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RECENT ADVANCES IN MARINE ARCHAEOLOGY

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Proceedings of the Second Indian Conference on Marine Archaeology of Indian Ocean Countries—January, 1990

Editor

S.R. RAO

Society for Marine Archaeology
National Institute of Oceanography
Dona Paula 403 004, Goa, India.
1991

Sponsored by
Society for Marine Archaeology

Co-Sponsors
Department of Ocean Development
Archaeological Survey of India
National Institute of Oceanography
Council of Scientific and Industrial Research, India

Edited and Published by
Dr. S.R. Rao,
President
Society for Marine Archaeology
National Institute of Oceanography
Dona Paula 403 004, Goa, India

Price: Rs. 600; US $70; £ Sterling 45

ISBN 81-900074-1-6

Phototypeset by
Art Prints
Madras - 600 004.

Printed in India by
Sudarsan Graphics
14, Neelakanta Metha Street,
T. Nagar, Madras - 600 017.

Contents

Acknowledgement

The Editor thanks Justice M. Rama Jois and Justice E.S. Venkataramiah for delivering the Inaugural and Valedictory addresses respectively as also Prof. G. Venkatasubbiah for declaring the Archaeological Exhibition open. Thanks are due to Prof. V. Gowarikar, Secretary, DST; Prof. A.P. Mitra, Director General, CSIR; Prof. V.K. Gaur, Secretary, DOD; Sri. M.C. Joshi, Director General, ASI; Dr. B.N. Desai, Director NIO.

Sri. N. Subramanian, Proprietor of Sudarsan Graphics deserves heartfelt thanks for the excellent production of the volume despite several revisions made in the text. Our thanks are due to all those who presented their papers and participated in the conference, panel discussion and Society meetings. We are grateful to the British Council and the French Embassy in India for deputing their experts; so also to the Government of Sri Lanka for sending their delegates.

We are obliged to the Management of Hotel Rama, to Mrs. Nagaratnama President and Sri. M.S. Nanjunda Rao, Secretary of Chitrakala Parishat for the hospitality, to Sri. K.P. Poonacha, Superintending Archaeologist, ASI for providing facilities to conduct the academic sessions.

We are indebted to the scientists and other staff of NIO who have laboured hard at every stage to make the exploration and conference a success. The Officers and staff of Marine Archaeolgoy Centre namely, Ms. Manavi Thakkar, Ms. Sunita Shettigar, Sri. P. Gudigar, Sri. Srinivasa Bandodkar, Sri. Sila Tripati, Sri. Sundaresh, Sri. A.S. Gaur and Sri. Satish Chitare, Sri. Alok Tripathi and Sri. Y.D. Sharma, trainees from ASI who have contributed to the success deserve our thanks.

S.R. RAO
Editor

Acknowledgement

PREFACE

The main theme of the Second Indian Conference on Marine Archaeology of Indian Ocean Countries held at Bangalore, the Capital of Karnataka State (India) on January 20 and 21, 1991, was "Recent Advances in Marine Archaeology" with special reference to target-search techniques adopted in the discovery of submerged cities and sunken ships. A survey of the important ports on Indian coast, the usefulness of marine records and the necessity of undertaking a careful study of the archival and literary sources were also discussed. The participation of Mr. C.T.C. Dobbs and Mr. Mensun Bound from the United Kingdom and Dr. O. Guillaume a classical archaeologist from France enabled the marine archaeologists of India to review their own progress in target-search technique and preservation of underwater cultural heritage Vis a Vis the progress made in the Mediterranean Sea and elsewhere. The Sri Lankan delegates brought to light the importance of the ancient ports on the east and south-east coast of Sri Lanka. For the first time the Indian Navy was represented by Commander A.V. Gupchup, whose guidance was available in formulating a programme of search for shipwrecks. The Chiefs of Naval Staff have been evincing keen interest in the pioneering work of exploration of submerged towns and wrecks undertaken by the Marine Archaeology Centre (MAC) which is now an integral part of the National Institute of Oceanography (NIO). As a part of the collaboration between the Navy and MAC the Commander-in-Chief of the Eastern Naval Command, Ramdas, presently the Chief of Naval Staff of India invited the Editor as Head of MAC to participate in the Golden Jubilee celebration of the Eastern Naval Command while the Commander-in-Chief of Western Command organised a survey of Byramgore shoals in which the Head and Chief diver of MAC took part. It is greatly encouraging to find that the Navy has not only formed an Archaeological Club but also deputed one of its diver officers to undergo training in Marine Archaeology.

Among the recent advances in marine archaeology made in the Indian waters the application of geophysical survey methods and deployment of underwater scooters for target search besides extensive documentation through video recording deserve special mention. In the absence of precise data needed for locating underwater objects of archaeological significance either in the marine records or from the traditional sailors and fishermen in India it becomes imperative for the marine archaeologist to resort to geophysical and magnetometer survey. The MAC took the help of geophysical survey groups of NIO. The Regional Centre of NIO at Waltair, under the guidance of Dr. T.C.S. Rao surveyed an area of 10 km × 5 km off Tranquebar on Tamil Nadu coast and recorded several features atleast one of which indicates a wreck and a few other submerged structures. The paper presented by him on the survey highlights the usefulness of geophysical survey. Earlier in 1983 Dr. K.H. Vora who had undertaken similar survey between Poompuhar and Tranquebar, also noticed anamolies but could not be verified by divers. In 1990 and 1991 some of the features recorded by T.C.S. Rao could be verified and a 200 year old shipwreck in 19 m depth which carried lead ingots has been identified off Vanagiri on Tamil Nadu coast. A few submerged structures in 7–10 m and a semicircular feature in 25 m depth are recorded near Poompuhar. Dr. Vora's survey in Dwarka waters revealed two submerged channels, one on either flank of the central channel on the banks of which the ancient city of Dvaraka stood. A scarp similar to the one found by diver archaeologists has been recorded in geophysical survey north-west of the central channel. In conclusion it can be said that a very significant contribution has been made by Geophysical Survey to marine archaeological studies in India. By deploying two underwater scooters (Aquazepp) in Dwarka waters it became possible to survey 2 × 3 km area in much shorter time and with less effort than has been possible by manual survey. The usefulness of underwater scooters in target-search technique where large areas of submerged towns are involved need not be doubted.

Apart from producing two video films, one each on the discovery of sunken Dwarka and exploration of a wreck near Poompuhar, two other films on training in marine archaeology and deployment of underwater scooter have been produced by Vision India in collaboration with MAC. All the films are of considerable educational value.

The results of underwater exploration of Dvaraka are highly significant for the archaeologist, historian and oceanographer. The existence and submergence of the legendary city of Dvaraka in 1500 B.C. are proved beyond doubt. Four fortified sectors of the port city have been traced. Some glimpses of a satellite town in Bet Dwarka island are also available. The discoveries have not only corroborated the description of ancient Dvaraka but also highlighted the fact that the second urbanization took place in the mid second millennium B.C. Preliminary surveys in Goa waters brought to light remains of a ship which carried cannons and granite blocks. The papers presented by the MAC Staff throw welcome light on the new ventures. A new dimension is added to marine archaeology by NIO scientists by their research on marine environment and sea level fluctuation which are relevant for marine archaeo logy. Historians and land archaeologists have by their painful research given much useful information on boat building, rise and fall of ancient ports, overseas trade and allied subjects.

The conference was inaugurated by Justice M. Rama Jois of the Karnataka High Court and the Valedictory address was delivered by Justice E.S. Venkataramiah, former Chief Justice of the Supreme Court of India. Both have in their addresses made valuable suggestions for preserving the underwater cultural heritage. Prof. G. Venkatasubbiah who declared the exhibition of antiquities of Dwarka mentioned that the discovery of ancient Dvaraka is an eye opener to other researchers.

Mr. Dobbs welcomed the publication of the Journal of Marine Archaeology. The Panel of experts discussed various problems of marine archaeology and gave guidelines for future research. The papers presented by young scientists and academics were of high order and it is hoped that more number of them will take part in future conferences.

The success of the conference despite the short notice was mainly due to the unstinted cooperation extended by the Department of Science and Technology (DST), Council of Scientific and Industrial Research (CSIR), Department of Ocean Development (DOD) and the Archaeological Survey of India (ASI) by giving financial assistance. But for the infra-structural and other facilities provided by the National Institute of Oceanography the Conference would not have taken place. The authorities of the Karnataka Chitrakala Parishath (Fine Arts Academy) were kind enough to lend the Auditorium and Exhibition Halls for the Conference. The music performance was enjoyed by all delegates.

At the end of the Second Day of the Conference a dinner was hosted by the President of the Society for Marine Archaeology at his residence at Bangalore.

PART I

Inauguration of The Second Indian Conference

Welcome Address

Dr. B.U. NAYAK

Hon'ble Justice Rama Jois, Prof. U.N. Roy, Prof. Venkatasubbiah, Dr. S.R. Rao, Mr. C.T.C. Dobbs distinguised delegates, ladies and gentlemen,

It gives me great pleasure to welcome all of you to the Second Indian Conference on Marine Archaeology of Indian Ocean Countries organized by the Society for Marine Archaeology. Although the notice of the conference was short the response from India and abroad has been highly encouraging. Before I say a few words about the guests I must mention why the organizers chose Bangalroe city as the venue of the conference. It is not because it is the fastest growing city of Asia or because of its celubrious climate but because of its pre-eminent position as a centre of art and science. Apart from beautiful parks and the co-mingling of ancient and modern architecture, it is rightly proud of more than 50 centres of music, dance, painting, sculpture, drama and literary activity on the one hand and such great institutions of scientific research as the Indian Institute of Science, the National Aeronautical Laboratory and Indian Space Research Organization. The very fact that the conference is being held in a premier institute of art and culture namely the Chitrakala Parishath is a proof of the interest of scientists in arts. On behalf of the Society I extend a hearty welcome to Hon'ble Justice Sri. M. Rama Jois who is an eminent jurist, author and scholar of repute. At present he is a judge of the Karnataka High Court. Justice Rama Jois comes from a family of pandits and has enhanced its prestige by his deep study of Manu Dharma and other Sastras and constitutional history of ancient and modern republics. On behalf of the Society for Marine Archaeology, I express my gratitude to him for agreeing to inaugurate the Conference. I welcome Prof. G. Venkatasubbiah, a well known scholar of Kannada and Sanskrit. He has to his credit the editing of Kannada Nighantu in 5 volumes. The Society is obliged to him for having kindly agreed to declare open the exhibition on Marine Archaeological Discoveries. I extend a warm welcome to Mr. C.T.C. Dobbs, whom the British Council has kindly deputed at our request for participation in the conference. He is an archaeologist and diver of reputation. His expertise in underwater exploration will be of immense help in training diver-archaeologists. He will be releasing the Journal of Marine Archaeology in the absence of Mr. Mensun Bound, Director of Archaeology in Oxford University.

On behalf of the Society I extend a warm welcome to Prof. U.N. Roy former Head of the Department of Ancient History, Culture and Archaeology in the University of Allahabad. He is an eminent scholar in history, archaeology and sanskrit literature and has several books to his credit. He has agreed to preside over the inaugural function and participate in the deliberations, for which act of kindness I thank him wholeheartedly.

I welcome distinguished delegates from Sri Lanka Commander Devendra Somasiri and Dr. Rohan Gunratne, also Dr. Olivier Guillaume Director, Centre of Human Resource in the Embassy of France in Delhi and Mr. Mensun Bound from Oxford who is expected any moment here. Several distinguished scientists from NIO and scholars from the Archaeological Survey of India, Universities of Waltair, Mysore and Tanjore, the National Museum Delhi, experts from the Indian Navy and Mr. and Mrs. Swali besides Prof. G.S. Dixit, Dr. M.V. Desikar and other guests have responded to our request to participate in the conference. I welcome all of them. I am sorry that this being the first conference organized by the Society there may be some lacunae in the arrangements for comfortable stay and hope the large-hearted delegates and guests will excuse us.

Welcome to all once again.

Last but not least, it is my duty to express the gratitude of the Society to Dr. B.N. Desai, Director of National Institute of Oceanography but for whose cooperation and encouragement the Society would not have been able to organize this conference.

Inaugural Address

Justice Shri M. RAMA JOIS

Dr. B.N. Desai, Professor Mensun Bound, Dr. S.R. Rao and friends,

I accepted with great pleasure the invitation extended to me by the Society for Marine Archaeology through Dr. S.R. Rao, to inaugurate this prestigious Second Indian Conference on Marine Archaeology of Indian Ocean Countries, and to open the exhibition of Dwaraka antiquities which is organised by the Society and is supported by Department of Science and Technology, Department of Ocean Development, Archaeological Survey of India and Council of Scientific and Industrial Research. I thank the society and in particular Dr. S.R. Rao, the dynamic personality spearheading the adventure of Marine Archaeology, for having provided this opportunity and conferring this honour.

"One should know what one does not know" are the words of wisdom. Therefore, at the very outset, I say that the subject of Marine Archaeology is entirely new to me and I know that I know little about the subject. I accepted the invitation because of my fascination for the study of the achievements of our ancestors thousands of years ago in evolving fundamental law for the establishment of the most civilized and cultured society and Governments establishing well organised Governments and construction of planned towns and cities. From some time past whenever any news item or article appeared in newspapers and magazines about the excellent results of underwater excavation off Dwaraka, which was the capital of Krishna of Mahabharata fame and the propounder of immortal Bhagavadgeeta, I have been reading them with great curiosity and admiration. It was a pleasant surprise to me when Dr. S.R. Rao met me for the first time and extended to me the invitation to inaugurate this conference. He also gave me the publication of the proceedings of the First Indian Conference on the topic held in October 1987. I have gone through some of the important articles published therein and after reading them I say that I have nothing but unstinted admiration for the excellent adventure successfully under taken by Dr. Rao and his colleagues. The information and material secured through underwater excavation off Dwaraka corroborates with the references to the City of Dwaraka, made in the Great Epic *Mahābhārata* and various other Sanskrit literary works. In *Mahābhārata*, there is a specific account about the submerging of Dwaraka, by the sea which reads thus :

> "The sea, which had been beating against the shores, suddenly broke the boundary that was imposed on it by nature. The sea rushed into the city. It coursed through the streets of the beautiful city. The sea covered up everything in the city. Even as they were all looking, Arjuna saw the beautiful buildings becoming submerged one by one. Arjuna took a last look at the mansion of Krishna. It was soon covered by the sea. In a matter of a few moments it was all over. The sea had now become as placid as a lake. There was no trace of the beautiful city which had been the favourite haunt of all the Pandavas. Dwaraka was just a name; just a memory."

The results of underwater excavation of Dwaraka has brought forth the following evidence :

> "Two gateways, fortwalls, bastion and jetty have been exposed at 10 metre water depth in the Arabian Sea off Dwaraka. The architectural features of the submerged city correspond more or less to the description given in the great epic Mahabharata. In Bet Dwaraka too, submerged city walls have been found. The importance of the discovery of Dwaraka lies not merely in providing archaeological evidence needed for corroborating the traditional account of the submergence of Dwaraka but also indirectly fixing the date of the Mahabharata-War which is a landmark in Indian history. The Thermoluminiscence date of the pottery from Bet Dwaraka which is also connected with the Krishna legend is 3520 years Before Present. Identical pottery is found in the submerged city of Dwaraka."

Thus the results have proved that the account in *Mahābhārata* as to the existence of a beautiful capital city of Dwaraka of Sri Krishna was not a mere figment of imagination but it did exist.

Archaeologically, India is perhaps the richest country in the world. Having a history of Civilization for over five thousand years, and far larger pre-historic period, enriched by the wealth of art and architecture, over the centuries India is really a goldmine for archaeologists. The Archaeological Survey of India, happens to be one of the oldest organisations of the kind in the World. The excavations carried out on the sites of Harappa and Mohenjodaro and other sites of most ancient cities have brought forth a valuable piece of evidence about the high water mark of development in the field of art and architecture, housing, and developed state of towns and

cities as early as in 2000 BC. The underwater excavations undertaken by the Society of Marine Archaeology Unit of NIO has added a new dimension to Indian archaeology.

When Dr Rao met me I told him that while I am not equipped to speak on the subject of Archaeology or underwater excavation, I could disclose some of the information relating to the existence of Law and Constitutional Law and material relating to the importance and the requirements of capital cities in ancient India, which I collected in the course of research undertaken by me and carried on for over twelve years between 1970 and 1982 on the basis of which I have authored the book '*Legal and Constitutional History of India*' incorporating the provisions of the ancient Indian Legal, Judicial and Constitutional system, which was published in 1984, with the subsidy sanctioned by the National Book Trust, being a text book for the Law degree course.

Before I refer to some important aspects of the topic, it would be appropriate to quote what Bharataratna P.V. Kane has said as to the study of the past. He said :

> "It may be asked : What in these days is the use of the study of the theory and practice of government in ancient India?
>
> It may be conceded that the situation in which we find ourselves now and in which we shall be placed in the near future is unique and much light cannot be thrown by a study of the past on the solution of the problems that will have to be tackled by us. But that study has certain useful purposes to serve.
>
> The Study of the past will give us hope and convey the assurance that we have in the past conducted governments and administrations of vast empires, that we evolved theories and practices which were not inferior to those of some of the most advanced nations of the world, that, allowed the opportunities and scope, we may rise equal to what the circumstances may demand of us."

This means, if we know what we were, what were our achievements, we will know what we should do and what we should achieve. The past would be of immense inspiration and guidance for future.

I shall now refer to a few aspects of Law (Dharma) and Constitutional Law (Rajadharma) evolved in ancient India.

Law has been defined thus :

> *Kshatrasya Kshatram Yaddharma*
> *tasmāt dharmātparam nāsti*
> *atho abatvyān baliyān sama sámsata dharmence*
> *yatrā rājna evam*
>
> Law is the King of Kings;
> Nothing is superior to law;

The law aided by the power of the King enables the weak to prevail over the strong.

Manu IX 324 :

> *Yathā sarvāni bhutāni dasa daśyate*
> *tathā sarvani bhutāni bibrtah pārthivarn vratam*

The King should support all his subjects without any discrimination in the same manner as the earth supports all living beings.

Kautilya sums up the duties of the King thus :

> *prajāsukhe sukham Rājnaha*
> *prajānāncha hite hitam*
> *nātmapriyam hitam Rājnaha*
> *prajānām tu priyam hitam*

In the happiness of his subjects lies the King's happiness; in their welfare, his welfare, whatever pleases himself the King shall not consider as good, but whatever pleases his subjects, the King shall consider as good."

The art of Government in ancient India was extremely well developed as indicated from the relevant provisions of Rajadharma. It was laid down that Council of Ministers was indispensable for the administration of the State.

> *Sahāya sādhyam rājatvam cakram ekam navartate*
> *Kurvitam sacivaram tasmāt teṣām ca śṛnuyām mantram*

The exercise of sovereign power (Rajatva) is possible only with assistance. A *single wheel can never move forward (the carriage of State)*. Therefore, the King shall appoint ministers and take their advise (Kautilya, p.12; 16-M.S).

Kautilya (300 BC) ordained :

> *mantra pūrvah sarvārambhāh*

Every kind of administrative decisions should be preceded by deliberations in the Council of Ministers and that on all emergent matters the King shall consult his ministers in council. Then he should follow the majority advice to achieve success.

There is historic evidence to indicate that in the administrative set up of Government, since the time of *Mahābhārata*, it had eighteen high officers among whom the powers of the State were allocated :

Kalhana has recorded in *Rajataranginī* that King Jalauka of Kashmir, who reigned a few decades earlier to 1184 B.C. (according to the data analysed by R.S. Pandit) had established eighteen such offices while organising his government.

Rajātaranginī, I - 120 :

> *Karmasthāni darmyāni tènastadaśa Kurvata*
> *tatah prabhrti bhūpena Krtā youdhiṣṭhiri sthiti*

Having created eighteen traditional departments of state the

king inaugurated during his reign the same type of constitutional system of government that Yudhiṣṭhira had adopted.

Regarding these eighteen offices, the following information is given by R.S. Pandit :

> "Yudhistira, the eldest of the five Pandava brothers and the hero of the *Mahābhārata*, is the model of a just ruler. Throughout the centuries history furnishes numerous examples of Indian attempts to model the state on the constitutional system of Yudhisthira."

The eighteen departments of state are mentioned both in the *Mahābhārata* (II.5.38) and the *Rāmāyaṇa* (II.100.36). They are also alluded to in the *Pancatantra* (Kielhorn's edition III.67-70), *Kalidasa's Raghuvamśa* (XVII, 68) and in *Śiśupālavadha* (XIV.9). According to Nilakantha, the commentator on the *Mahābhārata*, the eighteen offices of state are as follows.

> (1) *Mantrin*-Councillor, (2) *Purohita* Pontiff, (3) *Yuvarāja* - Heir-apparent, (4) *Senāpati* - Generalissimo, (5) *Dvārāpāla* - Chamberlain, (6) *Antarveśika* - Steward of the royal household, (7) *Kārāgārādhikārin* - Superintendent of Prisons, (8) *Dravyasamchyakṛt* - Treasurer (literally collector of the pile of treasure), (9) *Sannidhātṛ*- Auditor of the treasury and five other departments, (10) *Pradestṛ* Officer with joint executive and judicial functions, (11) *Nagarādhyaksha* - prefect of the city, (12) *Kāryanirmāṇakṛt* - Superintending engineer of works, (13) *Dharmādhyaksha* - Lord Chief Justice, (14) *Sabhādhyaksha* - President of the Assembly, (15) *Daṇḍapāla* - Warden with criminal jurisdiction, (16) *Durgapāla* - Warden of fortifications, (17) *Rāṣṭrāntapāla* - Warden of the marches, (18) *Aṭavipāla* - Conservator of forests.

K.M. Pannikkar has referred to these eighteen offices or departments cited in *Rājatarangiṇī* under the governmental set up established under *Rājadharma*.

CAPITAL CITY ONE OF THE SAPTĀNGĀS

Seven important Limbs of State were recognised. All the works on the law governing the constitution of the State in ancient India are unanimous that a Rajya consisted of *Saptāngas* (seven limbs).

Manu IX 294, 295, 297 :

> *Svām amātya puram rāṣṭram kośa daṇḍa suhrt tathā*
> *sapta prakrtaye hyetāh saptāngam rājyam wayate*

The King, his ministers, capital, realm, treasury, army and allies, are the seven constituent parts of a kingdom. Hence a kingdom is said to have seven limbs *(Saptāngas)*.

It was also laid down that among the aforesaid seven constituent parts of a kingdom, each earlier named is more important and its destruction brings forth greater calamity to the kingdom. Each one of the constituents is meant to accomplish certain object. Hence each is declared to be the most important for the purpose.

The view expressed in the above verses, with which all the works on the topic agree, shows that in order to bring into existence a corporate body like Rajya, the seven limbs mentioned were considered necessary. Among these, the King was the most important. Then came the ministers, the capital, the realm, the treasure, the army and the allies, in the same order. *Kautilya VIII pp. 353-356* makes a thorough discussion of these aspects, referring to the views of eminent authors of *Arthaśāstra*, like Bharadwaja, Vishalaksha, Parasara, Kaunapdanta, Pisuna and Vatavyadhi.

Great importance was attached to the construction and administration of capital cities. The capital was a place of great importance in the State for the reason that the most important limb of the state (namely, the King) and its other organs, like the ministers, the Kośa (treasury) etc., were to be located there. Having regard to the then prevailing social conditions, affording adequate safety to the king, the treasury and the ministers and keeping in view the strategical needs during war, proper protection of the capital was of vital importance. Any slackness in this regard could bring disaster to the entire kingdom. Therefore, special provision was made for the security of the capital, detection of persons whose activities were prejudicial to the interests of the state and also for the efficient administration of the city. The elite of the capital *(Paurajanapada)* held important constitutional position and they greatly influenced policy decisions of the State.

An officer called Nāgararaka (City Superintendent) was to be appointed to look after the affairs of the capital. Gopa was an officer appointed to supervise over a group of about 20 or 40 families. Sthānika was an officer appointed to look after a ward, the capital being divided into four such wards. The Gopa and the Sthānika were to maintain vital statistics concerning all the residents within their jurisdiction, bearing on their caste, profession, family's income and expenditure and so on. Managers of choultries would furnish information to these officers if any heretics arrive in the city as travellers and came to reside in their choultries. Also the head of every household was required to report about the arrival and departure of strangers within their knowledge.

A graphic description of the great capital *Pāṭalīputra* (Modern Patna), is given by Megasthanese and others.

> "Megasthanese (see McCrindle's Ancient India, Fragment XXXIV p. 187) describes the city of Palibothra (Pataliputra) and its administration. He says that six committees of five members each looked to the affairs of the city and were respectively in charge of (1) industrial arts, (2) entertainment and care of foreigners, (3) inquiries about births and deaths, (4) trade and commerce,

weights and measures, (5) manufactured articles, (6) collection of one-tenth the price of articles sold. Fragments XXX-XXVI (pp. 65-67) inform us that Palibothra was 80 stadia in length and 15 in width, that in shape it was a parallelogram, that it was surrounded by a wooden wall with holes for discharging arrows and a ditch in front. Arrian states *(pp. 209-210 of McCrindle's Ancient India)* that Palibothra had 570 towers and 64 gates. Patanjali, in his *Mahābhāṣya,* frequently brings in Pataliputra (e.g. in Vol. Ip. 380, on Pan II 1-16). He states that Pataliputra is alongside the river Sona; In Vol. II, p. 311, vartika 4, on Pan. IV 3.66 he refers to its walls and also to its palaces, in Vol.II, p. 321 on Pan. IV 3.134). In Fa-Hien's time (399-414 A.D.) the royal palace and halls in the midst of the city built of stone still existed and were so grand that they were then believed to have been the work of spirits. (Vide Rhys Davids: *'Buddhist India'*, pp. 34-41 for the ancient Indian capitals in the 7th century B.C.")

From historical records, the importance attached to a capital may be gathered. Great attention was given to the construction of palaces and forts and also to their security. The layout of Hampi, the capital of Vijayanagara empire was one of the best and it was also the largest city recorded in Indian history. Here is a gist of the account of this city as given by foreigners who visited it in the fifteenth and sixteenth centuries.

"... The city of Vijayanagar was encompassed by massive fortifications and was of enormous size... The circumference of the city is sixty miles; its walls are carried upto the mountains and enclose the valleys at their foot, so that its extent is thereby increased. In this city there are estimated to be ninety thousand men fit to bear arms... The king is more powerful than all the other kings of India... *This is the best provided city in the world.*"

The grandeur of the city and the manner of its administration is the indicium of the greatness of its rulers. From security point of view also, the capital was of vital importance to the kingdom.

From the above material concerning the construction and administration of capital cities, we can infer that the City of Dwaraka being the capital of the Yadava Kingdom must have been built, in accordance with the importance attached to a capital city, as one of the seven constituents of State and the evidence so far collected throws great light on this aspect and I am sure further underwater excavation off Dwaraka and surroundings, would secure many more valuable material.

In this conference several eminent experts on the topic will be delivering key note address, which will provide the necessary direction and guidance for the deliberation of the conference. I am confident that the Conference will result in invaluable contribution to the field of Marine Archaeology of Indian Ocean Countries and unearth many more pieces of evidence in support of our glorious past.

Wishing the conference a tremendous success, I inaugurate the conference.

Key note address

Dr. S.R. RAO

(Progress of Marine Archaeology in India)

Mr. President and distinguished delegates and guests,

At the outset I would like to express my gratitude to the organizers for having asked me to deliver the keynote address.

The main objective of marine archaeology is preservation of the underwater cultural heritage of the world by discovering, excavating and conserving submerged ports and sunken ships of historical importance which constitute the major source for reconstructing the maritime history of the country. The target is the man behind maritime activity, the man who designed and built boats, the navigator who charted sea routes, the merchant-Captain who took risk in his investment and all others who interacted with the people of unknown lands.

A multi-disciplinary study such as Marine Archaeology which demands adequate knowledge of the history and archaeology of the country of investigation and also the technical know-how of underwater search and excavation cannot be mastered by any single individual, nor can it be the sole concern of any single department of any University even at the theoretical level. The marine archaeologist who can dive must seek the cooperation of Oceanographers, Geologists, Geophysicists and technicians.

India's role in maritime trade goes back to the days of the Indus Civilization. The first tidal dock of the world was built by the Harappans at Lothal in Gujarat 4300 years ago (Rao S.R. 1979). Their boats carrying precious cargo reached the African and Sumerian ports. What they gave to other countries was not merely goods but also ideas. For instance the Harappan script was used on the Bahrain seals and the Harappan weight unit became the standard in Persian Gulf countries. The very origin of Semitic alphabetic system of writing can be traced to the Late Harappan alphabetic writing (Rao, S.R. 1982).

The Harappans were pioneers not only in building the dock but also in introducing new types of stone anchors suitable for different seabeds, shoals and beaches. The single-holed and two-holed spherical as well as triangular anchors were used (Konishi 1985; 145-153) by the Harappan sailors. Three-holed triangular anchors used in Dwarka (1500 B.C.) are earlier than the Late Bronze Age anchors of 14th-12th century B.C. used in Cyprus and Syria (Frost, H. 1985). We are yet to discover Harappan boats and reconstruct the maritime history of two thousand years before the Mauryan period. The earliest account of a naval establishment is given in the *Arthaśāstra*. The Buddhist *Jātakas* throw some light on sea voyages undertaken by merchants and missionaries. Although ports are mentioned in the *Periplus* and the *Jatakas*, port installations do not find a place in these and other ancient texts except perhaps in the Tamil text *Paddinappalai*. Shipwrecks are occasionally referred to in *Mahājanaka* and *Supparaka Jātakas* without giving bearings of wreck-sites. The marine archaeologist cannot therefore easily trace protohistoric and early historic wrecks in the absence of reliable data. From the 16th century onward marine records of European powers, Marathas, Mughals and Bijapur Sultans are useful in deciding the approximate position of wreck sites.

India is in an enviable position so far as underwater cultural heritage is concerned. It is perhaps the richest and also the least disturbed. While developed countries have made great progress in underwater search for shipwrecks during the last 40 years, India started investigations in 1981 with a team of 3 persons in the Marine Archaeology Unit (MAU) established in the National Institute of Oceanography (NIO) with the financial help given by the Indian National Science Academy. From 1984 onwards the Department of Science and Technology has been funding it. The NIO has been providing the logistic support and many other facilities. The Archaeological Survey of India has been funding the Training Programme and joint exploration. The main achievement of the MAU has been the discovery of the legendary city of Dvārakā of *Mahābhārata* Age, in the sea off modern Dwarka, to which a reference shall be made later. Other achievements which deserve mention may be stated here.

The steps taken within a short period of two years to give effect to the recommendations of the First Conference on Marine Archaeology of Indian Ocean countries held in 1987 and those of the expert committee on Marine Archaeology (Department of Science and Technology) are important.

TRAINING FOR SUPPLY OF MANPOWER:

The first conference recommended that a training programme under my direction should be organized. Hence a rigorous training programme for archaeologists, technicians and scientists was started with the financial help given by the Archaeological Survey of India (ASI). Among the trained personnel one scientist Dr. E.V. Gangadharan joined the

Centre for Marine Archaeology in Andhra University at Waltair and Dr. K. Rajan, Archaeologist trained in diving is now a lecturer in Tamil University. I must mention the yoeman service rendered by our Diver-Photographer Sri. Srinivas Bandodkar. The lone woman Scientist-Diver Ms. Manavi Thakkar has also joined us. I hope she will be an inspiration for women to take to diving. Five other trainees including two Diploma holders from the Institute of Archaeology will be shortly completing their course after Mr. C.T.C. Dobbs the renowned Diver-Instructor from UK conducts a course in diving. The Indian Navy has also offered to impart training in deep sea diving. But 5 diving archaeologists is too small a number for the country of the size of India with its 6200 km long coast line where hundreds of ships are lying buried and scores of ancient ports are submerged in the sea. The minimum number of trained archaeologists for 4 or 5 centres would be 40 or 50. An idea of the rigorous course of training given over a period of 18 months can be had from the note on training in the *Journal of Marine Archaeology* just published today.

A PERMANENT CENTRE FOR MARINE ARCHAEOLOGY IN NIO

Another important recommendation of the First Conference is that a permanent Division of Marine Archaeology should be established in NIO. A proposal for the Division under the Eighth Five Year Plan was sent to the Department of Ocean Development. As there was no response a small cell for marine archaeology as recommended by the Research Committee of NIO is being formed. The Director, Dr. B.N. Desai has initiated steps to form a nucleus of Marine Archaeological Centre and we are grateful to him for the unstinted help extended to the MAU and for his concern for the future of marine archaeological research in India. We are also obliged to Prof. Vasant Gowarikar, Secretary, Department of Science and Technology and Prof. A.P. Mitra, Director General Council of Scientific and Industrial Research for encouraging research in this field. Our thanks are due to Dr. Gaur, Secretary Dept. of Ocean Development for financial assistance for the conference. I must however emphasize that for a proper survey of wrecks and submerged ports in the Exclusive Economic Zone of India minimum scientific equipment, a research vessel and trained staff should be provided.

SOCIETY FOR MARINE ARCHAEOLOGY

The First Conference recommended the formation of an autonomous society for promoting marine archaeological research and conservation of underwater cultural heritage of India and I am glad to record that a Society has been registered and within three months of its existence it held a very useful workshop on Ocean, Religion and Archaeology. The papers presented have been published in the first issue of the *Journal of Marine Archaeology*. The workshop highlighted the active role of religion in promoting trade and better understanding among nations. May I appeal to you all to strengthen the Society by contributing research papers? Its doors are open to all genuinely interested in promoting underwater exploration and research.

COLLABORATION WITH UNIVERSITIES

The First Conference was of the opinion that the Universities should be associated with Marine Archaeological Research. Every effort is being made to induct the University teachers and students into a training programme. The Viswabharati and a few other Universities have expressed a desire to send students for training. I hope the next batch of trainees will come from the Universities. It is encouraging to find that the UGC has funded the Centre for Marine Archaeology in Andhra and Tamil Universities. The Tamil University Centre held a workshop on History of Traditional Navigation while the Waltair Centre organized a seminar on Potential for Marine Archaeology on the East coast. While appreciating the importance of both to marine archaeological research I may add that field work is what is urgently needed and this cannot be done unless an archaeologist with considerable experience in excavation is engaged. If proper onshore survey of Visakhapatnam site had been done before diving for locating the Visakheswara temple in the sea perhaps better results could have been obtained. The attempts made by the Navy to find the submerged port-installations of the Maratha period at Vijayadurg are laudable. Here again collection of onshore data should precede offshore exploration.

It is gratifying to find that the Indian Navy has been evincing keen interest in marine archaeology. My talks with the commander in chief of the Eastern Command at Vizag during the Golden Jubilee Seminar were fruitful. I hope two proposals submitted to the Naval Headquarters – one relating to the retrieval of the Indus which carried the famous Buddhist sculptures of Bharhut in Sri Lankan waters and the other about exploring the wreck *Byramgore* off Lakshadvip will receive priority.

NAUTICAL ARCHAEOLOGY

In Europe and America underwater archaeology has meant mostly shipwreck archaeology. In India, however, we have both wrecks and submerged cities which should receive equal attention. Last year MAU discovered a less than 100 year old steel-hulled wreck near Grandi Island off Goa. It could have served as a good base for training archaeologists, but finding that much that was useful had been pilfered, we were looking for a better wreck. This has been found in Amee Shoals in Goa waters. The ship carried cannons, three of which have been traced and one among them seems to be about 300 years old. The huge dressed granite blocks which must have been on their way to Europe have covered the cargo in the deck. The condition of the hull can be ascertained after removing the cannons and ballast. We are forced to postpone the retrieval of the wreck immediately for fear of exposing the small but precious finds to pilferage by clandestine divers especially when there is no adequate protection. This calls for amending the Ancient Monuments Act. I hope the ASI will soon circulate the draft amendments among those concerned with

marine archaeology, more so this Society. According to Marine Records of the Goa Achives there must be as many as 10 or 12 wrecks in Goa waters. We have noticed three so far and let us see what luck awaits further survey in Agauda Bay. The recently discovered wreck site has taken more than one toll as can be made out from an anchor and a propellor of other ships. The geological features are being studied to ascertain why Amee shoals took a heavy toll.

There has been a clamour from the public for exploring Kalinganagara on the East coast. The MAU hoped to undertake offshore exploration this year but paucity of funds and equipment has come in the way. This is true of the other equally important submerged city of Kaveripatnam. Gharapuri (Elephanta) where Pulakesin II the Chalukyan King fought a naval battle and defeated the Mauriyas of Konkan is another port to be excavated. The wrecks in the waters of Sri Lanka, Lakshadvip and Andaman islands are also included in the priority list.

GEOPHYSICAL SURVEY

NIO scientists recently undertook side scan sonar, profiler and echo-sounder surveys off Tranquebar on the east coast and off Dwarka on the west cost. The results are very encouraging off Tranquebar where submerged structures ranging perhaps from 2nd-3rd century A.D. to 17th century are indicated in 10-11 m depth. A shipwreck is also suspected. The offshore survey of Dwarka covering 30 sq.km. has just been completed and the data is yet to be analysed. However some important features such as the point of confluence of Gomati with the Sea and a few structures are likely to come to light. The submerged valleys on Andhra coast noted by T.C.S. Rao in the course of Geophysical survey are of significance for a study of quarternary sea level rise.

DISCOVERY OF SUBMERGED DVĀRAKĀ CITY

Before the legendary city of Dvaŕakā (near present Dwarka) was discovered some scholars were of the view that the *Mahābhārata* being only a myth it would be futile to look for the remains of Dvārakā and that too in the sea. Others held that the Mahābhārata battle was a family feud exaggerated into a war. When I started the onshore excavation at Dwarka in 1979-80 I had no idea of digging in the sea because Marine Archaeology was then an unknown discipline in India. Being an optimist I however argued within myself that even if the *Mahābhārata* is a myth, it contains much that is rational behind what can be termed as irrational. The results of underwater exploration have proved that my line of thinking was not wrong. Prof. Walter Spink in his thought-provoking essay says that Krishna was a human hero (Spink W 1982, 110) who was deified in due course. I am not trying to drag God into my investigations but am only interested in finding archaeological evidence for the existence of Dvārakā, the scientific and technological progress made and the thought process of the people of the Mahābhārata Age.

Many are not prepared to concede great concepts behind what superficially appears irrational in ancient texts like the *Mahābhārata* or the *Rgveda*. For instance sacrifice and Yoga are two important contributions of the Indus Civilization and the Vedic culture. In Vedic parlance sacrifice symbolises the attempt by the Individual Self to link itself with the Universal Self. The Vedic and Iranian forms of fire altars found at Lothal and Kalibangan and depicted on seals represents the form or matter while fire itself is called *Agni* and*Arka*. *The epithet tridhā* is given to Agni in the *Rgveda* and the so-called Pasupati of the Mohenjo-daro seal is none other than *Agni/Arka* with 3 heads. The Indus people seem to have conceded that there was a single source for all the three forms of energy. The geometrical rules for the construction of sacrificial altars mentioned in the *Vedas* are said to symbolise matter and form, while fire itself symbolises energy. The concept of *yoga* which, in essence, is meditation is another great contribution of the Indus Civilization. Its men and deities are shown in yogic postures on seals and even beasts are depicted as if under the spell of yogic powers. In an earlier paper on Ocean Religion and Archaeology, I had cited the views expressed by B.D. Josephson, the winner of Nobel Prize for Physics (1973). As they are relevant here also I quote what he says." The three experimental realities namely, ordinary reality, subtler reality and implicate order are experienced successively as one goes deeper into meditation (Josephson B.D. 1988). Thus we have to concede the existence of the rational even in what appears to some as an irrational myth. After much discussion archaeologists and indologists have concluded that there is much historical truth in the *Mahābhārata* (S.P. Guta and K.S. Ramachandran 1982) although there is still some controversy about the date of the War. The consensus date is 15th century B.C. (Rao, S.R. 1985, 38). As regards the identification of one of the three Dwarkas in Saurashtra as the most probable site of Sri Krishna's Dvārakā, the onshore archaeological evidence is clear at Dwarka in Jamnagar District where underwater explorations have also been conducted (Rao, S.R. 1987 and 1988).

