely safe at all times of the year.

People

The population of Lombok in 1930 was about 700,000, including nearly 30,000 Balinese and 570,000 'Sasaks' (Mohammedans). This represents a density of about 150 per sq. km. (580 per sq. mile)—but as in Bali this is a misleading figure since the bulk of the population is concentrated in the central belt (Fig. 100). The Balinese, though numerically inferior, are the dominant race; they dwell mainly in the wetter west.

Agriculture

Rice is the principal crop (Fig. 100), but cotton, coffee, tobacco, indigo and coconuts are also grown. There are salt-pans on the east coast at Tandjoengdoear, on Pidjoe bay.

SOEMBAWA

Separated from Lombok by the Alas strait, which affords the safest passage through the Lesser Soenda island arc, is Soembawa stretching some 240 km. (150 miles) to the east with an area of 13,370 sq. km. (5,200 sq. miles).

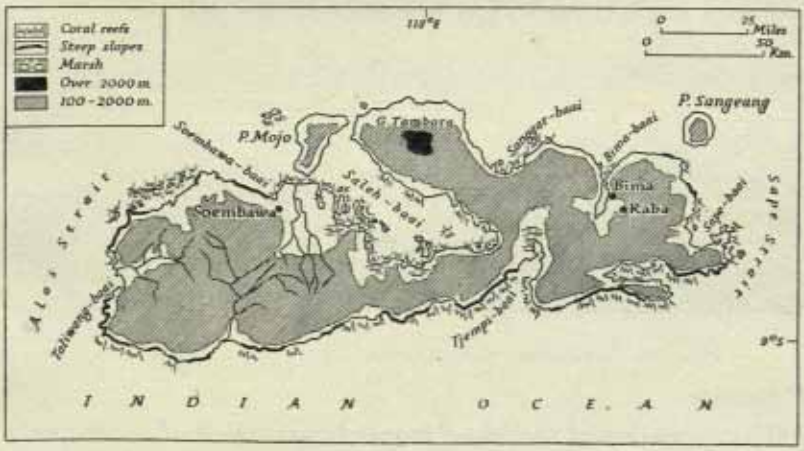

Fig. 101. Soembawa

Source: 1 : 1 M, sheet S.C. 50 (G.S.G.S. 4204).

Physical features

The island is peculiarly shaped consisting of two main masses joined by a narrow neck only 13 km. (8 miles) wide. It is very mountainous, the coastal plain being generally narrow or non-existent, and of some extent only west of Saleh bay. The mountains of the western half of the island are mainly limestone ridges about 1,000 m. (3,300 ft.) high, those in the eastern half being mostly volcanic. They culminate north of Saleh bay in G. Tambora, 2,851 m. (9,353 ft.) high, an active volcano with a large crater which erupted with disastrous effect in 1815.

None of the rivers is of great importance since there are no lakes to serve as storage basins; they accordingly tend to run dry in the season of drought, which becomes more marked to the east.

Coasts (Fig. 102)

The coasts of Soembawa are, as a whole, lofty and rugged with many indentations and well covered by vegetation. They are generally steep-to with occasional scattered reefs, and anchorages outside the large bays are few. On the south coast are Tjempi bay and Waworada bay, both of which offer many safe anchorages, while on the north coast there is Saleh bay (Fig. 103), stretching 70 km. (45 miles) south-east, with its entrance almost blocked by a hilly wooded island, P. Mojo. The north side of this bay is steep-to, the south side fringed by many reefs and shoals, hence it is not as useful as Bima bay further east, where a secure and landlocked anchorage for many vessels, as well as a seaplane anchorage, is available (Plate 73).

Fig. 102. North coast of Soembawa (drawn from a photograph).

Vegetation

The vegetation of the island is mainly savanna unlike that of the islands further north: useful trees include teak, sandalwood and various dyewoods, especially sapan.

Settlements

The population numbers about 250,000, very mixed in character in the coastlands. The majority are pagans, but there are also some Moslems and Christians. The inland settlements have a primitive

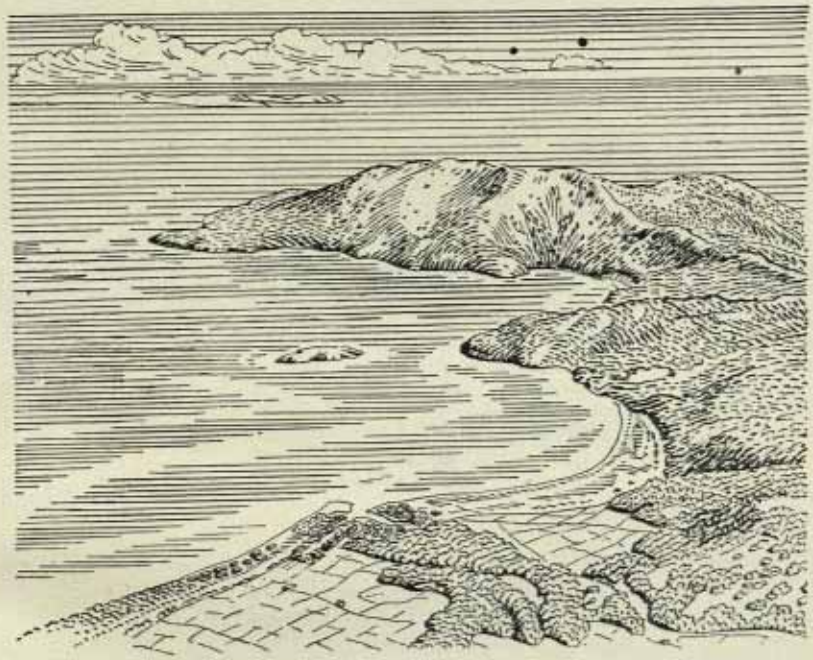

Fig. 103. Kempang, on the south-west shore of Saleh bay (drawn from a photograph).

economy, while the coastal peoples grow rice, maize, coffee, tobacco, fruit and vegetables and produce copra in increasing amounts. Fishing is a common occupation and the savannas in the interior carry numerous herds of horses and cattle. Soembawa, Bima and Raba are the largest settlements.

Adjacent islands

To the north of Soembawa, is a high volcanic island, P. Sangeang, with an active volcano, G. Api, 1,949 m. (6,395 ft.) high (see p. 22 and Fig. 12). Away further to the north are the Paternoster and Postiljon islands, two groups of coral reefs, banks and islets, many of which are planted with coconut palms (Fig. 7).

To the east of Soembawa, are numerous islands, most of which are close to Flores. The two largest, Komodo and Rintja, both mountainous, thickly wooded, and almost uninhabitable, are famous as the home of the 'Komodo dragon', the monitor lizard *Varadus komodensis*.

FLORES

Flores, with an area of about 23,000 sq. km. (8,870 sq. miles) is the second largest of the Lesser Soenda islands; it runs east to west for about 350 km. (220 miles) becoming gradually narrower eastwards (Fig. 104).

Fig. 104. Flores
Source: 1 : 1 M, sheets S.C. 50 and 51 (G.S.G.S. 4204).

Physical features

A range of mountains runs along the whole length, attaining a height of 2,400 m. (7,874 ft.) in Potjo Ranakah. About one-half of the island is composed of volcanic mountains; there are about fifty of them with more than twice that number of known eruption points. The volcanicity in the eastern part is of later date than that of the west, and activity continues; nine separate craters are known to have erupted—some of them with lava streams—within the last hundred years (see p. 22 and Fig. 12). The most active centre is the Lewotobi complex, which lies at the intersection of three lines of tectonic disturbance. One of the most interesting volcanoes is Keli Moetoe, with three coloured crater lakes (see p. 39 and Plate 81).

Details of the geology of Flores are largely unknown, but apart from the eruptive rocks there are outcrops of limestone with karst features in areas along the north coast. As there is practically no

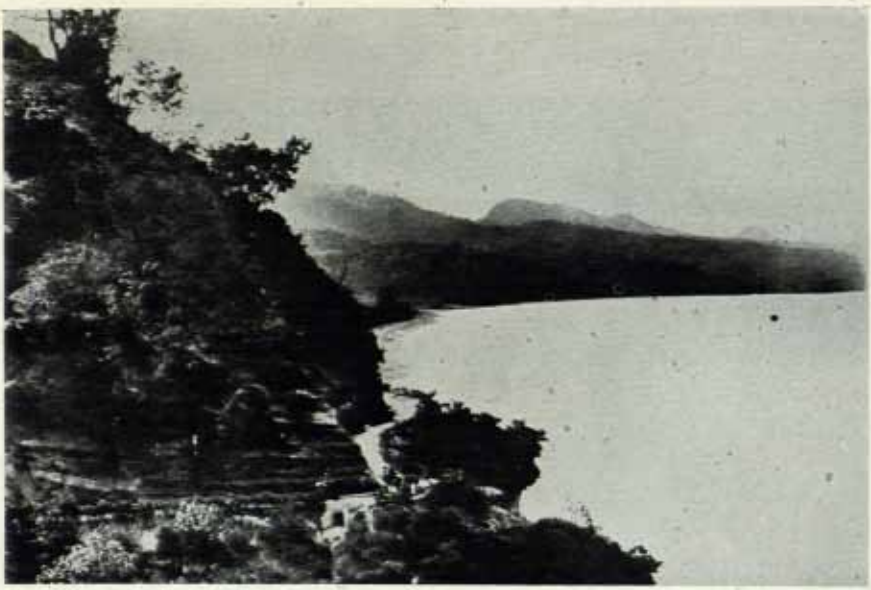

Plate 80. The south coast of Flores
One of the numerous bays in this high rugged coast; in the foreground a coast road winds along the cliff top.

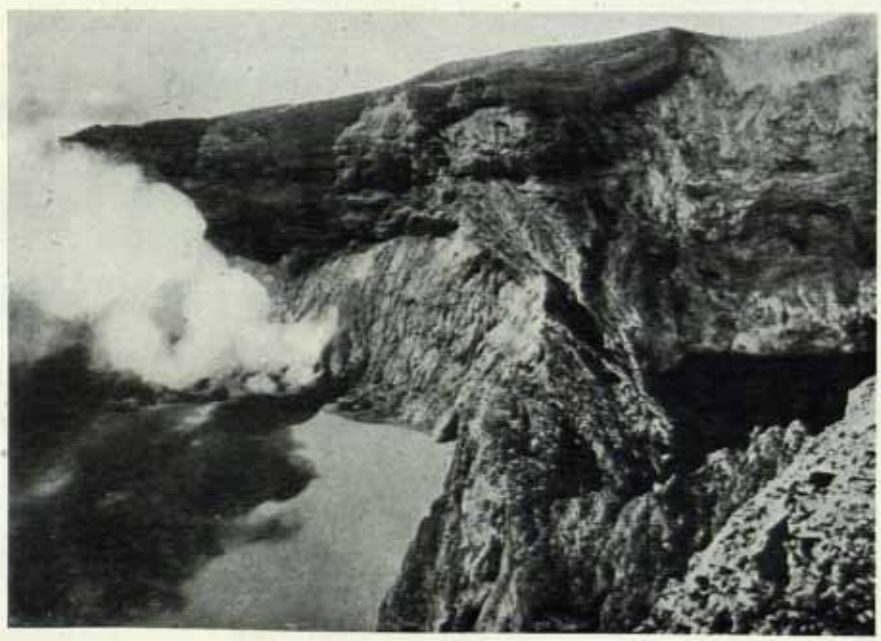

Plate 81. Keli Moetoe, Flores
Keli Moetoe, one of the many volcanoes of Flores, is famous for its coloured lakes: that on the left where smoke clouds from a solfatara can be seen, is turbid green, that on the right a deep red (see p. 39).

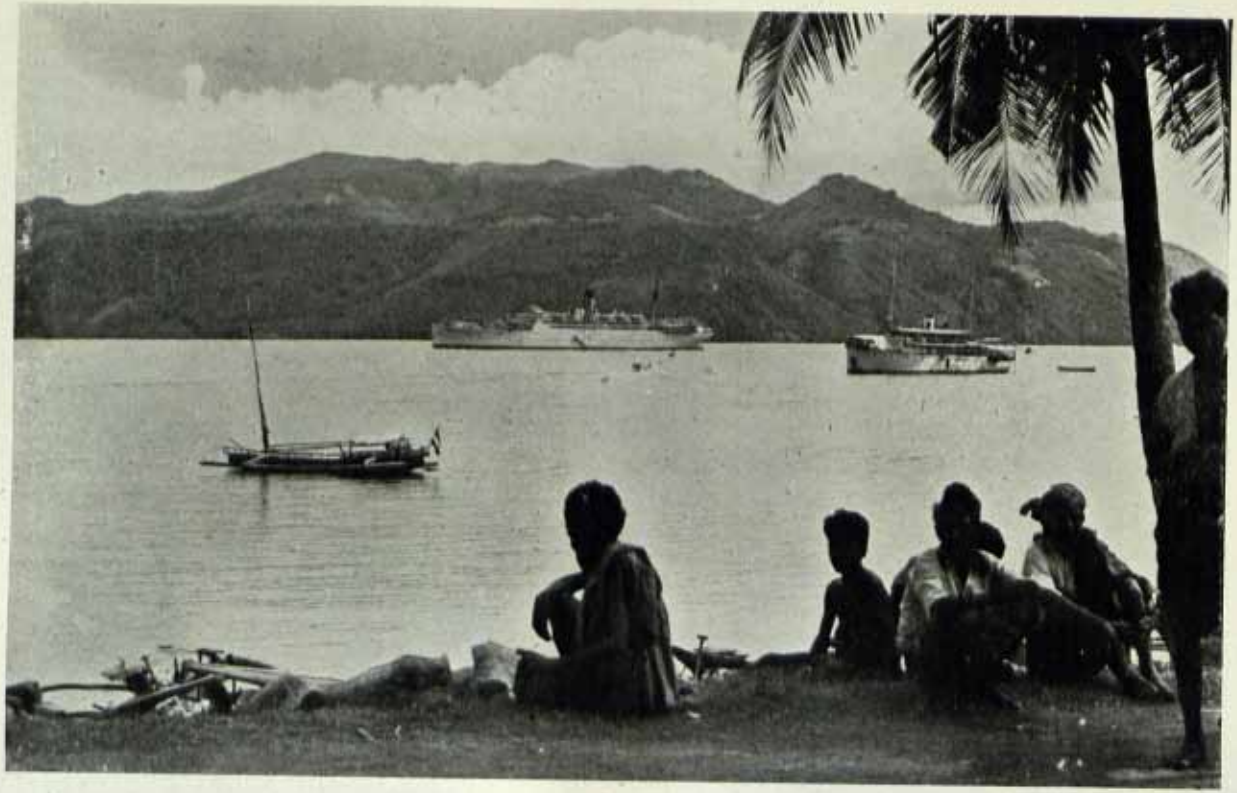

Plate 82. Kalabahi bay, Alor

The deep and narrow Kalabahi bay is surrounded by brushwood-covered hills. The liner in the centre of the photograph is on a pleasure cruise around the world.

coastal plain the numerous streams that rise in the wooded interior usually plunge headlong into the sea and are worthless for navigation.

Fig. 105. Goenoeng Ija seen from the sea
This active volcano (summit, 659 m.) is on the peninsula at the landward end of which Ende is situated. The last eruption was in 1882 and the fumaroles are now cool; but there is always a danger of landslides from the great clefts on the slopes, causing sea-waves.
Drawn from a photograph in *Vulkanologische Mededeelingen*, No. 10 (Weltevreden, 1931).

Coasts (Fig. 105, Plate 80)

The coasts are almost without exception, high and rugged, especially where spurs from the central mountains reach the sea in steep headlands, enclosing numerous bays between. Ende bay, the only large indentation on the south coast, is very deep and has few good anchorages; elsewhere the coast though without dangers, is steep-to and affords no anchorage. The north coast is very irregular and has several large bays of which Maoemere bay and Hading bay are the chief; there are few dangerous reefs and many sheltered anchorages can be found.

Vegetation

Little is known of the flora and fauna as the interior is largely unexplored. Sandalwood, sapan and cinnamon are found and the ubiquitous coconut occurs along the coasts.

Settlements (Fig. 106)

The population numbers about 600,000 and is a bewildering mixture of racial stocks, especially in the east. The majority are pagans with a primitive economy, but there are some few Christians and Moslems in the coast lands.

The chief occupations are fishing, hunting and agriculture, with maize as the chief crop, and rice, tobacco and coffee as subsidiaries. The chief settlements are Ende, the capital, Maoemere, and Larantoeka.

Fig. 106. The volcanic cone of Amboerombo (2,149 m.)
The village in the foreground is Boawai.
Drawn from a photograph in *Vulkanologische Mededeelingen*, No. 10 (Weltevreden, 1931).

Adjacent islands

Two outlying islands are found off the north coast of Flores, P. Besar and P. Paloe (Paloeweh—see p. 38), both of which, though steep and wooded, are well peopled.

THE SOLOR AND ALOR ISLANDS

These two closely associated island groups stretching for some 240 km. (150 miles) eastwards of Flores, consist of five large islands, Solor, Adonara, Lomblen, Pantar and Alor, together with a number of smaller ones, about all of which little is known (Fig. 107).

Alor

This island, which is also known as Ombai, is the largest and most easterly of the group and is separated by the Ombai strait from Timor, 27 km. (17 miles) to the south; it has a central ridge of mountains over 1,000 m. (3,300 ft.) high from which spurs, separated by deep ravines, reach the shore. The island consists of volcanic rocks with some outcrops of limestone; it has, however, no active volcanoes.

The coasts are generally rocky and in many places have cliffs; the greatest extent of coastal lowland is along the neck of the peninsula

forming the north-western portion of the island. South of this peninsula is the only indentation of any size, the long, narrow and deep Kalabahi bay, which affords a few anchorages (Plate 82). The coasts are generally clear of reefs and can be approached closely.

Vegetation on Alor is not dense and appears to be mainly scrub and brushwood, with large patches of *alang-alang*.

The population of the island, about 50,000 in number, is made up of fishing peoples on the coast, and in the interior hunters and primitive farmers growing rice, maize, tobacco, fruits and vegetables, and raising pigs and goats. They are almost all pagan and speak such a variety of languages that Malay is not as useful to the visitor as elsewhere in the Netherlands Indies.

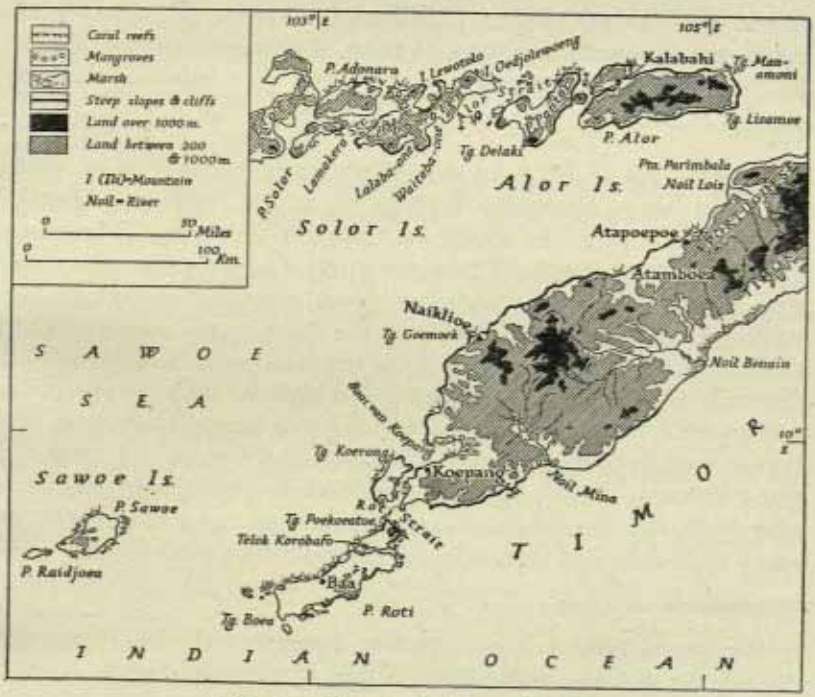

Fig. 107. Timor and adjacent islands
Source: 1 : 1 M, sheet S.C. 51 (G.S.G.S. 4204).

PANTAR

Pantar, to the west of Alor, is also very rugged and mountainous, its highest point being the active volcano, Delaki (Siroeng), 1,365 m. (4,487 ft.) at the southern tip.

The coasts are generally steep and rocky especially on the east side, while the north side is fringed by a reef.

The island has a long dry season when water is very scarce, hence the vegetation cover is thin, like that of Alor, with much *alang-alang*. It is a poor island and supports no more than 8,000 people, for there is a flow of emigration to the more favoured islands.

Lomblen

Lomblen, separated from Pantar by Alor strait, is the largest of the Solor group, running south-west to north-east for about 80 km. (50 miles). It is generally mountainous in character, with several active volcanoes. Ili Lewotolo (I. Wariran), 1,450 m. (4,757 ft.) in the north, Ili Weroeng and Ili Labalekang, 1,644 m. (5,394 ft.) in the south are the most important of these. The centre of the island is hilly rather than mountainous.

Coasts

Lomblen has an irregular shape with many indentations of which Lewoleba bay in the west, Warenga bay in the north, and Waiteba and Labala bays in the south, are the most prominent. The coasts are varied in character. The south coast alternates between rocky cliffs and sandy beaches backed by small stretches of coastal plain with coconut plantations. Owing to the deep waters anchorages are available at few points, except at the heads of bays, though reefs are generally absent. The north coast is also high for the most part, with patches of lowland and sandy beaches; it is generally steep-to and reefs are of frequent occurrence, hence anchorages are few. Parts of the west coast of Boleng strait are covered with mangroves, parts have sandy beaches, while other parts are steep and rocky. There are many coral reefs but there is good anchorage in Lewoleba bay.

Settlements

The population is about 32,000, concentrated mainly on the coast lands and the fertile lower slopes of the volcanoes.

The majority of the inhabitants are pagan Malayo-Papuans who live by fishing and primitive cultivation. Sago, rice and copra are the most important products of the island.

Adonara

Adonara lies between Lomblen and Flores and is approximately 32 km. (20 miles) long by 16 km. (10 miles) broad. Like the remainder

of the group it is mountainous and volcanic, the highest peak being the volcano Ili Boleng, 1,659 m. (5,444 ft.) high.

The coasts of Adonara which are without irregularities of any size, are generally low, sandy and wooded, rising gradually to the mountains, and with occasional patches of mangroves. An almost continuous series of coral reefs and islets runs around Adonara, but inside the reefs there are many safe anchorages, especially in Sagoe bay on the north coast.

The people of Adonara, who number 25,000, are of the same racial type as those of Lomblen and engage in the same activities of fishing and primitive agriculture, but are, however, largely Moslems.

Solor

Solor, the smallest of the group, is a boomerang-shaped island 32 km. (20 miles) long and lies to the south of Adonara. Lowlands stretching from coast to coast divide it up into four patches of highland, volcanic in character.

The coasts of Solor are mainly low and sandy or stony, occasionally backed by cliffs; almost everywhere there are safe and roomy anchorages.

The island is infertile and the vegetation cover thin, but there are a few coastal settlements; further details of the people or their mode of living are lacking.

SOEMBA

Soemba, or Sandalwood Island, the most westerly island of the Timor–Ceram arc, is separated from Flores, which lies to the north, by the Soemba strait. The island stretches WNW–ESE for about 210 km. (130 miles), and is about 65 km. (40 miles) wide, its area being approximately 12,000 sq. km. (4,633 sq. miles) (Fig. 108).

Physical features

The island though mountainous in the interior, has no very prominent summits, the highest being G. Wanggeti, 1,225 m. (4,019 ft.), in the Massoe range in the south-west. The uplands are composed mainly of Tertiary limestone and there are a few granite outcrops; the volcanic rocks so common in the chain of islands to the north are absent (cf. p. 14 and Figs. 8, 9). From the interior the mountains descend in a series of terraces to a coastal plain of varying width.

There are numerous rivers draining the highlands, the majority of which are obstructed by bars at their mouths; they are of some use for irrigation especially in the west of the island.

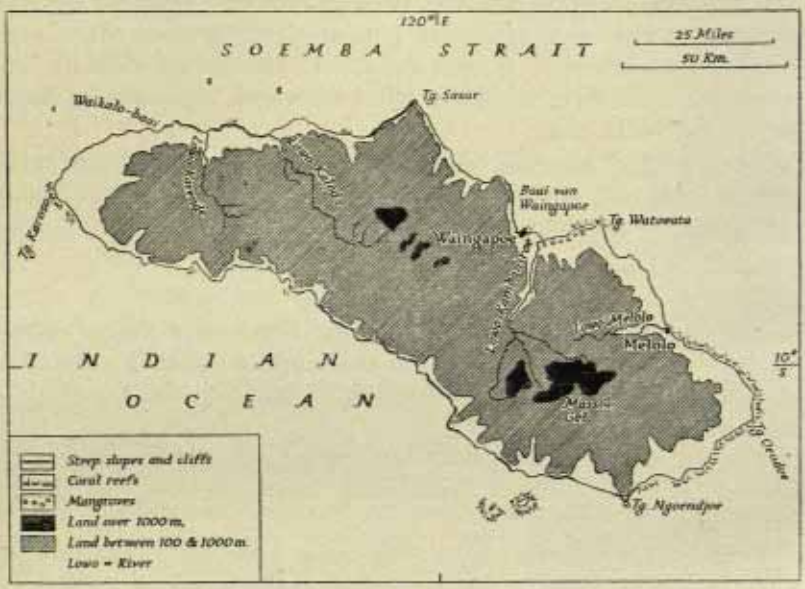

Fig. 108. Soemba

Source: Dutch 1 : 500,000 (copied as G.S.G.S. 4268) and *Atlas van Tropisch Nederland*, plate 27 (Batavia, 1938).

Coasts

The coastline has few indentations, though there are several small bays in the south. The north coast is generally low and sandy, usually wooded and with rocky points where spurs run seaward from the uplands. The best anchorages are to be found in Waikelo bay, in Waingapoe bay, and off Melolo and Palmedo (Plate 83). The eastern end of the island has a series of interrupted reefs offshore, within which sheltered anchorages can usually be found. The south coast, extremely steep and rugged and with many stretches of high cliffs, is difficult of access and good anchorages occur only in a few small bays.

Vegetation

There is a pronounced dry season and consequently there are large areas of grassland with few trees, especially in the eastern part. The

west of the island is more wooded, with teak, sandalwood, various dyewoods and cinnamon, all of some economic importance.

Settlements

The population numbers about 125,000 and is made up of the indigenous Soembanese of the Malayo-Papuan racial stock; settlers from other islands are found on the coasts. The majority are pagan but there are some Moslems in the coastal districts. The Soembanese are a farming people growing rice (both sawah and ladang), maize, tobacco, fruits, and vegetables, and rearing cattle and horses of which the 'sandalwood breed' is famous throughout the Netherlands Indies. The coastal peoples are fishermen, traders and producers of copra.

Waingapoe, on the bay of the same name, is the largest settlement and also the administrative centre.

TIMOR

The island of Timor, the largest as well as the most easterly of the Lesser Soenda islands, extends from SW to NE for 467 km. (290 miles), the greatest width being 100 km. (62 miles). In the north it is separated from Alor by the Ombai strait; to the south, across the wide Timor Sea, is the continent of Australia. The area of the whole island is about 25,000 sq. km. (10,000 sq. miles); east Timor and the Oeikoesi enclave in the north-west are Portuguese territory, the remainder, some 9,324 sq. km. (3,600 sq. miles) is part of the Timor residency of the Netherlands Indies; this includes the whole Lesser Soenda group except Bali and Lombok (Fig. 107).

Physical features

A chain of mountains, made up of a series of parallel ridges, traverses the whole island. The highest point is Tata Mailau, 2,920 m. (9,580 ft.) in the Ramelau range in Portuguese Timor; the highest point in the Netherlands territory is G. Moetis, which is 2,365 m. (7,759 ft.).

In the south-west of the island there are hills which gradually increase in height towards the north-west, and merge into the main mountain chain which has numerous bare summits of fantastic outline. The geological structure of Timor is very complicated, with intense folding of Miocene age, and indications of deep faulting (see p. 14, and Figs. 5, 8 and 9). Elevated coral reefs are found, some as high as 1,310 m. (4,300 ft.) above sea-level; another conspicuous

feature of the landscape is the *fatoe*, isolated plateau-like masses of limestone (Plate 85). The rocks are quite different from those of the island arc to the north. The majority are schists and sedimentary rocks with considerable outcrops of Triassic and Permian limestones. There are few volcanic rocks and no active volcanoes, but a few mud geysers. Severe earthquakes have been recorded.

There are numerous rivers in Timor, but none of them is navigable; many have short, steep courses to the sea and all, except the Noil Lois, fail to maintain their flow uninterruptedly for the whole year, partly because of the excessive drought of the dry season, partly because of the porous nature of the limestone and gravelly areas over which they run.

Coasts

Except for Koepang bay the coastline of Timor is not deeply indented; the coasts themselves show some variety but are generally high and steep-to. The south coast from Tg. Oisina east to Noilmina bay, a distance of about 60 km. (38 miles) is high and rocky with sandy beaches. As there are few dangers it can be closely approached everywhere; anchorages are numerous but practically unsheltered from the east monsoon and therefore little used. Noilmina bay extends for about 32 km. (20 miles) and has low sandy shores, with patches of mangrove swamp; anchorage in 7·7 m. (4¼ fm.) is available on the west side of the bay. From here the coast continues steep and rocky to Maoebesi bay, where the Noil Benain reaches the sea; this bay is backed by a low plain fringed with swamps, which extends beyond the boundary with Portuguese Timor. The best anchorage in this stretch is in Kalbano bay (11–33 fm.).

The west coast of Timor from Tg. Oisina to Koepang bay is not very steep, but is backed by hilly country; it is fringed by a broken reef and subject to dangerous tide rips. Koepang bay, which measures about 12 km. (7·5 miles) at its mouth penetrates eastwards for 20 km. (12·5 miles). The shores of the bay are low, especially at its head, where marshes and mangroves back a broad bank. Coral reefs are found on the north and south shores of the bay and around small islands at the entrance. Anchorage can be had off Koepang, the chief port of the island, in 18–33 m. (10–18 fm.). North of Koepang the coast is high and rocky as far as the wide sandy bay between Tg. Berate and Tg. Koeroes. It again becomes lofty to Tg. Goemoek, beyond which is Naikiloe, where there is a small sandy bay with an

Plate 83. North-east coast of Soemba, near Waingapoe

The shores of Soemba are generally low and wooded: in the background are low limestone hills, flat topped and scantily covered with vegetation.

Plate 84. Road from Koepang to Baoemata, Timor

The savanna vegetation characteristic of much of Timor is clearly evident here (cf. p. 394)

Plate 85. 'Stone of Kapan' in central Timor
This is one of the limestone 'fatoe' which are conspicuous features of the landscape of central Timor; they bear witness to the considerable structural disturbance which the outer fold-arc has suffered (see p. 11). The vegetation, owing to the long dry season, is of savanna type.

Plate 86. Tenan, near Koepang, Timor
From this bay in west Timor the land slopes gradually to the interior: trees are more frequent near the coast than further inland.

anchorage in 20 m. (11 fm.). The coast continues high and rocky with occasional reefs to the low sandy beach at Atapoepoe near the Portuguese boundary. Anchorages are available at Soetrana, Okusi, Wini, and at Atapoepoe itself (4–7 fm.).

Flora and fauna

The long dry season experienced in Timor, and its proximity to Australia gives the flora and fauna of the island an individual character. The common types of forest are casuarina and eucalyptus; there is much scrub and thorny jungle, especially in the north, savanna in the mountainous interior, and a denser vegetation cover with sandalwood and bamboo in the south. The fauna is more Asiatic than the vegetation, as only one marsupial is found, and few Australasian birds.

Settlements

The population of Dutch Timor is about 360,000; nearly every racial stock that ever lived in Indonesia exists in Timor, hence many widely different types occur. The Atoni and Koepangese tribal groups, mostly Malay in character, inhabit Dutch Timor; they are very largely pagan, though both Christianity and Mohammedanism have won adherents in the coastlands; there are very few Europeans but a fair number of Chinese, who generally are engaged in trading.

In Timor isolated farms are found as well as the village which is the normal unit of settlement; the staple crop of the native farmer is maize, rice being much less important; there is also some production of low grade coffee and of tobacco for home use, but agriculture in Timor is still extremely primitive. The coastal peoples fish and trade and are turning their attention more and more to coconut-growing. On the savannas some cattle and many poniès are raised but the pig is the commonest domestic animal.

The density of population is higher on the barren north coast, and in the interior, than on the more fertile and better vegetated south coast, due probably to epidemics and migration after the revolt in 1912. By far the largest settlement of Dutch Timor is the town of Koepang, which is not only the chief port of the island but the capital of the Residency of Timor. It had a population of 7,171 in 1930. The port of Atapoepoe and the inland village of Atamboea are the only other settlements worth mention.

Adjacent islands

South-west of Koepang bay is the small island, Poelau Semaoe, separated from Timor by Semaoe strait; it is a low island with flat wooded limestone hills, and a steep coast much encumbered by reefs. A sheltered anchorage in 33 m. (18 fm.) or more is available in the west monsoon at Hainisi which also has a seaplane anchorage.

South-west of Timor across Roti strait is the island Poelau Roti, which runs for some 70 km. (45 miles) north-east–south-west and is about 16 km. (10 miles) wide. Roti is hilly and has a much indented coastline, with steep rocky coasts and occasional sandy beaches. Good anchorages are available at Boeka bay (5–12 fm.) on the south coast, and in Korobafo bay (5–12 fm.), a landlocked basin in the south-west, though the shores of the island have an almost continuous reef.

Roti is fertile, well watered and thickly populated (47,000 in 1912). The inhabitants, many of whom are Christians, grow sago, rice, maize and tobacco, rear horses, sheep, goats and pigs, and engage in fishing. Baä, the administrative centre, is the largest settlement (Plate 83).

Some 80 km. (50 miles) north-west of Roti are the Sawoe islands—Poelau Sawoe, P. Raidjoea and P. Dana—all of which are low with bare rounded hills, and coconut palms along the sandy shores. Sawoe has some 27,000 inhabitants, including over 3,000 Christians, who cultivate maize and rice and rear horses, sheep, goats and pigs. There is a good anchorage in 13 m. (7 fm.) on the west side of Sawoe off the chief settlement, Seba.

PLANT AND ANIMAL LIFE

Travelling eastwards from Java through the chain of the Lesser Soenda islands even the most casual observer must be struck by the great change in the flora and fauna. In Bali the plants and animals are almost all the same as in Java; in Timor at the eastern end of the chain many of them are Australian. The change in flora and fauna is particularly marked between Bali and Lombok. Though Lombok strait is only 20 miles wide, on the western side all the birds belong to Javanese species, on the eastern white cockatoos and other Australian forms are at once noticeable. The importance of Lombok strait as a dividing line was first pointed out by the famous naturalist, Alfred Russell Wallace, who drew a boundary, since known as Wallace's line, dividing the Asiatic and Australian faunas. Though

later authorities have differed on the course the line should take, there is no doubt that the contrast between the western and eastern faunas is a real one and that it is largely due to the physical history of the islands and the way in which they were connected in remote geological periods.

At the same time it should not be forgotten that the present climate of the Lesser Soendas is much drier than that of Sumatra, Borneo and the western part of Java; this has important effects, especially on the vegetation. In the western islands, as well as in Celebes, the Moluccas and New Guinea, the characteristic natural vegetation is tropical rain forest, which depends for its existence on a climate in which rainfall is abundant all the year round. In the Lesser Soenda islands there is little forest and much of what there is is of a type in which many of the trees lose their leaves in the dry season. True evergreen forests are, however, found in the mountains at a considerable height above sea-level. Teak forests, none very extensive, and monsoon or mixed deciduous forests occur in the lowlands here and there. Gum trees (*Eucalyptus*), so characteristic of the Australian flora, are common in central Timor, where they form poor woodlands over large areas; their western limit in this part of the archipelago is central Flores and the strait between Timor and Roti. The huge *Dipterocarpus* trees, belonging to a family typical of the Malay Peninsula and the western islands, are found only in Bali and Soemba; near Bongkasa in Bali there is a famous sacred grove of them. Species of *Casuarina* or tjemara are common, especially in Timor. Whether forests originally covered the whole of the Lesser Soenda islands is uncertain, but at the present time large areas of uncultivated land are covered with open savanna, often with scattered groves of the lontar palm (*Borassus*). On some of these savannas, particularly on the eastern side of Lombok, dense thickets of the prickly pear, a cactus introduced from America, have established themselves.

The animal life is very poor compared either with New Guinea or with Java and Sumatra. There are many bats, but few other land mammals. Wild pigs and a monkey are common, but apart from these there are only deer, a civet cat, a porcupine, a shrew and a cuscus or opossum. The bird life is more interesting, but does not compare for variety or brilliance with, for instance, that of the Moluccas. Cockatoos and other parrots are numerous and varied in all the islands from Lombok eastwards. Various other characteristically Australian birds are found, but the bower birds, the black and red cockatoos and other forms common on the mainland of Australia are absent.

BIBLIOGRAPHICAL NOTE

The general works already mentioned in connection with Celebes, provide most of the information available for these islands.

A particularly good account of Timor is given in articles in the *Geographical Journal*. One of these, 'Exploration of Portuguese Timor' by S. F. Wittouck (vol. xcii, pp. 343–50, London, 1938) gives useful details applicable to the whole island, while the other, 'Exploration in the Lesser Soenda Islands' by H. A. Brouwer (vol. xciv No. 1. pp. 1–9, London, 1939) gives an account, mainly geological, of Timor, Alor, the Solor islands, and East Flores.

Other information about the group as a whole is given in B. Rensch, *Eine biologische Reise nach den Kleine Sunda-Inseln* (Berlin, 1930).

Chapter VIII

THE MOLUCCAS

Introduction: Halmahera and Adjacent Islands: Ceram and Adjacent Islands: Southern Moluccas: Plant and Animal Life: Bibliographical Note

INTRODUCTION

The island group known in Dutch as De Molukken (the Moluccas or Spice Islands) which lies in lat 2° 43′ N to 8° 23′ S and in long. 124° 22′ to 135 ° E, includes all the islands between Celebes on the west, New Guinea on the east, and Timor on the south (Fig. 109). Their shores are bordered by the Arafoera, Banda, Molucca, and Ceram Seas, and by the Pacific Ocean. As the islands command the shortest sea and air route from Australia, to the Philippines and Japan, they have vital strategic significance. The whole of the Moluccas has a land area of 91,000 sq. km. (35,000 sq. miles). Many hundreds of islands are included in the group, though only a few, such as Halmahera, Ceram, Boeroe, Soela, and Tanimbar, are large.

Most of the islands are mountainous and densely forested, but some, such as the Aroe and Tanimbar groups, are flat and in large part covered by swampy vegetation. The geological structure of the islands is little known. They appear to be disposed in a series of three arcs. The first arc passing through the Damar and Banda sub-group, continues the great chain of volcanoes found in Sumatra, Java, and the Lesser Soenda islands. The second arc is formed by the non-volcanic islands of Tanimbar, Kai, Ceram, and Boeroe; and the third runs through the large island of Halmahera in the northern Moluccas (Figs. 8, 9 and 10).

The population of the Moluccas, which totals about half a million is mixed in character. Javanese, Malay, Portuguese, and Dutch blood is mingled with that of the indigenous peoples, as for many centuries the islands have been important centres of trade. In the coastal districts, where most of the population lives, Mohammedanism is the predominant religion, except in Amboina, which is largely Christian. The settlements in the islands are mainly in the form of villages, though each main island group has at least one trading centre. Such are the towns of Amboina, Ternate, Tidore, and Bandanaira. Ternate and Amboina are respectively the capitals of

the northern and southern Moluccas, which are the main units in the Dutch administration of the islands.*

Within the main island group of the Moluccas, there are many sub-groups, such as those of Halmahera, Soela, Amboina, Ceram,

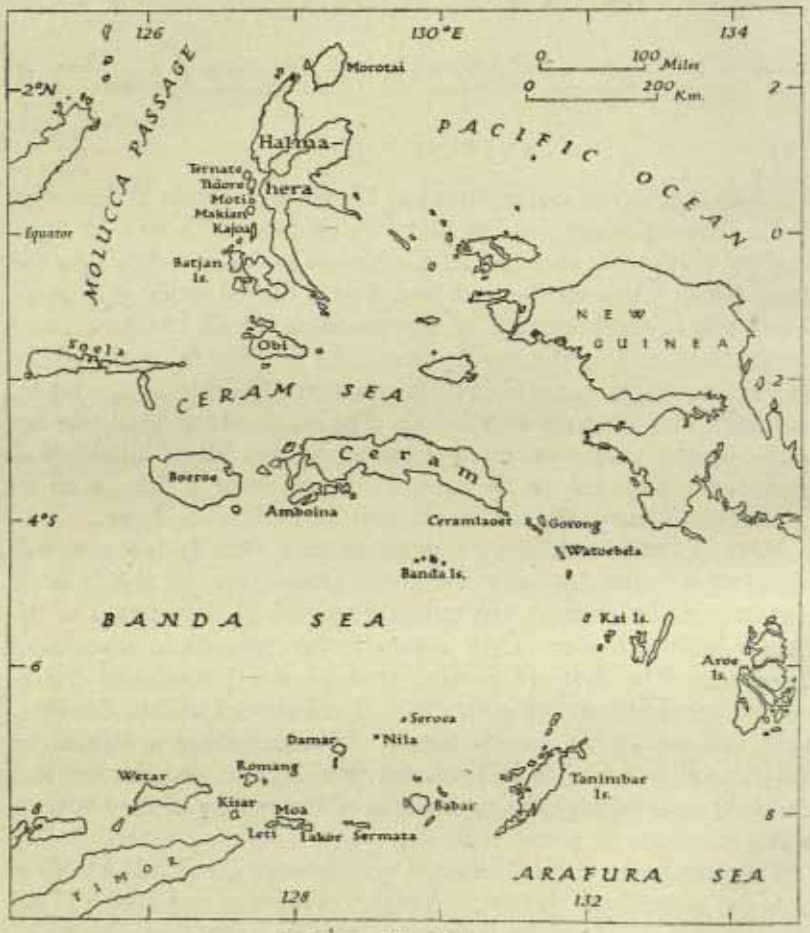

Fig. 109. The Moluccas
Source: *Atlas van Tropisch Nederland*, plates 28 and 29a (Batavia, 1938).

Banda, Kai, Aroe, and Tanimbar. The largest and most important islands of those sub-groups will be described in approximately geographical order from north to south.

* Northern Dutch New Guinea is included administratively in the Northern Moluccas, and Southern Dutch New Guinea in the Southern Moluccas.

Plate 87. Halmahera: Djailolo peak, seen from Toeda

The extinct volcano, Goenoeng Djailolo (1,130 m.) overlooks the small bay of Djailolo on the west coast of the island. Toeda is a village on the shores of the bay.

Plate 88. Baä, Roti island
Baä, the largest settlement of the well peopled island of Roti, is picturesquely set amongst coconut palms; the small harbour is a port of call for K.P.M. steamers.

Plate 89. Halmahera: Boeli-serani
The village of Boeli-serani lies near the head of Boeli bay on the southern shores of the north-eastern peninsula. It is a port of call for vessels of the K.P.M. A small wooden pier can be seen in the centre of the picture.

HALMAHERA AND ADJACENT ISLANDS

HALMAHERA

Halmahera is one of the largest islands of the Moluccas, with a length of over 300 km. (200 miles), and an area of about 16,800 sq. km. (6,500 sq. miles).

Physical features

The shape is extremely irregular, and closely resembles that of the island of Celebes (Fig. 110). Like the latter, it consists of four peninsulas, radiating north, north-east, south-east, and south, from a central region relatively small in extent. The peninsulas enclose the three large bays of Kaoe in the north, Boeli in the east, and Weda in the south. The northern peninsula is joined to the mainland by a low narrow isthmus, only 8 km. (5 miles) wide, on the western side of which are Djailolo and Dodinga bays (Plate 87). Almost the whole island is mountainous, and densely forested. Gamkonora (1,566 m.—5,139 ft.), an active volcano, is the highest summit. There are three other volcanoes, two of them active, and one dormant (Fig. 13). Earthquakes are frequent in the island. Raised coral terraces in the interior point to recent oscillations in the relative levels of land and sea. The island has numerous short rivers, of which the largest are the Taliaboe and the Lamo and there are several small lakes. Close offshore Halmahera is bordered by a large number of islands, some of considerable size such as Morotai, Batjan and Obi; others such as Ternate and Tidore are quite small, though politically and economically far more important than Halmahera itself.

Coasts

The coasts of Halmahera are mostly steep and rocky, with reefs and shoals lying close offshore. The western shores are irregular in outline, but not so deeply indented as those of the east, where the bays of Galela, Kaoe, Boeli, and Weda are such a striking feature. All these bays provide good anchorages (Plates 89 and 90).

Settlements

The total population of Halmahera is about 75,000, and consists mainly of immigrant Malay stock, though in the north there are groups with Papuan–Malay affinities, and a tribe near Galela has Polynesian characteristics. Most of the population is in the coastal

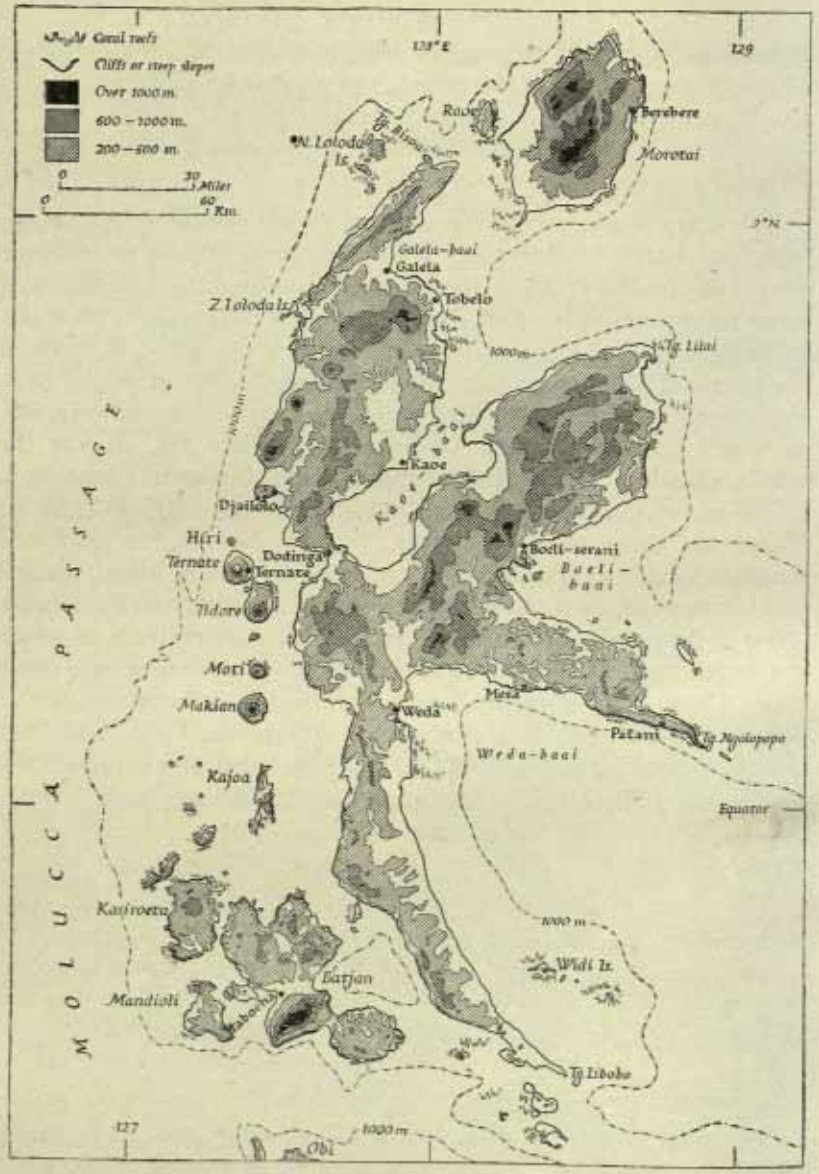

Fig. 110. Halmahera and adjacent islands

Source: Dutch map, 1 : 500,000 (Batavia, 1933) and Admiralty Chart No. 2788.

districts; the forested mountains of the interior are practically uninhabited and entirely undeveloped. Sago, coconuts, nutmeg, and rice, are grown by the natives. Patania, with about 2,000 inhabitants, is the largest settlement; it lies on the northern shores of Weda bay, and is a port of call for the *Koninklijke Paketvaart Maatschappij* (K.P.M.), and has a small pier. Other ports of call for vessels of this company are Galela, Tobelo, Kaoe, and Weda.

Morotai

This island lies about 18 km. (11 miles) eastward of the northern extremity of Halmahera. It is nearly 80 km. (50 miles) long, and is in large part mountainous, the highest point reaching an elevation of 1,250 m. (4,100 ft.). A number of anchorages are available off the shores of the island, but approach to the coast is made difficult by fringing reefs and shoals.

Almost the whole population of Morotai is found on or near the coast. The natives cultivate sago and rice; they also collect dammar gum from the forests, and fish in the coastal waters.

Ternate

Ternate lies west of Halmahera, opposite the narrow isthmus between Dodinga and Kaoe bays. It is 10 km. (6 miles) wide and has an area of 65 sq. km. (25 sq. miles).

Physical features

The island is almost circular in shape, and consists mainly of a volcano, 1,721 m. (5,646 ft.) in height, with three summits in each of which there is a crater lake. This volcano has been constantly active for more than 300 years (see p. 22 and Fig. 13). The northern half of the island has suffered most from the eruptions and here, where lava streams have flowed right to the sea, many bare tracts of land are seen. In other parts, the land is either cultivated or covered with a luxuriant tropical vegetation.

The shores of Ternate are steep with no off-lying dangers, except for a narrow coastal reef, and vessels can find anchorage almost anywhere.

Settlements

Ternate is one of the most densely peopled of the Molucca islands. It has a population of about 10,000 which gives a mean density of 400 per sq. mile. A high proportion of the people lives in the coastal

districts. Rice, maize, sago, pepper, nutmegs, and fruit are among the many crops grown.

The town of Ternate, with 6,500 inhabitants, is the seat of an ancient sultanate, and now the capital of the residency that bears its name. It has a picturesque site on the south-east coast of the island. There is a fine harbour in which are two piers; the northern can only be used by boats, but the southern one has a 'T' shaped head, with a least depth of 4 m. (13 ft.) alongside. Several buoys and bollards at the pier facilitate mooring. It is a regular port of call for vessels of the K.P.M.

Tidore

This is a small mountainous island a mile south of Ternate. The southern part is occupied by an extinct volcano, 1,756 m. (5,763 ft.) in elevation; the summit is bare, but the lower slopes are either densely wooded, or cultivated. Coffee, tobacco, and fruits are grown on the slopes below 300 m. (1,000 ft.). The northern half of the island is rugged, and the hills fall sharply to the sea, though there are a few level expanses near the shore.

Tidore, like Ternate, has a high density of population. The population is estimated at 20,000, giving a mean density of 660 per sq. mile. All the natives of the island are Moslems. The largest settlement, Soasioe or Tidore, is the administrative centre of Tidore Residency; it was formerly the seat of a sultanate, rivalling in power that of Ternate. The town has a pier off which anchorage may be obtained in a depth of about 18·3 m. (10 fm.).

The Malesain Islands

These are a group of three small islands: Moti, Makian, and Kajoa, which lie to the south of Tidore. All three, which have a combined area of about 50 sq. miles, are of volcanic origin. The volcano on Moti last erupted in 1774, that on Makian in 1940. The only good anchorage protected from both monsoons is found off the north-eastern side of Makian, in depths of from 29·3–60·4 m. (16–33 fm.). They have a population of about 10,000 altogether.

The Batjan Islands

This group, lying off the south-west coast of Halmahera, comprises about eighty islands, but only four of these, Latalata, Kasiroeta, Mandioli, and Batjan, are considerable in size. The largest, Batjan,

Plate 90. Halmahera: Coast near Tobelo
The photograph shows part of the eastern shores of the northern peninsula of Halmahera. The shores and the mountains inland are densely forested.

Plate 91. Ceram: Piroe bay
This bay lies on the south coast of Ceram and is fronted by the island of Amboina.

Plate 92. Hiri, seen from Ternate

The photograph is taken from the northern shores of Ternate, looking across the narrow stretch of water to the volcanic island of Hiri.

84 km. (52 miles) long, with a mean width of 37 km. (23 miles), is mountainous except in the central part, where there is a low isthmus. Small quantities of coal, gold, and copper are mined on the island. The only important settlement on Batjan is Laboeha, on the western shores of the central isthmus, near which are two piers. Anchorage may be obtained in depths of 12·8–16·5 m. (7–9 fm.) Laboeha is the residence of a Dutch government official, and of the Sultan of Batjan.

The Obi Islands

These islands lie to the south of Batjan, and east-north-east of the Soela group. Obi, the largest of the group, is over 80 km. (50 miles) long, and 30 km. (20 miles) wide, and rises to a height of 1,500 m. (5,000 ft.) at its centre. Several small mountainous islets lie off the shores of Obi. There are few permanent settlements on any of the islands of the Obi group; most of the inhabitants come here for short periods from the neighbouring islands. The Obi group was at one time a favourite resort of pirates.

Soela Islands

West of the Obi group are the Soela islands, which are geographically closely connected with Celebes. The two largest, Taliaboe and Mangole, separated by the narrow Tjapaloeloe strait, form a mountain range running east–west for nearly 240 km. (150 miles). A third large island in the group is Sanana, which runs in a north–south direction for 60 km. at right angles to Mangole. All the islands are narrow, mountainous, and densely forested, but, though fertile, are thinly peopled. The coasts, which are imperfectly known, are generally high with occasional sandy beaches, and an interrupted line of reefs offshore. There is only a small population on the islands, most of whom live under primitive conditions. Sanana, on the eastern shores of the island that bears its name, is the residence of a government official. In the bay at Sanana, is a small pier with a depth of 0·6 m. (2 ft.) at its head, while good anchorage may be obtained further offshore. Vessels of the K.P.M. call here regularly.

Boeroe

Boeroe, south-east of the Soela islands, is the third largest of the Moluccas, after Ceram and Halmahera. It is an oval-shaped island, about 130 km. (80 miles) long, 80 km. (50 miles) wide, with an area

of 8,800 sq. km. (3,400 sq. miles). Lofty mountains, rising to nearly 2,400 m. (8,000 ft.) occupy almost the whole of the island, except in the east, where is the extensive Namlea plain. This plain slopes to the shores of Kajeli bay, where anchorage is available in about 20·1 m. (11 fm.); a small boat pier with a depth of 2 m. (6½ ft.) at its head, is found at the village of Namlea. Dutch vessels call regularly at Namlea, which is the headquarters of a government official. Apart from Kajeli bay, the only other marked indentation in the otherwise regular coastline of Boeroe, is Bara bay, in the north-west.

The population is estimated at 20,000. It is mainly of proto-Malay stock. Much of the island is undeveloped economically. Sago palms grow abundantly in the low-lying regions, and there is good timber, especially teak and ebony, in the forests of the interior.

CERAM AND ADJACENT ISLANDS

Ceram

Ceram (Serang), the largest of the Moluccas, is 347 km. (216 miles) long, with an area of 17,748 sq. km. (6,621 sq. miles).

Physical features

From east to west the island is traversed by a range of mountains, the highest of which is Binaija (3,055 m.—10,023 ft.), whilst a number of other peaks exceed 1,800 m. (6,000 ft.). Ceram and Boeroe belong to the older of the two main fold arcs of the East Indies (see p. 14, and Figs. 8, 9 and 10). Thus while the mountains are mainly composed of crystalline rock, and volcanoes are absent, earthquakes are of frequent occurrence. The extreme western part of Ceram is formed by the irregularly shaped Hoamoal peninsula, joined to the mainland by a low, narrow isthmus. This is the only part of the island that is at all well known. A large number of rivers, the chief of which are the Masiwang, Bobot and Roeatan, rise in the central range. Most of them are unnavigable, and are often dry at certain periods of the year (Fig. 111).

Coasts

The coasts of Ceram are generally low and swampy in the north and east, but high and steep in the south and west. Seleman bay is the chief indentation along the northern coast. Mountains fall steeply to the sea at the head of the bay, while on its eastern side there are extensive marshy plains, with reefs and shoals offshore. The best

anchorages are found in the western part of the bay. On the east coast of the island are the smaller bays of Boela and Waroe. The former has considerable commercial importance owing to the petroleum wells in its vicinity. Anchorage may be obtained in a depth of about 21·9 m. (12 fm.), and vessels up to 13,000 tons can moor either alongside the pier at Boela village, or at mooring buoys in the bay. There are pipe lines on the pier for taking in water and fuel oil. Waroe bay, to the south-east of Boela, has a pier for small boats, and affords safe and secure anchorage at all seasons in a depth of 29·3 m. (16 fm.).

Fig. 111. Ceram and Amboina
Source: Dutch map, 1 : 500,000 (Batavia, 1921) and Admiralty Charts, Nos. 3241 and 3242.

The southern coasts of Ceram are deeply indented by the three large bays of Taloeti, Elpapoetih, and Piroe. Taloeti bay is nearly 40 km. (25 miles) wide at its entrance, and is surrounded by high mountains. Vessels may anchor at several places, but all are insecure during the south-east monsoon. Tehoroe, the principal settlement, has a pier which extends out to a depth of 4·9 to 6·1 m. (16 to 20 ft.). Elpapoetih, the second of the three larger bays, has a broad alluvial plain, partly covered with bamboos, at its head. Several anchorages exist, the best of which lies off Amahai village in 11–29·3 m. (6–16 fm) on the eastern side of the bay. This village, which is the headquarters of a government official, has two piers, the one with a depth of 2·4 m. (8 ft.), the other with a depth of 5·6 m. (18½ ft.) at its head.

The third bay, Piroe, is bounded on the west by the Hoamoal peninsula, and fronted on the south by Amboina (Ambon). The bay is broad at its entrance, narrowing considerably towards its head, where lies the settlement of Piroe. There is anchorage off this village in a depth of about 29·3 m. (16 fm.). Piroe, which is the residence of a government official, has a pier with a depth of 3 m. (10 ft.) alongside. Like Amahai and Tehoeroe, in the bays further east, Piroe is a regular port of call for vessels of the K.P.M. (Plates 87 and 88).

Population

Ceram has a population of 60,000 of whom 12,000 are Christian and 16,000 Mohammedan. In the coastal districts, considerable intermixture with peoples from Java, Makassar, and Ternate, has taken place. Only among the Alfoers of the interior, who have affinities with the Papuans, are indigenous customs to be found. Hunting and fishing are the chief occupations. Since the sago-palm, which provides the main article of food, requires little or no care in its cultivation, agriculture holds a secondary place among the occupations. Trade is mainly in the hands of Chinese merchants.

Amboina

The Amboina group of islands, which lie south of the western part of Ceram, comprise Amboina (Ambon), Haroekoe, Saparoea, and Noesalaoet. The last three are known as the Oeliassers. They have a total area of 1,300 sq. km. (500 sq. miles). All are traversed by mountain ranges, formed mainly of granite and other crystalline rocks. There are hot springs and sulphur beds, but no active volcanoes. Earthquakes are frequently experienced.

Physical features

Amboina, the largest and most important island of the group, is composed of two mountainous peninsulas, Hitoe and Loetinor, linked by a low isthmus only 1 km. wide. Hitoe, the larger of the two, has one summit rising to just over 1,000 m. (3,300 ft.), but Loetinor only attains 562 m. (1,844 ft.). The two peninsulas are separated for the greater part of their length by Amboina and Bagoeala bays. Volcanic rocks are found, but there is no trace of even an extinct eruption point. Numerous terraces, mostly of coralline limestone are seen around Amboina bay. All the rivers are small and unnavigable (Plate 91).

Plate 93. Ceram: A small settlement on the shores of Piroe bay

Plate 94. Geser island, an atoll to the south-east of Ceram

The group of buildings along the shore forms part of the village of Geser which is a trading centre and the headquarters of a government official.

Plate 95. Amboina

Amboina is the chief port in the Moluccas. The photograph shows a section of the wharves and the buildings (godowns) for the storage of goods.

Plate 96. River scene on the island of Amboina

The banks of the river are fringed by a dense tropical vegetation.

Population

The island of Amboina is thinly settled and has a total population of about 50,000. Its peoples are made up of mixed elements, but they are receptive of western civilization, and make good native administrators. Their customs, clothes, and dances show evidence of centuries old Portuguese influence. Christianity is the predominant religion in the south, Mohammedanism in the north of the island. The people live largely on fruit and vegetables, and on sago imported from Ceram.

Port of Amboina

The town and port of Amboina (population 17,334 in 1930) is the largest and most important commercial and administrative centre in the Moluccas. The bay, at the head of which Amboina stands, is about 8 km. (5 miles) wide near its entrance, but inland it narrows to form a sheltered harbour 5 km. (3 miles) long by 2 km. (1¼ miles) broad. In the inner roadstead there is anchorage for vessels not exceeding 74·7 m. (245 ft.) in length, in a depth of about 45·7 m. (25 fm.). The port has two wharves, a concrete one 95·1 m. (312 ft.) in length, and with a depth of 10·1 m. (33 ft.) alongside, and a coaling one 83·8 m. (275 ft.) in length, and with a least depth of 7 m. (23 ft.) at its western end. Near the concrete wharf is a small boat pier with a depth of 1·5 m. (5 ft.) at its head. Water, coal and fuel oil can be obtained at the port. The town of Amboina is well built with many government buildings and business premises.

Adjacent islands

Haroekoe, Saparoea, and Noesalaoet islands, east of Amboina, have an irregular coastline. They provide very good anchorages. The village of Saparoea, on the southern shores of the island that bears its name, is a port of call for vessels of the K.P.M.

Ceramlaoet, Gorong and Watoebela Archipelago

This archipelago lies off the south-eastern extremity of Ceram. It forms part of the fold-arc which swings round from Ceram through the Tanimbar islands to Timor (Figs. 8 and 9). Ceramlaoet is a rocky island covered for the most part with coconut palms and fringed by a coral reef. Further to the south-east are the Gorong islands, comprising Pandjang, Manawoka, and Gorong. All three are hilly, densely wooded, and fringed by coral reefs. Coconut and sago palms

grow abundantly, and there is also a fishing industry. The chain of small hilly islands is continued by the Watoebela group. The peoples of this archipelago are Mohammedans.

Banda Islands

The Banda islands lie about 100 km. (60 miles) south of Ceram, and 200 km. (125 miles) south-east of Amboina. They number ten in all, and their total area is only 260 sq. km. (100 sq. miles). The islands are volcanic in origin, and consist of the ruins of a great caldera invaded by the sea. Goenoeng Api (656 m.—2,152 ft.) is the active cone of the archipelago (Fig. 12 and Plate 94); the islands of Lontor (Groot Banda), Bandanaira, Pisang, Kapal, and Kiapah are fragments of the caldera rim. Dense vegetation clothes Goenoeng Api up to 200 m. above sea-level, while its upper slopes are bare; near the summit are two craters from which smoke and fumes rise continuously. Earthquake shocks are felt in the islands almost every day. There are no rivers, owing to the high porosity of the volcanic soils, and the water supply is obtained from wells and tanks.

The indigenous population of the Banda Islands is now extinct and the present population of about 6,000 includes a mixture of immigrants from Java, Celebes, and other parts of the East Indies. The islands were formerly a prosperous centre of the spice trade, and at the present day there are still extensive areas under nutmeg (Plate 93). Bandanaira, which has one of the finest harbours in the East Indies, is the chief administrative and commercial centre, and a regular port of call for vessels of the K.P.M. The port has two stone piers for boats and a wharf with depths of from 4·6–7·9 m. (15–26 ft.) alongside (Plate 92).

SOUTHERN MOLUCCAS

Kai Islands

The Kai (or Ewab) archipelago represents a broadening of the Ceram–Timor fold-arc. The Weber Deep (4,000 fm.) separates these islands from the Banda group to the west, and another deep trough (2,000 fm.) intervenes between them and the Aroe group to the east. The Kai islands are made up of four separate groups, proceeding from west to east: the Koer group, the Tajandoe group, Noehoerowa, and Kai Doelah and Noehoetjoet (Great Kei). They are mainly composed of coralline limestone. All the islands are relatively

Plate 97. Bandanaira
The view is taken looking south with the island of Lontor (Groot Banda) in the background. On the right is the island on which rises the active volcano of Goenoeng Api. Bandanaira, on Naira island, is a regular port of call for vessels of the K.P.M.

Plate 98. Unloading nutmeg at Bandanaira
Nutmeg is one of the chief articles of trade in the Moluccas.

Plate 99. Goenoeng Api (Banda)
The active volcanic cone of Goenoeng Api (656 m.), seen from the western part of Naira island.