PLAN OF DVĀRAKĀ CITY:

For want of time I can only mention the more significant results of the excavations off Dwarka (on the Arabian Sea) and Bet Dwarka (Gulf of Kutch) which are 30km apart. Four rectangular stone enclosures two each on the right and left banks of the submerged channel of the river Gomati have been traced 300 to 1000 m seaward of the Temple of Samudra Nārāyana (Sea God) at Dwarka. They are essentially protective walls with a number of circular or semi-circular bastions built at regular intervals. This sea port was thus protected against tides and waves. Each stone enclosure had one or more gateways flanked by bastion. The bank protection walls also served as anchorages as can be made out from the large number of stone anchors found at the foot of the walls and bastions. The technique of construction of piers, protective walls and bastions in waterlogged areas is interesting. A dry boulder foundation was prepared before raising the superstructure. The bastions stood on rectangular platforms of dressed blocks of sandstone, perhaps to a height of more

than 3 metres as can be judged from the number of fallen courses of masonry. The sea has been merciless to the glorious turrets, fort walls and even temples. Only four courses over the boulder foundation were in tact as they were buried in sediments; the rest of the masonry is swept away. The paucity of pottery and other antiquities is due to the flow in the Gomati channel which has a steep gradient of 11 m in 1.5 km. Besides the fortification or protective walls, gateways and bastions the stone bases of flag post suggest a warning system in the event of storms might have existed. An alternate use of the bases was for hoisting a flag of identification. It may be recalled that the *Arthaśaśtra* prescribes construction of bastions in city walls and enjoins that gateways should be flanked by towers. These features were shown in the famous carvings of the cities of Kapilavastu, Sfāvasti and Kuśinagara on the Gateways of Sānchi. It would not be too much to suggest that the city walls and gateways of Dvārakā found an echo in the cities of Sfāvasti and Kuśinagara, the only difference being the use of massive stones in the port-city of Dvārakā of 1500 B.C. and the use of bricks in the landlocked cities of Aryavarta in the 5th-6th century B.C. The walls and bastions of Dvārakā served not only as anti-erosion devices but also as defenses. In fact the *Harivamśa* graphically describes the measures taken to defend the city when attacked by Sālva. The term *nagarī* suggesting urbanisation is used in the *Mahābhārata* in the strictest sense for which Dvārakā provides the evidence. The city, well-planned and fortified by massive walls, was 1 km long and atleast 0.5 km broad. It was a city-state with Bet Dwarka (Shankhodhara) as a Satellite port-town and a pleasure resort. The remains of their ancient settlement extend over 4 km along the eastern shore. Three sectors of the city built in terraces have been traced so far. In the southern sector of the eastern shore, seaward and landward walls are found greatly disturbed. The pottery from this sector is dated 1500 B.C. by TL dating method. Similar pottery occurs in Dwarka. The central sector of Bet Dwarka had a 550 m long wall built for serving as pier. In the northern sector the entire township is washed away leaving a few buildings of the *Mahābhārata* Age. The Late Harappan finds may support the statement in the epic that a pre-Dvārakā township namely Kusasthali, existed here but was in ruins before Krishna migrated with his followers from Mathura. As regards reclamation of land from the sea referred to in the *Mahābhārata* there is now convincing evidence that the engineers of Dvārakā did reclaim land by erecting dry boulder foundations in backwaters or pools of water when the sea level was atleast 10 m lower than at present, The ancient walls and bastions exposed in sea bed are 10 m below MSL. The use of iron weapons and tools was known to the residents of Dvārakā as can be guaged from the iron stakes and nails found in underwater excavation. The ancient texts refer to iron stakes fixed in the moat to prevent the enemy from entering the city.

DATE OF ANCIENT DVĀRAKĀ:

I must hasten to add that two cultural periods are noticeable in Dwaraka as well as Bet Dwarka. The structures of Period I (1500-1400 B.C.) were destroyed by the sea and what little remained of it was further disturbed by the Early Historical settlement which ranges in date from 1st century AD/BC to 6th-7th century A.D. TL date of Period I of Bet Dwarka is 1500 B.C. and that of Period II is 200 B.C./A.D. (1800-2000 years Before Present). Antiquities of Period II are two fragmentary stone statues of deities (not identifiable). Copper, bronze and brass objects used for ritualistic purpose, iron anchors and timber of a wrecked boats are other finds.

The date of Mahābharata war depends on the date of the first use of iron objects in India. The earliest TL date of iron – associated pottery in Kumaranahalli in Karnataka (40° 19'N, 75°43.5'E) is 1380 B.C. and the date of iron at Gufkrol in Kashmir is 1528 B.C. The TL date of Dvaraka-Bet Dwarka Pottery namely 1500 B.C. is in conformity with the date of early use of iron. We need not ridicule the idea that Krishna used the Cakra a circular toothed weapon, for, his predecessors namely Harappans had already produced a bronze boomerang type saw with teeth on the inner edge. Hence a toothed disc would have been much easier for the successors of Harappans to produce.

The evolution in the shape of the stone anchors from a spheroid one to triangular and prismatic ones with 3 fluke holes is another important contribution by the sea-faring people of Dvārakā. The triangular 3-holed anchors are identical with the Late Bronze Age anchors (14th-12th century B.C.) of Kition in Cyprus (Frost 1985, 281-321) and can therefore be dated to 14th-15th century B.C. We have two other corroborative evidences for this date, namely the Late Indus type seal with a 3-headed animal motif and an inscribed votive jar. The inscription proves that the residents of Dvārakā were literate and used Old Indo-Aryan (Sanskrit) Language. An important contribution of the Bet Dwarka inscription is that it shows the evolution of the Late Indus alphabetic script into the Brahmi alphabetic script. The use of *mudra* (seal) by the citizens of Dvārakā referred to in the *Harivamsá* is also confirmed by the presence of the seal at Bet Dwarka.

SEA LEVEL FLUCTUATION

The data generated by marine archaeological investigations are of scientific value for eustatic studies. The net rise in sea level since 1500 B.C. is found to be 10 m and the rate of coastal erosion is 0.3 to 0.5 m annually and not 5 m as envisaged hitherto. Further analysis of data obtained this year by the Geophysical Survey of the NIO may alter the position.

Lastly, I should like to express my deep gratitude to various Departments of the Government of India and heads of National Laboratories for their unstinted cooperation in research and financial help for Marine Archaeological Studies. Prof. A.P. Mitra Director General Council of Scientific and Industrial Research has spared no effort to give all assistance, right from 1981 to see that Marine Archaeology has a firm footing in NIO. Dr. B.N. Desai Director NIO has gone out of his way to make laboratory facilities and services

of scientists available to us. Prof. Vasant Gowerikar, Secretary Dept. of Science and Technology and Sri J.P. Joshi Director General A.S. I have given financial assistance. Our thanks are due to all of them.

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Opening of the Exhibition of Artifacts and Underwater Exploration of Dvaraka, Bangalore

Prof. G. Venkatasubbiah

This Exhibition organized jointly by the Society for Marine Archaeology and the National Institute of Oceanography is unique in many respects. First, Marine Archaeology is itself an interdisciplinary study which involves much research by archaeologists, historians, scholars of ancient literature as well as scientists and technicians of the Institute of Oceanography. Bangalore being an important centre of art and science, the citizens are thankful to the organizers for holding the exhibition here, and I am sure, it will attract the experts as well as the nonexperts since everyone is anxious to know all about Krishna's Dvārakā. The expertise involved in the pioneering work of underwater excavation and photography is brought out in the beautiful photographs of submerged fortwalls and other buildings of ancient Dvārakā. We are grateful to the organizers for having brought important finds such as 3500 year-old seal, inscription, stone anchors, pottery and other antiquities. The report and the objects recovered confirm that much that is stated in the *Mahābhārata* is true – especially the founding of Dvārakā and its submergence by the sea. The hardships undergone by Dr. Rao's team and the dedication they have shown in discovering and preserving our cultural heritage are commendable.

This exhibition is sure to enthuse visitors to know more about what is being done in the field of Marine Archaeology in India. Each individual item has a big story to tell and the more you know about it the greater will be your wonder. For instance a short inscription on a votive jar refers to the owner's appeal to the Sea God to protect him. More important is the link it provides between the Indus Valley writing and the Asokan Brahmi script. Another find, namely the triangular 3-holed anchor links Dvārakā with Cyprus and Syria of 1400-1200 B.C. and suggests daring sea voyages of the Indians of those days. Take a third instance, the photographs show how the Engineers of Dvārakā built massive protection walls in the reclamation area by laying on modern principles the foundation of dry boulders. The stone mould of coppersmith gives a clue to the type of spearheads in use, while the iron objects attest to the development of iron technology to which *Mahābhārata* refers.

In brief, the underwater excavations in the Arabian Sea have brought to light a whole culture of the Mahābhārata Age which is being rebuilt slowly but surely. The artifacts recovered and the buildings exposed in the seabed show a very high water mark of Indian life. Dvārakā of Lord Krishna of the Epic period takes shape before our eyes as a city and a great reality. If what Dr. S.R. Rao's pioneering work is aiming at is to rebuild the whole story, then indeed the historicity of our two *Mahākāvyas* will be established on very firm grounds. This is a great salvage work bringing all the underground wealth of Ratnakara. I wish the whole attempt a great success.

Two other sections of the Exhibition explain through photographs the discovery of a shipwreck in Goa waters and submerged structural remains of a medieval township on Tamil Nadu coast at Tranquebar which was a suburb of Poompuhar, an Early Chola port.

Exhibits

1. Prismatic shapedstone anchors, Dvārakā, 15th century B.C. (Period I)-1st Century BC?(Period II)
2. Triangular stone anchor, Dvārakā. 16th–15th century BC (Period I).
3. Iron anchor, Dvārakā (Period II)
4. Bronze/Brass objects (Period II) (bell & lower portion of a chariot?)
5. Other Antiquities: (Late Harappan seal and votive jar with Late Harappan inscription, both of 15th century B.C., coppersmith's stone mould, semiprecious stone cores, shell bangles and cores, beads of terracota, fishbone and carnelian; chert blades, pottery of Late Harappan and post-Harappan periods.)
6. Artist's view of ancient Dwarka city (Painting)
7. Photographs (colour and black & white)
   (a) Dwarkadhish temple
   (b) Samudranarayana temple, Dwarka
   (c) Remains of two earlier temples below the Vishnu temple of 9th century A.D., Dvārakā.
   (d) Research vessel *Vedhavati* chartered for Marine Archaeological Exploration.
   (e) Diver plots the submerged bastion of Dvārakā.
   (f) Diver measures submerged stone wall of ancient Dvāraka.
   (g) Fortification wall on the cliff section in Bet Dwarka island.
   (h) Diver retrieves a stone pillar of ancient Dvārakā.
   (i) Lowering of the side scan sonar towing fish in Tranquebar waters.
   (j) Diver measures granite blocks in the shipwreck, Goa.
8. Pottery (Intertidal zone, onshore and underwater) (a) Black and Red Ware (b) Lustrous Red Ware, (c) Red ware, (d) Buff ware, jars, bowls, dish-on-stand and dishes of Period I and handle portion of amphora (Period II).
9. Sonograph and echograph of Geophysical survey which show certain 'objects' identified by divers as structural remains, Tranquebar.

Presidential Address

Prof. U.N. ROY

Fellow delegates and distinguished guests.

I am, indeed, very grateful to Dr. S.R. Rao for asking me to preside over the inaugural session of the Second Indian Conference on Marine Archaeology of Indian Ocean Countries organised at Bangalore, the capital of Karnataka, which had played, through the ages, a significant role in the history and culture of our country from many a point of view. I shall be less than human, if I fail to acknowledge at the outset the outstanding contributions of Dr. Rao who can rightly be assessed as the Founder of Marine Archaeology in India. His monumental work at Dvārakā (Dwarka) constitutes a new era in Indian archaeology and has placed Marine Archaeology in India on the world map so that it has tempted distinguished delegates from distant parts of the land and so also from the foreign countries, such as U.K., Sri Lanka and France to attend the Conference.

India enjoyed international repute as a developed mercantile nation right from the pre-Christian Era. Not only the indigenous but foreign testimony too evidences the western and eastern sea-coasts of India, teeming with several *pattanas* (harbours) and *droṇīmukhas* (ports near the conjunction of the river and sea) such as Bhrigukaccha (Broach) and Tamralipti (Tamluk) which served as renowned centres of export and import. There are literary traditions about their sinking under the deep waters of the sea. The submerged portions of these sea-coast cities need their unearthing and protection and should be treated as valuable relics of our great cultural heritage and national glory. By bringing to light the submerged parts of ancient Dvārakā, Dr. Rao has opened a new vista of research in the sphere of marine archaeology in India.

It will not be out of place to observe that the literary, epigraphic and numismatic evidence, throwing light on the ship-building and mercantile activities in ancient India should be attached full importance for corroborative study of the subject. Literary texts like the *Mahābhārata, Harivaṁśa, Śiśupālavadha* and *Purāṇas* contain traditions about foundation of Dvārakā, its planning and glory. Excavations done by Dr. Rao at Dwarka prove that the descriptions as found in these texts are not to be discarded as fanciful but are to be treated as based on actualities as seen by their authors. Besides indigenous account, foreign testimony also provides valuable information about sea-ports on the western and eastern coasts and their general environment. The varied material as found in them can prove useful from many a point of view.

I may also observe that the area of marine archaeology may be expanded so as to convert itself into underwater archaeology. Besides the sea-ports, there were renowned cities which were washed away by the rivers on whose banks they were situated. We may cite here the case of Hastināpura and Pāṭaliputra, situated on the bank of the river Gangā and falling worst victims of flood-fury. The Mahābhārata mentions that Hastināpura was washed away by the Ganga and consequently the Pāṇḍavas had to migrate to Kauśāmbī. Pātaliputra which was the premier city of the land *(agranagara)* and the test of the excellence of all the cities *(samasta-nagarī-nikasāyamāṇā)* in the words of Daṇḍin, the author of the *Daśakumāracharita,* had become the worst victim of inundation. The submerged parts of these cities are to be treated as protected monuments and great treasures of our ancient heritage. If Dwarka excavations throw a flood of light on the history of the city which was associated with the life-events of Kṛṣṇa, the under-water excavations of Ayodhyā situated on the bank of the river Sarayu might yield valuable information about the historicity of Rāma, his age and contemporary urban status.

A more detailed scheme of Marine Archaeology in India will require opening of more branches at appropriate centres with up-to-date equipments, comprehensive collaboration and a team of experts representing relevant disciplines for a fruitful completion of further undertakings and expeditions in this sphere. Such centres should be able to train young enthusiasts in accordance with most up-to-date courses in Marine Archaeology. In order to attract the talent in this new branch, the central and state governments should create splendid fellowships and suitable jobs and release adequate grant to the Centres for successful execution of their schemes. Opening of museums pertaining to Marine Archaeology will serve as useful media to take the subject to the masses. With these few words about measures to be adopted for future development of Marine Archaeology in India, I wish the Conference a brilliant success.

And lastly in the words of Kālidāsa I may also wish: 'May the utterances of those, eminent for knowledge, be honoured for all times to come *(Sarasvatī śruti-mahatām mahīyatām)*

Vote of Thanks

A.H. PARULEKAR

On behalf of the organizing committee of the second conference of Marine Archaeology of India and neighbouring countries, and on my own behalf, I record appreciation and gratitude of the marine scientific community ot Dr. S.R. Rao, for rekindling the interest in Marine Archaeology by his dedicated approach and exemplary contributions. But for him, the "Dwarka" and many more submerged heritages would have been in the cold graves.

To you sir, Justice Rama Jois, we are grateful for gracing the occasion of inaugration and making it memorable by a scholarly address. Our thanks to our numerous benefactors, who through sponsorship and acts of assistance, made this occasion, a reality. To all our esteemed delegates, from near and far, we owe a debt of gratitude. Thanks are also due to Karnataka Chitra Kala Parishath, Thank you all.

Panel Discussion

Participants

1. Dr. S.R. Rao ... Chairman
2. Mr. Mensun Bound
3. Lt. Comdr. Devendra Somasiri
4. Comdr. Gupchup
5. Dr. I.K. Sarma
6. Dr. B.U. Nayak
7. Dr. Guilleme

S.R. RAO

Mr. Bound, will you please let me know whether the commonwealth scholarship committee has selected any Indian student for study in Marine Archaeology in Oxford University? Should we have mostly young archaeologists in Marine Archaeology projects?

M. BOUND

I have been away for 2 weeks from England, but before that, there was no contact between the Commonwealth Scholarship Committee and the University of Oxford. The sholarship I beleive is being granted now. It is only a matter of arranging with the University. A lot of students come in with these Commonwealth grants and usually there are no complications with these grants. There is one other point in the training of Maritime Archaeologists here and elsewhere, and that is you should see that they get experience in land archaeology also. From my experience the best ones are those who learn on land the best techniques of excavation and all about publications. They can apply their knowledge to underwater archaeology. There are a couple of exceptions but the ones that stand out are those who have a long background in land archaeology. I think if one is going to take Maritime Archaeology as a career one should try in land archaeology to get a wider vision of the cultural heritage in the broader sense.

I was thinking of SCUBA diving for already trained archaeologists. Mental and physical fitness are absolutely essential. Without that kind of background, the sea is a very dangerous place. It would endanger not only yourself but the entire team. So if you could work out a special programme of training tailormade for archaeologist. i.e. this man can do and go thus far, then you have your classified graded set of archaeologists. Then you could put them through this course rather than the Naval course and this might make it easier.

S.R. RAO

What I suggest is that we should have a more broad based programme so that the navy could be involved in scientific diving suitable for scientists and archaeologists. The whole course of naval diving is not necessary for them. Secondly I would like to involve scientists in underwater collection of samples etc. The N.I.O. has a few diving scientists trained by the Navy and Institutes abroad. We are grateful to the Director General ASI, Secretary Department of Science and Technology and Director General Council of Scientific and Industrial Research for funding exploration and training. If some archaeologists of foreign countries are interested they can apply through proper channel for processing their applications by the Ministers of Foreign Affairs and Science and Technology.

M. BOUND

There is one other point that I think is important and that is you should make Maritime Archaeological studies available to nondivers. There will be some good people coming along but are scared of the water. They cannot swim. But they have an awful lot to give to the cultural heritage of India because they develop intellectual skills which, in some ways, are more important. Field archaeologists like myself spend more than 90% in practical work and we would like to be doing more writing and teaching.

S.R. RAO

We are interested in exploration of Indian wrecks in Sri Lankan waters and may be in Australian and African waters too. Of course the question that arises here is one of entering into an agreement with foreign governments. But supposing a foreign wreck is found in EEZ of a country I would like to know the conditions of agreement entered into by MARE etc.

M. BOUND

Going back to the Mediterranean we have multinational teams, greater percentage of our teams are Italian because much of our work is based out there. It is more convenient because in winter we leave much of our heavy equipment in Italy for maintenance. Our boats are there and a lot of our fund raising is carried on in Italy. Translations are carried out there but in addition to that we have students from Canada, the States, Brazil and Chile. We have never had an Indian student. When I was a student I worked with the Americans, Spanish and the French because back then there simply were no courses and University programmes to teach me, nor I could afford. There is a programme in the States but that is enormously expensive. So we have a belief that we must do all we can with students who want to develop Maritime Archaeology as a profession. So we are keen to take students on the Mediterranean project from any part of the world. What we also had in mind was that we should collaborate with

the Italian archaeological service with a variety of sites. Sometimes it is a collaboration in name, money and equipment. It depends on the situation. Sometimes the individual superintendent becomes too overburdened to give legal support, so it becomes a collaboration in name only. This summer we have a survey of the Island of Gorzone. Half the team is Italian and the other half is International from Oxford. Half the money comes from Oxford and half from Italy. We are working with the Italian navy who are providing the safety back up, medical expertise, the chamber and things like that. Unfortunately we are working very deep 50-60m. I had in mind a collaboration with the Institute in Goa but I have also met people here from other States and Maritime organizations in India whom I had not met before. I was thinking of something like collaboration work between Oxford and the Institute in Goa or one of the Universities. We can collaborate on the survey with the idea in mind that if the site is of sufficient archaeological importance then we can go ahead. At least a small programme of step by step excavation can begin. I find that people become interested in maritime archaeology very soon. I am interested in very old shipwrecks, for instance, the Giglio ship. This time I worked in Greece on the Dockos wreck which is the oldest wreck ever to be looked at. Also just before Christmas I was working on wrecks in S. America in the Falkland islands, because they are collapsing. So the whole scope of Maritime Archaeology is exciting and important to me.

S.R. RAO

I have to inform the participants that the sonar and magnetic surveys conducted by NIO scientists has yielded satisfactory results. A couple of the 'features' on sonograph are wrecks and relics of structures.

DISCUSSION

K.H. VORA

I was wondering if you could describe underwater metal detectors in detail.

M. BOUND

I am just a humble archaeologist. I use the detector but I don't always understand how that works. It was an earlier prototype developed by Prof. Kolon and used extensively in the North Sea. These days we tend to use magnetometers and I think they depend on the coil floated on Kerosene and this induces a current in that, and creates an artificial electro magnetic field which reacts with the earth's magnetic field and creates a disturbance and what you are looking at is an anomaly on the seabed reacting with the field of the coil. We do have an academic programme at Oxford. We are the only team in England that is academically based, that is to say, we have an academic teaching programme backed up by field activities in summer. We have a one year degree in Master of Studies which can develop into 2 years. If the candidates do well they can develop into a D.Phil or Ph.D. If there are any students wishing to come to Oxford I'd be happy to talk to them.

GUILLEME

Just a few words to introduce myself. I am a classical archaeologist meaning that I worked and studied in Greece and then I excavated a Greek township. Then I went to India where I spent 4 years in the Centre for Historical Studies at the Jawahar Lal Nehru University. But it is not as a archaeologist that I have come here today because I am not a specialist in Marine Archaeology. I came here as a person who is in charge of our programs of collaboration in the field of Art and preservation of Cultural Heritage and I just want to tell you that we have an agreement with the Archaeological Survey of India to send to France two marine archaeologists to get further training and to participate in French marine archaeological excavations. So I hope this is the beginning of further collaboration of the two countries and my purpose is to assess what would be possible to do together and what shape the collaboration could take. I knew of this seminar very late to have French people invited. I am here on behalf of France and soon I would like to have your suggestion if any to shape this collaboration.

COMMENTS

S.R. RAO

I was myself in France in 1961 and I have seen the excellent work the French have been doing in the preservation of Pre-historic and other sites. The excavations at Marsailles interested me very much. You have a Research Vessel *Archeonaute for* Marine Archaeological Exploration which can be a model for us to construct a similar one. I hope a young archaeologist from the Marine Archaeology Group will be selected for further training in shipwreck archaeology.

Valedictory Function of the Second Indian Conference on Marine Archaeology of Indian Ocean Countries

The function began with an invocation by Prof. S. Gururajacharya, Maharaja's College, Mysore.

Dr. B.U. Nayak, Secretary of the conference welcomed the Hon'ble Chief Guest Mr. S. Venkataramayya, Chief Justice (Retired) of the Supreme Court of India and requested Dr. S.R. Rao to give a brief account of the deliberations of the conference.

The representatives of Indian and foreign delegates namely Prof. U.N. Roy, Lt. Comdr. Devendra Somasiri, Dr. Guilleme and Mr. Mensun Bound gave their impressions of the conference. Justice Venkataramayya delivered the valedictory address and the resolutions were passed by voice vote. The meeting ended with a vote of thanks.

WELCOME BY DR. B.U. NAYAK

Hon'ble Justice Sri. S. Venkataramayya, Dr. S.R. Rao, distinguished delegates from India and abroad, ladies and gentlemen.

It gives me immense pleasure to welcome Justice Sri Venkataramayya who has kindly consented to spare his time and deliver the valedictory address at the concluding session of the conference. It would be appropriate on this occasion to mention how marine archaeology started in India. It all began with the prompt steps taken by Dr. S.R. Rao in 1981 when the Indian National Science Academy approved and funded his pilot project of Marine Archaeology. The NIO provided logistic support. Just with two assistants he was able to make headway in exploring the submerged city of Dvārakā of Mahābhārata fame. By 1984 he could convince the Department of Science and Technology that archaeological studies not only save the underwater cultural heritage but also generate data of scientific and educational value. He could thereby get scientific equipment. Dr. Rao was convinced that unless minimum trained manpower was made available underwater excavation of submerged cities and sunken ships in the coastal waters of India was impossible on scientific lines. Owing to his high standing in the field of archaeological research in India he got funds, a few young archaeologists, an oceanographer and a couple of photographers for receiving training in diving and underwater documentation and retrieval. The NIO spared its technicians and laboratories for Marine Archaeology. Today Dr. Rao can be rightly proud of having built up a well knit group of young archaeolgists, technicians and scientists who are able to dive on wrecks and sites and carefully study and retrieve the cultural heritage of India. The data so far collected is useful for eustatic studies also.

The first Indian Conference on Marine Archaeology of Indian Ocean Countries at Jamnagar in October 1987 organized by the Marine Archaeology Unit of NIO was a great success in the sense that the experts from India and abroad assessed the importance of the work done from 1983 to 1987 and recommended that a permanent division of Marine Archaeology be set up in NIO to facilitate exploration on a scale befitting the rich cultural heritage of the country, secondly, it also recommended that a society for Marine Archaeology be formed to hold periodically a Marine Archaeological conference and publish a research journal of Marine Archaeology. Lastly the conference recommended running an intensive training course in Marine Archaeology. From Dr. Rao's key note address to the conference it is obvious that all the three recommendations have been implemented. The present conference is the result of the action taken on the recommendation of the first conference. The success achieved so far is mainly due to Dr. Rao's efforts and to the generous help and cooperation extended to the society by Prof. A.P. Mitra, DG, CSIR, Dr. Vasant Gowerikar Secretary Department of Science and Technology, Dr. Gaur Secretary Department of Ocean Development, R.C. Tripathi Joint Secretary Department of Culture and Sri M.C. Joshi Director General Archaeological Survey of India, to whom our thanks are due. Now I request Dr. S.R. Rao to give the salient features of the deliberation by the ongoing conference and the results achieved.

SALIENT FEATURES OF THE DELIBERATIONS

S.R. RAO

Hon'ble Justice Venkataramayya and distinguished participants,

Before going into the details of the deliberations of the various sessions of the Second Indian Conference on Marine Archaeology of Indian Ocean Countries it is my duty and pleasure to say a few words about Justice Venkataramayya whom

we are fortunate in having in our midst today for giving us a word of advice. Justice Venkataramayya who had his education in the University of Mysore, which was also my alma-mater has risen by sheer dint of merit and hard work to the highest position in the country to which a legal luminary may rise, namely as Chief Justice of the Supreme Court of India. His humility is exemplary and reminds us of the saying in Sanskrit *Vidyā dadāti vinayam*. He is so simple that when I telephoned him a couple of days ago that the organizers of the conference shall be grateful to him if he accedes to our request to grace the valedictory function by his presence and participation he readily agreed in spite of the fact that he had arrived in Bangalore a few days ago and not even unpacked his baggage received from Delhi. It shows his great love for institutions of learning and research. It is our proud privilege to have him as our guide and philosopher especially at a conference like the present one which cares for the exploration and preservation of underwater cultural heritage of the world in general and Indian ocean countries in particular. Justice Venkataramayya, in his historic judgements has upheld the high values for which this great country stands and as a student of cultural history, he said, he welcomed the opportunity to know our deliberations.

The main purpose of holding the Second Conference a little more than two years after the first one was to exchange our views and experiences with those having greater experience in the field of underwater exploration. This explains the presence of Mr. Mensun Bound Director of Archaeology OXFORD MARE group who along with Mrs. Bound has been exploring the Mediterrancean waters for ancient wrecks. The latest one they have come across seems to belong to the Etruscan period. We also wanted to make sure that our young archaeologists, scientists and technicians trained by us in diving and underwater search and documentation maintain international standards expected of underwater archaeologists. This explains again the presence of Mr. C.T.C. Dobbs, the well-known diver from U.K. He is going to impart further training in observing safety measures. He as well as Mr. Bound have already expressed great satisfaction at the standard of underwater exploration at Dwarka; yet we cannot be too complacent over the conservation method in this field, especially in preserving underwater wood, metal and other materials; much research remains to be done. The archaeological laboratories have only touched the fringe of the problem. At the last conference and in the course of the training programme lectures, specialists in the field have made some suggestions which we are eager to implement if funds are made available. The conservation of underwater *in situ* buildings such as jetties, fortwalls, light houses, temples and secular buildings is an urgent necessity at Dwarka and similar problems of conservation are likely to present themselves in Tranquebar-Poompuhar waters. The problem gets aggravated when there is heavy run off. The near shore monuments on the east coast are subject to heavy erosion as in the case of the shore temple, Mahabalipuram, a Siva Temple near Madras, the Chola Temple and the Dutch Fort at Tranquebar. I must also mention the all important issue of the usefulness or otherwise of deploying side scan sonar, magnetometer, Echo-sounder, profilers etc in target search. The nautical archaeologists abroad did not favour the use of geophysical instruments mainly because they could find shipwrecks easily in the Mediterranean because of the information supplied by sponge divers, but we do not have that privilege in India, for there is no sponge-diving. There is a long history of diving for pearls on Dwarka coast but no wrecks are reported.

We have to depend to a greater extent on geophysical survey gadgets and the analysis of data done by NIO scientists. For four seasons the scientists have worked in close colloboration with marine archaeologists and achieved success which was not otherwise possible by manual survey.

There are several important papers on search methods, environmental factors, sea level fluctuations and excavation of submerged cities and wrecks. This conference has created great interest among eminent scholars from the Universities, Archaeological Survey of India and other research laboratories in saving the cultural heritage, and brought here scholars like Prof. U.N. Roy and many others. We are anxious to get data on wrecks from French, British and Dutch sources. Exchange of scholars would be the best way of getting data. Dr. Guillame has some plans which we welcome. Our Sri Lankan friends have shown interest in getting involved in the kind of work we are doing. Marine Art, a much neglected subject in India, has also received attention from experts like Mrs. Nalini Rao of California University. A look at the list of papers presented and discussed at the conference clearly indicates that we have made some headway in solving technical problems, though we are not out of the woods as yet.

There is another problem which is worrying us. After a shipwreck is located it takes a few years to expose, document, excavate and retrieve the ship as a whole or in parts. Finding money and solving technical problems may cause further delay. In the meanwhile treasure hunters are likely to pilfer antiquities and destroy the much needed archaeological evidence. The AMASR Act in force does not cover marine archaeological excavation. The Act needs to be amended to protect the sites and afford facilities to marine archaeologists to excavate them. No stumbling blocks should be put in the way. Sir, I am sure you will be able to tell us whether the old Act should be amended suitably or a new one enacted. The ASI is yet to make up its mind. In the meanwhile pilfering is going on in Goa waters. I don't think that the coast guard too can do much at present. The society intends holding a workshop soon on this subject.

IMPRESSIONS

MENSUN BOUND

Your honourable Mr. Chief Justice, Dr. Rao, Dr. Naik, colleagues and friends,

I was just thinking this is the fifth conference I have been to in the last twelve months, and I was at the one in last March, one at Athens in August on the ships of Aegean, one in North Italy on Amphora and more recently the one at London. But

I must say this is the most exciting and I think the most important conference, I have attended this year. I've been very impressed by the general enthusiasm, the positiveness, and keeness of this conference. It's not something you see very much elsewhere these days, conferences of this nature. Also the quality of the questions and answers is excellent. In the panel discussion the right questions are asked and everybody is very anxious to get it right. As underwater archaeology is just beginning, and has just come on the map here it is important that you ask the right questions so that you do not make the same mistakes that we in England have made and for which we are still suffering the consequences. In that regard let me just address very briefly the questionaire by Dr. Rao. He asked what should we do about the legislation? And he put it in 3 ways. Should we amend the existing legislation? Should we go in for a totally new legislation? Or should we accept the existing legislation?

Let me just urge you that you go in for a new legislation. Do not try to amend the old legislation, we've tried it in England twice, it did not work and were bogged down with old rules that were written in the last century where nobody could predict the problems we face today in preserving our Maritime heritage. As a result of that, in England we have people excavating wrecks in the name of Archaeology and selling the artifacts they bring out, which is disgraceful and we all are very ashamed. Let's make sure that the same sort of things do not happen here in India. We should legislate to stop looting. I could not think of a country which has more miles of coast line than India. Certainly not America or Canada, or Brazil or Argentina or Australia, possibly Russia. You have a vast coastline in India and that spells one thing, lots and lots of wrecks. Now one other thing that has impressed me here is the way you get things done. In England we often fall into what I call the endless art of admiring a problem. Here though, you make your resolutions and you see that they are done. In the last conference you made a resolution to start a new Society. You did it! you had a resolution to start a new Maritime journal, you did it. Let me urge you, that you establish a National Maritime Resource Centre in India. I think that's important because I predict constantly that you have an exciting future, the Maritime Archaeology of all these wrecks and with all this coastline, you're going to need a National depository for all these finds, where they can be properly conserved and properly shown to the public, so that more people become inspired by what you're doing. Finally I'd like to thank Dr. Rao and all his colleagues once again for all their enormous hospitality, and can I thank them also on behalf of the other foreign guests here today Mr. Guilleme from France, Mr. Devendra from Ceylon, my old friend Mr. Dobbs from England. We have all received much kindness and for that we are very, very grateful. I look forward personally to developing friendships and professional ties that have developed here in this conference and I leave you now feeling very optimistic and very inspired. Thank you all.

DR. U.N. ROY

Honourable Mr. Chief Justice Venkataramayya, Dr. Prasad Rao, Dr. Nayak and friends.

I am thankful to Mr. Nayak for giving me a chance to speak a few words about this conference. This valedictory session has started with an appropriate Hymn which was correctly interpreted by you, Sir, because from a historical point of view, that hymn is very important. It represents a stage when the Indians made an attempt to sink their discord and rivalry and made an attempt for religious reconciliations in the interest of National unity and integration. I take this conference as an International conference in the sense that it is graced by scholars and experts from all parts of the country and outside. We have among us Mr. Bound, Mr. Dobbs and also delegates from Sri Lanka and France. I assure you I have attended many international conferences in USSR and USA. But I frankly admit that qualitatively this is the best International Seminar I have attended so far. Dr. Rao has raised Maritime Archaeology to Himalayan heights. He is identified with Dwarka and will always be remembered in History with the History of Dwarka. His outstanding contribution to Marine Archaeology has made it grow into a multidisciplinary subject. I want to say so many things about the achievements of this conference and Dr. Rao. The conference has been a great success. As many as 23 papers have been presented. Normally what has been presented here in 2 days would have taken 4 days. A scholar would have taken 60 minutes but he had to summarize it to provide time for discussion. Qualitatively however each paper was well presented. I assure you that the conference has achieved a great success from many a point of view. On this occasion I am reminded of Kālidāsa. His date is debatable because he was one of the least self-advertising persons. He did not make any reference to his parentage or reigning king, whereas other poets such as Bhavabhuti were good but self advertizing. In *Kumāra Sambhava* there is a beautiful verse when Pārvati decides to practice penance, Kālidāsa says "you are too delicate; do not do it just as a flower can take a bee but not a bird" I have heard Dr. Rao about 4 times on Dwarka. Everytime I heard him I have felt a new pleasure. I suggested to Dr. Rao yesterday while discussing the collaborative work-plans that he should extend the work as much as possible to include river ports. The scope of Marine Archaeology should be converted into underwater archaeology. The prosperous cities like Hastinapur, Ayodhyā and Pātaliputra were washed away by the rivers. Dr. Rao, you have succeeded in bringing to light the Dwarka which was the very life of Krishna. Kindly extend your work to Ayodhya. It will solve the date of Rāma. I wish Dr. S.R. Rao continues to organize more such seminars. To do this, he needs funds, and I hope ASI and central and state Governments will provide adequate resources. I conclude by thanking Dr. S.R. Rao.

Valedictory Address

Mr. Justice E.S. VENKATARAMIAH
Former Chief Justice of India

Friends,

Although the assembly here consists of less than 50 persons yet the quality of the persons who are attending this particular meeting is very high. We have distinguished Professors and sholars before me. My knowledge of history is very rudimentry. Perhaps the same teachers who taught Prof. S.R. Rao taught me history in my B.A. course. Dr. M.H. Krishna was a Professor and Director of Archaeology in the State of Mysore. In those days, he was holding both the posts.

History in Sanskrit is called *'Itihāsa'* what is the meaning of the word *Itihāsa? Itihāsa* means 'it was like this' – so history means it was like this. In India particularly it is said that we lacked a sense of history for a long time. For instance we do not know precisely the date of Kalidasa and others. You find that in any book on Kalidasa and his works eg. 'Mallinatha's commentary, at least 10 pages are devoted to the date of Kalidasa. I don't think people are quite sure about it. Even now discussions go on whenever a Sanskrit conference is held, but these books, tradition and literary sources do have a bearing on our knowledge of history and our research into historical evidence and documents. But history does not depend on mere literary sources. We have now archaeology which has become a primary source particularly with regard to that period which you call the pre-historic period. We have got epigraphy, numismatics, the science of coins, and of course, literary sources. These literary sources sometimes are biased versions. When we read the Cambridge History of India or Smith's History of India, we find that some of the statements will be wrong and may not be true. But we can test them with reference to other evidences. In court we have a rule – rather, not a rule, we just follow certain principles while assessing evidence. One's friend may lie but circumstances won't. Secondly we always try to depend upon primary evidence and we reject secondary evidence unless there is no primary evidence at all available with regard to this matter. The third is that as far as possible whenever you find that some version is likely to be a biased one you must seek corroboration elsewhere from some other source which is reliable. Now whatever evidence is available in the epics and the *puraṇas* we have got to test it with reference to other evidence which is available. The same thing applies in the case of archaeology also, that is how we test it. Dr. Rao said that we are trying to find out whether what is stated in *Harivaṁśa* or in the *Bhāgavata* is true or not with reference to the archaeological finds in Dwarka. This is one way of testing. In all there are certain things archaeologists are very well aware of. For instance things that are found in caves for years. You know they have become inaccessible to people and when you open them out and when you find certain things there, they give you some evidence of what and how things were years ago. Then there are ash mounds where things are buried. They are lying under the surface. Then we have the things which are under the sea, shell mounds, then there are what archaeologists call as kitchen middens. We have got to overcome the difficulties presented by the ocean in reaching antiquity buried in the seas and try to find out what they are. The work done at Dwarka is indeed an eye opener to all of us. The nation is grateful to all of you and to Sri. S.R. Rao in particular. I thank you all for calling me to this conference to speak a few words of appreciation about the work you have been doing.

General Body Meeting of the Society for Marine Archaeology

The President, Dr. S.R. Rao welcomed all the members of the Society attending the first General Body Meeting held on 21st January, 1990 after the concluding session of the Conference at Bangalore and requested Dr. B.U. Nayak General Secretary and Dr. Hashimi Treasurer to present their reports.

GENERAL SECRETARY'S REPORT:

The First Indian Conference on Marine Archaeology of Indian Ocean Countries held at Jamnagar, Gujarat from October 12 to 14 of 1987 recommended in its resolution number four of October 14, 1987 that a Society of Marine Archaeologists be formed and a meeting be called in this regard at a suitable place during early 1988, for holding periodical conferences and publishing a Journal to promote Marine Archaeology in Indian Ocean Countries. The Organising Committee of the First Indian Conference on Marine Archaeology of Indian Ocean Countries decided at its 2nd meeting held at Goa on 16th January, 1988 that an Adhoc Committee be formed to draft a constitution of the proposed Society and circulate it among the interested Institutions including the Universities. The following persons were nominated as members of the Committee:

Dr. B.N. Desai, Director, National Institute of Oceanography – Chairman
Dr. S.R. Rao, Emeritus Scientist, National Institute of Oceanography – Convenor
Sri. M.C. Joshi, Joint Director General, Archaeological Survey of India, New Delhi – Member
Sri. M.H. Raval, Director, Gujarat State Archaeology, Ahmedabad – Member

A meeting of promoters of the Society was held on 8th December, 1988 at NIO, Goa for discussing the objectives, membership and management of the proposed Society. A draft memorandum of the association of the proposed Society was prepared and circulated among various interested institutions, academics and Universities for their comments. Comments received were considered by the Committee and a Memorandum of Association of the Society was finalised. Thereafter an application was sent to the District Registrar and Head of the Notary Services, Goa, in March, 1989 for registration of the Society. The Society for Marine Archaeology was duly registered under the Societies Registration Act 1860, Central Act 21 of 1860 with a registration No.57 Goa dated 28th June, 1989. The members of the Executive Committee to manage the activities of the Society as formulated in the Memorandum of Association are as follows:

1. Dr. S.R. Rao – President
2. Dr. B.N. Desai – Vice President
3. Dr. B.U. Nayak – General Secretary
4. Dr. N.H. Hashimi – Treasurer
5. Dr. N.C. Ghosh – Member
6. Dr. A. Sundara – Member
7. Captain V.S. Saptarishi – Member

The main objectives of the Society are (1) to promote and undertake research in Maritime History, shipping, trade and culture of Indian Ocean Countries; (2) to hold lectures, seminars, workshops and conferences; (3) to publish a periodical; (4) to promote research and development in Marine Archaeology and (5) to undertake and execute all other acts which shall promote the aims and objectives of the Society. The Executive Committee met on 27.7.1989, 30.8.1989, 30.9.1989 and 9.11.1989, discussed and approved various matters pertaining to the activities of the Society.

The Society has 4 life members, 25 ordinary members and 3 student members as on date. Every effort is being made to enrol more members. The most important achievement of the Society has been the publication of the first issue of the Journal of Marine Archaeology. Dr. S.R. Rao is the editor. At a very short notice the Journal has been brought out and if there are a few errors in printing we are sure that the readers will overlook them. But the quality of the papers presented is of a high standard. The next issue may come out some time in the second half of 1991 since we are yet to receive articles after the academics go through the present issue and appreciate the publication work undertaken by a Society with meagre means. Another very important achievement of the Society has been the holding of a Workshop at Goa on 5th August, 1989 on "Ocean, Religion and Archaeology". The papers presented at this Workshop have been published in the first issue of the Journal. The General Body approved the statement of accounts and the activities undertaken so far.

Income & Expenditure Account of the Society for Marine Archaeology upto 31.12.1989

Income	Rs.	Expenditure	Rs.
Life membership fee	4,000/-	Bank Commission	4/-
Membership fee	2,500/-	Cash at SBI, Donapaula	7,066/-
Student membership fee	90/-		
Admission fee	280/-		
Registration fee	200/-		
Total	7,070/-	Total	7,070/-

Dr. N.H. Hashimi
Treasurer

List of Participants

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Gujarat University,
AHMEDABAD (GUJARAT)

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PART II

Section 1

Sources of Marine Archaeology

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Sources of Marine Archaeology

The Brihatkathā-Śloka – Samgraha on Maritime Activities in the Gupta Age

U.N. ROY

The *Brihatkathslokasamgraha*, an important text of the Gupta Age, throws new light on various details of sea-voyage and mercantile activities in India during this period from many a point of view. Mention is made of *'pattana'* i.e. sea-port (centre of import and export) and *'dronimukha'* i.e. a commercial metropolis, vitally connected with sea and river at the same time. These centres were famous for dealers in rare gems and precious stones and flocked by merchants of distant countries. According to the text, the markets (*apanas*) of Pandya Mathura (*madura*) having connections with *trismudra* (three seas) were full of stocks of pearls and corals of varied shining lustre (*bhinnabha*). While speaking of the rich treasury of the Pandyas of Madura, Kalidasa observes in the *Raghuvamsa* that it consisted of best of pearls, collected from that part of the ocean where the river Tamraparni falls into it (*muktasaram mahodadheh*).

By the Gupta Age, India had developed as a mercantile nation of international repute. This can be gleaned from the Haraha Inscription (M.E. 611 = 554 A.D.) which mentions Gaudas of Bengal as characteristically a sea-faring people (*Gaudan samudrasryayan*) i.e. sea was the home of the Gaudas. In an inscription of Malaya, a Gauda named as Budhagupta has been mentioned as a great navigator (*mahanavika*). India was familiar in the Gupta Age with eighteen oceanic islands (*aṣṭadaśa-dvipa*) as mentioned in *Brihatkathasloka-samgraha* and also the *Raghuvamsa* of Kalidasa. While making distinction between sea (*samudra*) and ocean (*mahodadhi*), the text mentions their names also.

The work contains valuable information about joint commercial venture by sea-traders (*samyatrikas*) and also their risky and arduous expeditions. Samyatrika is mentioned as *'samudra-vyavahari sarthavaha* (i.e. chief merchant trading by sea) in the *Sakuntalam* of Kalidasa, where the king is depicted as highly shocked at the sad end of Dhanamitra, the head of the sea-merchants in a naval disaster.

The *Brihatkathasloka-samgraha* describes sea (*ambudhi*) as abode of all miracles (*nanascharyanidhi*), suggesting its rich resources and importance in the life of the Indian people. It contains interesting details about ship-disaster (*pota-bhanja*), band of sea-pirates (*taskara-sainya*), sea-creatures of strange shapes *(chitrakaran)*, ships carried away by cyclones, merchants driven to distant islands in the event of naval disaster, devices for sending signals for emergent aid, ethical and moral duty of sea-merchants for providing best assistance to ship-wreck traders and functions of service boats attached to the ships at critical moment etc.

The text indicates its familiarity with big docks *(visala sopana)* for safe landing of large-sized ships, vessels tossed by force of fast-moving wind and consequently going out of control like an enraged elephant *(matangajah)*, islands inhabited by males and females wearing nominal clothes or remaining semi-naked and freely mixing with each-other like animals *(pasudharmanam)*. On the coast-land stretching from Tamralipti to Pandya Mathura (Madura), there were rest-houses *(Punya-Salas)* furnished with toilet, bath, clothes and food for the facility of ship-voyage merchants especially the ship wreck victims and for those engaged in water sports. *(sagara-krida)*. Sea merchants reporting themselves to the king after successful voyage along with costly presents including gems and corals and receiving honours and encouraging awards from him in return for their notable enterprise and exploits and similar other interesting details about sea, sea-voyage and mercantile activities are to be found in the text abundantly.

The work has rightly been assessed by V.S. Agrawala as one of the foremost literary texts of the Gupta Age from the historical and cultural points of view. Although this text is a summary of the *Brihatkathā* of Gunādhya, it throws light on the cultural conditions of the period to which it belongs. The importance of the text lies in the sense that it contains a mine of information about the knowledge of the Indians regarding sea and mercantile activities during the Gupta Age. Amongst the *'pūrva-sūris'* (previous pioneers) for bringing this text to special light, mention may be made at this place of Felix Locate (1908) and subsequently of V.S. Agrawala who had published a critical edition of this work along with historical notes and a commendable discussion of the date of its authorship (Prithvi Prakashan, Varanasi, 1974). Quite recently (1986), Ram Prakash Poddar has also published a new edition of this text along with English translation in *Prāchya Bhāratī Series* 21,, Budhasvāmin's *Bṛhatkathā-Śloksamgraha*, Tara Printing Works, Kamachha, Varanasi.

The text speaks of *'aṣṭādeśa-dvīpa-mahi'* (XIX 180), indicating brisk cultural contact of India with eighteen islands. There is a similar reference to eighteen islands in the *Raghuvamśa* of Kālidāsa who records that in the course of his remarkable 'digvijaya, Raghu had fixed his victory stands in them *(aṣṭādaśadvīpa-nikhāta)*. In *Vāyu Purāṇa* also, a reference has been made to eighteen islands *(aṣṭādaśa-samudrasya dvīpān)*[1]. Then the writer of the *Prayāga-praśasti* of Samudragupta, *sandhivigrahika Harisena*

speaks of *Saimhalakādibhiścha – sarvadvīpa – vāsibhih* i.e. 'the dwellers of all islands including Sri Lanka'. The references as found in the *Raghuvaṁśa* and *Prayāga – praśasti* prove that effective political relation with eighteen islands *(aṣṭādaśadvīpa)* was an ancient ideal of *'digvijaya'*. In the above epigraph, we read that the rulers of these islands had made a humble submission *(ātma-nivedana)*, entered into matrimonial alliance with him *(kanyopāyana-dāna)* and made an entreaty to circulate his imperious commands stamped with *Garuḍa* seal in their respective territories *(garut – madaṇka – sva – viṣaya – bhukti – śāsana – yāchanā)*. The names of these islands are detailed in the *Ārya – mañju – śrīmūla – kalpa'* towards which Dr. Agrawala has already drawn our attention. The inclusion of the names of the islands of South-east Asia only in the list should not be used as an argument to prove that the western sea-borne trade was on decline at this stage. The *Bṛihat-kathā-śloka-saṁgraha* speaks of *'trisamudra'* which includes Arabian sea also *(Ratnākara)* besides *Mahodadhi* (Bay of Bengal) and the Indian Ocean *(Dakṣiṇa-payodhi)*.

Kālidāsa mentions these islands as *'dvīpāntara'* from where was brought clover flower to India. While introducing Indumatī to the king of the Mahendra mountain, Sunandā says, 'O princess! if you marry this king, you will sport with him on the sea-shore where the palm – leaf groves make a rustling noise and you will have the drops of perspiration removed by the breezes that bring forth with them the sweet scent of the clover flowers from the other islands:

"अनेन सार्धं विहराम्बुराशेस्तीरेषु तालीवनमर्मरेषु।
द्वीपान्तरानीतलवङ्गपुष्पैरपाकृतस्वेदलवा मरुद्भिः॥"

The writer of the Haraha Inscription of Maukhari Īśānavarmā (M.E. 611-554 A.D.), while indicating brisk mercantile activities with these islands mentions that the Gaudas had left their connections with the dryland for all times and taken shelter into the waters of the sea; *'kritvā-chāyati- mochita-sthala-bhuvo Gauḍān Samudrāśrayān'*. This points out that the Gauḍas of Bengal were essentially a sea-faring people. D.C. Sircar draws our attention to an ancient inscription of Malaya in which Budhagupta, the Gauḍa has been mentioned as *'mahānāvika'* i.e. the great navigator (J.R.A.S. Bengal, 1944). The text *Bṛihat-kathā-śloka-samgraha* mentions at one place even the deadly great ocean motif with its ferocious makara monsters, grinding the passengers of the ship (XV, 78).

Sāmayātrika and Sārthavāha:

The work contains valuable information about joint commercial venture by sea-traders *(Sāmayātrikas)* and also their risky and aurduous expeditions. He is mentioned as *Samudravyavahārī sārthavāha* (chief merchant trading by sea) in the *śākuntalam* of *Kālidāsa* where the king is depicted as highly shocked at the sad end of Dhanamitra, the head of the sea-merchants in a naval disaster *(nau-vyasana)*. This suggests that *Sārthavāha* mattered so much in society that even the highest ruling power was personally concerned with his personal welfare. In all the five land-grants of Bangaladesha, which belong to the Gupta Age, *Sārthavāha* is invariably mentioned as an important member of the representative council which advised the *Viṣayapatis* (district officers) in matters of administration.

Ship-wreck:

Naval disaster *(nauvyasana)* is frequently mentioned in the text by different words. The eighteenth canto says at one place that *Gaṅgādutta* who was an ornament of the city of Tāmralipti and was full of virtues had made a sea-voyage and become a victim of hurricane *(prabhanjana-parābritaḥ)*, as a result of which his ship was full of water, like sky covered with clouds:

"गंगदत्ताभिधानस्य ताम्रलिप्तिविभूषणः।
गुणवान्भागिनेयोऽसौ गतः पोतेन सागरम्॥
स च पोतः किलाम्भोधौ प्रभञ्जनपराहतः।
प्रविशीर्णः पयःपूर्णः पयोधर इवाम्बरे॥"

Similarly ship-wreck is frequently mentioned as *'nau-vyasana'*, *'vipanna-vahana'* (XVIII, 630), *'vahana – bhraṅśa'* (XVIII, 655), *'bhinnapota'* (XVIII, 314, 656), *potabhañjana'* (XVIII, 655) *'pota-vipatti'* (XVIII, 654) etc. The text speaks of a merchant, known as *Siddhārtha* who became a poor victim of naval disaster. He started from Tāmralipti from where his ship was carried away to *Pandu-purī*. Several interesting words occur for ship-wreck such as *'Sārtha-dhvaṁsa' 'vahana-bhranśa'*, *'bhinnapota'* in a glowing account of the tragedy:

"अन्तरे यच्च ते वृत्तं **सार्थध्वंसादिभीषणम्**।
ताम्रलिप्तिप्रवेशान्तं शिष्टं सिद्धार्थकेन तत्॥
भ्रष्टेनवहनभ्रंशाद् भ्राम्यता जलधेस्तटे।
पुनश्च **भिन्नपोतश्च** पाण्डुपुर्यां च यत्तव।
वृत्तं कर्पासदाहान्तं ताम्रलिप्त्यागमश्च यः॥"

Emergent steps and devices

The text speaks of emergent steps and devices which were adopted by ship-wreck merchants driven away to unfamiliar islands. Such immediate measures are technically known in the text as *'bhinnapota-vaṇika-vṛitta'* i.e. customs and practices of sea-traders involved in naval disaster. They gave signal of their ship-wreck and requirement of immediate aid by raising lofty banners *(prāñśurucchṛita-dhvaja)* in the day and lighting fire on the sea-coast in the night *(jvalano-jvālyatām*

rātran) to catch the attention of Sāmyātrikas perchance travelling in other ships in the neighbouring area. Besides, the text also speaks of *'vaṇika-dharma'* i.e. moral duty of other sea-merchants to rise to the occasion and discharge their proper role for their needful rescue from the serious catastrophe. The text also speaks of dangerous hurricances and cyclones *(vātālī)*, resulting in serious disaster:

" दिवा प्रांशोस्तरोरग्रे प्रांशुरुच्छ्रीयतां ध्वजः ।
ज्वलनी ज्वाल्यतां रात्रौ तुङ्गे सागररोधसि ॥
कदाचिन्नाविकः कश्चिदालोक्यावन्तरं द्वयोः ।
स्वदेशमानयेदावां धर्मोऽयं वणिजामिति ॥ "

Pattana and dronīmukha:

The text speaks of *pattana* i.e. a sea-port which was the centre of import and export. Besides, there was *droṇīmukha* which was vitally connected with river as well as sea-coast. The *śilpaśāstras*, while defining *pattana* observe that this was a metro-politan centre where ships were loaded and unloaded with commercial goods *(patantyasmin pattanam)* whereas *droṇīmukha* was one which was connected with river as well as sea – route *(nadyāścābheśca)* on account of its situation near the mouth of the river. The text frequently speaks of Tāmralipti which was a classical example of *droṇīmukha*. While drawing distinction between a *pattana* and a *grāma* in the *Mālavikāgnimitram*, Kālidāsa observes that a gem was to be tested in *pattana* but not in the village *(pattane sati grame ratna-parīkṣā)*. This suggests that only a *pattana* was assessed as an appropriate place for the precise test of a gem.

The text *(Bṛihat-kathā-śloka-saṁgraha)* speaks of Sānudāsa who had spent his life in the leading *pattanas* of the country and who was a great expert in testing the merit of a gem *(ratna-tattva-vid;* XVII, 371). While giving a glowing account of Pāṇḍyan Mathurā (Madurā), the text says that its markets abounded in jewellery shops where stocks of pearls and corals of varied brilliance reminded the observers of the sea itself whose vast treasures were exposed when Agastya had emptied it by drinking its water in full:

" तस्यामध्यासि भिन्नाभरत्नपञ्जरसंकुलम् ।
अगस्त्यपीतपानीय सागराकारमापणम् ॥ "

(XVIII, 315-316)

Kālidāsa makes a similar observation in the *(Raghuvamśa* where he mentions that Pāṇḍya kings had collected best of pearls from that part of the great ocean where the river Tāmraparṇī happens to join it. It looked as if the rich stocks of pearls were their accumulated glory:

" ताम्रपर्णीसमेतस्य मुक्तासारं महोदधेः ।
ते निपत्य ददुस्तस्मै यशः स्वमिव संचितम् ॥ "

(XVIII, 369)

The river Tāmraparṇī is still well-known for its pearly treasures. It is a very small stream, flowing past Pallamcotta and falls into the Gulf of Mannar. Because of its pearly treasures, this tiny river still enjoys a celebrated repute.

Award for notable success:

The text evinces that the kings used to encourage merchants for sea-voyage by personally receiving them and honouring them by rich awards for their distinctive success. This was to a large extent reciprocal also because such sea-merchants used to report themselves to the king concerned and make costly presents from the stock of their acquisitions in sea-voyage. *Samudra-vyavahārī-sārthavāha* i.e. the chief of the sea-merchants, as is clear from the land-grants of the Gupta Age as well as Kālidāsa's Śākuntalam, mattered immensely in State politics also at various levels, beginning from the stage of the district officers to the level of the provincial governors, central ministers and ultimately the king himself. It speaks of a *potavaṇija'* (sea-merchant), who related to the king his new experiences he had in course of his arduous journey. On the basis of what was seen by him all along, he says that sea is the womb of all miraculous treasures. He presented to the king precious gems and he was in return profusely rewarded.

" राज्ञोदत्तमहारत्नः स राज्ञा कृतसत्क्रियः ।
पृष्टस्तेन भवान्किं किमाश्चर्यं दृष्टवानिति ॥
तेनोक्तमम्बुधेस्तीरे देवेन वसता सदा ।
दृष्टं किं नाम नाश्चर्यमाश्चर्यनिधिरम्बुधिः ॥ "

(IV, 50)

This reminds us of the practice of kings of Spain and Portugal, rendering financial assistance to the great navigators like Columbus and Vascodagama who were honoured after their successful voyage and discoveries. At a different place in the text, Sānudāsa, the sea-merchant reports to the king that the residents of Suvarṇa-bhūmi honoured him in a special pavilion *(maṇḍapa)* covered by a multi-coloured and pictorial cloth of China *(Chīnāṅśuka)* by performance of local dance along with instrumental music. (XVIII, 583).

Strange experience of practices and beliefs:

On further enquiry about details, he relates that once his ship was carried away by the hurricane *(hṛit-pota-nabha-svatā)*. It was recklessly thrown upward and downward and got fully out of control of the pilots. The ship started behaving like an enraged elephant *(mataṅgajaḥ)*. When the disastrous wind *(utpāta-vāta)* finally had subsided and the water level became normal and tranquil, the merchants happened to see water animals of strange shapes *(chitrā-kārāñcha paśyāmo prāṇino jala - chāriṇaḥ)*. In an island, they saw groups of male and female figures who were totally naked and whose

ear-lobes were pricked. They were in communication with each other by sound only and enjoying freely like animals. Further, they saw sometimes flying sea-serpents which had wings of big size and were in the habit of lying hidden in the deep waters of the great ocean for fear of their wings being stripped off:

"अन्यत्र विद्धकर्णानां स्त्रीपुंसानामवाससाम् ।
ध्वनिमात्रकभाषाणां द्वंद्वानि पशुधर्मणाम् ॥
क्वचिदुपततस्तुङ्गान्नागानायतपक्षतीन् ।
पक्षच्छेदभयालीनान्नगानिव महार्णवात् ॥"

(XIX, 90-91)

The text speaks of a male dressed like a woman. He was holding a skull in one hand and peacock's feather in the other. He was wearing round his neck a strange garland interwoven with gems emitting multi-coloured brilliance of a rainbow.

"सहसा प्रमदावेषमपश्यं पुरुषं पुरः ।
कपालशिखिपिञ्छाभ्यां विराजितकरद्वयम् ।
अयुक्तेन्द्रधनुश्चायश्रृङ्गारगलकण्ठिकम् ॥"

(XIX, 103-103)

Facilities for foreign travellers

The text speaks, here and there, about facilities extended to foreign travellers. One such facility was related to the removal of the language problem. For this, there was arrangement of interpreters mentioned in it as *'dvibhāṣa'* i.e. a person knowing two or more languages whose services could be utilized so that adequate communication between the newly arrived travellers and local people could be made possible. The head of a family is reported as honouring him and taking the help of a *'dvi-bhāṣa'* (language interpreter) for understanding the conversation of a merchant stranded on the coast in his neighbourhood as a result of his ship having been carried away by hurricane. The traveller, eager to communicate his problems and circumstances became very-glad to meet him in the same way as he would have been to come across his dear son-in-law after a long time.

"अथैकेन द्विभाषेण गृहं नीत्वा कुटुम्बिना ।
जामातेव चिरात्प्राप्तः प्रियः प्रीत्यास्मि सत्कृतः ॥"

(VIII, V. 350)

When enquired about the sea-port *(pattana)* he hailed from, he informed that he belonged to the Pāṇḍya country situated along the southern ocean. This country, according to him, was a delightful one, worthy of being visited by the needy and was the source of acquisition of treasure of *'mahāpadma'* which according to the contemporary texts *(Vāmana Purāṇa,* 75, 32 and *Mārkaṇḍeya Purāṇa,* ch. 68, VV. 5, 13 & 14) was represented by rich stocks comprising of variety of pearls (muktā), rubies (mauktika), corals (pravāla) and gems (ratna) capable of lasting for several generations of the owner. He was received by the owner of the house and given delicious food and comfortable couch for enjoying a sound sleep.

"तं च स्वशयनासन्नमापृच्छं रजनीमुखे ।
देशोऽयं कतमो साधो कतमद्वात्र पत्तनम् ॥
तेनोक्तं पाण्ड्यदेशोऽयमनुदक्षिणसागरम् ।
महापद्मनिधिप्राप्तिरम्यं यत्रार्थिदर्शनम् ॥"

(XVIII, 351-352)

In the morning when he walked a distance of two *krośas,* he came across an alms-house *(satra-maṇḍapam)* in a beautiful campus where were grown plantain trees. It was equipped with needful facilities of shaving sets, toilet, bath, cloth and food for foreign travellers, *(Vaideśikān)* who had assembled there. He found them well-shaved, nicely dressed and well honoured with delicious food etc. There was arrangement of beds for spending comfortable night.

"प्रातः क्रोशद्वयातीतः कदलीखण्डसंवृतम् ।
पान्थसंहातसंबाधवपश्यं सत्रमण्डपम् ॥
पश्यास्मि स्म च वैदेशान्क्रियमाणक्षुरक्रियान् ।
अभ्यङ्गोच्छादनाच्छादभोजनाद्यैश्च सत्कृतान् ॥"

(XVIII, 355-356)

The text also informs that such *'satra-maṇḍapas'* (alms-pavillions) were to be found in our country every where on the sea-coast, in the cities and sometimes in forests also for the benefit of the merchants whose ships were driven away by strong wind.

"तेनापि सर्वदेशेषु कान्तारेषु तटेषु च ।
प्रवर्तितानि सत्राणि बेलातटपुरेषु च ॥"

(XVIII, 362)

Device for smooth landing

The text informs that a prince along with the chief Sāmayātrika and some other sea-merchants belonging to his organisation landed on a sea-coast which was approached by a big and lofty flight of steps constantly cleaned by the sea-waves dashing against it. The word *Sopāna'* used by the author for it is really very thought-provoking. Since the description in the context refers to smooth landing on the sea-coast with its help, it can be taken in the sense of a dock.

The text does not describe its constituent features, but we can infer from the word *'Viśāla'* and *'uccha'* that it would have been raised from the bottom of the well-levelled sea-basin in proxmity to the top so as to connect the surface of the coast for avoiding any problem or difficulty in landing.

"अम्भोनिधिजलकल्लोलं धौतनीलोत्पलं ततः ।
आशाकाशविशालोच्चं पोतः सोपानमासादत् ॥"

(XIX, III)

The importance of life-boats

The text also speaks of small boats attached to the main big ships. The services of these small vessels were significant from several points of view. They proved useful in the event of naval disaster. When the main ship was involved in storm, attempt was made to carry the passengers and the merchandise to the neighbouring sea-coast. Besides, when the main ship found some difficulty in reaching the coast in the absence of a suitable dock or arrangement for smooth landing, these small boats were sent to the sea-coasts to inform the local people of its arrival. The text speaks of a big ship which contained rich stocks and treasures of valuable and precious merchandise and which was lofty like the peak of Kailāśa mountain. It had to anchor away from the sea-coast under a similar condition. The services of small boats attached to it were utilised to inform the local people of its arrival so that their aid was available to carry the merchandise to the sea-coast. While giving its vivid description, it informs that the residents of the area saw a row of boats approaching fast in the morning like a row of sea gulls swiftly floating on the top of the high breakers each one of them manned by two oars-men.

"ततस्तुंगेषु रहन्ती भङ्गश्रृङ्गेषु भङ्गिषु ।
मद्गुपंक्तिरिवागच्छदुपनौकारुणोदए ॥
तां द्विनिर्यामकारूढमारूढः पटुरंहसम् ।
प्राग्वातालीमिवाम्भोदः प्रातिष्ठं दूरमन्तरम् ॥
ततः वाणिजमद्राक्षं महाद्रविणभाजनम् ।
कैलास इव शुभ्रांगं महापक्षमहानिधिम् ॥"

(XVIII, 317-18, 321)

Among other interesting details found in the text we may refer to *Sāgara-krīḍā* (sport on the sea) (XIX, 24) *Chaura-Sainya* (band of thieves), *taskara-sainya* (band of pirates) (XIX, 160-161) and also customs of foreign people, and life in the *pattanas*.

Conclusively, we may observe on the basis of the information available in the text that the Gupta Age witnessed a highly prosperous stage of arduous mercantile expeditions and enterprises of the Indian people who had basically grown by this time as a highly developed mercantile nation of international repute. Although the text is an attempt to present a resume of the *Bṛihat-kathā* of Guṇādhya, it is vitally connected with the real contemporary happenings in the domain of sea-borne trade. This Nepali version of the *Bṛihat-kathā* of Guṇādhya written by Buddhasvāmī, at times, becomes too original and quite different from the Kashmiri versions (namely the *Bṛihat-kathā-mañjarī* of Kṣemendra and *Kathāsarit-sāgara* of Somadeva) so that its very name *Bṛihat-kathā-śloka-saṁgraha* (compendium of big tale verses) becomes a total misnomer. The text still needs a further thorough probe for churning precious information about the economic life of India in the classical period of our history.

S.R. RAO

You have referred to flagposts. How much earlier to the Gupta period could these flagposts be? In our excavations at Dwarka we came across a huge stone, spherical or truncated sphere in shape, with a central hole. This is found at the entrance to the port-city. I don't know if there is any reference to flagposts in the *Mahābhārata*. Could this have served as a base for a flagpost or lamp-post of light house? During day time a flag could be hoisted in the event of a storm. At night it could serve as a post for a lamp. In Kanheri there is an inscription on the hill reading *Sāgarāvalokana*.

U.N. ROY

Very valid points have been raised by Dr. Rao. I will try to explore the references about flag posts on shore or in the ship. Establishing a *dhvaja* (flag) was an ancient tradition, So far as the standard of the ship is concerned I will have to refer to the texts. Burning fire at night was a symbol for a ship in distress (S.O.S.) and if there was any other ship in the neighbourhood it was supposed to go to the rescue of the ship in distress.

Some Important Archival Sources on Sunken Ships

RAGHU RAJ SINGH CHAUHAN

The entry of the Portuguese into Indian waters makes the beginning of a new era in world history. Whereas they carried on a relentless war victoriously against Afro-Asians during the 16th Century, they were not successful against the British, Dutch and French in naval wars fought in the next century. It is because of these violent actions that the Indian Ocean is littered today with hundreds of wrecks, though a very large number of ships were destroyed due to the hidden reefs, hurricanes and violent tempests. Some of the archival repositories in India are to be explored seriously in order to solve the mysteries we have been searching for, and which are buried with the sunken ships. The paper is a modest attempt in this direction.

INTRODUCTION :

The oft-repeated discovery of sea-route to India by the Portuguese in 1498 will remain a landmark in world history. It was for the first time that the world became larger for many countries. In the coming years, the Indian Ocean witnessed manifold maritime activities. However, Portuguese being the pioneers dominated the sea throughout the 16th Century, and it was as early as 1501 that the king of Portugal styled himself as the Lord of Navigation of Ethopia, Arabia, Persia and India! In order to control the rich spice trade of India and the spread of Christianity, they crossed swords for more than hundred years with their Afro-Asian enemies and triumphed. Entrance of the British, Dutch, French and other maritime powers in Indian waters was also resisted by them in the next century. It is because of these violent clashes and actions that Indian Ocean is littered today with hundreds of wreckages-known and unknown. Also, there were other natural factors like hidden reefs, hurricanes and violent tempests that destroyed a number of vessels. Although these maritime engagements brought different races of many countries together and their descendants can still be seen settled along several coasts, it is these silent sunken ships which, if explored scientifically, will unfold the mysteries we have been searching for. Fortunately, there is no dearth of information of these shipwrecks in the archival repositories of India as even a brief survey of a few relevant records housed at Goa Archives and National Archives of India fetched me an account of a good number of lost ships.

RECORDS OF GOA ARCHIVES :

The series 'Moncoes do Reino' kept in Goa Archives covering a period from 1586-1914 provides useful information relevant for our purpose. In it, one finds letters, instructions, orders, charters, etc., received at Goa from Lisbon yearly, covering almost all about Portuguese sea-borne empire in Asia and Africa as well as their trade rivalries with the Arabs and European powers. Another important series beginning from 1613 to 1808 in 24 volumes is 'Assentos do Conselho da Fazenda'. Since most of its documents bear headings summing up their contents, the information becomes easily traceable. Among other allied matters, this series contains invaluable material on ship-building and repairs, sea-traffic, sea-routes, naval wars etc. Next in importance come 2450 volumes of 'Alfandegas' (Customs) containing valuable data on the type of the vessel, port of origin, number of crew, period of voyage, tonnage capacity, cargo, etc. during the period beginning from 1593 to 1902[2].

RECORDS OF NATIONAL ARCHIVES OF INDIA, NEW DELHI :

The records housed in National Archives of India, New Delhi, disclose that a Marine Department was inaugurated by the British in India on 2nd May, 1838. Earlier, its affairs were handled by the Home (Public) Department. Until it was provincialised in May, 1843, the Marine Administration of Bengal was in the hands of the Government of India. Though the British started trading in India during the period of Jehangir it was not before 1795 that they formed a Marine Board to control its affairs. Till 1867, the Marine Branch remained attached to Home (Public) Department and thereafter it was transferred to Military Department.[3] Therefore, besides referring to records of Home (Public), Marine and Military Departments in National Archives of India, one has to consult earlier documents at the archival repositories of Bombay, Madras, Calcutta, Karnataka and Gujarat in this regard.

PORTUGUESE WRECKAGES :

Oldest as the Portuguese were among European naval powers in Indian Ocean, it is appropriate to glance first at

their lost ships. It was as early as 1502, that the Portuguese Commander Vicent Sodre, who accompanied Vasco-Da-Gama's fleet to India, sank 3 ships belonging to Coja Casem (Khwaja Kasim) off Calicut. It is interesting to note that the treasure looted by him from these ships included an image of Mohemmed of solid gold and jewels, according to the wellknown historian, F.C. Danvers. Considering that the Muslims never worshipped images there is nothing more than to believe that the golden image was of another person. However, we find the said commander sailing next year for the Red Sea as a pirate because at the coast of Cambay he again plundered and burnt 5 Arabian ships laden with rich cargoes. He halted only at Curia Muria islands where he was warned by the natives that the place of his anchorage was dangerous and prone to the high winds. Avaricious as he had turned out, he did not move like 3 of the Captains under him - and a sudden storm consumed him alongwith his treasure and brother[4].

Another unluckly Portuguese was Mathias de Albuquerque who came to India as Viceroy of Goa facing strong contrary winds in January 1590. While sailing for Portugal after completing his 6 years of Viceroyality at Goa, his flagship Nossa Senhora da Guadalupe containing the bulk of costly goods of his predecessor on board accidently, caught fire and was destroyed with entire cargo[5].

There is yet another Portuguese ship namely 'Santo Amaro' that was lost in 1621, and it can be located in the bar of Mombassa[6]. The tragedy struck the Portuguese again two years later, when a total of 8 vessels sailed from Lisbon in 2 fleets-one of the 3 ships under the command of Dom Antonio mello e Menezes, and the other of 3 galleons and 2 Pinks commanded by Dom Fillipe Mascarenhas. One ship was forced back to Lisbon and was lost at the mouth of Tagus, another was lost on the island of St. Helena. The 3rd ship and 2 galleons were lost off Mozambique and 1 of the Pinks wrecked on the coast of Arabia[7]. The ship Nossa Senhora da Milagres' which departed from Goa in 1685 to Lisbon is also recorded as lost in the sea-water[8].

When the Portuguese Viceroy Vasco Fernandez Cezas de Menezes sent his southern fleet to punish the enemies on the Karnataka coast in 1703, it burnt a total of 72 vessels in the ports of Barcelor, Mangalore and Gocorna[9]. Interestingly, the same viceroy reports in the same year that many Portuguese vessels had wrecked near Bassein and Diu[10]. Portuguese navy which suffered more when the Portuguese fort at Mombassa faced an attack of the Arabs in 1728. To repulse the Arab attack, the viceroy sent from Goa 2 frigates, 1 Pala, 1 Galia and 1 Galiota under the command of Luiz de Mello e Sampaio with 1411 men on board. This expedition touched the coasts of Africa with debilitated strength having been destroyed by a violent tempest that wrecked the frigate Capitania Mossa Senhora de Penha da Franca with most of the men abroad. The pala 'Nossa Senhora da Assumpcao and the galia 'Nossa Senhora de Nazareth' withdrew to Goa dismated, and the frigate 'Nossa Senhora da Madre de Deus' as well as the galitoa 'Nossa Senhora da Penha de France' followed suit[11].

The unfortunate wreckage of the Portuguese ship 'Marialva' which was lost in 1798, can be traced in the canal of Mosambique coast. Besides many lives, a large amount of coins and other valuables were lost. Though the wreck took place at a tranquil spot in low waters, there was nothing more than some coins that were picked up[12].

There was yet another Portuguese frigate namely 'Real Fidellissima' that was lost with some Portuguese seamen in 1802 while assisting the British expedition to Egypt against the indomitable Napolean near the island of Prim in the Red Sea. In the action some British embarkations were also sunk. To compensate the Portuguese loss, the British Captain-General of Bengal Marques Wellesley sanctioned a huge sum of 216,000 xerafins to the Portuguese.[13]

BRITISH WRECKAGES :

Two noteworthy British ships that wrecked in Indian waters are as follows: One ship 'Fatte Salam' commanded by Captain Freeman, bound to Merguee, is reported to have sunk in 1761 near Ganjam in a violent wind. Though 300 men aboard were saved no guns or goods could be salvaged[14].

Another ship 'Marquis of Rockingham' struck a little unknown rock along the coast of Coromandal in 1778 and the Court of Directors of British Company wrote to the President in Council at Fort. St. George regarding this loss asking him to send a vessel there with a proper surveyor to locate the rock[15].

It is on record that during 1497-1612, a total of 806 ships of various sizes left Portugal for India. Of them, 96 were lost in the sea[17]. This is the period when the British, Dutch and French had not entered the Indian waters. Therefore, if we take into account the naval wars that the Portuguese had to wage against Europeans and Afro-Asians, the number of lost ships in Indian waters would be more than 1000 vessels.

Lastly, I would like to plead with the authorities engaged in this wonderful work to expedite the salvage operations of known shipwrecks. I am sure that the recent discovery of a large shipwreck about 300 years old in Goa waters will convince the Government of India to invest more funds in this venture.

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4. Danvers, F.C., *The Portuguese in India*. Vol. I. pp. 92-94.

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   "After completing the 3 years of his viceroyalty at Goa in 1720, the Portuguese Viceroy Conde de Ericeira left for Lisbon in a ship 'Nossa Senhora de Cabo', taking with him a rich consignment of jewels for the Portuguese Government, and the proceeds of his own private trade. They were surprised by a heavy storm off the Cape. Not only the ship was dismasted, it also forced them back to Bourbon to refit. Taylor and La Buze, learning the helplessness of the Viceroy's ship sailed towards the anchorage under English colours. Seldom or never had such a prize fallen into pirate hands so easily. The jewels alone were estimated at over 3 million dollars, and the hard cash was valued to the tune of five hundred thousand crowns." *See* Col. Biddulph. John. *The Pirate of Malabar and an Englishman in India* 200 years ago. London, 1907. p.157.
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DISCUSSION

S.R. RAO

We know that a large number of Portuguese ships sank in Indian waters. Unfortunately even in the publication *Tres' Seculos no Mar* published in Lisbon information about the sites where the ships sank is lacking. If in the Archives of Lisbon or elsewhere this information giving bearings of the shipwrecks is available it would be of immense help in searching for the wrecks. The Naval Hydrographic charts show shipwrecks but they may be recent ones. A few days ago we discovered one wreck in Amee shoals of Goa. One more was found near Grandi Island earlier.

CHAUHAN

National Archieves of India does give information about British ships of a later period. The Portuguese ships used to come to get potable water in Aguada Bay. A ship accidently caught fire here. Near Bombay Bassein was an important port of call. It was on the silk route in the first four centuries of the Christian era. Buddhism as a religion of propagation unlike Hinduism which is a cult and was confined to India till the fifth century. The silk route was the first land/sea route for migration and exchange of ideaas. In the Chola time, specially in the reign of Raja Raja Chola, Hinduism spread eastwards due to brisk maritime activity with South east Asia.

GANGADHARAM

Dr. Chauhan's information regarding important archival work is useful. In most areas where an archival study needs to be undertaken it must be done by local people. Secondly antique maps are useful. My experience with the National Archives was good. Survey of India and Naval Hydrographic office would also have maps. But they don't know where they are. It is upto the National Archives to hunt them down. It would be major task for the archives to get them and preserve.

CHAUHAN

In reply to Dr. Rao's query I must say this work is being done by the archives in Goa or captain of ports office should have the old maps but we don't collect them.

S.R. RAO

We employed someone to read the old Portuguese records at the archives for an honorarum but he could not read it. All that we got is only 10 technical terms used in portuguese marine records of 18th century.

GUILLEME

A small piece of information I would like to share is that we are going to give some of the documents of the French archives relating to the French presence in India. This will be on loan basis and may be transferred to India in the next two years.

S.R. RAO

I am thankful to Dr. Guilleme for the information. I know that the French Marine Records would be of immense value to Marine Archaeology Unit as several French ships sank on the east coast.

Kuntasi: A Harappan port-settlement on the Western Coast

M.K. DHAVALIKAR

The ancient site at Kuntasi (Dt. Rajkot, Gujarat) located about 3 km from the present village was formerly wrongly identified as Hajnali. Locally known as Bibi-no-Timbo it is spread over an area of about 2 hectares and has 6 m thick cultural debris. The excavation revealed a large structure complex enclosed within a double fortification wall having a watch tower in the southwestern corner, all built of stone rubble set in mud masonry. It can be ascribed to the flourishing phase of the Saurashtra Harappan datable to c.2200-1800 B.C. but it continued to be occupied during the Late Harappan period (C.1800-1600 B.C.). There was habitation outside the fortified area also.

The structure complex on the west consists of large chambers (about 7 × 4m) containing storage facilities such as bins, jars, pits, and silos built of mud bricks as also pottery kilns and furnaces. There were no hearths or well made floors, not even ash and charcoal which are indicative of human occupation. This area therefore appears to mark the workshop whereas the structures in the northern part of the citadel were probably used as residences. A very large structure in between these two wings, but forming part of the workshop, was probably the residence of the chief, if the discovery of a squarish faience seal is any indication. Besides, the entry to the workshop was provided through the passage leading from this structure.

There were structures in the south also but they have been considerably destroyed by the Late Harappan occupation. Those in the east, will be exposed next season. It appears that inside the cițadel, there were structures on all four sides, resembling the *chatuhśāla* plan of the latter day Buddhist vihara. Outside the citadel, the habitation was very filmsy.

The Harappan settlement at Kuntasi thus conforms to those in Kutch which have a citadel but no lower town worth the name. These citadels very much resemble the British factories in India of 17th century. The British came to India first to trade and built factories (e.g. at Surat) which contained storage areas and residence of the factors. They purchased finished goods from the local people. The Harappans came to Saurashtra for trade; they acquired raw materials such as carnelian and shell, manufactured finished goods inside the citadel, and exported them to West Asia. The Lower Town was nothing but the shanties of the local people who were in the service of the Harappans. The Harappans - the chiefs and the artisans who came with them - lived inside the citadel. This mercantile model explains the Harappan occupation of Saurashtra.

Rare Evidences on Maritime Trade on the Bengal Coast of India

I.K. SARMA

The task before the archaeologists is to sail through different sources in order to understand and evaluate India's ancient history and culture. The branch of Marine Archaeology, though in a nascent stage, has opened up new areas of study on the overseas trade and cultural interactions. In an earlier paper of mine[1], I have taken stock of certain epigraphical, numismatic and gylptic evidences on the maritime trade of the South-east Coast of India during the early centuries A.D.