Plate 100. The port of Dobo in the Aroe islands
Dobo is situated on the north side of Wamar island in the Aroe group.

low-lying, with the exception of Noehoetjoet, which is a long and narrow island, with forested mountains rising to 800 m. (2,600 ft.). The coasts are for the most part fringed by reefs, but there are several good anchorages between the reefs and the shore. Elat bay on Noehoetjoet, and Toeal on Noehoerowa, are the principal places of call for commercial vessels.

The islands of the Kai archipelago have a population estimated at over 20,000, over half of whom live on Noehoetjoet. The indigenous type is almost non-existent, for there has been considerable intermixture with settlers from Ceram, Celebes, and New Guinea. The majority of the inhabitants are heathen, though Mohammedanism and Christianity are rapidly gaining ground. A large part of the islands is uncultivated and fishing plays a more important part than agriculture in the native economy.

Aroe Islands

East of the Kai islands, and on the western edge of the Sahoel Shelf, between New Guinea and Australia (Fig. 8), is the Aroe group, which consists of five large islands, Kola, Wokam, Kobroör, Maikoör, and Trangan, separated from one another by narrow channels; there are over one hundred smaller islands. The whole group is low-lying, and formed mainly of coralline limestone. Forests and mangrove swamps cover a large part of the surface, though there are grassy plains in the south of Trangan island. Coral reefs lie off the shores of all the islands, and the surrounding Arafoera Sea is shallow (Fig. 4).

The Aroe islands are thinly peopled, for the total population is only about 15,000. The inhabitants, who are of mixed Alfoer stock, are peaceful and respect Dutch authority. Little of the ground is under cultivation, though the soil is fertile. Pearl fishing is the chief occupation. Dobo, on the small island of Wamar, off the western shores of Wokam, is the main settlement and a regular port of call for commercial vessels (Plate 95).

The Tanimbar Islands

This group, which lies south-west of the Kai archipelago, and continues the Ceram–Timor fold-arc, consists of sixty-six islands, of which Jamdena is by far the largest. The islands are fairly low, but not flat. Several, e.g. Jamdena (eastern part), Seloe, Woeliaroe, Wotap, Moloe and Fordate, have a large part of their area over 100 m. (330 ft.), and Laibobar rises to 391 m. (1,283 ft.). Coralline limestone

is the predominant rock, and the islands have thus clearly experienced considerable recent uplift (see p. 11). The islands are forested, and there are also some swamps, notably on the western shore of Jamdena. Jamdena has an irregular coastline, and its shores, like those of the other islands, are fringed by a coral reef. Several good anchorages are available.

The Tanimbar islands have a population estimated at about 20,000. The people are mainly of mixed Alfoer stock, and, until recently, were actively hostile to European influence. Agriculture is little developed, though the natives supply all their own needs. Saumlakki, and Larat (Ritabel) are the main commercial centres.

South-Western Moluccas

Two chains of islands, separated by very deep troughs, link the Moluccas with the Lesser Soenda islands. The outer fold arc (see p. 14 and Figs. 8, 9 and 12) continues from the Tanimbar islands through Babar, Sermata and the Leti islands to Timor. This is a non-volcanic chain, folded and fractured; several of the islands rise to over 300 m. (1,000 ft.), and the culminating point of Babar is 755 m. (2,477 ft.). The inner fold-arc is divisible into two parts. For some 200 km. (125 miles) south of the Banda islands it is merely a submarine ridge, rising above sea-level only in the dormant volcano Manoek. Then, as the arc swings south-westwards, several volcanic islands appear. Seroea, Nila, Teoen and Damar each have recorded eruptions (see p. 22); they all rise to more than 600 m. (2,000 ft.). The second part of this fold-arc, where it approaches to within less than 100 km. (60 miles) of the first arc, is not actively volcanic (compare p. 15 and Fig. 12); it comprises Romang, with some smaller neighbours, and the large island of Wetar. Wetar is about 110 km. (70 miles) long and over 30 km. (20 miles) broad; it is mountainous, with two summits, one near each end, rising to about 1,400 m. (4,600 ft.). In places there is a narrow coastal plain, sometimes marshy; offshore the sea bottom drops quickly to great depths. The inhabitants are practically heathens and almost without civilization. The only important settlement is Ilwaki on the south coast which is visited by a K.P.M. steamer several times a year.

These island chains are too little known for any estimate of population to be given. The people are for the most part primitive and have little contact with the outside world. The chief port is Wonreli, on the island of Kisar (westernmost of the Leti islands);

this is an old East India Company port, but it no longer has a regular steamer service.

PLANT AND ANIMAL LIFE

The plants and animals of the Moluccas have been known to Europeans for a very long time. The celebrated Dutch naturalist Rumphius (1628–1702) lived for many years in Amboina and his life work, the *Herbarium Amboinense*, published in 1741–55, is the first scientific account of the plants of the East Indies.

Like other wet regions in the Netherlands Indies most of the Moluccas are, or were originally, covered with evergreen rain forest, but now, particularly in the more thickly populated islands such as Amboina, much of the virgin forest has been destroyed, its place being taken by cultivation and second-growth. In parts there are patches of open savanna. Not all the existing forest is rain forest; in places there are teak forests, though they are not very extensive, and the coasts are fringed with mangrove swamps where conditions are suitable. Among the more valuable trees are the sandalwood and the dammar (*Agathis alba*), which is particularly abundant on Obi and yields valuable timber and resin. The most important plant in the Moluccas is the sago palm (*Metroxylon*), which grows wild in swampy places and is also cultivated; except in the Oeliassers it everywhere provides the staple food of the natives.

The Moluccas are the original spice islands of the East and the part which their products have played in trade and politics is too well known to need description here. They are the native home of *Myristica fragrans*, the tree which is the source of nutmeg and mace. Though the nutmeg is still extensively grown (especially on Banda) and cloves are grown on Amboina and elsewhere, spices today play quite a minor part in the economy of the Moluccas. The cultivation of coconuts, a less laborious and now a more profitable occupation, has to a great extent replaced spice growing. Agriculture in general is not of a high standard in the Moluccas, partly because of the ease with which sago can be obtained.

The animal life of the Moluccas is of considerable interest, particularly the birds and butterflies, which are as varied and brilliant as almost anywhere in the archipelago. Land mammals other than bats are few; of the ten or so known only about four are certainly native. The marsupials are represented by a flying opossum and three kinds of cuscus. The civet cat, a deer and small shrews are found, but have

probably been introduced from elsewhere. There are wild pigs and the babirusa, the curious pig-deer of Celebes is found on Boeroe. The crested baboon, which also has its headquarters on Celebes, is known from Batjan, Boeroe and Soela. Among the birds there are many kinds of brightly coloured parrots and pigeons; there is one species of bird of paradise and brush turkeys are very abundant. The cassowary lives on Ceram. By the lakes on Ternate two very fine species of lizard are numerous. The Aroe islands have a fauna very like that of New Guinea, including the kangaroo, brush turkeys and various kinds of birds of paradise.

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Chapter IX

DUTCH NEW GUINEA

Introduction: Physical Features: Coasts: Adjacent Islands: Plant and Animal Life: Bibliographical Note

INTRODUCTION

Dutch New Guinea lies between the equator and 9° S lat. and between 131° and 141° E long. It includes almost half of the entire island of New Guinea. The area is 412,800 sq. km. (160,000 sq. miles) or more than twice that of Celebes and three times that of Java. It is nearly 1,100 km. (680 miles) in length from west to east and has a maximum width of about 650 km. (400 miles). The meridian of 141° E long. forms the boundary between Dutch New Guinea and the British mandated territories in the east, except for one short section where the boundary follows the course of the Fly river. In the south and west the shores of the country are bordered by the Arafoera (Arafura), Banda and Aroe Seas and in the north by the Pacific Ocean.

Among the land areas of the world Dutch New Guinea is one of the least known. Large areas still remain unexplored and practically the whole territory is undeveloped, except for the extreme western coastal districts around Sorong and parts of the northern coast near Manokwari and Hollandia. The population is estimated at about 300,000 or well under one person per square kilometre. Much of the country is uninhabited. Merauke, Kaimana, Fakfak, Sorong, Manokwari and Hollandia, all of which are on the coast, are the only important settlements.

PHYSICAL FEATURES

Dutch New Guinea is too imperfectly known for any detailed account to be given of its relief, geology and structural history. Many parts are entirely unknown and only in districts where the presence of oil has been suspected, such as the Vogelkop, are there large-scale maps available. A generalized view of the physical features will be given

on the basis of five physiographic regions into which the country may be divided:

(1) The southern lowlands.
(2) The central cordillera.
(3) The inter-montane trough.
(4) The northern mountains.
(5) The northern lowlands.

In general terms, Dutch New Guinea consists of a broad central area terminating in the west in two peninsulas, the Bomberai and the Vogelkop or 'Bird's Head'. The most striking physical feature is the high mountain range or cordillera which runs the entire length of New Guinea from the Vogelkop in the north-west to the Owen Stanley range in eastern Papua and is continued further east by the islands forming the Louisiade archipelago. In Dutch New Guinea the ranges of this cordillera trend east–west in the Tamrau and Arfak mountains of the Vogelkop, swing north–south through the narrow Bintini isthmus between McCluer gulf and Geelvink bay and then turn east again in the Charles Louis, Nassau and Orange mountains. South of the central part of the cordillera is a vast swampy lowland drained by the Fly, Digoel, Eilanden and other rivers; a low plateau zone between the mouths of the Digoel and Fly rivers forms the only break in the great expanses of marshy plain. A similar type of marshy lowland borders the shores of McCluer gulf in the Vogelkop and Bomberai peninsulas. North of the mountain backbone from Geelvink bay in Dutch territory to Huon bay in the east there is a low-lying zone occupied by the Rauffaer and Idenburg (headstreams of the Mamberamo river) and by the Sepik and Ramu rivers. This lowland zone is in turn bounded on the north by an almost continuous line of hills, including the Van Rees, Gauttier, Bewani, Torricelli and Finisterre ranges, through gaps in which the rivers of the inter-montane plains reach the sea. The northern coastal plain is narrow except near the mouths of the Mamberamo and Sepik rivers.

Relief (Fig. 112)

The southern lowlands

The southern lowlands of New Guinea, which stretch from the Vogelkop through the Bomberai peninsula to the plains around Merauke and Port Moresby, are a slowly sinking area. Subsidence is less active in the central part which faces the shallow flooded shelf of the stable Sahoel or Australian shield, than in the western and

eastern parts fronting great oceanic depths. The eastern part of Dutch New Guinea is made up of the great delta plains of the Digoel and Eilanden rivers, and these plains, with that of the Fly river farther east, form one of the most extensive areas of marshland in the world.

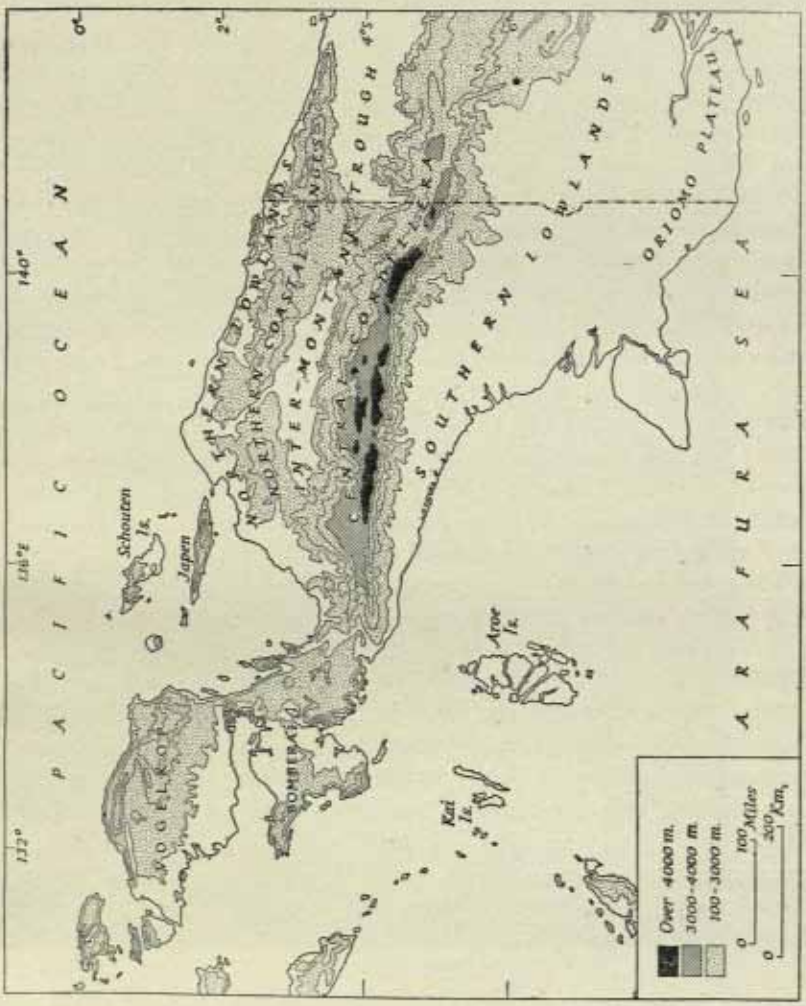

Fig. 112. New Guinea: Relief
The 100, 1,000, 2,000, 3,000 and 4,000 m. contours are shown.
Based on *Atlas van Tropisch Nederland*, plate 296 (Batavia, 1938).

Mangroves cover most parts of the plain near to the coast. The rivers have their source in the mountain ranges of the central cordillera; the softness of the rocks over which the rivers flow, the steep longitudinal profile and the exceedingly high rainfall combine to give a heavy run-off. The material carried from the hills is deposited at

the mouths of the rivers so that their deltas are rapidly being built out over the subsiding continental shelf which underlies the shallow Arafoera Sea. Frederik Hendrik island, south of the Digoel river, is separated from the mainland only by a narrow tortuous channel.

Although the plains of the Eilanden, Digoel and Fly rivers have in general a uniformly flat surface the levelness of the relief is broken by the low Oriomo plateau which runs for 500 km. (300 miles) between the mouth of Digoel river and the Daru district in British New Guinea. This plateau, formed mainly of limestone of Miocene and Pliocene age, seldom reaches more than 50 m. (150 ft.) in elevation; it is covered with open grassland, eucalyptus scrub and *Pandanus* providing a marked contrast with the forest vegetation in the plains to the north. Solution hollows are commonly seen on the limestone surface and the fertile soil at the bottom of these depressions is frequently utilized by the natives for their gardens. The plateau has had an important influence upon the course of the rivers, for it has caused the outward diverting of the Digoel and Fly rivers which are separated by only 32 km. (20 miles) in their middle reaches but by nearly 650 km. (400 miles) at their mouths. Structurally, the Oriomo plateau is closely related to the Aroe group of islands and to the Bomberai peninsula all three forming part of a stable continental shelf extending also into northern Australia (Fig. 8).

The western part of the southern lowlands has a more varied relief than the eastern part, but the same structural divisions are observed. The low, marshy plains around the shores of McCluer gulf, the Bomberai isthmus and the Vogelkop are slowly subsiding and are closely comparable with the extensive marshlands of the Eilanden, Digoel and Fly rivers. The Fakfak littoral is also a subsiding zone, but the coastline here is deeply indented, with many rocky headlands and sheltered inlets resembling in this respect the Port Moresby district in British territory. The coast near Fakfak is backed by a limestone plateau some 1,000 m. (3,000 ft.) in elevation; its structural affinities with the Oriomo plateau and the Australian shield have already been described.

The central cordillera

The central mountain range of New Guinea extends in a general north-west to south-east direction from one end of the island to the other. It consists of a number of crescentic arcs, the two main arcs which lie in the central part of the cordillera curving northwards and

Plate 101. Mouth of the Aika river in the southern part of Dutch New Guinea
Dense forest and swampland covers a large part of the southern coastal plain of Dutch New Guinea. The clearing at the mouth of the Aika river formed the site of the base camp for the expedition which climbed Carstensz-toppen (5,000 m.) in 1936.

Plate 102. Snow field on Carstensz-toppen

The snow-line on this and other mountains of the central cordillera is about 4,400 m. (14,500 ft.).

with structural troughs on their north side. The first of these northward curving arcs is almost entirely in Dutch territory and comprises the Nassau (formerly known as the Snow Mountains) and the Orange ranges, many summits of which attain a height of over 4,600 m. (15,000 ft.) above sea-level. The snowline in the Nassau range is approximately at 4,400 m. (14,500 ft.) and glaciers are formed on Idenburg-toppen (4,800 m.—15,750 ft.) and Carstensz-toppen (5,000 m.—16,400 ft.). (Plate 97). In the south these ranges present a precipitous face to the lowlands, and the zone of foothills, so prominent further east, is largely absent; in the north they overlook the crescentic-shaped basin of the Rauffaer, Idenburg and Soberger valleys. The second main crescentic arc comprises the Victor Emmanuel, Bismarck and Owen Stanley ranges of British New Guinea, fronting in the north the great lowland trough of the Sepik, Ramu and Markham valleys and in the south the plains of the Fly river and Port Moresby districts. The Sepik, Soberger and Strickland rivers have their source in the high col at the meeting place of these two main mountain arcs. The width of the cordillera varies greatly, for at this col it is only 56 km. (35 miles) across, while eastwards and westwards from here it broadens to over 240 km. (150 miles).

In the western part of Dutch New Guinea the central cordillera first turns sharply to the north through the Arfak mountains of the Vogelkop and then westwards, terminating in the Tamrau mountains. The Arfak mountains run in parallel ranges about 80 km. (50 miles) inland, except near Tanaroebo where high spurs abut closely on to the sea. They are volcanic in origin and G. Gerrisini, the highest summit (*c.* 2,700 m.) is said to be active. In the eastern part of these mountains there are two small lakes, Anggi Giji and Anggi Gita (Fig. 113), which were most probably formed when the Wajori and Ransiki valleys, between which they lie, were subjected to intensive folding or trough faulting. The Tamrau mountains in the extreme north of the Vogelkop have a rugged relief and reach to between 2,400 and 2,750 m. above sea-level; it is here that much of the oil prospecting in Dutch New Guinea has taken place and in 1936 a comprehensive aerial survey was made of the region. Complex limestone ranges are found south of the Tamrau mountains; in this region is lake Amaroe which lies at an elevation of about 300 m. (1,000 ft.) and is 8 km. (5 miles) long by 5 km. (3 miles) broad.

The mountain arcs which form the central cordillera have a complex structure. That they have been raised to their present level in geologically recent times is evident from the fact that the summit

of Carstensz-toppen is capped by marine sediments of Neogene (Miocene and Pliocene) age. Palæozoic sandstones and slates constitute the basic rock structure upon which much younger rocks have been laid. The folding and subsequent epeirogenic uplift of these ranges took place in Tertiary times contemporaneously with the

Fig. 113. Lake Anggi-Gita, Arfak mountains (drawn from a photograph).

Alpine–Himalayan upheaval. In a general way the structural relationship of the New Guinea cordillera to the lowlands of the south and to the Australian shield may be compared with that of the Himalayas to the Indo-Gangetic plain and to the Deccan in India. In the Nassau range the direction of the thrust is to the north, for the strata dip in this direction over long distances. The peaks and ridges in the highest parts of the cordillera have a more or less uniform summit level and the present relief may have resulted from the dissection of an older erosion surface. In the marginal regions of lower elevation much recent erosion on an intensive scale has taken place, leading to the formation of narrow steep-sided valleys, such as the upper courses of the Otakwa and Mimika rivers.

Dense and impenetrable rain forest clothes the slopes of the mountain ranges up to at least 3,000 m. (10,000 ft.). The forest was at one time believed to extend without interruption over all the lower slopes, but recent exploration in the Baliem valley, which is drained by a tributary of the Idenburg, has shown that a large area here has been cleared by the native population and is now under grass. Aerial surveys and further land exploration will no doubt bring to light similar clearances of the forest cover elsewhere (Plate 99).

The inter-montane trough

The great structural trough between the main cordillera and the northern ranges runs for several hundreds of miles from Geelvink bay to Huon bay. It has structural affinities with the central valleys of California and Chile. In late Tertiary times the region was a slowly subsiding marine trough and, though raised above sea-level by the Pleistocene folding, it is probably still a sinking zone. The Meer Vlakte (lake plain) in Dutch New Guinea, and the Sepik–Ramu valley in British territory form the main part of the inter-montane trough. Both are flat plains under 60 m. (200 ft.) above sea level. The Meer Vlakte is occupied by the Idenburg and Rauffaer rivers which unite to form the Mamberamo river. It is a low swampy region crescentic in plan and mountain locked; the Mamberamo, which drains the plain, cuts a gorge through the Van Rees range to reach the northern coastal plain. Geelvink bay is a drowned region continuing the line of the Meer Vlakte to the west.

The valleys of the Soberger and upper Idenburg and of the Gogol in British New Guinea are structurally related partly to the central inter-montane trough and partly to the northern ranges. The upper Idenburg has a level valley floor about 100 km. (70 miles) long from north to south and about 16 km. wide. It is bounded by the Bewani mountains on the north and is separated from the Meer Vlakte by a transverse range.

The northern mountains

The northern ranges of New Guinea run parallel to and about 160 km. (100 miles) north of the main cordillera from which they are separated by the central inter-montane trough. In Dutch territory the chief ranges are the Van Rees, Gauttier, Foya, Karamor, and Bonggo mountains; between the Dutch frontier and the Sepik river are the Bewani, Torricelli and Prince Alexander mountains. The height of the mountains is in general between 1,000 m. (3,000 ft.) and 1,500 m. (5,000 ft.), but in the Karamor range some summits reach nearly 2,200 m. (7,000 ft.). The Cyclops and Bougainville mountains and the Efar-Sidoas mountains which lie close to the coast, are probably structurally related to the northern chain.

Each of the northern ranges has a complex structure. They are formed of ancient crystalline rocks, including diorites, andesites and gabbro, covered in the main by Tertiary sediments. The ranges are probably still in process of uplift.

The northern lowlands

The northern lowlands are a region of active elevation in contrast to the slowly sinking lowlands along the south coast of the island. The rising of the land relative to the sea is reflected in the gradient of the river beds which is usually very steep near the mouths, making navigation upstream difficult and sometimes impossible even to light canoes. Other evidence of recent uplift is the raised coral terraces which are sometimes between 60 and 90 m. above sea-level, though in some parts they are found as high as 450 m. (1,500 ft.). In the neighbourhood of Humboldt bay these terraces extend 50 km. (30 miles) inland almost to the foot of the Bewani mountains. When these terraces were formed the Cyclops and Bougainville mountains were islands, Sentani lake on their landward side being the relic of a former sea strait. Between the Cyclops and Bougainville mountains and the Mamberamo delta the coastal plain is about 16 km. (10 miles) wide with a few tabular masses of coral forming prominent features.

The uplifted northern coastal region extends round the shores of Geelvink bay to the Vogelkop. The plains are broad where the Wapongga river enters the sea, but are only a narrow strip in the Bintini isthmus and the Vogelkop. The rivers flowing from the Arfak mountains have built up deltas, while raised coral reefs are seen near Manokwari, Befor, Warmandi and other places.

River System (Fig. 114)

The main watershed of the island follows the summit line of the main cordillera from which many rivers flow southwards to the Arafura and Ceram Seas and northwards to the Pacific Ocean. Subsidiary watersheds are formed by the Oriomo and Bomberai plateaux and by the northern mountain ranges. The rivers vary greatly in length and character. In the broad eastern part of Dutch New Guinea certain of the rivers such as the Mamberamo, Eilanden and Digoel are about 500 km. (300 miles) in length; on the other hand, those flowing from the northern ranges and from the Bomberai plateau are short, sometimes less than 160 km. (100 miles) from their source to the sea. The character of the rivers is equally variable. Some, such as the Eilanden and Digoel, have exceedingly steep longitudinal profiles in their upper courses and flow as torrents, but on reaching the plains meander slowly for long distances and build up large deltaic areas. Other rivers, like those which enter Triton and Etna bays, have narrow

mouths unencumbered by the deposition of alluvium, though many have shifting sand-bars which hinder navigation.

Along the south coast the chief rivers which rise in the central mountain range are the Digoel, the Eilanden, the Lorentz and the

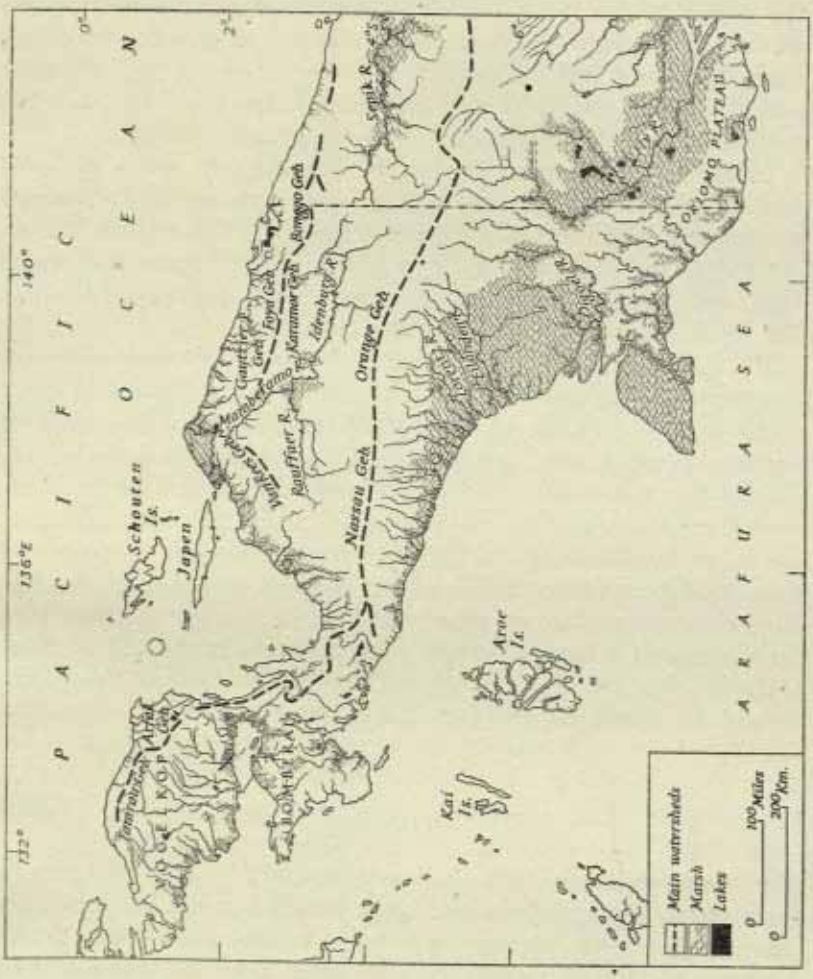

Fig. 114. New Guinea: Drainage pattern
Based on *Atlas van Tropisch Nederland*, plate 296 (Batavia, 1938).

Otakwa. The largest of these, the Digoel, probably has its source on Juliana-top, in the eastern part of the Orange range. Its basin covers nearly 20,700 sq. km. (8,000 sq. miles); in its lower course it flows through flat swampy land and it enters the sea by a mouth 10 km. (6 miles) wide. Vessels of 2 m. (6 ft.) draught can ascend this river

for nearly 650 km. (400 miles). The other rivers in this stretch of coast can be navigated by light craft for a considerable distance above their mouths. Little is known about their upper courses; frequently the only evidence of the source of a particular river is provided by the colour of the water, which is greyish-white when fed by the glaciers of the main cordillera, but muddy brown or yellowish brown when the source is in the foothills or in the jungle. In the high-water period many of the rivers, especially the Otakwa and Mimika, break their banks and flood large areas of the surrounding country.

In the Bomberai peninsula and the Vogelkop the rivers are short and of little use for navigation. The most important of the streams flowing into McCluer gulf are the Bomberai, the Kasoeri, the Wasian, the Sebjar and the Kamarin. The Ransiki, which drains lake Anggi Gita, and the Wajori, draining lake Anggi Giji, are the chief rivers in the Arfak mountains of the Vogelkop.

On the north coast the rivers are all short, with the important exception of the Mamberamo which has a basin estimated to cover 60,000 sq. km. (23,000 sq. miles) and which drains the whole of northern New Guinea from Leonard Darwin-gebergte in the west to Juliana-top in the east. In the low-lying Meer Vlakte between the central cordillera and the northern ranges it has two main branches, known as the Idenburg and Rauffaer rivers. Below the confluence of these branches, where the Mamberamo cuts a way through the Van Rees mountains, there are many rapids in its course. The river then flows through a marshy deltaic plain and enters the sea at Kaap d'Urville. Vessels of 2·4 m. (8 ft.) draught can ascend the Mamberamo for nearly 160 km. (100 miles) above its mouth.

COASTS

The coasts of Dutch New Guinea are marked by great diversity in form and in physical character. Large stretches in the south-east are low and featureless, backed by a broad coastal plain, while in the Kaimana and Fakfak regions there are rocky capes and long sheltered inlets with a mountainous hinterland. Reefs are commonly seen off the western and northern shores, but are generally absent elsewhere. In the peninsulas of the Bomberai and Vogelkop there are many natural harbours with sheltered anchorages and good holding ground. (Fig. 115).

For purposes of description it is convenient to divide the coastline

into six sections each of which has certain common physical characteristics. The first section extends from the Bensbach river on the boundary with British territory near Merauke to Tg. Nariki; the second includes the indented shoreline between this cape and Tg.

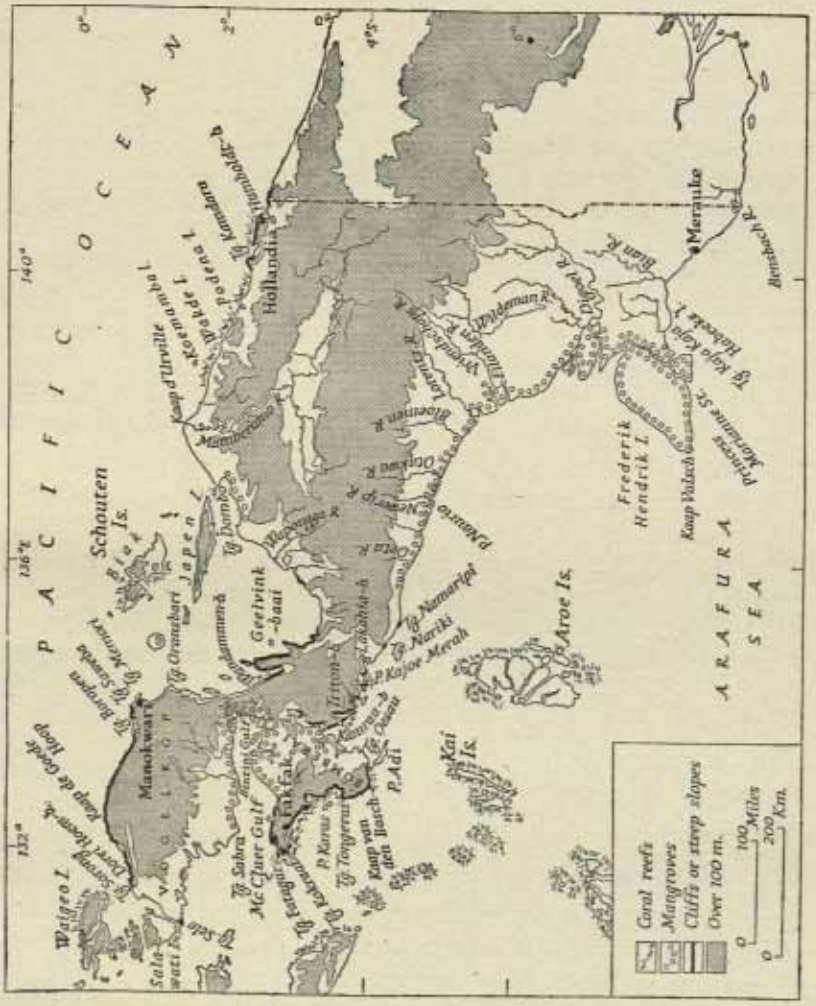

Fig. 115. New Guinea: Coastal features
Based on a map in *De Zeeën van Nederlandsch Oost-Indië* (Leiden, 1922).

Fatagar; then follows the low-lying section of coast in the north of the Bomberai peninsula and in the south of the Vogelkop to the Sele strait at the extreme westerly tip of New Guinea. The northern coast of the Vogelkop from Tg. Sorong to Tg. Saweba is the fourth section,

while the fifth is formed by the coast of Geelvink bay. The sixth and last coastal section lies between Geelvink bay and the frontier with British territory, a short distance to the east of Humboldt bay.

Bensbach river to Tg. Nariki

Between the mouth of the Bensbach river, at the southern point of the boundary with British New Guinea, and Tg. Nariki, a distance of over 1,100 km. (700 miles) in a direct line to the north-west, the coast is uniformly flat and largely covered with a dense growth of mangroves and trees. The mouths of the many rivers and an occasional low sandy ridge provide the only break in the monotonous appearance of the landscape (Plate 96). Few anchorages exist and along a large part of this coast it is difficult, often impossible to approach the land from the sea, owing to the shallowness of the offshore banks and to the inadequacy of the charts available.

The stretch of coast from the Bensbach river to Frederik Hendrik island has the shape of a broad bight or bay into which drain a number of small streams. Most of these streams rise in the Oriomo plateau (see p. 302). Mangrove swamps are found along the banks of the Bensbach river, but the aspect changes near Merauke, where there is a sandy beach overgrown with coconut trees. An anchorage is available near the entrance to the Merauke river in a depth of about 7·3 m. (4 fm.). This river can be ascended by a vessel drawing 3·2 m. (10½ ft.) for a distance of about 90 km. (60 miles) and by boat for 240 km. (150 miles). Another ridge of low sand dunes, rising behind a broad beach covered with coconut trees, is seen between Merauke and Tg. Kaja Kaja. A short distance south-east of this cape is the small island of Habeeke, off which there is a good anchorage in a depth of 5·9 m. (3¼ fm.). The rivers Bian and Boelaka which enter the sea in this region are, like the Merauke, navigable for short distances by vessels of light draught, but mud flats at their mouths and shoals offshore make the passage hazardous. West of the Boelaka river is the Princess Marianne strait which separates Frederik Hendrik island from the mainland; large praus can sail through this channel, but it is seldom used by steamers. Frederik Hendrik island, an expanse of featureless marshes covered with dense forest, is 160 km. (100 miles) long from north-east to south-west and 80 km. (50 miles) across at its greatest width. Kaap Valsch forms the south-western extremity of the island, off which there is very shallow water for many miles out to sea and vessels face the danger of running aground before sighting land.

The coastline between Frederik Hendrik island and Tg. Nariki is even more monotonous in appearance than the preceding section for, though the rivers are longer and have broader mouths, sandy beaches, a feature of the Merauke district, are almost absent. Dense forests and mangrove swamps fringe the shore and extend inland almost to the foot of the high central mountain range. The seaward approach to the coast is a difficult undertaking and is in places wholly impracticable. The most southerly of the large rivers entering the sea in this region is the Digoel which has a mouth about 10 km. wide and may be ascended for some distance upstream by vessels of 3·7 m. (12 ft.) draught. Farther north, there are the three mouths of the Odammoen river and the two mouths of the Eilanden river. The latter has deep water in the lower part of its course and, with a favourable tide, is navigable for about 160 km. (100 miles) upstream by vessels drawing 3·7 m. (12 ft.). The tributaries, Vriendschaps and Wildeman, are also navigable by vessels of this draught. Beyond the mouth of the Eilanden river the shoreline curves sharply to the north-west and the coastal plain narrows perceptibly. Although the snow-capped Nassau range is less than 160 km. (100 miles) from the coast it is frequently obscured by cloud. A large number of streams, such as the Lorentz, Bloemen, Otakwa, Newerip and Mimika flow into the sea from this range, but none is comparable in length to the Eilanden or the Digoel. A steamer, with 3·6 m. (11½ ft.) draught can ascend the Lorentz river to just below its confluence with the Dumas, a left bank tributary. Lighter craft may proceed farther upstream as far as about lat. 4° 40′ s, from which point the Lorentz expedition of 1909 climbed to the summit of Wilhelmina-top. The other rivers are shorter and less suitable for navigation, though all are connected by tortuous waterways, by which a boat drawing about 1·5 m. (5 ft.) and with a length of 24·4 m. (80 ft.) can sail between the Otakwa and the Eilanden rivers, a distance of about 270 miles. West of the mouth of the Newerip river is the island of Poelau Naurio off which there is an anchorage in a depth of 9·1 m. (5 fm.). Other anchorages are available in a depth of 11 m. (6 fm.) at the entrance to the Mimika river and in 11 to 15 m. (6 to 8 fm.) between the Oeta and Bokemau rivers. Near the steep headland of Tg. Namaripi the coastal plain is less than 30 km. (20 miles) wide and at Tg. Nariki a little farther to the north-west a high spur of the Charles Louis mountains abuts on to the coast.

Tg. Nariki to Tg. Fatagar

The coastline in this section is deeply indented and backed by

densely wooded hilly country, with the exception of the stretch along the southern shores of the Bomberai peninsula from Kamrau bay to Tg. Oesau. Many sheltered bays and inlets provide a number of secure anchorages.

For about 160 km. (100 miles) north-west of Tg. Nariki deep-water bays and high rocky headlands are a feature of the coast. Lakahia bay, known as Etna bay in its inner reaches, is 15 km. (8½ miles) wide at the entrance and extends inland for many miles. Anchorage with good holding ground may be obtained anywhere in this bay. Farther along the coast are the bays of Kajoe Merah, Triton, Bitsjaroe, Kaimana and Kamrau, all of which provide anchorages. Kajoe Merah island, which lies at the entrance to the bay of the same name, rises to over 550 m. (1,800 ft.); its shores are fringed by a reef. Other large islands offshore are Aidoena and Namtotte, both of which are high and mountainous. Kamrau bay, continued northwards as Argoeni bay, is the only inlet in this region not entirely surrounded by mountains; in the north and west it is bounded by the low marshy plains of the Bomberai peninsula.

The shores of the Bomberai peninsula turn sharply to the south-west from the mouth of Kamrau bay and continue in this direction as far as Tg. Oesau. In general character they resemble the shores of south-eastern New Guinea, for the landscape is monotonously flat and covered with mangrove swamps and dense forests. Vessels may anchor in the stretch of water between Kamrau bay and the Karoefa river, as well as in the Nautilus strait which separates Poelau Adi from the mainland at Tg. Oesau.

Mountains again fringe the shore in the section of coast from Tg. Oesau to Tg. Fatagar. Near Kaap van den Bosch, where the coast turns northwards, there are high and rocky cliffs which continue with scarcely a break to the prominent cape of Tg. Tongerai. Forested hills rise inland from this cape to a height of over 900 m. (3,000 ft.) and overlook the southern shores of the large Sebakor bay. Reefs lie close offshore around the bay and around the group of islands at its entrance. An anchorage is available in 49·4 to 69·5 m. (27 to 38 fm.) off the south-eastern shores of Karas, the largest of these islands. North-west of Sebakor bay, in the rocky stretch of coast to Tg. Fatagar, offshore reefs continue to be a prominent feature; their position is usually clearly marked by discolouration of the water. Fakfak, the chief settlement of this part of New Guinea, has a pier for small craft; larger vessels can anchor off the coastal reef in a depth of 45·7 m. (25 fm.). (Plate 98). The Onin peninsula, on which Fakfak

Plate 103. Fak Fak, Dutch New Guinea
Fak Fak, on the southern side of the Onin peninsula, is the chief settlement and trading centre of western New Guinea.

Plate 104. Aerial view of settlements and cultivated land in the Baliem valley of Dutch New Guinea
The Baliem valley, which is drained by a tributary of the Idenburg river, lies to the north of the main chain of the central cordillera. Until the discovery of this valley a few years ago, the whole of the mountainous region was thought to be densely forested and almost uninhabited. In the Baliem valley, the ground has been cleared and a considerable native population carries on a primitive form of agriculture.

Plate 105. The ash-cone of Goenoeng Batok, Tengger Highlands (Java)
A good example of gulley-erosion of loose material (volcanic ash), unchecked by a cover of vegetation. See also Plate 8.

Plate 106. Mangrove forest at low tide
The dominant tree is *Bruguiera* (see Fig. 132).

lies, has a rugged coastline; Tg. Kokraaf, Tg. Tegin and Tg. Fatagar are all conspicuous headlands fringed by reefs. The Pisang islands, which rise steeply from the sea a short distance off Tg. Fatagar, provide sheltered anchorages at all times of the year.

Tg. Fatagar to Tg. Sorong

This stretch of coast, which comprises mainly the northern shores of the Bomberai peninsula and the southern shores of the Vogelkop, resembles in many respects that part of the coast of New Guinea south-east of Tg. Nariki. Apart from the short section from Tg. Fatagar to Sekar bay, there is the same monotonously low relief and the same dense covering of mangroves and of tropical forest. The area of marshland is, however, much smaller and none of the rivers is as long as the Eilanden or the Digoel. Few good anchorages are available.

From Tg. Fatagar to the sheltered bays of Patipi and Sekar, the southern shores of McCluer gulf are high and thickly wooded, but the aspect changes east of the Bomberai river. Here, the coast is low and overgrown with mangroves and for over 50 miles the only conspicuous feature is the headland of Tg. Tanah Merah. This headland marks the entrance to the Bintini gulf which is the inner section of the broader McCluer gulf and into which flow several short streams from the range of hills at its head. These hills, rising to about 750 m. (2,500 ft.) above sea-level, form the backbone of the Bintini isthmus, a narrow neck of land joining the Vogelkop to the rest of New Guinea. The northern shores of the Bintini and McCluer gulfs are low and marshy; certain of the rivers, such as the Wasian, Kamarin, Kemoedan and Sebjar, can be entered, though they have bars at their mouths and the approach from the sea is difficult. Tg. Sabra, marking the northern entrance to McCluer gulf, has a sandy beach with a grove of casuarina trees growing on it. It is the only break for many miles in the vast expanse of low marshland.

Between Tg. Sabra, where the coast of the Vogelkop turns to the north-west, and Tg. Sorong many short rivers enter the sea, but none is easily navigable and shifting sandbanks make approach to the shore hazardous. Offshore reefs, which are so common a feature of the coast near Fakfak, again appear in the Sele strait, the narrow stretch of water separating the low-lying forest-covered Salawati island from the mainland. The southern entrance to this strait is marked by Tg. Sele, a rocky bluff about 30 ft. high, near which there is an anchorage in

depths of 11–16·5 m. (6–9 fm.). Another anchorage is available off Tg. Sorong in 20·1–25·6 m. (11–14 fm.). About 50 km. (30 miles) offshore is the large island of Waigeo (see p. 318).

Tg. Sorong to Tg. Saweba

Almost the whole of the northern coast of the Vogelkop between Tg. Sorong and Tg. Saweba is steep and backed by high mountains with the deep waters of the Pacific Ocean offshore. There are few large indentations and the coast is in general much exposed to the influence of the monsoons.

In the stretch of coast from Tg. Sorong to the Kaap de Goede Hoop (Cape of Good Hope) a distance of 130 km. (80 miles), reefs border the shores for long distances, but within the reefs a number of good anchorages are available. Dore Hoem bay provides a sheltered anchorage in a depth of about 27 m. (15 fm.); farther to the north-west there are other anchorages off the village of Mega and near the low-lying Mios Soe islands. East of these islands the Kaap de Goede Hoop, the northernmost point of New Guinea, rises gently from the sea with the ranges of the Tamrau mountains inland.

Eastwards from the Kaap de Goede Hoop the Tamrau mountains continue to provide prominent landmarks; spurs from them reach the sea in a number of headlands. Vessels can find anchorages at several places along this coast, though all suffer from exposure. Near Tg. Boropan the coastal plain broadens and the rivers flowing across it have their sources in the Arfak mountains. The coast is again high and steep east of Tg. Boropan all the way to Tg. Saweba, the northern entrance to the large Geelvink bay.

Geelvink Bay

The broad and deep Geelvink bay lies between Tg. Saweba in the west and Tg. Dombo in the east. It is fronted by the large island groups of Japen and Schouten (see p. 318) which protect it from the heavy seas of the Pacific Ocean. The western shores are flanked by densely wooded mountains, while the eastern shores are generally low and marshy. The water of the bay is discoloured for some distance offshore by river sediment.

About 20 miles south-east of Tg. Saweba is Tg. Memori in the shelter of which lies the important settlement of Manokwari (Fig. 116). This small town has a pier with a depth of 10 m. (5½ fm.) alongside. Sheltered anchorages in depths of about 11 m. (6 fm.) are

found offshore. Between Manokwari and Tg. Oransbari, over 80 km. (50 miles) to the south, the coast is bordered by the Arfak mountains, which rise to heights of 2,800 m. (9,000 ft.) a short distance from the sea. Other mountain ranges run near to the coasts of the Bintini isthmus. Offshore in this part of the bay there are a number of rocky islands fringed by shoals and reefs. Roemberpon and Mios Waar are the largest of these islands; mangroves appear in certain places along their shores. The irregularly-shaped island of Roön lies off the

Fig. 116. Manokwari harbour (drawn from a photograph)

northern extremity of a narrow mountainous peninsula enclosing the deep inlet known as Wandamen bay. This bay provides sheltered and secure anchorages in depths of from 55–61 m. (30–33 fm.). In the remaining stretch of coast to the head of Geelvink bay the shoreline is irregular with several small inlets and two conspicuous headlands, Tg. Manggoear and Tg. Maniboeroe. A chain of islands, reefs and banks runs parallel to the shore about 20 km. (12 miles) out to sea.

At the head of Geelvink bay, where the coast turns to the north-east, the shores are low-lying and continue so as far as Noesi island and the Haarlem island group. Several reefs lie offshore near these islands and also near the Moör island group, opposite which the coast is again low and cut by the mouths of the Siriwo, Warenai and Wapongga rivers. The Wapongga, the largest of the three, has a width of about ½ km. (¼ mile) in its lower reaches; there is a depth of 2 m. (1 fm.) over the bar at its mouth and within the bar depths increase to 18 or 20 m. (10 or 11 fm.). All three rivers deposit considerable bodies of sediment into the sea. Anchorages are available

off their mouths in depths of 30 to 40 m. (16 to 22 fm.) and other anchorages are found in 40–50 m. (22–27 fm.) off Geelvinks Oosthoek (East Point) further to the north-east. All these anchorages are insecure during the period of the north-west monsoon. For about 80 km. (50 miles) north-east of Geelvinks Oosthoek to Tg. Dombo the coast is low-lying and overgrown with mangroves which are submerged at high-water. Tg. Dombo, opposite the large island of Japen, forms the north-eastern point of entry to Geelvink bay.

Geelvink Bay to Hoek Germania

The northern coast of Dutch New Guinea from Geelvink bay to the boundary with British territory is low and monotonous, with the exception of the stretch eastwards from Tg. Kamdara, where the Cyclops and Bougainville ranges fall sharply to the sea. A number of small streams rising in the northern coastal ranges, and one large one, the Mamberamo, which has its source in the central cordillera, enter the sea along this section of coast. There are several anchorages, but few are protected from the monsoons.

The triangular shaped delta of the Mamberamo river, with Kaap d'Urville at its northern tip, is the main feature of the coast immediately east of Geelvink bay. Vessels with a draught of 2·4 m. (8 ft.) can sail across the bar at the mouth of the Mamberamo to the limits of its delta over 80 km. (50 miles) upstream. Between Kaap d'Urville, where the coast turns to the south, and Tg. Kamdara, the shores are low and consist of broad sandy beaches. Reefs and heavy surf make approach from the sea difficult. The Koemamba, Wakde and Podena island groups lie offshore; the Wakde group provides good anchorages in depths of about 13 m. (7 fm.). Behind the coastal plain in this region rise low tabular hills with the Van Rees and Gauttier mountains farther inland.

Between Tg. Kamdara and the boundary the coastline is for the most part irregular with high and steep shores backed by forested mountains. There are many rocky capes sheltering bays with sandy beaches at their heads, though as in the previous section of coast, reefs and surf are a danger to shipping. Humboldt bay which lies between Tg. Djar (Bonpland point) and Tg. Soeadja is the only bay frequently used by large vessels; off the small town of Hollandia along its north-western shores there is an anchorage in depths of 40–43 m. (22–24 fm.). For a short distance east of Humboldt bay the coast is low, but near the boundary it is high, rocky and wooded; the

Hoek Germania is a spur of the Bougainville range which rises inland to over 610 m. (2,000 ft.) above sea-level.

ADJACENT ISLANDS

A short distance off the coasts of Dutch New Guinea and separated from the mainland by relatively shallow waters are a number of islands which vary greatly in size and relief. Certain of these islands, such as the low-lying Aroe group, form part of the Moluccas and are described in chap. VIII. In the following account the islands described are the group which lie off the western shores of the Vogelkop, including Misoöl, Salawati, Batanta and Waigeo; and the group at the entrance to Geelvink bay, including the Schouten islands and Japen, Mios Noem and Noemfor to the south.

Islands off the western shores of the Vogelkop

Misoöl, which lies south-west of the southern entrance to Sele strait and about 80 km. (50 miles) north of Ceram, is 80 km. long and 32 km. across. It is almost entirely surrounded by innumerable islets. The north of the island is flat, but in the south a range of hills reaching to about 460 m. (1,500 ft.) above sea-level, is a prominent feature. The coasts are generally rocky, except east of Lelintah, on the south-east where the shores are low and overgrown with mangroves. On the east coast there is a deep indentation known as Tamoelol bay, to the south of which is the narrow, rugged Kaunutklolo peninsula. The chief settlements on Misoöl are Lelintah and Waigama; off the latter village vessels can anchor in a depth of 18·3 m. (10 fm.).

Salawati island forms the western border of Sele strait and is for the most part low-lying, though in the north limestone hills rise to about 300 m. (1,000 ft.). Almost the whole island is covered with impenetrable jungle. The coasts are low and swampy. Sailolof, off which there is an anchorage in 11 m. (6 fm.), is the principal village.

Batanta is a mountainous island to the south of Dampier strait and separated from Salawati by Sagewin strait. It is 64 km. (40 miles) long with a width of 6 to 13 km. (4 to 8 miles). The mountains rise to over 1,100 m. (3,500 ft.) and are densely forested. The north and east coasts are irregular in outline with high mountain spurs enclosing deep-water bays and there are several good anchorages; in Marchesa bay safe anchorage is available in 37–48 m. (20–26 fm.). A reef, over which there is a least depth of 4·6 m. (2½ fm.) lies a short distance off the eastern extremity of Batanta.

Waigeo, on the northern side of Dampier strait, is a large island about 137 km. (85 miles) long with a greatest width of 45 km. (28 miles). It has rugged forested hills reaching about 1,100 m. (3,500 ft.) in height; in the north are crystalline rocks and in the south coralline limestone. Buffelhoorn-berg in the north is formed of volcanic rocks, and igneous rocks are also seen in Fofak bay. The coastline is irregular, Majalibit bay on the south extending inland to within 3 km. (2 miles) of the north coast, thus nearly dividing the island into two. Coral reefs fringe the bay. Tapokreng, west of the entrance to this bay, is the main settlement and there is an anchorage near here in a depth of about 29 m. (16 fm.). Fofak bay on the north coast provides another good anchorage.

Islands at the entrance to Geelvink bay

The Schouten Islands are the outermost of the group of islands that shelter Geelvink bay. They consist of two main islands, Soepiori and Biak, and a multitude of smaller islands. The interior of Soepiori is hilly and is composed mainly of young Tertiary rocks. The coast is steep except in Korido bay, a long narrow inlet in the south and the only inhabited part of the island. Anchorage may be obtained in this bay in a depth of 54·9 m. (30 fm.). The larger island of Biak is separated from Soepiori by the very narrow Sorendidori strait. The north-western part resembles Soepiori, but the south-east is an extensive tableland of raised coral with small patches of young Tertiary rocks as well as of gabbro and serpentine. The southern coastal districts are well populated and Bosnek, which lies in this part of the island, is the main trading centre for the whole island group. To the south-east of Biak are a number of small raised coral islands known as the Padeaido archipelago.

Japen, 145 km. (90 miles) long from east to west and from 16–24 km. (10–15 miles) wide, is the largest of the southern chain of islands that mark the entrance to Geelvink bay. A range of mountains, attaining about 1,200 m. (4,000 ft.) in height, runs almost the entire length of the island; it consists mainly of elevated coralline limestone. There are three mountain complexes and these give Japen the appearance of being three islands when seen from some distance out to sea. Owing to the porous nature of the limestone no streams are found above a level of 120 m. (400 ft.). The south coast is much indented, has many wooded islets and reefs offshore and affords good anchorages; the two chief settlements, Seroei and Ansoes, are on this side of the island.

Mios Noem and *Noemfor* are two small and unimportant islands to the north-west of Japen. Both have reefs and shoals close offshore. Mios Noem is uninhabited.

PLANT AND ANIMAL LIFE

There are few countries in the world with a richer or more interesting plant and animal life than New Guinea. Since so much of the country is entirely unexplored, it is not surprising that the fauna and flora are as yet very incompletely known.

In general it can be said that the plants and animals are a mixture of Asiatic and Australasian types. The plants, for instance, though predominantly the same or nearly related to those of Java, Borneo and the Malay peninsula, include many, particularly in the savannas of the dry belts and on the mountains, which are identical with or similar to those of Australia. New Guinea has thus been peopled with plants and animals migrating both from the east and the west; in addition it has many peculiar forms and these give a very marked character of their own to its fauna and flora, and to that of the immediately adjoining islands.

New Guinea is a land of virgin forests and by far the greater part of the lowlands, particularly in Dutch New Guinea, is covered by evergreen rain forests. The trees which, as in most rain forests, are a mixture of species with no single one predominant, have straight slender trunks and reach a height of 45–60 m. (150–200 ft.). Many of them produce valuable hardwood timbers, but the mixture of species is so great and the difficulties of timber extraction so formidable that large-scale exploitation has not yet been attempted. Besides trees the lowland rain forests contain a wealth of palms, lianes, orchids and ferns. Much of the low country is swampy and here the tall rain forest gives place to low-growing swamp forests and vast expanses covered with sago palms, screw pines (*Pandanus*) and reeds. In sheltered bays and estuaries, particularly on the south coast, there are hundreds of square miles of mangroves and nipah palms.

In the mountains the character of the forest soon begins to change. Conifers, particularly, species of *Araucaria* (the genus to which the monkey puzzle and the Norfolk Island pine belong) are abundant in many of the higher mountains, first appearing at about 1,000 m. (3,000 ft.). Between 1,500 and 2,500 m. (5,000 and 8,000 ft.) the tall forest changes into one of dwarf gnarled trees smothered in a thick blanket of moss; this 'mist' or 'mossy' forest, which is similar to

that found on mountains elsewhere in the archipelago, coincides with a zone of almost uninterrupted mist and drizzling rain. Higher still the climate becomes drier and more sunny and the forest again becomes taller. Eventually, at about 3,700 m. (12,000 ft.) there are no more trees and one emerges on to open grasslands and stony mountain slopes. The mountain tops between the upper limit of the trees and the perpetual snow are the home of brightly coloured rhododendrons, gentians and other plants related to those of the Himalayas and European Alps.

Some parts of New Guinea, lying in the rain-shadow of the mountains, have a dry climate and here instead of rain forest there are other types of vegetation, grassland and savanna forests. In these dry belts are found plants such as gum (*Eucalyptus*), casuarina and sandalwood trees which also grow in the similar climate of northern Australia and the Lesser Soenda islands.

Animal life in New Guinea, though not as rich as the plant life, is of very great interest. There are no monkeys and no large animals such as the tiger and rhinoceros; most of the mammals are like those of Australia. Thus besides a kind of wild pig and various kinds of bat, nearly all the mammals belong to the group of pouched animals or marsupials; to this group belong the kangaroos, the wallaby and the opossums. New Guinea also shares with Australia the spiny ant-eater (*Echidna*), which besides the duck-billed platypus of Queensland, is the only surviving representative of the Monotremes, the most primitive of living mammals. Birds of paradise, the most gorgeous of all known birds, have their headquarters in New Guinea and the adjacent islands (Aroe, Waigeo, etc.); some species extend further west into the Moluccas and some into northern Australia. As far back as the sixteenth century the skins of birds of paradise have been an article of commerce and the numbers of some of the choicer kinds have been much reduced in consequence. As well as numerous peculiar birds not found elsewhere, New Guinea has many which also occur in Australia, such as cassowaries and the brush-turkeys or mound-builders.

Though New Guinea is so largely covered with virgin forests, much the same now as they have been since an unknown period in the geological past, it would be a mistake to think the native population, sparse though it is, has made no impression on the luxuriance of nature. Over large areas the forest has been replaced by grassland owing to human activities. The forest is cleared in the first place to make room for cultivation, but the most potent factor in destroying

it has been fire. The natives are ardent huntsmen and when pursuing the wild pig, the wallaby or the kangaroo, they light fires to drive their game. Constantly recurring hunting fires are largely responsible for the spread of grassland and for preventing the re-invasion of trees. It is now believed that the large extent of grassland on the New Guinea mountains above 3,000 m. (10,000 ft.) is due, not to the inability of trees to grow at that height, but to the destruction of the forests by hunting fires. The real climatic tree limit is thus much higher than it appears to be, perhaps not lower than 4,200 m. (14,000 ft.).

Apart from a certain number of coconut plantations near the coast, there is little agriculture on modern lines in Dutch New Guinea. The natives, as in most parts of the tropics, practise shifting cultivation, making clearings in the forest and after a short time abandoning them. More forest is then cut down and so the area of virgin forest constantly diminishes. The native crops include yams, taro, sweet potatoes, sugar cane, tobacco and many kinds of fruit trees. The sago palm, which grows wild over large areas of swampy country, is the main source of food of many of the native tribes.

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Chapter X

CLIMATE

Introduction: Pressure and Winds: Temperature: Relative Humidity: Visibility: Precipitation: Bibliographical Note

Introduction

The Netherlands Indies extend from 6° N lat. to 11° S lat. Thus, if five degrees on either side of the equator are taken as including the 'equatorial zone', by far the greater part of the archipelago lies within it. Here a typical equatorial climate can be expected and, moreover, none of the islands presents a mass of land large enough to modify to any great extent the climate found along the equator in the great oceans, the characteristics of which are constant high temperature with little variation throughout the year, high humidity, and high rainfall. Within the limits of 5° N and 5° S lat. there is little evidence of a wet and dry season, but some evidence of a 'wet' and 'wetter' season with dry spells rarely lasting more than a fortnight. Beyond 5° N and 5° S seasonal changes begin to be apparent, and in Java the month of August marks the culmination of a season distinctly drier than the rest of the year.

Near the equator the climate is monotonous and near sea-level too warm to be pleasant, though the nights inland are generally cool enough to make a light blanket acceptable; but above 2,000 ft. the heat is tempered and the climate is delightful. Most of the work of the country has to be done in the lowlands, and the conditions are such that Europeans find a holiday in a cooler climate necessary every few years.

When rain falls it does so thoroughly. A long drizzle such as is so familiar in England, is rare. The rainfall is usually of short duration and often heavy enough to limit visibility to a few score yards. Although the annual rainfall is far heavier than in the plains of England, 90 inches a year being nothing excessive, it falls in such a short space of time that there is abundant health-giving sunshine and a welcome freedom from those dull leaden skies so familiar in Britain. Severe thunderstorms are a frequent accompaniment of the rain and make thunderstorms in temperate climates seem mild.

At the hill stations of Java, a chain of which are available along

the backbone of mountains which runs throughout the length of the island, the climate is as near perfection as can be. Morning and evening twilight are short in the tropical lowlands, though much

Fig. 117. Location of meteorological stations

The majority of the stations for which data are given in the text and tables are shown Based on *Atlas van Tropisch Nederland*, plate 2 (Batavia, 1938).

longer in the mountains, but there is ample time to enjoy rich colours on the clouds and the brilliant afterglow that sometimes follows sunset.

Pressure and Winds

The Netherlands Indies lie between the two monsoon centres of Asia and Australia; from December to March the air flows from Asia to Australia, and from May to September in almost exactly the opposite direction. During the change-over from one direction to the other, in April and early May and again in October and early November, the winds are light and variable and their direction is such that they closely approximate to the normal system of north-east and south-east Trades. In January and February, while the north to south air flow is at its height, the mean pressure and winds are as shown in Fig. 118. The pressure gradient is 4 mb. in the 1,500 miles between Malaya and Timor and winds are fairly steady and fresh. The direction is northerly, or north-easterly, to the north of the equator, and westerly, or north-westerly, to the south of the equator. As the wind direction in Java is westerly, the season is referred to there as the west monsoon and the name is frequently applied else-

where in the archipelago, even north of the equator where the wind has no westerly component.

In July and August, when the south to north flow is well established, the mean pressure and winds are as shown in Fig. 120. The

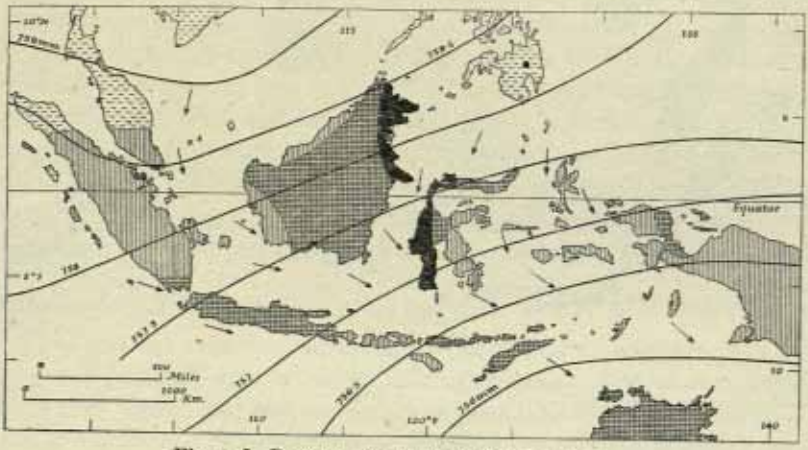

Fig. 118. Pressure, winds and rain. January
Source: A. Austin Miller, *Climatology*, p. 83, fig. 27 (London, 1931).

Fig. 119. Pressure, winds and rain. April
Source: A. Austin Miller, *Climatology*, p. 83, fig. 27 (London, 1931).

pressure difference is now 4 mb. in the opposite direction, and winds are south-easterly to the south of the equator, and southerly, or south-westerly to the north of the equator. This is the season of the so-called

'east monsoon', though the wind is nowhere due east. At the change-over season, the pressure gradient is very light and winds are feeble and variable (Figs. 119 and 121). The low pressure trough, towards which winds are directed when allowance has been made for deflection

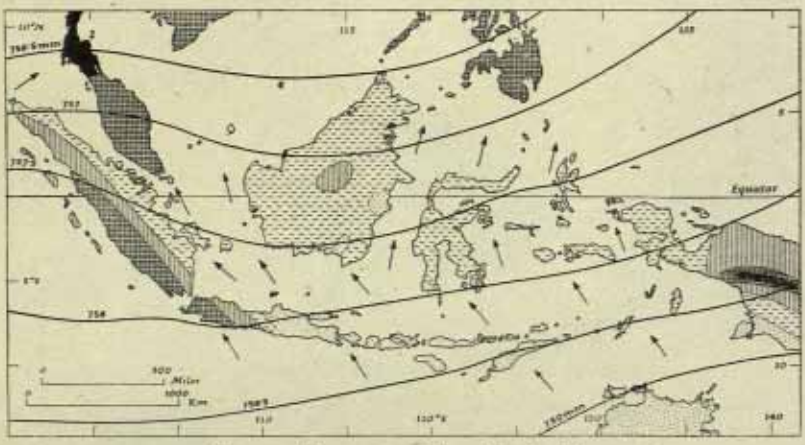

Fig. 120. Pressure, winds and rain. July
Source: A. Austin Miller, *Climatology*, p. 83, fig. 27 (London, 1931).

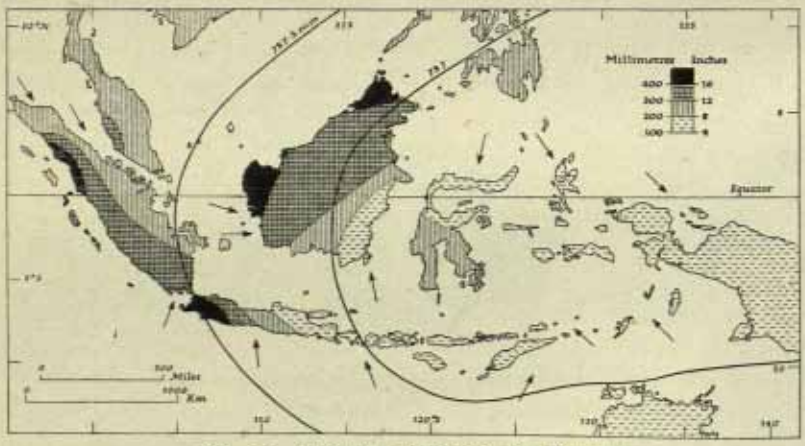

Fig. 121. Pressure, winds and rain. November
Source: A. Austin Miller, *Climatology*, p. 83, fig. 27 (London, 1931).

by the rotation of the earth, leaves Asia at the end of September and reaches Australia in early December, moving southwards across the islands through October and November. Thus the light convergent winds and associated 'doldrum' weather pass slowly southwards during these months, the change-over being established earlier in

the northern islands. During April and May it travels northwards again, the northward air-flow extending slowly to the north until by June it is established everywhere. The mean wind velocities in exposed stations (lighthouses) at the height of the monsoons are from 20 to 26 ft. per second (=force 4, Beaufort scale). The velocity and direction are maintained fairly constant over the open sea, but such is the complicated mingling of island and sea that both force and direction are considerably modified on land by land and sea breezes, mountain and valley winds and other effects, which are, in general, more powerful than the monsoons themselves, as can be seen from the tables of wind direction and wind force (see pp. 346–8). Where the monsoons are weak, as on the west and north-east coasts of Sumatra, land and sea breezes dominate the whole system.