A momentous discovery was recently made by Prof. B.N. Mukherjee when he recognised, for the first time, numerous Kharoshtī inscriptions on pots, plaques and seals earlier found from the excavations at Chandraketugarh, and nearby places, Bangarh and Hadipur etc. in the District of 24-Parganas North and Tamralipti Museum at Tamluk. Prof. Mukherjee deciphered the legends quite satisfactorily and held that 'in early centuries of the christian era a certain community or several communities migrated from the zone of *Kharoshtī* and North-western *Prākrit* to one or more than one area in the territory of lower west Bengal.[2]" Nearly 80 inscribed records are now available and being studied.[3] Again in his letters of 11th and 29th, May, 1990, Prof. Mukherjee reported the find of Kharoshṭī-Brāhmī inscriptions in Thailand and Bali. This shows that traders went from lower Bengal Coast to these sealocked lands. Here I would confine my observations to the seals rediscovered by B.N. Mukherjee[4].

(1) AND (2): TERRACOTTA SEALS FROM BANGARH AND CHANDRAKETUGARH (Pls. 5,6)

The first one is from Bangarh now in the Asutosh Museum of Indian Art, Calcutta (Acc. no. 1035). The seal impression having a diameter of 4.1 cm displays grain issuing out of a vessel flanked by conch and a taurine symbol. The inscription is in mixed script labelled as "kharoshṭī-Brāhmī" and clearly reads *'Sasyādidhṛta Sthālī,* meaning a vessel containing corn. This vessel is a bowl-shaped sailing boat full with corn and the bows at both ends are decorated with *Makara-mukhas* (2). The second one is also a terracotta circular seal (no. CKG-183) from Chandraketugarh in the collection of the Directorate of Archaeology, Government of West Bengal. It is 3.2 cm. in diameter and portrays a masted ship, with a flying banner, an ear of corn and taurine symbol. The legend along the margin outside, left to right in Kharoshṭī-Brāhmī script reads as *"Jidhatra dhana Jaśatrasa Tridhesa Jātrā"* sanskritized *Jitadatra dhana - yaśodasya tridēśa yātrā* meaning the journey or voyage in three directions by one Yasoda who has earned wealth in the form of food (selling food). This seal belonged to a trader in grain. The device has a portrayal of a sea-going vessel, a three – masted ship with a flying banner, flanked by a taurine symbol and corn.

SEAL: (3) FROM CHANDRAKETUGARH (Pl. 7)

This seal was found in Chandraketugarh. It was a single mast ship and bears a Kharoshṭī-Brāhmī Inscription in two lines. It can be read as (L.1) *Tasvadajana hovajinana trapya* (L.2) *gasa.* The second line is placed above the first line due to lack of space below the first line. The first line is to be read from left to right since its first letter *(ta)* is in Brāhmī. The second line is to be read from right, since its 1st letter *(ga)* is in Kharoshṭī. The legend may be translated as "of *trapyaka* belonging to the wealth earning Tasvadaja family". Trapyaka was a type of ship mentioned also in the *Periplus* and the *Angavijjā.*

The above vessel types as well as the flanking symbols recall the Sātavāhana ships on the coinage of Gautamīputra Yajña Śrī Sātakarṇi[5]. Such sea-going vessels also find a place among the cave paintings at Ajanta[6]. (Cave nos. 2, 17 - Simhaḷāvadāna; Cave no.1 - Janaka *Jāṭaka).*

The sea port towns of importance on the Bengal coast starting upwards of Ptolemy's *Maisolia* (Masulipatnam) and *Kalingae* (Kalingapatnam), were *Kainapāra* (Konark) Dosarene (Dhauli), and Gangae meant for Tamluk i.e. ancient Tamralipti. The last mentioned as also Kanthi were estuarine ports on the lower Bengal coast.[7] *Mahāniddesa* tells us that ships from Tamralipti and Polura (Gopalpur, Orissa), called at Sada, anchoring enroute at Gumpa. Tamluk[8] was in fact a large terminal port of sailing merchant ships bound for Malaya archipelago, Burma, Cambodia, Indonesia, Sumatra, Borneo and China. According to *Mahāvaṁśa* (XIX,6 and XIX 11-12) Aśoka came to despatch the *Bodhivriksha* (sapling) to *Simhala* in a highly religious manner. He descended into the water upto neck and set the

Bodhi Tree on the ship, stood with folded hands on the shore. This shows that the Port of Tamralipti was near an inlet of the sea. The *Vinaya* texts and *Jātakas* inform us that merchants from Sahajati, Kausambi, Varanasi, Pataliputra and Gompa brought their goods to Tamralipti for trade with South-east Asia. We know of a Master mariner named Buddhagupta, a native of *Raktamrittika mahāvihāra*[9] (Rangamati in dist. Murshidabad), going to Malay Peninsula in 5th century A.D. It appears that Kharoshṭī script-using tradesmen settled in lower Gangetic valley of Bengal in good numbers for a longer period, mixed up with the Brāhmī-using local merchants who were Buddhists too, and developed a *miśra.* "Kharoshṭī-Brāhmī" writing and North-western Prakritic expressions[10] Āṭghara and Deulpota in District 24-Paraganas have yielded certain reliable finds. A replica of a sea-going vessel, single-mast type with eye-socket symbol engraved thereon indicates an early trade contact with Egypt.[11A]

Some more evidences may be taken note of here. According to *Mahāvaṁśa* king Dutthagāmani (circa. 101-77 B.C.) of Śrīlanka celebrated with pomp the laying of great *stūpa.* Many monks and kings from foreign lands reached Ceylon and one Mahadeva from *Pallava-bhogga* with a large number of monks, and one Yōnamahā-Dharmmarakshita from Alasanda (Alexandaria) reached Śrīlanka. S.Levi associated 'Pallavas' with Pahlavas, i.e. Parthians [11B] and according to Geiger, *Palava* is a persian name, the sanskrit *Pallava* or *Pahlava-Bhoggam* means a feudal domain or landed estate. This land is regarded as the present day *Palnāḍu (Pallavanāḍu),* in Guntur-Prakasam districts of Andhra wherefrom early Pallavas of the Pre-Simha Vishṇu line (of copper plate charters), have been ruling soon after the Ikshvākus of Vijayapurī. It is very likely that these Pahlavas and monks from North-west tracked down right upto Śrīlanka during the early centuries B.C. and A.D. touching the Buddhist epicenters of Vaisali, Sravasti, Rajagriha, Nalanḍa, Sarnath, Tamralipti down to coastal Orissa and Āndhradeśa. In fact Dhānyakaṭaka (Amaravati, Guntur) was an emporium of trade on the South-east coast and of early Buddhism right from Mauryan times[12]. Śrīparvata Vijayapurī (Nagarjunakonda) was a centre of Mahāyāna Buddhism during 3rd-4th centuries A.D. and had close religious as well as commercial contacts, both inland and overseas, with the Gāndhāra country at one end to Śrī Lanka, South-east Asia and farther South China[13] on the other.

In this context, I would like to discuss before this august gathering, a unique find from Peddavegi, the ancient Vengīpura excavated recently[14]. In period IA, dated to 4th century AD, a Carnelian intaglio (an oval – shaped transparent locket), was found. It contained a depiction of a youthful female (PL. 8) in *abhanga* recalling the *Ampae* or *Ampa* the famous city goddess of *Pushkalāvatī* (Gandhara). The turretted crown, stitched silken lower-garment, the voluptuous stance with striking Hellenistic features can be regarded as a sole object of North-west origin. The deity of fortune, Tyche, depicted on the Imperial Parthian Coins (datable from 51 A.D. to 223 A.D.[16]) is well comparable to this find. What is more interesting is such an intaglio of Carnelian was reported from the excavations at Jetavana monastery (3rd century A.D.) in Anurādhapura[17], Śrī Lanka. It appears then that the tradition of worship and depiction of protectress of the city or monastery *(Durgā* or *Ambā)* in a seal, came from the Gāndhāra region to Peddavegi and Śrī Lanka as well.

Śālankāyanaka i.e. the country of the Śālankāyanas was first mentioned by Pāṇini in 6th century[18] B.C. It is quite probable that some members of this *gaṇa* migrated from their North-west homelands to the lower Ganga valley during 2nd-3rd century A.D. as we come to know of a Śālankāyana minister *(amātya)*, named Bhutila[19] stationed at Kausambi. Further a clay sealing with the legend *Śālankāyanasa* in 2nd century A.D. characters was discovered at Adam (Taluk Kuhi, Dt. Nagpur) in the heart of Vidarbha region which conclusively proves that Śālankāyanas were in powerful position and in touch with the rulers of Vidarbha region. However, Salakenois find mention by Ptolemy (140 A.D.) as rulers of the country north of *Maisolia*[20] on the south-east coast. Veṅgīpura their capital was Ptolemy's 'Benagouran'. The *Periplus Maris Erythraei* clearly points out that mariners of the Roman empire visited Scythia during the Parthian rule. It is clear therefore that the ruling family of Śālankāyanas', like Pallavas, migrated from North -West during the early historical periods.

En passant, it may be seen that the coast of Bengal was humming with trade and culture contacts and interlinked with the ancient land route as well starting from North-west reaching the plains of Ganga. The long South-east coast with convenient anchorage has not only been a transmitter of brisk overseas trade but of religions too, specially Buddhism. Certain art objects like unique Carnelian Intaglio from Vengīpura and Anurādhapuram are clear indications of transmission of religious thought.

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11.a. H.B. Sarkar, cit pp. 57-58. A Photograph of this boat is published in P.C. Das Gupta (ED) *Bengal's Post,* published by Director of Archaeology (West Bengal).

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Section 2

Exploration of Sunken Cities and Wrecks

A Wreck of Likely Etruscan Origin off the Mediterranean Island of Giglio (C.600 B.C.)

MENSUN BOUND

From 1982 to 1986 University MARE conducted excavations on a wreck of possible Etruscan origin which can be dated on the evidence of the pottery to c.600 B.C. The remains of the vessel were situated in 50m of water at the base of a reef in Campese Bay, Island of Giglio, North Italy. The vessel contained painted pottery of Corinthian, laconian, Samian and Etruscan manufacture. The amphorae came from Etruria, Samos and East Greece and contained pitch, olives, oil and wine. The metal finds consisted of helmets, arrowheads, tools, metal ingots and lumps of copper. The wooden finds included pieces of inlaid furniture, musical pipes, a pair of callpers, a carved lid, and a writing tablet. Ivory objects, a silver jug and pieces of uncut amber were also recovered. The hull itself was of sewn construction. The Giglio ship is the most important wreck to be found from the Archaic phase of Mediterranean history.

(Plates 9 – 11)

In August, 1961, a British diver called Reg Vallintine, discovered a wreck in 45-50 metres of water, at the base of a reef in campese Bay on the north-west side of the island of Giglio in the Tuscan archipelago off North Italy. The vessel contained a mixture of utilitarian and luxury goods, the latter of which included Greek painted pottery.

Twenty years later, in 1981 the word of the discovery reached archaeologists at Oxford University, who, in collaboration with the Superintendency of Archaeology for Tuscany, put together a team to go to Giglio to try to relocate the wreck.

After some days of searching, the wreck was found under the sand in the interphase zone between the rock of the reef and the soft sand of the seabed. There followed a survey of the site in which it was established that the wreck dated to c. 600 BC, making it the oldest wreck of post-Bronze Age antiquity.

Work on the site ended in 1986. At the height of the excavation, seasons were lasting over 3 months with teams that numbered up to 120. Money for the project came from a variety of individual sponsors, comapnies, learned societies and the University of Oxford.

The fine wares from the site consisted of so-called Ionian bowls, Samian lekythoi, craters and oinochoai from Corinth, aryballoi, bowls and mugs from Sparta, and bucchero kantharoi and aryballoi from Etruria. The aryballoi were particularly interesting and were in a range of sizes and painted styles that catered for every purse and artistic taste. Motifs on the aryballoi included animals, florals, gorgons, sphinxes and combating warriors. The oinochoai were painted with rows of animals; one of the craters sported a register of padded dancers.

The amphorae were mainly from Etruria but a small number were from East Greece and Samos, and one was of Phoenician-Punic origin. The Etruscan amphorae contained olives and pitch, and also, we suspect, wine. The small Samian jars most likely contained olive oil.

The metals on the wreck consisted of lead ingots, copper bun ingots, lead fishing weights, bronze weaponary, iron bars and copper nuggets that ranged from about the size of a pea to that of a tangerine. The bars and nuggets we believe functioned as currency. There were also a small number of iron tools, which, like the bars (or spits) survived only as void-concretions.

The weaponary included 31 socketed arrowheads, each with a single spur, or barb, on one side. The most spectacular item of weaponary, however, was a Corinthian helmet, beaten from a single sheet of bronze and decorated with boars on the cheeks and open-mouthed, forked-tongued snakes across the brows. This was clearly a prestige possession as well as a functional piece of defensive equipment. Unfortunately it was found soon after the wreck was first discovered, and, as a result, was illegally taken out of the country to Germany where it is today in a private collection.

Other finds include uncut amber, a silver olpe, Greek lamps, astragals, ivory and box-wood auloi, and a variety of carved wooden artefacts, the most important of which was the remains of a decorated couch leg, a beautifully carved, box-wood lid with ivory studs, and a pair of calipers which presumably belonged to the ship's carpenter. The partial, faded remains of inscriptions on the heads prove that they were of Greek manufacture.

During the summer of 1985, part of the ship's keel and some associated planking were recovered. The keel was without a keelson, shoe or wales, nor, in the short length surviving, was there any evidence to show that there had been flooring. The garboards were seated in diagonal rabbets along the arrises, and then fastened with treenails and lacing. What little remained of the lower planking showed that they had also been fitted edge to edge and then laced.

To lace the strakes, small triangular notches were cut into the wood *(pinus sylvestris* L.) on opposite sides of the seam. Holes were then drilled diagonally down through the notches to emerge on the outboard side of the seam. The lacing was threaded through the two holes, which were then plugged with small dowels of approx . 10 mm diameter. The seams and planking were caulked with pine pitch. 14 different species of wood have so far been identified on the Giglio ship, but not all of these can be shown to have come from the vessel's structure.

The importance of the Giglio ship is its early date, the evidence it provides for ship construction during the Archaic period, and the precious insights it gives on the Hellenisation of Etruria.

DISCUSSION

DEVENDRA

What was the big metalic object you found when you first used the metal detector?

MENSUN BOUND

The metal object was an iron concretion. It has not yet been fully investigated, but we think it was the ship's tool bag. It was very large and was adhering to the side of a boulder that was in the middle of the site. We separated it from the boulder using a car jack and then raised it to the surface with a lifting-bag.

The reason we thought it was a tool bag was because of its shape and size, and because when it was raised we found, directly underneath, a set of carpenter's calipers. At first we did not know what it was. Back at the headquarters building they were taken into the conservation lab where we all gathered around to have a look. We were all perplexed (for after all nothing like this had ever been found before) then one of the team looked up and saw a set of calipers that had been left further down the table by one of the draughtsmen. It was he who spotted the likeness. In fact the heads of our modern calipers and those we had just excavated were almost identical, except that the modern ones were made of stainless steel.

Several scholars have since seen them, and, because of their intricate, sophisticated nature, their first reaction was always that they must be contaminated from more recent times. This, however, is impossible; first because of the closed context from which they came, and second, because under oblique light one can see the remains of an inscription in Archaic Greek script.

Un Relitto a Punta Lazzaretto, Isola Del Giglio: Considerazioni Preliminari (A Wreck at Punta Lazzaretto, Island of Giglio: Preliminary Considerations)

MENSUN BOUND

From 1982 to 1986 Oxford University mare conducted excavations on a wreck of possible etruscan origin which can be dated on the evidence of the pottery to C.600 B.C. The remains of the vessel were situated in 50m of water at the base of a reef in campese bay, island of Giglio, North Italy. The vessel contained painted pottery of Corinthian, Loconian, Samian and Etruscan manufacture. The amphorae came from Eturia, Samos and east Greece and contained Pitch, Olives, oil and wine. The metal finds consisted of helmets, arrowheads, tools, metal ingots and lumps of copper. The wooden finds included pieces of inlaid furniture, musical pipes, a pair of calipers, a carved lid, and a writing tablet. Ivory objects, a silver jug and pieces of uncut amber were also recovered. The hull itself was of sewn construction. The giglio ship is the most important wreck to be found from the archaic phase of mediterranean history.

DEL GIGLIO, ITALIA: CONSIDERAZIOI PRELIMINARI

(Pls. 12 – 17 Fig. 1-5)

Durante i mesi di giugno e luglio del 1986, l'Università di Oxford Mare sotto la direzione dello scrivente è stata impegnata nell'esame di unrelitto con anfore greco-italiche a Punta Lazzaretto sul lato di levante dell'Isola del Giglio, poco a nord di Giglio Porto. Il luogo fu mostrato per la prima volta a Oxford da un subacqueo fiorentino Mario Galasso, nel 1985, mentre l'équipe era impegnata nello scavo del relitto arcaico nella baia di Campese all'altro lato dell'isola

Illuogo era conosciuto dai sommozzatori da circa trent'anni, manonostante fosse stato ben esplorato rimanevano profonde sacche disabbia che speravamo potessero contenere informazioni utili a ricostruire una credibile planimetria dellanave.

Da un certo lato i risultati sono stati scoraggianti, perchéi clandestini ed i cercatori di souvenir avevano, nel corso degli anni, rastrellato il luogo in modo tale che, sebbene si sia rimossa una grande quantità si sabbia con la sorbona, non abbiamo trovato il genere di informazioni che speravamo. C'erano grandi quantita di cocci, ma quasi tutti i frammenti di valore diagnostico erano stati asportati.

Nondimeno, il tipo di lavoro fatto a Lazzaretto è stato utile: stiamo perdendo la battaglia contro i clandestini ed è importante aver salvato ciò che era in nostro potere del patrimonio sommerso. C'è ancora untragico numero di luoghi di naufragio come Lazzaretto in tutto il Mediterraneo che non può essere ignorato. Ogni cosa che può essere recuperata da essi e inserita come documentazione permanente nelle pubblicazioni archeologiche è un servizio per il sapere.

Abbiamo spšō una considerevo le somma di denaro per il relitto di Lazzaretto, ma guardando indietro posso vedere che lo stesso risultato poteva essere conseguito praticamente senza spese, con un piccolo gruppo di circa otto persone con il solo equipaggiamento di un gommone e di un compressore: per piccoli gruppi di subacquei autorizzati, alle dipendenze di oro proficuo che può essere fatto in posti simili a Lazzaretto e che non costerebbe più di un'immersione difine settimana.

Campioni di cocci rotondi ed altri reperti provenienti dal relitto di Lazzaretto ci aiutano tutavia a datare l'affondamento al II sec. a.C.

Ciò che caratterizza questo sito è la rimarchevole varietà dei reperti. Nessuno dei frammenti che sono stati recuperati era dello stesso tipo diargilla. Alcuni pezzi sembravano appena fabbricati, altri erano consunti e sbeccati come se fossero stati usati molte volte.

Il relitto di Lazzaretto appartiene al periodo in cui le anfore venivano prodotte in grandi quantità per le maggiori correnti commerciali. Così quando esaminiamo le anfore provenienti da altri relitti greco-italici conosciuti, di solito troviamo che nel raggio del gruppo del relitto l'argilla è di un tipo molto omogeneo. La grande diversità della qualità di argilla nel relitto di Lazzaretto sembra indicare, quindi, un frequente riciclaggio di anfore; il che ci porta a concludere che la nave non era adibita al trasporto su una delle rotte maggiori, ma che invece svolgeva unservizio di traffico locale costiero.

Altri siti greco-italici noti nell'I-sola del Giglio si possono trovare a Punta del Morto, le Scole ed a Gallinara, sempre presso Lazzaretto: tutti questi fondali sono stati estensivamente saccheggiati.

Durante il periodo delle operazioni a Lazzaretto siamo stati condotti a visitare, appunto, la località Le Scole da sommozzatori austriaci in vacanza. Abbiamo trovato che questa area era ricca di anfore greco-italiche datate fra fine IV inizi

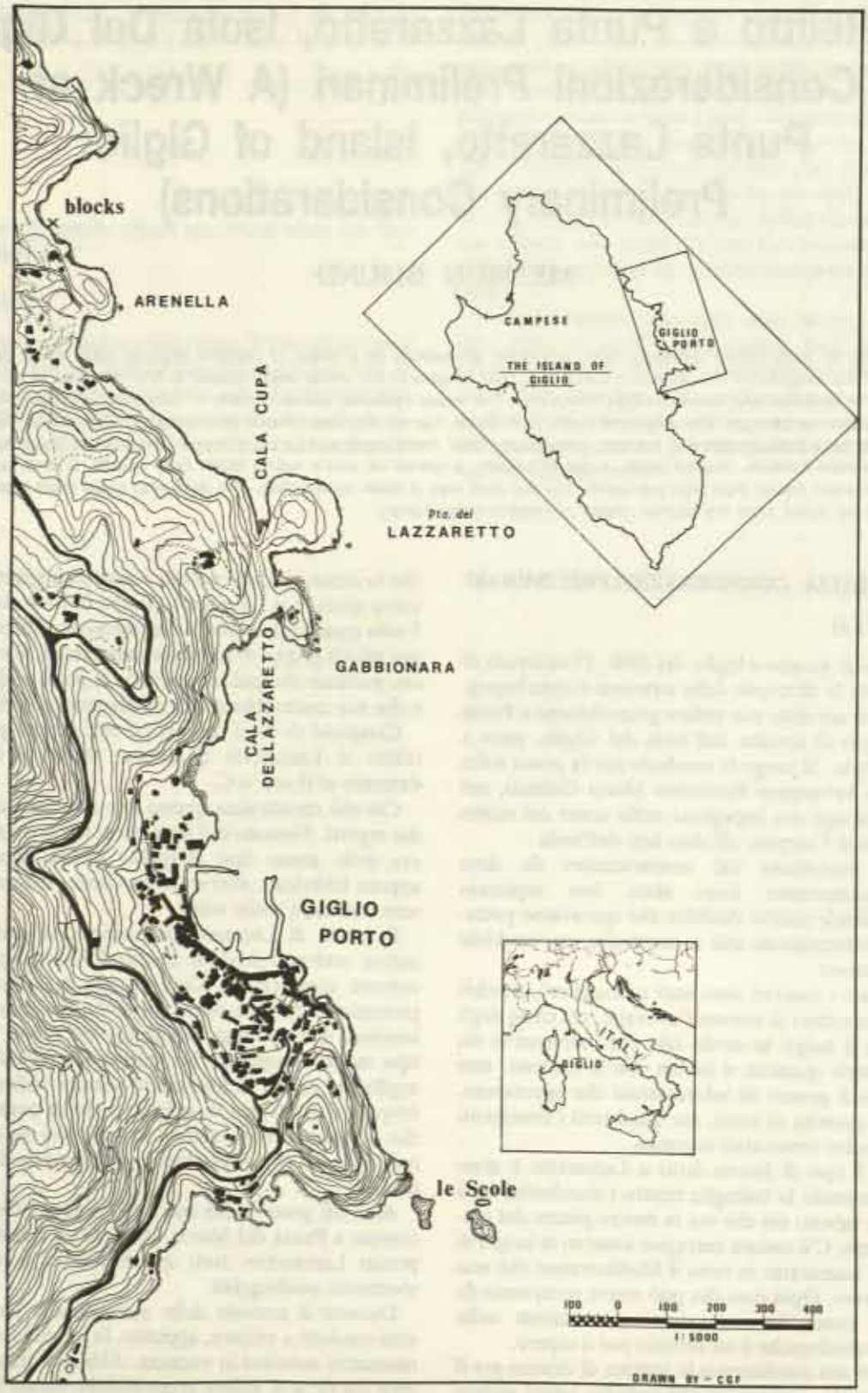
blocks
ARENELLA
CALA CUPA
Pta. del
LAZZARETTO
GABBIONARA
CALA DELLAZZARETTO
GIGLIO PORTO
le Scole
CAMPESE
GIGLIO PORTO
THE ISLAND OF GIGLIO
ITALY
GIGLIO
100 0 100 200 300 400
1:5000
DRAWN BY - CGF

Fig. 1

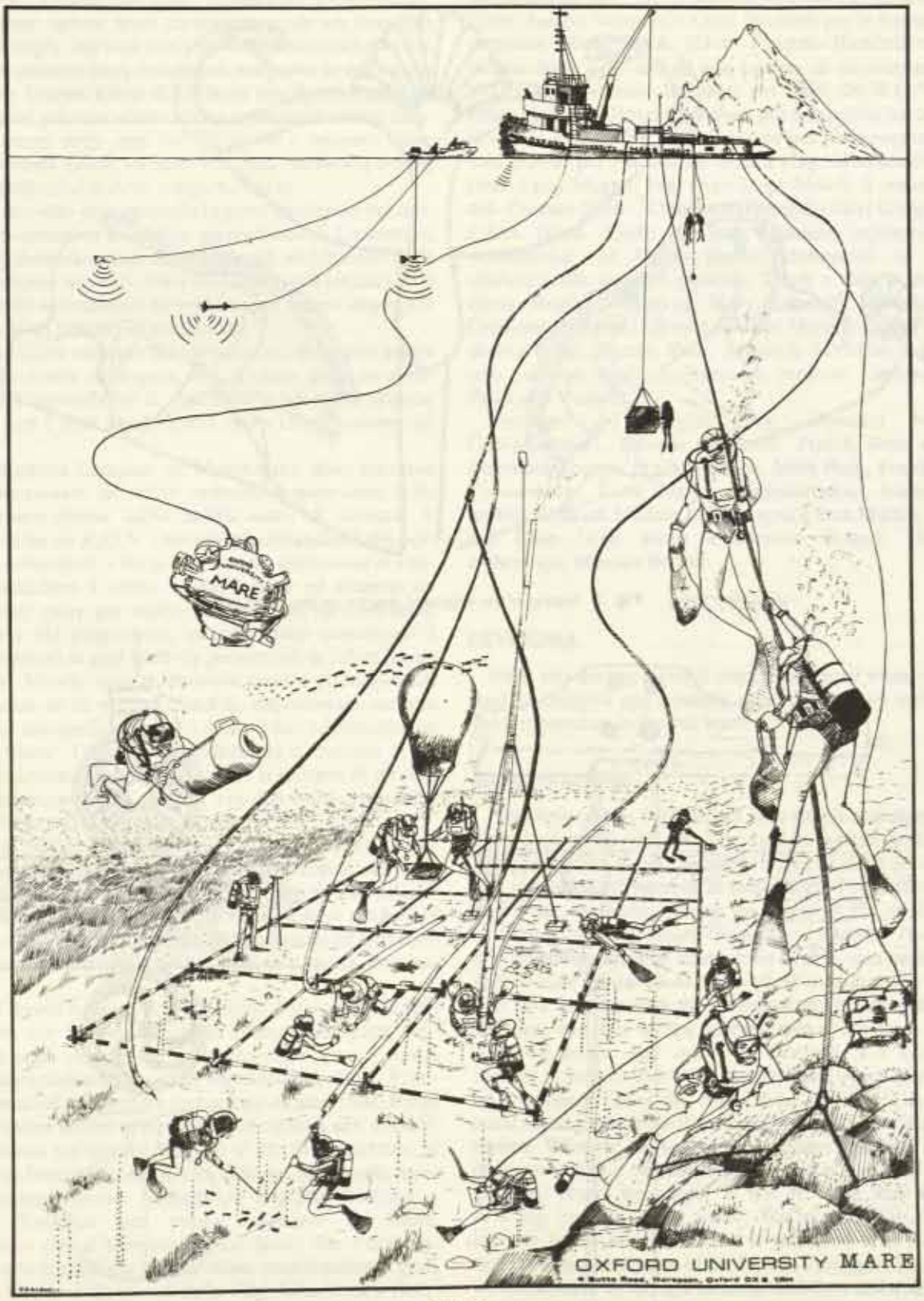

Fig. 2

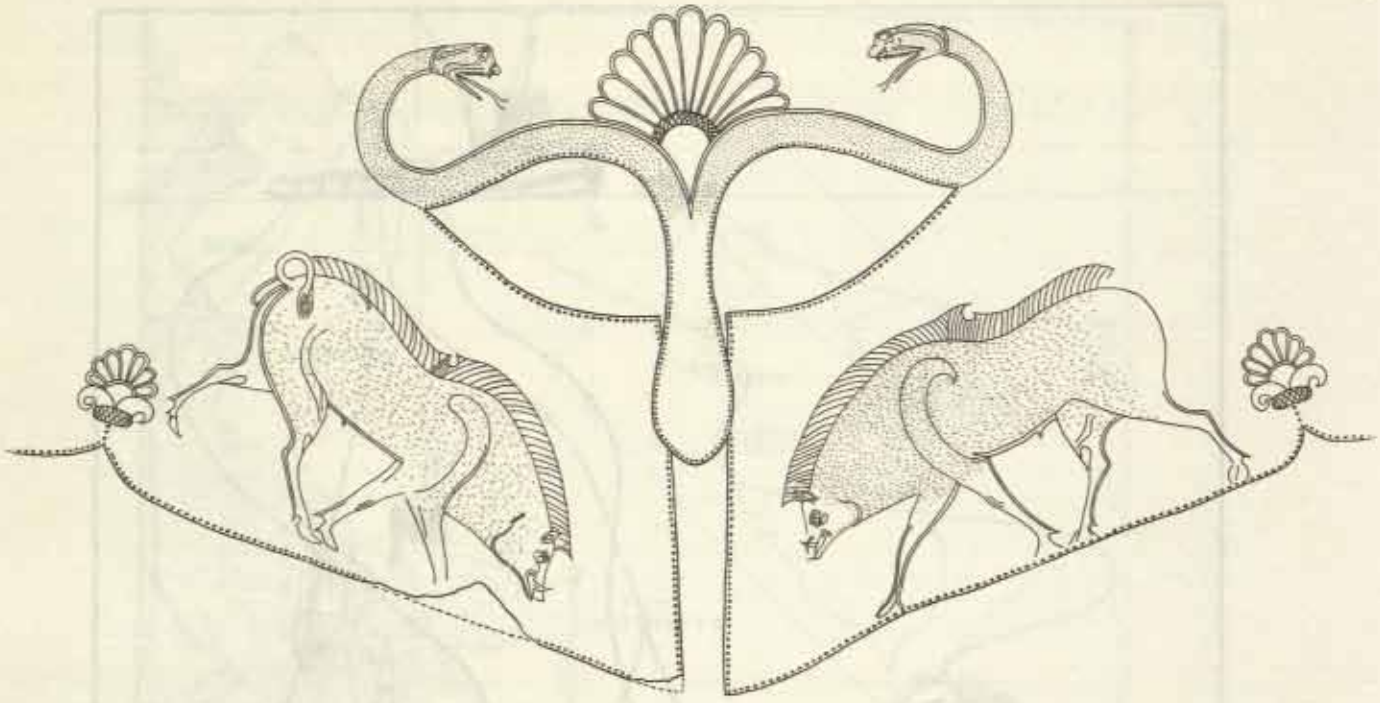

Fig. 3 Tracing of the engraved designs on the Giglio helmet.

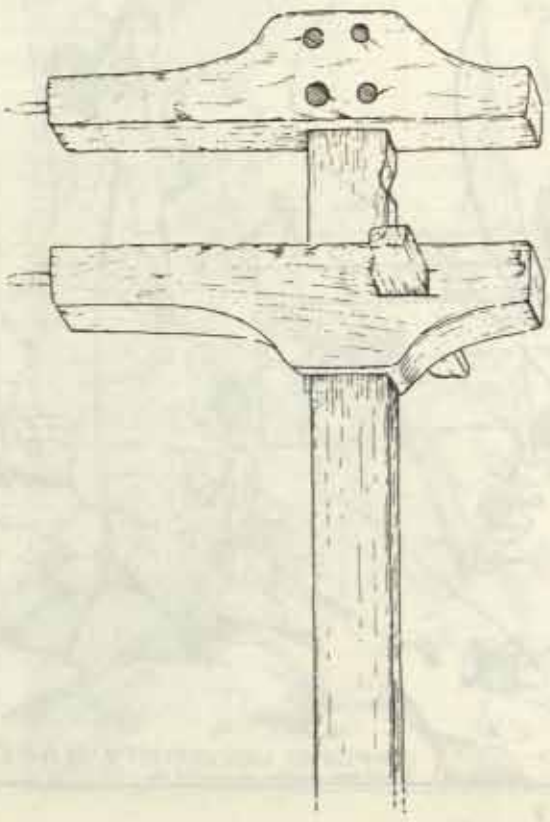

Fig. 4 Wooden Calipets from the Giglio Ship.

Fig. 5 Giglio ship.

III sec. a.C. (prima fase della produzione greco-italica). Queste prime anfore sono caratterizzate da un corpopiù corto e più largo, una base concava, una imboccatura svasata ed una ben definita linee orizzontale nel punto in cui il collo è più streto. Questo relitto di Le Scole non deve essere confuso, però col più conosciuto relitto contenente anfore cilindriche scoperto negli anni dal '50 al '60 e rapinato quasi immediatamente (vedi: Rendini P., 1982, *Archeologia Subaquea*, in Bollettino d'Arte, suppl. 4, 50-51).

Mentre stavamo concentrando la parte principale del nostro gruppo operativo sul relitto greco-italico di Lazzaretto, un piccolo distacca-mento ricercava negli altri fondali della Baia di Campese un relitto rinvenuto nell'ormai lontano 1970 da un piccolo sottomarino biposto; a quel tempo impiegato nella zona in un lavoro per acquedotto.

Abbiamo avuto successo nel ritrovamento del relitto grazie ad una telecamera subacquea, ma, a causa della poca visibilità e dell'impossibilità di registrare le immagini apparse sul video, non è stata possibile una esatta identificazione del reperto.

Essendo giunta Campese da Montecristo, dove eravamo stati ad ispezionare un relitto romano, disponevamo della nave «Corsaro Nero» adibir nostra «nave di ricerca». A bordo avevamo un R.O.V. (veicolo telecomandato) che portava delle telecamere. Con questo sistema speravamo di riuscire a rilocalizzare il relitto in alto fondale ed ottenere un film da poter usare per studio. Il maltempo ha complicato questa parte del programma, ma nell'ultimo pomeriggio il mare abbonocciò di quel tanto da permetterci di calare il nostro R.O.V. Mentre esso si muoveva appena al disopra del fondo marino ad 80 m di profondità, improvvisamente una larga forma arrotondata apparve dietro i due teleschermi sul «Corsaro Nero». Dapprima supponemmo si trattasse di un idia ma avvicinandoci costatammo che si trattava di un corpometallico ricoperto di urtanti: era una mina a contatto inesplosa della seconda guerra mondiale!

Abbiamo deciso, a questo punto, di smettere il lavoro per quella stagione. Non abbiamo avuto alcun successo nell'ottenere il film del relitto di alto fondale, ma non abbiamo desistito e speriamo che, con un R.O.V. e technologie similari, is possa essere in grado di studiare questo relitto ed altri consimili, interessanti proprio perchè fuori portata dei clandestini.

Tutto il lavoro a Lazzaretto del Giglio è stato fatto in collaborazione con la Soprintendenza Acheologica della Toscana ed è stato patrocinato da Archaeolgia Viva. I nostri piùvivi ringraziamenti vanno al sopritendente Dott. Francesco Nicosia ed all'ispettore archeologo di zona Dott. Paola Rendini. Siamo inoltre particolarmente riconoscenti al Dott. Mario Galasso per averci mostrato il sito di Lazzaretto; al prof. Mario Brandaglia per averci indicato due blocchi marmorei sommersi presso Arenella ed a Franz Wittholm e Reinhart Tausches per averci segnalato le anfore greco-italiche che si trovavano a Le Scole. Per l'equipaggiamento e la consulenza tecnica siamo profondamente grati alla Atlas Copco di Belgio ed Italia (Sig. John Cook e Dott. Mario Borsa) per l'uso di uno dei loro copressori; alla Pirelli (Dott. Sandro Veronesi e Clara Borzoni) per la donazione di gommoni. Rana S.p.A. (Dott. Faustolo Rambelli e Dott. Franco Nani per l'uso di una camera di decompressioine; STO (Dott. Antonio Bottiani) per l'uso del R.O.V.; Sig. Felice Rum dell'Hotel Saracenao per l'uso della barca «Corsichino»; il Club Zug della Svizzera per l'equipaggiamento; Tesi S.p.A. per l'assistenza tecnica (Ing. Mariano Nebiolo; Dott. Luigi Magno, Ing. Gian Luigi Sacco); il comandante del« Corsaro Nero», Claudio Varagnole; Coltri Compressori d'Aria (Dott. Coltri ed Ing. Gabriele Ingrosso) J.W. Automarine. Al Giglio siamo riconoscenti in ordine alfabetico alle seguenti persone: Trudy e Gigi Brandaglia, Elena Brizio, Filippo e Waly Fanciulli, Antonio Fei, Gerolamo Lubrani, Granco e Miria Merlini, Mario e Margherita Rossi, Nunzio Rum, Armando Schiaffino ed il Circolo Culturale Gigliese, Francesco Seratoni, Giuliano Tosi, Pier Luigi Vassallo.

Direttore dei progetti, Ing. Massimo Nebiolo: Capi-palombari, Thomas Cockerell, Franck Betts e Dave Dawnson. Disegni di Chris Fitton, Mike Haig, Frank Betts; Conservatore, Dave Stubbs; Amministratore, Joanna Yellowless; Ufficiali Medici, Luigi Magno e Stan Maihin; Fotografi Gian Luigi Sacco e Mensun Bound; Direttore archeologo, Mensun Bound.

DISCUSSION

DEVENDRA

What was the big metallic object you found when you first used the detector and secondly what is seur plank technology and is it based on carbon or lead?

MENSUN BOUND

Yes, it is carbon built. It is a very simple structure. It is a plain keel of 18×22 cm. The keel is rabited with simple V-shaped rabits down the upper edges of the keel and into that is fitted a garboard of 26 mm. width. The garboards are of 3.8 cm. thickness. Along the edges of the strakes they have made little notches of the width of 2 hands. The idea of a V-shaped notch is to allow them to drill scan angle. They drill into the inboard side of the plank in such a way that the drill hole comes out on the seam just on the inboards side of the seam and then on the opposite side of the seam. On the adjoining strain they make an identical drill hole, then through those two holes they put the coral which turns out to be a mooncot. Then the entire thing is notched over. The metal object is one of the three artifics that have not been investigated. What we think it was is the ships tool bag. And the reason we think it was the ships tool bag is because it was the last ship object we raised. It was very big and was near to a big boulder under water. The reason that it was so big and heavy and the reason it was shed to a boulder is that it was not in danger of the looters I thought. This is what we could leave to the last moment and then unfortunately at

the very last moment, we had a tragedy. One of our divers had a heart-attack and died at 50 and it was the last object we raised. We brought that tool and rather interestingly by taking a car jack under water and fitting the car jack between the concretions and the boulder and forcing them apart. That was the only way we could separate them. Then we removed them with lifting bags and found directly underneath two little saws beautifully hand-carved such as I have never seen before. I was not there at the moment. I was working at the large headquarter building and they were brought into the conservation. All the people gathered around and somebody said Mensun; what are they?" and at that moment I did not know. Then one of the lads in the team looked up on the sea and he had seen that one of the draughtsmen by chance had left a modern pair of callipers and they were absolutely identical in size and form except ours was made out of steel and the ancient ones were made out of wood. The scholars looked at these and the first thing they said to me is that this is to be contaminated, because they are so perfect. But we know it is not contaminated, first, because of the contacts and second when you hold it under an underwater light you see an inscription along one side in Ancient Greek script. But the whole thing was predicted upon intering pieces of wood, no metal in it at all. We have archaeological drawings of it being published in different journals. The rest of the concretions was in bad shape but we carried tools. Now it has been studied in Florence by X-rays and because there are so many items we cannot clear X-ray but later this year I will be back in the labs and one of the first things on the agenda is cutting into this for the first time.

Further Excavations of the Submerged City of Dwarka

S.R. RAO

Since 1983 the Marine Archaeology Unit of the National Institute of Oceanography is engaged in the offshore exploration and excavation of the legendary city of Dvaraka in the coastal waters of Dwarka in Gujarat. Brief accounts of the findings of the underwater search for the lost city have appeared in *Progress and Prospects of Marine Archaeology in India, 1987, Marine Archaeology of Indian Ocean Countries, 1988, 40 years of Research - A CSIR Overview, 1988 and Journal of Marine Archaeology, 1990*. The present paper deals with the more significant results of further excavations in 1988 and 1989 and discusses archaeological and literary evidence for the identification of the port city of Dvaraka of the protohistoric period. It also draws attention to the scientific data available from the underwater excavations in the Arabian Sea and the Gulf of Kutch.

A brief account of the discovery of the submerged city of Dvaraka of *Mahābhārata* fame and the salient features of the structures exposed as a result of underwater excavation conducted at Dwarka and Bet Dwarka by the Marine Archaeology Unit of the National Institute of Oceanography under the direction of the author from 1983 to 1987 appeared in 1988 (Rao, S.R. 1988, 47–53). Offshore exploration of the legendary city at Dwarka was resumed in 1988 and continued through 1990, further seaward of the Temple of Samudranārāyana (Sea God) at Dwarka with a view to trace the plan and extent of the port-city and the purpose of the massive stone walls built on the banks of ancient Gomati. It was also necessary to ascertain whether its architectural features were in conformity with the description of the city of Dvārāka given in the epic *Mahābhārata*. A second object was to obtain more corroborative evidence for reclamation referred to in the epic. Thirdly, the nick point where the ancient Gomati river joined the sea had to be determined. Lastly, the cause of submergence of the city was another problem that needed further investigation.

Onshore and offshore excavation in the island of Bet Dwarka which, according to tradition, was the resort of Śrī Krishna was resumed in November, 1987 and continued through 1988. The main objective was to trace the landward extension of the submerged protohistoric township near Balapur Bay where, in the intertidal zone a submerged wall had been traced in the earlier expedition (Rao, S.R. 1988, 49).

VI MARINE ARCHAEOLOGICAL EXPEDITION AT BET DWARKA

The trenches dug by the Public Works Department in the 'Talao' area near Balapur village for building an earthen embankment were examined, but no remains of any protohistoric settlement came to light confirming thereby that there was no landward extension of the ancient town. Most part of the ancient township was swallowed by the sea and the mud flats of Balapur extending over 1 km seaward had buried the ancient relics. One Trench (A) to the south of the Old Custom House, and the other Trench (A1) in the intertidal zone at the foot of the Custom House mound were sunk to establish the sequential relationship between the two sectors of habitation. (Fig.1) The short duration of 3 or 4 hours at low tide when land was exposed near the shore, rendered excavation in clayey deposit very difficult. Even so, a rubble foundation, 35 cm broad, and a few sherds of a large storage jar lying on the floor of the house were exposed in Trench A1. Several worked columella of conch shell found lying in a line suggested that the house belonged to a shell-worker. Excavation had to be abandoned after digging to a depth of 20 cm because of high water table in lowest tide also. Trench A1 was however extended on the west and the extension was marked XA1, but no structure came to light. Layer 1 of trench A1 is surface humus, layer 2 consists of fine grained silty sand mixed with shingle and layer 2A, where shells and pottery are found, is darkish clay. No pottery was found in layers 2 and 2A of XA1.

A trench 2 × 2 m was laid above the rain gully in the Custom House mound to ascertain the cultural sequence. In all, 10 layers were distinguished. Layers 1 to 4 upto 1m depth yielded Muslim glazed ware and red ware of early medieval period. In Layers 5 and 6 in 1–1.3m depth the Red Polished Ware assignable to the first five centuries of the Christian era was found. One sherd inscribed with the letter *sya* meaning 'of' in Brahmi characters of the 1st-2nd century A.D. was recovered. Layers 8-10 yielded a few sherds of the Lustrous Red Ware and coarse red ware of the post-Harappan phase. Natural soil could not be reached. A large number of shell bangles and a couple of worked columella were found in the medieval and early historic deposits. A bead of fish bone is the only find from the post-Harappan deposit. It was decided to postpone to a later date the excavation of the intertidal zone and the mound further north of the earthen embankment of the Talao where Late Harappan pottery has been found.

MASSIVE STONE PROTECTION WALL-CUM-PIER IN BDK VIII

In the course of exploration of the near shore and intertidal zones south of Balapur Bay on 4th January, 1988 Mr Rajan, diver-archaeologist and Mr Sirsath, photographer discovered a massive rubble wall exposed in lowest low tide and the site has been designated as BDK VIII (Pl. 18–19). The wall remains submerged at high tide under a column of 2 m water above its top. Excavation was conducted on both the sides of the eastern arm of this structure on the 9th and 10th January in order to expose to full extent the height of the structure and determine the nature and purpose of constructing such a large enclosure which is 558 m in its peripheral length. (Fig.2)

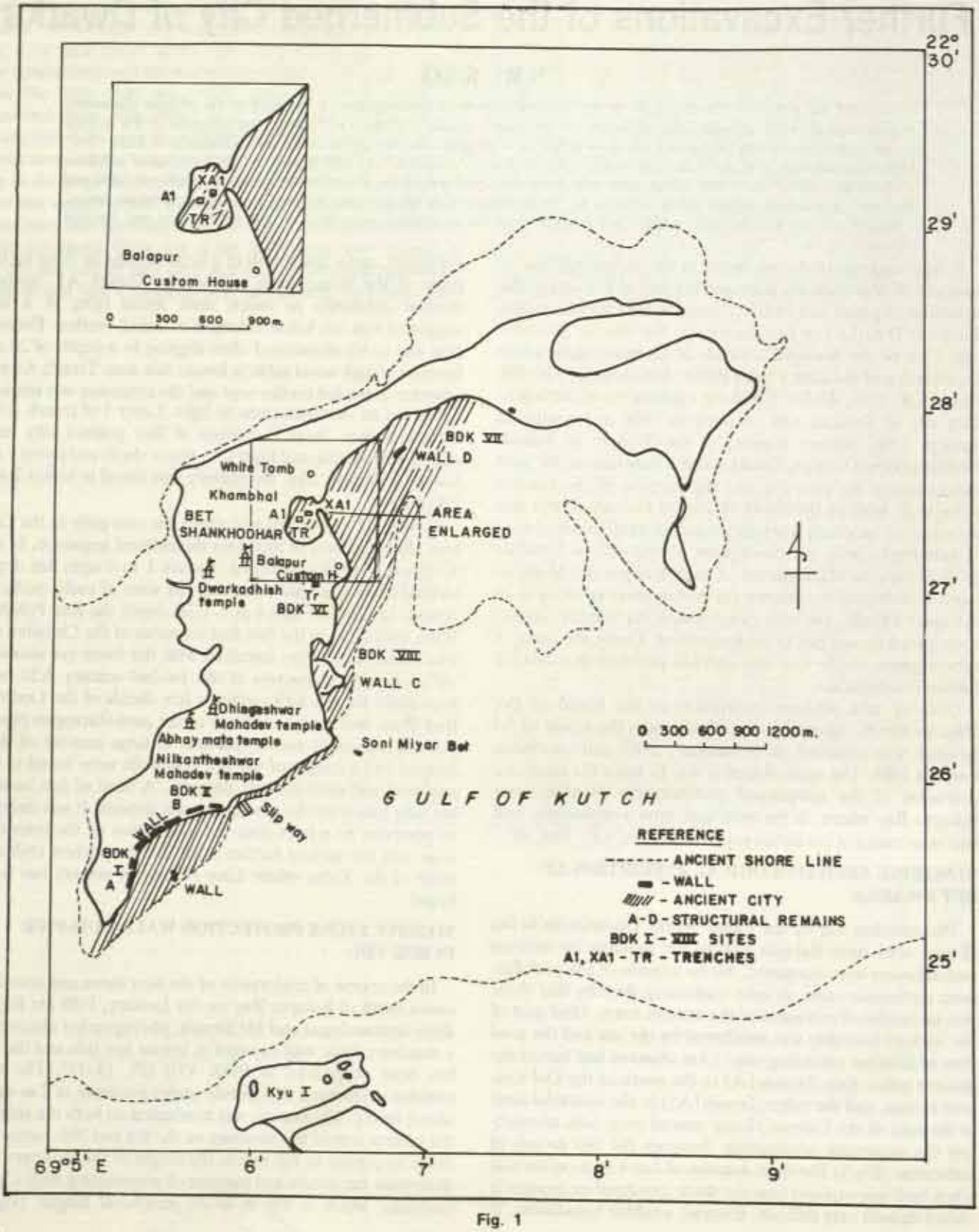
22° 30'
29'
28'
27'
26'
25'
69°5' E
6'
7'
8'
9'
A1
XA1
TR
Balapur
Custom House
0 300 600 900m.
BDK VII
WALL D
White Tomb
Khambhal
BET SHANKHODHAR
AREA ENLARGED
Balapur Custom H.
Dwarkadhish temple
BDK XI
BDK VIII
WALL C
Dhingeshwar Mahadev temple
Abhay mata temple
Nilkantheshwar Mahadev temple
Soni Miyar Bet
0 300 600 900 1200m.
GULF OF KUTCH
BDK X
WALL B
Slip way
BDK I
WALL A
Kyu I
REFERENCE
ANCIENT SHORE LINE
WALL
ANCIENT CITY
A-D - STRUCTURAL REMAINS
BDK I - XIII SITES
A1, XA1 - TR - TRENCHES

Fig. 1

Trenches measuring 1×1.2 m were laid on its southern and northern faces. In all, 9 courses of dressed and undressed stones, of which 4 courses are covered by silty clay deposit were traced The wall was constructed on the bed rock. The stone masonry is heavily incrusted with barnacles and other sea organisms. It is very difficult to remove the incrustation without chiselling it. Originally the wall must have been atleast 2.5 to 3 m high. Presently it is only 1.5 m in height. The enclosure wall is an irregular hexagon on plan. An interesting feature of construction is the use of wedge-shaped blocks of stone for the shell, while the core is made up of rubble-filling. That the structure is man-made becomes apparent from the use of dressed stones closely laid and also from the box technique of construction. The thickness of the wall at the base is 2.5m while the extant tapering top is 1.5 to 2m thick. The pottery found in the trench is coarse grey ware but heavily rolled resulting in the disappearance of the slip and decoration if any. Only one sherd of the sturdy red ware of the post-Harappan phase was found in the extremely small trench. Provisionally the structure is datable to 15th century B.C. on the basis of the sturdy red ware. Within the enclosure there must have been very important public buildings – may be warehouses and other structures relating to shipping, for, not far from here are two rock-cut slipways for launching boats. The massive protection wall could have also served as a pier.

DWARKA

The Research Vessel *Vedhavati* arrived on 31st December at Dwarka duly equipped with diving gear, echosounder, heavy compressor, airlift etc. For the next three days Sri. Srinivasa Bandodkar, Chief-diver-photographer and other divers and diver trainees searched for and cleared the submerged structures of the ancient city exposed in the earlier expeditions. They were found partly disturbed and partly covered by sediments and vegetation. Swells and currents had disturbed a few blocks of the top courses of walls. They were photographed and marked by fresh buoys. New areas beyond 500 m seaward of the Samudranārāyaṇa temple were explored and the thick growth of vegetation on ancient buildings were removed. On 3rd January a small stone structure was found 200 m north of buoy 35, and the overburden of 2–3 m thickness was airlifted before exposing the topmost course of dressed stones. Lying nearby is a partly damaged bastion which is semi-circular in plan (Pl. 20). The dressed stones used in its construction are 1–2 m long 0.3 m thick. A lunate-shaped dressed block appears to be the *chandraśilā* (moonstone of a temple).

Two stone walls, one each near buoys 40 and 41, were laid bare (Pl. 21-24). The stones used in the construction are 1 to 2 m long, 0.5 to 0.7 m wide and 0.3 m thick. All structures near here are gridded and their position is fixed by sextant. Excavation in layer 3 yielded a sherd of a miniature bowl with everted rim in Lustrous Red Ware of Rangpur III type. The slip has however completely disappeared and the core of the fabric has a pitted surface due to wave action. The sea became choppy and the currents strong from 15th to 21st January and the boats were heavily rolling. In an attempt to reach the shore the crew of the dingy was thrown out by heavy breakers but there was no serious injury to anyone. Underwater exploration was suspended for 3 days and limited search was undertaken next 3 days. In the solstice (14th January) arbital movements seem to be responsible for the abnormal roughness of the sea with waves breaking 3m high near buoy 19 and causing considerable damage to ancient structures in the sea bed. Taking advantage of the lowest tide – 0.12 (Okha) on 21st January the sea bed of nearshore zone from Samudranārāyaṇa Temple to the Light House was surveyed. Some well dressed architectural members including a semicircular moonstone *(chandraśila)* of a public building were exposed 30m seaward of Samudranārāyaṇa indicating the existence of an earlier temple. Two rock-cut channels were also exposed to the north of Samudranārāyaṇa. A few iron rings fixed in the wavecut bench at the foot of Samudranārāyaṇa indicated that small boats could be ferried through the rock-cut channels from the sea and river channel and secured to mooring rings in the early centuries of the Christian era.

A pier-like structure was exposed on the left bank of the channel opposite buoy 35 and the construction suggests that it could be used as a jetty or quay on the river bank, for several triangular and prismatic stone anchors were found lying nearby. Further seaward a large area was searched manually and buoys 41 to 54 were placed to indicate the location of structures or anchors. On the left bank 3 anchors were found near buoy 53, one each near buoys 50 and 51 and three more near buoy 55. Trench 15 was laid near buoy 53. Airlifting was done near buoy 54 for collecting samples. Layer 1 consisted of fine sand; layer 2 was slightly coarse sand, and layer 3 consisted of coral and shingle covering bed rock. The total thickness of sediment is 1 m. A sherd of a large sturdy jar and stem of a dish-on-stand were recovered from layer 3. Two bastions were exposed near buoy 59 on the right bank and Trench 12 was sunk here for obtaining stratigraphic evidence and pottery for determining the age of the structures. Stone anchors found near buoys 45, 46, 47, 48 and 51 have been documented. A large single-holed semispherical stone base of a flag post (Fig. 3) was found *in situ* near buoy 48. It is 53 cm in diameter at the base and the height is 30 cm.

The larger triangular 3-holed anchors are 63 to 95 cm in length, 43 to 50 cm broad at the base and 25 to 29 cm at the top (Fig. 4). The prismatic anchors are 1.2 to 2.3 m long, 33 cm broad at the base and are tapering at the top.

Excavation near buoy 35 yielded a copper *lota* and a white marble statue with broken legs, but the rest of the body is missing. A pedestal of black stone with 4 pointed feet for embedding in the earth may be an altar and it is doubtful if it was used as quern because there is no depression caused by rubbing Farther away near buoy 55 on the left bank a trench (15) was sunk and the sediments were removed through fanning action. It is here that a copper bell and brass parts of what looks like a miniature chariot (Pl. 26) were recovered. The perforated arches might have supported a canopy of a

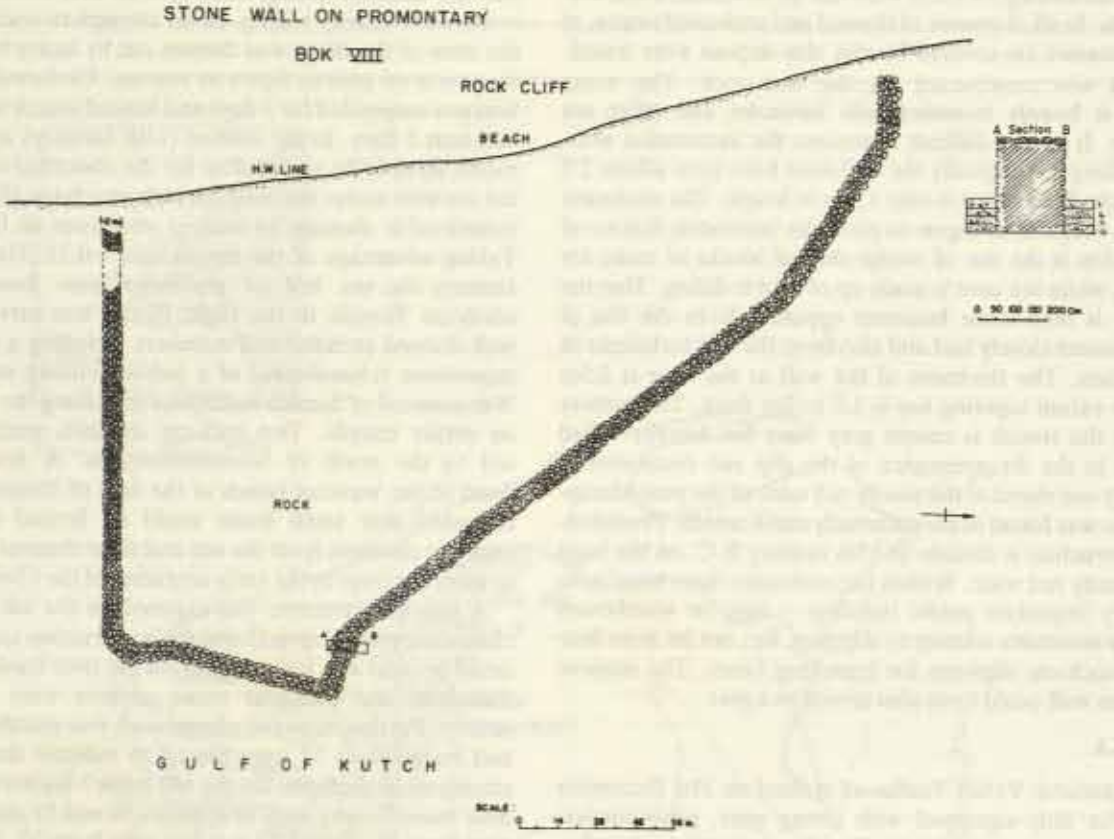

Fig. 2

STONE BASE OF FLAG POST DWARKA

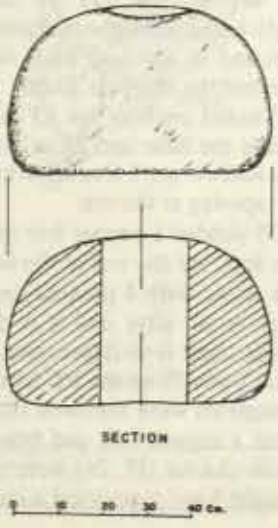

Fig. 3

STONE ANCHORS IN DWARKA WATERS

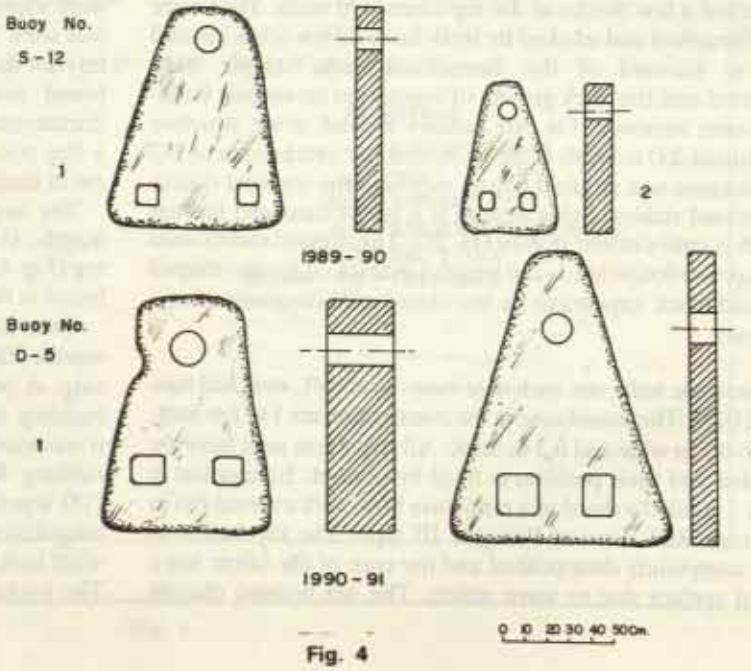

Fig. 4

wagon type chariot. As revetting was known to the Harappans it is no wonder if the metalsmith of protohistoric Dwarka could also revet the bars and drive holes in the brass-like metal. The metal objects of the Dwarka chariot are found to be made of brass. Unfortunately very little information is available on the antiquity of brass before 300 B.C. at Taxila and at Prakash in the late phase of NBP. The brass from Prakash is either copper-Zinc alloy (17.75% Zinc, remainder copper) or leaded brass (25.86% Zn, 8.34% Pb and remainder copper). Lead was used in Lothal in 2000 B.C. as can be seen from two lead pieces one containing 91.42% and the other 99.54% pure. The sleeved axe of Lothal contains 96.27 copper, and 2.51% lead, while the grooved rod contains 57.75 copper, 9.02% tin and 3.31%. The advanced metal technology can be inferred from the use of iron stakes in Bet Dwarka to which reference is made in the *Mahābhārata*. Ancient Indian steel dates back to 600 B.C. at Rajghat (Bharadwaj 1984, 143), but iron technology was developed by 1500 B.C. at Dwarka in Gujarat and at Gufkrol in Kashmir (A.K. Sharma in this volume).

The presence of several structural remains between buoys 51 and 55 and also between 51 and 53 necessitated gridding the entire area for purposes of preparing the site plan of the township. Further west near buoy 59 a stone pillar with a square base and cylindrical shaft was found in the seabed. It is indicative of the fact that a public building of religious or secular importance existed here. Two triangular anchors were found near buoy 58 and a single-holed anchor was traced near buoy 53.

In the absence of Mini Ranger III needed for very accurate fixing of positions, the sextant was used and checked with the distances between structures measured manually. For instance, buoy 53 is about 1200 m from Samudranārāyaṇa and the bastion of inner gateway (str.1) at buoy 35 is 200 m seaward of buoy 8 which itself is 200 m seaward of Samudranārāyaṇa. The bastion of the outer gateway is near buoy 59. The position of buoys especially those marking bastions, gateways and protection walls had to be rechecked subsequently with the help of Mini Ranger III.

Two coils of steel wire lost by a boat in comparatively recent times were found near buoy 35. As they were heavily damaged their retrieval was not attempted. A large prismatic anchor 137 cm long was recovered from the station marked by buoy 46. Rajan took soundings at 50 m intervals along the banks of the Gomati channel and across it also for studying the gradient and width of the channel, but these had to be further checked with the echosounder readings at closer intervals.

EXPEDITION 1989–90:

The main purpose of the expedition was to determine the limits of the submerged city and the nick point where the Gomati joined the sea 3500 years ago when Dwarka was built. This could be achieved by echo-sounding, side scan sonar and shallow seismic profiling surveys which could indicate anamolies and provide the bathymetric data. Simultaneously through optical and manual surveys the anamolies could be examined to distinguish man-made constructions from natural formations. It was also felt necessary to fix precisely the position of structures already discovered and determine the course of the ancient channel of Gomatī river. The profiles would help to establish the shifting of the flow channel, if any. The area covered in the course of the survey is 5 × 6 km upto 25 m depth so as to include a 'spit' referred to by Pathak (Pathak *et al* 1988, 58–62).

The MFV *Sea Master* and *Sharda Devi* were engaged for exploration and survey. A dingy with outboard engine ferried between the main boats and shore. At three locations namely A4, A5 and A3 along the right bank of submerged channel of Gomati anchors were found. Southward of A5 a stone pillar and bastion were located at the station P which is gridded. At 60° southwest of Dwārkādhīsh-Samudranārāyaṇa transit line a bastion in situ (S4), a fallen bastion (S3) (Pl. 24), a disturbed wall (Pl. 25) and a large stone slab (S4) were found. Further south of S4 is another bastion (S2). These structures are in 7 m depth. Towards the west several anchors were discovered at stations A2, A8 and A11, in 8m depth. Heavy growth of vegetation on the bastions and walls had to be cleared carefully before photographing and plotting them. A very interesting feature of the masonry is the L-shaped joints in setting heavy dressed blocks of stone for constructing bastions in high energy zone (Pl. 28). Even so a couple of bastions have collapsed, but others in deeper waters namely low energy zone are in situ. Three groups of structures at S2 were gridded. A spherical anchor with 2 holes is recorded at A12, about 70° NW of the grid. The following is the resume of anchors and structural remains found in the course of the present expedition:

A1 fragmentary anchor
A2, A3, A8, A9, A10, A11, A13 prismatic anchors
A7 and A12 triangular anchors
S1, S3 wall
S2 bastion (fallen), S9 bastion in situ

Others S4 to S8 and S10 to 13 are dislodged architectural members, mainly large dressed blocks. Two iron anchors were found near A13. One of them is 1.5m long and has 5 arms.

Geophysical Survey – a summary of the results of Geophysical survey carried out by Vora's team has been received. The salient points of observation and recommendations of the team are mentioned briefly below (Fig. 5).

High resolution Marine Geological and Geophysical Surveys carried out off Dwarka for marine archaeological purpose was aimed at finding direct or indirect evidences of the existence of relics of sunken ships and submerged ports beyond the area already surveyed by MAU. Another objective was to suggest places for diving based on the data collected.

The surveys were carried out in December 1989 in 2 to 22 m water depth over an area of 5 × 2 km by echosounding, side

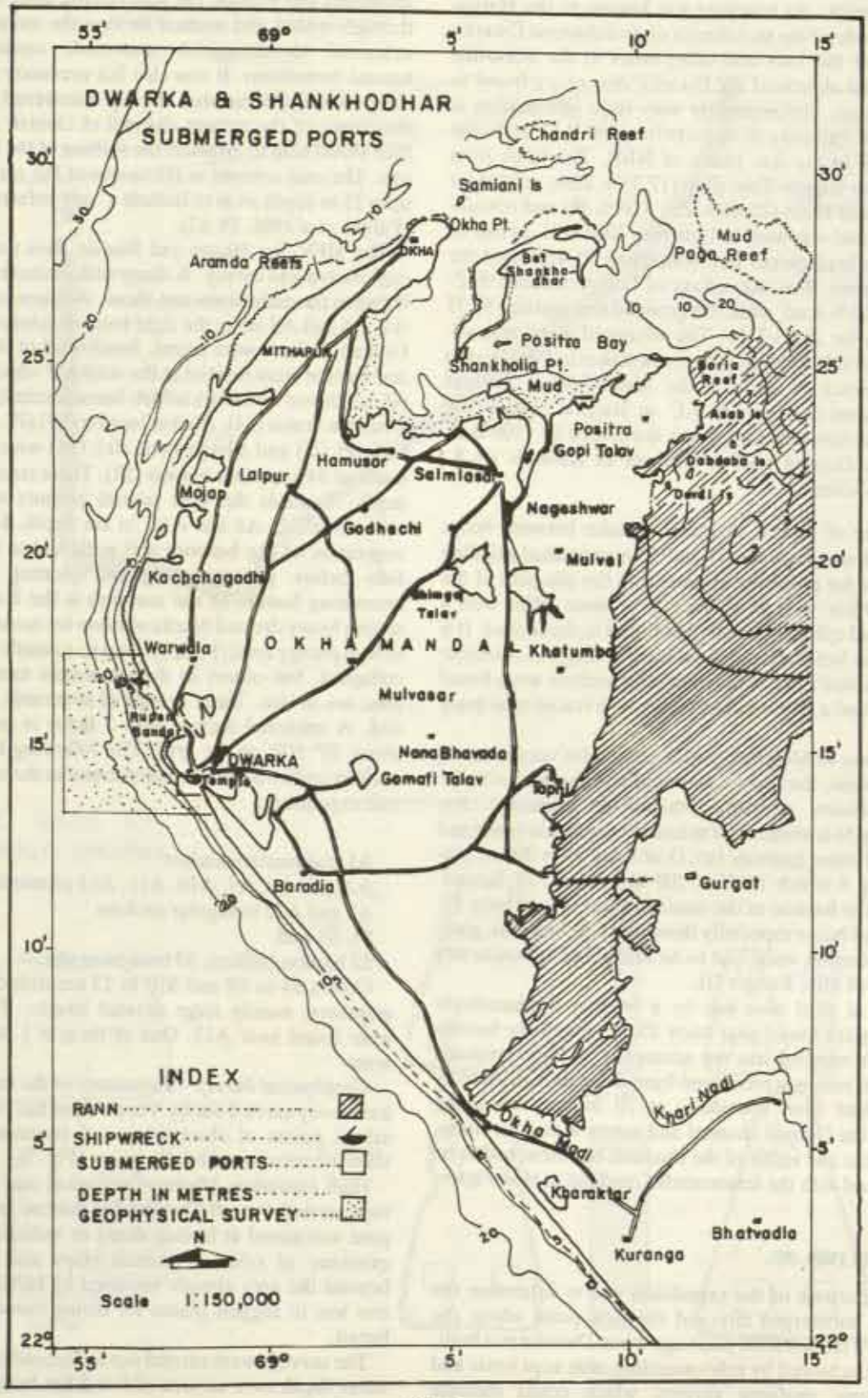
DWARKA & SHANKHODHAR
SUBMERGED PORTS
Chandri Reef
Samiani Is
Okha Pt.
OKHA
Aramda Reefs
Bet Shankhodhar
Mud
Paga Reef
Positra Bay
Shankholia Pt.
MITHAPUR
Mud
Soria Reef
Asab Is
Positra
Gopi Talav
Dabasha Is
Devdi Is
Hamusar
Salmiasar
Laipur
Majap
Nageshwar
Godhachi
Mulvel
Kachchagadhi
Khatumba
O K H A M A N D A
Mulvasar
Warwala
Rupen Bandar
DWARKA
Temple
Nana Bhavada
Gomati Talav
Baradia
Gurgat
INDEX
RANN
SHIPWRECK
SUBMERGED PORTS
DEPTH IN METRES
GEOPHYSICAL SURVEY
N
Scale 1:150,000
Okha Nadi
Khari Nadi
Kharaktar
Kuranga
Bhatvadia
55'
69°
5'
10'
15'
30'
25'
20'
15'
10'
5'
22°

Fig. 5

scan sonar and shallow seismic profiling (Fig. 5); scale adopted was 1:5000. The survey area was divided into two parts, north and south for convenience. In the northern part from Rupen port to Dwarka Light House, 45 lines perpendicular to the shore were surveyed while south of Dwarka Light House 22 lines parallel to shore were surveyed. The results of the survey indicated extension of Gomati for about 1.5 km in NE-SW direction and its channel is about 400 m wide. Apart from this channel, other submerged drainage systems were also noticed. Other Geomorphic features present in the area include scarps, terraces and pinnacles. Sonographs collected from the area show large tonal variations throughout the area which includes furrows of various sizes and directions, and at times ripples, boulders etc. The channels of Gomatī as revealed by echograms are highly significant. The present channel along the Gomatī Ghat was not the original course of the river 4000 years ago. It was to the south of temple of Samudranārāyaṇa and the channel was wider. The river seems to have joined the sea through more than one channel and the structures so far traced lie along the central channel. Nearshore, the submerged Gomati bed shows a deep wide symmetrical V-shaped channel, either side of which is at the same elevation. A small channel formation is seen to the south. Bending of contours in the area in more than 13 m water depth towards shore in southwest direction indicates a deposital phase, while in lesser contours there is a strong erosional activity. The result is that many structures built of smaller fractional blocks are destroyed in shallower waters, while those built of heavier blocks to serve as piers, wharf, protection walls and jetty are only partly destroyed and buried under 1 to 2 m thick sediment especially beyond 12 m water depth.

Though there are some anomalies present on the sea floor, nothing more could be said about them until divers verified whether they were natural phenomena or man-made objects. Shallow seismic profiles showed no penetration in the area. However five locations were given to the diving team of MAU for direct inspection. At one such point a large iron anchor was found by diver-archaeologists. Accurate position fixing of the five points with miniranger had to be postponed to the next season as the sea became rough, but the position of some of the marker buoys, where structures were discovered by MAU was fixed with sextant. The map obtained from Dwarka Municipality did not show accurately the present shore line and it is to be surveyed and redrawn for position fixing. On the left bank of Gomatī the divers uncovered three arms of a large rectangular structure (Str. 5–6) and a corner bastion (Str 7) at buoys 68–69 and 70. Opposite the inner gate way on the right bank, the width of one of the submerged channels of Gomati is 170 m. Further westward of structure 7, four 3-holed anchors were exposed.

On January 14, 1989 the wave-cut bench and iron rings fixed in it were exposed a few metres seaward of SN at lowest low tide. A mooring pillar and a fragmentary deity in black stone were recoverd from the rocky bed near the Light house. On January 21, two rock-cut channels meant for sluicing small boats were exposed to view between SN and Light House. The Iron rings and rock-cut channels belong to period II, while the protection walls, and enclosures on either bank at buoy 35 and extending 500 m seaward belong to period I. The farthest point of structural activity so far traced is about 1.2 km seaward of SN, but a plan of the city can be made out upto 800 m. A pier – like structure on the left bank where a platform which could be used for loading and unloading exists might have been the jetty for smaller boats. The terraced top of an escarpment nearly 1.5 km seaward of SN was the main anchorage for the ocean going vessels. That there existed a port-installation here is indicated by the collapsed building blocks lying scattered at the foot of the scarp but further examination of this scarp and another rock standing high further northwest will have to be made by divers for preparing the ancient limit of the port-town.

DISCUSSION

Dwarka was a city-state extending upto Bet Dwarka (Śankhodhara) in the north and Okhamadhi in the south. Eastward it extended upto Piṇḍāra. The 30 to 40 meter-high hill on the eastern flank of Sankhodhara may be the Raivataka referred to in the *Mahābhārata*[2]. The general lay-out of the city of Dvārakā described in ancient texts agrees with that of the submerged city discovered by MAU. Four enclosures are laid bare; each one had one or two gateways (Fig. 6). The port Aramda (*Árambhadvāra*) on way to Bet Dwarka was the first gateway in the outer fortifications. The bastions flanking gateways of submerged Dvārakā resemble those of Kuśinagara and Śrāvastī carved on the Gateways of Sanchi Stupa. The *prāsāda* referred to in the epic must be the high fort walls of Dvārakā a part of which is extant. The epic says that flags were flying in the city of Dvārakā. This can be corroborated by the stone bases of flag posts found in the sea bed excavation. Umashankar joshi is of the view that *antardvīpa* in the region of Kuśasthalī referred to in the *Mahābhārata* must be Bet Dwarka (Śankhodhara). The *Bhāgavata Purāṇa* says that before leaving his mortal frame Śrī Kṛṣṇa put the ladies and children in boats and sent them to Śankhodhara. Hirananda Sastry also identified the *antardvīpa* of *Mahābhārata* with Bet Dwarka.

The buildings built of smaller fraction stone blocks are razed to the ground leaving only small portions of the thick fort walls, bastions and protection walls (built with massive stones) which are too heavy to be moved by tides and currents. From the structural remains in Dwarka and Bet Dwarka waters, it is possible to visualise that the city-ports were large and well planned.

A very significant antiquity that corroborates a statement of the *Harivamśa* is the seal bearing the motif of a 3-headed animal representing the bull, unicorn and goat. The *Harivamśa* says that every citizen of Dvārakā had to carry a *mudrā* as a mark of identification.[2] The seal *(mudra)* found in the excavation belongs to 15th–16th century B.C.

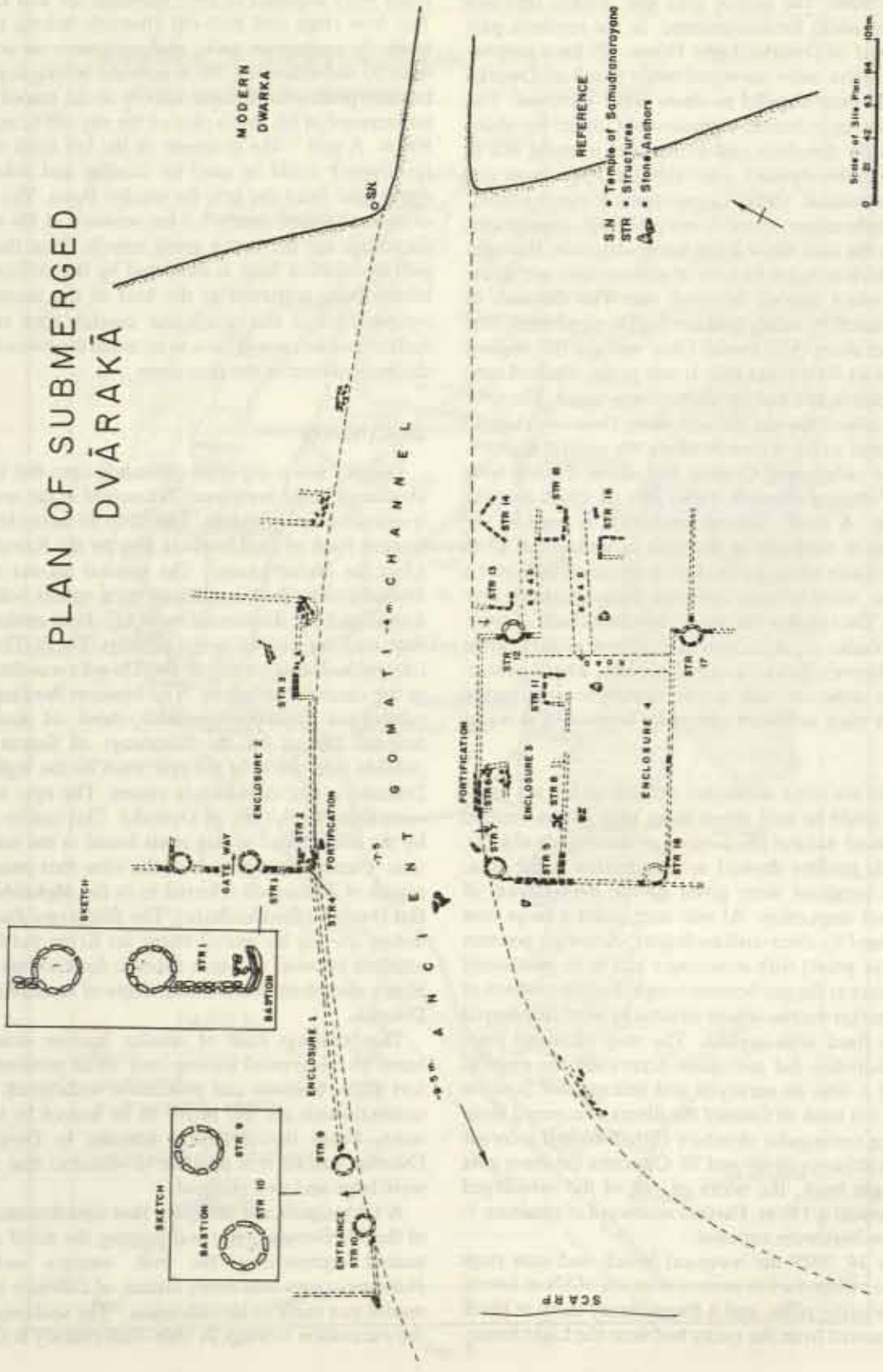
PLAN OF SUBMERGED DVĀRAKĀ
MODERN DWARKA
SN
REFERENCE
S.N • Temple of Samudranarayana
STR • Structures
⚓ • Stone Anchors
Scale of Site Plan
Structures enlarged
GOMATI CHANNEL
ENCLOSURE 1
ENCLOSURE 2
ENCLOSURE 3
ENCLOSURE 4
GATE WAY
FORTIFICATION
BASTION
ENTRANCE
SKETCH
STR 1
STR 2
STR 3
STR 4
STR 5
STR 6
STR 7
STR 8
STR 9
STR 10
STR 11
STR 12
STR 13
STR 14
STR 15
STR 16
STR 17
STR 18
STR 19
SCARP

Fig. 6

The reference in the *Harivamśa* to the reclamation of twelve *yojanas* of land from the sea for building Dvārakā has an element of truth in it, for the bastion and protection walls of Dvārakā are found built on boulder foundation. Such a technique is adopted even now for reclaiming land. When Dvārakā was built the sea level was 10 m lower with several pockets of water where boulder foundation became necessary.

The description of Dvārakā as a *nagarī* or *mahāpuri* is borne out by facts. All the features of urban planning and urban life are traceable in the sprawling fortified port-city unearthed in Dwarka waters. The prosperity of Dvārakā was due to pearl and shell-fishing as well as overseas trade. The residents were literate and used an Indo-Aryan (Sanskrit) language as can be made out from the inscription. They revered the Sea God, to which a reference is made in the inscribed jar.