Land and sea breezes, mountain and valley winds, and other local effects

Near the coast, land and sea breezes have a strong influence. The land wind usually sets in before midnight, near mountainous coasts soon after sunset, and lasts until about 9 a.m. The sea breeze generally sets in between 10 a.m. and noon. The land wind is only feebly felt in the plains, much of its force being lost by friction with the ground. In the mountains it is stronger, especially in valleys where its force is concentrated because the katabatic flow of cold heavy air keeps to low levels. The sea breeze effect is felt to a height of about 3,000 ft., that of the return current to a height of about 10,000 ft. Up-valley winds, which can be seen to carry the cumulus cloud to higher levels as the day warms up, set in rather earlier than land and sea breezes, usually about 9 a.m.; the down valley winds much earlier, about 6 p.m. during the east monsoon and as early as 3–4 p.m. during the west monsoon owing to the influence of the showers that originate on mountain slopes. Winds of a *Föhn* type occur on the lee side of mountains; the *Föhn* winds are hot and dry, and must not be confused with down-valley winds which are formed by cooling and are therefore, relatively cold. The most important 'Foehn' winds are (1) the *Bohorok* of Deli (Sumatra) occurring from May to September; (2) the *Padang Lawas* in the basin of the Panei river (Sumatra) from July to October, a west or north-west wind often blowing continuously night and day; (3) the *Koembang* in Cheribon and Tegal (north Java); (4) the *Gending* in the plains of Pasoeroean (east Java); (5) the *Broeboe* at Maros near Makassar (Celebes) during the east monsoon. These winds dry up the vegetation and do great harm to sensitive crops, such as tobacco.

Wind velocity; Gales

In general the wind velocities in the Netherlands Indies are not high and gales are rare. The high percentage of calms (25 to 40%) at Batavia and Christmas Island should be noted (Table 1). During the monsoons the mean wind velocity over the open sea is only force 4 (Beaufort scale) and the daily variation is small. On land it is less still (force 2) and the diurnal variation, due to land and sea breezes, is marked; on the plains and near the coast, the wind abates at night, often to a flat calm. In the mountains and valleys, however, the wind force is greater by night than by day owing to the mountain and valley winds. Typhoons occur to north and south, but the latitude of these islands is too low for their development. Timor, furthest from the equator, is occasionally visited, but even there the central area of the typhoon, with its destructive winds, is nearly always well away to the south. Some of the rare strong winds (*Barat* winds), approaching gale force, appear to be associated with remote cyclonic centres.

Maximum wind velocities averaged over a period of 1 hour at Batavia are as follows (feet per second):

1879–1918	J.	F.	M.	A.	M.	J.	J.	A.	S.	O.	N.	D.
Absolute max.	19	20	23	19	15	16	16	19	23	25	16	17
Mean daily max.	9	9	9	10	9	9	10	11	11	11	10	9

Source: C. Braak 'Het Klimaat van Nederlandsch-Indië' vol. 1, part 2, p. 37 (Batavia, 1923–5); *Verhandelingen Koninklijk Magnetisch en Meteorologisch Observatorium te Batavia*, No. 8.

Thus wind velocities exceeding 23 ft. per second (force 4) are not to be expected inland, but on the coast they are rather higher, as the following figures at Semerang show (feet per second):

1918–1921	J.	F.	M.	A.	M.	J.	J.	A.	S.	O.	N.	D.	Year
Absolute max.	36	46	39	27	28	29	30	31	33	32	29	35	46
Mean max.	21	24	20	17	19	20	19	23	24	22	21	19	21

Source: C. Braak, *op. cit.*, vol 1, part 2, p. 38.

Gale force is over 56 ft. per second and is scarcely ever reached.

Small isolated squalls occur with wind velocities reaching 66 ft. per second (force 8) for short periods, certain areas being especially susceptible, e.g. the Malacca straits where the storms are known as

Sumatras; they occur only at night. At Malacca the mean frequency of winds of gale force during the year 1914 was as follows:

J.	F.	M.	A.	M.	J.	J.	A.	S.	O.	N.	D.
0	0·4	0·2	0·2	0·6	3	2	2	1	3	0·6	0·6

Source: Meteorological Office, M.O. 404b *Weather in the China Seas*, vol. II, p. 57 (London, 1937).

The season of highest frequency of these squalls is given in Fig. 122.

Fig. 122. Months of maximum squalls

Source: C. Braak, 'Het klimaat van Nederlandsch-Indië', vol. I, part 2, p. 133, *Verhandelingen Koniklijk Magnetisch en Meteorologisch Observatorium te Batavia*, No. 8 (Batavia, 1923–25).

Whirlwinds that travel several miles sometimes cause damage to native buildings and plantations, cutting through the flimsy structures of the former and uprooting trees in the latter. Similar vortices give rise to waterspouts over the sea. The area each one affects is very small.

Temperature

The constant high temperature is the most trying feature in the climate of the Netherlands Indies near sea-level, the more so because of the usual accompaniment of high humidity. The combination of maximum temperature with high humidity, especially at the monsoon changes, is very oppressive, e.g. at Soerabaja in October and November.

Fortunately the islands are mostly mountainous, and since the fall of temperature with altitude is fairly constant and reliable (1° F. for 300 ft.) the pleasant temperatures of an early English summer may be found at 5,000 to 6,500 ft. For instance, Tosari (5,692 ft.) has a mean annual temperature of 61° F., while the appreciably lower temperature at even modest heights (Bandoeng, 2,395 ft., 72° F.) is a welcome relief from the heat of the lowlands where the mean temperature is 79° F. The fall of temperature, occasionally as much as 9° F., which accompanies heavy showers or the onset of a sea breeze, is also very welcome. At sea-level a mean annual temperature of about 79° F. is characteristic and almost universal and the variation from the warmest to the coolest month is slight, usually 2° F. and hardly ever exceeding 3° F. The annual range is greatest in the south and east (Timor 4·5° F.) where there is a dry season. Such minute annual variation makes it clear that there is really no such thing as a cool season; the diurnal variation exceeds the annual by a considerable amount and night is really the cool season. Table 3 gives the average temperatures at 2-hour intervals during the day and night for six stations of contrasted situation and aspect at different seasons. The following points should be noticed:

1. The diurnal range is 11 or 12° F. on the coast, 15 or 16° F. inland, high (18° F.) on the plateau except during the west monsoon and low (3 to 5° F.) on the high mountain slopes.

2. The maximum is reached very soon after noon, generally about 1 p.m., rather earlier at higher altitudes, and approaches 86° F. near sea-level.

3. The minimum is reached about sunrise and the temperature rises about 2° F. per hour to the mid-day maximum.

4. The season of the west monsoon has the smallest range, the constant warm wind preventing the night temperatures falling to comfortable levels.

5. The season of the east monsoon has the greatest range, with especially high day maxima. This is particularly so in the eastern and southern islands where the season is dry; the heat is therefore, not so unpleasant as the figures might suggest.

The onset of the sea breeze is often partly instrumental in checking the rise of the temperature after noon, but it seldom causes an actual fall. It may be detected in thermograph records, but is more obvious from the hygrograph which sometimes shows a quite sudden rise in humidity on its arrival. More important in checking the temperature rise is the increase in cloudiness and the onset of rain. For example,

a fall of 0·2 in. of rain occurring at Pontianak on 14 August, 1916, caused the temperature to fall 14° F. On showery days the effect of each rainstorm can be clearly detected on the thermograph record.

Table 4 shows the mean monthly maxima and minima of the highest and lowest months, together with the absolute extremes of temperature. The lowest mean minima tend to occur during the east monsoon in August or September and the highest mean maxima at many stations also tend to occur then. This is, therefore, the season of greatest extremes of temperature variation between night and day. At other places the highest mean maximum occurs in May, at the end of the period of monsoon change. Mean maxima for the hottest month are about 88° F. at sea-level, but the highest temperatures that may be experienced are about 7° F. higher. These temperatures are not excessive compared with stations in higher latitudes in the tropics and can be endured if the humidity is not too high. Indeed, judging from the experience of opencast tin mining in Bangka it is safe to assume that even higher temperatures may be endured; but on a still sunny day the heat in these mines brings one very near to heat apoplexy. Data for temperatures in underground workings are not available, but of course, bearable conditions depend on efficient ventilation.

The highest temperature recorded up to 1929 was 102° F. at Sawahan in central Java, the lowest 28° F. on the plateau at Pengelangen at a height of 5,000 ft. No station in Table 4, even Pangrango at about 10,000 ft., records extreme mimima below freezing, but it is not to be assumed that frost does not occur. Plateau and mountain situations, especially in enclosed basins where air drainage is not good, often experience frost at night.

Relative Humidity

Percentage figures for humidity do not convey a clear idea of the actual effects on the surroundings to those who do not know the country. The amount of moisture in the atmosphere, sometimes very near saturation, is such that household goods, books and wearing apparel suffer. Curtains rot, cloths get mildewed, pictures develop unwanted colours, and the covers of books are disfigured by patches of mould. Such domestic details may give a better impression of the real meaning of high percentage humidity in a hot climate, just as a bad attack of prickly heat may give a better idea than figures for daily, monthly and yearly averages, of what high temperature means in a damp climate.

The relative humidity is at a maximum at sunrise (often nearly 100%) but as the air warms up it decreases to a minimum in the hottest part of the day (about 70%) and increases again as the temperature falls. Some examples of daily range in the different seasons are given in Table 5. The low relative humidities at Koepang in the dry season (50–55% at mid-day in July to September) should be noted; mean minima of 25% occur here in the middle of the dry season and extreme minima of 15%. The greater dryness at Bandoeng as compared with Batavia, partly accounts for the strikingly more pleasant and bracing climate of the former place, although its temperature is only some 7 or 8° F. cooler.

In fact humidity decreases notably with altitude, especially in the free air. In east Java and regions to the east thereof there is often during the dry season a remarkable division of the atmosphere at 6,500–10,000 ft. The air above is very dry and clear, having been warmed by descent, but the air below is damp and hazy; the boundary layer, where a temperature inversion occurs, acts as a ceiling to ascending cumulus cloud which spreads out horizontally, often forming a sharply defined dark line. Hot dry weather occurs above this level.

Wet-Bulb Temperature

The wet-bulb readings give a good indication of the combined effect of temperature and humidity and therefore provide an index of physiological sensations of discomfort. In tropical lowlands the climatic conditions approach the limits of human endurance and under these conditions the human body is very sensitive to variations of temperature and humidity, i.e. to wet-bulb temperatures. A wet-bulb temperature of 77° F. begins to cause discomfort and to set a limit to the European's ability to work. The following figures for Batavia suggest that mid-day conditions are very unpleasant, but the morning and evening values, though only 4° F. or so lower make a great difference to comfort.

Wet-Bulb Temperatures (°F.)

1910–18	2 a.m.	4	6	8	10	12	2 p.m.	4	6	8	10	12
Jan.–Feb.	73	73	72	75	76	77	78	77	76	75	74	74
July–Sept.	72	72	71	73	75	77	78	77	76	75	74	73
Mar.–Apl. / Oct.–Nov.	73	73	72	75	76	78	78	78	76	75	74	73

Source: C. Braak, *op. cit.*, vol. 1, part 6, p. 376.

Buitenzorg, 750 ft. above sea-level, has wet-bulb temperatures about 3° F. lower, so that its mid-day figure is about the same as that of morning in Batavia and affords corresponding relief. Bandoeng, 2,400 ft. above sea-level is 7° F. cooler and the reviving and stimulating effects of this have already been noted.

Cloud and Sunshine

The amount of sunshine recorded varies from 30 to 70% of the possible hours and is closely related to relief and altitude (see Table 6). The lowest values are in the zone of maximum cloudiness on the mountains at about 5–8,000 ft., a zone which is frequently in thick cloud, especially during the afternoon, when strong ascending currents build up dense cumulus and cumulo-nimbus. Cloudiness is distinctly less in the lowlands and enclosed plateaux while the highest mountain tops, often well above cloud, enjoy a high duration of sunshine. The following annual means of sunshine illustrate the influence of altitude:

Place	Approx. height (ft.)	Annual mean % of sunshine
Batavia	Sea level	68
Buitenzorg	800	63
Tjipetir	2,000	52
Pasir Sarongge	4,000	49
Tjibodas	5,000	43
Pangrango	10,000	41

Source: C. Braak, *op. cit.*, vol. 1, part 4, p. 253.

In general cloudiness increases towards the equator (27% sunshine on the west coast of Sumatra) and is least in the south and east (59% sunshine in the Timor Sea), but the geographical distribution varies with the season and exposure to monsoons. The west monsoon is the cloudiest season at most places and the mountains may be completely enveloped in cloud for long spells. During this season the plains of west Java have 40–50% sunshine which increases to 50–60% in east Java and exceeds 60% at Soerabaja and the islands to the east. During the east monsoon the contrast is more pronounced, but in the same general direction. This is the time of least cloud, the islands east of Java having a dry and sunny season. Soerabaja and Madoera have practically cloudless skies, central Java has about 80% sunshine and west Java about 70%.

During the monsoon changes there is usually a well-marked and

regular diurnal variation of cloudiness. A similar regime is often characteristic of the monsoon months and is often described as a typical Java day, though the regularity is often overstated. The sequence is as follows: In the early morning, especially after rain, the low-lying land is sometimes covered with a blanket of mist. From the high land one looks down on this white feathery mass of cloud, shining in the morning sun, and sees ridges and mountain tops rising like islands out of the sea of fog. It does not last long and presently, as the sun warms the air, the mist gradually dissolves and in a short time the landscape is clear in brilliant light. Cumulus cloudlets soon begin to form, growing in size and towering higher and higher, perhaps growing to cumulo-nimbus and giving rain. Towards evening they begin to shrink and dissolve until by sundown the sky may be practically clear.

The figures in Table 7, giving the average hourly variations of cloud for the different seasons will show that this sequence, though general, is by no means a universal and regular recurrence. It holds good in a general sense only for the plains; it does not apply in the mountains.

Over the sea the diurnal incidence is reversed. Clouds form and grow by night and dissolve by day, thus an impression is often created that the clouds move in from the sea by day, and move back to the sea by night. They are, however, different clouds.

Visibility

Visibility and atmospheric transparency vary with the moisture content of the air. In the wet season, when atmospheric moisture is high, the actinic power of the sun is less than would be expected; the correct exposure for photography is little, if at all, shorter than in England. The intensity increases with altitude, being about 30% higher on Semeroe (at nearly 10,000 ft. in the Ijang-gebergte) than at Batavia.

In spells of dry weather haze is prevalent, limiting visibility of detail in a landscape. Thus the magnificent cone of a volcano such as Merapi in central Java may one day stand out with wonderful clearness, every irregularity on its slopes distinguishable, while on another at the same distance it will be visible only as a shimmering shadow in the hot air.

A striking difference in visibility before and after a downpour of rain is general, because the precipitation clears the air.

During heavy rain visibility is much restricted, but often the

downpour is very limited in area as well as in time. One sees a small heavy cloud approaching with an opaque curtain of rain hanging from it. As it comes nearer, the sound of falling rain is heard and then, heralded by a squall of wind, it envelopes everything in the immediate vicinity, blotting out all detail except of objects close at hand; but meanwhile a neighbour a mile away may be free from rain and able to enjoy a distant view. On other occasions, however, the rain-clouds cover a large area, resulting in extensive bad visibility which, coupled with the downpour, makes piloting an aeroplane a difficult matter; but generally the advent of heavy rain can be detected long enough before its arrival to delay taking off or to enable the pilot to fly round the storm clouds.

Precipitation

Annual Precipitation

The Netherlands Indies form probably the greatest area of heavy rainfall on the earth. Stations with less than 40 in. are exceptional, they occur only in the Lesser Soenda Islands, where, on account of the long dry east monsoon season the annual total of precipitation is exceptionally low. An average amount is 65 in.; many stations on mountain slopes have more than 100 in. and a few exceed 130 in. To the rain produced by the usual physical processes of the equatorial belt is added relief rain from the alternating monsoons. So important is this factor that over large areas the rainfall from the west monsoon makes the months of November to February the wettest of the year, wetter than the months of equatorial 'calms' at the change-over of the monsoons. But since this monsoon rain is dependent on relief and aspect its amount is bound to be very variable in an archipelago of mountainous islands. No simple statement can therefore be made about the yearly total of rainfall which is best described by a map (Fig. 123).

Seasonal distribution

Only in the east, approaching Australia, is there a dry season, which occurs in July, August and September, towards the end of the season of the east monsoon. It begins to be noticeable at the east end of Java where Pasoeroean has three months with less than 1 in. each and in the extreme south of Celebes where Makassar has two dry months. The duration of the dry season increases south and east until at Koepang (Timor) there are five dry months. Throughout the

remainder of the islands there is no dry season though the months of August and September are usually the driest (Table 8).

It is much more difficult to give a simple account of the time of occurrence of the wet season which varies from place to place

Fig. 123. Yearly total of rainfall

The map is highly generalized and cannot show the considerable differences in amount of rain between two stations geographically very close together, but contrastingly situated with relation to wind and aspect.

Source: *Handbuch der Klimatologie*, Band IV, Teil R, C. Braak 'Klimakunde von Hinterindien und Insulinde' (Berlin, 1936).

according to position and exposure. The facts can, however, be understood and to some extent anticipated by an understanding of the causes of heavy precipitation. These are:

1. Condensation in the equatorial rain belt, which tends to produce rain all the year round, especially near sea-level.

2. The west monsoon, which tends to give a Jan.–Feb. maximum, exceeding that from all other causes in localities exposed to this wind and backed by mountains which 'stow' the wind.

3. The east monsoon, as described above, tends to be a dry season.

4. Calms at the monsoon changes, when upward air movement occurs and conditions are favourable for the development of thunderstorms. These are the seasons of rainfall maxima except where overshadowed by the west monsoon rains. Since most of the thunderstorms originate on mountain slopes it is especially there that rainfall is relatively abundant at the monsoon changes. The first maximum (April and May) is more important in the north and west, the second (September and October) in the south and east.

5. Local causes. During the day mountains act as centres of strong ascending air movements and induce heavy rain. They also 'stow' the wind and produce very uneven rainfall distribution—torrential on the windward side and slight where the air descends to leeward.

Fig. 124. Months of maximum rainfall

Source: See Fig. 123.

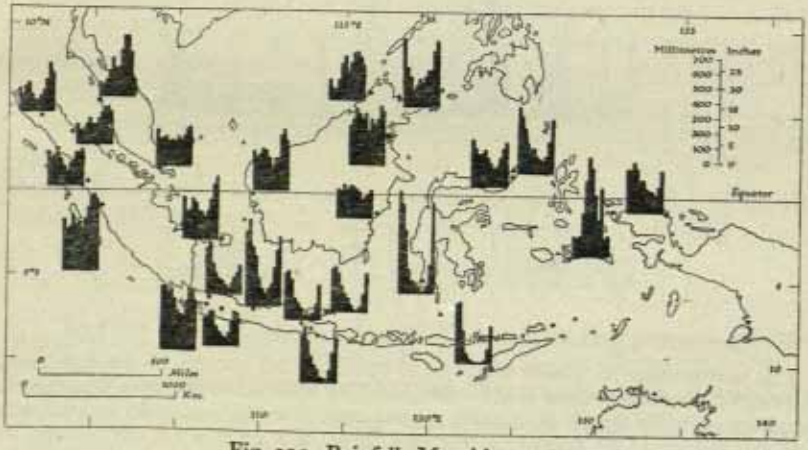

Fig. 125. Rainfall: Monthly means

Source: See Fig. 123.

The effects of these factors are shown in Figs. 124 and 125 which indicate the wettest month at each station and, in general terms, the distribution of the principal maxima which are due either to the west monsoon, or the convectional instability at the monsoon changes.

Droughts

Although the weather in monsoon climates is reliable and even monotonous, great differences occur in the strength of the monsoon in successive years, which are clearly connected with the general circulation and can therefore, to some extent be anticipated. Consequently the differences between the seasons may vary appreciably, so that in some years the farmer will wait in vain for the dry season, while in other years he will look out for months for the first good shower.

In Fig. 126 are shown the day-to-day occurrences of rain on Tangkoebanprahoe for 1931 and 1938. Especially noticeable are the contrasts in April and May, excessively wet in 1931, but with abormally small rainfalls in 1938.

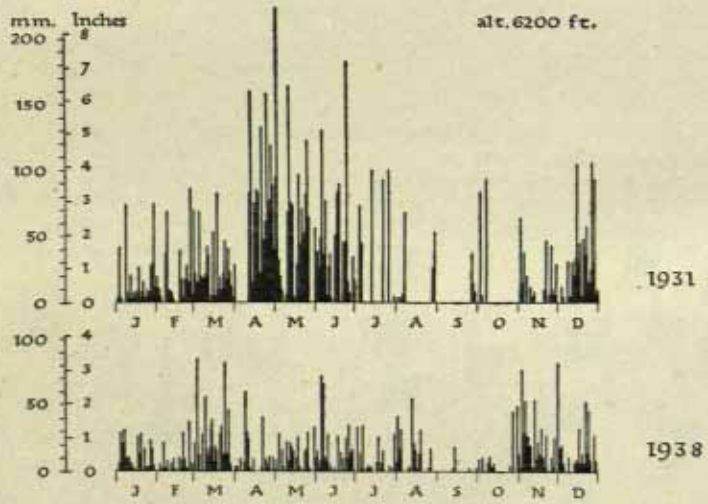

Fig. 126. Day-to-day rainfall at Tangkoebanprahoe in 1931 and 1938

The distribution of rainfall follows the same general pattern in the two years, though the actual amount is very different. The wide variations from year to year are concealed by figures of monthly means; there is an approximately equal chance of the rainfall being greater or less than these in a given year. For location of Tangkoebanprahoe see Fig. 69.

Source: *Bulletin of the Netherlands Indies Volcanological Survey*, vol. II, p. 88 and vol. IV, p. 124 (Bandoeng, 1931 and 1938).

The most serious droughts occur in eastern Java and in the Lesser Soenda islands. They may be regarded as an abnormal extension of the dry season, which occurs here, through early cessation or late

arrival of the rains. Three or four months may pass with no appreciable rain, causing serious failure of crops.

Diurnal variation

The general tendency in equatorial climates is for a regular and reliable occurrence of rain at a particular time of the day. This is mainly due to the diurnal variation of heat received from the sun. The results in their simplest form, are seen at land stations, unaffected by influence from the sea, where the daily rise of temperature causes ascending air movements culminating in heavy showers of convectional rain during the afternoon hours (e.g. Tosari, see Table 9). The actual hour of onset varies from place to place, but is fairly constant and reliable at each place.

Over the open sea the ascending air movement attains its greatest strength at about sunrise and this is the rainy hour of the day. This type of diurnal occurrence affects coastal stations where the wind blows off the sea (see figures for Discovery Oostbank, Table 9). A third period of rainfall occurs between midnight and sunrise at coastal stations. These three tendencies are met in various combinations at stations on and near the coast, and apart from local complications explain the diurnal regime. But the importance of each tendency naturally varies with the season, because of the change in direction of the monsoon and, with it, the change in sea influence.

From the figures for twelve stations given in Table 9 it can be seen that:

1. The afternoon maximum prevails everywhere at the monsoon change (March–April and October–November) and at most places during the east monsoon where this is not a dry season.

2. The early morning maximum appears at many coastal stations during the west monsoon, e.g. Batavia, Koepang, Manado, though always combined with a second maximum in the afternoon.

3. The sunrise maximum appears at Discovery Oostbank, the only open sea station, though there are traces of it at Amboina and Manokwari during the east monsoon.

4. The forenoon hours are everywhere the driest of the day. Thus although there are local variations, as pointed out above, many places enjoy for most of the year the same daily regime of weather which may be described as follows: The sun has risen in a clear sky, but by about 9 a.m. its warmth begins to start small cumulus clouds forming. At the same time the monsoon, which has abated to a calm during the

night, but has kept blowing at higher levels, springs up again. Wind and cloud increase as the sun climbs higher, the clouds grow denser and darker, piling higher and higher until in the afternoon, refreshing rain falls in heavy showers. Towards evening the sky clears, the wind abates, and the cloudless calm tropical night begins.

Precipitation intensity

Because of the high water vapour content of the air and because of the powerful ascending air currents the rainfall of tropical lands is more torrential than in temperate countries. Short thunder showers may occur in temperate latitudes with an intensity equal to those of the tropics and ½ in. may fall in five minutes, but these rates cannot be long maintained, for the water content of the air is soon exhausted. Rates of fall approaching this intensity may last for half an hour in the tropics, and while the heaviest rain in twenty-four hours at Ben Nevis is less than 8 in., most stations in Java have exceeded 12 in. On mountain sides exposed to the west monsoon 16 in. is often exceeded and Besokor recorded 20 in. on 1 February 1901 which is almost the average for the whole year in London. Several stations have an average of 16 in. in their wettest month and exceptional ones reach 30 in. (Batealit on the west slopes of Moerjo, Java, 32·8 in. in January due to stowage of the west monsoon). Moreover, while such falls are of limited local occurrence in Britain they may affect very large areas in the Netherlands Indies, especially during the west monsoon. In consequence the volume of rain falling is enormous, causing floods of varying mixtures of water and mud, washing away soil and causing landslides (see p 139).

The average intensity of rain in inches per hour at Batavia is:

J.	F.	M.	A.	M.	J.	J.	A.	S.	O.	N.	D.
0·20	0·22	0·20	0·22	0·23	0·26	0·20	0·22	0·27	0·28	0·19	0·20
Mean for W. monsoon 0·21		Mean for monsoon change 0·21				Mean for E. monsoon 0·23			Mean for monsoon change 0·23		

Source: C. Braak, *op. cit.*, vol. 1, part 3, p. 199.

A similar result is obtained for other stations and it appears that the intensity, based on the whole day, is about the same at all seasons. But when we consider the intensity rates for each hour of the day it

becomes clear that the afternoon (thunder) showers are the heaviest as the following figures for Batavia show:

Hours	1–2	2–3	3–4	4–5	5–6	6–7	7–8	8–9	9–10	10–11	11–12
Forenoon	0·19	0·17	0·16	0·16	0·17	0·14	0·16	0·21	0·20	0·23	0·26
Afternoon	0·29	0·33	0·32	0·29	0·24	0·22	0·19	0·18	0·18	0·19	0·19

Source: C. Braak, *op. cit.*, vol. I, part 3, p. 199.

During the seasons of the monsoon changes at Batavia these afternoon showers produce rain at the high average intensity of 0·35 in. between 2 and 3 p.m.; night rain is much lighter and less frequent at this season. During the west monsoon, on the other hand, rain at night is heavier and more frequent than by day. Midnight to 1 a.m. is the wettest time, with an average intensity of 0·25 in. per hour.

Table 10 gives the number of days with more than 0·02 in., and it is seen that the west monsoon at most stations produces the most rainy days and is the real 'rainy' season despite the very heavy showers of the monsoon changes, which, however, are of shorter

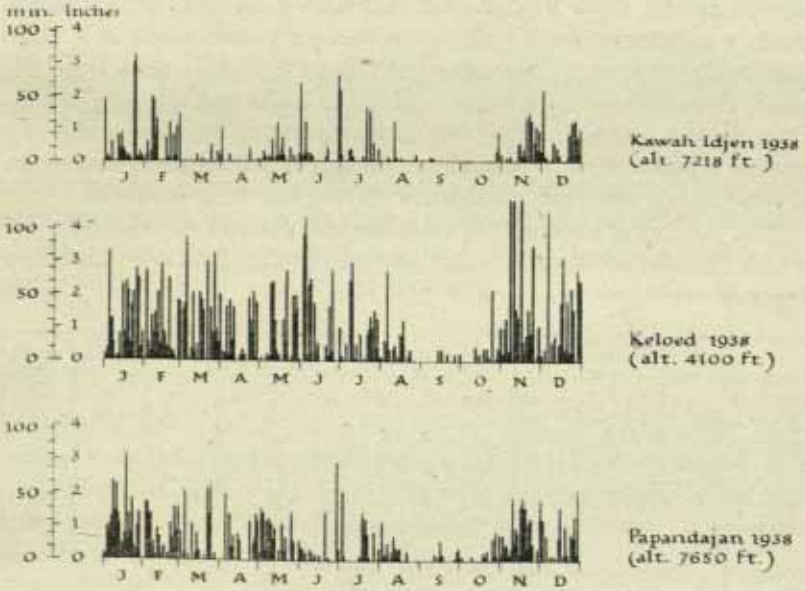

Fig. 127. Day-to-day rainfall at three stations on Javanese volcanoes in 1938
Source: *Bulletin of the Netherlands Indies Volcanological Survey*, vol. IV, pp. 126 130, 132 (Bandoeng, 1938).

duration, though greater intensity. It is a noteworthy fact that the intensity of rain when it falls is much the same at stations with a low annual total as at those with large totals. The amount of rain is thus due to its frequency of occurrence rather than to its intensity.

Fig. 127 shows the actual day-to-day occurrence of rain in 1938 at three stations on Javanese volcanoes. It shows how variable is the daily fall and that rainless days may occur even at the height of the wet season.

Thunderstorms

The strong ascending air currents during the heat of the day and the high humidity combine to make the Netherlands Indies the most thundery region on earth. The most favourable conditions for the development of storms are found on the slopes of the mountains, which therefore, record the highest frequencies of occurrence. At Buitenzorg thunder is heard, on an average, on 322 days in the year; other figures are given in Table 11, but the lower values are no doubt partly explained by differences in the diligence of observers.

The storms are all heat thunderstorms and are short-lived and of limited extent. Over the land the necessary conditions of instability reach a maximum during the afternoon hours and there is a clear maximum between 3 p.m. and 6 p.m. At most stations away from the coast, thunder is seldom heard during the night and morning hours. Over the sea, however, instability increases during the night and many coastal stations show a secondary, though much smaller, maximum about 3 a.m., especially prominent during the west monsoon.

The following data of the total annual number of occasions on which thunder is heard in each hour of the day illustrate these two regimes.

a.m.	0–1	1–2	2–3	3–4	4–5	5–6	6–7	7–8	8–9	9–10	10–11	11–12
Batavia	11	14	14	14	9	5	3	2	1	2	3	8
Buitenzorg	14	8	4	—	—	—	—	—	—	3	6	11
p.m.	0–1	1–2	2–3	3–4	4–5	5–6	6–7	7–8	8–9	9–10	10–11	11–12
Batavia	13	23	35	46	44	35	23	17	14	12	12	12
Buitenzorg	31	62	115	116	225	250	225	147	76	22	12	16

Source: C. Braak, *op. cit.*, vol. 1, part 7, p. 421.

It will be noticed that thunder is heard at Buitenzorg between 5 and 6 p.m. on 250 days in the year, but never between 3 and 9 a.m.

As would be expected the monsoon changes are the season of maximum frequency, March to May in the west (Sumatra and south Java), October to November in the east (Celebes and the islands to the east); but the west monsoon also gives high values and in many places is the season of maximum frequency (Fig. 128).

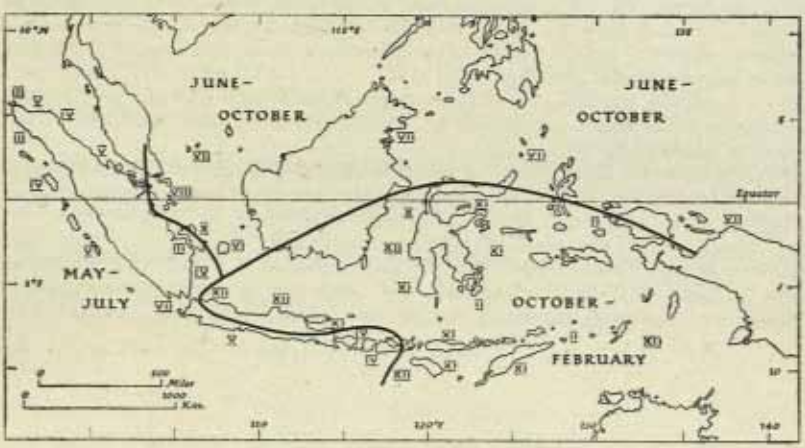

Fig. 128. Months of maximum thunder

Source: C. Braak, 'Het klimaat van Nederlandsch-Indië', vol. 1, part 7, p. 418, *Verhandelingen Koniklijk Magnetisch en Meteorologisch Observatorium te Batavia*, No. 8 (Batavia, 1923–25).

Despite the frequency and intensity of the lightning the damage to life and property seems to be slight, probably because of the number of tall trees which act as a protection. Coconut palms appear to be particularly frequently struck by lightning.

Hail

In spite of the powerful development of cumulo-nimbus reaching well above freezing-level (32° F. normally reached at 16,000 ft.) hail is not common in the Netherlands Indies probably because the frozen drops thaw on falling through the warm air layers. Naturally, therefore, it is more frequent in the mountains. The seasons of maximum frequency are those of the monsoon changes and the chief time of occurrence is during the afternoon; in fact it never occurs between 8 p.m. and noon.

BIBLIOGRAPHICAL NOTE

(1) The Royal Magnetic and Meteorological Observatory at Batavia has kept full records for over 70 years. The earlier records are unreliable but since 1912 a thorough set of observations has been made which provides very adequate material for study. They are published in the *Verhandelingen Koninklijk Magnetisch en Meteorologisch Observatorium te Batavia*.

(2) Between 1923 and 1925 Dr C. Braak made a full analysis of the records mentioned in (1) under the title 'Het Klimaat van Nederlandsch-Indië', with summaries in English, which formed No. 8 of the *Verhandelingen* in 3 volumes. These contain General, Regional and Statistical information respectively and provide the fullest single account of the climate.

(3) C. Braak also wrote the contribution to the *Handbuch der Klimatologie*, 'Klimakunde von Hinterindien und Insulinde' (Band IV, Teil R., Berlin, 1936) which has valuable tables of figures.

(4) No 18 of the *Verhandelingen* with an English translation entitled 'Rainfall types in the Netherlands East Indies' analyses the rainfall records of nearly 2,800 stations of which 2,200 are situated in Java and Madoera. It is written by Dr J. Boerema.

(5) Other important sources of information include Gallé, 'Climatology of the Indian Ocean', *Indisch Verslag*, 1930; Meteorological Office 404a, 'Weather in the China Seas'; *Atlas van Tropisch Nederland*, 1938 (with legend translated into English, French and German), containing temperature, pressure and rainfall maps.

CLIMATIC TABLES

Table 1. *Percentage frequency of Wind Direction*

Discovery Oostbank (1911–1918)

	N	NE	E	SE	S	SW	W	NW	Calm
J.	3	0	0	0	0	3	40	54	0
F.	3	0	0	0	2	3	25	67	0
M.	6	2	2	4	3	10	37	33	3
A.	4	8	6	26	11	10	17	13	6
M.	4	3	10	49	9	11	9	5	0
J.	1	4	10	69	9	3	3	1	0
J.	1	1	9	79	3	2	0	0	4
A.	1	1	11	82	3	0	1	1	0
S.	1	1	8	79	6	4	1	0	0
O.	4	2	4	54	16	11	6	3	0
N.	4	7	5	21	10	16	20	17	0
D.	3	1	1	1	3	9	44	37	0

Batavia (1891–1925)

	N	NE	E	SE	S	SW	W	NW	Calm
J.	13	5	1	4	7	8	18	18	27
F.	13	5	2	4	6	8	14	18	30
M.	12	7	4	7	9	8	13	11	28
A.	10	14	10	11	11	6	5	4	29
M.	9	16	13	13	9	4	4	2	30
J.	9	17	15	14	9	2	2	2	30
J.	10	18	16	15	10	2	1	2	26
A.	12	19	14	15	11	2	1	2	23
S.	17	16	10	13	12	3	2	2	24
O.	17	14	8	10	14	5	3	3	26
N.	15	8	5	8	15	9	8	6	26
D	11	5	3	5	10	11	17	12	26

Christmas Island (1910–19)

	N	NE	E	SE	S	SW	W	NW	Calm
J.	2	0	2	11	7	11	18	8	41
F.	2	3	6	10	2	8	20	9	40
M.	1	3	17	13	3	5	13	8	37
A.	0	3	31	15	1	2	4	1	44
M.	1	4	32	21	2	1	1	0	38
J.	2	4	40	21	0	0	1	0	31
J.	2	5	37	31	0	0	0	0	24
A.	0	5	38	36	0	0	0	0	20
S.	1	4	32	45	0	0	0	0	18
O.	2	1	30	42	0	2	1	1	20
N.	4	5	16	36	1	1	3	4	31
D.	3	1	6	21	6	11	8	6	38

Table 1 (*continued*). *Percentage frequency of Wind Direction*

De Bril (1911–18)

	N	NE	E	SE	S	SW	W	NW	Calm
J.	7	0	0	0	0	1	65	26	0
F.	9	0	2	0	1	3	57	27	2
M.	10	1	10	4	5	4	49	17	0
A.	3	3	61	3	3	1	6	3	6
M.	6	1	60	22	5	0	4	1	0
J.	0	1	71	24	2	0	0	0	2
J.	0	1	60	31	2	0	0	0	5
A.	0	0	63	36	1	0	0	0	0
S.	0	0	59	34	5	0	0	0	2
O.	2	0	45	40	9	0	3	0	1
N.	5	2	32	23	13	2	21	2	2
D.	5	1	6	0	3	3	63	10	9

Maety Miarang (1911–18)

	N	NE	E	SE	S	SW	W	NW	Calm
J.	4	0	0	0	3	11	24	57	0
F.	4	2	1	3	5	13	20	52	0
M.	3	1	5	8	7	14	23	38	0
A.	1	3	26	48	13	6	2	1	0
M.	0	2	37	52	7	2	0	0	0
J.	0	0	25	69	6	0	0	0	0
J.	0	0	30	64	6	0	0	0	0
A.	0	0	31	64	4	0	0	0	0
S.	0	0	25	60	12	3	0	0	0
O.	1	3	25	57	10	3	0	1	0
N.	4	7	21	35	15	7	4	6	1
D.	5	2	8	9	9	15	20	32	0

Herbertshöhe (1902–5)

	N	NE	E	SE	S	SW	W	NW	Calm
J.	4	3	1	8	35	9	5	30	4
F.	2	2	1	3	20	8	11	41	14
M.	4	5	1	5	36	13	4	22	10
A.	1	3	1	8	23	12	1	40	9
M.	2	2	3	54	22	3	0	8	5
J.	0	1	2	78	11	1	0	1	6
J.	0	2	2	81	8	1	0	0	5
A.	1	1	2	74	13	2	0	1	4
S.	1	2	3	76	10	3	0	0	3
O.	2	5	1	67	13	5	0	4	5
N.	1	4	1	64	13	5	0	5	7
D.	3	3	4	31	19	7	2	20	11

Source: C. Braak, 'Klimakunde von Hinterindien und Insulinde', pp. 111–112 (Berlin, 1936); this is *Band* IV, *Tiel R*, of *Handbuch der Klimatologie*, edited by W. Köppen and R. Geiger.

Table 2. *Mean Wind Velocity (ft. per second)*

KOEPANG (1913–17)

Period of day	J.	F.	M.	A.	M.	J.	J.	A.	S.	O.	N.	D.	Year
7 a.m.—12 noon	18	14	13	14	16	17	17	15	14	16	13	14	15
12—5 p.m.	18	15	13	14	16	16	17	15	15	16	14	14	15
5 p.m.—7 a.m.	8	7	6	6	7	7	7	7	7	7	7	8	7

BATAVIA (1866–1918)

Period of day	J.	F.	M.	A.	M.	J.	J.	A.	S.	O.	N.	D.	Year
7.30 a.m.—12.30 p.m.	6	6	6	6	5	5	6	6	6	6	5	6	6
12.30 p.m.—5.30 p.m.	7	7	7	7	7	7	8	9	9	9	7	7	8
5.30 p.m.—7.30 p.m.	2	2	2	2	2	2	2	2	2	2	2	2	2

PASOEROEAN (1901–10)

Period of day	J.	F.	M.	A.	M.	J.	J.	A.	S.	O.	N.	D.	Year
7 a.m.—12 noon	5	5	5	5	5	5	6	6	7	7	6	6	6
12—5 p.m.	7	7	6	7	7	8	8	10	10	10	8	7	8
5 p.m.—7 a.m.	3	2	2	2	2	3	3	4	5	5	3	3	3

Source: C. Braak, 'Het Klimaat van Nederlandsch-Indië,' vol. 1, part 2, pp. 100–1 (Batavia, 1923–25).

Table 3. *Daily Variation of Air Temperature (degrees Fahrenheit)*

BATAVIA (26 ft.)
coast (1866–1918)

TIME	A	B	C	D
2 a.m.	75	74	75	74
4	74	73	74	74
6	74	74	74	73
8	77	77	79	78
10	80	83	84	83
12	82	86	86	85
2 p.m.	83	86	85	85
4	81	83	83	83
6	79	80	80	80
8	77	78	77	77
10	76	76	76	76
12	75	75	75	75
Range	8	13	12	12

PADANG (23 ft.)
coast (1913–18)

TIME	A	B	C	D
2 a.m.	75	75	75	75
4	75	74	75	74
6	74	74	74	74
8	77	77	78	78
10	84	83	83	84
12	86	86	86	86
2 p.m.	86	85	85	85
4	83	83	82	83
6	81	80	80	80
8	78	78	78	78
10	77	76	80	77
12	76	75	75	75
Range	12	12	12	12

MODJOWARNO (164 ft.)
low flat interior (1905–15)

TIME	A	B	C	D
2 a.m.	75	71	74	73
4	74	70	73	72
6	74	69	72	71
8	78	76	79	78
10	83	84	85	84
12	86	88	88	87
2 p.m.	85	89	88	87
4	82	86	86	84
6	79	81	80	80
8	77	78	78	78
10	76	75	76	76
12	75	73	75	74
Range	12	20	16	16

BUITENZORG (787 ft.)
mountain base (1913–18)

TIME	A	B	C	D
2 a.m.	72	72	73	72
4	72	71	73	72
6	71	71	72	71
8	75	76	77	77
10	79	82	82	82
12	81	85	85	84
2 p.m.	80	86	84	84
4	78	84	80	81
6	76	78	76	77
8	74	76	75	75
10	74	74	74	74
12	73	73	73	73
Range	10	15	13	13

BANDOENG (2,395 ft.)
plateau (1912–18)

TIME	A	B	C	D
2 a.m.	70	66	68	67
4	68	64	67	66
6	67	63	66	65
8	70	68	70	69
10	74	75	76	75
12	77	80	84	79
2 p.m.	77	81	79	79
4	75	80	77	77
6	72	75	73	74
8	70	72	71	71
10	70	69	70	70
12	69	68	69	68
Range	10	18	18	14

TOSARI (5,691 ft.)
high mountain slope (1912–18

TIME	A	B	C	D
2 a.m.	60	57	59	59
4	60	57	59	59
6	60	57	59	59
8	62	60	62	61
10	64	62	64	63
12	64	63	64	64
2 p.m.	64	63	64	63
4	62	62	63	62
6	61	60	61	61
8	60	58	60	60
10	60	58	60	59
12	60	57	60	59
Range	4	6	5	5

A. West monsoon (Jan.–Feb.) B. East monsoon (July–Sept.)
C. Monsoon change (Mar.–April and Oct.–Nov.) D. Year.

Source: C. Braak, 'Het Klimaat van Nederlandsch-Indië', vol. 1, part 5, pp. 293–304 (Batavia, 1923–5); this forms No. 8 of the *Verhandelingen Koninklijk Magnetisch en Meteorologisch Observatorium te Batavia*.

Table 4. *Mean and Extreme Maxima and Minima of Temperature*

Station	Height (ft.)	Mean monthly maximum				Mean monthly minimum				Absolute	
		Highest	Month	Lowest	Month	Highest	Month	Lowest	Month	Max.	Min.
Amboina	13	88	March	81	July	75	Jan.	73	Aug.	93	66
Bandoeng	2,395	84	Oct.	79	Jan.	67	Jan.	62	Aug.	94	52
Batavia	26	88	Sept.	84	Feb.	74	April	72	Aug.	97	65
Fort de Kock	3,018	80	May	77	Jan.	65	April	63	Aug.	85	50
Koepang	935	91	Oct.	85	Feb.	75	Jan.	69	Aug.	96	59
Makassar	13	85	Oct.	80	Dec.	74	Jan.	65	Sept.	90	58
Manokwari	62	87	Nov.	85	June	75	Dec.	73	Jan.	92	68
Pontianak	10	88	May	85	Dec.	75	May	73	Aug.	94	68
Singgalang	9,439	57	May	54	June	46	Sept.	42	Feb.	63	37
Pangrango	9,918	57	May	52	Jan.	46	April	42	Sept.	69	33

Source: C. Braak, 'Het Klimaat van Nederlandsch-Indië', vol 1, part 5, pp. 303 and 304 (Batavia, 1923–25).

Table 5. *Diurnal Variation of Relative Humidity*

Relative Humidity (percentage)
BATAVIA, 26 ft. above sea-level (coast lowland, Java)

Hour	A	B	C
2 a.m.	95	92	94
4	96	93	95
6	96	93	95
8	90	81	84
10	81	66	72
12	77	60	68
2 p.m.	76	62	70
4	79	68	74
6	85	76	82
8	91	83	88
10	94	88	91
12	94	91	93

KOEPANG, 148 ft. (coast, Timor)

Hour	A	B	C
2 a.m.	94	83	90
4	94	84	91
6	94	85	92
8	89	68	76
10	83	55	68
12	79	51	65
2 p.m.	79	52	64
4	81	57	69
6	86	66	78
8	93	64	85
10	93	78	87
12	94	81	89

BANDOENG, 2,395 ft. (plateau)

Hour	A	B	C
2 a.m.	92	88	92
4	92	90	92
6	93	91	93
8	90	86	88
10	79	68	73
12	72	55	63
2 p.m.	72	53	66
4	78	58	73
6	85	68	82
8	89	80	88
10	90	85	90
12	91	87	91

A. West Monsoon (January–February). B. East Monsoon (July–September).
C. Monsoon Change (March–April and October–November).

Source: C. Braak, 'Het Klimaat van Nederlandsch-Indië', vol 1, part 6, pp. 350, 351 and 355 (Batavia, 1923–25).

Table 6. *Mean Monthly and Yearly Totals of Sunshine Hours*

Place	Period of observation	J.	F.	M.	A.	M.	J.	J.	A.	S.	O.	N.	D.	Total
Padang	1916–21	208	223	223	226	248	230	230	226	208	201	186	190	2,597
Pontianak	1916–21	146	183	186	193	193	215	219	201	164	168	175	179	2,229
Batavia	1898–1921	139	146	190	215	219	219	230	237	226	208	179	150	2,326
Pangrango	1917–21	80	51	88	99	161	172	219	186	172	131	110	73	1,522
Pasoeroean	1916–21	179	190	208	266	277	299	299	299	307	277	252	190	2,996
Makassar	1922–26	161	168	190	241	245	252	277	303	307	296	274	168	2,849
Koepang	1916–21	188	192	222	266	276	276	289	302	306	259	263	203	3,072
Manokwari	1916–21	134	176	173	155	176	155	200	207	192	179	207	165	2,119

Source: C. Braak, 'Klimakunde von Hinterindien und Insulinde', pp. 105–108 (Berlin, 1936); this is *Band* IV, *Teil R*, of *Handbuch der Klimatologie*, edited by W. Köppen and R. Geiger.

Table 7. *Daily Variation of Sunshine (% of possible amount)*

TOSARI (5,692 ft.)
1912–21

Time	A	B	C
a.m.			
8– 9	30	76	57
9–10	32	79	55
10–10	31	77	47
11–12	30	71	42
12– 1	29	61	34
p.m.			
1– 2	19	53	30
2– 3	13	46	24
3– 4	10	44	17

FORT DE KOCK (3,018 ft.)
1916–21

Time	A	B	C
a.m.			
8– 9	55	67	63
9–10	59	73	67
10–11	55	69	68
11–12	48	58	60
12– 1	46	56	52
p.m.			
1– 2	48	53	51
2– 3	48	52	44
3– 4	40	40	40

BANDOENG (2,395 ft.)
1912–21

Time	A	B	C
a.m.			
8– 9	57	81	70
9–10	64	85	77
10–11	67	87	77
11–12	63	82	69
12– 1	55	74	58
p.m.			
1– 2	49	67	47
2– 3	37	58	36
3– 4	25	50	27

PONTIANAK (10 ft.)
1916–21

Time	A	B	C
a.m.			
8– 9	54	61	58
9–10	59	68	71
10–11	58	70	68
11–12	54	65	60
p.m.			
12– 1	53	63	57
1– 2	51	63	56
2– 3	47	55	50
3– 4	43	48	43

AMBOINA (13 ft.)
1916–21

Time	A	B	C
a.m.			
8– 9	61	33	66
9–10	62	38	64
10–11	58	39	60
11–12	51	39	54
p.m.			
12– 1	51	38	55
1– 2	56	44	64
2– 3	57	48	66
3– 4	52	45	62

KOEPANG (148 ft.)
1916–21

Time	A	B	C
a.m.			
8– 9	60	90	82
9–10	64	91	83
10–11	62	90	83
11–12	58	86	80
p.m.			
12– 1	57	88	79
1– 2	55	90	77
2– 3	54	89	73
3– 4	48	84	63

A. West monsoon (Jan.–Feb.) B. East monsoon (July–Sept.)
C. Monsoon change (March–April and Oct.–Nov.)

Source: Based on C. Braak, 'Het Klimaat van Nederlandsch-Indië', vol. 1, part 4, pp. 265–268 (Batavia, 1923–25).

Table 8. *Mean Monthly and Annual Totals of Rainfall (inches)*

A. Maximum at West Monsoon

Place	Sandakan	Batavia	Pasoeroean	Tosari	Manado	Makassar	Koepang
Altitude (ft.)	105	26	16	5,692	30	13	148
Years	1879–1926	1879–1925	1879–1925	1879–1925	1879–1925	1879–1925	1879–1925
Jan.	18·2	11·9	9·6	12·4	17·7	26·6	15·2
Feb.	10·4	13·4	11·8	14·6	15·1	23·2	15·8
Mar.	7·9	8·0	8·0	10·8	11·6	16·4	8·5
April	4·1	5·6	5·2	6·9	7·9	6·0	2·6
May	5·8	4·1	3·5	4·6	6·3	3·4	1·1
June	7·4	3·7	2·3	3·3	6·5	2·9	0·4
July	6·4	2·6	1·1	1·5	4·6	1·4	0·2
Aug.	7·9	1·6	0·2	1·1	3·7	0·4	0·1
Sept.	9·5	2·8	0·3	1·0	3·4	0·6	0·1
Oct.	9·8	4·5	0·8	3·4	4·6	1·7	0·7
Nov.	14·8	5·7	2·5	7·8	8·7	7·2	3·6
Dec.	17·4	7·6	6·3	11·8	14·4	23·5	9·5
Total	119·6	71·5	51·6	79·2	104·5	113·3	57·8

B. Maximum at Monsoon Change

Place	Fort de Kock	Padang	Tandjoeng-pandan	Pontianak	Balikpapan	Bandoeng	Amboina	Manokwari
Altitude (ft.)	3,018	230	10	10	16	2,395	13	62
Years	1879–1925	1879–1925	1879–1925	1879–1925	1879–1925	1879–1925	1879–1925	1900–1925
Jan.	9·0	13·4	10·9	10·6	7·7	7·6	5·0	10·7
Feb.	7·2	10·9	7·1	8·5	7·5	7·7	5·0	10·7
Mar.	8·4	11·4	7·7	9·6	9·0	9·2	5·2	13·0
April	9·9	14·3	10·7	11·1	7·6	9·2	11·3	11·1
May	7·0	12·0	9·5	10·7	8·7	5·2	19·6	7·8
June	5·4	12·8	7·3	8·9	8·3	3·7	25·6	8·3
July	3·7	10·9	6·9	6·5	7·8	2·5	22·9	6·0
Aug.	6·0	13·4	5·6	8·6	6·9	2·2	15·8	5·3
Sept.	6·7	16·4	7·0	8·6	4·8	3·5	9·3	5·2
Oct.	8·7	19·4	10·4	14·7	5·7	6·6	6·0	4·2
Nov.	8·7	19·9	14·4	16·1	6·4	9·2	4·5	6·6
Dec.	9·6	18·7	16·3	13·1	7·5	8·7	5·2	10·6
Total	90·3	173·5	113·8	127·0	87·9	75·3	135·4	99·5

Source: C. Braak, 'Klimakunde von Hinterindien und Insulinde', p. 116 (Berlin, 1936); this is *Band* IV, *Teil R*, of *Handbuch der Klimatologie*, edited by W. Köppen and R. Geiger.

Table 9. *Daily Incidence of Rain. (Hourly Total per Month in Inches)*

A. West monsoon (Jan.–Feb.) B. East monsoon (July-Sept.)
C. Monsoon change (March–Apr. and Oct.–Nov.)

Time	Padang 1904–18 (Sumatra, W. coast)			Batavia 1866–1908 (Java, N. coast)			Sawahan 1905–15 1917–18 (Java, N. coast)			Pasoeroean 1905–18 (Java, N. coast)			Bandoeng 1912–18 (Java, plateau 2,395 ft.)			Tosari 1912–18 (Java, east 5,692 ft.)		
	A	B	C	A	B	C	A	B	C	A	B	C	A	B	C	A	B	C
a.m.																		
0– 1	0·6	0·8	0·6	0·7	0·1	0·1	0·4	0·1	0·2	0·1	0·0	0·1	0·1	0·0	0·2	0·1	0·0	0·0
1– 2	0·6	0·6	0·7	0·7	0·1	0·2	0·4	0·0	0·1	0·1	0·0	0·0	0·1	0·0	0·1	0·1	0·0	0·0
2– 3	0·4	0·6	0·7	0·7	0·1	0·1	0·5	0·0	0·0	0·1	0·0	0·0	0·1	0·0	0·1	0·0	0·0	0·0
3– 4	0·4	0·6	0·6	0·7	0·0	0·1	0·3	0·0	0·0	0·0	0·0	0·0	0·2	0·0	0·0	0·0	0·0	0·0
4– 5	0·5	0·4	0·6	0·7	0·0	0·1	0·3	0·0	0·1	0·1	0·0	0·0	0·1	0·0	0·1	0·0	0·0	0·0
5– 6	0·3	0·3	0·5	0·6	0·0	0·1	0·2	0·0	0·0	0·0	0·0	0·0	0·1	0·0	0·0	0·0	0·0	0·0
6– 7	0·2	0·2	0·4	0·5	0·1	0·1	0·2	0·0	0·0	0·0	0·0	0·0	0·1	0·0	0·0	0·1	0·0	0·0
7– 8	0·3	0·3	0·2	0·5	0·0	0·1	0·2	0·0	0·0	0·0	0·0	0·0	0·2	0·0	0·0	0·0	0·0	0·0
8– 9	0·2	0·4	0·2	0·4	0·0	0·1	0·2	0·0	0·0	0·0	0·0	0·1	0·1	0·0	0·0	0·0	0·0	0·0
9–10	0·2	0·2	0·2	0·4	0·0	0·1	0·2	0·0	0·0	0·0	0·0	0·1	0·0	0·0	0·0	0·0	0·0	0·0
10–11	0·2	0·1	0·4	0·4	0·0	0·1	0·2	0·0	0·0	0·0	0·0	0·0	0·0	0·0	0·0	0·1	0·0	0·2
11–12	0·2	0·2	0·2	0·4	0·0	0·2	0·2	0·0	0·1	0·0	0·0	0·0	0·2	0·1	0·1	0·5	0·0	0·3
p.m.																		
12– 1	0·2	0·2	0·2	0·4	0·1	0·3	0·3	0·1	0·2	0·2	0·0	0·1	0·2	0·1	0·4	0·8	0·0	0·7
1– 2	0·3	0·3	0·4	0·4	0·1	0·3	0·7	0·1	0·3	0·6	0·0	0·2	0·3	0·2	1·0	1·6	0·1	1·4
2– 3	0·5	0·7	0·6	0·5	0·2	0·4	1·5	0·3	0·6	0·9	0·0	0·3	0·8	0·1	0·9	2·5	0·1	1·3
3– 4	0·6	0·9	0·9	0·5	0·1	0·5	1·4	0·3	1·0	1·3	0·0	0·4	0·9	0·3	1·1	2·0	0·3	1·1
4– 5	0·9	0·7	1·1	0·6	0·2	0·5	1·3	0·3	1·1	1·6	0·0	0·6	0·7	0·3	0·9	1·8	0·6	0·7
5– 6	1·2	1·3	1·3	0·6	0·2	0·5	1·2	0·4	1·4	1·5	0·0	0·5	0·9	0·4	1·2	1·4	0·1	0·4
6– 7	0·9	1·4	1·4	0·5	0·2	0·4	1·0	0·4	0·9	1·2	0·0	0·4	0·7	0·3	0·6	0·7	0·0	0·2
7– 8	0·8	1·1	1·5	0·5	0·2	0·4	0·9	0·4	0·7	1·1	0·0	0·4	0·6	0·2	0·5	0·6	0·0	0·2
8– 9	0·7	0·8	1·2	0·4	0·2	0·2	0·7	0·4	0·6	0·7	0·1	0·3	0·4	0·1	0·4	0·4	0·0	0·1
9–10	0·6	0·7	1·0	0·5	0·1	0·2	0·7	0·3	0·5	0·5	0·1	0·2	0·2	0·1	0·3	0·3	0·0	0·0
10–11	0·6	0·6	0·9	0·6	0·1	0·2	0·5	0·2	0·4	0·2	0·1	0·2	0·2	0·1	0·3	0·2	0·0	0·0
11–12	0·6	0·8	0·7	0·6	0·1	0·2	0·6	0·1	0·2	0·2	0·1	0·2	0·1	0·1	0·3	0·1	0·0	0·0

Table 9 (*continued*). *Daily Incidence of Rain.* (*Hourly Total per Month in Inches*)

Time	Pontianak 1904–18 (Borneo, W. coast)			Discovery Oostbank 1920–22 (small reef in open sea)			Manado 1912–18 (Celebes, N. coast)			Koepang 1912–18 (Timor, N.W. coast)			Amboina 1905–18 (small island, coast)			Manokwari 1914–18 (New Guinea, N. coast)		
	A	B	C	A	B	C	A	B	C	A	B	C	A	B	C	A	B	C
a.m.																		
0– 1	0·4	0·2	0·2	0·1	0·0	0·1	0·9	0·1	0·2	0·7	0·0	0·1	0·1	0·8	0·2	0·3	0·2	0·3
1– 2	0·2	0·2	0·3	0·1	0·1	0·2	0·8	0·1	0·2	0·8	0·0	0·1	0·2	0·8	0·2	0·2	0·1	0·3
2– 3	0·2	0·2	0·2	0·2	0·0	0·3	0·8	0·1	0·3	0·8	0·0	0·1	0·1	0·6	0·2	0·3	0·3	0·2
3– 4	0·2	0·1	0·3	0·3	0·1	0·3	0·8	0·2	0·2	0·8	0·0	0·2	0·1	0·8	0·2	0·3	0·4	0·2
4– 5	0·2	0·2	0·2	0·2	0·4	0·2	0·8	0·2	0·2	0·7	0·0	0·1	0·1	0·9	0·2	0·2	0·5	0·2
5– 6	0·2	0·2	0·2	0·4	0·1	0·3	0·4	0·1	0·2	0·5	0·0	0·1	0·1	0·9	0·2	0·1	0·2	0·2
6– 7	0·2	0·1	0·2	0·8	0·0	0·2	0·4	0·1	0·1	0·5	0·0	0·1	0·2	0·7	0·2	0·3	0·3	0·2
7– 8	0·2	0·1	0·1	0·4	0·2	0·4	0·5	0·1	0·2	0·6	0·0	0·2	0·1	0·6	0·2	0·2	0·4	0·2
8– 9	0·1	0·0	0·2	0·3	0·3	0·4	0·3	0·0	0·2	0·6	0·0	0·2	0·2	0·8	0·2	0·3	0·2	0·2
9–10	0·1	0·0	0·2	0·2	0·2	0·5	0·4	0·0	0·2	0·7	0·0	0·1	0·2	0·8	0·2	0·2	0·6	0·1
10–11	0·2	0·1	0·2	0·1	0·2	0·2	0·7	0·0	0·2	0·7	0·0	0·3	0·2	0·8	0·2	0·3	0·4	0·2
11–12	0·2	0·1	0·4	0·2	0·1	0·4	0·9	0·2	0·5	0·6	0·0	0·3	0·3	0·7	0·4	0·4	0·2	0·1
p.m.																		
12– 1	0·3	0·2	0·7	0·2	0·2	0·6	1·0	0·4	0·8	1·0	0·0	0·4	0·2	0·7	0·6	0·2	0·2	0·2
1– 2	0·6	0·4	1·1	0·2	0·1	0·4	0·9	0·2	0·9	0·7	0·0	0·4	0·3	0·7	0·4	0·3*	0·2	0·4
2– 3	0·9	0·6	1·2	0·2	0·1	0·4	1·3	0·7	0·8	0·8	0·0	0·4	0·4	0·5	0·4	0·4	0·2	0·5
3– 4	1·0	1·0	1·3	0·3	0·3	0·1	0·9	0·7	0·7	0·8	0·0	0·3	0·4	0·4	0·4	0·7	0·2	0·6
4– 5	0·8	0·9	1·2	0·0	0·1	0·1	0·4	0·3	0·4	0·5	0·0	0·2	0·4	0·5	0·4	1·3	0·2	0·4
5– 6	0·8	0·8	0·9	0·1	0·0	0·1	0·4	0·2	0·3	0·8	0·0	0·2	0·5	0·6	0·4	1·6	0·1	0·6
6– 7	0·7	0·6	0·9	0·1	0·0	0·0	0·5	0·1	0·3	0·6	0·0	0·1	0·3	0·5	0·3	0·7	0·1	0·7
7– 8	0·6	0·5	0·7	0·1	0·0	0·0	0·9	0·0	0·2	0·6	0·0	0·1	0·2	0·6	0·3	0·6	0·1	0·7
8– 9	0·4	0·4	0·7	0·1	0·0	0·0	0·6	0·0	0·2	0·4	0·0	0·1	0·2	0·6	0·2	0·5	0·1	0·6
9–10	0·4	0·4	0·5	0·2	0·0	0·0	0·7	0·0	0·4	0·5	0·0	0·1	0·2	0·6	0·2	0·7	0·2	0·5
10–11	0·4	0·2	0·3	0·1	0·0	0·2	0·5	0·0	0·3	0·4	0·0	0·1	0·2	0·7	0·2	0·3	0·1	0·4
11–12	0·4	0·3	0·3	0·1	0·0	0·1	0·6	0·1	0·2	0·6	0·0	0·0	0·1	0·8	0·3	0·3	0·2	0·4

Source: C. Braak, 'Het Klimaat van Nederlandsch-Indië', vol. 1, part 3, pp. 183–193.