The existence of a pre-Dvārakā settlement referred to as Kuśasthalī in the *Mahābhārata* is indicated by the perforated jar and chert blades in the early levels of Bet Dwarka.

The use of iron stakes mentioned in the *Harivamśa* for preventing enemy attack on Dvarakā is also borne out by the recovery of an iron stake in Bet Dwarka.

CONCLUSION:

The available archaeological evidence from onshore and offshore excavations confirms the existence of a city-state with a couple of satellite towns in 1500 B.C. That they were submerged by the sea is also proved. The *Mahābhārata* and *Purānas* refer to the submergence of Dvārakā and no other city. It is therefore reasonable to conclude that the structural remains and antiquities found seaward of the area mentioned in the epic are of the city of Dvarakā of the Mahābhārata Age. This discovery has turned myth into history. The date 16th century B.C. for Mahābhārata war may be nearer the truth if we take into account the use of iron weapons in the Mahābhārata War. The introduction of iron technology in India is datable to 16th century B.C. at Gufkrol in Kashmir.

Participants in the Expeditions

S.R. Rao, Manavi Thakkar, P. Gudigar, Sundaresh, Sila Tripati, A.S. Gaur, Srinivas Bandodkar, Alok Tripathi, Y.D. Sharma, U.S. Shirsat, Sheikh Afi, S.B. Chitare, V.M. Date, K.H. Vora, P. Marathe, V.D. Khedekar, P. Ganeshan, D.K. Naik, C. Moraes, A. Sardar, N. Gauns, B. Sree Padma.

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Harivamśa, BORI, for relevant extracts from 1 & 2 above please see *Progress and Prospects of Marine Archaeology in India*, 1987 (ed.) S.R. Rao.

Rao, S.R. (1988) *Marine Archaeology of Indian Ocean Countries*, NIO, Goa.

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DISCUSSION

Q: You have not said anything about iron objects

A: RAO: We do get iron objects in the intertidal zone of Bet Dwarka. The site has been dated to 1500 B.C. by Thermoluminiscence dating technique; the dated pottery comes from a section of the wall in Bet Dwarka. We get identical pottery in Prabhasa as well as Dwarka. This date is corrborated by other finds such as the seal and inscription.

The use of seal (mudra) referred to in the *Harivamsa'* is also attested to by the late Indus type seal. The use of iron weapons in the Mahabharata war is of importance for dating the event. Iron nails and an iron stake were found in the excavation in the intertidal zone of BDK I-II at Bet Dwarka. It is necessary to note here that the *Harivamśa* refers to fixing of iron stakes in the moat to prevent the enessy from entering Dwarka city. The excavation at Gufkral in Kashmir has given the date 1500 B.C. In the south the date of iron is Circa 1300 B.C. It appears that iron technology was known in India by 1500 B.C., perhaps not much earlier because there is no evidence of iron objects before 16th century B.C. Hence in the present state of our knowledge we may comments: Mr. Dobbs: I think that it is extremely encouraging that a decision is being taken to have a center of Marine Archaeology based in Goa and also to have other areas of India with their own centers. Prof. Rao ended with an appeal to ASI to help in this endeavour and I hope they are able to reply to that appeal by assisting these centres.

Underwater Exploration of submerged towns near Tranquebar (Tarangambadi) on Tamilnadu Coast

S.R. RAO

The ancient ports of the East Coast of India have played a great role in overseas commerce with Burma, Ceylon, Indo-china, Malaysia and China from 3rd Century B.C. to the present day. The more famous among a dozen ports of the East coast are Tamralipti (Tamluk) in West Bengal, Kalingapatnam in Andhra and Kaveripatnam (Kaveripattinam) in Tamilnadu. The present paper deals with the maritime activities of Kaveripatnam situated at the mouth of the river Kaveri in Thanjavur District of Tamilnadu State. The *Periplus of the Erythrean Sea* refers to it as *Kabera*, while the Sangam literature especially *Śilappadikāram* and *Manimekhalai* give graphic account of Kaveripoompattinam (Kaveripatnam) which is also known as 'Poompuhar', meaning a place where the river enters the sea. The Anthology *Pattinappalai* describes it as Muttachirappin Pattinam. Another Tamil text namely *Śilappadikāram* calls Poompuhar a city in which people lived happily for centuries and would not like to migrate to other places.

The importance of *Śilappadikaram* as a source book for the archaeologist lies in the fact that Poompuhar is said to have extended over an area of 4 *Kavatham* approximately 30 squares miles. Its boundaries were Karuvendanathapuram and Kadarankondan on the west, Thirukadavur on the south, Kalikamur on the North and the sea on the east. The town stood on the northern bank of Kaveri and encompassed within its boundaries nearly 30 villages. Poompattinam is said to have 60,000 families. According to *Silappadikāram*, the western part of Poompuhar was known as Pattinapakkam, the eastern part as Maruvarpakkam and the central part as Nalangadi. Anciently Vanagiri, one of the suburbs, lay on the northern bank of Kaveri which has changed its course. The villages Vanagiri and Chinnavanagiri lie to the south of the present mouth of Kaveri (fig.1). Manigramam, Melaiyur, Velliyaniruppu, Pallavaneswaram and Kilaiyur were in the interior on the Northern bank of the ancient course.

According to *Manimekhalai*, Kaveripattinam was swallowed by the sea and its destruction is attributed to the wrath of God Indra, whose festival the people had failed to celebrate.

The submergence of Kaveripatnam (Fig.1), the most famous emporium of early Chola kings, has attracted the attention of historians and academics because of the legend of Kovalan, the merchant prince, who was unjustly beheaded by the Pandyan king on a false charge of theft. The righteous indignation of Kovalan's devout wife Kannagi and the subsequent events form the story of the epic *Manimekhalai*. Kaveripatnam was not only a busy port but also a great Buddhist centre. For reconstructing the early history of Tamilnadu it was essential to excavate both on shore and in the sea and reconstruct the social, economic and religious life of the people and their contribution to the cultural expansion of India in Southeast Asia.

According to the *Arthaśāstra* the sea ports should be situated preferably at the confluence of the river with the sea so that the products of the hinterland could be transported by the river and then from the port to distant overseas ports. The famous port city of Dvaraka was built at the confluence of the river Gomati with the western (Arabian) sea. According to the *Mahābhārata* 12 yojanas of land were reclaimed for building Dvaraka. The constructional features of the fortified port city of Dvaraka exposed by the author in the course of 7 years of underwater excavation confirm that reclamation was resorted to by the builders of Dvaraka in 1500 B.C. (Rao S.R. 1990, 59-98). Kaveripatnam is also said to have been situated at the confluence of the river Kaveri with the Eastern Sea (Bay of Bengal). This river flows past Uraiyur, the capital of Sangam Cholas (as distinct from the Late Chola's of 10th-11th century A.D).

The general impression is that Poompuhar was confined to the area between Kilaiyur and the present mouth of Kaveri, but the surface archaeological finds indicate that it extended from Kilaiyur to Chinnavanagiri and even up to Tranquebar (Tarangambadi) where lots of coins of various dynasties of the early historical period and of the foreign settlers of the 17th-19th Century are found in the intertidal zone. Wheeler considered Tranquebar as part of Kaveripatnam. The first systematic exploration of Poompuhar-Kaveripatnam by the Archaeological Survey of India under the direction of the author with assistance from Dr. K.V. Raman was started in 1962 at Kilaiyur, a suburb of Poompuhar. It was extended in subsequent years (upto 1965) to other suburbs such as Vanagiri, Velliyan Iruppu, Pallavaneswaram and Manigraman. The limited excavation in Kilaiyur (Mangaimatham area) in 1962 brought to light a very remarkable I-shaped brick-structure which was used as a wharf. It is lined by wooden posts and measures 18-20 × 7.62 ft. There is provision for flow of water through the channel built under the timber work supported by massive wooden posts. The carbon-14 date of the wood samples from the wharf is 233 B.C. which confirms that even before the Early Chola period Kaveripatnam was a flourishing port (IAR 1962-63, 13). The square copper coins

found in Melaiyur and Manigramam bear the emblem of tiger, the royal crest of Early Chola kings.

Wharf situated in one of the ancient channels of Kaveri provided anchorage for the boats while loading and unloading cargo. At present the ancient channel is completely silted up and the field is cultivated for growing rice. The very existence of a brick wharf must indicate that the main channel of Kaveri must be somewhere near Kilaiyur. The surface exploration revealed two flow channels one of which runs parallel to the shore while another discharges into the sea near Pudduppuram (11° N) north of Poompuhar. All along the shore from Puduppuram down south upto Tranquebar habitation deposits and occasional exposures of brick structures are encountered. The onshore excavation at Velliyan Iruppu has revealed early medieval brick structures (9th-12th century A.D.). The copper coin of Rajaraja I found here suggests 10th-11th Century date for the middle phase of occupation.

The terracotta figures recovered in excavation include two royal heads modelled in Chola style. In the course of excavation at Vanagiri a water reservior (IAR 1963 P1 XIV), semicircular in plan with 2 m high brick walls having an internal diameter of 8 m, was found connected to the river Kaveri through an inlet channel 83 cm wide. The structure is assignable to 1st-2nd century A.D. on the basis of the Roulletted Ware and Megalithic Black and Red ware. In this connection it may be recalled that the Sangam texts refer to the construction of tanks and irrigation channels by the Chola Kings.

A very important building laid bare at Pallavaneswaram, one of the suburbs of Kaveripatnam is a structure of 5 cells and a common verandah indentified as the Buddha vihara datable to 4th-5th Century A.D. The subsidiary structure contained an apsidal chaitya. A small bronze figure of Dhyani Buddha and a fragmentary terracotta figure of a goddess are among the important finds from one of the rooms of the main scrossing The longitudinal walls of the Vihara are 1.7 m thick and transverse ones are 0.9 m. Another building with stucco plaster and moulding has also been laid bare near the monastery. A large *buddhapāda* of limestone was discovered in a building exposed south of the structure decorated with stucco work. A large variety of bricks, some bevelled and others fluted or corbelled, are found used for the moulding of pillar corbels. These and other archaeological finds confirm the literary reference to Kaveripatnam as an important centre of Buddhism.

The excavations at Manigramam and Vanagiri yielded beautiful beads of quartz, crystal, chalcedony, agate, green and red jasper, coral etc. (Tr. ASSI 1965, 163-165). During the excavation resumed by K.V. Raman in 1966-67 with a view to check up findings of the proton magnetometer investigation in the area immediately to the east of the Pallavaneswaram Temple, the 3 m thick habitation debris yielded late Chola copper coins and flat terracotta tiles of pottery datable to early Medieval period (IAR 1966-67, 21).

In 1970-71 K.V. Soundara Rajan's excavation near Sampapati Amman Temple at Kaveripatnam revealed 2 terracotta ring wells in pre-Chola temple (10th – 12th cent. AD).

OFFSHORE SURVEY OF TRANQUEBAR – POOMPUHAR 1982

The onshore survey of Poompuhar-Kaveripatnam in the sixties had confirmed that there existed port-installations such as brick wharf in the 3rd century B.C. and that a part of the city of Poompuhar might have been buried in the sea. The Government of Tamil Nadu through the state Department of Archaeology approached the National Institute of Oceanography, Goa to undertake Geophysical Survey of the area seaward of the present Poompuhar monuments. Accordingly the Geophysical Survey team comprising of Mr. K.H. Vora, L.V. Subbaraju and others carried out echosounder, side scan sonar and magnetometer surveys in 1982.

The survey was on a scale 1-25000 with the line spacing of 250 m for sufficient overlap.

GRID SURVEYS

Between Kaveripatnam and Vanagiri, 23E-W and NW-SE lines and between Kaveripatnam and Tranquebar 2N-S lines were surveyed. The echosounder and side scan sonar were operated continuously and magnetometer most of the time.

Postion fixing was done with the Motorola Miniranger MRS III working in C band on a line of sight principle. When the Miniranger system developed some faults the conventional sextants were found useful for position fixing.

Detailed survey: Whenever either echogram or sonograph showed some anamalous features, detailed survey by crisserossing a number of times from different directions was undertaken to confirm the features and to record the view from different angles. Separate maps on a scale 1:5000 were prepared at 3 different locations where detailed survey was made.

Fishing trawler 17 × 5 m with 1.2 m draught was used for survey. A smaller vessel was available for crossing the surf zone.

Atlas Deso 10 echosounder provided a good resolution and also sub-bottom penetration. The bathymetry of the area was prepared on a scale of 1:25,000 with a contour interval of 1 m.

The EG & G side scan sonar system consisting of a transducer tow fish and a dual channel graphic recorder was deployed. The tow fish contains two sets of transducer arrays on either side and they were adjusted for 10° beam depression and 20° beam width. The recorder was operated usually with 125 m range to get a satisfactory coverage of the area. The signals received by the tow fish are recorded in terms of tonal difference on a specially treated wet paper.

The Barringer Oceanographic Magnetometer was deployed for collecting the total magnetic intensity values.

RESULTS OF THE SURVEY

Bathymetry: The survey was confined in certain areas of 7 to 23 m depth, and the gradient was found to be steeper in the shallow area. There is an abrupt change in the gradient at

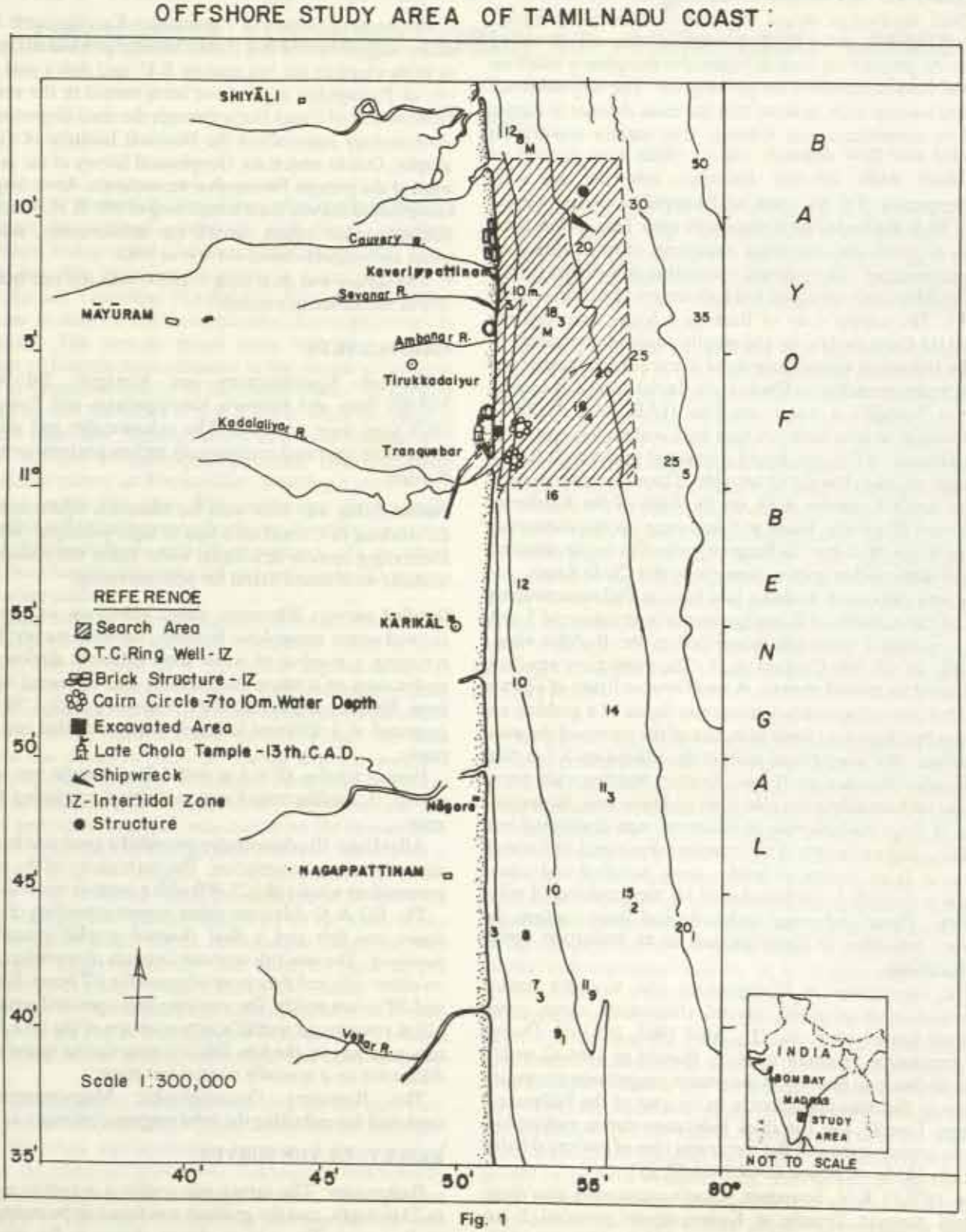
OFFSHORE STUDY AREA OF TAMILNADU COAST
SHIYĀLI
MĀYURAM
Cauvary R.
Kaveripattinam
Sevanar R.
Ambagar R.
Tirukkadaiyur
Kadalaiyar R.
Tranquebar
KĀRIKĀL
Nāgore
NAGAPPATTINAM
Vellar R.
BAY OF BENGAL
REFERENCE
Search Area
T.C.Ring Well - IZ
Brick Structure - IZ
Cairn Circle -7 to 10m. Water Depth
Excavated Area
Late Chola Temple - 13th C.A.D.
Shipwreck
IZ - Intertidal Zone
Structure
Scale 1:300,000
INDIA
BOMBAY
MADRAS
STUDY AREA
NOT TO SCALE
10'
5'
11°
55'
50'
45'
40'
35'
40'
45'
50'
55'
80°

Fig. 1

about 17 m depth after which the gradient is gentle. The echograms when correlated with the sonographs show that the seabed is covered with sand. The area near the shore shows no penetration to water depths of 7–8 m. The presence of the acoustically transparent clay in the rest of the area is indicated by echogram showing 2–3m penetration.

Some salient features noted on echograms are given below:

Sl. No.	Water Depth	Height of the feature	Remarks
1.	18 m	4 m	80-90 wide; has 2 peaks separated by about 25 m
2.	18 m	6 m	Sharp Peak
3.	18 m	3 m	Massive with twin peaks
4.	19 m	3 m	Two features separated by 30 m
5.	18 m to 7 to 1524 m	1.2 to 3 m	Features shown by echogram are slender; may be from a ship wreck or due to rough weather or heave of the boat etc.

A significant feature is noted at 79° 54′ E; 11° 12′ N, and another feature at 79° 54′ E, 11° 12′ N, the former is seaward NE of Puduppuram and the latter opposite Vanagiri. Vora has observed that a feature near Tranquebar may be a wreck.

A request was made in 1986 by Mr. M. Subramanian, Manager, Integrated Marine Fisheries Department, Tranquebar Branch and the Director of Archaeology and Museums, Tamil Nadu State to the National Institute of Oceanography (Marine Archaeology Unit), to remove the obstruction caused to fishing near Tranquebar by the presence of a shipwreck in the seabed. The author visited Tranquebar on 7th June 1986 for a preliminary survey and found that the massive brick jetty, pier and protection walls of 17th – 18th century (Pl. 34) have been destroyed by the merciless battering of the waves. Further landward, the 11th Century Chola Temple, locally known as Masalamani Temple, (Pl. 35) has also collapsed over half the portion owing to the transgression of the sea. What is however of great archaeological significance is that at the foot of the medieval habitation deposit north of the temple, terracotta ring wells get exposed in the intertidal zone at low tide. They are datable on ceramic evidence to the 3rd–4th Century A.D., if not earlier. The more crucial but baffling evidence comes from the same zone in the form of innumerable coins, mostly of copper, and a few of silver, lead and gold which are collected in low tide by local fishermen (Pl. 36). Unless there is a wreck or structure which got submerged in the sea such a large number of coins cannot be expected in a very limited area of just 300 metres of the Intertidal zones. The call from the deparments of Archaeology and Fisheries to investigate the wreck, the occurence of early historic and medieval habitation deposits and the likelihood of finding submerged features prompted the Marine Archaeology Unit to explore the seabed off Tranquebar upto Kaveripatnam in the month of May 1989. This was only a trial survey deploying side scan sonar and echosounder. The high surf zone is quite risky to cross here in small boats or catamarons especially when scientific equipment is to be carried to and from the survey vessels anchored about 0.5 to 1 km seaward. In the absence of landing facilities, all equipment had to be loaded and unloaded at Nagapattinam. Two trawlers *Sona* and *Pota* besides a motorised surf landing vessel were engaged from Vizag; In addition to our small team of diving archaeologists, the services of Vishal Diving Co. Vizag were requisitioned. The sea was rough all through and especially after 11 am. and visibility was nil upto 14 – 15 m water depth. However the main objective of the survey being bathymetric study and location of wrecks or structural remains by deploying side scan sonar, echosounder and magnetometer, we had to avoid high surf zone. Details of the bathymetric study and side scan sonar survey of the area upto Chinnarkudi in the south and Vanagiri in the north upto 18 m depth have been given in a paper presented by Dr. T.C.S. Rao who conducted the survey and the same has been published in this volume. As visibility was nil photographs of submerged circular objects noted by divers could not be taken. It is however fairly certain that a township was submerged between Tranquebar and Poompuhar and one or two wrecks lie buried. These will be investigated in March 90.

The pottery collected from the intertidal zone and the coins found earlier did however indicate continuous occupation from the beginning of the Christian era upto 19th century A.D. The habitation mound on the shore north of Masalamani Temple was scraped and Red Ware and course grey ware of 10th–11th century were found. Brick structures of a slightly earlier date which are visible in the intertidal zone will be examined and excavated if found sufficiently important.

Manavi Thakkar and Bandodkar dived in 9–11 m depth between Sinnarpet and Chinnavanagiri where the sonograph showed semi-circular objects opposite Chinnavanagiri temple and samples were collected. They are similar to those found in the circular cairn like feature with a tumulus of pebbles with large boulders underneath (Fig.2). They were reported by Sila Tripati, Alok Tripati, Manavi Thakkar and Srinivas Bandodkar at 7 m depth opposite the partly submerged brick wall between the Museum Building and Masalamani Temple. It is proposed to resume exploration of circular objects noticed in this zone in the next season.

In conclusion it can be said that some of the features recorded by the sonar and echosounder are man-made features. At present it is not possible to confirm whether the disjointed objects to the north of Masalamani temple were fragments of a linear structure.

Abbreviations

1. Tr. ASSI=Transactions of the Archaeological Society of South India, Madras
2. IAR = *Indian Archaeology – A Review.*

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CAIRN CIRCLE AT 7M. DEPTH IN THE SEA TRANQUEBAR

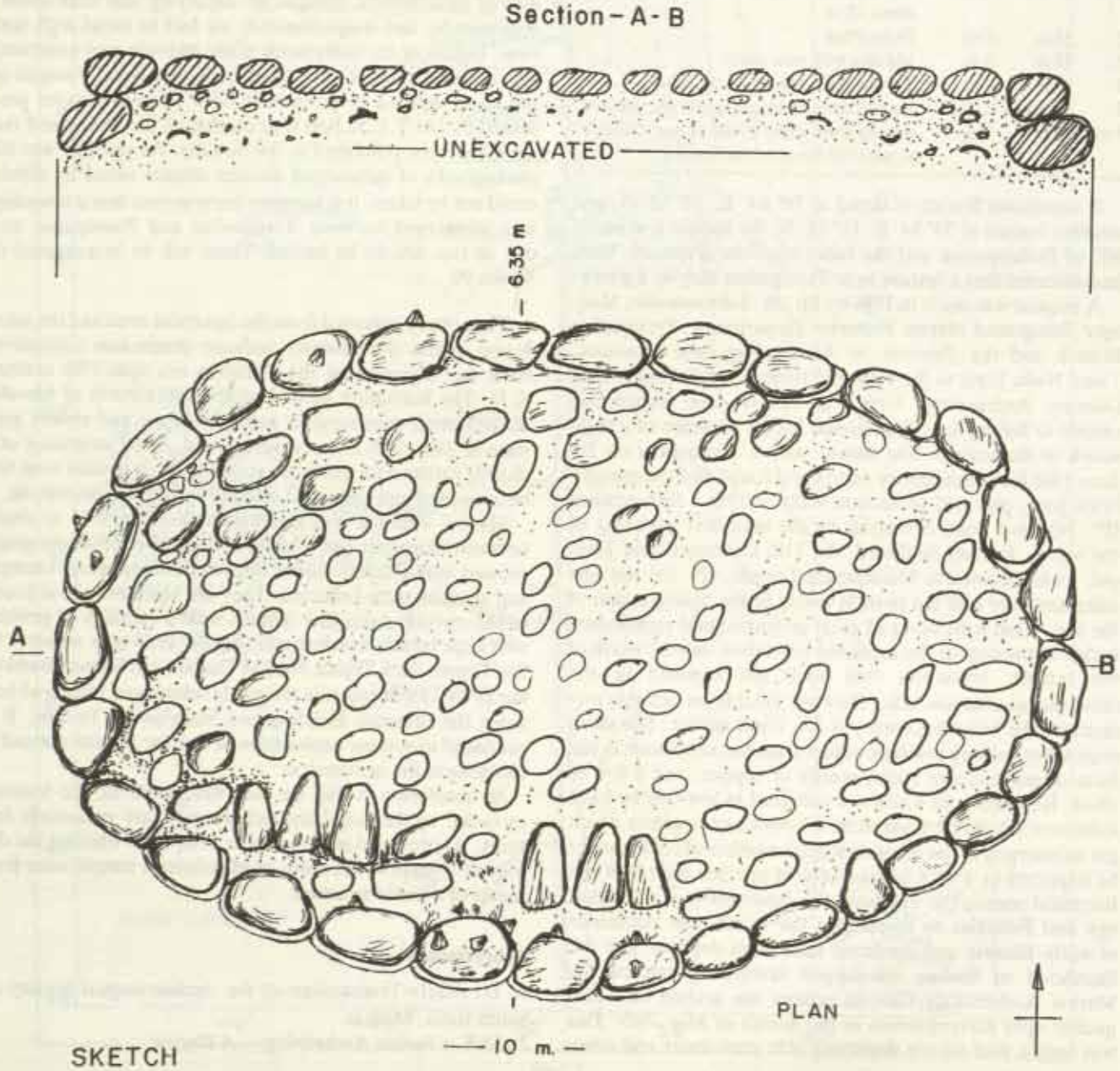

Fig. 2

Section 3

Ancient Ports and Sea Voyages

Section 3

Ancient Ports and Sea Voyages

Ancient Port-Towns of Karnataka with Special Reference to Honnavara

K.P. POONACHA and M.V. VISWESWARA

The coastal strip of Uttara Kannada district from Karwar to Bhatkal has played a significant role in the trans-oceanic trade of ancient and medeival Karnataka. Endowed with a number of wharfs to hold sufficient cargo, hundreds of miles of navigable water routes with deep water channels and creeks connecting rich hinter lands supplying up-ghat products like a variety of jungle wood, areca nut, spices and other forest produce; these places naturally formed the 'bone of contention' for many ambitious ruling dynasties of Karnataka.

Situated at the very mouth of the river Sharavati, Honnavar (Honnavura or Honnina Vuru of inscriptions) is a port-town of great antiquity. Right from the 2nd century A.D. upto the middle of 16th century A.D., the foreign travelogues supply abundant testimony to its importance as a port-town. Ancient Egyptians, Sumerians and Phoenicians brought their vessels near Karwar port. The existence of *Ullandi* (a safety device for a boat, like an anchor) discovered in the Pacific ocean establishes the maritime contacts of Uttara Kannada ports.

The paper highlights the archaeological potential of the coastal strip with special reference to Honnavar, in the light of epigraphical, literary and archaeological sources and provides the basic data for scientific and systematic exploration and excavation from the point of view of underwater archaeology.

Karnataka is endowed with a coastal line of about 400 km length having a gradual transition between the Konkan coast in the north and that of Kerala on the south. This stretch, in fact, forms part of the west coast, accomodating such well known ports as Cochin in the south and Dwaraka in the north-west and having fairly long continuum of maritime activities in the form of coastal and overseas trade from the very Harappan times down to the colonial phase of the history of the Indian sub-continent. In Karnataka, the coastal stretch is distributed in two districts viz. Uttara Kannada and Dakshina Kannada accommodating many important port-towns of great antiquity. These port-towns, besides nourishing the then contemporary economic and political powers, acted as centres from which emanated socio-cultural and religious expansion through brisk trade contacts with far off regions, right from the early centuries of the christian era.

Though the ancient port-towns of the adjoining states of Andhra Pradesh and Tamil Nadu on the one hand and Maharashra and Goa on the other are comparatively well known, the importance of and the role played by the coastal strip and ports of Karnataka are hardly known, obviously due to the relative scarcity of authentic data.[1]. The present paper attempts to collate the sparse and scattered information from various sources which, it is hoped, would serve as a preliminary data for undertaking well planned intensive surface and sub-surface investigations.

I GEO-SETTING AND VARIETIES OF PORTS

The Uttara Kannada coastal strip stretches to a length of 145 Km in a long and neat straight line in the South – South-western direction. This strip endowed with natural harbour amenities like wharfs holding sufficient cargo, navigable water routes with deep water channels and creeks, is obviously dotted with more than a dozen active major and minor port-towns, some of which enjoyed inter-continental celebrity since early times. The geo-setting has gifted this coatal strip with an unique combination of different types of harbours namely: two island ports (Devgadh and Anjadiv), a bay port with perfectly sheltered cove, a river port as well as a swarp (Sadashivagadh) and a creek port (Karwar). A chain of conducive gorges, caused due to torrential monsoon floods, throughout the coastal strip well connected with hinter lands rich with up-ghat forest produces helped these places to grow as port-towns. The estuaries of Kali, Bedthi (Gangavali), Sharavati and Aghanasini as also their *rivulets* having navigable upstreams upto scores of kilometres and the existence of pre-sail halting stations like Jalikunda *(Karēnitrān)* Ptolemy's *Kanāthra* and Periplus's *Kaincitai* Haigunda (Pls. 30-33), Basavaraja durga, etc in the near proximity, have considerably contributed to this quick growth. The up-ghat products like a variety of wood, arecanut, spices – especially pepper and other forest products – were the chief export items.[2]. Teak wood *(Tectona grandis)* of the finest quality grown in the Gunda (Supa taluk, Dist. Uttara Kannada) region was used for ship building by the Europeans till the end of the 18th century A.D. China-silk in the early days and good quality war horses in the medieval times formed the main imports[2](a). Naturally, in due recognition of the economic, political and strategic importance of these port-towns, several forts were also built in the subsequent periods.

II PRE AND PROTO-HISTORIC TIMES

The activities associated with the ocean appear to have begun in the coastal strip, right from the days of its earliest occupants. The information pertaining to the first inhabitants of this region however is very meagre. In this connection, the discovery of a few mesolithic sites near Belekeri and Hattikeri (both in Ankola taluk, Dist. Uttara Kannada) by the exploration team of the Deccan College[3] is significant. The absence of the palaeolithic cultural assemblage was obviously due to the non-availability of suitable raw materials such as Quartzite and Crypto-crystalline Silica on the one hand and the impregnable forest on the other. The team, however, opined that "the changes in the relationship of the land sea level during the Quarternary and Holocene periods have also contributed to the growth of cultures in the region".

Earlier explorations in the coastal plains had already brought to light the rock shelters around Gokarna,[4] especially at Ramatirtha, yielding a few sherds of gritty red ware as also a fragmentary polished stone axe. The evidence, followed by the discovery of a neolithic settlement near Shimoga[5], where the river Sharavati rises, suggested that the valley had contacts with neolithic folk; Honnavar situated at the mouth of the Sharavati served as an important outlet for the forest and mineral products of the west coast. Based on these evidences, Dr. Rao[6], postulated that the neolithic folk moving down the escarpment of the western ghats to the small rock shelters around Gokarna perhaps brought with them gold which they mined in the Shimoga-Dharwar[7] region for export purposes.

Recent explorations in the Malnad region have brought to light a number of sites in the Shimoga region[8] along the river valleys yielding cultural artefacts ranging from the Palaeolithic to the early historic times. Of these, the occurrence of numerous Neolithic/Chalcolithic sites in the up-ghat region is of special significance and may corroborate Dr. Rao's observations. However, further probe by way of extensive excavation in some of these sites is necessary to substantiate this view.

With the emergence and spread of Iron age this coastal strip seems to have attained more significance and became better occupied[9]. The traditional nomenclature of the area as *'Parsúrāma kshētra'* [10] is noteworthy in this regard.

Some of the scholars[11] opine that the region got the name Tulunadu derived etymologically from the Dravidian root *Tulai* meaning 'to row' (obviously a boat). There are two more words *'tulai' 'tulaiyan'* also signifying 'to ply into water" and 'to play in water' respectively[12] This derivation suggests that the people of this coastal strip, besides being basically fishermen, were connected with business and sea faring activities from the very early ages.

III EARLY HISTORIC TIMES

In the early centuries of the Christian era, the frequent references of foreign travellers like Pliny[13], Ptolemy[14] and the Sea Manual *'Periplus of the Erythraean Sea*[15] seem almost unmistakable in testifying to the vigorous trans-oceanic contact of Alvakheda *(Ólokhōira),* Malpe, Mangalore *(Mangarouth),* Udyavara and Barkur (in District Dakshina Kannada), Basrur and Honnavara *(Naura* in District Uttara Kannada) which have been throughout the history of the coastal strip, vibrant with variegated activities. These ports played a significant role in shaping the economic prosperity of the region by contributing considerably to the affluence of the people of the port or hinterlands as also of the far off political centres having control over both. A number of early Roman and Byzantine solidi[16] found in the hinterlands and along the coast attest to this fact.

Coming to the epigraphical sources, besides the existence of a number of inscriptions giving us the details of taxes[17] on the import and export commodities, the recent comparative studies of the epigraphical literature of Karnataka with those of the south-east Asian countries shed more light not only on the cultural contacts that Karnataka had with these countries but also on the brisk maritime activity through which such contacts were made possible. Such a comparative study has established that many of the inscriptions ranging in date from 4th to 9th century A.D. found especially in Jawa, Sumatra, Borneo, Thailand, Malasia, Cambodia, Phillipines, Maldives, Vietnam and Burma have some common features to share with the contemporary epigraphs in Karnataka, in so far as epigraphical similarities and content, format, pattern of mentioning the details pertaining to the date and certain names of the kings and toponyms are concerned. The names akin to those of the Ganga kings Didiga and Mārasimha, Ālupa ruler Chitrasēna of *Ālvakhēda* etc are specially noteworthy.

From the point of view of marine archaeology, it is of special interest to note that the inscriptions which give ample information about the two *Mahānāvikas* (master mariners) - Buddhagupta[19] and Usaūna[20] contain some letters having a striking resemblence to those in the early Chalukyan inscriptions. More than all, the recently discovered inscription as far away as Mexico (America) has much resemblance to the Kannada-Telugu alphablets testifying to the adventurous visits of the people, possibly from Karnataka, to these countries especially for trade. What is more important in this newly discovered inscriptions is that one of them refers to *Mahānāvika* Usalūna and some letters bear resemblence to the Kannada - Telugu letters of the contemporary times[21] (7th century A.D.). It is quite certain that this *Mahānāvika* hailed and sailed from some part of South India and in view of the above similarities, the possibilities of his belonging to some part of the erstwhile Karnataka empire which trans-

gressed the present day geographical limits of the State cannot be ruled out.

It is worth remembering here that during the above period (from 4th to 9th century A.D.), the coastal strip of Karnataka around Honnavar was continuously under the control of the three major dynasties of Karnataka viz. the Kadambas of Banavasi (circa 325 to 540 A.D.), the Western Chalukyas of Badami (circa 543 to 757 A.D.) and the Rashtrakutas of Malkhed (753 to circa 976 A.D.). The local chiefs Chitrasena *Āluparasa*, Chitrasēna Mahākella, Bhōja Āśankita etc either had matrimonial alliances with the ruling monarchs or were close relatives of them. Moreover, the epigraphs of the period mention that the mighty army of the Chalukyas[22] *(Karnātaka balam ajeyam)* subjugated the Mauryas of Konkan near *Gharapuri* (Elephanta Island). Vikramaditya II is also stated to have conquered among other countries Ceylon and Cambodia[23].

Within the region under consideration, three copper plate charters issued by the rulers of the coastal area deserve our special attention. They are Hiregutti copper plates of Bhoja Āśankita[24], Honnavar plates of Kaikaya Chitrasēna[25] and the Haldipur plates of the Pallava Chief Gōpāladēva[26]. Significantly, the first two copper plates refer to grants made to the *Āryasamgha* (Buddhist *Vihāras)* and are the only copper plate records of the Buddhist affinity of the early period so far known.

It is interesting to note here that while commenting on the term *Dīpakavishaya* occurring in the Hiregutti plates, Dr. Desai[27] opined that 'if these names are to be derived from *dipa* meaning 'light', they would have derived the appellation on account of the existence of some lighting arrangements like light-house on them."

It is too well known a fact to stress here that the spread and development of Buddhism had a direct bearing on the trade activities especially in the South Indian context. The grants made by the rich merchants of Banavasi to the *Chaityas* of Karle[28] is a significant point to be noted here. Within the region under discussion, the explorations by Dr. Sundara[29] have brought to light as many as three sculptures of the Buddha, Yakshas of the Buddhist affinity as also some of the associated brick structures. In the light of the above information, a re-examination of the sites, especially around Honnavar[30] has brought to light certain important and interesting evidences. Haigunda (a small hilly island in the midst of the river Sharavati, about 20 Kms east of Honnavara, which was earlier explored by Dr. Sundara), appears to be a very potential site from the point of view of marine archaeology. (Pls. 31-33).

This island (referred to as *Pāyvegundupura* in the inscriptions) was the capital of the Kalikaya kings[31] and abounds in cultural artefacts comprising brickbats and potteries datable to the early centuries of the Christian era. The structural activity is concentrated on the hill located in the northern part of the island, as also in the agricultural fields on the east of the hillock. The vantageous position of the hillock and the structural activity noticed there indicate that besides a religious structure that was existing there - most possibly a *stūpa* - it might have accomodated a light house. Similarly, the remnants of the structures especially those noticeable in the flat terrain below on the periphery of the island, much eroded due to the rain waters, may indicate some sort of warehouse. Their exact plan, form and function, however, cannot be discerned due to the age long accumulated debris.

Udyavara (located about 6 Kms south-west of Udupi) in the Udupi taluk of Dakshina Kannada district is another equally potential site in this regard. Referred to as *Udēvura, Udiyāvura, Udayapura,* etc in the inscriptions[32] and mentioned as *Odāra* in the *Oxyrhynchus Papyri*[33], this place was the capital of the Ālvakhēda *(Olokhōira)* for a fairly long time. The ancient habitation mound[34] in the village is fortified with mud rampart pierced by as many as three gateways. Within its orbit is a well defined citadel (locally known as *Balērgudda)* and a lower town facing the sea. Covering an area of 500 x 150 metres, the site yields large quantities of pottery comprising the Megalithic Black-and-Red Ware, black polished, plain red and cream wares both in the lower town as well as in the sections of the citadel mound. The ceramic evidence suggests a date of 3rd-4th century A.D. to this ancient port-town. The occurrence of chert blades in small quantity may push back the date much earlier to the proto-historical period.

Extensive excavation in these sites, on par with Arikamedu (Pondicherry) may throw valuable light on the trans-oceanic commercial ties of the coastal strip of Karnataka with Rome.

Coming back to the Uttara Kannada district, based on the stylistic similarites of the sculptural art of the region with those of the Buddhist sites of Andhrapradesh on the one hand and of the western Deccan on the other, Dr. Sundara[35] opined that "there are clearly two distinct phases of the Buddhist sculptural art having two different regional sources: the Amaravati and the western Deccan, one almost immediately following the other". Quite significantly this observation holds good for the trade contacts that the North Kanara coastal strip had with South-East Asian countries during the first 5 centuries A.D. under the Sātavāhana-Chutu regimes in the first three centuries and under the Kadambas during the succeeding two centuries.