Table 10. *Number of Days per Month and Year with more than 0·5 mm.* (0·02 in.) *of Rain*

Place	Period of observation	J.	F.	M.	A.	M.	J.	J.	A.	S.	O.	N.	D.	Total
Fort de Kock	1879–1922	18·1	15·2	17·3	18·6	14·7	11·9	10·7	14·5	16·3	19·0	19·2	19·6	195
Padang	1879–1922	15·9	13·5	14·9	17·1	13·8	11·7	11·9	14·1	16·5	19·5	21·4	19·4	190
Pontianak	1879–1922	16·0	13·5	14·1	15·9	15·2	12·9	10·1	12·5	13·2	19·0	20·6	18·4	182
Balikpapan	1899–1922	12·7	13·0	13·6	12·0	11·7	11·1	10·2	9·8	8·1	9·6	11·3	13·7	137
Batavia	1879–1922	19·7	20·3	15·8	12·1	8·6	7·8	5·8	4·2	6·4	9·0	13·2	15·9	138
Bandoeng	1879–1922	16·3	16·5	17·3	16·5	10·3	8·4	5·4	4·7	7·2	11·3	16·7	15·7	146
Pasoeroean	1888–1922	17·1	19·4	14·5	9·3	6·2	5·0	1·9	0·6	0·5	1·5	5·4	13·1	94
Tosari	1895–1922	20·0	21·1	19·3	13·8	10·4	6·3	4·4	3·2	3·1	7·2	14·5	18·7	142
Manado	1879–1922	20·9	19·8	15·5	13·3	12·7	13·0	9·1	8·6	7·8	10·1	14·4	19·0	164
Makassar	1879–1922	24·1	22·0	17·7	10·7	7·5	6·7	4·0	2·2	1·9	4·5	11·9	21·7	134
Koepang	1879–1922	17·6	17·3	11·8	25·1	2·9	1·1	0·8	0·3	0·3	1·4	7·4	14·7	80
Manokwari	1900–1922	16·0	14·9	16·0	14·7	11·8	12·9	10·4	11·0	9·3	8·9	9·8	14·5	150

Source: C. Braak, 'Klimakunde von Hinterindien und Insulinde', p. 116 (Berlin, 1936); this is *Band* IV, *Teil R*, of *Handbuch der Klimatologie*, edited by W. Köppen and R. Geiger.

Table 11. *Mean Number of Days per Month and Year with Thunder*

Place	Period of observation	J.	F.	M.	A.	M.	J.	J.	A.	S.	O.	N.	D.	Total
Fort de Kock	1916–19	10·5	11·5	13·3	19·3	13·3	8·9	10·3	11·1	13·5	10·1	9·1	6·9	138
Pontianak	1916–19	5·2	5·7	8·8	9·1	6·6	5·9	3·7	5·2	6·6	7·9	6·4	2·0	73
Batavia	1916–19	10·6	12·4	14·0	14·7	11·8	7·4	4·2	8·8	9·9	12·8	18·1	11·1	126
Buitenzorg	1916–19	27·8	27·7	25·5	27·9	26·3	25·2	23·1	23·9	28·7	29·8	26·7	29·8	322
Bandoeng	1916–19	23·6	26·2	22·9	22·1	19·4	9·6	4·7	11·8	11·5	20·9	22·1	23·4	218
Manado	1916–19	3·2	5·4	1·3	4·4	4·6	2·0	0·3	2·7	2·3	3·4	3·9	1·7	35
Amboina	1916–19	6·6	6·5	6·9	6·1	2·3	2·5	1·8	2·3	3·0	3·9	8·9	6·4	57
Koepang	1916–19	9·5	8·9	6·2	2·3	0·5	0·0	0·0	0·5	0·3	4·7	11·5	22·1	66
Manokwari	1916–19	9·5	7·9	13·7	16·2	12·3	4·6	5·9	10·6	8·9	12·8	11·2	11·8	126
Herbertshöhe	1902–5	7·4	6·2	7·2	6·8	4·2	1·0	3·2	2·7	4·8	5·2	10·1	10·8	70
Labuan	1924–27	3·4	4·1	4·1	5·9	3·9	4·1	5·4	5·1	6·9	4·1	5·3	4·1	56
Medan	1916–19	9·1	8·9	15·7	21·3	20·4	14·7	17·0	18·7	14·7	18·0	15·7	12·6	187

Source: C. Braak, 'Klimakunde von Hinterindien und Insulinde', p. 116 (Berlin, 1936); this is *Band* IV, *Teil R*, of *Handbuch der Klimatologie*, edited by W. Köppen and R. Geiger.

Chapter XI

SOILS

Soil-forming Processes: Soil and Natural Vegetation:
Soil and Agriculture: Soil Erosion: Bibliographical Note

In the Netherlands Indies there is a great variety of soils both in different islands and from place to place in the same island. Within the space of a few miles the soil may change completely and a soil map of almost any of the islands would look like a complicated mosaic. Differences of soil which appear slight to the eye may be of great importance for the growth of plants both wild and cultivated; consequently they have a great effect on animals and on the human population. The geographer and the economist, therefore, no less than the botanist and agriculturist, need to know something of these soil differences and their underlying causes.

Soil-Forming Processes

Soils are formed by the breakdown or weathering of mineral materials, which may be hard rock, soft alluvium, volcanic ash or some other deposit. The process of weathering is long and complicated. Climate and parent material, the plants and animals living in the soil and on its surface, as well as physical factors such as slope and drainage, all play a part in determining its speed and final result. The factors governing soil development—climate, parent material, plants and animals, relief and drainage—are interconnected in a very complicated way. Now one, now another, seems to play the leading part and we are compelled to regard all of them as forming a single very complex system in which no one component can change without affecting all the others. Because the parent rock is only one among a number of factors determining the nature of the soil, a soil map by no means coincides with a geological map. The soil map shows a relation as close or closer to a map of climate or natural vegetation.

Weathering

Weathering of rocks is of two kinds, mechanical and chemical. In mechanical weathering the rock or other mineral material is broken down to finer particles by frost and sudden changes of temperature.

In the East Indies, where frost is unknown except at high altitudes and the temperature varies only within narrow limits, mechanical weathering is of little importance. The breakdown of rocks here, as in all tropical countries, is brought about mainly by chemical changes and in these rain water, with carbon dioxide in solution, plays the chief part.

The complex silicates which form the main constituents of most rocks are first of all broken down by hydrolysis to less complex substances, chiefly bases, silica, alumina, kaolin (hydrated aluminium silicate) and iron oxides. These products, in their turn, undergo further changes, while some constituents of the parent rocks, materials such as quartz, remain unaltered or weather extremely slowly. The rain can thus be said to act as a solvent on the rocks, though strictly speaking it first converts certain of their constituents from insoluble to soluble substances and then dissolves them.

Looked at from a geological point of view, weathering is a very rapid process, but by the human time-table, it is slow. Since the most important processes involved are chemical the rate depends directly on the temperature. In a hot climate like that of the lowlands of the East Indies, where the soil temperature is 25° C. (77° F.) at a depth of a metre (39 in.) and varies very little, soil formation goes on enormously faster than in a temperate climate, such as that of Europe or even of the high mountains of Java and New Guinea.

Even after a soil has come into existence weathering still continues. Like an organism the soil develops, and we can speak of it as being young and immature, or old and mature. The measure of its age however, is not its actual age in years, but the degree to which weathering has advanced, or the amount of weatherable material remaining in it. As the rate of weathering depends on many factors, it is not surprising that two soils of the same actual age may be at very different stages of maturity. The great diversity of soils in the Netherlands Indies is thus due partly to the variety of parent materials and partly to the existence of soils at different stages of maturity derived from the same materials.

Movement of water in the soil

In addition to temperature the climatic factors which most influence soil development are rainfall and evaporation, or rather the ratio of rainfall to evaporation. When rainfall exceeds evaporation, and provided the soil is sufficiently porous, the movement of water in the soil must be mainly downwards, the excess draining away to streams

and rivers. When rainfall is less than evaporation, this downward movement does not occur. Whether there is a downward movement or not is of fundamental importance for soil development. Descending water consists of rain water, that is water with a small amount of air, including carbon dioxide and nitrogen compounds, in solution. As it passes down through the soil, the rain water takes up a certain amount of organic matter from the dead plant and animal remains at the surface, it becomes richer in carbon dioxide and dissolves small quantities of salts. It is this very dilute solution which acts on the rock beneath. On the other hand where there is no downward movement, there is no tendency for salts to be removed from the soil; on the contrary, they may accumulate in the surface layers. Since the soluble substances include the mineral nutrients of plants, where the downward movement of water predominates the trend of soil development may be said to be towards soil impoverishment, while where there is no such movement the trend may be towards soil enrichment. Similarly because the soluble substances include bases, soils with a predominantly downward water movement tend to become acid, while those without it remain basic.

Over the greater part of the Netherlands Indies, including Sumatra, Borneo, West Java and much of New Guinea, the rainfall is heavy and fairly evenly distributed throughout the year. Rainfall exceeds evaporation and the movement of soil water is mainly downwards. Under these conditions, though the natural vegetation is luxuriant tropical rain forest, the soil is not suited to permanent agriculture, except under special local conditions, though where it is still immature it may be very fertile for a time. In central and east Java, Bali, Lombok and other islands where there is an east monsoon and several consecutive months are nearly rainless, for part of the year the downward water movement ceases and the process of soil impoverishment is checked. The soils in this part of the archipelago are on the whole very fertile, hence the contrast between the dense population and ancient civilization of east Java and the comparatively thin population of west Java.

Formation of podzols and laterites

The descending water current removes the primary products of weathering in the order of their solubility. The first to go are the highly soluble bases. These are washed down from the upper into the lower layers of the soil; eventually they are carried away in the drainage water, though for a while they may be retained by adsorption

on humus or other colloidal substances. Later the silica, alumina and iron oxides may follow suit, but the order in which they are removed depends largely on the amount of organic matter carried in the soil water. In water containing large quantities of organic matter alumina and iron oxides are more soluble than silica, thus silica remains behind, while alumina and iron oxides are carried down into the deeper layers; under these conditions the mature soil consists largely of silica and owing to the loss of iron oxides, to which most soils owe their colour, it has a bleached or whitish appearance. In water containing little or no organic matter, silica is more soluble than alumina and iron oxides. Silica is therefore carried down, while as the soil matures it tends to consist more and more largely of alumina and iron oxides, the latter giving it a red, yellow or brown colour. The process by which alumina and iron oxides are removed preferentially leaving silica behind is called *podzolization;* the opposite process is *laterization.* The soils ultimately resulting from these processes are respectively called podzol and laterite. Laterite is a bright red rock-like soil consisting of little else than alumina and iron oxides. It is a highly infertile soil, but fortunately it does not appear to be of common occurrence, at least in the Netherlands Indies. Generally the process of laterization stops short of true laterite and then the mature soil is termed lateritic. The degree of laterization can be measured by determining the ratio of silica to alumina and iron oxides in the clay fraction of the soil.

The amount of organic matter in the soil water, which thus has such an important effect on soil development, is mainly a function of temperature. In a well aerated soil dead leaves and other organic remains are acted on by fungi and bacteria which gradually convert them to a mixture of substances, usually brown or black in colour, known as humus. In course of time the humus itself is attacked and converted mainly to carbon dioxide and water, any mineral matter in it being set free in the soil. The amount of humus in the soil depends on the balance between the rate of formation and the rate of breakdown of organic matter. Where humus is formed faster than it is broken down, it will tend to accumulate; where the breakdown is faster than the formation the soil will contain little or no humus. The relative speed of the two processes depends on temperature. Where it is high, as in tropical lowland soils, plant growth is luxuriant and dead plant remains are continually being added to the soil in great quantities; on the other hand the high temperature also accelerates the action of micro-organisms, so that the plant remains are broken

down as fast as they are deposited. It is found that at a temperature of 25° C. (77° F.) or higher, under conditions of good aeration, the breakdown processes overtake the formation of organic matter; in practice this does not mean that there is no humus at all, but the quantity is relatively small. Below 25° C. the rate of formation of organic matter exceeds the rate of breakdown and humus tends to accumulate.

What has been said is only true as long as the soil is well aerated. When it is badly aerated, that is to say when there is a deficiency of oxygen, as when the soil is waterlogged, the activity of the micro-organisms is hindered and humus may accumulate even at temperatures over 25° C. This is especially liable to happen when the ground water is exceptionally poor in lime and other bases, as when it drains rocks initially very poor in these substances. In the lowlands of Sumatra and Borneo under such conditions humus may accumulate to such an extent that layers of peat are formed, sometimes many feet thick.

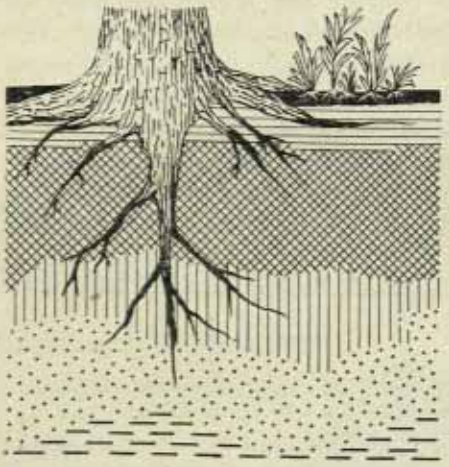

Fig. 129. Profile of a tropical red earth
Source: P. Vageler, *An introduction to tropical soils*, plate IX (London, 1933).

In the lowlands of the Netherlands Indies then, except in swamps, the soil contains very little humus and the descending current of soil water will be deficient in organic matter. If this is so, silica, as has been shown, will be removed preferentially to alumina and iron

oxides; the dominant soil-forming process will be laterization. Where there is in addition a high and well-distributed rainfall a reddish lateritic soil is formed known as a tropical red earth (Fig. 129). This is the characteristic soil of most of the region in which the tropical rain forest is the natural type of vegetation (see p. 381), that is to say in a broad belt stretching from Sumatra and west Java, through Borneo to the northern Moluccas and New Guinea. Where the rainfall is particularly heavy and there is practically no dry season, lateritic soils are found which are yellowish or brownish rather than red. These soils are often distinguished from the tropical red earths as tropical yellow earths. As they do not differ chemically from the red earths except in the higher degree of hydration of the iron oxides, the distinction seems of little importance.

In the higher mountains of Sumatra, Java, Borneo, etc. the mean temperature is less than 25° C. (it falls about 1° C. for every 160 m. of ascent), so that humus accumulation becomes possible. The consequence of this is that alumina and iron oxides, not silica, will be removed from the soil in weathering, podzolization becoming the chief soil-forming process. The resulting soil is pale in colour, not red like a tropical red earth, and is known as a bleached earth. The superficial layers of these soils are coloured black or dark brown by humus. In many respects these soils resemble the podzols which are the characteristic soils of cool, moist climates, for instance, in northern Europe. The change in character of the weathering products from the same rocks with increasing altitude can be well followed on the older volcanoes of the Preanger residency in west Java, as shown diagrammatically in Fig. 130.

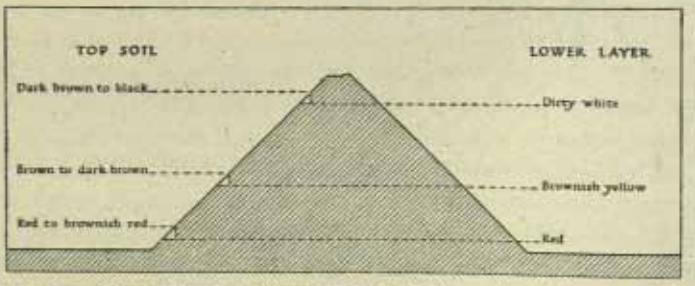

Fig. 130. Change in soil colour with altitude on the volcanoes of the Preanger Residency, Java

Based on E. C. J. Mohr, 'Tropical soil-forming processes and the development of tropical soils with special reference to Java and Sumatra', *College of Agriculture, University of the Philippines, Experiment Station Contribution No.* 655 (Philippine Islands, 1930).

It will now be useful to summarize the chief combinations of rainfall, evaporation, temperature and drainage, and the chief characteristics of the main soil types associated with them:

1. High temperature (mean 25° C. or higher). Rainfall greater than evaporation throughout the year. Drainage good (i.e. soil well aerated). Main soil-forming process laterization, leading to the formation of tropical red or yellow earths.

2. Low temperature (mean under 25° C.). Rainfall greater than evaporation throughout the year. Drainage good. Chief soil-forming process podzolization, leading to the formation of bleached earths.

3. High temperature (mean 25° C. or higher). Dry season long, with several almost rainless months. Drainage good. Bases tend to collect near the surface during the drought period and these give the humus a characteristic intense black colour. These soils may be provisionally termed black earths.

4. High temperature (mean 25° C. or higher). Rainfall greater than evaporation throughout the year. Soil waterlogged or under water through the greater part of the year. A type of bleached earth develops, consisting of little else than kaolin and silicic acid. If the parent material and the ground water are very deficient in bases, peat formation may take place.

5. High temperature (mean 25° C. or higher). Dry season long. Soil waterlogged or submerged during the wet season, drying out and becoming alkaline during the dry season. The soils formed are black like 3, but have more humus and less base.

The above five soil types are only general categories; within each there are many variations.

Influence of parent material

Little has been said so far about the effect of different parent materials on soil formation. In the tropics the influence of differences in the parent materials is certainly less marked than in most other climates and almost identical soils can develop from very diverse rocks. Tropical red earths, for instance, can arise from parent materials as different as granite and soft Tertiary limestones. The physical and chemical characteristics of the rock are not however altogether unimportant. For instance, passing eastwards from western to eastern Sumatra through Java to Bali and Lombok the igneous rocks become on the whole more basic and less acid. This change is accompanied by an increase in the soil fertility, because the older acid rocks contain

less calcium and phosphorus and weather more slowly than the younger volcanic rocks, thus giving rise to poorer soils. A very striking example of the influence of the parent rock is the development of podzols on certain coarse sands and sandstones in the lowlands of Borneo and Bangka (and probably elsewhere). Usually, as already noted, the chief soil-forming process under lowland tropical conditions is laterization. Why laterization should be locally replaced by podzolization is far from clear, but evidently it is connected with the nature of the parent rock, which is very porous and extremely deficient in bases.

No attempt will be made here to sketch in more detail the regional distribution of the various soil types in the Netherlands Indies, indeed much of the necessary information for doing so is not available. There is, however, an excellent regional account of the soils of Java and Sumatra in Mohr's admirable work, referred to at the end of this chapter.

Soil and Natural Vegetation

In the British Isles the correlation of soil and vegetation is very striking. A characteristic vegetation, for instance, is associated with calcareous soils derived from chalk and limestone and when the soil changes from a calcareous type to a non-calcareous type, such as an acid sand, the natural vegetation immediately changes also. The relation of vegetation to soil is so close that the natural vegetation is generally a sure index to the type of soil.

In tropical countries such as the Netherlands Indies the influence of soil on the natural vegetation is usually much less marked, though each of the main types of soil is associated with a type of natural vegetation, for instance tropical red and yellow earths with tropical rain forest, bleached earth with montane (or temperate) rain forest. Bare limestone crags, such as are found in parts of Borneo and Celebes, seem to have a special flora, but soils derived from limestone may have a vegetation little different from soils derived from entirely different rocks, such as granite. The reason for this is not difficult to understand; the influence of the climate is so powerful that it tends to override differences of soil due to different parent rocks. As we have seen, in a damp lowland tropical climate granite and limestone alike eventually weather to tropical red and yellow earths.

The importance of soil in determining the type of natural vegetation in the tropics, must not, however, be underestimated. In

chapter XII several examples are given of types of vegetation in the Netherlands Indies which are restricted to special types of soil.

Soil and Agriculture

When the natural vegetation is destroyed and replaced by an agricultural crop, differences of soil which showed little effect on the original vegetation may take on great importance. An appreciation of these soil differences and their effects may therefore decide the success or failure of the crop. To understand why this is so, it is necessary to consider the relation of vegetation to soil a little more closely.

It is a remarkable fact, and one which is very disconcerting for the agriculturist, that a soil which under natural conditions bears a luxuriant rain forest, when cleared and cultivated, may give good crops for only a very few years or may prove a total failure from the start. The explanation lies in the fact that the plant nutrients such as salts containing calcium, phosphorus, potassium, etc., on which soil fertility largely depends, constantly circulate between the plants and the soil. These plant nutrients, as has already been shown, are among the first products of rock weathering and are also the most soluble. In a damp climate the percolation of water through the soil continually tends to wash these soluble nutrients from the upper to the lower layers of the soil, where they may be out of reach of the plant roots. Eventually they are lost in the drainage water which carries them down to the sea. When there is a covering of natural vegetation, for instance a tropical rain forest, a large proportion of these nutrients is taken up by the plant roots immediately they are set free by weathering. Part is also held by adsorption on the humus and colloidal clay particles. When the plants shed their leaves or die their dead remains are converted to humus and the mineral nutrients are again set free in the soil. There they are of course immediately taken up again by plant roots or adsorbed by colloids. Thus after they are liberated from the rocks the mineral nutrient substances are always circulating from soil to plant and back again. Only a small amount is lost in the drainage water and this is made good by fresh supplies set free by weathering. There is thus a nearly perfect equilibrium between vegetation and soil, an illustration of the statement made earlier that plants and soil form parts of a single interconnected system.

When the forest is cleared to make way for cultivation this

equilibrium is suddenly upset. The felled trees are either burnt or left to rot at the surface of the soil. Their remains are rapidly converted to humus by micro-organisms and the humus itself is broken down to carbon dioxide and water. When the soil surface is exposed to the direct rays of the sun, the soil temperature goes up and the breakdown of organic matter is accelerated, so that the small amount of humus previously present in the soil soon disappears. The net result of all this destruction of organic matter is that most of the mineral matter which was safely locked up in living plant tissues and in the humus is suddenly set free. As one writer puts it: 'The entire mobile stocks of mineral nutrients are put into liquidation and, as is usual at a forced sale, they go at give-away prices and the advantage reaped is nothing like commensurate with their value'. The sudden release of mineral matter may mean that very good crops can be obtained for a few seasons, but as the minerals are gradually washed away by the rain and removed in the crops the soil becomes less and less fertile until it soon becomes unprofitable to cultivate.

It is now easy to see why the native agriculturist prefers the extremely destructive system of shifting cultivation in which only a very few crops are taken from the same piece of ground. Much European agriculture in the tropics, including the Netherlands Indies, has been little more permanent. The forest has been cleared, the mineral capital of the soil consumed in a very few years and then the land has been abandoned. This sort of procedure is clearly an abuse of the land and has justifiably been called 'soil mining'.

The first aim of any stable system of tropical agriculture must be to conserve soil fertility. This can be done by planting a ground cover to prevent exposure of the soil to the sun, and by other measures. Even with the most careful system of soil conservation, it is doubtful whether many soils in the wetter parts of the Netherlands Indies can maintain their fertility for long under ordinary crops. In such climates these soils would probably be best left under their natural forest cover.

The fertility of the soil and the length of time which it is maintained will depend to a large extent on the initial richness of the parent rock in calcium, phosphorus, potassium and the other plant nutrients, as well as on the speed of weathering. It has already been noted that the young volcanic rocks of east Java and Bali, which have a higher base content and weather more quickly, give rise to more fertile soils than the older acid rocks found, for example, in the Batak region of Sumatra (cf. p. 61). The native cultivator is often well aware of

the difference in fertility of soils derived from different rocks. Near Fort van der Capellen in Sumatra the native farmers plant fruit trees on hills of granitic rock, but the quartz-rich Eocene marl, shales and conglomerates are left alone; these rocks are *batoe-mati* (dead rocks).

A very important factor in maintaining the fertility of the soil in the East Indies, especially in Java, is the volcanic eruptions, which cover the ground with volcanic ash, mud flows, etc. This volcanic material is very rich in plant nutrients and weathers quickly. It greatly increases the fertility of the land and rejuvenates exhausted soils. A typical example of this rejuvenation is the improvement in the fertility of the southern Lampoeng district of Sumatra by the eruption of Krakatau in 1883, the good effects of which are still apparent at the present day (see also pp. 25 and 155).

Soil Erosion

No account of tropical soils is complete without some reference to erosion. In the tropics the rain is as a rule far more violent than in temperate climates. Not uncommonly 12 cm. or more will fall in an hour, and far more of the rain falls as heavy downpours, often during thunderstorms, than as persistent gentle rain. This great intensity of rainfall means a constant tendency for the soil to be washed away bodily, especially on steep slopes. In extreme cases all the soil may be carried away leaving only the naked rock. The activity of erosion is well seen on the bare volcanic cones of Java which very soon become carved into a multitude of gullies and ridges (Plate 105). The power of erosion in the tropics is witnessed by the extreme muddiness of most tropical rivers. The rivers of Java carry 300–2,000 gm. of silt per cubic metre, the Irrawaddy 766, the Ganges 1,981, compared with 40 in the Seine and 54 in the Rhine (cf. p. 139).

The amount of erosion from the soil surface is of course largely determined by the nature of the plant covering. Under dense forest, such as a tropical rain forest, erosion is reduced to the minimum, but when the forest is cleared and the soil laid bare, erosion is given its opportunity. An essential for stable agriculture in a climate like that of the East Indies is a method for preventing excessive erosion. One of the main reasons for the dense population and relative prosperity of Java and Bali is that the natives have developed a system of terrace cultivation which is extraordinarily successful in checking erosion. This system has been encouraged, copied and extended by the Dutch (see Plates 33, 36 and 73).

BIBLIOGRAPHICAL NOTE

The standard work on the soils of the Netherlands East Indies is E. C. J. Mohr's valuable *De Grond van Java en Sumatra*, Edition 2 (Amsterdam, 1922). There is a mimeographed English translation by R. L. Pendleton under the title *Tropical Soil Forming Processes and the Development of Tropical Soils, with Special Reference to Java and Sumatra*, College of Agriculture, University of the Philippines, Experiment Station Contribution No. 655, 1930.

Other important works are *De Eigenschappen van de Suikerrietgronden op Java* by C. H. van Harreveld-Lako, Groningen, 1928 (English translation by R. L. Pendleton entitled *The Properties of Sugar Cane Soils in Java*, Peiping, 1932) and *Biological Processes in Tropical Soils* by A. S. Corbet (Cambridge, 1935). The latter deals primarily with British Malaya.

The Rape of the Earth, a World Survey of Soil Erosion by G. V. Jacks and R. O. Whyte (London, 1939), gives interesting details and illustrations of methods of combating erosion in Java.

Chapter XII

VEGETATION

Introduction: Flora: Types of Vegetation: Coastal Vegetation: Tropical Rain Forest: Special Types of Primary Forest: Secondary Vegetation: Monsoon Forest: Savanna: Mountain Vegetation: Bibliographical Note

Introduction

Botanically the Netherlands Indies form part of Indo–Malaya, a plant-geographical region which includes not only the Philippines and the whole of the Malay Archipelago, but a vast section of the earth from India in the west to New Guinea and the Fiji Islands in the east, and extending north as far as Formosa and southern China. Throughout this region the vegetation has a certain similarity and in the islands of the Netherlands Indies it is on the whole very like that of the neighbouring continents. The vegetation of Sumatra, for instance, does not differ in any important respects from that of the Malay Peninsula, while that of Timor and the other islands in the south-east of the Archipelago is much like that of northern Australia.

The greater part of Indo–Malaya lies within the tropics and much of it has a heavy, evenly distributed rainfall, a climate which favours plant growth at all seasons of the year. It is not surprising therefore that among the great regions of the world Indo–Malaya is unequalled for the luxuriance of its plant life and the richness of its flora. This is especially true of the islands composing the Netherlands Indies. Many of them are covered with magnificent virgin forests and even in densely populated areas, such as Java, where the original vegetation has largely made way for cultivation, towns and villages seem half buried in a mass of vegetation which grows with almost overpowering vigour.

Flora

This luxuriant vegetation is made up of a vast wealth of species, especially of trees—indeed for its size the Netherlands Indies is probably one of the richest countries in the world in plant species. The flora is still so little known that no accurate figures can be given, but van Steenis estimates the total number of flowering plants at 20–30,000 species. In the island of Borneo alone there are probably, according to Merrill, at least 10,000 species. These figures may be

compared with some 2,000 species in the British Isles and some 6,000 in the whole of tropical West Africa, the area of which is at least 2½ times as great as that of the Netherlands Indies. Of the 20–30,000 species, some 3,000 (10–15%) are trees with trunks over 40 cm. (16 in.) in diameter, for here, as in all damp tropical climates, woody plants form a large fraction, probably a majority, of the whole flora. By contrast, in the British Isles barely 1% of the native species are large trees. The extraordinary richness of the flora has been an obstacle to the botanical investigations of the islands and in nearly all of them a large number of the species are unnamed and undescribed. Only for Java is the flora even approximately completely known.

Among the enormous number of species of which the flora of the Malay Islands is composed are some of the strangest and most remarkable forms of plant life found anywhere in the world. To mention only two examples, the Netherlands Indies is the home of *Rafflesia Arnoldi*, a parasitic plant with flowers up to a metre (over a yard) across, and of the genus *Nepenthes*, the most elaborate and beautiful of the insect-eating pitcher plants (Fig. 131).

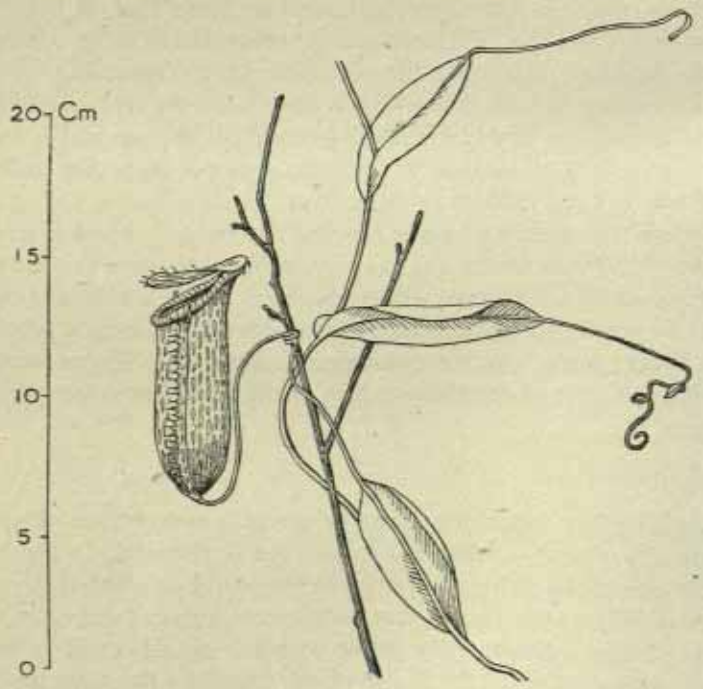

Fig. 131. Pitcher Plant (*Nepenthes tentaculata*) (from a drawing by P. W. Richards)

The richness of the flora of the Netherlands Indies is due partly to its warm and predominantly moist and equable climate, which has probably been not very different from what it now is since a very distant geological period, and partly to the very varied relief and the large number of islands into which the land area is split up. In many of the islands it is only a journey of a few miles from coastal swamps to high mountains and the vegetation changes with a no less dramatic suddenness.

A further factor which has contributed to the richness of the flora is the situation of the islands between the two great land masses of Asia and Australia. During their eventful geological history, streams of plant migration have flowed through the islands northwards as well as southwards, and though the bulk of the flora is certainly of Asiatic origin, there are many species whose relatives are mostly Australian. The two elements, Asiatic and Australian, are much intermingled and it is doubtful if any line can be drawn for plants such as Wallace's Line for animals, which divides the archipelago into a western half with a mainly Asiatic fauna and an eastern half with a mainly Australian fauna (see p. 280).

Types of Vegetation

Almost the whole of the Netherlands Indies was originally forest covered. Except for a few of the highest mountain tops and a few small areas where the climate may be too dry for trees (e.g. the Paloe district in Celebes, with a rainfall of less than 500 mm.) the whole land area is potentially forest, and by far the greater part of it was actually forested until very recently. At the present day, however, a large and ever-increasing area of the original forest has been destroyed and replaced by cultivation or semi-natural vegetation such as *alang-alang* grassland, savanna or scrub of various types. These types of semi-natural vegetation owe their existence to felling, burning and grazing; they cover an area which is probably far greater than that actually under cultivation. This is mainly because of the widespread practice of *ladang* or shifting cultivation, a system under which forest is cleared by felling and burning to provide land for cultivation, but very few crops (often only two) are taken successively from the same piece of ground. The land is afterwards abandoned and is invaded by weeds and semi-natural vegetation. If it is not further interfered with a *bloekar* or secondary forest will grow up in a few years. This is less tall but more impenetrable than the original virgin forest and consists of trees mostly worthless as timber. As the natives who practice

shifting cultivation prefer to grow their crops on virgin soil and rarely return to an old site, even after a long period of years, prodigious areas of virgin forest are destroyed every year. In spite of this 'robber cultivation', the area of forest in a more or less primitive condition is still very great, for in the Buitengewesten (Outer Territories) 1,233,000 hectares or 70% of the land area is forested. This figure includes secondary forest (*bloekar*) inside forest reserves but not outside them. As might be expected, the extent of the surviving virgin forests varies inversely with the local density of the population; Borneo, for instance, which is relatively thinly populated, is still very largely forest covered (in South and East Borneo 89% of the area is forested), while Java and Madoera have been to a great extent deforested and only 39% of the area is now forest.

Vegetation and climate

The virgin forest of the lowlands is not uniform, but belongs to two main types depending on a difference of climate. Where the rainfall is evenly distributed through the year and there is no strongly marked dry season the natural forest is a tall and luxuriant evergreen type known as tropical rain forest. This kind of forest covers vast areas in the Malay Peninsula, Siam and Indo-China and occurs more locally in India, Burma and Queensland. Further afield it is found in tropical Africa and in South and Central America. The other main type is the tropical deciduous or monsoon forest, which is found where there is a dry season with several consecutive almost rainless months. The monsoon forest is more open and less tall than the rain forest and is considerably less rich in species, but its most striking characteristic is that most of the taller trees are not evergreen but shed their leaves during the annual dry season. Forests similar to the monsoon forest of the Netherlands Indies cover large areas in India, Burma, Siam and tropical Australia. A corresponding type of deciduous forest occurs in parts of South America and tropical Africa where there is a well marked dry season. The difference between the monsoon forest and the tropical rain forest is not always sharp and a number of intermediate types exist.

The tropical rain forest is the natural forest type in the lowlands and lower mountain slopes over all the northern and western parts of the Netherlands Indies, in fact it forms a broad belt stretching from Sumatra through Borneo, Celebes and the northern Moluccas to New Guinea. The distribution of the monsoon forest is more restricted; it occurs only in the south-eastern part of the archipelago where during

part of the year the climate is dominated by a dry wind from Australia, the so-called 'east monsoon'. The division between the two main types of forest cuts across Java; the western provinces belong to the tropical rain forest area, the rest of the island from about Krawang eastwards (including Madoera) to the monsoon forest area (Fig. 136).

A careful study of the distribution of the natural vegetation in Java shows that the relation of vegetation to climate is by no means simple. The boundary between rain forest and monsoon forest is not determined by any simple meteorological factor such as the total annual rainfall or even the number of rainy days. The effect of climate on vegetation is so much modified by local features such as drainage and porosity of soil that no such simple relation is to be expected. It is clear however that the boundary is closely related to the length of the dry season, in other words, to the intensity of the 'east monsoon'. It has been shown that the number of rainy days during the four driest months of the year has a very significant relation to the distribution of certain plants. Thus the pitcher plant *Nepenthes gymnamphora* grows in Java only where there are at least thirty rainy days in the four driest months; it is therefore found only in west Java and certain small areas in central and east Java where there is a locally moist climate. The grass *Andropogon contortus* on the other hand prefers a dry climate and shows the opposite kind of distribution; it is found (with a few exceptions) only in localities with less than ten rainy days in the four driest months. Similar relations seem to govern the distribution of certain agricultural crops; the area of successful tea cultivation lies entirely within the region with at least thirty rainy days during the dry months; large scale cultivation of sugar cane on the other hand is only possible in districts where the number of rainy days during the dry months does not much exceed twenty.

Most of the islands of the Netherlands Indies are more or less mountainous and three chief zones of vegetation can be distinguished, the coastal vegetation, the vegetation of the lowlands (including the lower hills and lower slopes of the mountains) and the mountain vegetation. As the contrasts between the vegetation in the different zones of the same island are far more striking than those between the vegetation of one island and another, it will be more convenient to consider the vegetation of the whole archipelago zone by zone than to take it island by island. Both the coastal and the mountain vegetation are, to a certain extent, uniform through all the islands, but the lowland vegetation, as has been seen, has two climatic divisions, the

tropical rain forest and the monsoon forest area, which must be considered separately.

Coastal Vegetation

On rocky shores seaweeds (algae) grow between and just below the tide marks. Here and there also in shallow water grow marine flowering plants, similar to the eel grass (*Zostera*) of the British coast. In sheltered bays there are sometimes veritable 'submarine pastures' of these submerged flowering plants.

At a slightly higher level grows the coastal vegetation proper, and under this term may be included all land vegetation growing near enough to the sea or to estuaries for the ground water to be salt or brackish. All of it is either covered periodically by certain tides, liable to occasional flooding by sea water or exposed to sea spray. Behind this coastal vegetation there is often a wide belt of swamp forest in which the ground water is fresh or only very slightly brackish: these freshwater swamps will be described later in connexion with the lowland rain forest.

The coastal vegetation is very different according to whether the shore is rocky, sandy, muddy or made of coral. On sandy shores low growing herbs, grasses and shrubs are found, similar to the strand vegetation of beaches in Europe. In some places a type of forest with a very characteristic composition is found behind the strand vegetation; this is the beach forest. On coral reefs and on sheltered muddy shores, including those of estuaries, is found the mangrove forest, a peculiar type of forest flooded by high tides. On rocky shores the lowland forest, or some other non-coastal type of vegetation, generally comes down almost to high tide mark, but sometimes there is a narrow fringe of poorly developed mangrove or beach forest.

The colonization of sandy beaches begins at or near the drift line. The species found are few in number and are specially adapted to the peculiar conditions under which they live. Among the commonest are *Ipomoea pes-caprae*, a convolvulus with a long trailing stem, and prickly-looking grasses belonging to the genus *Spinifex*. Unlike most land plants these strand plants are not injured by occasional flooding by salt water. Most of them have creeping stems and, like other plants tolerant of salt water, fleshy leaves. The seeds or fruits can generally float in water and are carried from place to place by ocean currents. How effective is the dispersal of these seashore plants was strikingly shown on the small volcanic island of Krakatau in the Soenda strait. In the famous eruption of 1883 the original vegetation was entirely,

or almost entirely, destroyed, yet when the island was visited three years later, eight species of plants had already established themselves on the beach. The colonization of newly emerged coral islands by plants is equally rapid.

Beach forest

If the beach is wide enough and the vegetation is left to develop as it will, shrubs and later trees appear and eventually a beach forest is built up. A well developed beach forest forms a narrow zone, usually under 100 m. wide, and the trees, which mostly belong to species rarely seen inland, may reach a height of 30 m. or more. Very often, however, the beach forest is destroyed or reduced to a mere vestige to make room for plantations of coconut palms. The most conspicuous and characteristic tree of the beach forest is *Casuarina equisetifolia* (tjemara or ru), which is related to the she-oaks of Australia, and has the appearance of a conifer. This tree is widely spread through all the islands (though in Java it is rather rare) and in some places it forms almost pure stands. Other species of the genus are found in the inland and mountain forests. Other noteworthy trees of the beach forest are the strange-looking 'screw pines' (species of *Pandanus*), *Calophyllum inophyllum*, an evergreen tree with broad leathery leaves, and species of *Barringtonia*. The last-named is so characteristic that the beach forest is often termed the '*Barringtonia* formation'. The coconut palm which is so characteristic a feature of sea beaches in the Netherlands Indies, as elsewhere in the tropics, is sometimes self-sown, but more often planted.

Mangrove forest

Mangrove forests are found on muddy shores throughout the tropics of the Old and New Worlds: they are widely distributed in the Netherlands Indies, though in Java they are not well developed. The most extensive mangrove forests in the archipelago are those on the east coast of Sumatra, especially in east Atjeh, Aroe bay and in Palembang to the north of the Lalang river (Figs. 52–4).

Mangroves grow where the land surface is rising, sometimes as fast as 35 mm. a year, owing to the deposition of silt. As new land is built up and consolidated, so the mangrove forests push out further and further seawards. There has been some controversy as to whether the mangroves bring about the deposition of silt or whether they can grow only where silt is being deposited, but there is probably truth in both views. Mangroves can only colonize shores where there is some degree

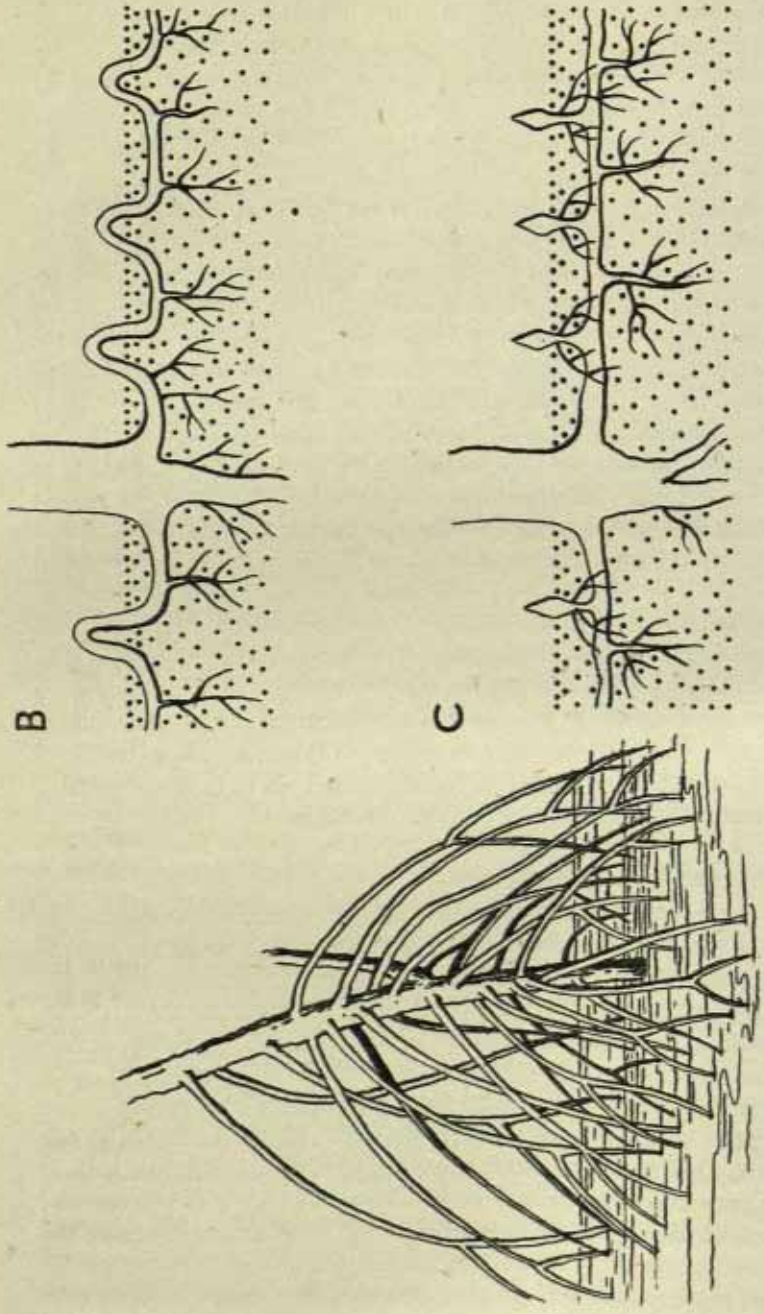

Fig. 132. Aerial roots of mangroves (semi-diagrammatic)

A. Stilt roots of *Rhizophora*. B. Root system of *Bruguiera* in section, showing 'knee roots'. C. Root system of *Avicennia* in section, showing lateral roots growing upwards into the air.

of shelter and therefore where any silt in suspension is necessarily deposited, but the development of a mangrove forest also obstructs the tidal currents and therefore speeds up the rate of deposition.

Mangroves are of great importance because of the part they play in reclaiming land from the sea; they are also of very great economic value because they are an important source of firewood for domestic use, steamships, etc., and make good charcoal. The larger species are valuable as timber (some are resistant to the boring mollusc, *Teredo*, and therefore useful for underwater construction) and also provide tan bark and several other useful products.

The mangroves are a group of trees not related to each other botanically, but having certain remarkable features of structure and life-history in common, as well as the ability to grow on unstable muds which are periodically washed by the tide. Some twenty to thirty species of mangrove trees are known in the Netherlands Indies and with them grow some thirty species of shrubs and herbaceous plants, including the fern *Acrostichum aureum*. Mangroves are evergreen trees varying in height from 3 or 6 to over 35 m. Most of them have shiny, leathery leaves and inconspicuous flowers, but their most striking features are their buttressed trunks and peculiar roots (Fig. 132). In trees of the genus *Rhizophora* the trunk is supported on a mass of slender curved aerial roots, like very slender flying buttresses. In the genera *Avicennia* and *Sonneratia* the main lateral roots are horizontal and produce large numbers of small branches which grow vertically upwards through the mud and project several inches above the surface. These branch roots have the appearance of cigars or sticks of asparagus and beneath a large tree they are so numerous that one can hardly put one's foot between them. In the genus *Bruguiera* the large lateral roots make a succession of upward bends or loops above the mud, the loops being known as knees. The mud in which mangroves grow is almost completely deficient in oxygen and as the aerial roots of *Avicennia*, *Sonneratia* and *Bruguiera* are provided with very numerous lenticels (breathing pores) their main function was until recently supposed to be to act as aerating organs for the root system. Though they probably do this to some extent, they seem to have equal or greater importance in providing a means by which fresh rootlets can be given off at higher and higher levels as the mud accumulates.

A remarkable feature of many mangroves is that the seeds germinate before leaving the parent plant; in some they grow into a heavy, fleshy seedling as big as a small candle. When the young plant eventually

drops off it is heavy enough to stick firmly in the mud at low tide and anchor itself before the current can wash it away. The seeds and seedlings of mangroves float well in sea-water and may be carried by currents for long distances.

The different species of mangrove differ very much in the amount of tidal inundation they can tolerate. *Avicennia* and *Sonneratia* can grow where they are covered even by moderately high tides, but the majority of the species will grow where they are reached only by normal high tides. A few are confined to situations flooded by spring tides or exceptional tides only. As well as being very sensitive to the tidal regime, mangroves have strong preferences for certain kinds of substratum, some liking mud and fine silt, others a more sandy soil, while others again demand a high percentage of organic matter (humus). Because of the importance of soil to mangroves, the species found on coral reefs are different from those found on muddy coasts.

Owing to the different amounts of tidal flooding tolerated by different mangroves, the species are not distributed at random, but are arranged in a series of belts or zones, generally more or less parallel with the shore line. The pioneers, which colonize the least stable and most frequently submerged muds at the outer fringe of the mangrove forest are usually *Avicennia* and *Sonneratia*, under some conditions perhaps *Rhizophora*. Other species requiring less frequent submergence and different soil conditions follow when the ground has been prepared for them by the pioneers. The zonation thus represents an actual plant succession in which one group of species is superseded by another. As the pioneers are succeeded by more exacting species new land is added at the seaward edge and so the mangrove forest extends slowly out to sea. At the same time the soil level on the landward side rises and as the effect of the tides is felt less and less the mangrove swamp with salt ground water gradually turns into a freshwater swamp inhabited by quite different trees.

Because of the softness of the mud and the dense growth of the trees and their aerial roots, mangrove forests are extremely unpleasant, but by no means impossible, to traverse.

Associated with the mangrove forests in the Netherlands Indies is a very characteristic plant community dominated by *Nipa fruticans*, a palm with a very short stem and feathery leaves 6 m. long or more. *Nipa* forms a dark green belt, contrasting with the lighter green of the mangroves, along estuaries in many of the islands: *Nipa* communities are particularly extensive and well developed along the rivers of Borneo. *Nipa* likes brackish not salt conditions; at high tide

it is washed by brackish water, at low tide the water is almost fresh. Unlike the mangroves it is not confined to places where mud is accumulating. It has a tenacious root system and can grow well where the tidal current is very strong.

Tropical Rain Forest

It is difficult to give a clear picture of what a virgin tropical rain forest is like; travel books, even those written by scientists of repute, often give very misleading and inaccurate accounts of it.

In the first place the rain forest is evergreen, tall and luxuriant, but it is easy to get an exaggerated idea of its gloominess. One can safely walk through it all day without a hat, but it is never so shady that no sunflecks filter through to the ground. When the sun is shining the forest floor is dappled with patches of light and shade; the contrast between them is so sharp that it is impossible to take good photographs except when the sun is behind clouds.

Books of travel almost invariably describe the forest as impenetrable, though the fact is that in virgin, as opposed to secondary, rain forest the undergrowth is always fairly thin. Except for dense patches where a large tree has fallen down, it is possible to move about with little difficulty, though a man is seldom visible at a greater distance than perhaps 20 yards. It is usual to 'cut a path' with a *parang* (cutlass) when traversing the forest, but this is as much in order to be able to retrace one's steps if necessary as for any other reason. Where there is any kind of break in the forest, for instance where a road or wide river crosses it, the undergrowth does in fact become very dense. The edge of the forest along a clearing, road or river appears as a solid wall of vegetation, but it gives a misleading idea of conditions in the forest interior. One of the most striking things inside the forest is the extraordinary stillness of the air; except during the squalls which generally precede thunderstorms (in many parts of the rain forest an almost daily event), smoke ascends quite vertically and small scraps of paper never blow away.

Tropical rain forests are not a mass of brilliant and varied coloured flowers. Plants with showy flowers do exist, but they are not common and need looking for; the majority of the trees have very small greenish or whitish flowers, inconspicuous except to the eye of the botanist. The forest as a whole is a sombre green.

Structure of rain forest

The finest forests in the Netherlands Indies are probably those in

Sumatra. Here the tallest trees may be over 60 m. (190 ft.) high, but it would usually be misleading to speak of the whole forest as being of this height. The crowns of the trees in a tropical rain forest are arranged in about three superposed layers or storeys, somewhat like the layers of oak and hazel in an English coppice, though from ground level this is by no means obvious. The topmost storey consists of trees sometimes over 60 m. high, but often only 30–45 m.; these tallest trees do not generally touch each other, each stands out separately from the mass of less tall trees forming the second storey. The second storey trees average 18 to perhaps 27 m. in height, the third about 8 m. (26 ft.). Below this again there are shrubs and saplings, and a layer of herbaceous plants, thinly scattered, not massed like the primroses and bluebells in an English wood.

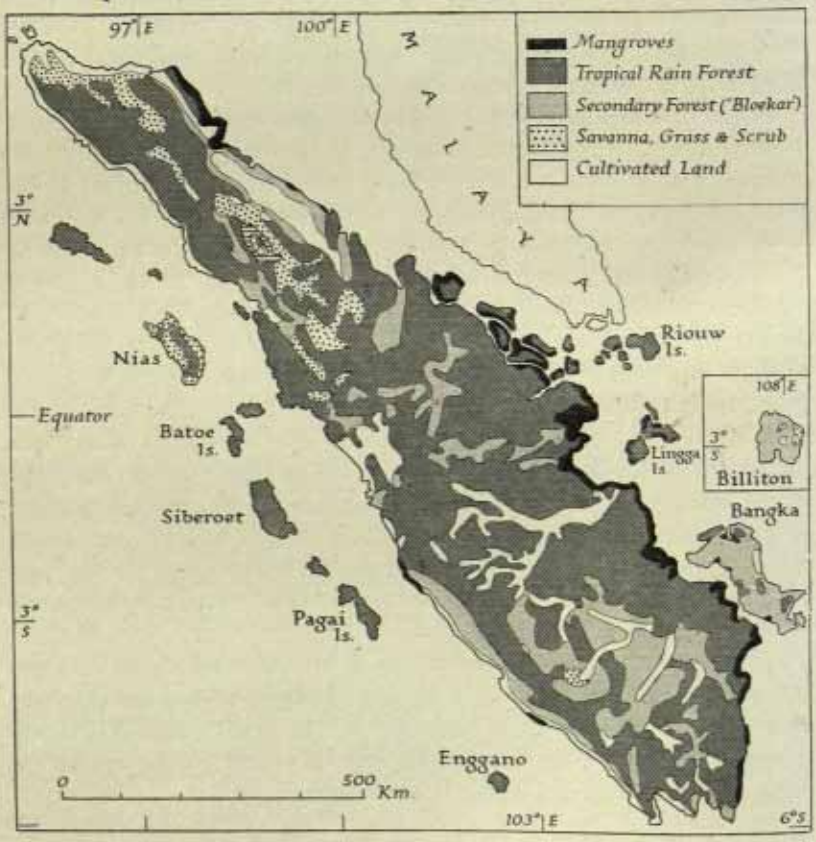

Fig. 133. Distribution of vegetation types, Sumatra
Source: *Atlas van Tropisch Nederland*, plate 7 (Batavia, 1938).

In all the storeys the trees are mostly evergreen in the sense that the leaves do not drop all at once, or if they do, the new leaves expand before the old have all gone. Some of the taller trees however may be deciduous and are bare for a few days or weeks. They differ from the deciduous trees of colder climates (and from those of the monsoon forest) in being less synchronized in their behaviour. Where several individuals of the same species are growing side by side, one may be fully green, another bare, another just producing a crop of fresh young leaves. A characteristic feature of rain forest trees is that the young leaves are often brilliant red or purple, occasionally dead white like paper; often when they first expand they hang down limply as if wilted.

The trees of each storey have their own special characteristics. Those of the top storey have tall straight trunks, thin in proportion to their great length; trunks over 1 m. in diameter are rare. The crown is often rather flattened and when seen in an isolated tree seems disproportionately small. The leaves are commonly oval, undivided and leathery, of about the size, shape and consistency of a laurel leaf.

A striking feature of many of the taller trees (first and second storey) is the plank buttresses which support the base of the trunk (Fig. 134). These are thin plate-like outgrowths extending up the trunk sometimes for 6 m. or more, and outwards along the ground for about the same distance. They add greatly to the labour of felling the trees, as a platform has to be built so that the axeman can cut the trunk above them.

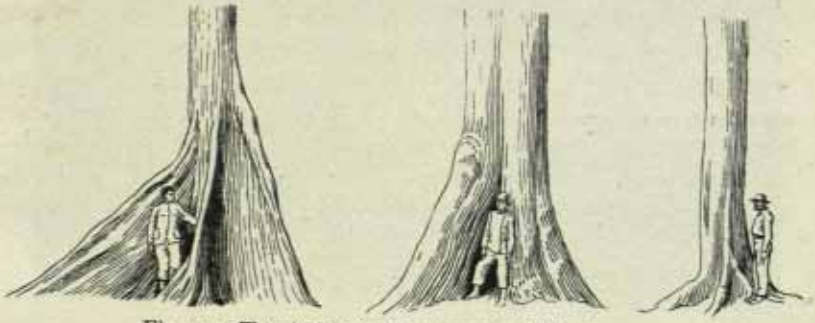

Fig. 134. Tropical Rain-Forest trees with buttresses
Source: F. W. Foxworthy, 'Commercial timber trees of the Malay Peninsula', *Malayan Forest Records*, No. 3 (Singapore, 1927).

The second and third storey trees have much smaller and narrower crowns than those of the first storey and their trunks are of course

still more slender. The average size of their leaves is greater and they are often drawn out into characteristic long fine points at the tips.

Besides the trees, shrubs and low-growing herbs, the rain forest includes two other groups of plants, both highly characteristic of it, the lianes or woody creepers and the epiphytes. The lianes are climbing plants which attach themselves to the trees, usually not the tallest, by twining round or scrambling over them, sometimes by fixing themselves by special structures such as hooks or tendrils. Like the ivy they use the trees merely as a support and do not take nourishment from them. They spread from tree to tree, often hanging down in huge loops and festoons, and their stems may reach a length of several hundred feet. The leaves and flowers of these lianes are mostly far out of sight among the tree tops. Their stems vary in thickness from a little finger to a thigh; some are round in section, others flattened like a gigantic ribbon, others twisted and closely resembling a stout rope. Among the most important lianes of the forests of the Netherland Indies are the rattans (or rotangs), climbing palms often with thorny stems, which because of their great length and strength are used by the natives for innumerable purposes in place of rope, wire and cord.

The epiphytes include many orchids with strange and beautiful flowers and a large variety of ferns. They grow perched up on the branches of the trees and like the lianes most of them are not parasites. There are others, related to the British mistletoe, which are semi-parasites; these have no roots and obtain part of their food from the tree on which they grow. The only soil available for epiphytes consists of the dead leaves which becomes entangled with their roots or is brought there by ants. Perhaps the most remarkable of the epiphytes are the 'strangling' figs belonging to the same genus as the edible fig. They start life as epiphytes, but soon strike down roots into the ground. In course of time, the tree which supports them becomes surrounded by a network of tough roots; eventually it dies and the fig is left as an independent tree, its 'trunk' consisting of a hollow cylindrical network of roots.

Composition of rain forest

By far the most important characteristic of the tropical rain forest and the one in which it differs most from temperate woodlands is the enormous number of species of trees composing it. In an English wood the great majority of the trees are, say, oaks, with perhaps a few birches or ashes and other trees intermingled. In a rain forest in the

Plate 107. Virgin Tropical Rain Forest

This forest is 800 m. above sea-level in the Arfak mountains, New Guinea.

Plate 108. Virgin Tropical Rain Forest
This example is between Lomira and Lake Kamakawallar in the southern New Guinea.

East Indies on the other hand, no one species of tree is dominant; there is a mixture of a vast number of different kinds of trees, no one of which forms a large fraction of the whole number. There may be as many as thirty species of 20 cm. diameter and over on a piece of forest 122 by 122 m. in extent (about 1.5 hectare). One may often see only a single tree of a particular species during a whole day's march. The species in each storey are different, though of course the lower storeys include many young individuals of trees which reach the higher storeys when fully grown.

Though rain forest is normally a fairly even mixture of species, exceptionally a single species may be dominant over a considerable area. Thus in parts of Sumatra there are patches up to about 20 hectares in extent dominated by the Borneo camphor tree, *Dryobalanops aromatica*. Still more extensive are the ironwood forests found on certain sandy and gravelly soils in Sumatra and Borneo; in these the tree *Eusideroxylon Zwageri* forms an almost pure stand.

Even where no one species is dominant, a single family of trees may form a large proportion of the stand in the higher storeys. In much of the rain forest of the Netherlands Indies (especially in Sumatra and Borneo, but not in Java), trees of the family *Dipterocarpaceae* form up to half or more of the trees 40 cm. in diameter and over. These trees, which are often of colossal dimensions, may be recognized by the characteristic veining of the leaves and the peculiar winged fruits (Fig. 135).

The several thousand species of trees which form the rain forests of the Netherlands Indies include many which furnish valuable timbers or other useful products such as gums, resins and camphor. The great majority, however, have at present no known uses, though doubtless future research may discover some. Since the valuable species are found scattered through a mass of more or less useless species, the mixed composition of rain forests is a serious economic disadvantage. The majority of the large trees in virgin rain forest are hardwoods, often excessively hard and so heavy that they will scarcely float in water. Good timbers for constructional work are common; there are also many beautiful ornamental woods, but practically no soft woods which will serve the purpose of deal.

A number of the rain forest trees are poisonous; there is *Antiaris* for instance, said to be the original of the fabled Upas Tree. Among trees to be specially avoided are the species of *Melanorrhoea* and *Gluta* (Malay name rengas), belonging to the same family as the American

poison ivy. Contact with the wood or resin exuded from them produces in most people an almost intolerable irritation of the skin which lasts for several days.

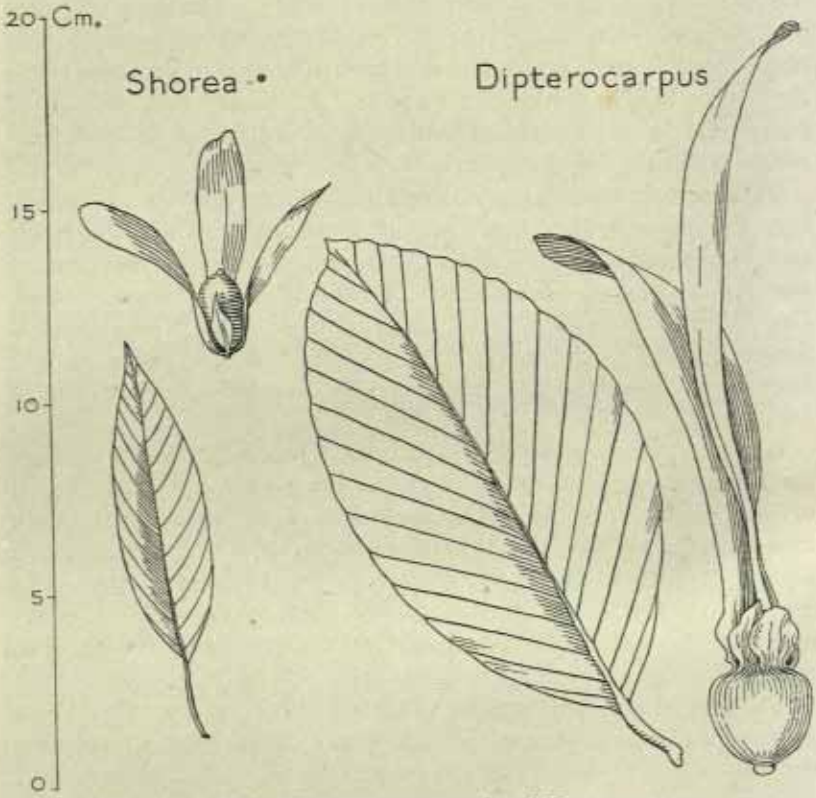

Fig. 135. Fruits and leaves of two species of *Dipterocarpaceae*
Members of this family may be recognized by the peculiar winged fruits and the very straight, parallel side veins of the leaves. Drawn from specimens.

Special Types of Primary Forest

The rain forest which has just been described is the primary or virgin rain forest of well drained situations in the lowlands on ordinary soils (typically a reddish or yellowish clay, technically known as tropical yellow earth). Where the ground becomes swampy or the soil is different, the character of the forest changes. In parts of Borneo and Sumatra, for instance, there are tracts of an almost pure white and very porous sand (tropical podzol). A peculiar kind of rain forest is found on this, in which many species of plants occur

Plate 109. Undergrowth of Tropical Rain Forest

The photograph was taken on Misoöl and shows a tree with small plank buttresses. A small palm is locally abundant.

Plate 110. Freshwater Swamp Forest, Sumatra

which are usually absent in the normal lowland rain forest, e.g. the pitcher plants (*Nepenthes*) and several coniferous trees, including species of *Agathis* nearly related to the kauri pine of New Zealand, and like it producing a valuable gum (dammar). On these white sand soils forest growth is sometimes absent altogether and replaced by patches of heath-like vegetation composed of small shrubs, grasses, etc.

In some parts of the Netherlands Indies, particularly in Borneo and Celebes, there are limestone hills and on these the forest is much less tall and luxuriant than on other soils. These limestone forests have been little studied, but there seem to be many trees and other plants peculiar to them.

Swamp forests cover vast areas, especially in the coastal districts of Borneo and the low-lying country behind the mangrove forests on the east coast of Sumatra. There are many different types of swamp forest, probably depending on differences in soil and in the depth and duration of flooding. In all of them the trees tend to be fewer in species and less tall than in rain forest on well drained soil. Buttresses are often very well developed and some species have stilt or knee roots like mangroves. Palms are generally a conspicuous feature of swamp forest and sometimes a single species of palm is dominant over a large area; thus in New Guinea and elsewhere there are large tracts of *Metroxylon*, the sago palm or roembia. In northern Sumatra large areas are dominated by *Phoenix paludosa* and in parts of Sumatra and Borneo *Onchosperma filamentosa* forms a belt behind the mangrove swamps. As in mangrove swamps, and for similar reasons, it is extremely difficult to move about in freshwater swamp forest.

Under certain conditions a very peculiar type of swamp forest is found in which the soil consists of a water-logged peat, resembling dark brown porridge. This peat is composed entirely of the partly rotted remains of the leaves and wood of trees; it may reach a depth of several metres. Like the 'raised bogs' of northern climates (e.g. Ireland), the surface of these swamps is convex, the centre being several metres higher than the edges. These 'wood moors', as they have been called, are found chiefly on the east coast of Sumatra and in Borneo.

Secondary Vegetation

As has already been mentioned large areas of tropical rain forest have been destroyed and are now replaced by semi-natural vegetation.

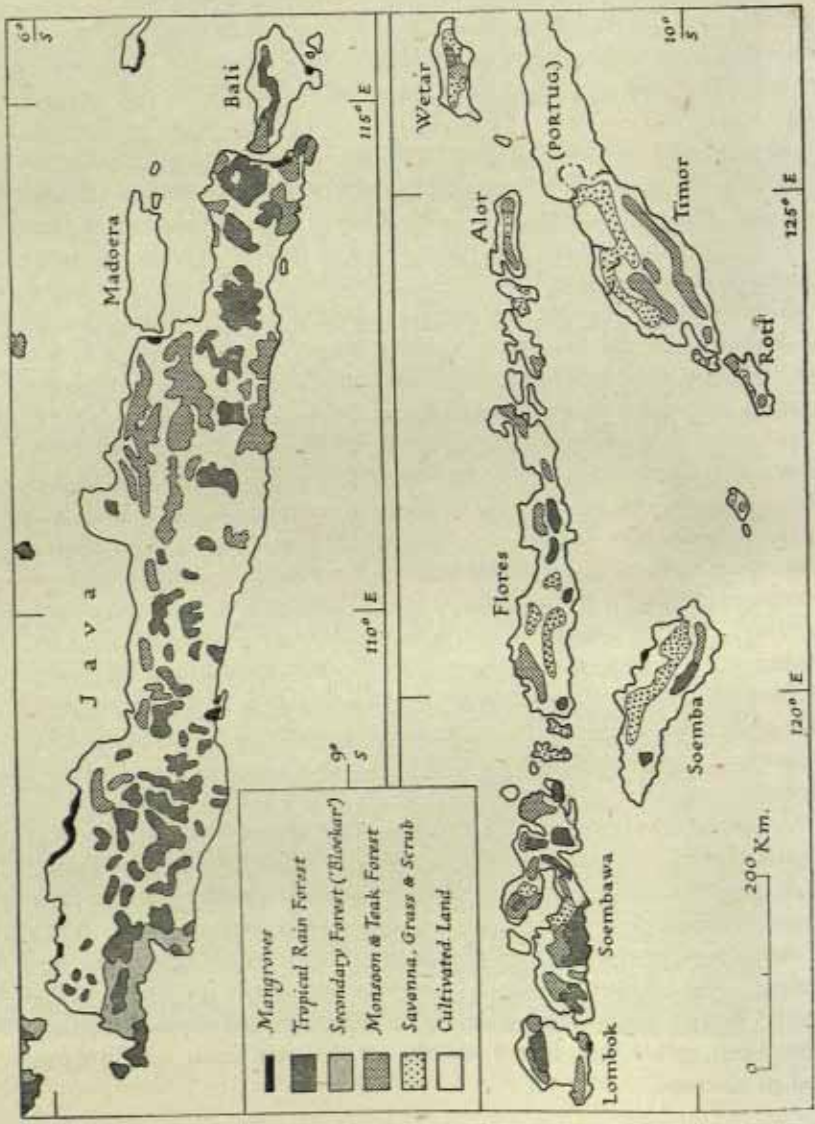

Fig. 136. Distribution of vegetation types, Java and the Lesser Soenda islands

Source: *Atlas van Tropisch Nederland*, plate 7 (Batavia, 1938).

The chief types of this semi-natural vegetation are *bloekar* (*bēlukar*) or secondary forest, fern-brakes, *alang-alang* grassland and scrub of various types. Some of these types cover extensive tracts—it has been estimated that the last three without the *bloekar* form 20% of the uncultivated area of the Netherlands Indies.

The various types of semi-natural vegetation cannot be sharply distinguished from one another; they are in fact stages in the often complicated series of changes which take place when the original forest vegetation has been destroyed. Rain forest may be cleared to exploit the timber, though since the valuable trees are scattered this usually amounts to thinning rather than to clear felling, to establish permanent cultivation such as tea or rubber plantations, and above all as part of the excessively wasteful native system of shifting cultivation. Sometimes it is destroyed by natural causes such as cyclones and volcanic eruptions. The number and sequence of stages in the development of vegetation on old cleared or cultivated land depends on many factors—the length of time the land was cultivated and the extent to which the soil has suffered from erosion and impoverishment, the original nature of the soil, the nearness of undestroyed forest from which plants can spread, and so on. There are thus several different series of changes or plant successions which may take place. About the details of these we have very little information at present, but it seems certain that the general tendency of all of them is towards the re-establishment of forest, identical with or very similar to the original. The time taken to reach this final stage may be one or two centuries, or perhaps longer. The semi-natural types of vegetation which form the stages in the various plant successions are not stable, because, unlike the original rain forest, they are not in equilibrium with the environment; they tend always to change into more stable types. In thickly populated areas, however, it often happens that after the abandonment of felling or cultivation, the land is not left to itself, but is grazed by native cattle or subject to frequent fires. In this case the succession towards forest is checked for as long as the interference continues. In this way some of the semi-natural types come to appear stable; it is known, for instance, that *alang-alang* grassland sometimes maintains itself in the same place for many years and doubtless it will continue to do so as long as it is periodically burnt.

The simplest succession is where the forest has merely been cleared and then abandoned, or cultivated only for a short time. Under these circumstances the land is generally colonized first by herbaceous

'weeds of cultivation' and small shrubs, later by trees. The early colonists are mostly plants whose seeds or fruits are easily carried by the wind, by birds, fruit-bats, or other animals. The same species colonize gaps in primary forest where an old tree has fallen down: owing to their good means of dispersal they arrive on the scene before the species which are the permanent inhabitants of the forest.

Young *bloekar* forest about 6–18 m. high develops in a very few years and then undergoes a series of changes during which it becomes more and more like virgin rain forest. Young *bloekar* is easily recognized by its dense undergrowth and many lianes, which make it very laborious to walk through. Other characteristics are the small number of tree species, the rank herbage in which wild gingers (*Zingiberaceae*) are often conspicuous and the tendency for one species to form a nearly pure stand over a large area. The trees, belonging to such genera as *Macaranga*, *Ficus* (fig) and *Trema*, are nearly all fast-growing soft woods of little economic value. Even very old *bloekar* is easily distinguished from primary forest by an expert. How long it takes *bloekar* to become indistinguishable from primary forest is not known, but some idea of the speed with which *bloekar* can cover a big area can be obtained from the history of Krakatau. In less than fifty years after the eruption a thick *bloekar* forest had grown up over the greater part of the island. In this case the succession was doubtless delayed by the fact that it had to start with a sterile volcanic soil and by the distance which the seeds of colonizing plants had to come.

Scrub, fern-brakes and *alang-alang* are stages in successions in which the amount of human interference both before and after abandonment has been great. Semi-natural scrub is composed of low-growing shrubs such as the 'Straits rhododendron', *Melastoma malabathricum* and *Lantana camara*, a shrub which originated in tropical America, but is now abundant in most parts of the tropics. Scrub covers great areas in Java and on the Toba plateau in Sumatra, where the whole countryside has long since been deforested, there are many square miles of it. Fern-brakes are also very widespread in some districts; they consist of nearly pure stands of the bracken fern, *Pteridium* (similar to or identical with the English bracken) or other ferns.

Alang-alang (or *lalang*) grasslands are formed by the coarse tussocky grass *Imperata cylindrica*, which grows to a height of several feet. *Alang-alang* often has the appearance of a true savanna, but it is almost certain that in most parts of the Netherlands Indies, it is not a

natural 'climatic' type of vegetation, but maintains itself only if repeatedly burnt. It is very inflammable, but not easily killed by burning. *Alang-alang* vegetation may establish itself immediately after the abandonment of the land and if protected from fire, would probably change first into scrub and afterwards into *bloekar*. *Alang-alang* seems to have a deteriorating effect on the soil and the mattress of dead leaves tends to suppress the growth of other plants, so efforts to cultivate or re-afforest these grasslands meet with considerable difficulties. Other grasses, such as *Saccharum spontaneum* (glagah or wild sugar cane), establish themselves under similar conditions to *alang-alang* and now cover large areas in Java and elsewhere.

The above by no means exhausts the list of semi-natural types of vegetation probably derived from rain forest. One more of special interest may be mentioned, the pine or *toesam* woods of northern Sumatra. These are formed by *Pinus Merkusii*, one of the very few species of pine which grow at fairly low altitudes in the tropics. In Atjeh the pines are found as clumps or small woods in *blangs* or savanna-like grasslands between about 50 and 800 m. above sea level. Under wholly natural conditions the pine probably occurs only as scattered individuals or small groups in rocky places in the rain forest; the pinewoods and the *blangs* in which they are found depend for their survival on periodic fires.

Monsoon Forest

Monsoon forest is found chiefly in central and east Java, the lesser Soenda islands and the northern Moluccas and New Guinea, wherever the east monsoon causes a strongly marked dry season. In dry weather it becomes very inflammable and constant fires have converted much of it into savanna. The monsoon forest in consequence does not cover enormous uninterrupted areas like the tropical rain forest. Much of what still remains has been modified to some extent by fires and is no longer in its primitive condition.

Mixed monsoon forest

During the rainy months a typical mixed monsoon forest does not look very different from a rain forest, except that it is less tall and luxuriant and somewhat more open. During the dry season, however, a large (but variable) percentage of the taller trees shed their leaves, so that the forest as a whole looks bare, though most of the undergrowth is evergreen. The difference from rain forest is one only of

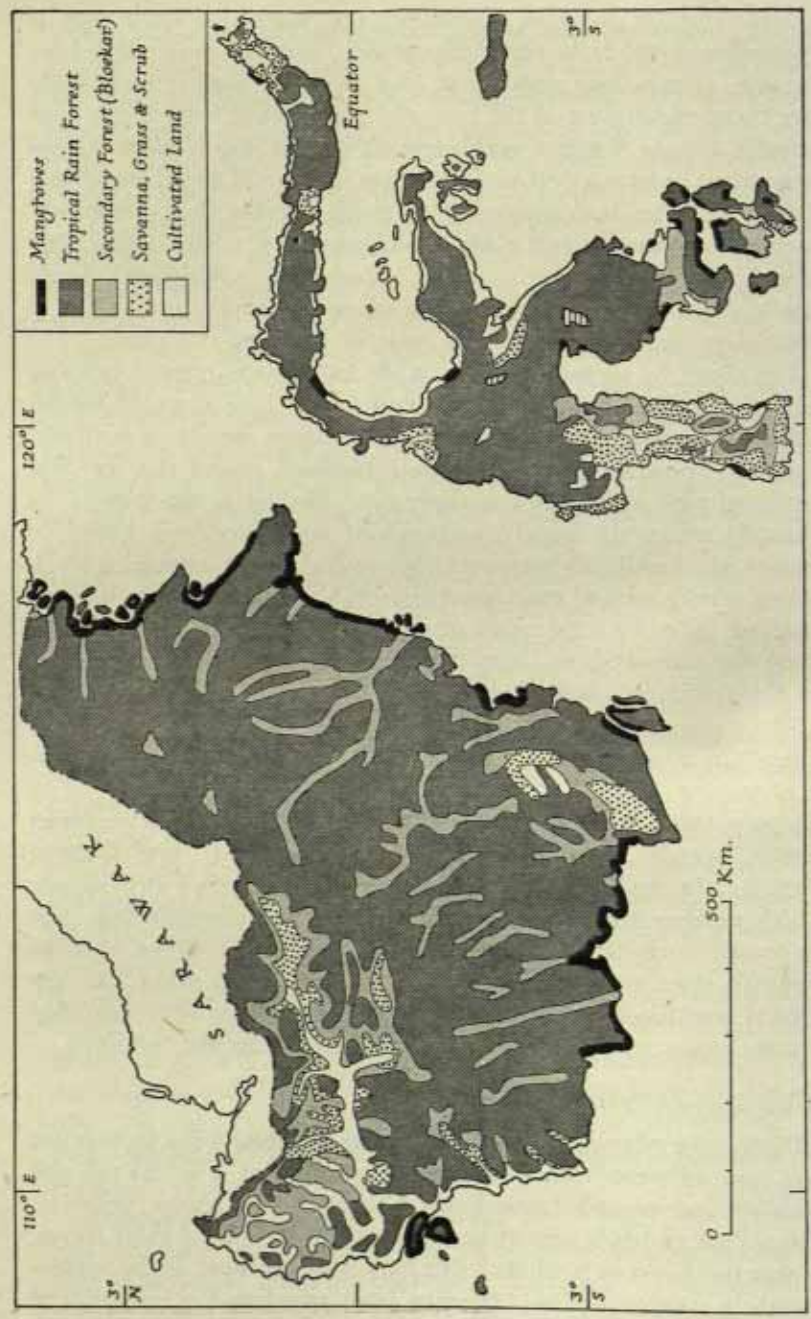

Fig. 137. Distribution of vegetation types, Borneo and Celebes

Source: *Atlas van Tropisch Nederland*, plate 7 (Batavia, 1938).

Plate 111. Teak Forest, Java, in the rainy season

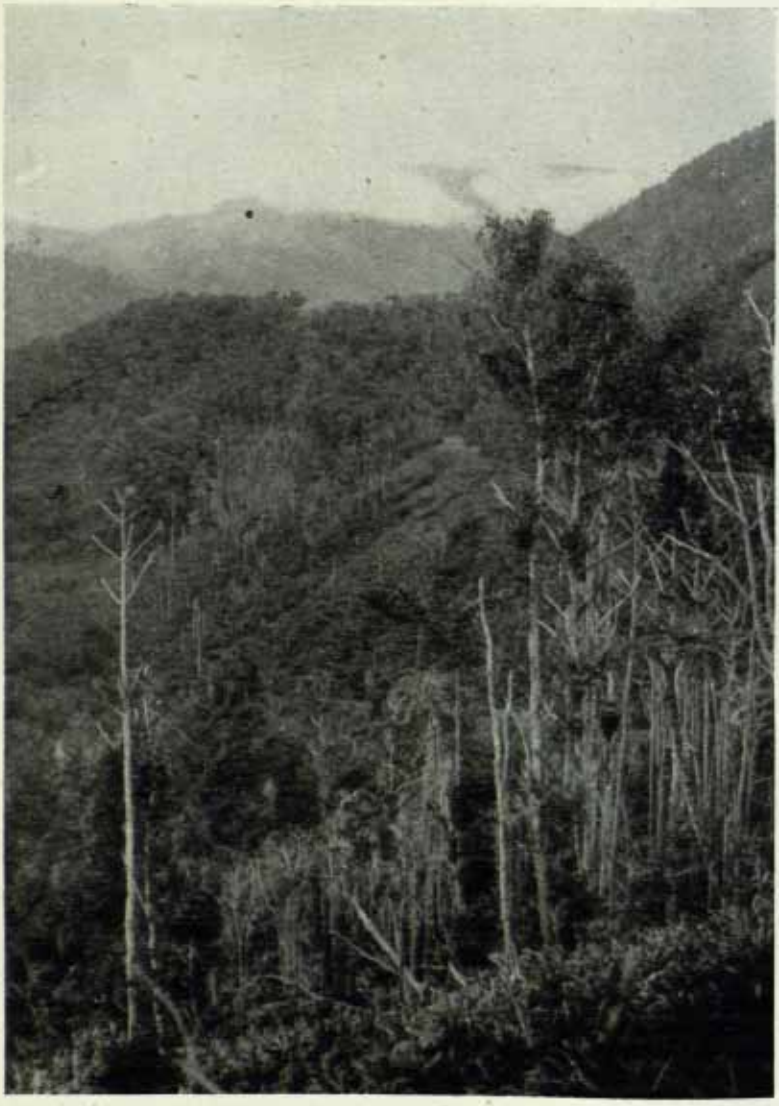

Plate 112. Mountain Forest
At 1,600 m. above sea-level in the Arfak mountains, New Guinea.

degree as even in the wettest rain forests a few of the trees are deciduous.

Like the rain forest, the monsoon forest includes herbaceous plants and lianes, as well as trees and shrubs. Epiphytes are few and many of the herbs die down in the dry season.

The species of trees are mostly different from those in the rain forest and fewer in number. The *Dipterocarpaceae* are absent and in their place are found such trees as *Acacia leucophloea* (pilang), belonging to the same genus as the Australian wattles, and species of *Albizzia*. The *Leguminosae* (pea family) plays an important part. Many of the trees found are identical with species found in the monsoon forest of south-eastern Asia, which does not extend further south than the extreme north of the Malay States; their area of distribution is thus cut in two by a belt of rain forest over 2,500 km. wide.

Teak forest

Far more important economically than these mixed monsoon forests are the teak forests, which are a special type of monsoon forest with a single dominant species. It is uncertain whether *Tectona grandis*, the teak tree or djati, is truly native in the archipelago, but there are over 800,000 hectares of teak forest in Java from Krawang eastwards, in addition to smaller forests in Kangean, Boetan, Moena, the Moluccas and Lesser Soenda islands. The chief home of the teak is Burma and Siam, but because of the value of its timber it has been planted in most tropical countries where the climate is suitable. Teak is a relatively fire-resistant tree and it is fairly certain that, like *Pinus Merkusii*, it does not form pure forests under natural conditions, but grows scattered through mixed forest. The teak forests thus owe their existence as such to the effect of fires, or to planting or the artificial removal of trees of other species. The teak forests are one of Java's most valuable resources and consequently they have for many years been carefully tended by the Forestry Service; hence few if any of them are in anything like a natural condition.

The appearance of a teak forest is quite unmistakable. The teak, which occurs mixed with very few other trees, grows to a height of 40 m. or more, and a maximum diameter of about 1·5 m.; there may be 20 m. of straight bole without a branch. There is little brushwood, but there is a layer of wild gingers and other herbaceous plants, many of which die down in the dry season. The ground is carpeted

with the large broad leaves which become so hard and brittle when dry that when walking over them one can hardly hear oneself speak because of the crackling. During the rains the fallen leaves curl up and hold innumerable pools of water in which mosquitoes breed. The young leaves are at first red in colour and unfold about November.

Bamboo forest

Another type of semi-natural vegetation in the monsoon forest area is the bamboo forest. Many kinds of bamboo are found in the Netherlands Indies, both in the rain forest and in the drier regions; several of them are planted by the natives who use them for innumerable domestic purposes. Forests of bamboo are chiefly found in central and east Java and other districts with a monsoon forest climate. When not planted, they mostly seem to spring up after clearing or fires; it is very doubtful whether they are ever found under completely undisturbed conditions.

Eucalyptus forest

Standing in much the same relation to the mixed monsoon forest as the teak forests are the *Eucalyptus* (gum) forests which also depend for their existence on fires. *Eucalyptus* is a genus of trees most of which are natives of Australia; a few extend as far west as Celebes and the Philippines. Several species will grow well when planted almost anywhere in the East Indies and have been used on a large scale for reafforestation, especially in Java. Native *Eucalyptus* forests are found only in New Guinea, Timor and the Lesser Soenda islands as far west as central Flores.

Savanna

By savanna is meant open country covered by coarse grasses with or without scattered bushes and clumps of trees. Several kinds of savanna cover large areas in north-east Java, Celebes, the Moluccas, New Guinea and Timor. Most of these savannas are found in areas with a sharply marked dry season and some of them may be truly natural, but the majority certainly occupy land which was once covered by forests, in most cases monsoon forest, and if protected from fire they would eventually revert to forest.

Savannas grade into *alang-alang*, but in many of them, e.g. in the Lesser Soenda islands, there is little or no *alang-alang*, other grasses taking its place. In parts of Java the savannas are covered with scattered trees of the lontar or siwalan palm, *Borassus flabellifer*.

Plate 113. Mossy Forest

About 2,450 m. above Kandang Badak, Java.

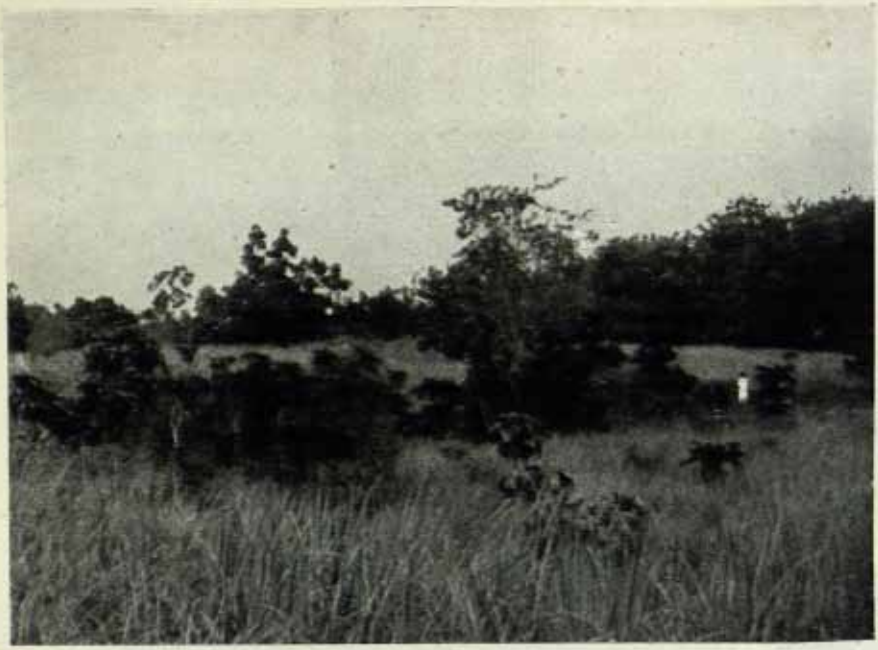

Plate 114. Savanna, East Java
This savanna is derived from forest by repeated burning; numerous young trees can be seen scattered among the tall grass.

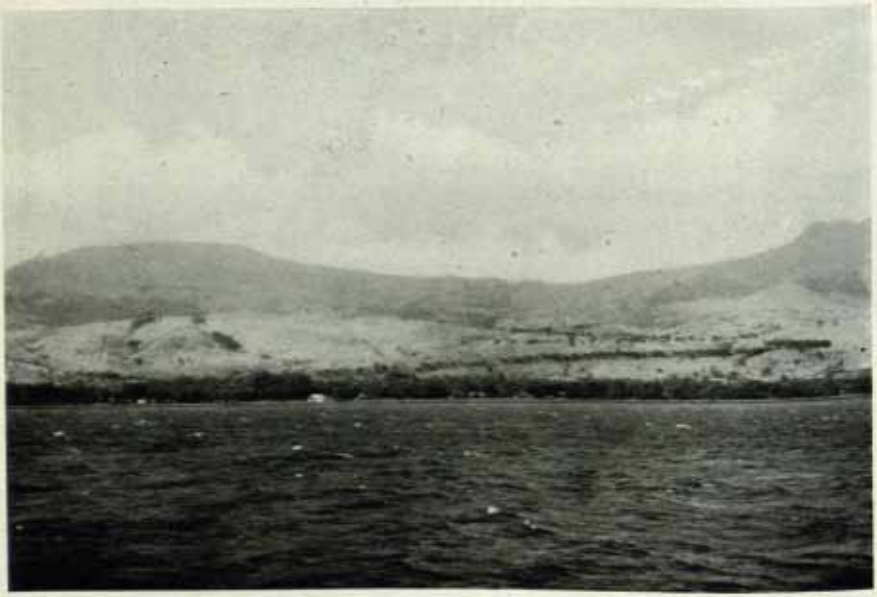

Plate 115. Savanna country near Aimere, Flores (Lesser Soenda islands)
The open landscape contrasts sharply with the well wooded scenery in the wetter parts of the Netherlands Indies. Trees are mostly confined to the coastal plain and inland to the stream valleys.

In some kinds of savanna other palms are common; palm savannas are particularly extensive in Timor (Plate 84), Flores, Soemba and north-western Bali. In parts of north-east Java and in Celebes, Lombok and Flores there are savannas in which the prickly pear,

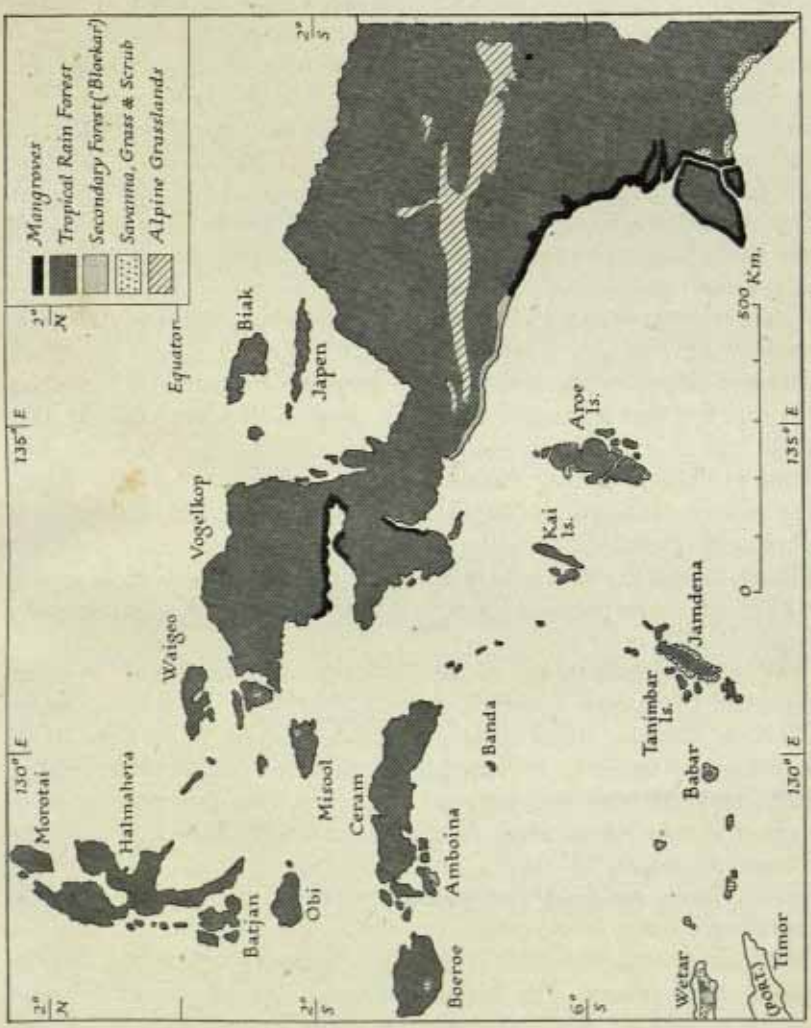

Fig. 138. Distribution of vegetation types, New Guinea and the Moluccas
Source: *Atlas van Tropisch Nederland*, plate 7 (Batavia, 1938).

Opuntia (introduced from America) and other spiny, cactus-like plants form dense thickets.

Mountain Vegetation

The mountain vegetation of the Netherlands Indies is superbly beautiful and of very great scientific interest. As one climbs the mountains the vegetation steadily changes in response to the change of climate. Different types of vegetation follow in much the same sequence on all the mountains, so that a series of altitudinal belts or zones may be distinguished. The passage from one zone to the next is often almost imperceptible, but sometimes it is very sudden and striking. The limits of height of each zone vary greatly on different mountains and even on different sides of the same mountain, depending on differences in exposure to the wind and other factors. On isolated peaks, especially when they rise directly from the sea, all the zones tend to be lower than on large mountain ranges; they are, as it were, telescoped together.

Generally speaking all but the very highest mountains are forested, though on exposed ridges and summits the trees become much dwarfed. Many of the mountains of Java and Sumatra are bare near the top, but this is because of past or present volcanic activity rather than because the climate makes it impossible for trees to grow (see Plate 7). The Javanese volcanoes also have patches of scrub (in which the woolly white shrub *Anaphalis javanica* is characteristic) and of grassland interspersed among the forest at high altitudes. In New Guinea, however, where there are peaks rising to over 5,000 m., some with glaciers and perpetual snow, there is a true alpine, or climatically treeless, zone.

In the mountains, as in the lowlands, the vegetation is often modified by human activities, especially by fires. In the mountains of New Guinea, for instance, the natives start bush fires when hunting the wallaby; in this way much forest has been converted into grassland with the appearance of true alpine grassland.

In the rain forest area, as in Sumatra and Borneo, the forest sometimes begins to show a distinct change in character as low as 450 m. above sea-level, but sometimes not till 700–1,000 m. Above this height many of the trees common in the lowlands, such as the *Dipterocarpaceae*, become scarce or disappear altogether, others taking their places. The higher one goes the commoner become plants related to those of temperate latitudes, such as buttercups (*Ranunculus*) and violets (*Viola*). The lowland rain forest is succeeded by evergreen forest similar in appearance, but generally not so tall and composed of different species. In this zone, which has been

given various names, oaks (*Quercus*) and chestnuts (*Castanopsis*) are often common. In gullies and openings tree ferns are characteristic. Somewhat higher the forest becomes very moist and ferns and mosses are plentiful. At a height varying on different mountains from about 900–1,700 m., the whole appearance of the forest changes, sometimes gradually, sometimes abruptly. It becomes much lower and less shady and the trees become thinner and extraordinarily gnarled and twisted. Often, but not always, the change is accompanied by a sudden increase in the amount of moss and this dwarf forest is often called mossy forest (also montane rain forest or mist forest from its climate). In the mossy forest the trees seem many times their real thickness from their thick covering of wringing wet mosses and liverworts, which also clings to the branches in huge sodden masses and hangs in streamers from the twigs. No vegetation in the world has a more fantastic appearance. Still higher the trees become even smaller and the amount of moss generally diminishes again.

On the very high ranges of New Guinea at about 4,200–4,800 m. tree growth at last becomes impossible and up to the permanent snow there is a vegetation of tiny shrubs, grasses and herbs, including gentians and other plants similar to those found above the tree-line in the Alps and Himalayas.

In the dry regions where the lowland forest is of monsoon type, owing to the locally damp climate the mountain slopes generally bear evergreen forest. A characteristic feature of the mountains of central and east Java is the woods of *Casuarina Junghuhniana* (bergtjemara), a tree similar to the casuarina of the sandy sea coasts.

BIBLIOGRAPHICAL NOTE

The only comprehensive and up-to-date account of the vegetation of the Netherlands East Indies is 'Maleische Vegetatieschetsen' by C. G. G. J. van Steenis (*Tijdschrift van het Koninklijk Nederlandsch Aardrijkskundig Genootschap*, Reeks 2, deel 52, 1935, and reprinted), to which this chapter is much indebted.

Much useful information on the botany of the Netherlands Indies is in the form of scattered papers in various periodicals. Among these should be mentioned especially the *Annales* and *Bulletins* of the Buitenzorg Botanic Garden (Java), with papers mostly in English, French or German, *De tropische Natuur* (Weltevreden), and *Tectona* (Buitenzorg) (mainly forestry). The papers in the last two are mainly in Dutch (generally with an English summary).

The accurate identification of plants from the East Indies is a difficult matter even for the expert and demands access to the large herbaria at Buitenzorg, Leiden, Utrecht, Kew and Berlin. Two 'floras' of some assistance are *Flora of the Malay Peninsula* by H. N. Ridley, 5 vols. (London, 1922–5), and *Handboek van de Flora van Java* by C. A. Backer (Parts I–III, Batavia, 1924—incomplete), *Wayside Trees of Malaya* by E. J. H. Corner (Singapore, 1940) is valuable for identifying the common trees of the Netherlands Indies.

Chapter XIII

MEDICAL SERVICES AND HEALTH CONDITIONS

Medical Organization: Insect-borne Diseases: Intestinal Diseases: Other Important Diseases: Other Diseases: General Health Conditions: Hints on the Preservation of Health: Bibliographical Note

MEDICAL ORGANIZATION

The medical services date from the time of Bontius, 1626. There is now a large public health service which works in active co-operation with the military medical service, the missions and local administrative bodies. There are also many private practitioners in the towns and on the big estates. It is the view of the Government that curative medicine belongs properly to the sphere of private enterprise and of the local administrative bodies.

By 1936 there existed the following medical institutions: 500 hospitals of various sizes, 15 asylums for the insane, 42 leper colonies, 6 sanatoria for tuberculosis (since increased to 10) and 970 dispensaries. Many of these are administered directly by the Government Medical Service, many by outside bodies with subsidy from Government, and many by purely private enterprises.

For the training of medical men there are two medical schools, one at Batavia and one at Soerabaja, and there is also a school for dentists. At these institutions natives graduate—in 1936 there were 363 medical students, including 16 women—the graduates practising in the Netherlands Indies and forming the greater part of the medical services there.

The auxiliary staff of the medical department are trained at many places. There are 18 categories in all, from nurses of many grades to midwives, malaria and plague assistants, vaccinators, laboratory technicians and subordinate employees.

In the public health service and that of the native states there were, in 1939, 170 physicians, 325 native doctors, 16 other medical officers and 24 semi-official doctors. In private practice there were 526 physicians and 163 native doctors. In addition there were 163 military medical officers, of whom 52 worked with the public health authorities. Dentists in private practice numbered 157. There were 82 European and 1,209 native nurses and 225 midwives in official employ,

with 476 private midwives, and 426 vaccinators, 55 technicians and 12 pharmacists, while 372 pharmacists were privately employed.

For the large population of these islands this medical organization is still far from adequate, but as time goes on the service will increase as more natives graduate from the medical schools.

Hospitals fall into three classes: those controlled by Government, those administered by private bodies with Government subsidy, and those controlled solely by private enterprise. The three largest Government hospitals are at Batavia (1,000 beds), Semarang (1,000 beds), and Soerabaja (643 beds). Of the subsidized hospitals the Petronella hospital near Jogjakarta, is one of the largest; it is surrounded by daughter establishments which are in close touch with it by telephone and travelling clinic.

Under the direction of the public health service are the Pasteur Institute and Government smallpox institute at Bandoeng, where all kinds of vaccines are prepared. The medical laboratory at Batavia is also the headquarters of the malaria control organization, and there is a laboratory at Bandoeng which deals especially with problems of water analysis. There are four quarantine stations.

Maternity and Child-welfare centres are established at several places; the number of confinements supervised by midwives is steadily increasing and in 1939 amounted to 22,720, while in Batavia almost two-thirds of the deliveries are conducted by these trained women. There are 76 pharmacies under the care of trained men.

In spite of the long association of the natives with the Dutch, they still retain a large measure of distrust of western medicine and a deep faith in their own healers. To counteract this distrust, instruction in the elements of hygiene is given in schools, and there is also a bureau for popular health literature, which has produced booklets on hygiene and pamphlets on hookworm, cholera, eye diseases, scurvy, rabies, beriberi, maternity and child-welfare and other subjects. Many of these have been put on sale, and others are available in the People's Libraries.

INSECT-BORNE DISEASES

Malaria

As in all tropical countries, malaria is the commonest disease and constitutes the most important public health problem. Malaria is transmitted from man to man by mosquitoes of the genus *Anopheles*, and the different species of these mosquitoes differ widely in their

habits. All mosquitoes need water in which to breed, but whereas certain *Anopheles* breed only in fresh water, others require a slight degree of salinity, some prefer water open to the sun, others shady water; some seek the grassy backwaters of streams, others will breed in stagnant pools or even the trifling collections of water present in animal hoof marks. Some require a degree of warmth in the water which other hardier species do not need.

Not all *Anopheles* attack man with equal avidity; many prefer the blood of animals and will seek them in preference to man, though if animals are not available the blood meals necessary to the female mosquitoes will be taken from man. While it is true that not all species of *Anopheles* transmit malaria in nature, it is also true that of those which can transmit the disease, the most frequently infected are those which tend to attack man. That is to be expected in a disease which does not affect animals. There is a still unexplained anomaly in that certain species active in transmission in one country may be of no importance in this respect in another.

It is therefore evident that many factors play a part in the intensity of malaria in any country. The matter is of more than academic interest, since in the multiplicity of *Anopheles* species usually present in tropical countries, and in view of the fact that prevention of the disease entails prevention of breeding of the mosquitoes, it becomes evident that control must be selective and aimed at the dangerous species. Such control (known technically as species sanitation, and originally conceived by Sir Malcolm Watson in Malaya) is carried out in the Netherlands Indies.

Before passing on to the distribution of malaria and its relation to the kinds of mosquitoes indigenous to these islands, it is well to consider the general position. Malaria causes more deaths than any other disease, and is so widespread that there can be few persons, except young children, living between sea-level and the highlands at 5,000 ft., who are not affected. In the endemic areas the disease causes high infant mortality, though the birth-rate is not particularly low, and in these areas the general death-rate at all ages is higher than in those places where malaria is less prevalent. The general death-rate is about 20 per 1,000 per annum; the rate in the endemic areas (where the disease is rife) may rise to 25–50; it reached 400 in the Cheribon Regency during an epidemic in 1917. It is stated that the malaria death-rate is higher in towns than in rural areas.

Malaria is a disease against which immunity may be acquired as a result of constant infections. At birth, infants do not possess this

acquired immunity, and, since they become infected usually within the first year, and since the natives are ignorant both of prevention and cure, there are many deaths at this period. If the child survives the early attacks, however, it passes through a phase of recurring bouts of fever, with the wasting and anæmia which result, and gradually, after a few years of miserable but decreasing ill-health, attains a state of equilibrium in which the malaria parasite continues to live and multiply in the blood but lacks the power to provoke attacks of fever. If, however, the reinfections are not constant, but are seasonal, depending on the seasonal breeding of mosquitoes, the immunity gained in one season is considerably diminished during the interval so that at the next transmission season the child again suffers from malarial attacks, and may continue to do so up to adult life. The position therefore arises that in the places where malaria is most constantly present, human immunity is most complete, and where transmission is seasonal, immunity is but partial.

This again is of more than theoretical interest. Where transmission is constant and mosquito control impossible, every effort should be made to tide infants over the dangerous period until immunity can be established. Where transmission is seasonal every effort should be made to render mosquito breeding impossible. Europeans should fully understand that it is most unlikely that they themselves could exist in any comfort in conditions under which they could acquire immunity, and that for them the problem is one of avoiding infection.

As a result of attacks of malaria, the spleen becomes enlarged: greatly so in children exposed to frequent infection. As immunity increases the spleen becomes smaller. An enlarged spleen can be felt in the abdomen and may, in fact, be so large as to cause great protuberance of the abdomen. An index of the prevalence of malaria is therefore the proportion of children in the area who show enlargement of this organ. In endemic areas this proportion may be very high; in seasonal transmission it may vary according to the time of the year.

In the Netherlands Indies malaria is particularly intense in the coastal districts, where it is transmitted by *Anopheles ludlowi*, a species which breeds in brackish pools open to the sun, for instance where mangrove growth has been cut, and in lagoons and brackish fish-ponds. This mosquito breeds in association with certain algae which float on the surface of the fish-ponds. *A. ludlowi* is always dangerous; it attacks man readily, and in a series of examinations of over 20,000 specimens a relatively high proportion has been found infected.

A. ludlowi is not found in Celebes, where the brackish water breeder is the relatively harmless *A. rossi*. Coastal malaria is also transmitted in some areas by *A. umbrosus*, which is also found in the interior of Borneo and in the island of Bangka.

In the inland plains and mountains malaria is transmitted by *A. aconitus*, a species which breeds in rice-fields, fresh-water fish-ponds, canals and occasionally in streams. In rice-fields the breeding is largely seasonal, taking place after the cutting of the rice, when the fields cannot be run sufficiently dry to prevent it. Improvement in the drainage of such fields has, however, reduced this seasonal breeding to such an extent that not only has the general death-rate been lowered, but the natives, who, because of the unhealthiness of the districts, had begun to leave, have returned. In the mountains the important mosquitoes are *A. minimus*, which breeds in grassy streams, and *A. maculatus* which is found in streams left open to the sun after the felling of jungle trees. In this respect the malaria caused by *A. maculatus* is man-made and must be taken into account in the agricultural development of the country; it may be prevented by leaving the stream shade intact.

In Celebes some malaria is transmitted by *A. subpictus* which may breed in the same habitat as *A. ludlowi*, though it is not so dependent on surface algae. It may also breed in fresh water.

These are the principal vectors of malaria in these islands, but there are others which, though less important, still play a part in transmission. Of these *A. hyrcanus* breeds in the swamps of south Sumatra and west Java, in canals, and rice-fields, *A. kochi* in pools, streams and rice-fields, and *A. leucosphyrus* in shaded pools.

The mosquitoes so far referred to are found in Sumatra, Java and Celebes, and the smaller islands near, but in the eastern part of the archipelago the mosquito fauna is quite different. In New Guinea and the surrounding islands, the vectors are *A. punctulatus*, which breeds in almost any collection of water open to the sun, such as drains, tins, boats, footprints, clear or turbid water, but not in streams, *A. punctulatus moluccensis* which breeds in similar water and also in large rivers, and *A. barbirostris bancrofti* which in the interior of New Guinea breeds in shade along the banks of small lakes.

It is therefore evident that malaria can be transmitted widely throughout the Netherlands Indies, but as has been stated, the distribution is not uniform. On the coast it is general and constant, inland the incidence depends on factors such as the clearing of forest streams, the cultivation of rice, or the presence of swamps or hill

streams; it may therefore show seasonal variations of great importance and unusual conditions of rainfall may, by creating breeding places in abundance, so increase the number of mosquitoes that malaria may be spread in epidemic form. This is particularly the case in those areas where transmission is not normally equal all the year round and where the state of immunity of the population is not high.

The three common forms of malaria, benign tertian, malignant tertian and quartan, are found throughout the islands. It is the malignant tertian which is the most serious and which causes the highest mortality. Blackwater fever, a sequel of malignant tertian, is found sporadically.

Control measures are important. It has repeatedly been found that treatment of the disease cannot be carried out sufficiently thoroughly to eradicate it; it is impossible to treat every attack in a whole massive population. The control measures which give most promise of success are those aimed at the prevention of anopheline breeding. These measures vary with the habits of the species concerned. For *A. ludlowi*, breeding in salt water fish-ponds, very efficient control is obtained by draining once each month. This kills the surface algæ on which the mosquito larvæ depend. To avoid destroying the fish (which are bred for food) ditches are dug round the ponds, into which the fish may retreat during the process of drying of the fish-pond proper. Fresh-water fish-ponds are either dried out and converted into rice-fields, or are stocked with small fish which prey upon the mosquito larvæ. In the rice-fields breeding takes place shortly after the cutting of the rice. For control the fields are planted all at the same time, and after reaping are completely dried. In the earlier stages of flooding the rice-fields are allowed to remain wet for nine days and then dried for two, the cycle being repeated. The drying destroys the mosquito larvæ. Irrigation water is carefully controlled, and the channels so constructed that sluggish backwaters are avoided.

In the hills where *A. maculatus* may breed, control is effected by maintaining the shade of natural vegetation along the streams.

In recent years there has been an increase in malaria in those areas in which the house improvement campaign for the suppression of rats (and therefore of plague, see below) has been pressed. The reason for this is that in the process of house improvement small pools and puddles are formed in the holes from which earth has been dug and these make breeding places for the mosquitoes. Much of the house improvement is done by the natives themselves, and supervision from the point of view of malaria is not easy.

Plague

Plague is primarily a disease of rodents, in the Netherlands Indies of rats. The cause is a bacillus which is present in the blood of diseased animals. This bacillus is transmitted from rat to rat fleas, which suck the blood of the animals. In the stomach of the flea the bacilli multiply to such an extent that the food passages become blocked, and when such a blocked flea next bites an animal the vigorous but unavailing attempts to swallow cause bacilli to be ejected from the proboscis into the bitten animal. Fleas leave dead rats, and in default of living rats, will attack man.

Rats are found in ships, sewers, grain stores and in houses, and it is through these connexions with man that the disease is spread. Rats and fleas are carried in merchandise along trade routes, and outbreaks may be found spreading along these routes.

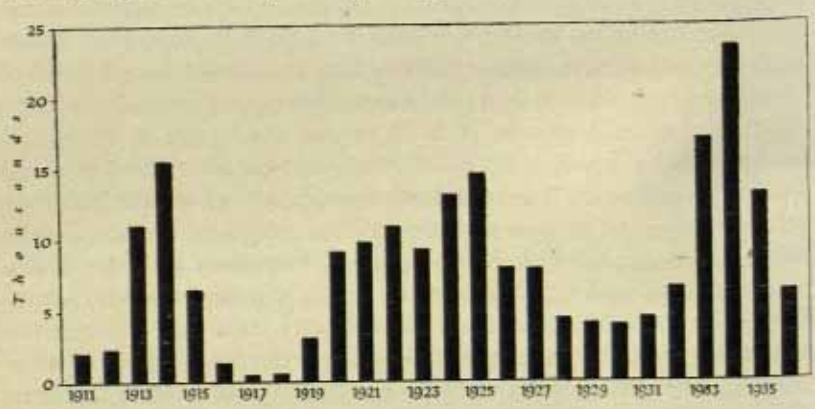

Fig. 139. Deaths from Plague in Java

Source: *League of Nations Intergovernmental Conference of Far Eastern Countries on Rural Hygiene. Preparatory papers: National Reports. Report on the Netherlands Indies*, p. 169 (Geneva, 1937).

In the Netherlands Indies plague has been present since the great eastern pandemic of 1894, but from Sumatra and Celebes it soon disappeared. In Java it still persists and has risen and fallen in great epidemic waves, the last three of which occurred in 1913–15, 1920–27 and 1932–36 (Fig. 139). In the interepidemic periods, moreover, considerable numbers of cases have been reported. In the earlier years the epidemic foci were in central and east Java, in the later years in west Java (Fig. 140). The known deaths from plague during the period 1911–36 numbered 207,666.

In Java, human plague is almost exclusively a disease of the natives, whose houses are infested with rats. It is found especially in the hill country above 1,600 ft., particularly at the beginning of the rainy season in December and January. Bubonic plague is, as in other

Fig. 140. Distribution of Plague in Java

Source: *League of Nations Intergovernmental Conference of Far Eastern Countries on Rural Hygiene. Preparatory papers: National Reports. Reports of the Netherlands Indies*, p. 168 (Geneva, 1937).

countries, the commonest form; in this form the infective bite of the flea takes place usually on a leg, occasionally on an arm, and the characteristic sign is swelling of the glands in the groin or armpit, known from early times as buboes. In Java the case-mortality from this form is very high, usually from 60 to 70%. Another type occurs in which spread is direct from man to man without the intervention of fleas. This form is a plague pneumonia which may arise in the course of bubonic plague; the sputum is laden with bacilli and these are expelled into the air by the patient in the act of coughing or even talking. There is great danger that persons in contact with these patients will contract the disease through the inhalation of droplets of sputum expelled by the patients. Pneumonic plague is invariably fatal; it is found in Java in small outbreaks of two to ten cases, and accounts for 6–8% of the total plague cases seen.

The rats affected are the brown Malayan house rat *Rattus rattus diardii*, *Rattus concolor* inland, and, to a very small extent *Rattus norvegicus*, the brown sewer rat. The principal flea involved is the tropical rat flea *Xenopsylla cheopis*, notorious in this respect throughout the tropics.

In Java control measures fall into two categories; measures of rat control, and protective inoculation. Rat control in ports follows the usual procedure: fumigation of ships, quarantine, and construction of rat-proof godowns and stores. In the country districts, where the

majority of cases are found, the Dutch have instituted the campaign of house improvement, which has as its object the alteration of existing houses, or the construction of new houses, in such a manner that facilities for rat nesting are eliminated. To this end double walls are abolished, so that rats may not nest in the space, bamboos used in building are sealed at each end for the same purpose, or replaced by wooden beams, the use of tiles to replace thatch is encouraged, and regular inspections are made. The Dutch have carried out this campaign without compulsion but with the aid of a small bonus for each completed house, and report astonishing success; by the end of 1938 no less than 1,525,364 houses had been improved. The unexpected effect of this activity in causing an increase in malaria has been referred to above.

Preventive inoculation has been developed in an unusual manner. It is usual, in inoculating against bacterial diseases, to employ vaccines of bacteria killed by heat, but the Dutch bacteriologist Otten some years ago isolated a bacillus, presumably a plague bacillus, of such feeble virulence that it could not, even in the living state, provoke the disease in small animals. It was found that this organism similarly failed to produce ill effects when injected in man, and that the protective power developed in animals was greater after injection of suspensions of these bacilli than after the injection of killed vaccines. This method of inoculation with the living vaccine has been applied in Java on a massive scale since 1934, and by 1938 over 7,000,000 persons had been so immunized. The Dutch have great faith in this measure, and certainly, since it was instituted, the epidemic wave of plague has steadily and steeply declined.

Typhus

The typhus group of fevers is represented in the islands by mite fever, in which the causative organism is transmitted by the larvæ of scrub mites from rodent to man, and by endemic or murine typhus which is a disease of rats spread to man by rat fleas. Mite fever, now regarded as identical with the scrub typhus of Malaya and Japanese river fever, is commonly contracted in scrub country, and may particularly be expected in groups of labourers engaged in clearing bush; it is seen especially in northern Sumatra and New Guinea, though a few cases have been reported from Java and west Borneo. The incidence is not high, about 500 cases are reported each year from north Sumatra, and the case-mortality is no more than

about 5%. The mite incriminated is the larva of *Trombicula deliensis*, but it is suspected that ticks of the genus *Amblyomma* may also transmit the disease.

Murine typhus is seen in Java and is a more serious condition. It is not so fatal to rats as plague, and there is not, therefore, the same tendency for fleas to seek human hosts. It is for this reason unlikely that murine typhus would cause extensive outbreaks in man, though in Shanghai and Mexico this form has been transmitted to man and has then spread in epidemic fashion from man to man through the human louse.

These diseases are not sufficiently prevalent to warrant prophylactic vaccination, but care should be taken to avoid mites in the scrub country. For natives the smearing of a mixture of coconut oil, 18 litres, and Cajuput oil 800 cc. on the legs before clearing work is undertaken, is reputed to be valuable.

Dengue Fever

Dengue fever is stated to be generally distributed through the islands. This is a painful but trivial fever, which causes much temporary ill-health. It is transmitted by the mosquito *Aëdes aegypti*. This mosquito, in Africa and South America, is the transmitter of yellow fever, and though yellow fever has never been found in the Far East, the probability of wide spread, should it be allowed to enter, is not in doubt.

INTESTINAL DISEASES

Cholera

Cholera has in the past swept through the Netherlands Indies, as it has through all the neighbouring countries. In 1910 there were 64,733 deaths from this disease, in 1914 just over 1,100, in 1918 almost 10,000, but in 1920 only 17. From 1923 to 1934 there were only 17 cases. Cholera is an intestinal disease the cause of which is a microscopic organism, *Vibrio choleræ*. The striking feature of cholera is the immense and profuse diarrhœa, with the passage of fluid motions which soon lose their fæcal character and resemble rice water. In this thin fluid the vibrios are present in countless millions.

Cholera is transmitted through the contamination of food or drink with fæcal matter, or by direct contact with patients, or through

the intervention of flies. It is particularly connected with water supplies, and contaminated water from wells and rivers has in the past played the chief part in the enormous epidemics which have taken place in the east. The protection of water is therefore probably the most important step which can be taken in the prevention of this disease. Though this has been done in many places in the Netherlands Indies, it has not been possible in most rural districts, and the public health authorities have in the past resorted to mass inoculation with cholera vaccine, together with strict control of immigrants and pilgrims. It is not easy to determine the efficacy of each of these measures, but the fact remains that in the last twenty years the true classical cholera has not presented a serious problem, though in view of the fact that it constantly occurs in India and Indo-China, there is always the possibility of its reintroduction.

In 1938, however, a disease broke out in Celebes which was indistinguishable from cholera but which, on investigation, proved to be due to a vibrio apparently identical with that found in pilgrims at El Tor, on the Red Sea. This El Tor vibrio had never before been found capable of producing disease in man, but there was no doubt of its effect in Celebes, where cases were found up to 1940, though the outbreak was not large.

Typhoid

Typhoid is another intestinal disease characterized by diarrhœa and the passage of the causative organism in the stools. It is spread through the contamination of food or water, but there is the particular danger that persons in apparently good health may carry and pass out the bacilli for long periods after an attack, or even without an attack having occurred. These carriers are dangerous, especially as they may contaminate the food they prepare for others; they have been responsible for many outbreaks. Another source of danger is found in those natives who use human excreta for fertilizing the soil of gardens in which vegetables are grown. Europeans would be well advised first to have their cooks and servants examined, secondly to eat no vegetables, and drink no milk or water, provided by natives, without thorough boiling and thirdly to be inoculated against the disease.

In Batavia the cases of typhoid in 1927 were: Europeans 6·7 per 1,000 of the population, natives 1·1, Chinese 3·8. This high rate in Europeans indicates the danger they run. In 1937 there were about

5,000 reported cases of true typhoid in the Netherlands Indies, and in addition there were 946 cases of the related disease, paratyphoid A. Inoculation against these diseases should be insisted upon by Europeans; it affords good protection but should be repeated at intervals.

Dysentery

Dysentery is a disease characterized by diarrhœa and spread largely by contact and by flies. The bacillary form affects all ages, but it is common in children; this disease and infantile diarrhœa are responsible for a high proportion of infant deaths in all tropical countries. Dysentery is constantly present, but increases to epidemic proportions from time to time. About 70% of the cases are due to the Flexner organism, and the disease is relatively mild, but the severe Shiga type is also found, especially in the Bantam region. In Java and Madoera in 1939 there were 5,031 cases of bacillary dysentery with 536 deaths; these are only known cases and many others must go unrecorded. This disease causes about 4·5% of all hospital deaths.

Amœbic dysentery

Amœbic dysentery is widely spread but much less acute. Two features of this disease are important. The first is that the causative organism, an amœba, may be passed in cyst form in the excreta for many years and may even be present in persons who have never suffered from an attack of the disease. The second is that it gives rise to abscess of the liver as a late result. Epidemics rarely occur, though the method of spread is similar to that of bacillary dysentery.

OTHER IMPORTANT DISEASES

Hookworm and other Helminthic Infections

Of the diseases caused by worms, hookworm infection is the most widespread in the Netherlands Indies. To understand the spread of this disease it is necessary to have some knowledge of the life history of the parasite. The common species is *Necator americanus*, which is found in 91·8% of cases, the remainder being *Ancylostoma duodenale*. The worm lives in the human small intestine and the female produces a constant stream of eggs which are passed out in the fæces. In suitable conditions of shade and moisture the eggs, if

deposited on the surface of the ground, hatch out into minute larval worms which are able to move in the moist earth. After undergoing certain changes these larvæ cease to feed and are ready to attack man. This they do by penetrating the skin whence they are carried by the blood to the lungs. They then make their way up the air passages to the throat, pass down into the stomach and, when mature, attach themselves to the mucous membrane of the small intestine. There they suck blood for their own nourishment.

These worms are only about ½ in. in length, and the amount of blood a single worm can take is small, but since there may be hundreds present, the continuous drain of blood over long periods may, and frequently does, lead to serious anæmia. This is not often directly fatal, but leads to loss of strength and energy and to lowered resistance to other diseases. Hookworm infection is therefore a general public health concern, both because of its effect on community health and because its prevention is a matter of sanitation. It is a disease of great economic importance, since the working capacity of labourers is involved.

A consideration of the life history of the worm makes it clear that spread is a question of bad sanitation. Natives usually deposit their fæces indiscriminately and commonly choose shady bushes for the purpose. Plantations offer many opportunities for this practice, and the conditions of shade, temperature and moisture are favourable for the development of eggs which may be in the fæces. Further, it is in just these places that natives walk barefoot, offering to the larvæ the bare skin necessary for their entry into the body. On the other hand, fæces deposited in deep pit or bored hole latrines are harmless, though from shallow pits the larvæ are able to reach the ground surface. Latrines, the edges of which are fouled with fæces, however, are dangerous because bare feet are constantly placed well within range of the larvæ.

In the Netherlands Indies hookworm infection is widespread in the rural districts, where 80 to 90% of the natives may be affected, but fortunately the average number of worms is not high. This means that although minor disabilities no doubt exist, serious illness is not common. This may be a result of the measures of control which have been taken. These consist of campaigns to encourage the construction and use of proper latrines, and the treatment of most hospital patients with one of the many drugs efficient in the elimination of hookworms. It has been observed that there is a marked decrease in the incidence of this infection where intensive sanitary work has been carried out.

The combination of hookworm infection and malaria gives rise to a condition of severe anæmia, which is commonly found in some districts.

Other intestinal worms are common, but are less important. Tapeworm infection is found especially in Bali, where *Tænia saginata*, the tapeworm acquired from the eating of undercooked infected beef, is found. In other places *Tænia solium*, the pork tapeworm, is found. Both worms are widespread, but infection is rarely serious.

Trichinosis is another infection acquired from eating ill-cooked pork; it is generally more severe than tapeworm infection, though some persons do not experience more than a passing illness. The presence of these worms in the Netherlands Indies indicates the importance of cooking all meat thoroughly, since heat will kill the larvæ present in the meat fibres, while superficial cooking, during which the interior of the meat may not become really hot, may be insufficient.

Infection with *Echinostoma ilocanum* is found in Java among the insane who live in colonies, and in Celebes among the people who live round lake Lindoe. This worm passes one stage of its life history in certain fresh water snails, and the second stage either in snails of other species or in fresh water mussels (in Celebes). These snails and mussels are often eaten insufficiently boiled, so that the larval forms of the worms are not killed, and proceed to their third developmental stage, in the intestine of man, where they reach maturity. The symptoms caused are slight, some diarrhœa and abdominal pain, and the infection usually dies out in the course of several months. Round lake Lindoe up to 96% of the population of some villages are infected.

Infections with the round worm *Ascaris lumbricoides*, and whipworm *Trichuris trichiura* are common, especially in children. They indicate bad sanitary habits, but are not often the cause of severe disease.

Filariasis

Filariasis is a disease caused by worms, but of an entirely different kind. In this case the embryo worm is found in the blood of man, whence it is taken up by certain species of mosquitoes, and after a period of development in the body of the mosquito, is reinoculated into man at a later feed. This stage is now able to develop to maturity in the human body, and seeks as its habitat the lymphatic glands. Here the adult worms pass their lives and mate, the female thereafter

producing constant swarms of minute embryos which are passed into the blood stream. They cannot develop further unless taken into a mosquito, but are available to any mosquito which bites. They cannot, however, develop in all mosquitoes, but each species of worm embryo can grow in several mosquito species.

There are two common filarial worms, *Wuchereria bancrofti* and *W. malayi;* the embryo of the latter was first recognized by Brug in the Netherlands Indies. *W. bancrofti* is found in Batavia, the island of Kabaena, Celebes, New Guinea and elsewhere. It is carried by the mosquitoes *Culex fatigans*, *Anopheles ludlowi*, *A. subpictus*, *A. aconitus*, *A. barbirostris* in the more western islands. In New Guinea, where the mosquito fauna is quite different, it is carried by *A. punctulatus typicus*, *A. punctulatus moluccensis* and *A. barbirostris bancrofti*. The breeding places of most of these have been indicated in the sections on malaria—control of breeding is not easy.

Wuchereria malayi is found in Borneo, Batavia and elsewhere in Java (especially in the Serajoe delta), Celebes, New Guinea, the centre of Sumatra and other places. It is carried principally by mosquitoes of the genus *Mansonia*. These mosquitoes have breeding habits quite unlike the mosquitoes already mentioned in that the larvæ, developing in water, obtain their oxygen by piercing the roots of certain water plants. This is important because the larvæ cannot develop if these plants are not present, and removal of the plants is therefore effective in control; unfortunately some of the mosquito species attach themselves to the roots of swamp trees which cannot be effectively removed. The species of *Mansonia* concerned are *M. annulifera*, *M. uniformis*, *M. indiana* and they breed largely in association with water plants of the genera *Ipomoea* and (in some places) *Pistia*. In Martapoera (Borneo) infection was found in 22% of the specimens of *M. annulifera* and in 6% of *M. uniformis* examined. It is stated that *Anopheles barbirostris* in Celebes and *Anopheles hyrcanus* in Java are vectors of *W. malayi*.

Filariasis may entail no more than the presence of the worms in the glands and of the embryos in the blood; there may be no ill-health. The embryos are found in the blood in far greater numbers at night than in daytime, but the reason for this is not clearly known. The percentage of people in whom the embryos are found varies from 9·3 in part of New Guinea to 42 elsewhere in that island, from 20 in Kabaena to 24·7 in Celebes, from 11·8 in children in Borneo to 32·2 in adult males in the same area. In a minority of cases, however, filarial infection produces marked physical disabilities, the most

striking of which is the condition known as elephantiasis, in which, owing to the blocking of the lymphatic drainage, limbs or scrotum enlarge to an enormous size.

There is no effective treatment for filariasis, other than surgical removal of elephantoid tissues, and prevention by control of mosquito breeding is exceedingly difficult.

Leprosy

It is estimated that there are about 50,000 lepers in the islands and that in some areas the incidence reaches 1–1½% of the population. It is generally accepted that leprosy is a disease transmitted from man to man by direct contact, but that, in general, contact must be prolonged and intimate. For this reason it is a disease commonly transmitted within families. It is very slow of development, and in its early stages may show little sign beyond a small patch of pigmentless skin, or loss of sensation over a small area of the body, but the late effects may be devastating, with paralysis of the limbs, loss of fingers or toes, and large unhealing ulcers, or it may be characterized by the appearance of gross irregular thickenings of the skin and exaggeration of the normal folds, giving the face the typical leonine aspect. It is this latter form of the disease which is particularly infectious, since the bacilli which are the cause of the disease are present in the profuse discharge which comes from the nose.

Leprosy itself is rarely fatal, and lepers commonly live many years; death is usually due to other diseases, notably tuberculosis of the lungs and pneumonia.

For the treatment and isolation of lepers there were, in 1939, 49 institutions in the Netherlands Indies, with accommodation for 5,300 patients. The majority of lepers are therefore living at large, and to reduce the risk of infection of healthy persons, the Government encourages the isolation of patients in separate huts in their own districts. Such isolation is usually but partial, but in a disease in which long intimate contact is a feature of infection, such partial isolation may have some value.

Treatment may be successful if undertaken at an early stage of the disease, but it must be long continued. Leprosy is still a serious problem in these islands, but may not be as devastating as its reputation would suggest.

Tropical Ulcer

Ulcers of the legs are general. They arise commonly from trivial

injuries and attain their greatest extent in the mal-nourished. These ulcers may be enormous, destroying the tissues down to the bone, and even necessitating amputation. They are often found in plantation labourers who are especially prone to the injuries which initiate the process. Much working time is lost through these ulcers, and often needlessly so; if slight abrasions were at once treated, many ulcers would be prevented, but when once they become large, which they do rapidly, cure is a lengthy process.

Yaws

This is a disease which may give rise to ulcers whose late results simulate those of tropical ulcer, but it is an entirely different disease, caused by an organism indistinguishable from that to which syphilis is due. It is, however, not a disease which is transmitted by sexual contact. In its acute stage it is characterized by sores on various parts of the body, in the discharges of which the organisms are found. Yaws is transmitted by direct contact, especially to children. In the Netherlands Indies surveys have been made; in one of these 20·7% of the population examined was found to be infected, 8·9% in the infectious stage, but in some villages the rate was as high as 60·3%. The total number of cases in the islands is therefore enormous, but fortunately the disease is rarely fatal, though it may lead to much ill-health and sometimes to crippling deformities.

Treatment with the salvarsan preparations is very effective, especially in the early stages, and the Dutch conduct special and widespread treatment campaigns. In 1927, 731,000 persons were treated, and the Government adopt the policy of demanding a small payment from those who can afford it, on the ground that this makes the people appreciate the value of treatment.

Venereal Diseases

These are widespread and are responsible not only for much ill-health, but also for much sterility and infant mortality. It is estimated that 10–15% of the population of Java and Madoera, between the ages of 18 and 50, are infected with one or other of these diseases. Syphilis has been found in 4·1% of Indo-European women, in 7·7% of Chinese, and 4 to 6% of native women in Batavia. In general gonorrhœa is found twice as frequently as syphilis. Brothels flourish in the cities, and these diseases are consequently much more common in urban than in rural communities.

Syphilis is often passed from infected mothers to the children they bear. Many of the infants are born dead or die soon after birth, but in Batavia 4 to 5% of the surviving children are syphilitic. Syphilis may give rise to late effects which may not be evident until years after the first infection. In many tropical countries certain late results in which the brain is affected are more rare than in Europe, but these late results, including general paralysis of the insane, are seen in the Netherlands Indies.

Treatment for syphilis is generally available in hospitals, but three-quarters of the natives who receive treatment do not complete the full course. Further, more than half of the infected people do not attempt to undergo correct treatment, but rely on the many native quack remedies. It is therefore evident that, as in most other tropical countries, the syphilis position is unsatisfactory.

Gonorrhœa is not transmitted congenitally to new-born infants except that the eyes of the infants may be infected in the act of birth, as the head traverses the diseased passages of the mother. Untreated gonorrhœal infection of the eyes not uncommonly leads to permanent blindness. Gonorrhœa is also a frequent cause of sterility in women, and in men causes stricture of the urethra and the consequent urinary troubles. It is a more serious disease than many people think, and in the days before the discovery of the new sulphonamide drugs, was difficult to cure. Even now these drugs cannot be available for the mass of natives of the Netherlands Indies, and the disease is largely untreated.

The other venereal diseases, soft sore, lymphogranuloma inguinale and the foul condition granuloma venereum are seen, but are not nearly so common as syphilis and gonorrhœa. In 1937, 1,281 cases of granuloma venereum were reported; for this, treatment with tartar emetic injections is often effective.

Tuberculosis

Tuberculosis is prevalent, especially in towns. The common form, as elsewhere throughout the world, is that in which the lungs are affected, and in this form infection is transmitted from man to man directly. The bacilli are present in the sputum of diseased persons, and are expelled into the air in the acts of coughing, sneezing and even talking. Bacilli thus shed may be inhaled by those close to the diseased person. Spitting may be dangerous, since when the sputum dries on the floors of houses, the bacilli may be spread into the air and inhaled by those inhabiting the building.

In Europe a considerable amount of human tuberculosis, especially of glands, bones and joints, is contracted by the drinking of milk from tuberculous cattle, but in the East this danger is not nearly so great.