IV.- EARLY MEDEIVAL AND MEDEIVAL TIMES

During the early medeival period, i.e., 9th to 13th centuries A.D. as many as eight Arab travellers visited this place and have left graphic accounts of the maritime activities of the coastal strip in general. These accounts give a strong impression about the presence of Arab merchants in the coastal region since 9th century A.D.[36] and speak highly

of *Balhāra* rulers (Rashtrakutas) who maintained very cordial relationship with the Muslims, obviously for commercial advantages. To these Arab merchants, the entire western coastal strip upto Konkan is familiar by the name *Malibār* or *Manibār*. Their description mentions the location of the port-towns, the commodities that were traded in, the hinter lands supplying these commodities and the natural scenario of the ports. All of them pointedly refer to the production of good quality teak. Diminisqui[36] (A.D. 1323) mentions that *Manibār* adjoins *Hunnur* (Honnavar) and it is named as the 'country of pepper'. Ibn Batuta[37] (A.D. 1359) refers to Honnavara and testifies to the fact of its prosperity through trade and commerce.

The epigraphs of the period also throw ample light on the then contemporary trade activity[38]. The famous mercantile organisation of *Ayyāvole*[39] claims in a record of 1150 A.D. that they procured for kings many costly materials through water and land routes *(Jalasthala vātrās)*. Another specific illustration is that of a certain Kammatachetti Setti, a royal merchant of the Hoysala king Viraballala II (1173-1220 A.D.)[40] who procured for the king horses, elephants and pearls. In the succeeding centuries a large number of European travellers[41] visited the region. Their accounts are really valuable in assessing the economic prosperity achieved through brisk maritime trade that the coastal strip witnessed during the 15th-18th centuries A.D.

A variety of good quality war horses *(Yāmani, Shāmi, Bahri, etc)* were regularly imported from Arab and Persian countries during the Vijayanagara period. Though Bhatkal came to limelight during this period, Ankola, Mirjan and Honnavara also continued to be the chief ports. To have direct control over the region and to centralise the horse trade through these ports as also to effectively check the menace of the ever increasing piracy, the Vijayanagara kings established new territorial divisions like *Bārakūru - vishaya, Honnāvara-vishaya,* etc and trusted officials were made incharge of them[42]. The *Honnāvara-vishaya* comprised three divisions *(rājyās)*, Haive, Tuluva and Konkana respectively covering the territory in the south upto Bhatkal, from Bhatkal to Gangavali and the area below Gangavali. The places had regular administrative office *(chāvadi)* established obviously for the effective political and economic control over the trade activities.

Fernao Nuniz[43] whose name is inseparably linked with the history of the Vijayanagara empire, who was himself a horse dealer, remarks that "(The king) caused horses to be brought from Oromuz (Persia) and Adeem (Aden) into his kingdom and thereby gave great profit to the merchants, paying them for the horses just as they asked. The king every year buys thirteen thousand horses of Oromuz, and country-breds, of which he choses the best for his own stables, and he gives the rest to his captains....." It is interesting to note in this connection that Krishnadevaraya in his *Āmuktamālyada*[44] urges to improve the harbours and port-towns of the kingdom so that imports of various articles are smooth.

In the post-Vijayanagara period also, the local chiefs having well understood the importance of these ports continued to encourage their development. Hyder Ali[45] not only built the naval-yard at Honnavar but also erected a fort for the protection of the town. Buchanan[46] however, informs that Honnavara was sacked and demolished by Tippu Sultan which must have been done under peculiar political circumstances.

V SHIPWRECKS

In the light of the above literary and archaeological evidences, it is certain that the coastal strip of Karnataka is very potential and deserves detailed investigation. Even with regard to the shipwrecks, we have ample references.

The fact that the Chalukyan monarchs succesfully invaded many an island aided by powerful troops suggests that there might have been disastrous naval combats resulting in the total submergence of many a ship/boat along with their cargo. From this point of view, epigraphical reference[47] mentioning the naval battle fought off *Gharapurī* (Elephanta island) cited earlier is significant.

In the 17th century A.D. in a naval engagement between the Dutch and the Portugese in and off Honnavara port, as many as 52 vessels sank[48]. This must have happened when the Keladi ruler Shivappa Nayaka drove the Portugese out of the Honnavara fort with the help of Dutch army[49]. It is already mentioned that Hyder had established a dock unit for building new ships as well as for repairing the damaged ones at Honnavara. Lastly, Buchanan[50] says that "in the lake (he calls the mouth of the Sharavati river as the lake of Honnavara) remain the wrecks of some which were sunk by our troops after the fort was taken by assault."

Besides the above mentioned evidences, there are some indirect clues for the possible shipwrecks. The coastal strip of Karnataka is having comparatively low agricultural productivity with smaller hinterlands than the northern Konkan or the Gujarat ports[51]. This was probably one of the reasons why the southern part of the Western Coastal strip was infested with pirates from a very early period. Ptolemy had good reasons to label this area as *"Andron Pieraton"*[52]. The early medieval period witnessed regular piracy in the Indian ocean which some times assumed menacing proportions. Literary works are replete with references to a variety of piracy in the Indian sea coast including the right to salvage the commodities out of a wrecked ship. These piracies also must have resulted in a good number of shipwrecks the details of which, however, cannot be known.[53].

NOTES AND REFERENCES

1. Genevieve Bouchon and Denys Lombord seem to be very reserved in their opinion that "Serious studies of ancient

Arab, Indian or Nusantarian (Indonesian) voyages are still too few and inaccurate to enable a real synthesis." The archaeological and literary sources available come in handy in constructing the maritime activities in the Indian Ocean prior to the 15th century A.D., especially in the Indian context." vide their paper "The Indian Ocean in the Fifteenth Century", Ashin Dasgupta and M.N. Pearson (ed), *India and the Indian Ocean 1500 – 1800*, Calcutta, 1987).

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2.a. Anil De Silva, "The Spice and Silk Road", *Indias Contribution to World Thought and Culture: Vivekananda Volume*, (Madras, 1970) p. 304 (Hence forth, this volume is abbreviated as V.C.V). An epigraph of Hosabasti, Mudabidre (S.I.I. vol. VII No. 198) of A.D. 1429 mentions the purchasers of the China silk *(Chināmbara - Vikriya - priyakarin)* who seemed to have added to the beauty and glory of the town Vēṇupura. This evidences to the fact that even during the 15th century A.D., silk from China had market in the coastal region.

3. *Indian Archaeology* 1972-73 - *A Review p.* 25 ff. (Hence forth abbreviated as I.A.R.)

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11. Govinda Pai M, *Tulu-nādu- Pūrvasmrti* (Kannada) (1947) p.19. For details also see Saletore, B.A., *History of Tuluva*, chapter I pp.1-8.

12. *Tamil-Lexicon* Vol. II, p. 2002

13. *The Naturalis Historia of Pliny*, tran. H. Rackrn, (London and Cambridge, Mass. Rept.) 1942.

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17. Chidananda Murti, M, *"Kannada śāsanagala Sāmskritika Adhyayana* (Kannada) (Mysore, 1979) pp. 385 ff.

18. For a more detailed comparative analysis of the epigraphs under reference, pl. see (a) Nagaraju, S. *Āgnēya Eśiadodane Karnāṭkada Sāmskritika sambandha* (Kannada), *Prabuddha Karnāṭaka*, 1967), p. 39 ff., (b) Nagaraju, S, "The Palaeography of the Earliest Inscriptions of Burma, Thailand, Cambodia and Vietnam", *Svastiśrī: Dr. B. Ch. Chhabra Felicitation Volume*, ed. by Dr. K.V. Raman, *et al*, (1984), p.67 ff; specially the painstaking and illuminating chart appended at the end.
(c) Madhav N. Katti, "Karnataka and South-East Asian Epigraphy : A Comparative Study", *Indological Studies : Essays in Memory of Shri S.P. Singhal*, ed. by Devendra Handa (Caxton, New Delhi, 1987), pp. 207 ff.

19. B. Ch. chhabra, *Expansion of Indo Aryan Culture*, p. 20, pl. 3 and Madhav N. Katti, *Opp. cit;* p. 207

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21. See references under Sl. No. 18-20 above.

22.a. Nagaraja Rao, M.S. (ed) *"The Chalukyas of Badami"*, (Bangalore, 1978), pp. 53 ff., 91 ff and p 226;

22.b. Ramesh, K.V., *Chalukyas of Vatapi*, p. 108.

23. *E.I. Vol. VI*, p. 253, XXXII, p. 317 and XXXIII p. 311 etc.

24. Desai, P.B. "Hiregutti Plates of Bhōja Āśankita", *E.I. XXVIII*, pp. 70 ff. This record bears no date and has been assigned to the end of 5th or the beginning of the 6th century A.D. on Palaeolographical grounds. This charter was found in Hiregutti village in the Kumta taluk of Uttara Kannada district.

25. Dhavalikar, M.K. and Nagaraja Rao, M.S. "Honnavara plates of Kaikaya Chitrasēna, year 1., *E.I. XXXVII*, pp. 33 ff.

26. Lakshminarayana Rao, N, "Haldipur Plates of the Pallava Chief Gōpāladeva", *E.I. XXI*, p. 173 ff. These plates were discovered while digging for a garden in Guddehittal area of Haldipur village in the Honnavar taluk of Uttara Kannada district. This also does not bear any date and on palaeographical grounds the editor has ascribed it to the middle of the 8th century A.D.

27. Desai, P.B. *op cit.*,p. 74. It is significant to note here that *Dīpavati* mentioned in the *Skandapurāṇa* is identified with the island of Divar located north of Goa. See *'Geographical Dictionary of Ancient and Medieval India'* p.57.

28. The inscription in the large Chaitya hall on the left end of the verandah mentions that the Chaitya was caused to be carved by Bhutapala Sethi of Vaijayanti *(Vējayaṁtitō Sēṭhinā Bhūtapālēna Sēlāghāraṁ parinithāpitaṁ* Jambūdībaṁhi Ūtamaṁ [|]. See Lüder's list no. 1087; Senart (1903) No. 1 and Nagaraju, S *'Buddhist Architecture of Western India*, (1981), p. 336.

29. Sundara, A, *"Ittichina Kelavu Mukhya Purātattva Shodhanegaḷu"*, (Kannada), *Karṇātaka Bhārati*, (Dharwar), Vol. 8, p. 14 ff. and "Buddhist Sculptures in North Kanara district; their implication", *The Karnataka Historical Review*, (Dharwar, 1979), Vol. XIV, No. 2; p. 35 ff.

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39. *E,C, VIII, Shikaripur* 118.
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53. A careful study of some clusters of the hero-stones depicting war scenes, reported from the minor ports as well as the hinterlands along the coast like Bailur, Kaikini (Taluk Bhatkal); Chitakula (Taluk Karwar); Bedasgaon, Pala and Gunjavathi (Taluk Mundagod) and Bedakini (Taluk Siddapur) may throw more light in this regard.

M. VISWESWARA

I have a comment to make on this first Deepaka Vishaya and this problem was actually discussed with several other epigraphists like Dr. K.V. Ramesan, Mysore and the inscription clearly says it is Deepaka Vishaya.

Inscription number two refers to *Amudweepa* which is identified as *Anjawadeep* island. What is significant here is the reference to Dweepa in the river Sharavati. In the inscription it is mentioned as Dweepavishaya.

S.R. RAO

It is a good paper in the sense that it highlights the need for undertaking Marine Archaeological research on Karnataka coast. In fact one of the reasons why we are holding the conference in Karnataka is that we should bring to the notice of the Government of Karnataka and the universities in this region the necessity of saving underwater cultural heritage namely wrecks and submerged ports. As dredging is going on in the shallow waters on Karnataka coast, all archaeological evidence will be lost. If sufficient funds are made available it would be possible to salvage the shipwrecks. Mr Visveswara and Mr Poonacha have collected valuable evidence about marine activities. I hope the State Government will see that steps are taken in time to save the nation's underwater cultural heritage on Karnataka coast.

VISWESWARA

I have to make a comment, Mr Poonacha is going to excavate at Gudnapur, a very important site which has early Brahmanical temple. Other relics suggest overseas contacts. Another observation is to be made on the reference to Deepakvishya. Vishaya is territory; Deepak may mean Dvipa. Dvipa *Vasuvikayam* is mentioned in several inscriptions. The Prakrit word for Deepa in Sanskrit is 'Diya'. Diya is light. It has been pointed out that Roman contacts existed in the early historical period and there is evidence for it from Udyavara on the west coast and upto Coimbatore on the east coast.

DR. RAJAN

Some Megaliths are also associated with Roman coins in Coimbatore District. The site of Kudimalai which the Tamil University in Tanjore is excavating has yielded bagfuls of carnelian beads both unworked and worked. Some etched beads are found within the Megaliths. This is an indication for the existence of prolific trade relations of Coimbatore, with the west coast because Cambay was the main centre of Carnelian.

Kalingapatnam Port through the Ages

SREE PADMA

The study of the buried ports with a glorious past forms a fascinating subject in the marine history of India. Kalingapatnam is one of the important ports on the east coast in Srikakulam District of Andhra Pradesh. Kalingas, said to be the early mariners on the east coast, ventured into the open sea and carried on extensive trade with countries like Java, Sumatra, Borneo, Sri Lanka as mentioned in the travellogues and inscriptions. Kalingapatnam, being a major partner in south east Asian trade and spread of Indian culture, the centre for Marine Archaeological studies of Andhra University proposes to investigate that part of the ancient port which has been swallowed by the sea. Onshore evidence has indicated that since 2nd century B.C. it had trade contacts with other countries.

Kalingapatnam, an ancient port city, is situated at the mouth of the river Vamsadhara in the District of Srikakulam in Andhra Pradesh. The city lies 32 Kms north east from Srikakulam proper.

The name Kalingapatnam means the town or the city of the Kalingas, the ancient tribe. The history of Kalingapatnam is nothing but the history of Kalingas, who earned reputation for their bold maritime activities on the east coast.[1]

Mention of Kalingas was made first in *Mahābhārata* and subsequently by *Rāmāyana, Jātakas, Purāṇas* and Ceylonese Chronicles. The origin of Kalingas in the *Mahābhārata*[2] is, however, an interesting story where sage Dīrghatamas begot five sons through Sudheshna, at the request of her husband, king Bali. These five sons Anga, Vanga, Kalinga, Surma and Pundra were given tracts and these tracts were named after the rulers. This was the tract ruled by Kalinga Prince and came to be called as Kalinga country and its people as Kalingas.

The rulers of Kalinga paid much attention to seafaring activities. Shipping and Maritime Trade were the compulsory subjects among other studies[3] learned by the Kalinga Princes.

Kalingas were the pioneers of Indian colonization in further India and Indian archipelago[4] especially Burma, Ceylon, Bali, Java, Sumatra, Borneo and Malaya. Some of the traders settled in these lands. In Java, these people are still called as "Klings" after the name of Kalinga. They started using an era in 75 B.C.[5] Till today the remains of Hindu culture are visible in numerous magnificent Hindu structures and inscriptions and historical poetical compositions in Sanskrit language.[6]

As far back as 2nd Century B.C. Kalinga has been noted for its fine muslins[7] which were exported to the far off countries. The other exports[8] of Kalinga were grains, jaggery, cotton, elephants, peacocks etc., Some of the Indian exports retained their native names in the languages of foreign countries.

KALINGAPATNAM AS A CAPITAL

The inscriptional evidence[9] shows that Kalinga was an independent kingdom in 3rd Century B.C. The boundaries of the kingdom expanded during the reign of Eastern Gangas[10] from the river Mahanadi in the north to the river Krishna in the south.

As the extent of Kalinga country changed from time to time, so the capital shifted from one place to another. The *Mahābhārata,* mentions two capitals for two separate groups of Kalingas viz. Rajapuram and Dantapuram. The *Rāmāyana* refers to Kalinganagara as the capital. According to Ceylonese Chronicle Simhapura is the capital.

Asoka states in his inscription that Dhauli is the capital. Most of the rulers of Kalinga have mentioned Kalinganagara as their capital.

There is a lot of controversy among the scholars in identifying these capitals with modern sites. It is difficult to identify any one place as Kalinganagara since the name was given to so many places which served as a capital at a particular time. Among these Kalingapatnam is one which served for some time as the capital of Kalingas.

Kharavela, the Chedi King states in his famous Hatigumpha inscription[11] that he repaired the buildings, walls and gateways of Kalinganagara, the capital city. This is substantiated by Kalidasa in his works *Raghuvamśa*[12] and *Daśakumāra Charitra*[13] where he alludes to the capital of Kalinga situated on the sea shore. The Eastern Ganga king, Indravarman in his Chicacole grant[14] and Hastivarman in his Narasingapalli plates[15] also refer to Kalinganagara, the capital city as situated near the sea. From this evidence it can be established that Kalingapatnam quite for some time enjoyed the position of the capital of Kalingas.

KALINGAPATNAM AS A PORT

The ancient geographer Ptolemy[16] refers to the then existing ports on the east coast among which Palur was a prosperous port till the advent of Europeans. There were other port towns like Dantapuri, Ganjam, Kalingapatnam and Visakhapatnam mentioned by Pliny.

Kalingapatnam was previously called by the names[18] Kannagara, Katikardana and Kartikeyadhama. It was a famous port town, said to be once washed off by the sea. Kharavela

continued in the old capital of Kalinga Kings by repairing its gates, walls and buildings that had been damaged by storm. Scholars are of the opinion that the capital of Kalinga washed away by the sea lay near the present town of Kalingapatnam. Now it has been silted up.

At present there is a port office maintaining the records from 1930[19].which suggest that the port was situated on one side of the river mouth at latitude 18° 20′ North and logitude 84° 8′ east. Its landmark is Garah hill about 4 miles inland, on which is built white Pagoda, but as it is sometimes obscured in hazy weather, a beacon has been erected on the long, low reef which extends for about half a mile sea-ward. In passing this point, vessles cannot approach nearer than a mile. The bay near the port is a broad and deep expanse of water of a crescent shape opening towards the east. The port is equipped with a light house. There is a beach road built in 1937 connecting the entrance to the port limit.

The port was functioning up to 1952 and the loading and unloading to the ships have been undertaken with the help of small boats. The abovesaid lighthouse is now covered by sand dunes. A new light house was constructed nearly 1 K.M. away from the old light house. Likewise, olden installations might have suffered the vagaries of the sea and submerged during successive periods.

The ancient city of Kalinganagara is at present a big mound nearer to the present town of Kalingapatnam. Some gold coins were found in the site bearing the script of Gupta age.[20] The site was excavated in 1928 by Mr. Bhattacharya. The different layers of the trial trenches revealed pottery, large-sized brick walls, glazed tiles etc., which proved beyond doubt that the site was a fortified city or a capital right from the 2nd Century B.C. up to early medieval times[21]

The subsequent excavations by the Archaeological Survey of India (1977 to 79) in the Stupa mound revealed that the occupation took place in 300 B.C.[22] Among the findings there are some remains of a brick wharf. The stupa must have existed opposite to the old port. As we know the course of the river mouth changes every 20 years or so the port installations had to be to reconstructed from time to time. So, before studying the old ports that are located at the mouth of the rivers, we have to acquire a thorough knowledge of the old river courses. Application of remote sensing techniques and geophysical exploration of the area are likely to bring to light the submerged port installations and provide data for the reconstruction of the maritime history of the east coast in general and Kalingapatnam port in particular.

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Centre for Marine Archaeological Studies Present Status and Future Plans

Pro. T.K.S. PRAKASA RAO

The Centre for Marine Archaeological Studies established in Visakhapatnam by Andhra University is now one year old. This inter-college Centre has been set up with the objective of carrying out multi-disciplinary and inter-disciplinary research work into all aspects of marine archaeology of the entire east coast in general and the coast of Andhra Pradesh in particular. It is hoped that the Centre has a significant role to play on the east coast in the years to come in view of the following favourable circumstances :

(i) Scope for inter-departmental cooperation, particularly in marine archaeological studies in the different science, engineering and humanities departments of Andhra University, (ii) keen interest shown in the objectives of the Centre and cooperation extended by Naval, Port and other Oceanographic institutions stationed in Visakhapatnam and (iii) geographic location of Visakhapatnam on the east coast.

The Centre for Marine Archaeological Studies came into existence with the appointment of Co-ordinator in December 1988. Subsequently, an Advisory Committee has been constituted with a senior Professor of geography, Head of the Department of History and Archaeology, Scientist-in-charge of the National Institute of Oceanography (Waltair Regional Centre), representatives of Eastern Naval Command and Naval Science & Technology Laboratory, a specialist in Marine Archaeology besides the co-ordinator as members. The Centre is housed in the Department of Geophysics. A specialist in History and Archaeology, Dr. B. Sree Padma is assisting the Co-ordinator and looking after the research activities of the Centre. Recently, Dr. E.V. Gangadharam, a specialist in Marine Archaeology, has been appointed as U.G.C. Visiting Professor for a period of one year.

One of the first investigations that the Centre has taken up is on a submerged temple. Responding to the centre's request for cooperation, a diving team of the Eastern Naval Command carried out search operations in an area of 400 x 800 metres. Further work on the collection of authentic information on the existence of the temple is in progress.

The National Institute of Oceanography (Waltair Regional Centre) gave training in geophysical data acquisition to a member of the Centre by permitting him to participate in one of its cruises. Dr. B. Sree Padma has visited libraries and archives at Hyderabad, Goa and Bombay. She had participated in the recent Dwaraka expedition and had the unique opportunity of working with Dr. S.R. Rao. During the course of her stay at Goa, Dr. Sree Padma has collected information on 17 ship wrecks, all in the vicinity of the Andhra Pradesh.

Exploration of a submerged port near Odacheepurupalli has been undertaken along with experts from State Archaeology Department. Potsherds and bricks have been collected. A detailed study of bricks revealed that they belonged to medieval period. Electrical resistivity survey in the same area brought to light anomalous subsurface conditions. The causative features may be inferred to be brick walls or dumps of bricks or pottery buried at shallow depth. More detailed resistivity surveys are planned to delineate the features of interest.

In order to be able to implement the objectives of the Centre more effectively, a workshop was organised on "Potential for Marine Archaeological Research in Andhra Pradesh" on 2nd and 3rd October 1989 which was attended, among others, by Dr. S.R. Rao, Prof. G. Victor Rajamanickam and Prof. K.S. Behra. Key note address by Dr. S.R. Rao and 15 articles on different aspects of Marine Archaeology on the one hand, and discussions with the specialists on the other greatly helped in framing the future plans of the Centre. The Centre was assured of co operation and assistance from (i) Marine Archaeology Unit in the National Institute of Oceanography, Goa (ii) Department of Ancient Industries, Tamil University, (iii) Orissan Institute of Maritime and South-east Asian Studies, Bhubaneswar, (iv) National Institute of Oceanography (Waltair Regional Centre), (v) Eastern Naval Command, Visakhapatnam and (vi) Naval Science and Technology Laboratory, Visakhapatnam. Among other organisations, Port Trust, Visakhapatnam and Hindustan Shipyard Limited co-sponsored the workshop.

On the strength of the experience of past one year, the outcome of the workshop, and the cooperation assured by the University departments and other marine institutions in Visakhapatnam, the Centre will be formulating schemes to work on the following aspects :

Systematic archival record and document search for creating a reliable data base for marine archaeology of Andhra Pradesh.

Comprehensive study of old ports of Andhra and their role in the economic history and maritime trade of India.

International maritime trade of Andhra with South-east Asia and the rest of the world during early historic, Portuguese, Dutch and British periods.

Boat building traditions of the past and their survival and relevance to the present.

Geological, geomorphological and satellite imagery studies of the coast of Andhra Pradesh to locate ancient human habitations.

Marine geophysical investigation of definite target areas and potential localities of ship wrecks along the coast of Andhra Pradesh.

The Centre is consulting the Archaeological Survey of India and the State Archaeological Department about the modalities of formulating a research scheme on "Marine Archaeological Studies of Kalingapatnam Port Area". The Orissan Institute of Maritime and Southeast Asian Studies and the Marine Archaeology Unit, N.I.O., Goa have assured the Centre of their cooperation in this area of acti vity.

DISCUSSION

S.R. Rao: I had been to Waltair and participated in the workshop the University conducted. I think that the Waltair centre will come up soon. We are always ready to help other centres. I had told Prakash Rao and others that they should have an experienced archaeologist in their centre. Otherwise, even if they do good work, there will be comments from others that it has not been done as scientifically as an archaeologist would have done. For example exploration for submerged temple of Vishakesvara was done by the naval divers about 2 km away from a more potential site where there is a rivulet and a late medieval site. Onshore survey was essential before undertaking offshore survey. If, on shore, antiquities such as pottery are found it is easier to locate a submerged port or temple. Atleast now exploration should be done by an experienced archaeologist. Our intention is not to monopolise all marine archaeological work. India has a very vast coastline and there must be atleast four or five centres of Marine Archaeology supported by the State Governments and Universities. They must be involved in preserving underwater cultural heritage. If an expert archaeologist is associated with the onshore and offshore exploration then the team will be sure of the antiquarian value of what it finds. The environment is also important. Careful excavation without damaging the object, meticulous documentation and systematic study of environment and antiquities are possible if trained archaeologists, geologists and technicians join together in analysing and interpreting the data.

Section 4

Indian Ocean Trade

Section 4

Indian Ocean Trade

Jeram Sewjee of Kutch And Zanzibar, a Seafaring 19th Century Tycoon From the West Coast of India

HARIDAS SWALI

Kutch-(KACHHA) is a small district of Gujarat, adjacent to the Pakistani border covering an area of less than 281 × 80 Km. The district is bounded on the south by the Gulf of Kachha, on the west by the Arabian Sea, and on the north, east and south east by Rann of Kachha - an uninhabitable desert which during the monsoon season (June to October) is often completely submerged by floods.

Mundra-a port town on the Gulf of Kachha and once a walled city is famous for the shrine of the saint Shah Murad who had come from Bukhara to Kachha in the years 1665-66 and then made Mundra his home. He died there and eventually became the patron saint of fishermen, pilots and traders.

During the very early nineteenth century, one such trader and a devotee was a Hindu Bhatia Jeram Sewjee struggling to make good in his home town Mundra. Oral tradition says that when Jeram decided to go to far off Zanzibar, Shah Murad blessed him and gifted a charmed gaddi for his use. Sitting on the gaddi (quilt) Jeram rose in life as a man of integrity with business acumen and goodwill for all. A well known bard from Mundra, later described Jeram in a Kachhi, couplet as "Jeram - the generous, hailed from Mundra. He did Mundra proud in far off Zanzibar, he was as good as the Ra-Rao of Kachha."

Jeram almost walked his way to the port town at Mandvi, a distance of 40 km from Mundra. He set sail for Zanzibar on a long voyage which was to change his fortune. Mandvi, his port of embarkation was famous both in the East and the West for its skilful pilots, good seamen, adventurous merchants and boasted of many a *Lakhpati* (millionnaire) owning a lakh of Rupees or more. Later Jeram was to prove that he was a worthy son of the soil and his own fleet was to operate between Zanzibar and Mandvi bringing not only merchandise in exchange but also rendering service and help to all those who wanted to try their luck in Zanzibar and its hinterland. Jeram did so with grace and humility befitting a seafaring merchant prince who himself had passed through hard times.

The name Zanzibar spelt magic both for the Arabs and the Indians. The east African coast and Zanzibar had contacts with people from many different lands since early times. By the 7th/8th century A.D. they were colonised by people from Arabia. By the 10th century A.D. most of the coastal Africans and Zanzibaris had embraced Islam.

The Portuguese made their presence felt in the Indian Ocean by the end of the 15th century. A struggle for power ensued between the Portuguese and the Arabs. It ended almost 200 years later when the Portuguese withdrew from the area of conflict much to the relief of traders sailing through the Indian Ocean.

Trade between Zanzibar and Kachha received a new fillip when the dynasty of the Imamas of Muscat founded by Sultan Seyyid Said (1791–1856) took firm roots in Zanzibar. Under the Sultan, Zanzibar expanded its trade with the outside world. An American consulate was opened in 1837 and a British Consulate in 1841. Jeram Sewjee who had already firmly established himself in Zanzibar, built up a cordial business relationship with the Sultans, the Americans and the British which was to stand him in good stead. He fearlessly forged ahead in his endeavours of spearheading the commercial revival in Zanzibar by acquiring the rights to farm the customs, by acting as a trader par excellence, as a banker to the Royalty, the Americans, the British and the Europeans, as a financier to the Arabs and as an able importer and exporter of goods from and to Zanzibar, following the maritime traditions of India.

Jeram was once called upon to prove his financial worth to the British who later ascertained his investments in Zanzibar to be more than $4,00,000 exclusive of his surpluses in Kachha.

Around the year 1844, Sultan Seyyid Said of Zanzibar complained to the Governor of Bombay that the Rao of Kachha was treating his friend Jeram with severity. Evidently, Jeram had excited jealousies not only as an outstanding business leader of his times but also as an extremely wealthy person in the land of his birth of which he was so proud.

Jeram was a devout follower of the Krishna cult of Vallabhacharya and whenever he was in India, he undertook long pilgrimages to Vaishnava centres of worship. He visited Mathura around 1844 when there was no train service in India. Jeram was not unaware of the culture, arts and crafts of the Indian sub-continent and the aspirations of its people.

But Jeram's heart lay in the business arena of the East Coast of Africa which he was to serve to the end of his life around the late sixties of the nineteenth century.

"Travel! Thou will find a friend in place of him thou leavest,
And fatigue thyself; for by labour are the sweets of life obtained
To a man of intelligence, there is no glory in a constant residence
Therefore, quit thy land and travel."

Jeram Sewjee of Kutch and Zanzibar was evidently the

first 19th century tycoon from Kutch (India) to be inspired by the above poetic words of an Arab savant. Jeram gave up his home town Mundra (Kutch) and sailed over 2500 miles in a country craft across the Indian Ocean. He settled in Zanzibar and built up an excellent rapport with the Arab Sultan, the Arabs, the Americans, the British and others. He remained their friend during the period of about 35 years he spent in Zanzibar. He knew no fatigue and verily obtained the sweets of labour by the sweat of his brow. Jeram typified the man of intelligence who saw no glory in a constant residence. He quit Kutch except for occasional visits. When he finally returned to Kutch he left his large business in Zanzibar in charge of his brilliant agent Ladha Damji. Jeram died in 1866 at the height of his glory.

A well known bard from Mundra, later described Jeram in a Kutchi couplet as 'Jeram the generous who hailed from Mundra (Kutch). In far off Zanzibar he was as good as the Rao - the ruler of Kutch. Jeram became a folk hero and the subject of a novel in Gujarati and Hindi called Dariyalal - the son of the sea.

SEAFARING INDIANS AND THE PROTECTIVE DEITIES OF COASTAL INDIA

Seafaring Indians living on the coastline and depending on the safe arrival of ships sailing across the seas, offered annual ritual homage to the mighty ocean and Varuna, the overlord of primordial waters on the fullmoon day of the month of Shravana (July-August). In medieval sculptures Varuna is shown riding on his fabulous aquatic animal called the makara and endowed with magical powers relating to the fertility of rivers, lakes and the sea described as the abode of the makara (crocodile).

All those connected with seafaring activities also worship some protective female deities of the sea, like Samudramata (the goddess of the sea) and Shikotarimata (inspired by the island of Socotra at the mouth of the Red Sea and occupied by the seafaring Indians in the remote past). The other female favourite deities are Hinglajimata and our Lady of Navigation.

As far as Jeram Sewjee is concerned it is significant that Muslim saints variously called as Pir, Daryapir and Daryalal have been deified both by the Muslim and Hindu seafaring fishermen, pilots and sailors and the adventurous traders and their kith and kin. Jeram was a firm believer in the divine powers of Pir Shah Murad of Mundra which was Jeram's hometown. Shah Murad came from Bukhara to Kutch in the year 1665-66 and made Mundra his home. He died there and the shrine built in his sacred memory is considered as the tallest building in the once walled town of Mundra. It is visible as one approaches this town, once described as the 'Paris of Kutch'. However, Zanzibar was already known as the "Paris of East Africa" as a tribute to its eternal fascination for visitors and residents from far and wide.

SPECIAL BLESSING OF SHAH MURAD FOR JERAM SEWJEE

Jeram earnestly and devoutly sought the guidance and blessings of Shah Murad before his departure for Zanzibar. Oral tradition maintains that in token of his unique devotion to Shah Murad, Jeram received from the Authorities of the shrine a seat (gaddi) placed before the Saint's tomb. Jeram used it in Zanzibar whenever he had important decisions to take. Thus twice blessed, Jeram went from success to success and became a trader and a statesman par excellence.

It is significant that unlike some orthodox Bhatias of the early 19th century Jeram was never loathe to sail across the seas for fear of excommunication which then haunted many of his countrymen. On the other hand Jeram was equally at ease with the Hindus, Muslims and Christians. Caste and creed did not matter to him. Transparent integrity was his watchword which opened all the vistas before him and many associated with him.

EARLY CONTACTS BETWEEN ZANZIBAR AND THE ARABS, INDIANS AND THE PORTUGUESE

The name Zanzibar spelt magic both for the Arabs and Indians. The East African coast and Zanzibar had contact with the people from many different lands since early times. By the 7th/8th century A.D. it was colonised by people from Arabia. By the 10th century A.D. most of the coastal Africans and Zanzibaris had embraced Islam.

The excavations of Indian glass beads along the coast and at Zimbabwe and Ingombe Ilede, the use of Indian system of weights and measures and of Indian cowries as currency, and the Indian origin of certain African plants - notably the coconut palms are an indication of early Indian contacts with East Africa. However, Freeman Grenville explains :- "The contribution of India to the civilisation of the Swahili cannot easily be measured; but its presence is certain." The Portuguese made their presence felt in the Indian Ocean by the end of the 15th century. A struggle for power ensued between the Portuguese and the Arabs. It ended almost 200 years later when the Portuguese withdrew from the area of conflict much to the relief of traders sailing through the Indian Ocean.

SULTAN SEYYID SAID OF MUSCAT IN 19TH CENTURY ZAZIBAR AND JERAM OF KUTCH

Trade between Zanzibar and Kutch received a new fillip when the dynasty of the Imams of Muscat founded by Sultan Seyyid Said (1797-1856) took firm roots in Zanzibar. Under the Sultan, Zanzibar expanded its trade with the outside world. An American consultate was opened in 1837 and a British consultate in 1841. Jeram Sewji who had already firmly established himself in Zanzibar, built up a cordial bus-

iness relationship with all. He acquired the rights to farm the customs for 40 years (1835-1875) as the highest bidder every five years. He acted wisely as a trader and as a banker to the Royalty, as well as the Americans and Europeans. He was a friend and financier to the Arabs and an able importer and exporter of goods from and to Zanzibar, in his own dhows, following the maritime traditions of India.

Noticing with favour the ability of Jeram to continue as the customs master after making the highest offer for the same for over two decades, the famous explorer R.F. Burton recalls the able organisational set-up of Jeram in his book (Zanzibar city, island and coast, 2 Vols. London 1872) as under :-

'Ladha Damji farms the customs at Zanzibar, at Pempa island, his nephew Pisu has the same charge; Nombasa is in the the hands of Lakhmidas and some of his co-religionists; Pangani is directed by Trikamdas and contains twenty Bhatias.... Ramji an active and intelligent trader, presides at Bagamoyo and the customs at Kilwa are collected by Kisandas.....'

JERAM MAINTAINS GOOD RELATIONS WITH BOMBAY GOVERNMENT

It was obvious in the early 19th century that the Bhatia was not a colonist. He began his worklife before his teens and after about 10 to 12 years chose to return to India to marry and become a householder. Jeram seems to have done likewise, only to come back to Zanzibar. Between 1844 and 1860, he was periodically in India on long pilgrimages and to establish fresh connections. Perhaps, this was the period when he chose to have an office in Bombay not to be far away from the seat of the Government of Bombay. Since 1841, the Government of Bombay had appointed and paid the British consul in the territories of the Imams of Muscat and he was subject to overall direction from Bombay. Thus Jeram added one more link to the traditions of private intelligence and laison. As a result, Jeram's firm was in later years allowed to consign goods ordered by the Sultan duty free from Bombay. In 1873 Jeram's firm presented the Governor of Bombay with the gift of an elephant - specially shipped from Zanzibar for the purpose.

TRADING ITEMS, AMERICANI, CLOVE TRADE AND JERAM SEWJEE

The growth of trade between India and Zanzibar was accelerated by the general peace in Europe, by the effective check on Arab piracy and the presence of Muscat Arabs at Zanzibar and on the coast. The English, the Americans and the Germans soon followed. The trade during the early 19th century was based largely on the traditional pattern of exchange of Indian goods like cloth, metalware, grain, beads, etc. for African products like ivory, cloves, gum-copal, hides, horns, copra, etc.

As early as 1825 Lt. James Emery at Mombasa gave details of the cargo carried by a dhow bound from Nombasa to Bombay as $556\frac{1}{2}$ frasilas (35 pounds each) of ivory, 337 frasilas of gum-copal and $4\frac{1}{2}$ frasilas of rhinoceros horn.

Between 1837 and 1841, Americans had a field day in Zanzibar because of Jeram's aggressive marketing of their coarse cloth through his outlets on the main land. Evidently, Jeram did such a good job that this cloth became well-known as 'americani'. By the last decades of the 19th century 30 per cent of 'americani' was produced in India.

The Zanzibar clove was famous throughout the world for its natural flavour. The apple-pie in the English home could not be the same without Zanzibar cloves. The clove trade with which Jeram was deeply concerned saw many ups and downs between 1830 and 1856 the year when the famous Arab ruler of Zanzibar Sultan Seyyid Said passed away. Jeram was financing the Arab plantation owners who sold the cloves at $40 per frasila (35 pounds) in 1830. By 1850, there was tremendous growth in planting of high yielding clove trees in Zanzibar and Pemba and the prices crashed to $2 per frasila. The Arabs were shocked and dazed. However, Jeram must have proved a shock absorber and made up the losses in course of time.

JERAM AS A FINANCIER IN ZANZIBAR AND AS A WEALTHY TYCOON

It is interesting to note that in 1844 Jeram was able to outbid a rival claimant to the custom-house and had apparently strengthened both his financial position as well as his relations with the Sultan.

All this news had reached Kutch and the Rao of Kutch was inclined to compel Jeram to part with two million dollars being one half of the total assets of the firm which were claimed by his former partner resident in India. Sultan Seyyid Said came to Jeram's rescue and appealed to the Governor of Bombay on his behalf. It seems that the Government of Bombay shared with the Sultan and its own Consul the confidence reposed in Jeram's uprightness. It was well-known that no one was more esteemed for his upright conduct by all classes.

Jeram was the cynosure of all eyes. In 1849 the then British Consul Hammerton explained ".... from the custom master Jeram Sewjee I can get in a few hours notice any reasonable sum even to the extent of five thousand dollars."

By 1850 the activities of the Indian merchants coupled as they later were with the enterprise of European and American traders contributed to the rise of Zanzibar as a major entrepot of East African trade.

R. Coupland in his book *'East Africa and its Invaders'* Oxford, 1965 is somewhat ambivalent about Indians in Zanzibar. However, he quotes Rigby who was British Consul at

Zanzibar between 1858 and 1861 stressing that Rigby was asked by the old man (Jeram) to make his will and recorded that he left three million dollars in hard cash, i.e. about £650,000.

JERAM, RIGBY FREES 8000 SLAVES

General Rigby who was the consul (1858-1861) for England in Zanzibar referred to the extensive trade with Bombay, Kutch and Arabia carried entirely in dhows.

Rigby estimated that about 5000 British Indian subjects handled almost the entire foreign trade. Ivory was consigned to them from the interior, gum-copal was handled by them and the entire cargo of American and Hamburg vessels was purchased by them. Jeram with his vast resources participated in all legitimate trade activities. He could not have become a tycoon, otherwise.

While the trade estimates were approximate, it was then believed that Zanzibar-India trade exceeded the European and American trade and accounted for $157,000 worth of imports and $173,000 worth of exports. A great deal of cloves, gum-copal, hide, ivory, India rubber etc. was shipped in dhows to Kutch.

In all trade activities and policy making, the English Consuls and other eminent Englishmen played a positive and tactful role to make Zanzibar the 'Gateway to East Africa' and rid it of the evils of slavery. General Rigby took energetic and harsh steps to ensure effective freedom for 8000 slaves and came down heavily upon those who indulged in slave traffic. His brilliant career was rather brief (1858-1861) as he suddenly became very ill and was forced to leave Zanzibar in 1861.