Tuberculosis of the lungs is especially severe in the first half of adult life, and is a serious cause of mortality at a time when men and women are raising families. As a result of the ignorance and bad hygienic habits of the natives, infection is commonly transmitted to young children, especially in the infected families, but also to children living close by or frequenting places where infected persons are to be found. The effect of such chance infection is usually not serious, but in a minority of cases it may lead to the development of definite disease, of glands, bones, or joints in children, of the fatal tuberculous meningitis in infants, or of tuberculosis of the lungs in adolescents. The extent to which infection has spread is indicated by the results of the tuberculin test in Batavia and rural Java where the percentage of positive results is 10 in infants, 35 at ages 5–14, and 68 to 70 in adult life. The number of cases in which infection progresses to actual disease is, of course, very much smaller.

That tuberculous meningitis is not rare is shown by the fact that 180 cases were seen in a Batavia hospital from 1932 to 1940. This number constitutes half of the total cases of meningitis admitted. These can only be a fraction of the cases actually existing in the population.

During 1939 there were 8,677 patients admitted to hospital in the Netherlands Indies for tuberculosis of the lungs, and 1,273 for other forms of the disease. The actual number of cases in the islands must be much higher than these figures indicate. Tuberculosis of the lungs accounted for 10·53% of all hospital deaths, and other forms for 1·02%. In a survey of 330,000 estate labourers in Sumatra in 1930 it is stated that tuberculosis caused more disability and deaths than any other disease except acute respiratory diseases (for instance, pneumonia). Though the disease is not usually acute, its course, unless great care is taken in treatment, is usually steadily progressive to death in native races.

Tuberculosis is therefore a serious problem and probably one of increasing importance, and no doubt it is true that the natives do not possess the same standard of resistance as the white races. Other factors influence the extent and spread of the disease, especially the habit of overcrowding in the homes, the poor state of nutrition of many natives, and possibly the presence of hookworm disease and malaria.

To deal with this situation the Dutch have taken certain steps. A tuberculosis study committee has been set up, to investigate the position. Instruction in measures of prevention is given in association with the other health campaigns which are conducted, for instance the hookworm campaign. There is continuous effort to improve diet and housing conditions. For treatment and isolation of the patients sanatoria have been built, four by the Government and three by other bodies, while ten of simpler type are projected. There are fifteen consultation bureaux, equipped with X-ray apparatus. The sanatoria are so much in demand that they cannot accommodate all the patients seeking admission, and a system has been developed under which the owners of houses round the sanatoria take in the patients who receive their treatment at the institution.

Pneumonia

This is one of the principal causes of death in both children and adults. It is three or four times as common in the natives as in the Europeans, and the case mortality rate (30%) is twice as high. In the army it is more important than typhoid, and in prisons in Java it occurs in epidemic form. It is thought that the chilling effect of clothing wet with rain has something to do with the frequency of this disease, and that other diseases, especially malaria, predispose to it. Preventitive measures in the general population cannot easily be taken, but from experience gained in South Africa, it would seem that the avoidance of overcrowding in the sleeping quarters and barracks may lead to diminution of incidence. It therefore appears that close contact leads to transmission of the disease from one person to another, though such infection is not the whole explanation of the occurrence of the disease. Treatment has been enormously improved in recent years through the introduction of the sulphonamide drugs.

Smallpox

This is not now a serious menace. In 1913 there were 35,000 cases with 8,000 deaths, but this high incidence has fallen; in 1927 there were only 400 cases, and since then there have been very few. A vaccine institute was established in 1891 and vaccination is now carried out widely and consistently.

Diphtheria

Diphtheria is important. In 1939 there were 786 cases with 106 deaths in Java and Madoera. Cases are also seen in the outer provinces.

Other Diseases

Scarlet fever is stated to occur sporadically, and *measles* and *chicken-pox* are seen. *Influenza* is seen every year but occasionally assumes epidemic proportions. There are a few cases of *cerebrospinal meningitis* each year, and several cases of *infantile paralysis* have been reported. *Rheumatic fever* has been recorded.

Rabies is reported, and in 1932, 522 persons were treated through the organization of the Pasteur Institute. This does not mean, of course, that all these persons were actually infected. Cases of *rat bite fever* are found from time to time; treatment with the salvarsan drugs is effective. More important than this is *leptospirosis* or Weil's disease. This is primarily a disease of rats, and, to a smaller extent, of dogs and cats; it may affect man. It is caused by microscopic organisms, *Leptospira icterohæmorrhagiæ* or *L. bataviæ*, which are present in the urine of diseased rats and which may pass through human skin or mucous membranes. There is no intermediate insect carrier, as in plague. In other countries this disease is known as mud or slime fever, and is contracted through contact of human skin with mud or water contaminated by rats. Thus, bathing in contaminated water, or working in rat-infested sewers may lead to infection. In the Netherlands Indies the rats concerned are *Rattus norvegicus*, *R. brevicaudatus* and *R. concolor*. The disease in man may be severe and even fatal, but on the other hand it may be so mild as to be missed. Diagnosed cases are not rare in Batavia, and examination of the blood of 150 healthy persons revealed the fact that 39% had been infected.

Rhinoscleroma, a bacterial disease which affects the nose and throat, and which is most common in women aged 20–35, is reported from the Batak lands of Sumatra.

The infectious eye disease *trachoma* is frequently seen, and is responsible for much of the blindness which exists. The incidence varies, and some parts of the islands are free from it. A campaign of treatment is carried out by specially trained nurses working under an eye specialist.

Skin diseases are very common, *impetigo* is seen, especially in children, *tinea imbricata*, a skin infection due to a fungus, and other fungus diseases, are reported quite frequently. Infestation with head and body lice is frequent.

All forms of *cancer* are found.

Insanity is a condition which has necessitated the institution of

four large asylums with 8,000 inmates, five observation asylums with 1,100 inmates, and seven observation stations with 316 inmates. The use of *opium* is widespread, but the drug is, in general, used by moderate smokers, and, except in a few cases of gross addiction, does not present a serious problem. There is little *alcoholism*.

Stone in the bladder or kidney is not uncommon; it is thought that this condition may be a result of deficiency of vitamin A in the diet.

GENERAL HEALTH CONDITIONS

Infant Mortality

The infant mortality of Batavia has been carefully studied. In the period 1934–36 there were 12,000 native infant deaths, representing 30% of the live births, but in the poorest native class this rate may be almost 50%. In the Chinese the rate was 15, in the Europeans 6 in the same period; for comparison the Amsterdam rate of 3 is given. The native rate is one of the highest reported from tropical cities.

The first three months of life are the most critical; the causes of death are many, but malaria is regarded as one of the most important. No doubt, as in other primitive communities, infant diarrhœa and congenital syphilis are also important.

Housing

Houses are made usually of wood, bamboo and palm leaves, but brick is used for the larger dwellings. Doors and windows are insufficient to provide adequate light and ventilation. Overcrowding is not common in rural areas, but occurs in towns.

House improvement is therefore desirable, but is only considered urgent when there is direct danger of disease, as in the case of plague. The Government supports schemes for good housing by giving financial help and by expropriating land for building.

Native Nutrition

The nutrition of the natives is not good, their diet consists largely of carbohydrate (starchy) foods, is poor in fats, and contains little animal protein though there is a considerable amount of vegetable protein. Rice is the staple food and is largely cultivated. The peasants use a crude method of husking in which the pericarp and embryo (i.e. those parts of the grain which contain the important vitamin B)

are not removed. This rice is therefore satisfactory, but in other communities the practice of eating polished rice is common. Polished rice is the grain from which the pericarp and embryo have been removed in the mechanical method of preparation which is largely used and which produces a grain white and clean in appearance. The rice commonly eaten by Europeans is polished, and this sets a standard imitated by the natives; it is devoid of vitamins and contains only starch. In the diet of Europeans the lack of vitamins is not important since these are present in the other articles of diet, but in the natives for whom rice is the staple food, this deficiency is serious.

Maize is used in some areas, but in parts of Java it is the custom to remove the pericarp and give it to the poultry, and to wash the endosperm in running water for three days, a process which removes the vitamin B. In Madoera, however, the pericarp is eaten as porridge, with good results. Other starchy foods are sweet potatoes (which contain vitamin A), cassava, sago (in the Moluccas) and cane sugar. The government encourages the cultivation and use of the soya bean. Peas and beans (gram) are extensively eaten and provide protein (but the djengkol bean sometimes causes damage to the urinary system); vegetables of several kinds are grown, and are commonly taken as soup.

A considerable amount of fish is eaten in coastal districts, but milk, meat and eggs are little used except by the wealthy, or at feasts. Some animal protein, however is eaten in the form of bee larvæ, grasshoppers, frogs and snails, which are appreciated by some of the natives. Coconut oil and ground-nuts supply fats, and the latter contain vitamin B. Chillies, rich in vitamin C, are used.

There are two native foods which may give rise to fatal poisoning; they are prepared by allowing moulds to act on ground nut cake (*Ontjom*) and coconut cake (*Bongkrek*).

Fruits are usually eaten raw and include the egg plant, the Goa bean and the mango; the use of fruit protects against scurvy.

The use of tea and coffee is general.

Deficiency Diseases

The diet of the native population is deficient in several respects, sometimes it is deficient in quantity, and hunger œdema (a condition of dropsy of the limbs, associated with emaciation) is not unknown, though it is rare. But the more widespread deficiencies are not of bulk or quantity of total food, but of the vitamins essential to good health. Deficiency of vitamin A is perhaps the most common and is an

indication of the lack of animal fats, and other substances, in diet. The signs of this deficiency are certain eye troubles and possibly a reduced resistance to infective disease and the formation of stone in the kidneys or bladder.

Beriberi

Deficiency of vitamin B_1 is reflected in the disease beriberi, which, though it does not now occur in the epidemic form it once assumed, is still seen, and is often found in the wealthy. It is a disease particularly associated with the eating of polished rice or of sago, and only affects those whose diet consists of more than two-thirds carbohydrate. It is seen in cities, where imported rice is eaten; it is not common in rural districts where the rice is only partly cleaned. It was common during the years of the rubber boom, when agriculture was neglected and rice was imported into Sumatra. In Chinese women it is seen in an acute form during pregnancy, and is due then to the custom of feeding on a diet almost exclusively of polished rice. It tends to break out when maize crops and fishing are poor and when the people are thrown back on to a diet too exclusively composed of rice.

Beriberi may be an acute condition leading to sudden death from heart failure, or it may be chronic, giving rise to a condition of general dropsy or to paralysis of the limbs; it affects infants as well as adults. Treatment with preparations of concentrated vitamin B_1 is effective, but the essence of the problem of this disease is prevention, which is a matter of taking a diet having a sufficiency of the vitamin, and resolves itself chiefly into the elimination of polished rice, with the substitution of red, or partly polished, rice. The Government encourages the cultivation of leguminous plants and the distribution of red rice and green gram, all rich in vitamin B_1. In controlled populations, for instance in prisoners, the use of polished rice is not permitted. In 1939, beriberi caused 3·41% of deaths in hospital.

Pellagra

Pellagra, a disease due to lack of nicotinic acid, is seen sporadically, usually in those who suffer from chronic intestinal disease; in this case the essential fault is, probably, inability to absorb the vitamin which may be present in the food.

Other deficiency diseases

There is no evidence of deficiency in vitamin C in the rural

population, and scurvy, the sign of this deficiency, is not seen in it. Rickets, a disease connected with lack of vitamin D and with absence of sunlight, is not reported. Of all the vitamin deficiencies, that of vitamin A is probably the most common.

Deficiency of iodine in water and food is observed in certain mountainous regions. In these districts goitre is common, but the general health of the people is not seriously affected.

In general the natives have excellent teeth.

Water Supplies

The water supplies of the rural population consist of rivers, streams, wells and collections of rain water, and are not usually controlled. They are therefore dangerous and are the means of transmitting intestinal diseases. But there are 281 plants for the supply of good and protected water, 138 of which exist in Java. In Soerabaja the controlled supply was instituted in 1903; in Batavia in 1922. In both there was a fall in the incidence of typhoid fever as a result.

The provision of safe water is one of the chief measures necessary to good health. Rivers and streams, in addition to providing drinking water, receive the refuse of man and animals; the danger is evident. Wells are usually shallow and receive not only contamination introduced directly from the hands or feet of the users, or from utensils employed, but contaminating material is often deposited on the ground nearby, and may either be washed directly into the water, or may reach it by percolation through the soil.

Sanitation

The disposal of sewage on a large scale is only possible in the larger towns. Elsewhere cesspits, septic tanks or pit latrines are used, but in the rural districts the natives commonly defæcate into streams or indiscriminately on the soil. It has already been pointed out that water for drinking is taken from streams and that wells may be contaminated with material from the surface of the ground in the vicinity; they may also be contaminated by percolation from cesspits.

In some places a solution of this problem is sought in methods whereby excreta are collected and, by a system of composting, are converting into manure which may be used to enrich the soil. When properly carried out, this method is harmless, as during the process of composting, which consists of packing the excreta and maintaining it in a moist condition together with vegetable refuse, the organisms

which are associated with human disease are destroyed by the heat spontaneously generated in the mass. After a few weeks the material is converted into an odourless compost of high agricultural value. This process may be exceedingly useful but the human factor is involved, as it depends for success upon careful attention to the details of routine in periodical turning of the mass.

In China and neighbouring countries human fæces are used as a fertilizer without any treatment, and have acted as a potent agent in the spread of disease. Efficient composting excludes this danger, but it is not difficult to imagine that a native who is, on the one hand, warned of the danger of spread of disease through human fæces, and on the other is taught that excreta can be safely used in the cultivation of human food, after undergoing a simple process, may be somewhat confused.

Disposal of refuse

The disposal of refuse is only a problem round the towns, since rural refuse is easily burned. The dustbin system is used in towns and refuse is dumped in the manner adopted in Europe. Stable refuse, however, presents a problem as yet unsolved in many places.

HINTS ON THE PRESERVATION OF HEALTH

The list of diseases given above appears formidable. But it should be remembered that the list refers to the native population. Europeans can avoid most diseases by taking simple precautions.

A point to remember is that at home the private citizen hardly needs to take steps to preserve his health. The community sees to it that the water supply is fit to drink, the food up to standard and so forth. But in such a country as the Netherlands Indies the individual must know how to avoid needless disease, and may have to take active steps to keep in good health. The following simple points are important:

1. Many diseases are liable to be picked up from the native inhabitants. It is advisable to live as far as possible from villages and labour camps.

2. Malaria is only conveyed from man to man by certain sorts of mosquito (*Anopheles*). The mosquito must first bite a man whose blood contains the germ of malaria: the mosquito incubates the germ for a week, and is then prepared to inoculate it into a man if it

should bite him. All mosquitoes breed in water; unfortunately many can fly a long way, seeking blood. To avoid malaria:

(*a*) camp as far as possible from swamps, rivers, and irrigated land: half a mile will afford good protection. Camp away from villages because the *Anopheles* often picks up the germ from the natives.

(*b*) Sleep under a mosquito net carefully used and tucked in and kept in good repair. If sleeping on the ground, tuck the edge of the net under a ground sheet.

(*c*) Avoid being needlessly bitten: no bare legs or arms at or after sundown.

(*d*) If possible kill mosquitoes in tents, etc., with fly spray.

(*e*) Destroy the mosquito larvæ in water, by oiling, using poisonous dusts, draining, etc.

(*f*) A dose of 5 grains of quinine taken each evening has some action in preventing attacks of malaria.

(*g*) Treat a case of fever by making the patient lie down, giving ten grains of quinine and a dose of salts.

3. In warm climates, intestinal ailments are very common in Europeans. They may take the form of gripes and looseness: or a frequent diarrhœa; or dysentery (which means the passage of blood and mucus, often with severe griping pains); or more serious things such as typhoid fever and cholera.

All these troubles are due to germs, which come from some other person's excrement and have been swallowed by the sufferer. They may be swallowed in water, or milk, or uncooked food (raw fruit, salads, etc.). They are carried about in a variety of ways: for instance the cook may soil his hands in the latrine and then infect the food he is serving; flies may feed on a deposit of human fæces, and then on a lump of sugar or piece of bread, etc.

These diseases may be avoided

(*a*) by chlorinating or boiling all water (however clean it looks) before drinking it or cleaning teeth in it;

(*b*) by never drinking unboiled fresh milk, or locally prepared mineral waters;

(*c*) by not eating lettuces, etc. (which cannot be cleaned by reason of the folds);

(*d*) by endeavouring to make cooks, and those who serve food, wash their hands;

(*e*) by providing facilities for hand washing in all latrines;

(*f*) by insisting on the cleanliness of cookhouses, and burning of odd scraps of food;

(*g*) by keeping latrines clean, and as far as possible fly-proof;
(*h*) by insisting that latrines, and no other spots, are used;
(*i*) by keeping the body warm at night;
(*j*) by being inoculated against typhoid, paratyphoid and cholera.

Minor intestinal troubles should be treated by rest (i.e. lying down, taking water only for a day or so), warmth and a dose of salts.

4. If lice appear in the clothes take immediate steps to get rid of them. In the Netherlands Indies there may be some risk of typhus and of relapsing fever, which are transmitted by lice. In some parts fleas carry disease.

5. If it is windy and dusty, use celluloid eye screens. A drop of castor oil will often soothe an eye inflamed by dust.

6. In parts of the Netherlands Indies great changes of temperature occur, especially in the mountains where it may be very cold at night. Clothes should give protection from wind and cold. The sun is much less dangerous than people used to think.

7. Whenever possible wash all over, not only because one gets so dirty in a hot and dusty place, but also because soreness may easily develop, particularly between the toes and in the crutch: if these parts become inflamed it is not easy to cure them. Do not walk about barefoot.

8. Venereal diseases are more common than at home, and one particularly nasty tropical one exists. Take no risks.

9. To prevent septic sores and ulcers avoid minor injuries; if they occur treat at once with iodine; maintain the general health with local fruit wherever possible.

10. Discipline in all matters relating to health (e.g. boiling of water, avoidance of raw bazaar foods, use of mosquito nets), will go a long way to prevent unnecessary illness.

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Appendix I

THE PLACE NAMES OF THE NETHERLANDS EAST INDIES

The following notes present brief statements of the policy adopted by the various authorities, with a short analysis of the principles followed in this Handbook.

1. *Dutch maps and charts*

The Dutch have transliterated phonetically into their own orthography (see p. 430) the multitude of native names and geographical terms in Malay, Javanese and a score of other languages and dialects. It is not surprising, therefore, that there should be occasional discrepancies between one map or series and another, in view of the difficulty of accurately recording certain native vowel sounds and the glottal stop which figures prominently in some languages. Even the *Atlas van Tropisch Nederland* does not maintain absolute consistency as between one map and another.

One particular source of trouble is the native name for river: on some maps a certain river will be recorded as Soengai ——, whereas on others it will appear as Air ——. Many physical features in the East Indies—particularly large ones—have no known native name and in consequence Dutch names are employed. Thus whilst a certain mountain range may have native names for all its individual peaks, the name for the whole range will be Dutch, e.g. the Wilhelmina-keten in northern Sumatra, and the Sneeuw-gebergte in New Guinea. Also, whilst in general capes and headlands always have the native appelation 'tandjoeng' or 'oedjoeng', bays often have no native name and are called 'baai'. Again, individual islands in a group will have native names generally prefixed by 'poelau' (island), but the group as a whole will be known as —— Eilanden.

One of the most difficult languages to transliterate is that used in the Atjeh district of northern Sumatra. Here, owing to the 'u' sound being written in Dutch as 'oe', an 'e' vowel following has to be rendered 'oeë' (e.g. kroeëng, a river). The glottal stop ' given on the 1 : 40,000 maps of northern Sumatra (dated 1911–24) is transformed in the 1 : 1 M series and in the Atlas into a 'k', e.g. Lho' Simaneh becomes Lhoksimaneh.

2. *Permanent Committee on Geographical Names* (*P.C.G.N.*)

The use of the Dutch orthography has been recommended by the P.C.G.N. Short glossaries of Malay in both Dutch and English orthography have been prepared by the Committee.

3. *British Admiralty Sailing Directions* (*Pilot Books*)

From 1920 until 1938 the Hydrographic Department used the 'R.G.S. II' system for the transcription of place-names in its Pilot books. The broad features of this system may be summarized as:
(i) Vowels are pronounced as in Italian and consonants as in English;
(ii) Every letter is pronounced and no redundant letters are used;
(iii) The system aims at giving a close approximation to the local pronunciation. In other words, the system is a guide to pronunciation, and has no relation to the actual spelling used in the countries concerned.

In 1938 it was decided to adopt the orthography appearing on the official maps of all countries using the Roman alphabet—in the present instance Dutch. There are however three exceptions to this general rule:

(i) That the accepted Anglicized form of Malay geographical terms be used, e.g. tanjong, ujong, instead of tandjoeng, oedjoeng..

(ii) That English geographical terms are to be used with names which are not in the native language nor in that of the administrators, e.g. names of persons concerned with exploration or discovery, such as Gaspar strait.

(iii) That 'international' seas and waterways will continue to be spelt in the English way, e.g. Malacca strait, not Straat Malaka.

At the time of writing the only volumes conforming to this policy are the *Eastern Archipelago*, vol. IV of 1939 and vol. III of 1943 (though the Introduction, in each case, through an oversight, still states that 'R.G.S.II' is used), but supplements to the other volumes in the series have given lists of revised spellings.

4. *British Admiralty Charts*

The policy used for charts naturally coincides with that used for Pilot books, but there is a much greater time-lag in effecting changes on charts, and in consequence the spelling of names and geographical terms on charts is less consistent. The revised policy of 1938 has, at the time of writing, been put into effect on only two charts, but even on these there are still discrepancies. Thus, chart 3471 is entitled

Straat Banka, though the Dutch spelling is Bangka; the same chart also contains the name Gaspar Straten, despite the ruling noted in para 3 (ii), above. Chart 3243 has been only partly revised, for its title remains 'Banda islands to Aroe islands', the Dutch term 'eilanden' not having been used.

5. *Geographical Section General Staff* (*G.S.G.S.*)

The G.S.G.S. has produced very few maps of the East Indies, apart from direct copies of Dutch maps. The 1 : 4 M map (GSGS 3860), of 1928, employs the 'R.G.S.II' system, but the 1 : 2 M Java (GSGS 1981 of 1919, fourth edition 1941) adopts the Dutch form of all names, but uses English coastal terms throughout, such as cape, bay and strait.

G.S.G.S. policy, however, as from 1938, is the same as that of the Admiralty, viz. to use the native forms of all names and terms.

6. *Policy adopted in this Handbook*

(i) Proper names are always given in their Dutch form, spellings in all cases being taken from the *Atlas van Tropisch Nederland*, 1938, which is the latest authoritative publication covering the whole of the Netherlands East Indies. There are only three exceptions to this general rule. The first is Malacca strait (not Straat Malaka), which is an international waterway; the second is Molucca (Sea and Islands), the reason for this being that it is the only important name in the whole region which in Dutch is adjectival in form (the islands are either called simply De Molukken, but more commonly Moluksche Eilanden, and similarly Moluksche Zee). The third is New Guinea; the English form is employed in preference to Nieuw Guinee, in order to avoid using the Dutch form for the Dutch territory and the English form for the whole island.

(ii) Dutch transliteration of Malay and other native words is used throughout, i.e. the exception permitted in the Pilot Books is not allowed. The reason for this is that no territory other than Dutch is referred to in this Handbook, and it seems inappropriate to use English transliteration for certain geographical terms and Dutch for proper names. Only thus can certain inconsistencies be avoided. For example, a certain promontory on the east coast of Sumatra is called Tandjoeng Tandjoeng (literally 'cape Cape'); if the English form of the Malay word is used whilst retaining the Dutch form of the name, this becomes Tanjong Tandjoeng. Further, when Malay words actually form parts of proper names, as they frequently do,

they must be rendered in the Dutch form—e.g. Tandjoengpriok, Teloekbetoeng, and so confusion is avoided by adopting Dutch spellings throughout.

(iii) As pointed out above, it is general in the East Indies to find that only small individual features of the landscape have native names; the broader regional names for ranges, plateaux, etc. and many coast and sea names, are Dutch. Moreover, in many cases neither native nor Dutch regional physical names exist, and it is necessary to coin descriptive names. In this Handbook, in order to make for easier reading, broad descriptions usually employ English geographical terms such as plateau, range, bay and strait instead of hoogvlakte, gebergte, baai and straat, the Dutch equivalents being given in brackets on the first mention. On maps, however, especially those of coastal areas, the Dutch terms are normally used.

(iv) In order to assist the reader, a list of well-known place names is appended, giving the common English form and the Dutch. Glossaries of common words in Dutch and in the native languages (mainly Malay and Javanese) are also appended, giving English equivalents. Glossaries are also sometimes given on individual maps.

Dutch and English transliteration of Malay and other Native languages

The chief differences in orthography between the Dutch and English forms of East Indian place-names are due to the different treatment of certain vowels and consonants. The English 'j' becomes 'dj' in Dutch, 'y' becomes 'j', 'u' becomes 'oe', 'ch' becomes 'tj', and 'sh' becomes 'sj'.

The following list includes a number of places which are well known in their English forms, with their Dutch equivalents.

English	*Dutch*
Achin	Atjeh
Arafura	Arafoera
Aru	Aroe
Bandung	Bandoeng
Banka	Bangka
Banyuwangi	Banjoewangi
Bachan	Batjan
Benkulen	Benkoelen
Buru	Boeroe
Chilachap	Tjilatjap
Indrapura	Indrapoera
Jokyakarta (Djokjakarta)	Jogjakarta
Karimun Jawa	Karimoendjowo
Kei	Kai
Kupang	Koepang
Kuta Raja	Koetaradja
Macassar	Makassar
Madura	Madoera
Olehleh (Ulee Lhoë)	Oeleëlheuë
Rhio	Riouw
Sangi	Sangihe
Siau	Siaoe
Sula	Soela
Sumba	Soemba
Sumbawa	Soembawa
Sunda	Soenda
Surakarta	Soerakarta
Surabaya	Soerabaja
Tanjong Priok	Tandjoengpriok
Teluk Betung	Teloekbetoeng
Uliasser	Oeliasser
Una Una	Oena Oena

Glossary of Dutch and English Geographical terms

Dutch	*English*	*English*	*Dutch*
Archipel	Archipelago	Nord	North
Baai	Bay	Oost	East
Berg	Mountain	Punt	Point, Corner
Bosch	Wood, Forest	Reede	Roadstead
Bovenlanden	Highlands	Rivier	River
Eiland	Island	Schiereiland	Peninsula
Gebergte	Mountain range	Straat	Strait
Groot	Great, Large	Vaarwater	Channel, Fairway (navigable)
Heuvel	Hill		
Hoek	Cape, point	Vlakte	Plain
Hoogvlakte	Plateau	West	West
Hout	Wood	Zand	Sand
Kaap	Cape	Zee	Sea
Klein	Little, Small	Zuid	South
Meer	Lake		

Glossary of Malay and other East Indian languages

The Dutch form is given first, in *italics*; then the English form; then the language; then the meaning.

Air; Ayer; Malay; water, stream, river. Note also *Air bena*=tidal bore; *Air masin*=salt or brackish water; *Air mati*=slack water, also dead channel of river.
Api; Api; Malay; fire (thus *Goenoeng api*, or *G. merapi*, or *G. berapi*=a volcano).
Api-api; Api-api; Malay; 1. mangrove (*Avicennia*, etc.). 2. firefly (*Lampyris* spp.).
Aroeih; Aroih; Achinese; strait.
Banjoe; Banyu; Javanese; water, small stream.
Batang; Batang; Malay; 1. stem, tree-trunk. 2. river (lit. 'course of a stream'). Note also: *Batang air* (ayer)=river, middle reach of river; *Batang hari*=main stream of river (Sumatra); *Batang kali*=river (Java).
Bateë; Batee; Achinese; rock, stone (=Malay *batoe*).
Batoe; Batu; Malay; rock, stone (used in cliff names, e.g. *Batoe poetih*=white rock).
Besar; Besar; Malay; great, large.
Boekit; Bukit; Malay; hill (usually under about 500 m. high, but sometimes applied to mountains; note Boekit Barisan, the mountain backbone of Sumatra).
Boekoe; Buku; ? (in northern Moluccas); hill, mountain.
Boeloe; Bulu; Bugis; mountain.
Danau; Danau; Malay (also Minangkabau and Sundanese (*danu*)); lake, tarn, mere.
Deleng; Deleng; Karo Batak; mountain.
Djene; Jene; ? (S. Celebes); river, stream.
Dolok; Dolok; Toba Batak; mountain.
Gili; Gili; Java-Malay; island, rock.
Goenoeng; Gunong; Malay; mountain (generally more than about 500 m. high).
Ili; Ili; ? (E. Flores); mountain.
Kali; Kali; Java-Malay; river.
Kampoeng; Kampong; Malay; village.
Kanan; Kanan; Malay; right (side) (employed in river names for left-bank tributaries, i.e., right side looking upsteam).
Karang; Karang; Malay; coral-reef, coral.
Kawah; Kawah; Malay; cauldron—hence crater; any place which shows volcanic activity.
Keli; Keli; ? (E. Flores); mountain.
Kënohan; Kënohan; ? (E. Borneo); lake.

Kĕtjil; Kĕchil; Malay; little, small.
Kiri; Kiri; Malay; left (side) (employed in river names for right-bank tributaries, i.e., left side looking upstream).
Koeala; Kuala; Malay; river mouth, estuary; junction of tributary with main stream.
Koeta (*Kota*)*;* Kota; Malay; fort, fortified town.
Kroeĕng; Krueng; Achinese; river.
Laboean (*Laboehan*)*;* Labuan; Malay; bay, anchorage.
Lae; Lae; ? (Batak); river.
Laoet; Laut; Malay; sea.
Lebak; Lebak; Sundanese; marsh, fen.
Lhok; Lho'; Achinese; bay (=Malay '*Teloek*' (telok); the Malay word 'Lok' means 'bend in river').
Long; Long; ? (Borneo); river mouth; junction of tributary with main stream (=Malay '*Koeala*').
Moeara; Muara; Malay (Sumatran dialects); river mouth, estuary.
Noesa; Nusa; Javanese; island (only in island names; not a generic term for islands).
Oedjoeng; Ujong; Malay; cape (lit. 'extreme point', 'tip').
Padang; Padang; Malay; plain, open ground.
Pantai; Pantai; Malay; beach, strand.
Pasir; Pasir; Malay; sand (sometimes also used for 'hill' in Sumatra); note also *Pasir pandjang*=sandy beach; *Boesoeng pasir*=sand-dunes (lit. 'a swelling of sand').
Pĕmatang; Pĕrmatang; Malay; hog's back ridge; low dry elevation in swampy region, e.g., an old beach or sandy area.
Poelau; Pulau; Malay (Javanese 'poeloe'); island.
Poetih; Puteh; Malay; white (thus *Batoe poetih*=white rock).
Ranoe; Ranu; Malay=mere; stagnant pool; Java-Malay=mountain lake; Sundanese=lake (spelt '*Ranau*' in Borneo and Celebes).
Rantau; Rantau; Malay; reach (of a river); stretch of coast-line.
Sawah; Sawah; Malay; ricefield ('wet' rice-field, natural or irrigated; '*sawah air*' =natural swamp, '*sawah beutjeh*'=irrigated).
Selat; Selat; Malay; channel, strait.
Sitoe; Situ; Java-Malay (from Sundanese); tarn, mountain lake.
Soengai; Sungai; Malay; river.
Tanah; Tanah; Malay; earth, ground, land.
Tandjoeng; Tanjong; Malay; cape, headland, promontory (also= 'turning-point', e.g., a sharp convex bend in a river-bank).
Tasik; Tasek (Tasik); Malay; lake, mere.
Telaga; Telaga; Malay; small lake, pool, well.
Teloek (*Telok*)*;* Telok; Malay; bay, cove, haven (also concave bend in river bank).
Timoer; Timor; Malay; east, eastern.
Tji; Chi; Sundanese; water, river.
Wai; Wei; ? (S. Sumatra); river.

Appendix II

CAMPING IN RAIN FOREST

Camping in tropical rain forests presents certain difficulties not met with in other places, though the abundance of building material and firewood go some way to offset the disadvantages of climate.

These notes are intended as a guide to the methods which have been found in practice to be the simplest for Europeans to adopt when they have little or no assistance from natives. Whenever possible, however, it is very desirable to employ native assistants; local camping methods, with which the assistants will be familiar, should then be employed.

Stores

The most essential stores are an axe, a large knife (cutlass or machete) with at least a 9 in. blade, matches, a hammock, and food according to availability and needs. A blanket, a lamp and various other articles of furniture and equipment will also be found useful.

A short list of the most generally needed medicines is given below, though many more which might be needed could be added:

Antiseptic (Eusol is very good for septic sores)
Atebrin or quinine (for malaria)
A laxative
Aspirin
Ferric chloride (for leech bites)
Chlorodyne (for diarrhœa)
Lint and sticking plaster
Potassium permanganate (for remote risk of snake bite).

Shelters

Temporary shelters. As the frequent heavy rain storms usually last only for a short time, it may be worth while to shelter from them, thus avoiding discomfort and the risk of a chill. If palm leaves are obtainable half a dozen or more should be cut, laid on top of each other and tied or wedged in the fork of a small tree. These make a good shelter from the rain, which usually falls vertically in thick forest. Other large leaves, such as those of wild bananas, can be substituted for palms. If neither shelter nor a change of clothing is obtainable, it

is advisable to remove some or all of the clothes and keep them as dry as possible until the rain is over as severe chilling results from wearing wet clothes, even at tropical temperatures.

Sleeping places. The type of shelter to be constructed for a night or two depends on whether hammocks or beds are to be used. For hammocks a strong framework is constructed as shown in Fig. 141, using lianes for the laskings. Lianes vary in their suitability for use as rope; this can only be determined by experience unless there are

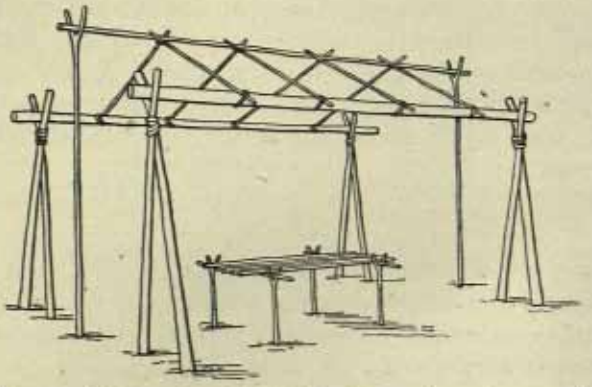

Fig. 141. Construction of a shelter. Drawn from photographs.

local inhabitants who can be questioned. The strength and pliability of a liane can be improved by twisting and this is also some test of suitability, as the worst ones will break.

A ridge pole is erected (Fig. 141) and the roof thatched with palm or other large leaves secured with liane. If tarpaulins are available, these can be used instead of leaves for roofing; they should be secured by tying to stakes driven in at intervals along the sides. In exposed situations or very wet weather it may be desirable to cover one or more sides of the hut with palm leaves held in place by lacing between slender stakes. Alternatively the split stems of very soft wooded trees or bamboo can be used. It is usually easier to make several huts for a large party, each with room for about four hammocks, rather than one large one.

If beds are used a light frame-work to support the thatch is all that is necessary. Beds are in general less convenient than hammocks as they are awkward to carry about and are more accessible to ants and other pests.

A single blanket is adequate covering for the night.

Fires

Dry wood can be obtained on the wettest day by splitting a dead, but not rotten, log. Many of the trees have very hard wood, but soft wood can always be found with a little searching; this burns better and saves a great deal of time. Thin shavings cut from the split surface of the log are an effective substitute for paper for kindling; dry leaves are seldom satisfactory.

Food

Animal

Mammals and birds. Local sources of animal foods are nearly always poor. Game is very difficult to see in the forest, and, unless it can be approached quietly and shot before it moves, it almost invariably gets away. Local inhabitants can often obtain a certain amount of meat where a European, even though a good shot, will get none.

Chickens are general in villages and settlements.

Fish. Fish provide the most generally obtainable animal food. Any of the usual means of catching fish can be tried, though angling is extremely inefficient. It is best to use local fishing methods, where these are known and the apparatus is available. The commonest are nets, various types of trap and fish poisons. Fish poisons are made from a variety of plants and are in use in most tropical countries. When put in a stream or small river they stupify or kill the fish, which can then be picked out as they float on the surface. Poisoned fish are quite wholesome to eat.

Other animals. Tortoises, turtles and many large grubs may be eaten, the latter with caution as some are very unpleasant.

Vegetables, fruits and nuts

These are generally scarce, and it is unwise to eat even the most tempting looking fruits without certain knowledge or the guidance of local inhabitants. The young shoots of palms, raw or cooked, are a safe and easily recognized food which can usually be obtained.

Yams are generally to be found in villages or cultivation patches in the forest. There are many varieties known by a number of local names the chief of which are Taro, Tannia, Eddoe, Yuca and Sweet Cassava. These may all be boiled, or roasted and thorough cooking is desirable, particularly with cassava which is poisonous when raw. If palm oil or other fat is available a kind of 'potato cake' may be

made from any of these by boiling, mashing and frying. Sweet potatoes, another commonly grown tuber, are eaten boiled and have a flavour reminiscent of Spanish chestnuts.

Sago, made from the pith of a palm, is much used. Young fern fronds are boiled and eaten in some districts.

Drink

Water should always be well boiled, except when obtained from mountain streams in uninhabited districts.

Certain lianes contain a large quantity of sap which pours out when a piece of stem is cut off. This sap can often be drunk, but the guidance of natives is desirable as some lianes are poisonous.

Bread making

In all warm damp climates spores of yeast float in the atmosphere and grow rapidly when they settle on any suitable substance. This yeast can be caught and used for bread making by exposing a small quantity of dough in the air in a shady place for a few days. This lump of dough is then kneaded in with the main mass and the bread allowed to rise. When the loaves have risen they are put in an empty gasoline can, or other suitable tin, cut open at one end to serve as an oven. The fire is then built on the top and round the sides of the oven, but not underneath it. The addition of a small quantity of sugar to the dough makes it rise better.

Finding the Way

Visibility in rain-forest seldom exceeds 20 yd. and it is very easy to get lost. A compass is almost essential for a cross-country journey, though blazing the trunks of the larger trees and cutting through saplings at every few steps is all that is necessary for finding the way back to the starting point. To begin with it is essential to concentrate on following the blazed trail when returning, but this becomes automatic with practice.

Whistles and guns are of very little use for attracting the attention of people who are lost, as sound only carries a short distance in the forest.

Paths are scarce, and away from villages usually absent. Rivers are everywhere the chief travel routes. If a European boat with an outboard motor is used, paddles or oars should always be carried as few outboards survive for long on tropical rivers. Native people are

familiar with paddles, but have rarely used oars; paddles are therefore preferable if there is a prospect of employing natives. Paddles can be fairly easily made from the thin buttresses of certain trees.

Rafts can be constructed with tree trunks and lianes, but care is necessary in selecting the trees, as many tropical hardwoods are heavier than water. No other type of craft can easily be made by the inexpert.

With a little practice is is easy to tell the time by the sun with considerable accuracy.

Pests

Large dangerous animals are rare and often entirely absent in rainforest; snakes too are much scarcer than is generally believed and very few kinds will attack man, if not molested.

Insects. Ants are ubiquitous and frequently unpleasant, being specially in evidence when trees are felled. They are very difficult to avoid altogether.

Mosquitoes, certain kinds of which may carry malaria, are mostly active after dark. Mosquito nets are desirable for sleeping under; these can be used for hammocks as well as beds, though a rather different type is necessary. Two layers of thin clothing are a more effective protection than one layer of thicker material. Sandflies are often very local and found only near rivers. They are so small that protection from them is almost impossible.

Other invertebrates. Leeches are particularly active after rain. They may be removed by applying salt or a hot cigerette end and the bleeding stopped by painting the wound with ferric chloride solution.

Ticks are ubiquitous. They may be removed in the same way as leeches. The annoyance of ticks can be minimized by avoiding contact with the undergrowth as far as possible.

Scorpions are rare and easily avoided by the observant.

It is particularly desirable to avoid scratching an itching bite, as septic sores, very difficult to cure, nearly always result. For the same reason any wound, however slight, should be immediately treated with antiseptic.

Clothing

There has in the past been much discussion about the advantages of shorts compared with knee breeches. Breeches provide slight protection against mosquitoes and ticks, but fail to keep out leeches.

Shorts are much cooler and more comfortable and make the detection and removal of parasites easier.

Gym shoes are the most satisfactory footwear, and it is important never to go barefoot, even in a hut. Socks or stockings can be worn if desired; they are of little use as protection and very unpleasant when wet.

Very few raincoats are effective in a tropical storm and any additional garment causes the wearer to sweat so much that he gets just as wet with it as without it.

Hats may not be needed as a protection against the sun within the forest, but are very useful when it rains.

Care of Personal Property

Keeping clothing and stores dry is very difficult and many things rapidly go mouldy in the warm damp atmosphere of the forest. Leather suffers in this way more rapidly than any other material and should be avoided as far as possible. A waterproof haversack is invaluable for small objects such as matches and watches, which suffer as much from sweat as from rain if carried in the pockets.

In camp stores, clothes and all other objects which might be damaged by wet should be kept on low 'tables' which can be readily constructed from saplings as shown in Fig. 141.

Appendix III

MAPS AND CHARTS OF THE NETHERLANDS EAST INDIES

The Dutch colonial empire in the East Indies covers nearly two million square kilometres. Much consists either of lofty mountain ranges or of extensive marsh land, and nearly three-quarters is forest-covered. The mapping of this great area is therefore a formidable task, but is necessary both for the progressive economic development of a richly endowed empire and for military reasons. The earliest maps were produced in the eighteenth century by the *Vereenigde Oost-Indische Compagnie*. After 1800 an increasing number of surveys were made round the larger settlements by various sections of the *Departement van Marine* and of the *Departement van Oorlog* (War).

After undergoing a number of changes, the survey services achieved autonomy in 1907, and by 1937 had an organization including printing and engraving departments and a section concerned with aerial survey. This organization, known since 1874 as the *Topografische Dienst*, also produced maps for several other government departments.

The Organization of the *Topografische Dienst*

In 1940 the *Topografische Dienst* consisted of a central establishment at Weltevreden, near Batavia, and nine sections, as follows:

(i) *Triangulatiebrigade*

This section became responsible in 1882 for all geodetic and astronomical work formerly carried out by the *Geografische Dienst* of the *Departement van Marine*. Its major operations were the triangulation of Java (1862–80), Sumatra (1883–1941), Celebes (1910–31), Lesser Soenda Islands (1912–23), Bangka (1917–20, 1926–31), Bawean (1917–18), Amboina (1919–26), Riouw-Lingga Archipel (1933–6) and Borneo (1933–41), the precise levelling of Java (1925–30), and the tertiary levelling of Celebes (1924–7) and Bangka (1927–31). This work is described in detail under the various islands.

Astronomical observations were made to orientate correctly the respective primary triangulations. The earliest observations were taken at Genoek in Java (1873). In all, thirteen points have been orientated with every refinement of accuracy, including two in Java, four in Sumatra, five in Celebes, and one each in Borneo and Bangka. In eastern Sumatra and in western Borneo the swampy jungle-covered plains made triangulation extremely difficult and expensive. Many points were fixed astronomically, as a basis for the topographical survey, instead of by a triangulation network.

The section also made valuable contributions to the related sciences of geodesy and geophysics. The position of the Netherlands Indies across the equator affords facilities for research into the figure of the earth, while the juxtaposition of island arcs and ocean deeps has encouraged geophysical research. The most notable work included observations of movement of the poles, geodetic adjustments of primary triangulation systems along the equator in conjunction with the survey departments of the Federated Malay States and of the United States, various gravimetric surveys,

and observations of the geodetic control of the relative movement of islands with related problems of continental drift.

Routine work of continuous observations was carried on at Weltevreden and at the *International Breedtewaarnemingen* (International Latitude station) at Tjililitan near Batavia, founded in 1931. In conjunction with the *Nederland-Indië Sterrenkundige Vereeniging* (Astronomical Union), much research work is carried out at the observatory at Bosscha, near Lembang in Java (*Koninklijk Magnetisch en Meteorologisch Observatorium en de Bosscha Sterrenwacht*). Observations were made and computed at this station for the international longitude calculations in 1926 and 1933, and at Bosscha and Tjililitan for the international latitude calculations in 1931.

The Netherlands East Indies have contributed much to the advancement of science by active membership of the *Union Géodesique et Géophysique Internationale* and of the *Union Astronomique Internationale*. Among outstanding research must be mentioned the gravity surveys off the coasts of the East Indies by Professor F. A. Vening Meinesz on behalf of the *Geodetische Rijkscommissie*, made in a submarine during the years 1926–30 (see pp. 15 and 46).

(ii) *Opnemingsbrigade*

These three survey units were stationed in 1940 at Makassar (for the survey of Celebes), at Samarinda (for the survey of Borneo) and at Medan (for the survey of Atjeh and the Riouw archipelago). These brigades were concerned with new topographical survey work.

(iii) *Herzieningsbrigade*

Three sections carried out periodic revisions of large scale surveys, both for the land tax (*landrente-metingen*) and for the smaller scale topographical maps. In 1940, the brigades were working at Bandoeng (revision of West-Java), Magelang (Midden-Java), and at Malang (Oost-Java). There were also separate detachments at Makassar (surveys of Zuid-Celebes) and at Singaradja (Bali and Lombok); these large scale surveys were similar to the work of the *herzieningsbrigade* in Java, but were completely new.

(iv) *Fotogrammetrische Brigade*

Faced with the problem of mapping extensive areas of difficult terrain, the *Topografische Dienst* has experimented since 1920 with various photographic survey methods. The value of this work was recognized in 1924 by the establishment of an advisory commission (*Adviescommissie voor Luchtkaarteering*), and finally in 1937 a separate section was formed to carry out all aerial and photogrammetric surveys, with its headquarters at Weltevreden.

Its work included (*a*) photogrammetric surveys on the ground, using phototheodolites, (*b*) the production or revision of large scale sheets and plans by aerial survey of areas with an existing ground triangulation and (*c*) the mapping by aerial triangulation of hitherto unsurveyed regions.

The chief surveys executed by the last method were in Bangka (1932–4), covering 4,000 sq. km. on a scale of 1 : 25,000), in Sumatra (1935–7), covering 5,300 sq. km. on 1 : 25,000, and (1935–8), covering 4,000 sq. km. on 1 : 50,000), and in New Guinea (covering 15,000 sq. km. on 1 : 100,000). It was hoped that aerial survey methods would enable the whole archipelago to be mapped on a scale of 1 : 100,000 or less in some thirty to forty years.

A considerable amount of aerial survey of a reconnaissance nature has been carried out by the *Koninklijke Nederlandsche-Indische Luchtvaart Maatschappij* (K.N.I.L.M.) and by the *Nederlandsch Nieuw-Guin e Petroleum Maatschappij*.

(v) *Kartografische Afdeeling*

This unit at Weltevreden was concerned with the compilation and drawing of maps from data supplied by the survey and revision sections, and with the correction

of proofs. The standard of cartography was high and the majority of the series was most attractively produced. Especially notable was the use of hill shading and of layer tinting for the representation of relief.

(vi) *Reproductiebedrijf*

Formerly known as the *Topografische Inrichting*, this section at Weltevreden was responsible for the printing and publishing of all maps made in the Netherlands East Indies. It also produced an annual list of current maps published by the *Topografische Dienst* entitled *Opgave van Kaarten, Legendas, Verslagen, enz.*, and an annual *Jaarverslag van den Topografischen Dienst*. The latter is a detailed and well illustrated year-book, summarizing the activities of the *Topografische Dienst*; it usually contained special articles, specimens of maps, etc.

(vii) *Kaartenmagazijn*

This section at Weltevreden was in charge of the storage and sale of maps.

(viii) *Instrumentmakerswinkel*

A small department at Weltevreden was concerned with the issue, maintenance and repair of all survey instruments.

(ix) *Opleidingsbrigade*

The training brigade at Malang has been responsible since 1896 for the training of all personnel employed by the *Topografische Dienst*, including advanced and 'refresher' courses for officers, and the recruitment and training of semi-skilled native labour. Not only field workers, but computers, draughtsmen and engravers were trained.

The State of the Survey, 1940

The whole of Java and some two-fifths of the rest of the Netherlands East Indies have been topographically surveyed with a satisfactory degree of accuracy (Fig. 142). A number of areas, including Alor, Halmahera, Soemba, Timor and a small part of New Guinea, were satisfactorily mapped without any geodetic basis. The maps thus produced included the small scale *overzichtskaarten*, the *graadafdeelingsbladen* or administrative maps of residencies, and the *detailbladen* on scales ranging from 1 : 50,000 to 1 : 2,500.

Topographical Survey

The state of the topographical survey of the various parts of the archipelago on 1 January 1940, was as follows:

Territories	Total area, in sq. km.	Total surveyed area, in sq. km.	% surveyed
Java and Madoera	132,200	132,200	100
Sumatra	473,606	433,043	91
Borneo	539,460	192,336	36
Celebes	189,035	32,201	17
Lesser Soenda islands	73,615	34,051	46
Moluccas	88,862	24,462	28
New Guinea	409,594	11,473	3
Total	1,904,372	859,766	41

Source: *Jaarverslag van den Topografischen Dienst in Nederlandsch Indië, over 1939*, p. 2 (Weltevreden, 1940).

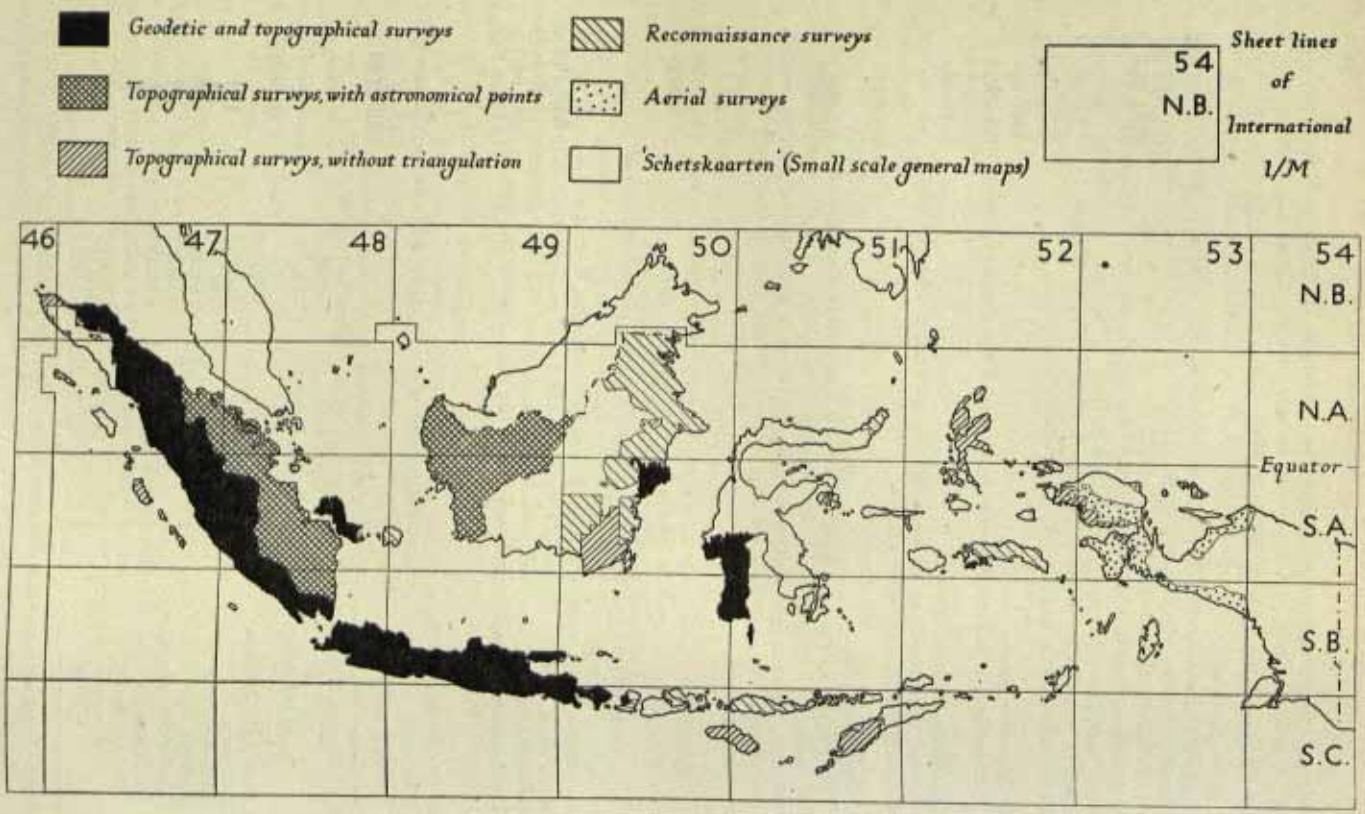

Fig. 142. Cartography of the Netherlands East Indies at the end of 1939.
Source: *Jaarverslag van den Topografischen Dienst in Nederlandsch-Indië over 1939* (Weltevreden, 1940).

Schetskaarten and *verkenningskaarten*

The area not covered by the regular topographical survey has been mapped on small scales. The data for these series have been compiled at various times by military expeditions, by missionaries, by mining companies and by explorers. Notable examples include maps of Celebes (1 : 1,250,000, 1927), Borneo (1 : 2,000,000, 1934), New Guinea (1 : 1,000,000, 1919), Flores (1 : 300,000, 1928) and Ceram (1 : 500,000, 1922). The maps of the Archipelago as a whole were necessarily based in large part on these *schetskaarten*.

The following table summarizes the work of the *Topografische Dienst* during the last seven years. Every sheet published is included; revised and reprinted sheets are italicized.

Island	Scale	1933	1934	1935	1936	1937	1938	1939
International	1 : 1,000,000	2		4				1
Bali	1 : 50,000	1	1					
"	1 : 200,000			1				
Bangka	1 : 25,000	7	11	11	9	3		
Borneo	1 : 100,000							2
"	1 : 200,000	3	1					
"	1 : 2,000,000		1					
"	1 : 5,000,000						1	
Celebes	1 : 50,000	4	4					
"	1 : 100,000				6	1	3	8
Halmahera	1 : 100,000	2	1					
"	1 : 500,000		1					
Java	1 : 25,000	*1*	*12*	*9*				4
"	1 : 50,000	*4*	*13*	*9*	*17*	*17*	*42*	*40*
"	1 : 100,000 (geological)	3	1	2		1	4	
"	1 : 250,000				*2*			
"	1 : 1,000,000			1	1			
"	1 : 2,000,000				*1*			
Lombok	1 : 25,000		1					
New Guinea	1 : 100,000				3		1	
"	1 : 250,000				19	1		4
"	1 : 2,500,000							1
Soemba	1 : 100,000		1				2	2
Sumatra	1 : 20,000	*4*						
"	1 : 40,000	*3*		*6*	*3*	*2*	*1*	*1*
"	1 : 50,000	5	1			1	4	14
"	1 : 100,000	22	8	23	10	10	11	9
"	1 : 200,000 (geological)	3	2			3		
"	1 : 250,000			1	1		1	1
"	1 : 750,000			4	2			
Timor	1 : 100,000			1		2		2
Wetar	1 : 150,000							1
New sheets		52	34	48	51	22	27	49
Revised and reprinted		12	25	24	23	19	43	45
		64	59	72	74	41	70	89

DESCRIPTION OF MAPS

The maps of the Netherlands East Indies are described under the following heads: A. Dutch maps, plans and atlases. The majority of the series listed are published

by the *Topografische Dienst*, but a few miscellaneous maps produced by scientific scientific expeditions, by automobile clubs and by private companies are also included.

B. Maps published by the Geographical Section of the British General Staff (G.S.G.S.).

C. Geological maps.

D. Charts published by the British Admiralty, by the United States Hydrographic Office, and by the Dutch *Departement van Marine*.

In each of the first three groups, the maps of the Archipelago as a whole are listed, then those of each island or group of islands in alphabetical order. The individual series are arranged in order of scale, the larger scales first, and are numbered consecutively throughout to facilitate reference. In general, only series which were still in use in 1941 are listed, although some had been partially superseded; where several editions of the same series have been produced, details are given in full for the first, and changes only noted for subsequent editions.

The following particulars are given where applicable for each series:

(1) Scale and title.

(2) Authority responsible for its production. The great majority of series were published by the *Topografische Dienst*; the responsible authority is therefore only stated when this was not the case.

(3) Date of production, with subsequent revisions.

(4) Number of sheets in the series, both the intended total and the number actually produced to March, 1944 (G.S.G.S.) or to 1941 (Dutch government).

(5) Size of sheets, measured to the margin of the area mapped.

(6) Graticule or marginal divisions (with meridian of origin) and grid.

(7) Miscellaneous marginal information.

(8) Whether coloured or in black.

(9) The method of representation of relief.

(10) Details of roads, railways, land utilization and other information.

The projection of each series is not stated, as owing to the position of the East Indies athwart the Equator, the projection used is almost invariably Mercator. The zenithal equal area and Lambert's conical equal area projections are occasionally used.

A. DUTCH MAPS

Maps and Atlases of the Archipelago

Small scale sheets of the whole archipelago were numerous in the nineteenth century, derived from information collated as the *Departement van Marine* gradually finished the coastal surveys. These maps were produced by private individuals such as von Hinderstein, Tindal, Beyerinck and Edeling, and were usually published in Holland. The first complete and reasonably accurate series was the *Algemeene Atlas van Nederlandsch Indië*, compiled by P. Melvill van Carnbee and W. F. Versteeg, published by Kolff in Batavia. The first series on a uniform scale was the fifteen sheet edition on a scale of 1 : 1,800,000, compiled by Dr J. Dornseiffen and published by Seyffardt of Amsterdam in 1873, followed in 1879 by four sheets on a scale of 1 : 4,000,000 compiled by S. H. Serné and also published in Amsterdam.

The *Topografische Inrichting* has been responsible for the publication of two uniform series covering the whole archipelago; the *Overzichtskaart* (1 : 2,500,000) and the *Internationale Wereldkaart* (1 : 1,000,000).

(1) 1 : 1,000,000 *Internationale Wereldkaart*

Published 1925. Twenty-six sheets have been published of the intended twenty-eight (Fig. 142). International sheet numbering NB 46, 47; NA 47–52; SA 47–54;

SB. 48–54 and SC. 49–54; SA. 54 and SB. 54 (both in New Guinea) remain to be published. Sheets 44 × 48 cm. (north margin) and 50 cm. (south margin). Graticule at degree intervals (longitude from Greenwich). Each sheet covers 6° longitude and 4° latitude.

Relief shown by contours and layer-colouring, on some sheets by hill shading and spot-heights only. Roads in red (four grades), railways in black (three grades), towns of five orders of importance by different symbols, water in blue.

In addition to the Dutch editions, certain sheets (NB 46, 47 and NA 47, 48) have been published by the Government of India Survey, and in Siamese characters. See also G.S.G.S. Series 4204 (p. 483).

(2) 1 : 2,000,000 *Telegraafkaart van Nederlandsch-Indië*

Published by the *Topografische Inrichting* for the *Hoondbureau van den Post-, Telegraaf- en Telefoondienst* (1915). Two sheets, 72 × 62 cm. referring to Java on a scale of 1 : 750,000; six sheets, 87 × 46·5 cm. referring to Sumatra (2), Borneo, Celebes en Soenda-eilanden (2), and Molukken (2). Java is on a scale of 1 : 750,000, the others on a scale of 1 : 2,000,000. In colours.

Lines in green and black, with miscellaneous green and black symbols for telephone and telegraph stations.

(3) 1 : 2,500,000 *Overzichtskaart van den Oost-Indischen Archipel*

Published in 1908, with revised edition 1926. Six sheets 72 × 60 cm., with 62 pp. gazetteer. Margins divided into degree intervals (longitude from Batavia). In colours.

Coastline in black. Relief shown by hill shading in brown, with black spot-heights. Spot-depths in blue. Rivers, lakes and marshes in blue.

Roads in red (two grades), railways and tramways in black. Telegraph cables by dotted black line. Administrative boundaries by black pecked line. Miscellaneous red, blue, and black symbols for anchorages, harbours, lighthouses, etc.

(4) 1 : 3,000,000 *Kaart van den zeediepten in het Oostelijk deel van de N.I. Archipel*

Published in 1918. Single sheet, in colours.

(5) 1 : 4,000,000 *Kaart der geregelde Postverbindingen en der onderzeesche Telegraafkabels in den Nederlandsch Oost-Indischen Archipel*

Published by the *Topografische Inrichting*, for the *Chef van den Post, etc., in Ned. Indië* (1901). Two sheets, in colours.

(6) 1 : 5,000,000 *Dieptekaart van den Oost-Indischen Archipel*

Published by the *Topografische Dienst* in 1934, from a map drawn by P. M. van Riel of the Snellius Expedition. Single sheet, 96 × 53 cm. Margins divided into ten minute intervals (longitude from Greenwich), with graticule drawn every five degrees. In colours.

Relief shown by contours at every 1,000 m., tinted in five shades of brown, with spot-heights. Submarine contours at 200 m., 1,000 m. and every 1,000 m. to 10,000 m. with layer-tinting in twelve shades of blue, and numerous spot-depths.

(7) 1 : 6,000,000 *Overzichtskaart van den Oost-Indischen Archipel, aandevende de staandplaatsen, der Europ. Ambtenaren bij het B.B.*

Published in 1909. Two sheets, in colours.

(8) 1 : 6,000,000 *Nederlandsch Oost-Indië*

Compiled by S. C. Bruins, published by J. J. Tijl (Zwolle, 1932). Single sheet, 80 × 61 cm. In colours.

Administrative areas tinted. Insets of Batavia (1 : 60,000), Java (1 : 1,750,000), New Guinea (1 : 18,000,000) and Semarang (1 : 125,000).

(9) 1 : 6,500,000 *Overzichtskaart van den Nederlandsch Oost-Indië*

Sheet I, 93 × 57 cm., of the *Atlas van Nederlandsch Oost-Indië*, compiled by J. W. Stemfoort and J. J. ten Siethoff (1901). In colours.

(10) 1 : 10,000,000 *Overzichtskaart van den Oost-Indischen Archipel*

Published in 1920. Single sheet, in colours.

(11) *Atlas van de Gewesten der Buiten-bezittingen* (*Ned. Oost-Indië*)

A series of 23 sheets covering the East Indian Archipelago published in 1917–23. Scales range from 1 : 200,000 (*Schetskaart van Minehasa*), to 1 : 8,000,000 (*Kaart van de grondsoorten in het Noordelijk deel van Sumatra's Oostkust*). Although available in an album as a collected series, the sheets were also published individually, and are included under the various islands.

(12) *Atlas van Nederlandsch Oost-Indië*

A series of sixteen sheets, with forty-two individual maps, compiled by J. W. Stemfoort and J. J. ten Siethoff, and published in 1900–07. Sheets, 93 × 57 cm. Although available in an album as a collected series, the sheets were also published individually. The sheets are as follows:

Blad (i) 1 : 6,500,000 Overzichtskaart van Nederlandsch Oost-Indie.

(ii) 1 : 2,000,000 Java en Madoera, four maps showing communications, language, geology and relief.

(iii)–(v) 1 : 500,000 West-, Midden-, en Oost-Java.

(vi)–(viii) 1 : 900,000 Noord-, Midden, en Zuid-Sumatra.

(ix)–(x) 1 : 600,000 Sumatra's West-kust, Oostkust.

(xi) (*a*) 1 : 500,000 Bangka; (*b*) 1 : 400,000 Blitoeng; (*c*) 1 : 750,000 Riouw- en Lingga Archipel.

(xii) 1 : 1,000,000 Wester- afdeeling van Borneo.

(xiii) 1 : 500,000 Ooster-afdeeling van Borneo.

(xiv) 1 : 2,000,000 Celebes.

(xv) (*a*) 1 : 1,000,000 Kleine Soenda-eilanden; (*b*) 1 : 5,000,000 Timor- en Alor- eilanden.

(xvi) (*a*) 1 : 3,000,000 Molukken, (*b*) 1 : 4,000,000 Nederlandsch Nieuw-Guinea.

In addition to these main maps, there are numerous insets of town-plans.

(13) *Atlas van Tropisch Nederland*

Published by the *Koninklijk Nederlandsch Aardrijkskundig genootschap* (Royal Geographical Society of the Netherlands), in conjunction with the *Topografische Dienst* (1938). Thirty-one double page sheets, containing 165 maps, bound as a single volume, 34 × 44 cm. The maps vary from double page size to small insets. A detailed gazetteer is appended separately.

The preface, list of maps and text accompanying each sheet is given in Dutch, French, German and English.

The series of maps portrays very successfully in full colour many aspects of the Archipelago, including relief, volcanicity, geology, soils, climate, vegetation, animal distribution, density of population, types of settlement, agricultural distributions, linguistic distributions, history, etc. There are numerous large-scale plans. These maps summarize the results of the most recent topographical and land utilization surveys by the *Topografische Dienst*.

(14) *Atlas van Regenval in Nederlandsch-Indië*

Published by the *Topografische Inrichting* for the *Koninklijk Magnetisch en Meteorologisch Observatorium te Batavia*, 1925–33. Compiled by Dr J. Boemera.

The following volumes have been published:

(i) *Kaarten van den gemiddelden jaarlijkschen en maandelijkschen regenval op Java en Madoera* (1925). Three volumes, of which vol. I consists of tables, vol. II of maps and vol. III of text. Vol. II includes fourteen sheets, 105 × 33 cm., giving a location map of meteorological stations, one of mean annual rainfall, and twelve of mean monthly rainfall. Layer-tinting in blue, superimposed over light brown shading of relief.

(ii) *Kaarten van den gemiddelden jaarlijkschen en maandelijkschen regenval op Sumatra* (1931). Details as for (i).

(iii) *Kaarten van den gemiddelden jaarlijkschen en maandelijkschen regenval op Borneo* (1932). Details as for (i), but duplicated (not printed) in black and white.

(iv) *Kaarten van den gemiddelden jaarlijkschen en maandelijkschen regenval op Celebes* (1933). Details as for (i).

Maps of the Individual Islands and Territories

Adonara

(15) 1 : 100,000 *Schetskaart van het eiland Adonara*

Published in 1911. Single sheet, 42 × 28 cm. Margins divided into one minute intervals (longitude from Greenwich). In colours.

Coastline in blue, with sea tinted faint blue. Relief shown in outline by brown hachures, with a few spot-heights in black. Footpaths by red dotted line. Provincial boundaries by black pecked line.

Alor

(16) 1 : 100,000 *Overzichtskaart van het eiland Alor*

Published in 1932. Three sheets, 50 × 49 cm. In margins are index diagrams of adjoining sheets, with latitudes and longitudes of sheet corners (longitudes from Batavia), and of administrative divisions, with numbered and lettered list. In colours.

Coastline in blue, with sea tinted faint blue. Relief shown by brown contours at 50 m. interval, every 500 m. emphasized, with intermediate form-lines pecked, and spot-heights in black. Rivers, names of rivers, lakes and swamps in blue.

Roads in red (one grade), tracks by thin red line, footpaths by red dotted line. Administrative divisions by black pecked line. Native villages in solid green. Miscellaneous red and black symbols for woodlands and plantations, houses, Christian churches, temples, Chinese graves.

(17) 1 : 600,000 Alor

An inset on sheet 2 of *Overzichtskaart van het afdeeling Flores*, published in 1928. Size of inset, 27 × 10 cm.

Details of relief, etc., as on main sheet (No. 81).

Amboina

A base was measured near Tawari in 1919 and the triangulation of the main and adjoining islands was completed in 1926. The detailed topographical survey was carried out between 1921–6.

(18) 1 : 5,000 *Hoofdplaats Ambon*

Published in 1924. Single sheet in colours.

(19) 1 : 50,000 *Ambon en Ternate*

Published in 1924, in the series *Detailbladen Molukken*. Single sheet in colours.

(20) 1 : 100,000 *Ambon en Ternate*

Published in 1924, in the series *Gradafdeelingsbladen Molukken*. Single sheet, in colours.

(21) 1 : 2,500,000 *Overzichtskaart van de residentie Amboina en de afdeeling Nederlandsch Nieuw-Guinëë*

Published in 1915. Single sheet, in colours.

Babar

(22) 1 : 100,000 *Schetskaart van het eiland Babar*

Published in 1912. A reconnaissance map, surveyed in outline by compass and barometer. Single sheet, 36 × 34 cm. In colours.

Coastline, rivers and names of rivers in blue. Relief shown by discontinuous brown form-lines at 50 m. interval, but with large areas left blank. Villages and bivouac sites named. No other detail.

Bali

The first map of Bali was a *schetskaart* (scale 1 : 250,000) produced in 1897, with revisions in 1905, 1909 and 1922. Between 1912 and 1923, the primary triangulation of Java was extended eastwards over Bali and Lombok, and topographical surveys based on this network were carried out between 1919 and 1933. In 1924, the first of the 1 : 50,000 series was published, and in 1935 a new layered map on a scale of 1 : 200,000. In 1939, one of the revision units began a large-scale survey (1 : 2,500) for the land-tax returns.

(23) 1 : 50,000 *Bali*

Publication started in 1924, and is still in progress. In colours.

(24) 1 : 200,000 *Bali*

Published in 1935. Single sheet, 77×48 cm. Margins divided into one minute intervals (longitude from Batavia). List of administrative areas in margin. In colours.

Coastline in blue. Relief shown by brown contours at 100 m. interval, with faint layer tinting in green, yellow and three shades of brown, faint brown hill-shading, and spot-heights in black. Bathymetric contours in blue at 100, 200 and 500 m. interval, with spot-depths in blue, and sea tinted faint blue. Rivers, names of rivers, lakes and swamps in blue.

Roads in red and black (three grades), bridle paths by thin red line, footpaths by red dotted line. Administrative divisions by black pecked line. Native villages in black. Rice fields by diagonal grey lines. Miscellaneous red, black, blue and grey symbols for houses, rest houses, bridges, churches, temples, air-fields, volcanoes, sand-banks, reefs, etc. (see also Section B. No. 4).

(25) 1 : 250,000 *Schetskaart van het eiland Bali*

Published in 1897, with a second edition in 1905. Single sheet, 63×42 cm. Margins divided into two minute intervals (longitude from Greenwich). Table of road distances in margin. Inset on scale of 1 : 1,000,000 in colours to show administrative divisions.

Coastline in blue, with sea tinted faint blue. Relief shown by brown contours at 100 m. interval, with spot-heights in black, and with layer tinting in eight shades of green and brown. Rivers, names of rivers, lakes and swamps in blue.

Bridle paths by thin red line. Footpaths by red dotted line. Administrative divisions by black pecked lines, emphasized variously in pink and yellow. Inhabited places by black dots. Miscellaneous red and black symbols for churches, temples, harbours, anchorages, lighthouses, sand-banks, reefs, etc.

(26) 1 : 250,000 *Schetskaart van het eiland Bali*

Third (1909) and fourth (1922) editions of (25). Similar detail to (25), but without layer-colouring or table of road distances.

Bangka

The triangulation of Bangka was begun in 1917; the work was interrupted in 1921, but completed during the years 1926–31. At first an isolated system, it was linked in 1936 to the network of the Lingga Archipel and to that of Billiton. The detailed topographical survey based on this triangulation was carried out between 1927 and 1935.

The earliest map of Bangka was a *schetskaart* on a scale of 1 : 300,000, produced in 1894 by the *Militairen Commandant* of the island from a series of army reconnaissance surveys. In 1916, a more detailed *overzichtskaart* on a scale of 1 : 150,000 in four sheets was published, and in 1924 the island appeared on sheet 22 of the 1 : 250,000 series of Sumatra (No. 169). The first sheet of the 1 : 25,000 *detailbladen* appeared in 1931.

(27) 1 : 25,000 *Bangka*

Published in 1931–7. Forty-one sheets have appeared. In colours.

(28) 1 : 150,000 *Overzichtskaart van het Gewest Bangka en onderhoorigheden*

Published in 1916. Four sheets, 78 × 65 cm. Margins divided into five minute intervals (longitude from Greenwich). Inset diagram to show administrative divisions, with numbered and lettered list. In colours.

Coastline in blue, with sea tinted faint blue. Relief shown in outline by faint brown hachures, with spot-heights in black. Rivers, names of rivers, lakes and swamps in blue.

Roads in red (three grades), footpaths by red dotted line, tramways by filled black and white lines. Administrative boundaries by various pecked line, residency emphasized in yellow. Inhabited places by red and black symbols and dots (six grades). Miscellaneous red and black symbols for lighthouses, anchorages, sand-banks, reefs, etc.

Sheet 1 has inset plan of Muntok, on scale of 1 : 5,000, 36 × 50 cm. Roads by double red lines, buildings tinted red or yellow, various symbols for huts, temples, graves, trees, etc., pier in blue.

Sheet 2 has small inset plan 10 × 17 cm. in black of Pankalpinang, on scale of 1 : 20,000.

(29) 1 : 250,000 *Overzichtskaart van het eiland Sumatra—Blad 22: Bangka*

Published in 1924. For details see No. 169.

(30) 1 : 300,000 *Kaart van de residentie Bangka*

Published by the *Topographische Bureau* (1894), from surveys by the *Militairen Commandant* with the collaboration of the *Departement van Marine*. One sheet, 74 × 73 cm. Margins divided into five minute intervals (longitude from Greenwich). Numbered and lettered list of administrative divisions. In black, brown and blue.

Coastline in blue, with sea tinted faint blue. Relief shown in outline by brown hill-shading with a few spot-heights. Submarine contours in black at 3 and 5 fm.

Roads in black (two grades), footpaths by dotted black lines. Administrative boundaries by various pecked lines. Inhabited places by black dots (three grades). Miscellaneous brown and black symbols for temples, graves, anchorages, lighthouses, sand-banks, reefs, etc.

Bawean

(31) 1 : 25,000 *Kaart van het eiland Bawean*

Published in 1886. Single sheet, in black.

(32) 1 : 50,000 *Kaart van het eiland Bawean*

Published in 1926. Single sheet, in black.

Billiton

(33) 1 : 200,000 *Topografische Kaart van het eiland Billiton*

Published in 1882, with a second edition in 1894. Single sheet 60 × 45 cm. Margin divided into five minute intervals (longitude from Batavia). In black and grey.

Relief shown in outline by hill-shading, with spot-heights in black.

Roads by double black line (one grade), tracks by single line, footpaths by dotted line. Tramways by double lines filled black and white. Administrative boundaries by various pecked lines. Miscellaneous symbols for buildings, graves, temples, springs, wells, anchorages, sand-banks, reefs, etc.

Inset 30 × 18 cm. on scale 1 : 20,000 of Tandjoengpandan. (See also Section B. No. 3.)

Boeroe

(34) 1 : 250,000 *Schetskaart van het eiland Boeroe*

Published in 1910, with a second edition in 1915. Single sheet, 63 × 48 cm. Margins divided into ten minute intervals (longitude from Greenwich). In colours.

Coastline in blue, with sea tinted faint blue. Relief shown in outline by brown hachures, with spot-heights in black. Rivers, names of rivers, lakes and swamps in blue.

Bridle-tracks by thin red line, footpaths by red dotted line. Miscellaneous black symbols for inhabited places, individual houses, anchorages, sand-banks and reefs.

Borneo

The great extent of Borneo, largely covered with tropical forest and marsh, has caused the topographical survey to be a long and difficult business. By 1940, only 36% remained to be surveyed, but a considerable proportion of the completed part had no triangulation network and was scheduled to be resurveyed.

During the years 1886–95, an outline survey was carried out in the *Westerafdeeling*, based on a number of points astronomically fixed. During this time, a number of reconnaissance and coastal surveys produced sufficient data to complete small-scale *schetskaarten* of the whole island and of the various residencies. Between 1926–9, the *Nederland Nieuw-Guineë Petroleum Maatschappij* carried out a geodetic survey of parts of eastern Borneo, notably between Balikpapan and Samarinda, and this was used for the later topographical surveys by the *Topografische Dienst*. Between 1920 and 1927, the *Zuideren Oosterafdeeling* were surveyed, a number of points being astronomically fixed to orientate the survey. The *Triangulatiebrigade* surveyed in 1937 a base at Djoewai near Amoentai, and the primary triangulation was in progress in 1940.

Small areas were mapped by aerial survey by the *K.N.I.L.M.* (see p. 440) and by the *Nederlandsche Nieuw-Guineë Petroleum Maatschappij*. It was hoped that the estimated 35–40 years needed to survey the central parts of Borneo would be much reduced by an extensive programme of aerial triangulation and photogrammetry.

Overzichtskaarten of the whole island are numerous. Seyffardt's of Amsterdam produced a general map on a scale of 1 : 4,200,000 in 1883, followed by J. H. Schmüll's map on a scale of 1 : 2,600,000, also published in Amsterdam (1891). A 1 : 2,000,000 sheet by the *Topografische Inrichting* in 1899 was revised in 1909, 1914 and 1934 as further surveys produced more detail. Larger scale maps of the residencies include the four sheets of the *Westerafdeeling* on a scale of 1 : 500,000 in 1898, revised 1912; the twenty-six sheets of the same area on a scale of 1 : 200,000 in 1889–97, revised 1928–32; and the 1 : 100,000 series of the *Zuideren Oosterafdeeling*, which, begun in 1926, was still in progress in 1940. Two of the last series were produced in 1939. A few large scale *detailbladen* were produced for military purposes, such as 1 : 20,000 maps of Singkawang in 1887 and of Bandjermasin in 1916. In 1924, the first sheets of the 1 : 50,000 series of the *Zuideren Oosterafdeeling* were issued; the immensity of this project is shown by the fact that by 1940 only twelve of the contemplated 371 sheets had been published. A similar series was also in progress for the *Westerafdeeling*.

(35) 1 : 5,000 *Detailkaarten van hoofdplaatsen en omstreken*

Published in 1887–93. Fourteen sheets in colour, of Bengkajang, Mampawah, Montrado, Nang Pinoh, Ngabang, Pemangkat, Pontianak, Sambas, Sanggau, Singkawang, Sintang (two sheets), Soekadana and Eiland Tajan.

(36) 1 : 20,000 *Detailkaarten van hoofdplaatsen en omstreken*

Published in 1887–90. The following sheets were issued, in black: (i) Mampawah, one sheet; (ii) Singkawang, one sheet; (iii) Pontianak, four sheets; (iv) Montrado, one sheet; (v) Mandor, one sheet; (vi) Bengkajang, one sheet; (vii) Sambas, one sheet; (viii) Sintang, one sheet.

(37) 1 : 20,000 *Schetskaarten van de hoofdplaats en Bandjermasin en omliggende terrein*

Published in 1916. Single sheet, 58 × 52 cm. In colours.

Roads in double black lines, rivers in blue. Native villages in green, buildings in red. Marsh shown by horizontal blue lines. Black symbols for various trees.

(38) 1 : 25,000 *Detailbladen van Balikpapan en omgeving*

Published in 1932. Single sheet, in colours.

(39) 1 : 50,000 *Map of the Djagoei Territory and agreed boundary.*

Surveyed by Captain D. W. Buys (1923), and attached to the Convention concluded between Great Britain and the Netherlands, s' Gravenhage, 26 March 1928, for the delimitation of the boundary line in the island of Borneo. With location inset, 1 : 200,000. Dutch edition produced by *Topografische Dienst* (1928), English edition produced by the Ordnance Survey, Southampton (1928). Single sheet, 47 × 51 cm. Margin divided into minute intervals (longitude from Greenwich). In colours.

Coastline in blue, sea tinted faint blue. Relief shown by brown contours at 25 m. interval, with every 250 m. emphasized, occasional pecked form-lines and spot-heights in black. Rivers in blue.

Footpaths by red dotted line. Agreed boundary by black pecked line, emphasized in red. Inhabited places in solid green, Dyak villages in black, astronomical stations and signals by black symbols.

(40) 1 : 50,000 *Detailbladen van de Zuider- en Ooster- Afdeeling van Borneo*

Published 1924– . Twelve sheets 37 × 37 cm., of the intended total of 371, had been published by 1940. Inset diagrams of administrative boundaries and of adjacent sheets. In colours.

Coastline in blue, with sea tinted faint blue. Relief shown by brown contours at 25 m. interval, with every 250 m. emphasized; occasional pecked form-lines, and spot-heights in black. Rivers, lakes, and marshes in blue.

Roads by double red lines, bridle paths single red lines. Administrative boundaries by various pecked lines. Inhabited places by black circles. Native villages in solid green. A variety of black symbols for woodland and plantation crops. Miscellaneous red and black symbols for bridges, churches, temples, graves, anchorages, lighthouses, sand-banks, reefs, etc.

(41) 1 : 50,000 *Detailbladen van de residentie Westerafdeeling van Borneo*

Publication started in 1925. Seventeen sheets had been produced by 1940, 55 × 55 cm. Margins divided into five minute intervals (longitude from Singkawang). In black.

Relief shown by contours at 25 m. interval, every 250 m. accentuated, with occasional pecked form-lines, and spot-heights in black.

Roads by double lines (two grades), bridle-tracks by thin line, foot paths by dotted line. Miscellaneous symbols, for woodland and plantation products, rice fields, buildings, mosques, temples, anchorages, sand-banks, reefs, etc.

(42) 1 : 100,000 *Graadafdeelingsbladen van de residentie Zuider- en Oosterafdeeling Borneo*

Published in 1926. In colours.

(43) 1 : 200,000 *Graadafdeelingsbladen van de residentie Westerafdeeling van Borneo*

Published in 1889–97, with a second edition in 1922–32. Twenty-six sheets, 55 × 55 cm. Margins divided into minute intervals (longitude from Singkawang). Inset diagram of administrative boundaries in black, blue and brown.

Coastline in blue, with sea tinted faint blue. Relief shown by brown contours at 100 m. interval, with occasional finer form-lines at 25 m. and 12·5 m., faint brown hill-shading and spot-heights in black.

Roads in black, tracks by thin black line, footpaths by black dotted line. Administrative boundaries by black pecked lines, emphasized in pink and green. Inhabited places by black circles, Malay and Dyak villages by open squares. Diagonal blue ruling for rice-fields, variety of black symbols for woodlands and plantation products. Miscellaneous symbols for temples, graves, anchorages, lighthouses, sand-banks, reefs, etc.

(44) 1 : 500,000 *Kaart van de residentie Westerafdeeling van Borneo*

Published in 1898, with a second edition in 1912. Four sheets, 65 × 57 cm. Margins divided into five minute intervals (longitude from Singkawang). Numbered and lettered index to administrative areas in the margin. In colours.

Coastline in blue, with sea tinted faint blue. Relief shown by brown hill shading with spot-heights in black. Rivers, names of rivers, lakes and marsh in blue.

Roads in black (one grade). Administrative boundaries by black pecked lines, emphasized in green and yellow. Miscellaneous symbols for villages, anchorages, lighthouses, sand-banks, reefs, etc.

(45) 1 : 750,000 *Schetskaart van de residentie Zuider- en Oosterafdeeling van Borneo*

Published in 1913. Four sheets, 63 × 65 cm. Inset map of administrative divisions, 1 : 1,500,000. Margins divided into ten minute intervals (longitude from Singkawang). In colours.

Coastline in blue, with sea tinted faint blue. Relief shown in outline by brown hachures, with spot-heights in black. Rivers, names of rivers, lakes and marsh in blue.

Roads in red (two grades), footpaths by red dotted line. Administrative boundaries by black pecked lines, emphasized with pink, yellow, green and orange. Miscellaneous black and red symbols for villages, temples, lighthouses, anchorages, etc.

(46) 1 : 1,000,000 *Schetskaart van Midden Borneo, en het Landschap Koetei*

Published in 1905. Single sheet, 66 × 56 cm. Margin divided into ten minute intervals (longitude from Greenwich). In black and blue.

Coastline in blue, with sea tinted faint blue. Relief of small isolated areas shown by contours with spot-heights, but large areas blank. Rivers, names of rivers, and lakes in blue.

Roads (one grade), tracks, footpaths and telegraph lines by various solid and pecked lines. Administrative and military centres by black circles.

(47) 1 : 1,750,000 *Wegenkaart van Borneo*

Published in 1941. Single sheet, 77 × 46 cm. In black, with roads tinted.

Roads in black, red, yellow and green (eight grades according to surface), with bridges. Navigable waterways indicated by dots (three grades). Harbours indicated by symbol. Colonized areas ('kolonisatie terreinen') by 'k' symbol.

(48) 1 : 2,000,000 *Overzichtskaart van het eiland Borneo*

Published in 1909, with a second edition in 1914. Single sheet, 64 × 76 cm. Marginal list of administrative divisions, table of trade of each port in 1908 by value, and annual summaries of trade 1905–8. Imports and exports printed on map in red for each port. The second edition has trade figures for 1913. In colours.

Coastline in blue, with sea tinted faint blue. Relief shown in outline by faint brown hill-shading, with spot-heights in black. Rivers, names of rivers, and lakes in blue.

Roads in red (one grade), tracks in red pecked lines, footpaths in red dotted line, railways in filled black and white double lines. Telephone and telegraph lines and cables in blue. Administrative boundaries by pecked lines with divisions tinted. Administrative centres and inhabited places by black symbols. Miscellaneous red and black symbols for post-offices, harbours, anchorages, lighthouses, sand-banks, reefs, etc.

Chief plant products shown by green symbols, chief mineral products by orange symbols.

Insets, both on scale of 1 : 8,000,000, are: (i) *Overzichtskaart van de politikie Indeeling van Borneo*, showing administrative divisions by tints; (ii) *Dichtheid van Bevolking van Nederlandsch Borneo*. This shows the distribution of population in 1905 in nine shades of yellow and brown.

(49) 1 : 2,000,000 *Overzichtskaart van het eiland Borneo*

Published in 1934. Single sheet, 66 × 77 cm. Margins divided into ten minute intervals, with graticule drawn at degree intervals (longitude both from Greenwich and Batavia). Inset map of administrative divisions, with numbered and lettered list.

Coastline in blue. Relief shown by a 200 m. contour, with land below 200 m. tinted green, above tinted brown, with superimposed brown hill shading, and spot-heights in black. Submarine contours drawn at 100, 200, 500 and every 500 to 5,000 m., layer tinted in white and twelve shades of blue. Rivers, names of rivers, lakes and marsh in blue.

Roads in red (two grades), footpaths by red dotted line, railways in black, and cables by thin black lines. Administrative boundaries by black pecked lines, emphasized in pink and yellow. Miscellaneous red and black symbols for post-offices, temples, graves, radio stations, astronomical points, harbours, anchorages, lighthouses, sand-banks, reefs, etc.

(50) 1 : 2,600,000 *Kaart van het eiland Borneo*

Compiled by J. H. Schmüll and published by R. A. Eekhout (Amsterdam, 1891). One sheet in colours.

(51) 1 : 4,200,000 *Borneo*

Published by Seyffardt (Amsterdam, 1883). One sheet in colours.

Celebes

The geodetic survey of Celebes began in 1910, when a section of the *Triangulatiebrigade* was stationed at Makassar, and in the following year a base was measured near Djeneponto in the extreme south of the island, and a control point was astronomically fixed at Montjonglowe, east of Makassar. The primary triangulation was gradually extended north into Midden Celebes, where an independent base was measured at Korodolo in 1920. Since 1931, the primary network has been extended over the Golf van Tomini by way of the Togian-eilanden into Noord Celebes, and adjusted to the Minahasa network, originally developed independently from a base measured in 1915 near Tondano. The secondary and tertiary triangulation has been completed for Zuid Celebes and Minahasa, and provisionally calculated for Midden Celebes.

Future plans envisaged the continuation of the primary network into Zuid-Oost Celebes from the base at Korodolo, and in both directions from Noord- and Midden Celebes round the western shores of the Golf van Tomini. To this end, preliminary reconnaissance surveys had been made by 1940, and trigonometrical stations erected at selected points.

Other work carried out by the *Triangulatiebrigade* included a tertiary levelling in 1924–7 in Zuid-West and Noord Celebes.

The first detailed topographical survey began in 1912, when an *Opnemingsbrigade* was stationed at Makassar. The topographical work went on slowly, owing to more pressing work elsewhere in the Archipelago but the numerous reconnaissance surveys provided material for *schetskaarten*. The survey of Zuid-West Celebes was completed, and in 1939 the brigade was working near Mandar and Loewoe in Midden Celebes, while the *Fotogrammetrische Brigade* was working in the neighbourhood of Malili.

The first official *overzichtskaarten* of the whole island was not produced until 1909; this map, in a scale of 1 : 2,500,000 has remained the standard small scale sheet, and revised editions appeared in 1918 and 1927. Larger scale regional maps include the 1 : 500,000 sheets of Noord en Midden Celebes (1919), Zuid-West Celebes (1919) and Zuid-Oost Celebes (1924), and a 1 : 200,000 sheet of Minahasa (1921).

Detailbladen, apart from a number of large scale plans of Makassar, were limited to areas of Zuid- and Zuid-West Celebes, where various series on scales of 1 : 25,000, 1 : 50,000 and 1 : 100,000 were in progress. Eight sheets of the latter series were issued in 1939. It was hoped to cover the remainder of Celebes (about four-fifths of the total area) in some 30-40 years.

(52) 1 : 5,000 *Detailbladen van Makassar en Omstreken*

Published in 1916. Two sheets, 70 × 83 cm. In seven colours.

Very detailed plans, with great variety of symbols for buildings, land utilization, etc.

(53) 1 : 10,000 *Detailbladen van Bonthain en Omstreken*

Published in 1922 with a second edition, 1924. Single sheet, in colours.

(54) 1 : 20,000 *Detailbladen van Makassar en Omstreken*

Published in 1894. Single sheet, in colours.

(55) 1 : 25,000 *Detailbladen van Zuid Celebes.*

Published in 1921. Number of sheets not known. In colours.

(56) 1 : 50,000 *Graadafdeelingsbladen van het Gouvernement Célèbes en Onderhoorigheden (Zuid-West)*

Published in 1922–32. Number of sheets produced not known, 37 × 37 cm. Index of adjacent sheets in margin. Latitude and longitude of each sheet corner given (longitude from central meridian of Celebes). In colours.

Coastline in blue, with sea tinted faint blue. Relief shown by brown contours at 25 m. interval, every 250 m. emphasized; simple brown hachures for minor eminences, and spot-heights in black. Rivers, names of rivers, lakes and marsh in blue.

Roads in red, yellow and brown (eight grades), tracks by thin red line, footpaths by red dotted line. Railways by double line filled black and white. Administrative boundaries by various black pecked lines. Native villages in solid green, rice fields by light blue diagonal shading, woodlands and plantation products by various black symbols. Miscellaneous symbols in red, blue and black for houses according to the types of construction, temples, churches, graves, harbours, anchorages, lighthouses, sand-banks, reefs, etc.

(57) 1 : 50,000 *Kaart van de vlakte van Gowa*

Published in 1900. Single sheet, in colours.

(58) 1 : 100,000 *Graadafdeelingsbladen van het Gouvernement Celebes en Onderhoorigheden* (Zuid- en Zuid-West)

Published in 1918, with a second edition of some sheets in 1931. Number of sheets not known. In colours.

(59) 1 : 100,000 *Kaart van het voormalig rijk Gowa*

Published in 1902, with a second edition in 1914. Single sheet, in colours.

(60) 1 : 200,000 *Schetskaart van de Minahasa*

Published in 1921. Single sheet, in colours.

(61) 1 : 250,000 *Schetskaart van het landschap Boetoeng met de Toekang b'si eilanden*

Published in 1916. Two sheets, in colours.

(62) 1 : 250,000 *Topografische Skizze aus dem Ostarm der Insel Celebes*

Compiled by Dr J. Wanner, published by J. Perthes (Gotha, 1905). Single sheet, 37 × 40 cm. Margins divided into ten minute intervals (longitude from Batavia). With location diagram and geological cross sections in the margin. In colours.

Coastline in blue, with sea tinted blue. Relief shown locally by brown contours at 100 m. interval, but much of the map is left blank; a number of spot-heights in black. Rivers, and names of rivers, in blue.

Bridle-tracks by thin red line, inhabited places by black dots, hot springs by red dots.

(63) 1 : 400,000 *Schetskaart van het landschap Boetoeng*

Published in 1916. Single sheet, in colours.

(64) 1 : 500,000 *Schetskaart van Noord en Midden Celebes*

Published in 1919. Two sheets, 88 × 63 cm. and 88 × 71 cm. In colours.

Coastline in blue, with sea tinted faint blue. Relief shown by brown hachures, with spot-heights in black. Submarine contours in blue at 180, 1,000 and 2,000 m. Rivers, and names of rivers, in blue.

Roads in red (two grades), bridle paths by thin red line, footpaths by red dotted line. Administrative boundaries by various pecked lines, emphasized in pink, yellow and green.

Miscellaneous red and black symbols for inhabited places, military posts, triangulation pillars, lighthouses, sand-banks, etc.

(65) 1 : 500,000 *Schetskaart van Zuid-Oost Celebes*

Published in 1924. Single sheet, 61 × 52 cm. In colours.

Coastline in blue, with sea tinted faint blue. Relief shown by brown hill shading, with spot-heights in black. Rivers, names of rivers, and lakes in blue.

Roads in red (three grades), footpaths by red dotted line. Administrative boundaries by various black pecked lines. Miscellaneous black symbols for inhabited places, military posts, temples, graves, triangulation pillars, etc.

(66) 1 : 500,000 *Schetskaart van Zuid-West Celebes*

Published in 1919. Single sheet, in colours. Details as for (65).

(67) 1 : 500,000 *Kaart van Zuid-West Celebes*

Published by J. Smulders (den Haag, 1905). Single sheet, 40 × 57 cm. Margins divided into minute intervals (longitude from Batavia).

Coastline in blue, with sea tinted faint blue. Relief shown by hill-shading in brown, with spot-heights in black. Rivers, names of rivers, lakes, and marshes in blue.

Roads in red (two grades), footpaths by red pecked line. Administrative boundaries by green line. Miscellaneous symbols for harbours, lighthouses, sand-banks, coral reefs, etc.

Insets:

(i) 1 : 6,000,000 *Overzichtskaart van Celebes*, showing administrative divisions.

(ii) 1 : 20,000 *Platte grond van Makassar*. A detailed town plan with native settlements in solid green, rice fields by blue diagonal shading, administrative buildings named and details of natural vegetation and land utilization.

(68) 1 : 1,000,000 *Automobielkaart van Zuid Celebes*.

Compiled by the *Koninklijke Vereeniging Java Motor Club*, and published by G. Kolff (Batavia, 1930). Single sheet 54 × 63 cm. Detailed list of administrative divisions in the margin. In colours.

Coastline in blue, with sea tinted faint blue. Relief shown in outline by faint brown hachures; peaks indicated, but no spot-heights given. Rivers, and names of rivers, in blue.

Roads in red and yellow (four grades), with railways by double line filled black and white. Administrative boundaries by various pecked lines. Harbours by black symbols.

(69) 1 : 1,000,000 *Automobielkaart van Noord Celebes*

Compiled by the *Koninklije Vereeniging Java Motor Club*, and published by G. Kolff (Batavia, 1930). Single sheet, 79 × 57 cm. Details as for (68). With an inset of *Sangihe en Talaud eiland*.

(70) 1 : 1,250,000 *Overzichtskaart van het eiland Celebes*

Old edition published in 1909, with a revised edition in 1918. Single sheet, 63 × 82 cm. Margins divided into thirty minute intervals (longitude from Greenwich). Marginal list of administrative divisions, table of trade of each port in 1908 by value, and annual summaries of trade, 1905–8. Imports and exports printed on map in red for each port. The second edition has trade figures for 1917. In colours.

Coastline in blue, with sea tinted faint blue. Relief shown in outline by light brown hill-shading, with spot-heights in black. Rivers, names of rivers, and lakes in blue. Roads in red (two grades), footpaths by thin red lines.

Administrative boundaries by various black lines, with divisions tinted. Administrative centres and inhabited places by black symbols. Miscellaneous red and black symbols for harbours, anchorages, lighthouses, sand-banks, reefs, etc. Chief vegetable products shown by green symbols, chief mineral products by orange symbols.

Insets

(i) 1 : 2,500,000 *Afdeeling Sangi- en Talaud- eilanden*, showing relief and products as on main map above.

(ii) 1 : 5,000,000 *Overzichtskaart van de Politikie Indeeling van Celebes*, showing administrative boundaries, telegraph and telephone lines and cables.

(iii) 1 : 5,000,000 *Dichtheid van Bevolking van Celebes*, showing density of population in seven shades of yellow and brown (first edition refers to 1905, second edition to 1915).

(71) 1 : 1,250,000 *Overzichtskaart van het eiland Celebes*

New edition, published in 1927. Single sheet, 63 × 82 cm. Margins divided into ten minute intervals (longitude both from Greenwich and from Batavia). In colours.

A revised edition of (70), with no economic details, but with much greater detail of relief and drainage.

Inset of the *Afdeeling Sangi- en Talaud- Eilanden*, scale 1 : 2,500,000.

Ceram

(72) 1 : 100,000 *Schetskaart van het eiland Ceram*

Published in 1919. Thirteen sheets, in colours.

(73) 1 : 100,000 *Graadbladen eiland Ceram*

Published in 1926. Thirteen sheets, in colours.

(74) 1 : 200,000 *Schetskaart van het Westelijk deel van het eiland Ceram en omliggende eilanden*

Published in 1919. Single sheet, in colours.

(75) 1 : 250,000 *Schetskaart van Ceram en omliggende eilanden*

Published in 1905, with a second edition in 1914.

(76) 1 : 500,000 *Sketskaart van het eiland Ceram en omliggende eilanden*

Published in 1922. Single sheet, 67 × 33 cm. Margins divided into ten minute intervals (longitude from Greenwich). List of leased properties and mining concessions in margin, numbered to correspond to map. In colours.

Coastline in blue, with sea tinted faint blue. Relief shown by brown contours at 100m., 250m., then every 250 m., with every 1,000 m. accentuated; spot-heights in black. Rivers, names of rivers, lakes, and marsh in blue.

Roads in red (two grades), footpaths by dotted red line, and steamer routes in red. Administrative boundaries in yellow. Inhabited places by black symbols (four grades). Miscellaneous black symbols for anchorages, sand-banks, reefs, etc.

Flores

(77) 1 : 50,000 *Schetskaarten van het districten*

The following sheets have been published:

(i) *Endé*. Two sheets, in colours (1920).
(ii) *Laboeanbodjo*. Four sheets, in colours (1921).
(iii) *Lio*. Two sheets, in colours (1928).
(iv) *Maoemere*. Four sheets, in black (1922).
(v) *Ngada*. Four sheets, in colours (1916).

(78) 1 : 100,000 *Verkenningskaart van de Onderafdeeling Oost-Flores en Solor-eilanden*

Published in 1931. Two sheets, in colours.

(79) 1 : 100,000 *Verkenningskaart van de Onderafdeeling Maoemere*

Published in 1931. Single sheet, in black and brown.

(80) 1 : 250,000 *Schetskaart van het eiland Flores en omliggende eilanden*

Published in 1911. Two sheets, 85 × 58 cm. Margins divided into ten minute intervals (longitude from Greenwich). Printed in black, with sea tinted faint blue.

Relief shown in outline by hachures, with some spot-heights.

Bridle-paths by thin line, footpaths by dotted line. Administrative boundaries by pecked lines, with divisions numbered and list in margin. Administrative centres and inhabited places named.

(81) 1 : 300,000 *Overzichtskaart van het Afdeeling Flores*

Published in 1928. Two sheets, 89 × 40 cm. with inset of Alor on sheet 2, 27 × 10 cm., on scale of 1 : 600,000 and inset on sheet 1 giving sheet boundaries and administrative divisions. Margins divided into ten minute intervals (longitude from Greenwich).

Coastline in blue, with sea tinted faint blue. Relief shown by faint brown hill-shading, with spot-heights in black. Rivers, names of rivers, and lakes in blue.

Roads in red (two grades), tracks by thin red line, foot-paths by red dotted line. Administrative boundaries by various black pecked lines. Inhabited places by black dots (five grades). Miscellaneous red, blue and black symbols for temples, rest-houses, wells, springs, sulphur springs, anchorages, lighthouses, sand-banks, reefs, etc.

Halmahera

The whole of Halmahera and of adjoining small islands has been topographically surveyed, with a fair degree of detail, but without any geodetic triangulation. The northern part of the island was surveyed in 1915–21, the adjoining Batjan-eilanden in 1921–3, the remainder of the main island in 1922–9, and the Morotai-eilanden in 1929–33.

The first general map on a scale of 1 : 500,000 was published in 1910, followed by an attractively printed second edition in 1933. In 1918, a two sheet edition on a scale of 1 : 300,000 appeared, and between 1921–32 a number of the 1 : 100,000 sheets. This series was suspended in 1932 on grounds of economy, and has not since been completed.

(82) 1 : 100,000 *Graadafdeelingsbladen van het eiland Halmahera en omliggende eilanden*

Published in 1921–32, in colours.

(83) 1 : 300,000 *Verloopige Schetskaart van het eiland Halmahera en omliggende eilanden*

Published in 1918. Two sheets, 80 × 71 cm. Margins divided into thirty minute intervals (longitude from Greenwich), with a graticule drawn at degree intervals. In colours.

Coastline in blue, with sea tinted faint blue. Relief shown by faint brown hachures, with black spot-heights. Rivers, names of rivers, and lakes in blue.

Roads in red (one grade), bridle tracks by thin red line, footpaths by red dotted line. Administrative boundaries by various black pecked lines, with list of divisions in margin. Miscellaneous symbols for inhabited places, temples, anchorages, harbours, lighthouses, sand-banks, etc.

(84) 1 : 500,000 *Schetskaart van het eiland Halmahera en omliggende eilanden*

Published in 1910. Single sheet, 85 × 52 cm. Margins divided into ten minute intervals (longitude from Greenwich). In black, with sea tinted blue.

Relief shown in outline by hachures, with a few spot-heights.

Roads by solid line (one grade), footpaths by dotted line. Administrative boundaries by various pecked lines, with divisions numbered and lettered to correspond to list in margin. Inhabited places and anchorage indicated by black symbols.

(85) 1 : 500,000 *Schetskaart van het eiland Halmahera en omliggende eilanden.*

Published in 1933. Single sheet, 86 × 67 cm. Margins divided into five minute intervals (longitude both from Greenwich and Batavia). Plan of administrative divisions in margin. In colours.

Coastline in blue, with sea tinted faint blue. Relief shown by brown contours at 100, 200, 500, 750, 1,000, 1,250, 1,500 and 1,750 m., layer-tinted in nine shades of green, yellow and brown, and spot-heights in black. Submarine contours in blue at 100, 200, 500, 1,000, 2,000, 3,000, 4,000 and 5,000 m., layer-tinted in nine shades of blue, with spot-depths in blue. Rivers, names of rivers, lakes and marsh in blue.

Roads by double red line (one grade), footpaths by dotted red line. Administrative boundaries by various pecked lines. Inhabited places by black dots (four grades). Miscellaneous red and black symbols for harbours, anchorages, lighthouses, sand-banks, reefs, etc.

JAVA AND MADOERA

As might be expected, the mapping of Java is considerably further advanced than that of any other part of the archipelago. The whole island has been geodetically and topographically surveyed, while a considerable area has undergone one or more revisions.

Geodetic surveys. The first astronomical observations on the Netherlands East Indies were carried out in Java by Dr de Lange in 1850–3 for the *Departement van Marine*. The primary triangulation of the island began in 1862, and bases were surveyed at Simplak in 1872 for West-Java, at Logantoeng in 1875 for Midden Java, and at Tangsil in 1877 for Oost-Java. 114 points of the first order were fixed throughout the island. The primary triangulation was completed in 1880, and the secondary in 1897, both by the *Triangulatie Afdeeling* (known after 1899 as the *Triangulatiebrigade*). The tertiary and quaternary triangulations were carried out by the survey brigades, and were completed in 1927.

In 1925, the *Triangulatiebrigade* began a precise levelling of Java. It was carried out along the main roads, in circuits of 300–400 km. divided into sections of 1–2 km. by permanent bench-marks. This work was completed in 1931.

Constant revision of certain astronomical control points has taken place at Weltevreden, Genoek, Tjililitan and Bosscha near Lembang (see p. 440).

Topographical surveys. The topographical survey followed steadily behind the primary triangulation; it was carried out by residencies, as follows: Batavia, 1849–53, revised 1869–79; Cheribon, 1853–7; Bagelen, 1857–9; Banjoemas, 1857–60; Kedoe, 1860–2; Semarang, 1861–4; Soerakarta, 1861–6; Jogjakarta, 1862–4; Tegal, 1863–6; Pekalongan, 1863–6; Madioen, 1864–71; Djapara, 1866–9; Rembang, 1868–75; Kediri, 1869–75; Soerabaja, 1871–8; Preanger Regentschappen, 1871–86; Pasoeroean, 1873–9; Probolinggo, 1875–83; Besoeki, 1875–83; Madoera, 1878–82; Bantam, 1878–85. When this survey was finished, the brigades were moved to Sumatra and Borneo, but the topographical revision survey began in 1897 after the secondary triangulation was completed.

After 1905, the large scale cadastral and land tax surveys (*landrente-metingen*) were taken over by the *Topografische Dienst*, together with the forestry and land utilization surveys. These surveys were carried out by four *landrente-opnemingsbrigade*, which became *herzieningsbrigade* in 1924 (see p. 440). Though these surveys were made for other government departments, they provided the detailed basis for the revision of some topographical series and for the production of new sheets, especially of the 1 : 50,000 series. The three *herzieningsbrigade* have worked since 1924 in West-Java (stationed at Bandoeng), in Midden-Java (at Magelang) and in Oost-Java (Malang).

Between 1926 and 1930, certain areas near Batavia and Soerabaja were surveyed for the *landrente-metingen* by aerial photography as an experiment. The results were not satisfactory, and it was decided that this method could most usefully be used for small-scale series in the largely unsurveyed areas of Borneo and New Guinea.

Chief series. One of the earliest extant maps of Java was made on a scale of 1 : 532,160 by the *Vereenigde Oost-Indische Compagnie*. In 1817, T. S. Raffles produced a map on a scale of 1 : 1,013,760, while in the first half of the nineteenth century there were a number of military maps of the chief towns and small-scale sheets of various residencies and of the island as a whole.

After the formation of the *Topografische Dienst* in 1864, with the resultant rapid progress of the topographical surveys, numerous maps were issued. They may be broadly classified as follows:

(i) Maps of the whole island in one or more sheets (*overzichtskaarten*) on scales of 1 : 500,000, 1 : 1,000,000 and 1 : 2,000,000; the latest editions of these series were 1922, 1931 and 1936 respectively.

(ii) Maps of the individual residencies on scales of 1 : 100,000 (1889–1900, revised 1900–25) and of 1 : 250,000 (1887–1924).

The latter is complete, but only 49 of the intended 146 of the former series had been published by 1940.

(iii) *Detailbladen*, including sheets of towns and adjoining areas on scales between 1 : 2,500 and 1 : 40,000 and the attractive 1 : 50,000 series. The last has been in course of production since 1915; in 1932, a revised series of the whole island was begun to replace the haphazard issue by residencies, but the output of new sheets decreased considerably during the economic depression. After 1935, work went on steadily. In 1941, forty-one new sheets were published, and about half of the projected total of approximately 480 had been issued. A similar revised series for the whole island was begun on the scale of 1 : 25,000 in 1932.

(86) 1 : 2,500 *Detailbladen van Hoofdplaatsen en Omstreken*

The following sheets have been published: *Banjarnegara*, two sheets, in black (1922); *Banjoemas*, one sheet, in colours (1920–1); *Magelang*, two sheets, in brown and black (1923); *Temanggoeng*, one sheet, in black (1922).

(87) 1 : 5,000 *Detailbladen van Hoofdplaatsen en Omstreken*

The following sheets have been published:

Bandoeng, seven sheets, in black (1921); *Bangil*, one sheet in grey and black (1922); *Buitenzorg*, two sheets, in colours (1921–2); *Cheribon*, one sheet, in colours (1921); *Djember*, one sheet, in grey and black (1922); *Kediri*, one sheet, in colours (1913); *Madioen*, two sheets, in colours (1917); *Pasoeroean*, one sheet, in grey and black (1922). Sheets of variable size, most commonly 84 × 80 cm. Details are given of built-up area, roads, churches, administrative buildings, plantation boundaries, etc. On some sheets, relief shown by brown contours at 2·5 m. interval.

(88) 1 : 10,000 *Detailbladen van Hoofdplaatsen en Omstreken*

The following ten sheets have been published:

Bandeng (1910); *Bangkalan* (1882); *Banjoewangi* (1883); *Besoeki* (1884); *Jogjakarta* (1925); *Malang* (1924); *Pamekasan* (1833); *Sampang* (1882); *Semarang* (1909). Each is covered by a single sheet, except Semarang (two sheets). In colours.

(89) 1 : 10,000 *Bevloeïngskaarten*

Irrigation maps published by the *Topografische Inrichting* for the *Departement van Verkeer en Waterstaat*. Not dated. The following sheets have been published, in colours: Bekatjak, three sheets; Tanggoel, one sheet; Pategoean en Kepoeloengan, two sheets.

(90) 1 : 20,000 *Detailbladen*

The following sheets have been published:

Bantam, 199 sheets, in black (1887–1908), with some sheets revised in colour (1915); *Batavia*, 196 sheets, in black (1898–1908); *Besoeki*, 195 sheets in black (1883–1908), some sheets revised in black (1913–16), and in brown and black (1919); *Buitenzorg en Omstreken*, one sheet, in colours (1880, revised 1921); *Kediri*, 209 sheets, in black (1894–1908), some sheets revised in black (1913–16); *Idjenhoogland*, number of sheets not known, in colours (1919); *Madoera*, number of sheets not known, in colours (1916–19); *Pasoeroean*, 169 sheets, in black (1882–1908),

some sheets revised in black (1912–16), and in colours (1915); *Preanger-Regentschap*, 449 sheets, in black (1887–) with some sheets revised in black (1907–16), and in colours (1918); *Rembang*, 214 sheets in black (1895–); some sheets revised in colours (1922); *Soerabaja*, 169 sheets in black (1886–).

(91) 1 : 20,000 *Bevloeïngskaarten*

Irrigation maps published by the *Topografische Inrichting* for the *Departement van Verkeer en Waterstaat*. The following sheets have been published in colours:

Terreinkaart van de afdeeling Ledok der Residentie Bagelen, two sheets (not dated); *Bevloeïngskaarten van de irrigatieafdeelingen Brantas en Serang*, one sheet (1907).

(92) 1 : 25,000 *Topografische Detailbladen*

The following sheets have been published:

Bagelen, in black (1898–1909); *Banjoemas*, in black (1898–1909, with revisions 1920), revised in brown and black (1922); *Batavia* (*afdeeling Krawang*) in colours (1909–16), with revised edition (1918); *Besoeki*, in colours (1922, revised edition 1926); *Cheribon*, in colours (1923); *Kediri*, in colours (1903–9); *Lembang*, one sheet in colours (1920); *Madioen*, in colours (1919, revised edition, 1924–6); *Pasoeroean*, in colours (1924–6); *Pekalongan*, in colours (1918); *Preanger-Regentschappen*, in colours (1919); *Rembang*, in colours (1924–6); *Semarang*, 132 sheets in black (1907–15, with revisions 1922); *Soerabaja*, in colours (1923), with revised edition (1924–6); *Soerakarta en Jogjakarta*, in colours (1924–6).

(93) 1 : 25,000 *Topografische Detailbladen van Java en Madoera*

A uniform series to cover the whole island and to replace the haphazard publication by residencies. Published from 1932 onwards. In colours.

(94) 1 : 40,000 *Detailbladen*.

The following sheets have been published:

Bantam, 25 sheets, in black (1887); *Besoeki*, 34 sheets, in black (1884).

(95) 1 : 50,000 *Detailbladen*

The following sheets have been published by the *Topografische Inrichting*. The numbers of sheets published are not known for all the series.

Banjoemas (1898–1909); *Bantam* (1922, revised edition, 1924); *Hoofdplaats van Batavia* (1918, revised edition, 1925); *Batavia* (*zonder afdeeling Krawang*), sixteen sheets (1902–9); *Batavia* (*afdeeling Krawang*), (1909–16); *Besoeki*, forty-three sheets (1924–7); *Cheribon* (1922); *Kediri* (1916–19, revised edition, 1926); *Kedoe*, twenty-seven sheets (1907); *Madioen* (1926); *Madoera* (1919); *Hoofdplaats van Magelang en Omstreken*, single sheet (1882, revised edition, 1915); *Hoofdplaats van Malang en Omstreken*, single sheet (1916, with revisions 1931); *Pasoeroean*, single sheet (1922, revised edition, 1926); *Preanger-Regentschappen*, fourteen sheets, in black (1887), and in colours (1908–10, revised edition, 1916–22); *Soerabaja*, twenty-three sheets (1918, revised edition 1926); *Salatiga en Ambarawa en Omstreken*, single sheet (1915); *Hoofdplaats van Soerabaja en Omstreken*, single sheet (1916, revised edition, 1925); *Soerakarta en Jogjakarta* (1916–19, revised editions, 1926, 1932).

The sheets are published in three styles:

(*a*) *Coloured edition*

Sheets 37 × 37 cm. with a few 37 × 44 cm. Latitudes and longitudes given only at the sheet corners (longitude from Batavia).

Coastline in blue, with sea tinted faint blue. Relief shown by grey-green contours at 25 m. interval, with spot-heights in black. Rivers, names of rivers, lakes, fish-ponds and marshes in blue.

Roads, tracks and footpaths in red (with a varying number of grades), railways and tramways by filled double black and white lines. Administrative boundaries by various black pecked lines. Inhabited places by red and black symbols, native villages in solid grey-green. A variety of black symbols for woodland and plantation crops, rice-fields by diagonal blue shading. Miscellaneous red, blue and black symbols for bridges, churches, temples, graves, anchorages, lighthouses, sand-banks, reefs, etc.

(*b*) *Black and grey*

Details as for (*a*), but monochrome.

(*c*) *Black and brown*

Details as for (*b*), but contours in brown.

(96) 1 : 50,000 *Topografische Detailbladen van Java en Madoera*

A revised series, published in 1932. Stype and details similar to (95) (*a*).

(97) 1 : 50,000 *Garnizoenskaarten*

Published in 1925– . Number of sheets not known. Sheets 64 × 50 cm. Kilometre grid superimposed in black. In colours.

Sections of sheets of Nos. 95 and 96 assembled to form larger sheets of strategic towns and their neighbourhood. Details as for (95a).

(98) 1 : 100,000 *Topografische Kaart der Residentie*

Published as follows:

Kediri, two sheets (1889); *Kedoe*, two sheets (1889); *Bagelen*, four sheets (1890); *Banjoemas*, three sheets (1892); *Jogjakarta*, four sheets (1892–4, revised edition, 1907); *Pekalongan*, one sheet (1892); *Cheribon*, six sheets (1894); *Djapara*, four sheets 1894); *Soerakarta*, six sheet (1894); *Soerabaja*, four sheets (1895, revised edition, 1907); *Tegal*, two sheets (1895); *Rembang*, four sheets (1897); *Semarang*, six sheets 1898); *Besoeki*, nine sheets (1900); *Pasoeroean*, four sheets (1900).

Sheets 62 × 51 cm. Margins divided into one minute intervals (longitude from Batavia). In colours.

Coastline in blue, with sea tinted faint blue. Relief shown by brown hill-shading, with black spot-heights. Rivers, names of rivers, lakes and marshes in blue.

Roads in red, purple and yellow (four grades), footpaths by black dotted line. Administrative boundaries by black pecked lines, emphasized in pink, yellow and orange. Inhabited places and administrative centres by red, blue and black symbols. Land utilization (native villages, woodland, plantations, etc.) by superimposed tints. Detailed miscellaneous symbols for bridges, churches, temples, graves, anchorages, lighthouses, sand-banks, etc.

(99) 1 : 100,000 *Graadafdeelingsbladen van West- en Midden-Java*

Published in two series.

(i) *Midden-Java* (*residenties Banjoemas, Kedoe, en Semarang*). Twenty-five sheets (1898–1915).

(ii) *West-Java* (*residentie Batavia*). Fourteen sheets (1910–1925). Sheets 37 × 37 cm. Latitude and longitude given on corners of index diagram in margin (longitude from Batavia). Administrative divisions numbered and lettered to correspond to list in margin. In colours.

Coastline in blue, sea tinted faint blue. Relief shown by brown contours, usually at 50 m. interval, with light brown hill shading and spot-heights in black. Rivers, names of rivers, lakes and marsh in blue.

Roads in red (two grades), footpaths by red dotted line, railway by double line filled black and white. Administrative boundaries by various black pecked lines. Towns and inhabited places in red, native villages in solid green. Woodland and plantations by various black symbols, on some sheets plantations outlined in yellow and numbered to correspond to list in margin. Detailed miscellaneous symbols for bridges, churches, temples, graves, anchorages, lighthouses, sand-banks, etc.

(100) 1 : 100,000 *Java: Tourist map*

A series published by the *Topografische Inrichting* for the *Officieele Vereeniging voor Toeristen Verkeer* (Official Tourist Bureau), Weltevreden. Number of sheets not known. Sheets 73 × 42 cm. Margin divided into ten minute intervals (longitude from Batavia). Legend, notes, etc., in Dutch and English.

Coastline in blue, sea tinted faint blue. Relief shown by brown contours at 100 m. interval, every fifth emphasized, land under 700 m. (approximately) tinted green and over 700 m. brown, with brown hill shading and spot-heights in black. Rivers, names of rivers, lakes, marsh and fish-ponds in blue.

Roads in red (two grades), bridle-paths by red pecked line, footpaths by red dotted line, railways and tramways by filled black and white double lines. Administrative boundaries by various black pecked lines. Inhabited places in red and black (three grades). Points of interest for tourists printed in red. Miscellaneous red, blue and black symbols for embankments, aqueducts, waterfalls, hot springs, volcanoes, etc.

(101) 1 : 250,000 *Overzichtskaarten der residenties*

The following sheets have been published by the *Topografische Inrichting*: *Banjoemas* (1910); *Bantam* (1922); *Besoeki* (1887, revised 1912); *Jogjakarta* (1921); *Kediri* (1891); *Kedoe* (1915); *Madioen* (1923); *Madoera* (1924); *Pasoeroean* (1907); *Preanger-Regentschappen* (1893, revised 1911); *Rembang* (1919); *Semarang* (1914); *Soerabaja* (1893, revised 1919); *Soerakarta* (1922).

Sheets of various size. One sheet of each *residentie*, except *Preanger-Regentschappen* (three sheets). Margins divided into two minute intervals (longitude from Batavia). Each sheet has one or more inset maps of communications and administrative areas. In colours.

Coastline in blue, with sea tinted blue. Relief shown by brown contours at every 200 to 1,000 m., then 1,300, 1,600, 2,000, 2,400, 2,800 and 3,000 m., with spot-heights in black. Some sheets have light brown hill-shading as well as contours, while four have layer tinting in fourteen shades of green and brown. Rivers, names of rivers, and lakes in blue.

Roads in red (two grades), bridle-paths by thin red line, footpaths by red dotted line, railways and tramways in black. Administrative boundaries by various black pecked line. Towns by red and black symbols (five grades). Miscellaneous red, blue and black symbols for stations, halts, sugar factories, temples, graves, springs, volcanoes, anchorages, lighthouses, reefs, sand-banks, etc.

(102) 1 : 250,000 *Overzichtskaart van Java en Madoera*

Published in 1924–35. Ten sheets, usually 90 × 68 cm. Margins divided into twenty minute intervals (longitude from Batavia). Inset diagrams of adjoining sheets and administrative boundaries. In colours.

Coastline in blue, with sea tinted faint blue. Relief shown by brown contours at every 100 to 600 m., every 200 to 1,200 m., and every 400 to 2,800 m. then 3,000 m., layer-tinted in fourteen shades of green and brown, with spot-heights in black. Rivers, names of rivers, lakes, and fish-ponds in blue.

Roads in red (three grades), footpaths by red dotted line, railways in heavy black, tramways in black and white filled double lines. Administrative boundaries by various black pecked lines. Towns and inhabited places by red and black symbols (four grades). Miscellaneous red and black symbols for temples, graves, anchorages, lighthouses, sand-banks, reefs, etc.

(103) 1 : 500,000 *Schoolkaart van Java en Madoera*

Published in 1923. Four sheets, in colours.

(104) 1 : 500,000 *Overzichtskaart van Java en Madoera*

Published in 1905. Eight sheets, 54 × 77 cm. Margins divided into five minute intervals (longitude from Batavia). In colours.

Coastline in blue, with sea tinted faint blue. Relief shown by brown hill shading, with spot-heights in black. Rivers, names of rivers, and lakes in blue.

Roads in red (two grades), footpaths by red dotted line, railways and tramways in black, cables by double black lines. Administrative boundaries by black pecked lines emphasized in green. Administrative centres and inhabited places by black dots (five grades). Miscellaneous red, blue and black symbols for anchorages, lighthouses, sand-banks, reefs, etc.

(105) 1 : 500,000 *Overzichtskaart van Java en Madoera.*

Published in 1912, with a second edition in 1922. With an accompanying 16 pp. booklet, *Toelichtingen op de Economische Kaart van Java en Madoera*, containing lists of administrative boundaries and of sugar refiners, tables of population, and trade figures. Four sheets, 53 × 77 cm. Margin divided into five minute intervals (longitude from Batavia). In colours.

Coastline in blue, with sea tinted faint blue. Relief shown by contours in brown at 100, 250 and every 250 to 3,500 m., layer tinted in sixteen shades of green and brown. Rivers, names of rivers, lakes, fish-ponds, marsh, and hot springs in blue.

Roads in red (three grades), footpaths by red dotted line, railways and tramways in black. Administrative boundaries by black pecked lines. Towns and inhabited places by black circles (five grades). Miscellaneous red, blue and black symbols for garrison points, sugar factories, customs-houses, harbours, anchorages, lighthouses, sand-banks, reefs, etc. Trade of each port printed in red on map.

Insets

(i) Adjoining small islands.

(ii) Sheet 2 has 1 : 2,000,000 *Regenval en Irrigate op Java en Madoera*, showing mean annual rainfall in ten shades of green, yellow and blue, prevailing winds in red and black, and temperature in red in degrees Celsius. Irrigated areas tinted pink. Smaller insets of 1 : 5,000,000 show winter and summer rainfall.

(iii) Sheet 3 has 1 : 2,000,000 *Geologische Overzichtskaart*, showing chief geological formations, mines and springs in heavy red and blue symbols, and volcanoes in red.

(iv) Sheet 4 has unnamed economic map, showing chief plantations, forests, etc. Towns over 50,000 inhabitants shown.

(106) 1 : 500,000 *Kaart van Java en Madoera*

Published by the *Koninklijke Java Motor Club* (1930). Four sheets, in colours.

(107) 1 : 500,000 *Automobielkaart van Java en Madoera*

Published by the *Koninklijke Vereeniging Java Motor Club* (1930). Three sheets, in colours.

(108) 1 : 1,000,000 *Overzichtskaart van Java, Madoera en Bali*

Published in 1931. Two sheets, in colours. With alphabetical gazetteer in margin. A revised edition in black was published in 1935–6.

(109) 1 : 1,000,000 *Spoor en Tramwegkaart van Java en Madoera*

Published in 1905, with subsequent editions in 1906, 1909, 1913 and 1922. Single sheet, 110 × 50 cm., and also as two sheets, 55 × 50 cm. Both in black and in colours. The edition of 1905 has a list of railway and tramway companies, with length of line in kilometres, and a series of gradient profiles.

Coastline in blue. Relief shown in outline by faint black hill shading, with spot-heights in black. Rivers, and names of rivers in blue.

Main roads in black, railways in filled black and white double lines (three grades), tramways in red (three grades). Miscellaneous symbols for towns (four grades), stations, halts, anchorages, etc.

Insets on scale of 1 : 125,000 of *Batavia, Semarang* and *Soerabaja*.

(110) 1 : 1,000,000 *Bestuursindeelingskaart van Java en Madoera*

Published in 1928, with a revised edition in 1935. Two sheets, in black, showing administrative divisions.

(111) 1 : 2,000,000 *Kaart van Java en Madoera*

Published in 1906 with subsequent editions in 1920 and 1936. Single sheet, 55 × 18 cm. Margins divided into ten minute intervals. In colours.

Coastline in blue, with sea tinted blue. Relief shown by light brown hill shading, with spot-heights in black. Rivers, and names of rivers in blue.

Roads in red (two grades), railways and tramways by filled black and white double lines. Radio-telephone stations by red symbols.

(112) 1 : 2,000,000 *Overzichtskaart van de Spoorwegen en S.S. Automobieldiensten op Java en Madoera*

Published in 1941. Single sheet, 54 × 20 cm. Margins divided into ten minute intervals (longitude from Batavia). In colours.

Motor roads in green (three grades), railways in red (four grades according to gauge and ownership, commercial and mineral lines in black (three grades). Administrative boundaries by black pecked lines.

(113) 1 : 2,000,000 *Bestuurindeelingkaart van Java en Madoera*

Published in 1928. Single sheet, both in coloured and in black editions.

Kangean-Eilanden en Sapoedi Archipel

(114) 1 : 250,000 *Schetskaart van de Kangean-eilanden en Sapoedi Archipel*

Published in 1921. Single sheet, in colours.

Leti

(115) 1 : 25,000 *Schetskaart van het eiland Leti*

Single sheet, in colours, 1912.

Lombok

Between 1912 and 1923, the primary triangulation of southern Java was extended eastwards through Bali and Lombok into Soembawa. Only three primary points were fixed in Lombok, and although the secondary and tertiary triangulations were completed on this basis, they were considered inadequate. The future programme of the *Triangulatiebrigade* included a new triangulation of Lombok, with a base measured within the island.

The detailed topographical survey was completed during 1925–32 for the western part of the island, but the rest is covered only by reconnaissance maps and *schetskaarten*.

The standard map of Lombok is on the scale of 1 : 200,000, first published in 1897, with editions in 1908 and 1927. Part of central Lombok was mapped on 1 : 100,000 in 1897, revised in 1908, and two series of *detailbladen* on 1 : 25,000 and 1 : 50,000 were begun in 1926 and 1928 respectively. These last were stopped in 1931 on grounds of economy and had not been resumed by 1941.

(116) 1 : 20,000 *Kaart van Ampenan, Mattaram en Tjakranagara*

Published in 1894. Single sheet, in colours.

(117) 1 : 25,000 *Detailbladen van het eiland Lombok*

Published in 1926–31. In colours.

(118) 1 : 50,000 *Detailbladen van het eiland Lombok*

Published in 1928–31. In colours.

(119) 1 : 100,000 *Overzichtskaart van Midden Lombok*

Published in 1897 with revised editions in 1908 and 1937. Single sheet, 73 × 40 cm. One latitude and longitude (from Greenwich) given in margin. In colours.

Coastline in blue, with sea tinted light blue. Relief shown by red contours at 50 m. interval, with occasional pecked form-lines, and spot-heights in black. Rivers, names of rivers, lakes and marshes in blue.

Roads in black (two grades), bridle-paths by thin black lines, footpaths by dotted line. Administrative boundaries by various pecked lines. Native villages by black diagonal shading, rice fields by blue diagonal shading, woodlands and plantations by various black symbols. Miscellaneous black symbols for inhabited places, houses, bridges, temples, graves, anchorages, sand-banks, reefs, etc.

(120) 1 : 200,000 *Overzichtskaart van hat eiland Lombok*

Old edition, published in 1897, revised in 1908 and 1937. Single sheet 56 × 46 cm. One latitude and longitude (from Greenwich) given in margin. In colours.

Coastline in blue, with sea tinted faint blue. Relief shown by brown contours at 100 m. interval, with occasional form-lines at 20 and 50 m., and spot-heights in black. Rivers, and names of rivers in blue.

Roads in red and black (two grades), bridle-paths by thin black line, footpaths by dotted black line. Administrative boundaries by various pecked lines. Native villages in solid green, rice fields by blue diagonal shading, woodlands and plantations by various black symbols for buildings, bridges, temples, graves, anchorages, lighthouses, sand-banks, reefs, etc.

(121) 1 : 200,000 *Overzichtskaart van de Afdeeling Lombok*

Published in 1927. Single sheet, 56 × 46 cm. Margins divided into five minute intervals (longitude from Batavia). In colours.

Details as for (120) except that relief is shown by light brown hill shading with spot-heights in black; roads and paths in red.

Mentawai-eilanden

(122) *Schetskaarten van de Mentawai-eilanden*

A series of maps on various scales on a single sheet. Published in 1909, with a revised edition in 1914.

See also No. 162.

Natoena- en Anambas-eilanden

(123) 1 : 100,000 *Schetskaart van het eiland Groot Natoena- en Anambas-eilanden*

Published in 1923. Single sheet, in colours.

Nias

(124) 1 : 150,000 *Schetskaart van het eiland Nias*

Published in 1910, revised edition 1916. Single sheet, 72 × 77 cm. Margin divided into ten minute intervals (longitude from Greenwich). In colours.

Coastline in blue, sea tinted faint blue. Relief shown only in a few places and by very simple hachures, with a few spot-heights. Rivers, names of rivers, and marsh in blue.

Roads in red (two grades), footpaths by red dotted line. Administrative divisions by various pecked lines. Miscellaneous symbols in red, blue and black for inhabited localities, resthouses, mangrove swamps, coral reefs, etc.

See also No. 162.

Nederlandsch Nieuw-Guinee

Only some three per cent. of Dutch New Guinea has been topographically surveyed; even this small part was done only by reconnaissance methods in recent years. The most suitable method for the mapping of the difficult terrain is aerial survey. A considerable amount of reconnaissance survey by air has been carried out by the *Koninklijke Nederlandsche-Indische Luchtvaart Maatschappij* (*K.N.I.L.M.*)

and by the *Nederlandsche Nieuw-Guinee Petroleum Maatschappij*. In 1937 the *Fotogrammetrischebrigade* turned its attention to this part of the empire, and by 1940 some 15,000 sq. km. had been mapped on a scale of 1 : 100,000, although not published. It was hoped to survey the whole of Nieuw-Guinee from the air in detail in some 40–45 years.

The earliest complete map of New Guinea was published in 1897 by the *Topografische Bureau* on a scale of 1 : 2,000,000. In 1912, there appeared a four-sheet edition on a scale of 1 : 1,000,000, revised in 1919. The first 1 : 250,000 sheet was published in 1936; by the end of 1939, twenty-four of the projected thirty-seven sheets had appeared, four of them in 1939. This series will cover all New Guinea except the north-west, which will appear with the adjacent islands on seventeen 1 : 200,000 sheets and an unspecified number of 1 : 100,000; four of the latter had been published by 1939.

(125) 1 : 100,000 *Schetskaart van Nieuw-Guinee* (*Nederlandsch Gebied*)

Published in 1936. Number of sheets not known. In colours.

Coastline and all line detail in brown. Relief by solid contours and pecked form-lines. Sea tinted blue, marsh by horizontal blue shading. Roads in red, native villages in solid green, miscellaneous brown symbols for woodland, jungle, plantations, etc. Lettering in black.

(126) 1 : 250,000 *Schetskaart van Nieuw-Guinee* (*Nederlandsch Gebied*)

Published in 1936. Twenty-four sheets of the projected thirty-seven had been published by 1939. In black.

Relief shown in places by contours and form-lines at irregular intervals, in others by simple hachures, in others by isolated spot-heights without detail. Roads by solid lines, tracks by pecked lines, footpaths by dotted lines. Marsh by horizontal shading.

Considerable areas of these sheets are left blank.

(127) 1 : 300,000 *Deutsch-Holländisches-Grenzgebiet*

Compiled by Professor L. Schultze (Berlin, 1914), to show the international boundary. Single sheet, in colours.

(128) 1 : 500,000 *Schetskaart van het terrein in Zuid Nieuw-Guinee*

Published by the *Exploratie-Detachement Gooszen* (Amsterdam, 1908).

(129) 1 : 1,000,000 *Schetskaart van Nederlandsch Nieuw-Guinee en omliggende eilanden*

Published in 1912, with a revised edition in 1919. Four sheets, 69 × 60 cm. Margins divided into one minute intervals (longitude from Greenwich). In colours.

Coastline in blue, sea tinted blue. Relief shown by brown hill shading, with spot-heights in black; the 1919 edition has considerably more detail. Rivers, names of rivers, lakes and marshes in blue.

Footpaths by red dotted line. Inhabited places by black dots.

Supplement. The 1919 edition has a supplementary sheet with four quarter-maps.

(i) 1 : 250,000 *Hollandia en Omstrecken*.
(ii) 1 : 250,000 *Schiereiland Onin*.
(iii) 1 : 250,000 *Mêrauke en Omstreken*.
(iv) 1 : 50,000 *Mênoekwari en Omstreken*.

(130) 1 : 2,500,000 *Schetskaart van Nederlandsch Nieuw-Guinee*

Published in 1939. Single sheet, in colours.

(131) 1 : 2,500,000 *Overzichtskaart van de residentie Amboina en de afdeeling Nederlandsch Nieuw-Guinee*

Single sheet, in colours. Published in 1915.

SCHOUTEN- EN PADAIDO-EILANDEN

(132) 1 : 100,000 *Schetskaart van de Schouten- en Padaido eilanden*

Published in 1916. Two sheets, 65 × 64 cm. In black, brown and blue.

Coastline in black, with sea tinted blue. Relief shown in outline by brown hachures, with a few spot-heights in black. Rivers in black. Chief plantations shaded in black.

(133) 1 : 250,000 *Schetskaart van de Schouten- en Padaido-eilanden*

Published in 1927. Single sheet, in colours.

SIMEULOËR

(134) 1 : 250,000 *Schetskaart van de eiland Simeuloë en omliggende eilanden*

Published by the *Encyclopaedische Bureau* (Semarang, 1918). Single sheet, 63 × 48 cm. Margins divided into five minute intervals (longitude from Padang). In black, blue and brown.

Coastline in blue, with sea tinted faint blue. Relief shown by brown contours at 100 m. interval, with brown layer-tinting, and spot-heights in black. 180 m. submarine contour in blue. Rivers, names of rivers, and marsh in blue.

Tracks in brown, footpaths by brown dotted line, railway under construction in black, steamship routes in brown, cables in black. Administrative boundaries by various black lines. Miscellaneous symbols in black and brown for inhabited places, anchorages and lighthouses.

SOELA-EILANDEN

(135) 1 : 250,000 *Schetskaart van de Soela-eilanden*

Published in 1927. Single sheet, in colours.

SOEMBA

(136) 1 : 100,000 *Topografische graadafdeelingsbladen van Soemba*

Published in 1927. Number of sheets not known. In colours.

(137) 1 : 300,000 *Schetskaart van het eiland Soemba*

Published in 1915, with revised edition in 1929. Single sheet, in colours.

(138) 1 : 500,000 *Schetskaart van het eiland Soemba*

Published in 1911. Single sheet, 50 × 38 cm. Margins divided into five minute intervals (longitude from Greenwich). In black.

Relief shown in outline by simple hachures, with very occasional spot-heights. Mean low water line by black dotted line.

Roads in heavy black, footpaths by dotted line. Administrative boundaries by pecked lines, with list of land concessions in margin. Miscellaneous symbols for administrative and inhabited places, harbours, anchorages, reefs, etc.

Soembawa

(139) 1 : 250,000 *Schetskaart van Soembawa*

Published in 1915, with a revised edition in 1926. Two sheets 62 × 52 cm. Margins divided into five minute intervals (longitude from Greenwich). In black and brown.

Coastline in black. Relief shown by brown hachures and hill shading with spot-heights in black. Rivers in black, marsh by horizontal black lines.

Roads in brown, footpaths in black. Administrative divisions by various black pecked lines.

Inset. Plan of Bima and district. 1 : 50,000, 11 × 13 cm. in black.

Sumatra

The mapping of Sumatra stood next to Java in priority; as a result, in spite of its great size, over ninety per cent had been topographically surveyed by 1940.

Geodetic surveys. The geodetic survey began in 1883, when a base was measured near Padang for the survey of the Westkust. The triangulation of West-Java, with its base at Simplak, was extended over the Straat Soenda into Zuid-Sumatra, and gradually extended north along the west coast. Errors in the linking of the two systems were adjusted in 1927, when the Padang base was re-measured, using an invar tape. Astronomical observations for the orientation of control stations were made at Padang (1883), at Batoe in Tapanoeli (1896), at the Goenoeng Dempo in Zuid-Sumatra (1897), and at Boeloe Serati in Oost-Sumatra (1916). The primary chain was gradually extended along the western mountains, and by 1940 had reached southern Atjeh, while the primary, secondary and tertiary triangulations had been completed for the western part of the island.

The triangulation of Atjeh did not begin until 1938, when a base was measured at Seulimeum. A chain of triangles had been surveyed and provisionally computed by 1940, thus completing the last section along the whole length of the island. The secondary and tertiary triangulations were still in progress in 1940; in 1939, three secondary and fifty-seven tertiary pillars were erected and their positions computed. It was hoped to complete the entire triangulation of Atjeh by the end of 1941.

It was at first intended to cover the whole of Sumatra with a primary triangulation network as a basis for the detailed topographical survey. During the progress of the Westkust triangulation, it was decided that such a network for the flat swampy lands of the eastern parts of the island would be very costly, and much less necessary than in the western mountainous region. Instead, a considerable number of points were fixed astronomically in Palembang and in the Lampoengsche Districten (1920–5), in Djambi (1922-5), and in the Oostkust (1922–5, 1927), as a basis for the topographical survey.

Topographical survey. This followed closely behind the primary triangulation. In 1885, the first detailed survey of Java was completed, and an *opnemingsbrigade* was transferred to Padang, to be followed later by two others, stationed at Palembang and at Teloekbetoeng. In 1925, one brigade moved to Djambi, and as the others completed their work they were moved to Borneo and Celebes. By 1936 only one brigade was left in the island, stationed at Medan to carry on with the survey of Atjeh and Riouw. Its work was still in progress in 1941.

The coastal areas of Sumatra's Westkust were completed in 1885–1905, southern Tapanoeli in 1890–1909, the Lampoengsche Districten in 1906–13, Palembang in 1906–26, Medan province in 1911–33, Djambi in 1924–36, certain mountainous areas in western Sumatra in 1924–34, northern Tapanoeli in 1929–34, and the remainder of eastern Sumatra by 1936. The survey of Atjeh began in 1933, and was still in progress in 1940.

A number of forest and agricultural surveys have been carried out in Sumatra, as well as some *Bevolkingsrubberrestrictie-metingen*, but there are none of the large scale land-tax surveys as in Java.

Chief series. A large number of series of maps on different scales have been issued, most of which are still incomplete. Since 1932, however, the *Topografische Dienst* has concentrated on the production of four main series; the *detailbladen* on 1 : 50,000, the *graadafdeelingsbladen* on 1 : 100,000, and the *overzichtskaarten* on 1 : 250,000, and on 1 : 750,000. Only a small proportion of the intended total of the first two series has been published. Eighteen of the twenty-eight projected sheets of the 1 : 250,000 and all ten of the 1 : 750,000 had appeared by 1940.

Apart from the last two series, the most useful small-scale *overzichtskaarten* include the single sheet editions of the 1 : 1,650,000 (1929), the 1 : 1,750,000 (1928), the 1 : 2,000,000 (1913), and the 1 : 2,500,000 (1917).

(140) 1 : 2,500 *Kadastrale Overzichtskaart van de Onderafdeelingshoofd-plaats Sabang*

Published in 1918. With an inset, 1 : 400,000 of *Poelau Wè*, on which Sabang is situated. Single sheet, 63 × 78 cm. In colours.

Coastline in blue, with sea tinted pink. Hotels, government establishments, and military posts named. Buildings coloured: stone, pink; wood, yellow; and galvanized iron, blue. Estates shown by pecked lines and numbered to correspond to list in margin. Limits of 1 : 1,000 cadastral plans by thin black lines, and tertiary triangulation points indicated.

(141) 1 : 5,000 *Detailkaarten van Hoofdplaatsen en omstreken*

The following sheets have been published:

Medan, four sheets (1913, revised edition, 1924); *Padang*, two sheets (1886, revised edition, 1915); *Palembang*, six sheets (1922); *Teleokbetoeng*, two sheets (1916).

Sheets are variable in size, usually 70 × 65 cm. or 95 × 69 cm. Very detailed sheets in colours.

Sheets are drawn in considerable detail, although this differs slightly from sheet to sheet. *Palembang*, for example, has six grades of roads in pink, brown, yellow and white, footpaths by red dotted lines, different types of houses in colours, detailed symbols for bridges, temples, graves, pumps, etc. *Padang* has all important buildings numbered 1–69, to correspond to a list in the margin.

(142) 1 : 10,000 *Detailkaarten van Hoofdplaatsen en Omstreken*

The following sheets have been published:

Benkoelen (1924); *Moearaenim* (1925); *Lahat* (1925); *Medan* (1895); *Padang* (1896). One sheet each, in colours.

(143) 1 : 20,000 *Detailbladen van Hoofdplaatsen en Omstreken*

The following sheets have been published:

Padangsidimpoean en omstreken (1893), one sheet in colours; *Taroetoeng en omstreken*, one sheet in colours (1907).

(144) 1 : 20,000 *Detailbladen van Sumatra's Westkust*

Published in 1889–99, with a few sheets revised in 1932. 172 sheets, 46 × 46 cm. Margins divided into fifteen second intervals (longitude from Padang). Diagrams of adjoining sheets and of administrative divisions in margin. In black, with contours in brown.

Relief shown by brown contours at 10 m. interval, with occasional pecked form-lines, every 100 m. emphasized.

Roads by double line, bridle-paths by single line, footpaths by dotted line. Administrative boundaries by various pecked lines. Miscellaneous symbols for inhabited places, native villages, woodlands, rice-fields, plantations, anchorages, sand-banks, etc.

(145) 1 : 25,000 *Detailbladen van Zuid-Sumatra*

Sheets have been published of the *Residenties Benkoelen, Lampoengs* and *Palembang* in 1910–19, with some sheets revised in 1916–22.

(146) 1 : 40,000 *Detailbladen van Atjeh en Onderhoorigheden*

Published in 1911–16. Eleven sheets, 47 × 51 cm., of the projected total of fifty-one. In colours.

Coastline in blue. Relief shown by brown contours at 10 m. intervals with spot-heights in black. Rivers, lakes and marshes in blue.

Roads in red (two grades), footpaths by red lines. Administrative boundaries by various black pecked lines. Inhabited places by red and black symbols, native villages in solid green. Miscellaneous black symbols for woodland, plantation products, bridges, temples, graves, harbours, anchorages, sand-banks, reefs, etc.

(147) 1 : 40,000 *Detailbladen van Sumatra's Westkust en Tapanoeli*

Published in 1893–1907, with a few sheets revised in 1932–40, 126 sheets, 46 × 46 cm. Margins divided into thirty-minute intervals (longitude from Padang). Diagrams in margin of adjacent sheets and of administrative boundaries. In colours. Two styles:

(i) Coastline in black. Relief shown by brown contours at 10 m. interval, emphasized every 100 m., with spot-heights in black. Rivers in black, swamp by horizontal black shading.

Roads by double black lines, bridle-paths by single black line, footpaths by dotted black line, railways by filled black and white double line. Administrative boundaries by various black pecked lines. Inhabited places by black symbols, native villages in solid green. Miscellaneous black symbols for buildings, woodland, plantations, rice-fields, temples, graves, anchorages, sand-banks, etc.

(ii) In greater range of colouring than (i). Coastline in blue, rivers in dark blue, swamps by horizontal blue lines, rice-fields by light blue shading. Roads in red and yellow (four grades). Miscellaneous symbols as for (i), but some in red and green.

(148) 1 : 50,000 *Graadafdeelingsbladen van Sumatra's Oostkust*

Published in 1915–20, with some sheets revised in 1931. Fifteen sheets had been issued of the intended sixty, each 37 × 37 cm. In colours, except four sheets of the first edition in grey, which were re-issued in 1931 in uniform colours.

Coastline in blue, with heavy blue line round the coast, and sea stippled faint blue. Relief shown by light grey-green contours at 25 m. interval, with additional pecked form-lines, and spot-heights in black. Rivers, names of rivers, lakes, fish-ponds and marsh in blue.

Roads in red (three grades), bridle-paths by thin red line, footpaths by red dotted line. Administrative boundaries by various black pecked lines. Miscellaneous red, blue, grey and black symbols for buildings, native villages, cemeteries, graves, docks, anchorages, aerodromes, lighthouses, sand-banks, etc.

(149) 1 : 50,000 *Graadafdeelingsbladen van Sumatra's Westkust*

Published in 1925. Number published to date not known. A series similar to No. 148.

(150) 1 : 50,000 *Detailbladen van Midden-Sumatra*

Published in 1932. Number published to date not known. A series similar to (148).

(151) 1 : 50,000 *Detailbladen van Atjeh en Onderhoorigheden*

Published in 1936. Number published to date not known. Fourteen sheets were issued in 1939. A series similar to (148).

(152) 1 : 80,000 *Graadafdeelingsbladen van Sumatra's Westkust en Tapanoeli*

Published in 1890–1907, with some sheets revised in 1931. Sheets 46 × 46 cm. Margins divided into minute intervals (longitude from Greenwich). In colours; some sheets were issued in 1927 in monochrome brown.

Coastline in blue, with sea tinted faint blue. Relief shown by brown contours at 25 m., every 250 m. emphasized, and occasional form-lines with spot-heights in black. Rivers, names of rivers, lakes and marsh in blue.

Roads in red (three grades), bridle-paths by thin red line, footpaths by red dotted line, railways in filled black and white lines. Boundaries by various black pecked lines, emphasized in pink, yellow and green. Towns by red and black symbols, native settlements in solid green. Miscellaneous red, blue and black symbols for woodlands, plantations, rice-fields, bridges, graves, temples, anchorages, sand-banks, etc.

(153) 1 : 80,000 *Graadafdeelingsbladen van Atjeh en Onderhoorigheden*

Published in 1922–8. Four sheets of sixteen intended, each 46 × 46 cm. In colours; two sheets were also printed in brown (1927).

A series similar to (152).

(154) 1 : 100,000 *Topographische graadafdeelingsbladen van Zuid-Sumatra*

Published in 1910–27, with revisions 1932. Twelve sheets, 27 × 27 cm., some sheets 49 × 47 cm. In colours, some sheets also in brown monochrome and in black editions.

Coastline in blue, with sea tinted faint blue. Relief shown on most sheets by finely drawn brown contours at 50 m. interval, with every 500 m. emphasized, with light brown hill shading, and spot-heights in black. A few sheets have brown hill-shading and spot-heights, without contours. Rivers, names of rivers, lakes, fish-ponds and marsh in blue.

Roads in red, brown and yellow (eight grades by width and surface), tracks by thin red line, footpaths by red dotted line, railways and tramways by filled black and white double lines. Administrative boundaries by various pecked lines, with numbered list in margin. Inhabited places in solid red, native villages in solid green. Woodlands tinted light green, with superimposed black symbols for various trees, rice-fields by light blue diagonal shading. Miscellaneous red, blue and black symbols for bridges, temples, anchorages, lighthouses, etc.

(155) 1 : 100,000 *Graadafdeelingsblad van Sumatra's Oostkust*

Published in 1922. Number of sheets not known. Details as for (154).

(156) 1 : 100,000 *Graadafdeelingsblad van Midden-Sumatra*

Published in 1927. Number of sheets not known. Details as for (154).

(157) 1 : 100,000 *Historisch-Chronologische Overzichtskaart van den Atjeh-Oorlog*

Date of publication not stated. Single sheet, in colours.

(158) 1 : 160,000 *Verkenningskaart van het residentie Benkoelen*

Published by the *Topografische Bureau* (1894–5). Ten sheets, 46 × 46 cm. Margins divided into two minute intervals (longitude from Padang). In colours.

Coastline in black. Relief shown by red-brown contours and form-lines at varying intervals, every 1,000 m. emphasized, with spot-heights in black. Rivers in black.

Roads in black (one grade), footpaths by dotted black line. Administrative boundaries by various pecked lines, with diagram and numbered list in margin. Inhabited places in black, native villages in solid green. Black symbols for woodland and plantations, rice-fields by black diagonal shading. Miscellaneous black symbols for temples, anchorages, etc.

Sheet V has an inset 19 × 24 cm. of Koto Benkoelen, on scale of 1 : 20,000, with details of the town.

(159) 1 : 200,000 *Overzichtskaart van Atjeh en Onderhoorigheden*

Published 1913. Sixteen sheets, 47 × 51 cm. In colours.

Coastline in blue, sea tinted faint blue. Relief shown by brown contours at 25, 50, 100 and every 100 m., with spot-heights in black. Rivers in blue.

Roads in red (two grades), footpaths by red and black dotted line, tramways by filled black and white double lines. Administrative boundaries by various pecked lines, main ones emphasized in red. Administrative centres and inhabited places by black dots (five grades). Miscellaneous blue, red and black symbols for military positions, springs, hot springs, anchorages, lighthouses, rocks, sand-banks, etc.

(160) 1 : 200,000 *Overzichtskaart van de Residentie Oostkust van Sumatra*

Published in 1889, with a revised edition in 1907. Thirty-six sheets, 47 × 51 cm. Details as for (159).

(161) 1 : 200,000 *Schetskaart van het noordelijk deel van Sumatra's Oostkust*

Published in 1915. Four sheets, 62 × 56 cm. With a 13 pp. booklet listing concessions. In colours.

Coastline in blue, with sea tinted faint blue. Relief shown by light brown hachures, with black spot-heights. Rivers, names of rivers, lakes and marsh in blue. Roads in red (two grades), footpaths by various black pecked lines, emphasized in yellow, pink and green. Towns by black symbols, with letters to distinguish administrative importance, native settlements in solid green. Miscellaneous blue, red, and black symbols for woodlands, plantations, rice-fields, anchorages, etc.

(162) 1 : 200,000 *Kaart der Bataklanden en van het eiland Nias*

Published in 1886–90. Sixteen sheets, 46 × 55 cm. Margins divided into ten minute intervals (longitude from Greenwich). In black.

Coastline in heavy blue. Relief shown by brown hill shading, varying in detail from sheet to sheet, with superimposed symbols for summits, craters, etc. Rivers and lakes in heavy blue.

Roads by double black lines, bridle-paths by single black line, footpaths by dotted black line, railways by filled black and white lines, telegraph lines by black pecked line. Administrative boundaries by black pecked line, emphasized in yellow. Miscellaneous black and blue symbols for woodland, plantations, houses, graves, waterfalls, anchorages, sand-banks, reefs, etc.

(163) 1 : 200,000 *Schetskaart van het noordelijk deel der Residentie Tapanoeli*

Published in 1916. Single sheet, in colours.

(164) 1 : 200,000 *Overzichtskaart van de Afdeeling Kerintji (Residentie Djambi)*

Published in 1915. Single sheet, in colours.

(165) 1 : 200,000 *Schetskaart van de Residentie Benkoelen*

Published in 1918. Five sheets, in colours.

(166) 1 : 200,000 *Schetskaart van de Residentie Lampongsche Districten*

Published in 1911. Four sheets, two of which are 55 × 56 cm., two 73 × 56 cm.

Coastline in blue, with sea tinted faint blue. Relief shown in outline by brown hachures, with spot-heights in black. Astronomical stations by red stars. Rivers, names of rivers, lakes and marsh in blue.

Roads in red (two grades), bridle-tracks by thin red line, footpaths by red dotted line. Administrative boundaries by various pecked lines emphasized in red, green and yellow. Towns by black dots (four grades).

(167) 1 : 200,000 *Schetskaart van Zuid-Sumatra*

Published in 1904. Twelve sheets, in colours.

(168) 1 : 200,000 *Overzichtskaart (economischekaart) der erfpachtsperceelen en Landbouwconcessies op Sumatra*

Published in 1914. No details available.

(169) 1 : 250,000 *Overzichtskaart van het eiland Sumatra*

Published in 1924. Eighteen sheets published, 89 × 67 cm., of intended twenty-eight. Margins divided into ten minute intervals (longitude from Greenwich). In colours.

Coastline in blue, with sea tinted faint blue. Relief shown by brown contours at 100 m. interval to 600 m., then every 200 to 1,200 m., then every 400 m., with spot-heights in black. Rivers, names of rivers, lakes and marsh in blue.

Roads in red (three grades), bridle-paths by red pecked line, footpaths by red dotted line, railways and tramways by black lines, cable railway by line of crosses, oil pipe-line by line through crosses. Administrative boundaries by various pecked lines. Miscellaneous red, blue and black symbols for towns, villages, anchorages, jetties, lighthouses, airfields, mines, oil-wells, hot springs, sand-banks, coral reefs, etc.

(170) 1 : 250,000 *Schetskaart van Indragiri en Zuid Pelawan*

Published in 1910. Two sheets, 60 × 80 cm. Margins divided into ten minute intervals (longitude from Padang). In colours.

Coastline in blue, sea tinted faint blue. Relief shown by light brown hachures. Rivers, names of rivers, lakes and marshes in blue.

Roads in red (two grades), footpaths by red dotted line. Administrative boundaries by various pecked lines, emphasized in pink, yellow, and green. Miscellaneous red and black symbols for inhabited places, bridges, anchorages, sand-banks, reefs, etc.

(171) 1 : 250,000 *Schetskaart van een deel der Batakland*

Published in 1905. Single sheet, in black.

(172) 1 : 250,000 *Schetskaart van het Tobameer en aangrenzende landstreken*

Published in 1909. Two sheets, in colours.

(173) 1 : 250,000 *Schetskaart van de Residentie Djambi*

Published in 1920. Two sheets, in colours.

(174) 1 : 250,000 *Schetskaart van de Batanghari Districten*

Published in 1910. Single sheet, in colours.

(175) 1 : 300,000 *Schetskaart van de Residentie Palembang*

Published in 1914. Four sheets, 79 × 64 cm. Margins divided into thirty minute intervals (longitude from Greenwich). In colours.

Coastline in blue, sea tinted faint blue. Relief shown in outline by brown hachures, with black spot-heights. Rivers, names of rivers, lakes and marshes in blue.

Roads in red (two grades), bridle-paths by thin red line, footpaths by red dotted line, railways by black line, telephone lines by brown line, telegraph line by brown pecks. Boundaries by various black pecked lines, emphasized in pink, yellow and green. Miscellaneous red and black symbols for post-offices, military posts, lighthouses, harbours, sand-banks, reefs, etc.

(176) 1 : 500,000 *Overzichtskaart van Atjeh en onderhoorigheden*

Published in 1901. Single sheet, in colours.

(177) 1 : 500,000 *Schetskaart van het stroomgebied der Indragiri-rivier en aangrenzende landstreken*

Published in 1907. Single sheet, in colours.

(178) 1 : 500,000 *Kaart van de erfpachtsperceelen in de Lampongsche districten*

Published in 1914. Single sheet, in colours.

(179) 1 : 500,000 *Kaart van de cultuurondernemingen in het Gouvernement Sumatra's Oostkust*

Published in 1918. Single sheet, in colours.

(180) 1 : 500,000 *Afstandswijzerkaart van de Residentie Palembang*

Published in 1921. Single sheet, 90 × 75 cm. In colours.

Coastline in blue, with sea tinted faint blue. Relief not shown. Rivers, names of rivers, and marshes in blue.

Roads in red and black (three grades), with kilometrages in black, bridle-tracks by thin red line, footpaths by red dotted line, railways by filled black and white double lines. Inhabited places in black (four grades), with information about stations, petrol pumps, etc.

(181) 1 : 600,000 *Schetskaart van de Residentie Sumatra's Westkust*

Published in 1922, with a revised edition in 1930. Single sheet 55 × 67 cm., margin divided into five minute intervals (longitude from Padang). In colours.

Coastline in blue, with sea tinted faint blue. Relief shown only by spot-heights. Rivers, names of rivers, and marshes in blue.

Roads in black (three grades), footpaths by black and white double lines, railways by filled black and white double lines. Administrative boundaries by various pecked lines, emphasized in pink, yellow and green. Another edition appears in black.

(182) 1 : 650,000 *Economische Overzichtskaart van Sumatra*

Published in 1923. Single sheet, in colours.

(183) 1 : 750,000 *Overzichtskaart van het eiland Sumatra*

Published in 1934–40. Ten sheets, 59 × 40 cm. Margins divided into ten minute intervals (longitude from Padang). In colours.

Coastline in blue, with sea tinted faint blue. Relief shown in most areas by brown contours at 100, 250, 500, 750, 1,000, 1,500, 2,000 and 2,500 m., with attractive layer-tinting in nine shades of green, yellow, orange and brown, and spot-heights in black. Some areas have relief shown by brown hill shading and black spot-heights, with no contours. Rivers, names of rivers, lakes and marshes in blue; unsurveyed rivers by pecked line.

Roads in red (three grades), bridle-tracks by red pecked line, footpaths by red dotted line, roads and railways in black. Boundaries of administrative divisions by various pecked lines. Plantations tinted green, numbered to correspond to a list (with chief crop) in margin. Towns by black dots. Miscellaneous symbols in red, blue and black for airfields, post and telegraph offices, pipe-lines, lighthouses, harbours, anchorages, hot springs, coral reefs, sand-banks, etc.

(184) 1 : 750,000 *Overzichtskaart van het Residenties*

The following sheets have been published:

(i) *Atjeh en Onderhoorigheden*, single sheet (1923); (ii) *Benkoelen*, single sheet (1922); (iii) *Djambi*, single sheet (1923); (iv) *Lampoengsche Districten*, single sheet

(1927); (v) *Palembang*, single sheet (1919–20), with an edition in black (1927); (vi) *Riouw*, two sheets (1922); (vii) *Sumatra's Westkust*, single sheet (1919); and (viii) *Tapanoeli*, single sheet (1919).

Sheets are of various sizes, between 53 × 36 cm. and 66 × 42 cm. Margins divided into ten minute intervals (longitude from Padang). In colours, except 1927 edition of *Palembang*, which is in black.

Coastline in blue, sea tinted faint blue. Relief shown variously: (i) by brown contours at 100, 250, 500, 750, 1,000, 1,500, 2,000, and 3,000 m.; (ii) by these contours, with layer-tinting in eight shades of green and brown; (iii) in outline by faint brown hachures. All have spot-heights in black. Rivers, names of rivers, lakes and marsh in blue.

Roads in red (two grades), bridle-paths by a thin red line, footpaths by red dotted line, railway lines by filled black and white double lines, steamer lines in red. Administrative boundaries by various pecked lines emphazised in colour. Towns by black symbols (seven grades of importance). Miscellaneous red, blue and black symbols for temples, graves, lighthouses, harbours, anchorages, reefs, sand-banks, etc.

(185) 1 : 1,000,000 *Schetskaart van Sumatra's Oostkust*

Published in 1917. Single sheet, in colours.

(186) 1 : 1,500,000 *Schoolkaart van het eiland Sumatra*

Published in 1929. Two sheets, in colours.

(187) 1 : 1,650,000 *Overzichtskaart van het eiland Sumatra*

Published in 1922, with a revised edition in 1929. Single sheet 75 × 82 cm. Margins divided into one degree intervals (longitude from Greenwich), with graticule at degree intervals. In colours.

Coastline in blue. Relief by brown contours at 100, 250, 500, 750, 1,000, 1,500, 2,000 and 2,500 m., layer-tinted in nine shades of green and brown, with black spot-heights. Submarine contours in blue at 18, 180, 1,000 m., and every 1,000 to 5,000 m., layer-tinted in white and seven shades of blue. Rivers in black, lakes in blue.

Roads in red (three grades), bridle-tracks by thin red line, footpaths by red dotted line, railways and tramways in black. Administrative boundaries by various pecked lines. Inhabited places by black symbols (seven grades of administrative importance). Miscellaneous red, blue and black symbols for harbours, lighthouses, reefs, sand-banks, etc.

Inset 1 : 5,000,000 *Overzichtskaart van de Politieke Indeeling van Sumatra*, giving details of roads, railways, navigable waterways and signal communications.

(188) 1 : 1,750,000 *Overzichtskaart van het eiland Sumatra*

Published in 1928. Single sheet, 71 × 77 cm. Margins divided into twenty minute intervals (longitude both from Batavia and Greenwich). In colours.

Coastline in blue. Relief shown by brown contours, with layer-tinting in nine shades of green and brown, and spot-heights in black. Submarine contours in blue at 200, 500, 1,000 m. and every 1,000 to 5,000 m., layer-tinted in white and six shades of blue. Rivers, names of rivers, lakes and marsh in blue.

Roads in red (three grades), bridle-tracks by thin red line, footpaths by red dotted line, railways in solid black, narrow gauge railways by filled black and white lines.

Administrative divisions by various pecked lines, residencies emphasized in pink. Miscellaneous symbols in blue, red and black for harbours, anchorages, sand-banks, reefs, etc.

Inset 1 : 5,000,000 *Overzicht van de Politieke Indeeling van Sumatra*, giving administrative boundaries, railways, tramways, signal communications, steamer routes, navigable rivers, wireless stations, automobile services, etc. List of railway companies in margin.

(189) 1 : 1,750,000 *Wegenkaart van Sumatra*

Published in 1940. Two sheets, 79 × 46 cm. In colours.

Coastline and rivers in black. Roads in black, red and yellow (eleven grades). Navigable rivers in blue (three grades).

Railways and tramways in filled black and white lines.

(190) 1 : 2,000,000 *Overzichtskaart van het eiland Sumatra*

Published in 1908, with a revised edition in 1913. Single sheet, 61 × 67 cm. Margins divided into thirty minute intervals (longitude from Greenwich). In colours.

Coastline in blue, with sea tinted faint blue. Relief shown in outline by faint brown hill shading, with spot-heights in black. Rivers, names of rivers, lakes and marsh in blue.

Roads in red (two grades), bridle-paths by thin red line, footpaths by red dotted line, railways and tramways by filled black and white double lines. Administrative boundaries by various pecked lines. Miscellaneous red, blue and black symbols for military posts, harbours, anchorages, lighthouses. Chief plant products by green symbols, mineral products by brown.

Summary of trade for 1906, 1909 and 1911 in margin.

Inset 1 : 5,000,000 *Politieke Indeeling van Sumatra*, with a numbered list of administrative divisions.

(191) 1 : 2,500,000 *Oro-hydrografische schetskaart van het eiland Sumatra*

Published in 1917. Single sheet, in colours.

(192) 1 : 3,000,000 *Overzichtskaart van de Spoorwegen en S.S. Automobieldiensten op Sumatra*

Published in 1941. Single sheet, 40 × 44 cm. Margin divided into thirty second intervals (longitude from Greenwich). In colours.

Outline of coast and rivers in black. Motoring roads in green (two grades), railway lines in red (three grades), tramways and mineral lines in black.

(193) 1 : 8,000,000 *Kaart van de groondsoorten in het Noordelijk deel Sumatra's Oostkust*

Date of publication not stated. Single sheet, in colours.

Ternate en Hiri

(194) 1 : 20,000 *Schetskaart van de eilanden Ternate en Hiri*

Published in 1916. Single sheet, in black.

Tidore en Maitara

(195) 1 : 20,000 *Schetskaart van de eilanden Tidore en Maitara*

Published in 1916. Single sheet, both in black and in colours.

Timor

Netherlands Timor was topographically surveyed, but without any geodetic or astronomical basis, between 1922–39.

The earliest *schetskaart* was published in 1911 on a scale of 1 : 500,000 followed in 1920 by a 1 : 250,000 sheet; the latter was revised in 1941. In 1924 began the 1 : 100,000 series based on the new topographical survey.

(196) 1 : 100,000 *Graadafdeelingsbladen van het eiland Timor*

Published in 1924– . In colours.

(197) 1 : 250,000 *Schetskaart van Timor (Nederlandsch Gebied)*

Published in 1920. Single sheet, 86 × 64 cm. Margins divided into five minute intervals (longitude from Greenwich). In colours.

Coastline in blue, sea tinted faint blue. Relief shown by light brown hill shading, with spot-heights in black. Rivers, names of rivers, lakes and marsh in blue.

Roads in red (two grades), roads under construction by red pecked lines, bridle-tracks by thin red line, footpaths by red dotted lines. Administrative boundaries by various pecked lines. Towns and villages by black circles (seven grades). Miscellaneous red, blue and black symbols for military posts, lighthouses, anchorages, harbours, sand-banks, etc.

Inset 1 : 1,250,000 *Overzichtskaart*, 23 × 15 cm., showing administrative boundaries, roads and telephone lines.

(198) 1 : 250,000 *Schetskaart van Timor (Nederlandsch Gebied)*

Published in 1941. Single sheet, 86 × 64 cm. Margins divided into ten minute intervals (longitude from Greenwich). In colours.

Relief shown by black contours at 100, 200, 500 m. and every 500 to 2,000 m., layer-tinted in seven shades of green, yellow and brown, with spot-heights in black. All other features as on (197), but in considerably greater detail.

(199) 1 : 500,000 *Schetskaart van Nederlandsch Timor en omliggende eilanden*

Published in 1911. Single sheet, 72 × 68 cm. Margins divided into ten minute intervals (longitude from Greenwich). In blue, brown and black.

Coastline in blue, with sea tinted faint blue. Relief shown in outline by simple brown hachures, with occasional spot-heights in black. Low water mark in places by black dotted line. Rivers, names of rivers, lakes and marsh in blue.

Tracks in brown, footpaths by brown dotted line. Administrative boundaries by various black pecked lines. Towns and villages in black (four grades). Miscellaneous black and brown symbols for harbours, lighthouses, sand-banks, reefs, etc.

Insets (i) 1 : 1,000,000 *Overzichtskaart van Timor*, showing the Dutch–Portuguese frontier.

(ii) 1 : 500,000 *Sawoe-eilanden*.

WETAR

(200) 1 : 150,000 *Schetskaart van het eiland Wetar*

Published in 1911. Single sheet, 80 × 44 cm. In colours. Revised edition in black (1939).

Coastline in blue. Relief shown in outline by simple brown hachures, with large areas left blank, and spot-heights in black. Rivers and names of rivers in blue.

Tracks in brown, footpaths by brown dotted lines. Administrative boundaries by various black pecked lines. Miscellaneous black and brown symbols for villages (two grades), bivouacs, anchorages, lighthouses, sand-banks, etc.

B. MAPS PUBLISHED BY THE GEOGRAPHICAL SECTION OF THE GENERAL STAFF

The G.S.G.S. have reproduced a considerable number of maps published by the *Topografische Dienst*. Usually the series are exact copies of the Dutch original; the chief exceptions are Series 3860 and 3981, both compiled from a variety of sources, while one or two are monochrome reproductions from coloured originals.

The following features have been added in most cases by the G.S.G.S.:

(i) Legend in English.
(ii) A list of Dutch and native abbreviations for natural features with their English equivalents.
(iii) An extra scale-line in miles and/or yards.
(iv) Conversion tables of metres/feet.
(v) A grid superimposed in red or blue.
(vi) Longitudes from Greenwich where not already given.
(vii) Magnetic declination.
(viii) Reliability diagram and index of adjoining sheets.
(ix) Date of original Dutch maps.

The following list includes all G.S.G.S. publications referring to the Netherlands East Indies to March, 1944. Details are given only when they differ from the Dutch source, or if they are original compilations.

(1) 1 : 1,000,000 *Series* 4204. *East Indies*

Twenty-five sheets. Reproduction of No. (1).

(2) 1 : 1,000,000 *Series* 4204. *East Indies*

Second edition, Ground/Air, (1942–3). Fourteen sheets. Based on No. (1), but with revised detail, lines of equal magnetic declination superimposed in blue, local mean time relative to Greenwich in margin, co-latitudes and co-longitudes in margin in blue. No grid.

(3) 1 : 4,000,000 *Series* 3860. *East Indies*

Two sheets, 83 × 56 cm., first edition (1928), second edition (1941), layered edition (1942). Compiled from a variety of authorities listed in the margin. Margins divided into twenty minute intervals, graticule ruled and numbered at two degree intervals to form a map reference.

Two styles:

(*a*) One latitude and longitude (from Greenwich) given in margin. In colours. Coastline in blue. Relief shown by brown contours at 200, 500, and every 500 to 3,000 m., then every 1,000 to 5,000 m., with some intermediate form-lines by

pecked lines, with spot-heights in black. Submarine contours in blue at 200, 500, 1,000 m., then every 2,000 to 7,000 m. with spot-depths in blue. Rivers, names of rivers, lakes and marsh in blue.

Roads in black (two grades), tracks by black pecked line, telegraph and telephone lines in black, railways in heavy black. Administrative boundaries by various black lines (three grades). Towns by black symbols (five grades).

(*b*) Similar in detail to (*a*), but with relief shown by layer-tinting in nine shades of brown and red, submarine relief by seven shades of blue.

(4) 1 : 200,000 *Series* 4265. *Bali*

Reproduction of No. (24), but with no layer-tinting.

(5) 1 : 200,000 *Series* 4264. *Billiton*

Reproduction of No. (33).

(6) 1 : 50,000 *Series* 4211. *Borneo, Western Division*

Reproduction of No. (41), with gridded and ungridded editions.

(7) 1 : 200,000 *Series* 4215. *Borneo, Western Division*

Reproduction of No. (43), but in black and grey only.

(8) 1 : 300,000 *Series* 4269. *Flores*

Reproduction of No. (81), but in four sheets, 47 × 41 cm.

(9) 1 : 50,000 *Series* 4202, *Java and Madura*

Reproduction of Nos. (95) and (96). 111 sheets.

(10) 1 : 100,000 *Series* 4201. *Java and Madura*

Reproduction of No. (99), but contours in green-grey instead of brown. Thirty-two sheets.

(11) 1 : 250,000 *Series* 4200. *Java and Madura*

Reproduction of No. (101), but in monochrome grey and black instead of in colours. One style has rivers and sea blue. Ten sheets.

(12) 1 : 2,000,000 *Series* 1981. *Java and Madoera*

Compiled from various sources, first edition (1919), fourth edition (1941). Single sheet, 56 × 19 cm. Margins divided into degree intervals (longitude from Batavia and Greenwich), with graticule drawn at degree intervals (longitude from Batavia). In colours.

Coastline in blue, sea tinted faint blue. Relief shown by brown contours at 100, 750 and 1,500 m., layer-tinted in white and three shades of brown, and spot-heights in black. Rivers and names of rivers in blue.

Roads in red (two grades), tracks by pecked red line, railways in black, tramways by pecked line. Administrative boundaries by various pecked lines. Towns by black symbols (three grades).

(13) 1 : 200,000 *Series* 4266. *Lombok*

Reproduction of No (121).

(14) 1 : 1,000,000 *Series* 4284. *New Guinea*

Reproduction of No. (129), but in monochrome grey and black, with rivers and sea in blue, instead of colours.

(15) 1 : 150,000 *Series* 4263. *Nias*

Reproduction of No. (124).

(16) 1 : 250,000 *Series* 4262. *Simaloer*

Reproduction of No. (134).

(17) 1 : 500,000 *Series* 4268. *Soemba*

Reproduction of No. (138).

(18) 1 : 250,000 *Series* 4267. *Soembawa*

Reproduction of No. (139).

(19) 1 : 40,000 *Series* 4293. *Northern Sumatra*

Reproduction of No. (146), but contours in green-grey instead of brown. Seven sheets.

(20) 1 : 50,000 *Series* 4199. *Sumatra—part of the east coast residency*

Reproduction of No. (148).

(21) 1 : 100,000 *Series* 4278. *South Sumatra*

Reproduction of No. (154), but contours and hill shading in grey instead of brown. Twelve sheets.

(22) 1 : 100,000 *Series* 4294. *East Sumatra*

Reproduction of No. (155), but contours and hill shading in grey instead of brown. Fifteen sheets.

(23) 1 : 100,000 *Series* 4198. *Djambi and Palembang area*

Reproduction of No. (156), but contours and hill shading in grey instead of brown. Five sheets.

(24) 1 : 250,000 *Series* 4197. *Sumatra*

Reproduction of No. (169). Seventeen sheets. In black.

(25) 1 : 750,000 *Series* 4184. *Sumatra*

Reproduction of No. (183), but with layer-tinting in grey instead of colours. Ten sheets.

(26) 1 : 250,000 *Series* 4272. *Dutch Timor*

Reproduction of No. (198), but in two sheets, 64 × 46 cm.

(27) 1 : 500,000 *Series* 4271. *Timor and islands*

Reproduction of No. (199).

(28) 1 : 150,000 *Series* 4270. *Wetar*

Reproduction of No. (200).

C. GEOLOGICAL MAPS

The geological surveys of the Netherlands East Indies are carried out by the *Dienst van den Mijnbouw* at Bandoeng, a section of the *Departement van Openbare Werken*. The maps are reproduced by the *Topografische Dienst*. A description of each year's geological survey work, together with many infolded maps and much explanatory text, is contained in the *Jaarboek van het Mijnwezen in Nederlandsch Oost-Indië* (Buitenzorg, 1872–1940). The various *Jaarboek* contain a large number of geological maps which are not published separately, and which cannot be listed in this Appendix owing to lack of space.

Since 1850, there have been a large number of geological reconnaissance expeditions, carried out chiefly by officers (*hoofdingenieurs*) of the *Dienst van den Mijnbouw*, and also by mining companies and by private scientific expenditions. Details of these surveys are contained either in the *Jaarboek van het Mijnwezen* or in the *Jaarboek van het Geologisch mijnbouwkundig genootschap voor Nederland en koloniën*. The bibliography of geological memoirs and maps referring to the Netherlands East Indies, collated and published by the latter society, totalled over 6,000 items by 1938.

The most important individual piece of work was the survey of Java and Madoera, carried out in 1886–94 by the *Dienst van den Mijnbouw*. The results were collated by by R.D.M. Verbeek and R. Fennema to form a twenty-six sheet series on the scale of 1 : 100,000 covering the whole of Java, published in 1896.

The geological reconnaissance surveys other than those of Java were necessarily scattered and incomplete. It was decided to systematize these surveys by producing a *geologische overzichtskaart* on a scale of 1 : 1,000,000, which would cover the whole archipelago in twenty-one sheets. By 1930, twelve sheets had been published but no further sheets had appeared by 1941.

The discontinuance of these reconnaissance surveys was due partly to the economic crisis, but also partly to the systematic detailed surveys of Java and Sumatra. It was intended to cover Java by some hundred sheets with accompanying text; by 1940, eleven had been published, two were in course of publication and a further forty-seven had been wholly or partly surveyed.

The first of the forty-three projected sheets of southern Sumatra appeared in 1931; thirteen had been published by 1941.

(1) 1 : 100,000 *Geologische Kaart van Java en Madoera*

Compiled by R. D. M. Verbeek and R. Fennema, published by J. G. Stemler (Amsterdam, 1896). Twenty-six main sheets 55 × 44 cm. with an *overzichtskaart*, and a number of sheets of geological cross sections and special maps.

Coastline and rivers in blue and spot-heights in black. Other detail of roads, towns, etc. in black. Geology superimposed in colours.

The *overzichtskaart* 40 × 34 cm. on 1 : 12,500,000 shows the chief mountain areas, volcanoes and ocean depths. In black, with sea tinted blue.

There are seven sheets of special vulcanological areas, small islands, etc., on scales of 1 : 10,000, 1 : 20,000 and 1 : 50,000.

(2) 1 : 100,000 *Geologische Kaart van Java en Madoera*

Published by the *Dienst van den Mijnbouw* (1931–40). Eleven sheets had been published by 1940, with accompanying *Toelichting* (explanation) of about 70 pp., including text, sections and plates. Sheets 37 × 37 cm. with marginal cross sections and full key. Margins divided into minute intervals (longitude from Batavia).

Coast, rivers, spot-heights, and other detail in black, with geology in colours. Detailed petrological and structural information superimposed in brown.

(3) 1 : 200,000 *Geologische Kaart van Sumatra*

Published by the *Dienst van den Mijnbouw* (1931–40). Thirteen sheets had been published by 1940, with accompanying *Toelichting* (explanation) of about 70 pp., including text, sections and plates. Sheets 37 × 37 cm., with marginal cross sections and full key. Margins divided into minute intervals (longitude from central meridian of southern Sumatra, which is 132° 33′ 27·8″ east of Greenwich).

Coast, rivers, spot-heights, and other detail in black, with geology in colours. Detailed petrological and structural information superimposed in green and brown.

(4) 1 : 1,000,000 *Geologische Overzichtskaart van den Nederlandsche-Indischen Archipel*

Published by the *Dienst van den Mijnbouw* (1915–30). Twelve sheets, 67 × 65 cm., have been published of the intended twenty-one. Margins divided into ten minute intervals (longitude from Greenwich). Each is accompanied by short explanatory text.

Coast, rivers, roads, spot-heights and other detail in black with geology superimposed in colour. Submarine contours in blue at 50, 100, 1,000 and every 1,000 to 5,000 m., layer-tinted in eight shades of blue.

D. CHARTS

British Admiralty Charts

Index plans to the various charts published by the Hydrographic Department of the Admiralty are contained in the following publications of H.M.S.O., London:

(i) *Eastern Archipelago Pilot*, vol I (5th edition, 1935), comprising the Philippine Islands, Sulu Sea, Sulu Archipelago and the north-east coast of Borneo.

(ii) *Eastern Archipelago Pilot*, vol. II (6th edition, 1943), comprising the south-eastern end of Sumatra, Sunda Strait, Java, islands eastward of Java, southern and eastern coasts of Borneo, Makassar Strait, Celebes, and the western part of the Sula Islands.

(iii) *Eastern Archipelago Pilot*, vol. III (3rd edition, 1930), comprising the north-eastern end of the Celebes, Molucca and Jailolo Passages, and the western end and southern coast of Dutch New Guinea.

(iv) *Eastern Archipelago Pilot*, vol. IV (2nd edition, 1939), comprising the western end of Java, the southern and eastern coasts of Sumatra, Straat Soenda, Straat

Banka, Gaspar Strait, Straat Karimata, the western coast of Borneo from Tanjong Sambar to the extrance to the Kleine Kapoeas river, the Riouw and Lingga Archipel, with the various routes leading to Singapore and the China sea.

(v) *Malacca Strait Pilot* (2nd edition, 1934), comprising the Malacca Strait and its northern approaches, Singapore Strait and the west coast of Sumatra.

It should be noted that a number of new charts have been issued since the dates of publication of these *Pilots* and are listed in the *Supplements relating to the Pilots*.

American Hydrographic Office Charts

Index plans to the various charts published by the U.S. Hydrographic Office at Washington are contained in the following *Sailing Directions :*

(i) *No.* 126 *Asiatic Pilot*, vol. v. *Sunda Strait and the southern approaches to China Sea* (1934).

(ii) *No.* 162. *Malacca Strait and Sumatra* (3rd edition, 1932).

(iii) *No.* 163. *Celebes, south-east Borneo, Java and islands east of Java* (3rd edition, 1935).

(iv) *No.* 164. *New Guinea and the islands eastward of Celebes and Timor* (3rd edition, 1936).

It should be noted that a number of new charts have been issued since the dates of publication of these *Sailing Directions*, and are noted in *Supplements* and *Notices to Mariners*.

Dutch Charts

An excellent set of charts covering the whole of the Netherlands East Indies is published by the *Departement van Marine, Afdeeling Hydrografie* at The Hague. A complete list of the total of 364 charts (1939) is contained in the *Catalogus van Nederlandsch Oost-Indië Zeekaarten en Boekwerken* (latest edition, 1938).

The charts are divided into twenty groups as follows: (1) *Archipel*, sixteen sheets, of which two are on a scale of 1 : 3,000,000, and a series of fourteen cover the whole archipelago on 1 : 1,000,000; (2) *Nordkust Sumatra*, five sheets; (3) *Westkust Sumatra*, forty-nine sheets; (4) *Oostkust Sumatra*, forty-four sheets; (5) *Zuidkust Sumatra*, three sheets; (6) *Westkust Borneo*, twenty-one sheets; (7) *Zuidkust Borneo*, thirteen sheets; (8) *Java en Java Zee*, twenty-eight sheets; (9) *Kleine Soenda eilanden en Flores Zee*, forty-six sheets; (10) *Straat Makassar*, six sheets; (11) *Oostkust Borneo*, seventeen sheets; (12) *Westkust Celebes*, nine sheets; (13) *Noordkust Celebes*, nine sheets; (14) *Oostkust Celebes*, twenty-two sheets; (15) *Zuidoostkust*, eight sheets; (16) *Zuidkust Celebes*, seven sheets; (17)*Moluksche Archipel*, twenty-two sheets; (18) *Sermata-Tanimbar- Kai- en Aroe-eilanden*, nine sheets; (19) *Noordkust Nieuw Guinee*, fifteen sheets; (20) *West- en Zuidkust Nieuw Guinee*, fifteen sheets.

Index plans to these charts are contained in the *Catalogus van Nederlandsch Oost-Indië Zeekarten en Boekwerken* (1938); there are two large folding maps, *Westblad*, and *Oostblad*, each on a scale of 1 : 3,750,000.

Index plans are also conveniently accessible in the following *Zeemansgids:*

(i) *Zeemansgids voor Nederlandsch Oost-Indie*, Deel I *Westelijk Gedeelte*) (*zesde druk*, 1931).

(ii) *Zeemansgids voor Nederlandsch Oost-Indie, Deel* II (*Midden, Gedeelte*), *zesde druk*, 1931).

(iii) *Zeemansgids voor Nederlandsch Oost-Indie*, Deel III (*Oostelijk Gedeelte*), *zesde druk*, 1933).

It should be noted that a number of new charts have been issued since the dates of publication of the *Zeemansgids* and are noted in subsequent *Aanvullingsbladen* (supplements).

CONVERSION TABLES

Metric and British Units

It is customary to think of the 'metre' and the 'yard' as representing unalterable units of length. This is not so. The metre was originally intended to be the 10,000,000th part of the earth's meridional quadrant. But the accurate determination of this length proved to be extremely difficult—partly for technical reasons, and partly because of different conceptions of the 'figure of the earth'. In view of these difficulties it became necessary to define the length of the metre in terms of suitable metal bars measured under specified conditions of temperature, pressure, humidity, etc. Similar standard bars were also used to define the length of other units such as the yard. As all these metallic standards are subject to change, conversion tables differ according to the date of comparison between different bars. The tables that follow are based on the comparison between the yard and the metre made in 1895. This made 1 metre equivalent to 39·370113 in.

Metric System. List of Prefixes

Deca means ten times.	Deci means a tenth part of.
Hecto means a hundred times.	Centi means a hundredth part of.
Kilo means a thousand times.	Milli means a thousandth part of.

In abbreviations the Decametre, etc., is Dm., and the decimetre, etc., dm.

Note on 'Nautical', 'Geographical' and 'Statute' miles

A British 'nautical mile' is the length of the minute of the meridian at any given latitude, and is therefore a variable unit. It is given in feet for Clarke's 1880 spheriod by the formula:

$$60771{\cdot}1 - 30{\cdot}7 \cos 2 \text{ Lat.}$$

This is the sea mile of the scale of latitude and distance of the Admiralty Charts. From the above formula it will be found to vary from 6,046·4 ft. at the equator to 6,107·8 ft. at the poles, being 6,077·1 ft. at latitude 45°.

The so-called 'international nautical mile' of 1,852 m. or 6,076 ft. is the length of the minute of the meridian at latitude 45° on the international spheroid. This corresponds to the 6,077 ft. for Clarke's spheroid.

A 'geographical mile' is a fixed unit, being defined by some as the length of a minute of the equator and by others as that of the minute of the meridian at latitude 45°. According to the former definition its value on Clarke's spheroid is 6,087 ft. and according to the latter 6,077 ft. The round figure 6,080 is usually adopted for the purposes of ordinary navigation.

The British 'statute mile' measures 5,280 ft.

List of Conversion Tables

Table 1. *Length*

Nautical mile	Statute mile	Kilometre	Metre	Yard	Foot	Inch	Centimetre
1	1·152	1·853	1853	2027	6080*	72,960	185,300
0·8684	*1*	1·60934	1609·34	1760	5280	63·360	160,934
0·5396	0·621372	*1*	1000	1093·61	3280·84	39,370·1	100,000
0·0005396	0·0006214	0·001	*1*	1·09361	3·28084	39·3701	100
0·0004934	0·0005682	0·0009144	0·914399	*1*	3	36	91·4399
0·0001645	0·0001894	0·0003048	0·3048	0·33333	*1*	12	30·48
0·0000137	0·0000158	0·0000254	0·0254	0·02778	0·083333	*1*	2·54
0·0000054	0·0000062	0·00001	0·01	0·0109361	0·032808	0·393701	*1*

* This is the customary British practice, and not the 'international nautical mile', which Great Britain has not adopted.

Table 2. *Area*

Square mile	Square kilometre	Hectare	Acre	Square metre	Square yard
1	2·58998	258·998	640	2,589,980	3,097,600
0·386103	*1*	100	247·106	1,000,000	1,195,990
0·003861	0·01	*1*	2·47106	10,000	11,959·9
0·0015625	0·0040469	0·404685	*1*	4046·85	4840
0·00000039	0·000001	0·0001	0·000247	*1*	1·19599
0·00000032	0·00000084	0·0000836	0·000207	0·836126	*1*

Table 3. *Yield per Unit Area*

Tons per acre	Metric tons per hectare	Quintals per hectare
1	2·51071	25·1071
0·398294	*1*	10
0·0398294	0·1	*1*

Table 4. *Volume and Capacity*

Kilolitre	Cubic metre	Cubic yard	Bushel	Cubic feet	Imp. gall.	Litre	Pint
1	1·000027	1·30799	27·4969	35·3157	219·976	1000	1759·80
0·999973	*1*	1·30795	27·4962	35·3148	219·970	999·973	1759·75
0·764532	0·764553	*1*	21·0223	27	168·178	764·532	1345·43
0·0363677	0·0363687	0·0475685	*1*	1·28435	8	36·3677	64
0·028316	0·028317	0·037037	0·778602	*1*	6·22882	28·3160	49·8306
0·0045460	0·0045608	0·0059461	0·125	0·160544	*1*	4·54596	8
0·001	0·001000	0·001308	0·027497	0·035316	0·219976	*1*	1·75980
0·0005682	0·0005683	0·0007433	0·015625	0·020068	0·125	0·56824	*1*

Table 5. *Weight*

Ton	Metric ton or millier	Quintal	Kilogram	Pound
1	1·01605	10·1605	1016·05	2240
0·984207	*1*	10	1000	2204·62
0·0984207	0·1	*1*	100	220·462
0·0009842	0·001	0·01	*1*	2·20462
0·0004464	0·0004536	0·004536	0·453592	*1*

Table 6. *Temperature: Equivalents of Fahrenheit and Centigrade Scales*

°F.	°C.	°F.	°C.	°F.	°C.	°F.	°C.	°F.	°C.	°F.	°C.
100	37·7	79·25	26·25	58	14·4	37·4	3	17	− 8·3	− 4	−20
99·5	37·5	79	26·1	57·2	14	37	2·7	16·25	− 8·75	− 5	−20·5
99	37·2	78·8	26	57	13·8	36·3	2·5	16	− 8·8	− 5·8	−21
98·6	37	78	25·5	56·75	13·75	36	2·2	15·8	− 9	− 6	−21·1
98	36·6	77	25	56	13·3	35·6	2	15	− 9·4	− 6·25	−21·25
97·25	36·25	76	24·4	55·4	13	35	1·6	14	−10	− 7	−21·6
97	36·1	75·2	24	55	12·7	34·25	1·25	13	−10·5	− 7·6	−22
96·8	36	75	23·8	54·5	12·5	34	1·1	12·2	−11	− 8	−22·2
96	35·5	74·75	23·75	54	12·2	33·8	1	12	−11·1	− 8·5	−22·5
95	35	74	23·3	53·6	12	33	0·5	11·75	−11·25	− 9	−22·7
94	34·4	73·4	23	53	11·6	32	0	11	−11·6	− 9·4	−23
93·2	34	73	22·7	52·25	11·25	31	−0·5	10·4	−12	−10	−23·3
93	33·8	72·5	22·5	52	11·1	30·2	− 1	10	−12·2	−10·75	−23·75
92·75	33·75	72	22·2	51·8	11	30	− 1·1	9·5	−12·5	−11	−23·8
92	33·3	71·6	22	51	10·5	29·75	− 1·25	9	−12·7	−11·2	−24
91·4	33	71	21·6	50	10	29	− 1·6	8·6	−13	−12	−24·4
91	32·7	70·25	21·25	49	9·4	28·4	− 2	8	−13·3	−13	−25
90·5	32·5	70	21·1	48·2	9	28	− 2·2	7·25	−13·75	−14	−25·5
90	32·2	69·8	21	48	8·8	27·5	− 2·5	7	−13·8	−14·8	−26
89·6	32	69	20·5	47·75	8·75	27	− 2·7	6·8	−14	−15	−26·1
89	31·6	68	20	47	8·3	26·6	− 3	6	−14·4	−15·25	−26·25
88·25	31·25	67	19·4	46·4	8	26	− 3·3	5	−15	−16	−26·6
88	31·1	66·2	19	46	7·7	25·25	− 3·75	4	−15·5	−16·6	−27
87·8	31	66	18·8	45·5	7·5	25	− 3·8	3·2	−16	−17	−27·2
87	30·5	65·75	18·75	45	7·2	24·8	− 4	3	−16·1	−17·5	−27·5
86	30	65	18·3	44·6	7	24	− 4·4	2·75	−16·25	−18	−27·7
85	29·4	64·4	18	44	6·6	23	− 5	2	−16·6	−18·4	−28
84·2	29	64	17·7	43·25	6·25	22	− 5·5	1·4	−17	−19	−28·3
84	28·8	63·5	17·5	43	6·1	21·2	− 6	1	−17·2	−19·75	−28·75
83·75	28·75	63	17·2	42·8	6	21	− 6·1	0·5	−17·5	−20	−28·8
83	28·3	62·6	17	42	5·5	20·75	− 6·25	0	−17·7	−20·2	−29
82·4	28	62	16·6	41	5	20	− 6·6	−0·4	−18	−21	−29·4
82	27·7	61·25	16·25	40	4·4	19·4	− 7	− 1	−18·3	−22	−30
81·5	27·5	61	16·1	39·2	4	19	− 7·2	− 1·75	−18·75	−23	−30·5
81	27·2	60·8	16	39	3·8	18·5	− 7·5	− 2	−18·8	−23·8	−31
80·6	27	60	15·5	38·75	3·75	18	− 7·7	− 2·2	−19	−24	−31·1
80	26·6	59	15	38	3·3	17·6	− 8	− 3	−19·4	−24·25	−31·25

Table 7. *Pressure: Equivalents of Millibars, Millimetres of Mercury, and Inches of Mercury at 32° F. in Latitude 45°*

Mercury in.	Millibars	Mercury mm.	Mercury in.	Millibars	Mercury mm.	Mercury in.	Millibars	Mercury mm.	Mercury in.	Millibars	Mercury mm.	Mercury in.	Millibars	Mercury mm.
27·02	915	686·3	27·82	942	706·6	28·62	969	726·8	29·41	996	747·1	30·21	1,023	767·3
27·05	916	687·1	27·85	943	707·3	28·65	970	727·6	29·44	997	747·8	30·24	1·024	768·1
27·08	917	687·8	27·88	944	708·1	28·67	971	728·3	29·47	998	748·6	30·27	1,025	768·8
27·11	918	688·6	27·91	945	708·8	28·70	972	729·1	29·50	999	749·3	30·30	1,026	769·6
27·14	919	689·3	27·94	946	709·6	28·73	973	729·8	29·53	1,000	750·1	30·33	1,027	770·3
27·17	920	690·1	27·97	947	710·3	28·76	974	730·6	29·56	1,001	750·8	30·36	1,028	771·1
27·20	921	690·8	28·00	948	711·1	28·79	975	731·3	29·59	1,002	751·6	30·39	1,029	771·8
27·23	922	691·6	28·03	949	711·8	28·82	976	732·1	29·62	1,003	752·3	30·42	1,030	772·6
27·26	923	692·3	28·05	950	712·6	28·85	977	732·8	29·65	1,004	753·1	30·45	1,031	773·3
27·29	924	693·1	28·08	951	713·3	28·88	978	733·6	29·68	1,005	753·8	30·48	1,032	774·1
27·32	925	693·8	28·11	952	714·1	28·91	979	734·3	29·71	1,006	754·6	30·51	1,033	774·8
27·35	926	694·6	28·14	953	714·8	28·94	980	735·1	29·74	1,007	755·3	30·53	1,034	775·6
27·38	927	695·3	28·17	954	715·6	28·97	981	735·8	29·77	1,008	756·1	30·56	1,035	776·3
27·41	928	696·1	28·20	955	716·3	29·00	982	736·6	29·80	1,009	756·8	30·59	1,036	777·1
27·44	929	696·8	28·23	956	717·1	29·03	983	737·3	29·83	1,010	757·6	30·62	1,037	777·8
27·46	930	697·6	28·26	957	717·8	29·06	984	738·1	29·86	1,011	758·3	30·65	1,038	778·6
27·49	931	698·3	28·29	958	718·6	29·09	985	738·8	29·89	1,012	759·1	30·68	1,039	779·3
27·52	932	699·1	28·32	959	719·3	29·12	986	739·6	29·92	1,013	759·8	30·71	1,040	780·1
27·55	933	699·8	28·35	960	720·1	29·15	987	740·3	29·94	1,014	760·6	30·74	1,041	780·8
27·58	934	700·6	28·38	961	720·8	29·18	988	741·1	29·97	1,015	761·3	30·77	1,042	781·6
27·61	935	701·3	28·41	962	721·6	29·21	989	741·8	30·00	1,016	762·1	30·80	1,043	782·3
27·64	936	702·1	28·44	963	722·3	29·24	990	742·6	30·03	1,017	762·8	30·83	1,044	783·1
27·67	937	702·8	28·47	964	723·1	29·26	991	743·3	30·96	1,018	763·6	30·86	1,045	783·8
27·70	938	703·6	28·50	965	723·8	29·29	992	744·1	30·09	1,019	764·3	30·89	1,046	784·6
27·73	939	704·3	28·53	966	724·6	29·32	993	744·8	30·12	1,020	765·1	30·92	1,047	785·3
27·76	940	705·1	28·56	967	725·3	29·35	994	745·6	30·15	1,021	765,8	30·95	1,048	786·1
27·79	941	705·8	28·59	968	726·1	29·38	995	746·3	30·18	1,022	766·6	30·98	1,049	786·8

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