THE YEAR 1866 - JOURNEY'S END FOR JERAM

Jeram had spent many years in Zanzibar as a devout worshipper of Krishna as Srinathji. He kept with himself circular paintings depicting Srinathji on different festive occasions and during daily rituals of morning, noon and evening. Thus he felt, like many Hindus of yore that he was close to his personal Deity all the time, even in distant Zanzibar. While in India Jeram went on long pilgrimages by bullock carts accompanied by armed guards. Jeram had his own armoury which survived for many years after his death. Like the Sultan of Zanzibar, Jeram now lived in a simple household surrounded by mementos of his travels and tribulations in his hometown Mundra.

Jeram's relations with the Rao of Kutch and his former partner resident in Kutch improved with the passage of time because of his own genial temperament and the generosity of the Rao and his former partner.

Jeram had every reason to feel satisfied and grateful to his Pir Shah Murad. He now lived in the same town.

For Jeram, the end came in 1866 when he finally attained the lotus feet (Sriji-charana) of his beloved Krishna.

Jeram was no more. An epoch had ended !!

LADHA HELPS THE BRITISH EXPLORERS AND SLAVERY, FRERE CLEARS INDIANS OF SLAVERY IN 1873

It is interesting that the British and other 19th century explorers entered the mainland of East Africa mostly through Zanzibar. It began with Richard Burton and John Speke (1857-59), Speke and James Grant (1860-63), Samual Baker (1863-64), Henry Stanley and Dr. Livingstone (Last Journey 1872-73) Baker (1872-73), Stanley (1874-77) etc.

Enjoying a good standing in the Zanzibar Sultanate and imbued like his late Master Jeram with a sense of gratitude to the English Consuls, the firm of Jeram Sewjee, through its agent Ladha Damji, acted as the local banker for Burton and Speke and found them their outfits of beads, brassware and cloth which were the circulating medium instead of money in inner Africa. Damji also helped to equip Livingstone's expeditions. However, both Burton and Livingstone singled the Indians in Zanzibar as the worst offenders in the slave trade.

The accusations of Burton and Livingstone were denied by Speke (team mate of Burton), Rigby (the strongest opponent of the slave trade) and Kirk (the then Consul for England in Zanzibar). However, the hue and cry raised by the famous explorers led to a detailed enquiry into the slave trade by Sir Bartle Frere, who in 1873 inter alia observed :-

'The slave trade generally is in the hands of Arabs or men of mixed Arab and African descent. Beyond furnishing the capital for it, I do not think that the Indian or other foreign traders are often directly implicated in it and as regards the European merchants and the more respectable Indian houses, I doubt whether any case of wilful and direct participation in slaving ventures could be established against any of them, though few could escape implication for indirect aiding and abetting, often unconsciously, if all the ramifications of their commercial connections were laid open'. (F.O. 84/1391, Frere to Granville, 7 May, 1873).

Frere was trying to clarify the somewhat confused picture created by the explorers and others while making scapegoats of the submissive and docile Indians. What was lost sight of were the predatory actions of the Arabs and the concealed or indirect operations of other western countries like France, Portugal and American adventurers who were in need of a larger and larger labour force on their plantations. One interesting case of ignoring of reality was that of the English firm Fraser and Co. quietly owning 500 to 700 slaves during the 1860's for running plantations within the territories of the Sultan of Zanzibar and successfully keeping a low and undisturbed profile for many years.

YEAR 1990 FIRST MAYOR OF NEW YORK RECALLS TORTURED ANCESTORS

The beginning of the year 1990 witnessed the election of the first black Mayor of the city of New York in U.S.A. Soon after Mayor David Dinking was sworn in at the City Hall he told a crowd of 10,000 admirers :-

'To-day we mark more than a transfer of power. To-day we travel another mile on freedom's road...

I stand before you today as the elected leader of the greatest city of a great nation to which my ancestors were brought, chained and whipped in the hold of a slave ship'.

No words are strong enough to condemn slavery which existed then in its most naked form and which has been raising its ugly head now and then in more sophisticated contractural terms.

Sri Lankan Ports in Ancient & Medieval Times

DEVENDRA SOMASIRI

The designation of sites as Ports in ancient and medieval times has so far been based on references in historical chronicles and from foreign sources. The present study attempts to utilise newly available material to add to the meagre list of port sites hitherto compiled from such sources.

A Port, or any one of its many synonyms, merely denotes a place of shelter. By connotation, however, it is a place provided by the citizens of a country where facilities for seamen are added to shelter, so that both parties benefit. To designate a site as a port it is necessary to examine whether it conforms to the requirements of a port site. Such requirements include geographic and climatic factors; winds, tides & currents; types of craft and Sea-routes serviced. By these criteria, and other available data, it has been possible to identify a great number of sites that could, and, did service the many kinds of craft that sailed Sri Lankan waters. They can be broadly categorised as those that catered to international, coastal and purely indigenous shipping. While the distinctions between the first two categories are amorphous and indeterminate, an yet valid differentiation exists.

This paper presents the thesis that both the local Chronicles and foreign sources so far relied on over-emphasised the role of Mahatittha (Mantai) to the neglect of many ports in the South-West, South and East; and that the number and importance of these ports kept pace with the developments in ship design, shifting of sea-routes, population shifts & shifts in the power nexus inland and the change of the economic base from subsistence agriculture to maritime commerce.

Historical Chronicles and travellers' tales, literary works, charts, periplì sailing directions and early colonial records were consulted to identify, locate and rationalise the rise and fall of port sites. Hard archaeological evidence, however, is badly missed and the perforce abortion of the excavation at Mantai is nothing less than a tragedy in this context.

INTRODUCTION

Any attempt to identify which sites along the coast of Sri Lanka were those that served for a period of their existence as ports has to take as its canvas what maritime activities were taking place in the Indian Ocean as a whole. Ports, being subjuncts of maritime activity (even of a very localised nature) came into being and passed into oblivion as the particular maritime activity that served as its *raison d'etre* passed through these same phases. The maritime activities that led to the emergence of ports, or port sites, in Sri Lanka included colonisation, merchant shipping, cultural contact, fishing and technological development of the ships that sailed these seas. Ports themselves served as interfaces between those who sailed the seas and those who inhabited the lands they sailed to, and so must be considered as centres of prime importance in the economy of the country. Over the last two thousand five hundred years or more, Sri Lanka was the home of a people who were not primitive in any sense of the word: hence for Toussaint to say, as late as 1966 that "The Sinhalese people never looked towards the sea and the navigators whom history records were always foreigners. The outriggers are themselves of foreign origin, and it is not in Ceylon that we shall really comprehend the ocean's story," verges on the indefensible. However, these remarks of his, particularly his references to "navigators whom history records" and "it is not in Ceylon that we shall really comprehend the ocean's story", provide me with my theme today.

The major part of this paper will not, therefore, be an attempt to locate and list those points on the coast that we can point to and say "This was a port". This exercise has been already done and the latest compilation is found in the National Atlas which was published last year, which is reproduced in this paper. However, as all of us have our hobby-horses, I have taken the liberty of superimposing certain other sites I have become aware of. The major part of this paper will, therefore, comprise an attempt to justify a thesis that both the navigators that Toussaint speaks of, and the many authors of the *Mahāvamśa* and *Culavamśa* and other early Sri Lankan chronicles, did us a great dis-service by their over-emphasis of Mantai as the "Great Emproium", by turning our eyes away from the very many ports in the south west, south and southeast; the rise, fall and existence of which go a long way to help us really comprehend the ocean's story. This thesis, I must affirm, is not new and has received support from schools and researchers far more qualified than I am and my intention in presenting it here is to give it a chance of getting wider acceptance, so that the further researchers of those of you who are here will take this point of view into account of this thesis which, I feel, has not been as emphasized as its other aspects, namely, the nature of the ships that sailed these seas. The peculiar characteristics of the craft in any region will determine the type of port it requires and it is hoped to demonstrate that this holds true for Sri Lanka as well.

ESSENTIAL FEATURES OF A PORT

Under this heading I expect to discuss Ports in relation to Sri Lanka. I cannot do better, in making my point, than to quote Neville Chittick :

> "Before considering in more detail the pattern of ports and trade, it is well to consider the character of the ports themselves. Under the influence of the modern model, we tend to think of the ideal port as a largely enclosed expanse of deep water, suitable for the construction of quays alongside which ships may be moored. This is a type evolved in north-western Europe, originally because of the heavy swells found there and the nature of the beaches.... In much of the Indian Ocean region... the circumstances were different. The winds are comparatively moderate, steady and predictable,.... The beaches, at least in the west, usually have an almost flat foreshore below a steep, sandy beach. Boats can therefore be conveniently beached at high tide on the foreshore, unloaded onto mens' shoulders and carried up the beach when the tide recedes. Vessels are consequently built in a fashion to make such beaching possible. Quays and lighters are in general unnecessary. Only when there is inadequate shelter is it necessary for ships to anchor and unload cargoes into small boats. Such adequate shelter is, however, available in long stretches of the coast. The shelter may be provided by either a coral fringing reef or by an offshore island, or by an inlet or creek, or even by a headland, used on either side according to the duration of the monsoon..." A further requirement is fresh water. Even taking this into account there are a great many places suitable for adoption as ports around the Indian Ocean. The corollary to this is that the geographical reasons (in the widest sense) for a substantial port having come into being in a given place are insufficient for it necessarily to continue to exist, or to continue to be of insignificance. Ports have come and gone throughout the last 2,000 years; there seems to be a curious, but presumbaly fortuitous flourishing of such ports with a cycle of 200 or 300 years.

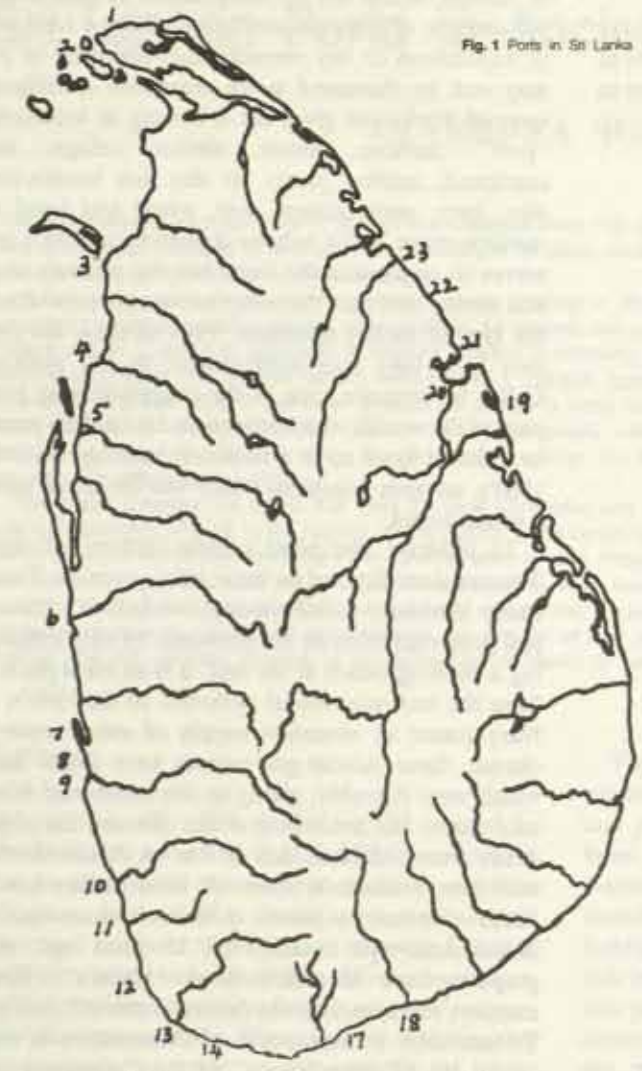
Chittick was not, but may well have been, speaking specifically of Sri Lanka: the type of shore, the build of the ships, the inlets and coves, the appearance and decline (and sometimes the re-emergence) of ports are very apt in the Sri Lankan context.

In identifying a site as a port, therefore, this description must be borne in mind. Many of the places that have been identified as port sites by reference to records, whether local or foreign, would not be recognizable as such today and, in the absence of any archaeological evidence (due to the lack of exploration or any serendipitous discovery of evidence), may well be dismissed as an erroneous identification. My copy of Thesaurus gives the following as synonymous with "port": harbour, haven, shelter, refuge, anchorage, roadstead, landing place. (It also lists breakwater, mole, pier, jetty, embankment, key, wharf and bund which, in modern usage, refer only to appurtenances of a port). This serves to emphasize the facts that the primary requirement was shelter and that the other words are more descriptive of the type of shelter provided. Thus all these are ports, however little they may approximate to our preconceptions. Galle, for instance, one of the longest-serving ports in this part of the world, which served as Sri Lanka's principal port in Colonial times up to a hundred years ago was, till the late 1960's, an open roadstead which was the grave-yard of many a proud vessel.

To illustrate this point a little further; let me speak of Trincomalee; first of a little inlet, outside Trincomalee's Inner Harbour, called (today) Nicholson's Cove. Narrow and protected from all but seawards by hilly ridges, and having a shelving beach at the end, it is an ideal place to shelter from the inter-monsoonal cyclones. In the 1940's, the Royal Navy found an abundant supply of sweet water here. By chance, three Arabic gravestones were found here, two of which were dateable, giving us thirteenth and fifteenth century dates. The suitability of the site and the objective evidence found indicate that it was an Arabic settlement for well over a hundred years. A little further south, up the Mahaveli estuary is Mutur, a Muslim colony which built and sailed Arab-type coasters till 15 years ago. Arab carto graphers have identified it as "Matura". There is yet another, more ancient site further south still, but yet close to Trincomalee. A little north of Trincomalee is modern Palvakki, the "Pallava-Vanka" of the Culavamsa from which Parakkramabahu I landed a fleet against Ramanna, or Burma. Thus, when we speak of the port of Gokanna as being Trincomalee, one has to pause and consider whether it is the Trincomalee we know of or whether it was one of the other sites which, given the ships that sailed in earlier times, would have been the more likely location. Could, in fact, Gonagamaka where Panduvasudeva landed at the mouth of the Mahakandera river (Mahaveli) not be modern Mutur?

To illustrate another coastal configuration that could lead to the use of such a site as a port, let me speak of such a beach as Chittick descries. Dodanduwa is a little town a little to the north of Galle. It is protected by a reef which blunts the fury of the South-Western monsoon, has a shelving beach up which craft could be hauled, and is the home of a sea-going and mercantile people. Today it rates as a fisheries harbour for motorised and traditional outrigger fishing craft. Yet, upto the 1930's, it was home to about 40 "yathra dhonies": 75-foot, two-masted, fore-and-aft rigged, outrig-

Fig. 1 Ports in Sri Lanka



1. Jambukola
2. Uratota
3. Mannarampattana
4. Magama
5. Uruvela
6. Salavatota
7. Negombo
8. Wattala
9. Colombo
10. Kalatittha
11. Bhimatittha
12. Dodanduwa
13. Gimhatittha
14. Galle
15. Mahavalankagama
16. Nilvalatittha
17. Tendiratota
18. Gothapabbata
19. Ilankaturai
20. Gokannatittha
21. Nicholson's Cove
22. Kuchchaveli
23. Palliavavanka

(Source: National Atlas of Sri Lanka, with interpolations underlined using modern names.)

(After Raghunathan)

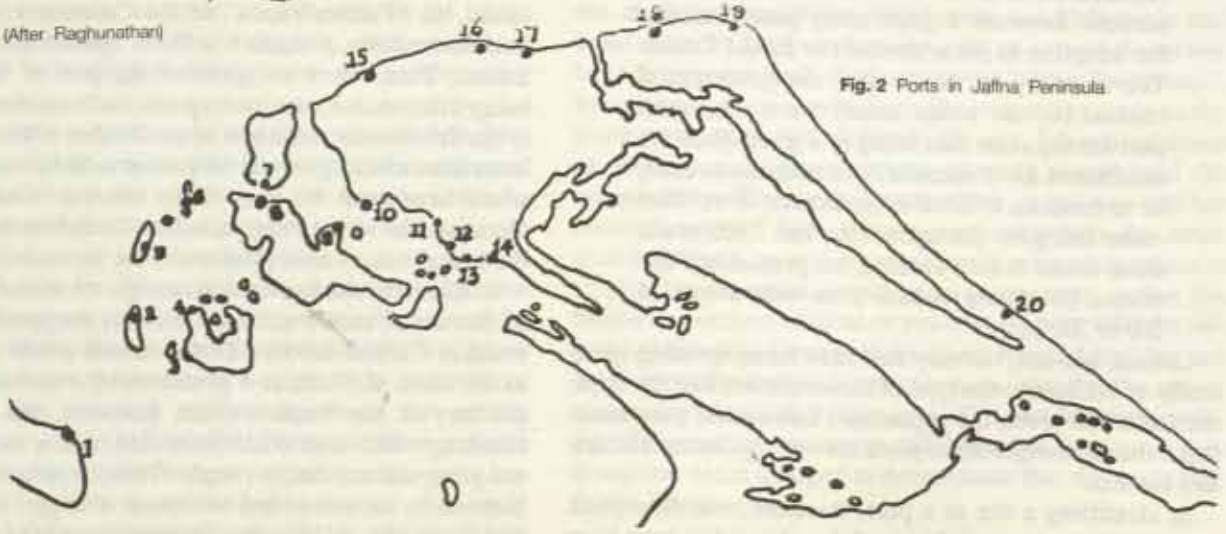


Fig. 2 Ports in Jaffna Peninsula

1. Mavalittrai, 2. Nayinativu, 3. Kurikattuvan, 4. Kalutaipitti, 5. Analaitivu, 6. Eluvaitivu, 7. Karainagar, 8. Urkavatturai, 9. Velanai, 10. Arali, 11. Navanturai, 12. Pannaiturai, 13. Kurunagar, 14. Kolumputurai, 15. Matakalturai, 16. Kankesanturai, 17. Mayilitti, 18. Valvettiturai, 19. Paruttiturai, 20. Talaiyati.

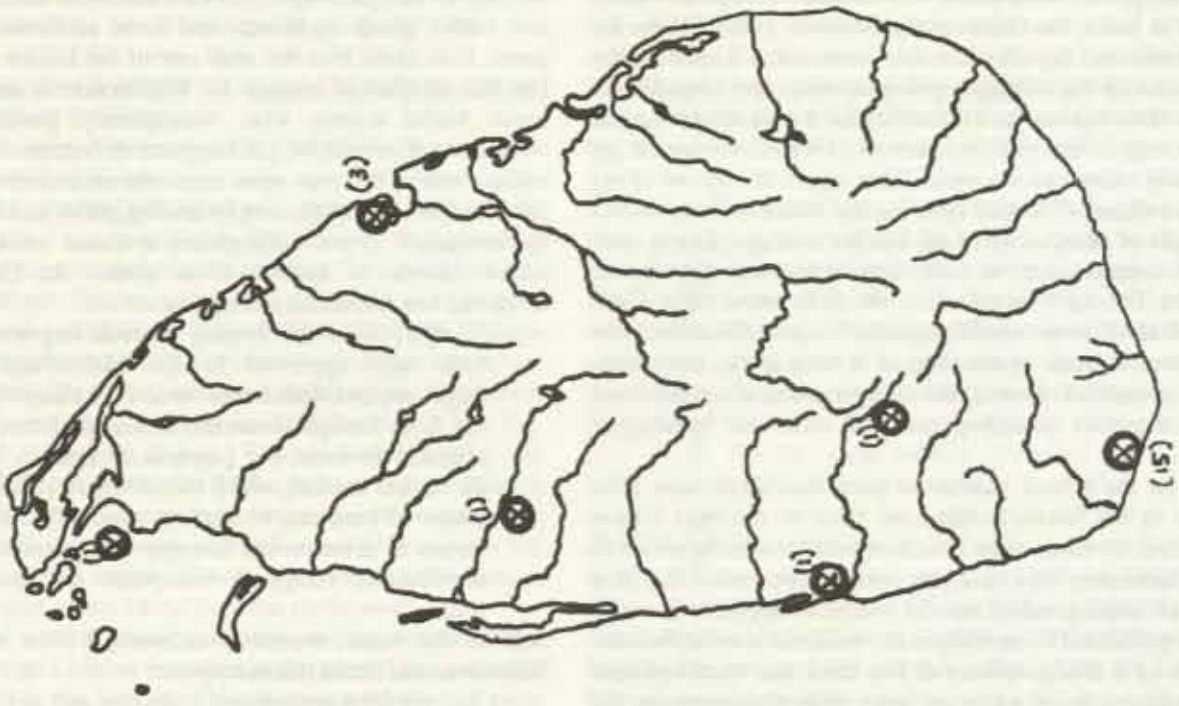


Fig. 4 Location of Arabic inscriptions discovered, showing number found at each location.

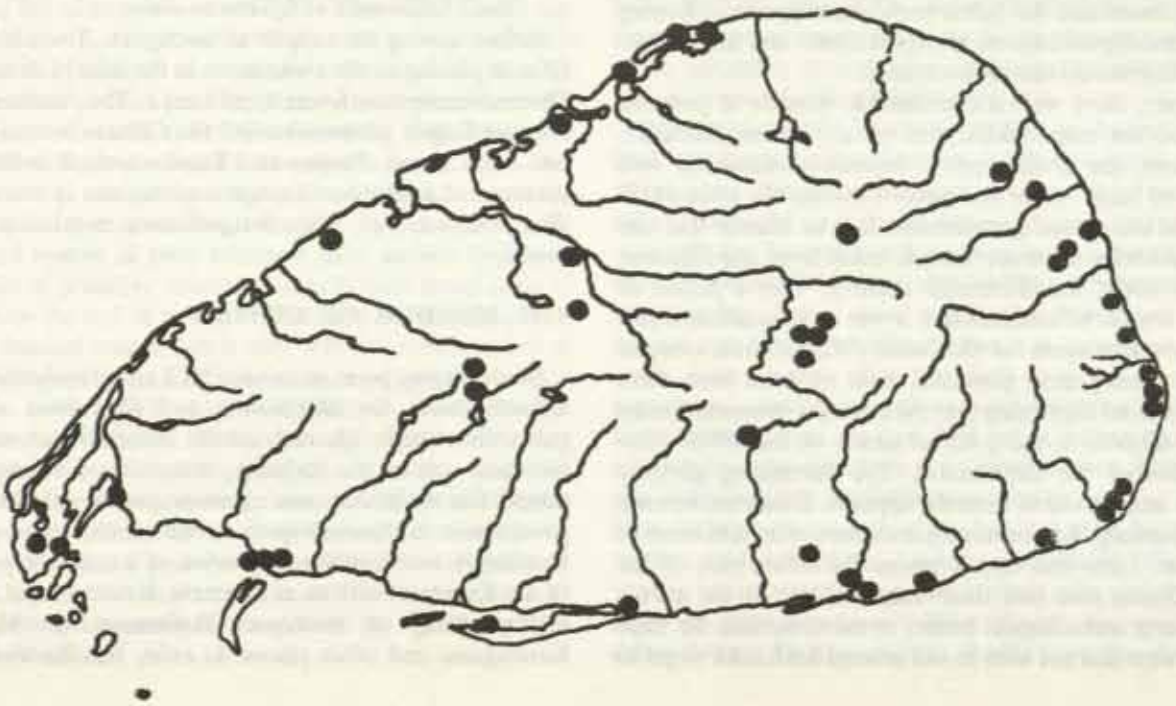


Fig. 3 Location of findspots of Roman coins prior to 600 AD

gers-equipped, sewn-plank carvel-built schooners which sailed to India, the Maldives and Malacca, coming home for the monsoonal lay-off when they were safely hauled up the beaches with the outrigger giving the necessary bi-pedal stability. Here too one sees the ability for a craft of appropriate technology to use as home port a site which one would not normally class as a port. The sight of up to forty "yathra-dhonies" hauled up along the beach is no more, but the sight of many more of the smaller outrigger fishing-craft is yet common and, at such times it becomes possible to imagine the sight described in the Culavamsa when Parakramabahu I, in the twelfth century, "... gave the order without delay to make ready ships of various kinds, many hundreds in number. Now all the country round about the coast was one great workshop occupied with the building of ships..."

By far the greater number of ports that would have been in use in Sri Lanka would have been of the type I have described. Ports at river mouths would have to be added to their number as they resemble them to the extent that they were all making use of natural coastal configurations: were either populated by an indigenous maritime/mercantile community or a foreign colony of like kind; and would prosper or decline leaving no more trace than footprints on the sea-shore. A more significant use of river-mouth ports was their ability to use the rivers as routes to ferry cargo to and from inland. Sri Lanka had a well-developed tradition of sailing the inland waterways and many specialised craft were evolved and are yet in use. The map clearly indicates how most of the South Western and Southern ports were sited at river mouths, showing this interaction between the coast and the interior. Equally significantly it shows the lack of waterways at Mantai and the Jaffna ports unambiguously showing their entire dependence on entreport trade: and their inevitable decline should sea-routes change.

However, there were a considerable number of ports, as shown on the map, which were of a different character. These were the greater ports, intimately connected with established trade routes and under the control – even nominally – of the central government. It is to Mantai that one would first refer of these. Since it lasted from pre-Christian times to about the thirteenth century, with a period of decline, it must be assumed that it was constructed as a port in the modern sense of the word. Warehouses, customs posts, a cosmopolitan populace, must all have been there and it is indeed frustrating that the evidence from excavation is not available, as the political unrest of the 1980s effectively aborted the exploration. The tantalising glimpses afforded only served to whet the appetite. I shall not venture into archaeology here, since my concern is why it became so important. Here one comes across the bifurcation of the Indian Ocean into two trade zones which, in the earlier years, was a technological barrier in the sense that the ships of those days did not wish to sail around Sri Lanka to get to the Bay of Bengal. Ships from East and West therefore met and traded goods at Mantai and some south-west Indian ports. It is likely that the seas east of Sri Lanka were not familiar, or charted enough for Meditteranean and pre-Islamic Arabic seamen who, consequently, permitted the emergence of certain Sri Lankan ports as centres of entrepot trade. Ports of this type were under the control of state officers but were effectively run by trading guilds and inhabited by foreigners. Some epigraphical evidence exists of the state's efforts to control these ports. At Devundara (Dondra) was found this inscription:

> "...apart from the levying of such imposts as have been approved by the Maha-Pandithe illegal imposts shall not be levied. To those coming from foreign countries, means shall not be afforded to avoid the payment of imposts and duties that are due, which they do by establishing places of business, corrupting royal officers by means of presents and keeping with friends the merchandise smuggled from their own countries..."

And at the other, northern, extremity of the island, at Nainativu, was found this inscription:

> *"..... the foreigners should come and stay at Uratturai (Uratota), that they should be proected and that foreigners from many ports should come and gather at our ports; as we like elephants and horses, if the vessels bringing elephants and horses unto us get wrecked, a fourth (share of cargo) should be taken by the treasury and the (other) three parts should be left to the owner; if vessels laden with merchandise get wrecked, an exact half sheuld be left to the owner...."*

Before leaving the subject of inscription, I would like to refer in passing to the sites shown in the map of Arabic and Chinese inscriptions found in Sri Lanka. The Arabic inscripions are largely gravestones and the Chinese is a tri-lingual one - in Chinese, Persian and Tamil – and all indicate the presence of established foreign communities in these sites. This evidence, too, bears a significance in relation to my thesis.

THE RECORDS OF HISTORY

In identifying ports in ancient Sri Lanka, early historians naturally took the *Mahāvamśa* and *Culavamśa* as their guide. Information gleaned was not incorrect and, although the focus was on the Rajarata, other sites were also mentioned. But the Mahavamsa's pre-occupation with the seat of government at Anuradhapura is one of its weaker points. Reading it, one would not conceive of a southern province (if not Kingdom) with an as extensive, if not so royal, a community being in existence. References to Magama, Kataragama and other places do exist, but the view is as

from far away, from almost another country. These chronicles are certainly no help in piecing together what the Ruhuna civilization was like. Inscriptions and some archaeological finds have filled in some of the gaps, but yet no clear picture has emerged.

Unfortunately, "the navigators whom history records" – in the words of Toussaint – only served to buttress the *Mahāvamśa* view of Sri Lankan ports and trade, so far as the ancient period was concerned. Of the over forty classical Greek and Roman authors who mention Sri Lanka, ten provide significant information of the geography and products of the country; and these include Onesicritus (4th Century B.C.), Megasthenes and Eratosthenes (3rd Century B.C.), Strabo, Pliny the Elder and the *Periplus of the Erythraean Sea* (1st Century A.D.), Dionysius (2nd Century A.D.), Palladius (5th Century A.D.) and Cosmas Indicopluestes (6th Century A.D.). Viewing Sri Lanka from a western vantage point, and concerned with their own mariners' routes which did not, during their times, extend beyond Mantai, very few were able to give any significant information of the ports in any other part of the island than the north-west.

From an eastern standpoint, too, nothing was forthcoming. Although Chinese travellers and traders did come to Sri Lanka during this period, the information concerning ports is nil.

Yet, objective evidence that whoever used Roman coins sailed not only round the island, but left their coins largely out of the north-western area, is available as the accompanying map indicates. Of 42 findspots, 18 are coastal sites between Colombo and Tissamaharama, 5 are similar sites between Tissamaharam and Kuchchaveli, and only 8 are north-western coastal sites. Inland, 4 are in the Rajarata and 6 in the hill contry, about which the Chronicles hardly say anything. In all, only 8 of the 31 coastal (or adjacent) sites and 4 of the 10 inland sites are in the Rajarata. Further, all the sites that yielded pre-5th Century coins were from the south west or inland, in the hills. Given the statistics that 31 of the 42 sites are coastal, the inescapable conclusion is that the coins were carried, by whoever it was, by sea and, in the south-west, upriver to the hills, Sri Lanka had a very advanced system of river transport from ancient times and log-boats of primitive construction have been found even 15 feet below the bed of rivers: hence this is no speculation.

The classical assumption is that with the abandonment of the Rajarata with the Chola invasion, a progressive shift of capitals took place to Polonnaruwa, Dambadeniya, Yapahuwa, Dambulla, Gampaha, and Kotte. This was accompanied by internecine warfare, destruction of tanks, dwindling of central control, rise of independent principalities and urban centres, decline of subsistence agriculture and the rise of maritime commerce. The movement of capitals was ever south-west-wards, and the development, or coming into prominence of this part of the island was attributed to this fact.

From foreign sources however, there emerges another picture. Post-Islamic Arab navigators accelerated and effected a mutation to a process that had already begun. With the growth and development of fore-and-aft rigging, of confidence in open-sea sailing with the monsoons, wider use of the magnetics compass, *Kamal* and cross-staff, larger ships than could sail the narrow Mannar strait came to be built and sailed. The straits themselves became silted up and came to be used more for localised than international traffic. An understanding of the pattern of alternating currents added to that of the monsoons made longer voyages across the open sea feasible. Consequently, ships began to progressively sail around Sri Lanka and the importance of the north-western ports waned. Carrying this further, the Arabs began to sail right across the Indian Ocean, making only Sri Lanka their port of call. The very large number of coastal points in the south-west, south and east, marked in relation to their latitude indicate that not only did they did call at these places but that communities had to be in existence for them to do so. This southern route began to be in use before the fall of Anuradhapura to the Cholas and one has to accept that, notwith-standing the pre-eminence of Anuradhapura in the classical era, and the pre-occupation of the Sri Lankan Chronicles and western writers with the Raja-rata, the south-west, south and the southe-east, as well as the hill-country, were continuously occupied and deeply involved in maritime traffic throughout the whole of the historical period, if not earlier.

SRI LANKAN SHIPS

The concluding part of this paper concerns the ships that frequented the ports of Sri Lanka – the indigenous ships, to be more precise, since part of my thesis, already mentioned, is the suitability of indigenous ship-types to use the lesser and more abundantly available ports.

How correct would it be to argue that, in classical times at least, Sri Lankans were content to let foreigners do their shipping for them? In the absence of any large, sea-going ships mentioned in colonial times, it may be considered excusable for Toussaint to have come to his conclusion; particularly when a flourishing ship-building industry existed in neighbouring India, from which the Portugese, Dutch, French and British benefitted. Yet it is imprudent to conclude that a nation that had such long and continuous acquaintance with ships and mariners never wondered what lay over the horizon. In fact, Sri Lankan sources have referred to indigenous ships from pre-Christian times. More objective references are available from foreign sources. Onesicritus, sailing to the mouth of the Indus at the behest of Alexander, had noticed Sri Lankan craft which sailed badly "owing to the wretched quality of their sails and the peculiarity of their structure." Pliny shared his opinion but deduced from the characteristic double prow that these craft

were designed to navigate in narrow straits. It is not known whether the craft seen were outrigger-equipped and square-rigged: if they were, Pliny would have been very perspicacious indeed.

Other foreign references are to more respectably-built ships. Li Chao, a Mandarin of the T'ang Empire, speaking of the arrival of ships in Chinese ports, says "the ships from the Lion Kingdom (Sri Lanka) were the largest, with stairways for loading and unloading, which are several tens of feet in height." Ships capable of transporting elephants and horses between Sri Lanka and Burma, are mentioned in Sri Lankan and Indian sources. A more interesting note is struck by Bhuvanekabahu I, in the 12th Century in a letter sent by hand of an envoy, in which he offers to build twenty vessels per year for the Mamluk Sultans, as the necessary raw material is available. But though the skills were available then, and the materials even now, we have no hard evidence of what these stately ships really were.

Of the older types that the Greeks wrote about, we know more. Although Hornell concluded, and others repeated, that the "Yathra-dhonies" had disappeared decades before his time, the last of them did sail in the 1930s. A faithful model of respectable size, constructed about a hundred years ago shows how the basic design continued for 1500-2000 years successfully. How they used the ports has already been described. Similar was the use of the ports by the different sizes of outrigger fishing craft, the larger of which can be classed ocean-going. The Dhonkies or Thonies, of Jaffna sailed between India and the Jaffna peninsula and also between the many jetty ports which are, in all probability, the sites of more imposing ports in the hey-day of the Mannar passage. The map indicates ports both on the sea and the lagoon. More ancient and yet used are the log-rafts of north-west Sri Lanka and India. The fact that these, and the outrigger craft, the most ancient types yet survive is proof enough of the success of the design in relation to utility and environment.

What really the Sri Lankan ships that sailed the length and breadth of this Ocean, and beyond, carried is a matter for conjecture. It would, however, not be out of place to venture the opinion that, in a total Indian Oceanic context, Sri Lankan shipping did exist but not as a major force nor a monolithic one: the limitations of resources and size would have ensured this. With the emergence of dominant maritime nations – Arab, India, Chinese and, later, European – Sri Lankan shipping which would have thrived only in a multi-user environment, would have declined. The first to disappear would have been the ocean going craft, next the regional and coastal craft which survived into this century, till all that is left is the fishing craft, the oldest of them all. Yet, when Sri Lanka was an essential port of call for all Indian Ocean shipping, it assimilated elements of ship design that had their genesis in the far corners of the ocean, and preserved them well into this century long after they had been lost in the lands of their birth. If, therefore, the story of ship design in the Indian Ocean is to be searched for in depth, it is – in my opinion – in Sri Lanka that the search must begin.

Finally, having thus far tried to focus your interest in the many ancient ports and port sites of South Western and Southern Sri Lanka, I have yet to answer the question how and why they existed when our usually trustworthy chronicles makes no mention of ancient littoral settlements strung out over this area. The answer I suggest is that there were settlements that existed from before the date the Chronicles use as their starting point and that Sri Lanka was first settled all along the coast most certainly by a people who were no strangers to sea-going. A map of megalithic sites in Sri Lanka confirms this, as do excavations into Southern pre-historic sites that have yielded dates older than 28,000 B.P. Thus it was these earliest Sri Lankans who established the beachheads which ultimately developed into the truly indigenous port sites which the Chronicles of a later Establishment paid scant attention to.

Portuguese Trade: 1948–1961

Dr. B.S. SHASTRY

Virtual naval supremacy and trade monopoly of the Portuguese in the Indian Ocean during the 16th Century. Decline in the 17th century owing to the Dutch rivalry and rising power of the Marathas and the Nayakas of Ikkeri. Further decline in the 18th century owing to the Peshwas and the rulers of Mysore (Hyder Ali and Tipu Sultan). Dpmination of the British in the 19th and 20th centuries and their Free Trade Policy.

1. COMING OF THE PORTUGUESE TO INDIA

Twin objectives of Portuguese trade were to find christians and obtain spices. Significance of the discovery of the Sea Route via the Cape of Good Hope: greatest event in human history next only to the birth of Jesus Christ; beginning of the Vasco da Gama Epoch in the Western Dominance over Indian Ocean. Full marks to da Gama? (Bartholomeu Dias, Ibn-Majid; Pero de Cavilheao). Profits of da Gama's voyage were 60 times the cost of the voyage. Annual fleets to India thereafter; 4 to 5 a year on an average during the next 100 years or so. End of Arab monopoly of eastern trade. Francisco de Almeida and Afonso de Albuquerque in acquising Role of supremacy over the Indian Ocean.

2. THE SEABORNE EMPIRE OF THE FORTUGUESE

The implications of the term 'Seaborne'. Portuguese possessions along the Indian Ocean Littoral: (a) Sofala, Mombasa, Mossambique; (b) Mascat, Ormaz; (c) Diu; Daman; Bassein (including Bombay, Mahim, Bandra, Thana); Cheul; Goa (old conquests); Anjediva; Honavar; Basrur; Mangalore; Cannanore; Cranganor; Calicut; Cochin; Chaliam; Quilon; (d) Ceylon (e) Settlements of Sao Thome and Nagapattanam; Hooghly; (f) Malacca, Solor, Timor, Macao.

3. ARTICLES OF TRADE

From Portugal, African coasts, Arab and Persian Coasts, India, Ceylon, South East Asia, East Indies, China, Japan. Exchanges in Africa, Arab and Persian Gulf regions, India, etc. Major components of trade: pepper, horses, slaves, war materials, rice, wines and liquors, gold and other precious metals and stones, silk and cotton textiles, ivory and leather, timber, salt-petre, lead, copper. Royal monopolies (Pepper, horses, tobacco); no private trade in these.

4. STATISTICS

No regular, continuous statistics. Some statistics here and there regarding volume of trade, its value, quality of articles, their prices (retail, whole sale), investments.

5. ORGANISATION OF TRADE

(a) The Fortress-Factory System: The Factor and his functions. Agents, brokers, linguists, contractors. Portuguese as the *linqua franca* in the 16th, 17th and 18th centuries. Merchant families of Goa.

(b) The System of Cartazes (sailing permits): The Portuguese declared themselves Lords of the Seas. Their permission needed for others to use the seas. The system did not apply to other European powers. Why? (Weakness of the Portuguese vis-a-vis other Europeans; the latter were believers like the Portuguese while the Asiatics and Africans were non-believers and pagans). Contents of a *cartaz*; description of the ship, its name, owner's name, tonnage, masts, equipments, captain's name, pilot's name, articles on board; (b) conditions for granting the cartaz: not to sail into enemy ports; not to carry articles like horses, pepper, Christian slaves; (c) Period of validity: 1 year only. Fees for a *cartaz:* Varied, depending on destination of the ship – coastal or across the seas. *Cartazes* could be obtained only in Goa for overseas trade and at any port for coastal trade. Some free *cartazes* to local rulers. Confiscation for the violation of any of the conditions. The system worked well during the 16th century when the Portuguese naval might was unchallenged in the waters of the Indian Ocean.

(c) Treaties and Agreements between the Portuguese and the Indian rulers helped the organisation of trade. Clauses regarding the establishment of trading centres, shops, concessions in custom duties, supply of goods compulsorily or otherwise, etc. were laid in such agreements.
(d) Commercial companies during the 19th and 20th centuries.

6. WEIGHTS AND MEASURES

Usually local people insisted upon using their own weights and measures. These varied from place to place, from commodity to commodity.

7. CURRENCY AND COINS

Real, bazarucu, tanga, pataka, ashrafi, cruzado; pagoda, pardao. Copper, silver and gold coins. 1 *ashrafi* = 360 *reis* = 1 *Pardao* ; 1 *tanga* = 60 *reis;* 1 *ashrafi* = 6 *tangas. Pagoda* = *cruzado* = *São Tomó* = 420 *reis*. 1 Re = 160 *reis* in latter half of the 19th century.

8. TRANSPORTATION AND COMMUNICATION

(a) Trade routes; sea routes and land routes; (b) Means of transportation; horses, palanquins, beasts of burden, head loads; boats and carts; (c) Types of ships: *Nau*, the largest with 3 or 4 decks, 70 guns, 800 passengers; *fragata* (frigate) smaller than *nau*, 2 decks, 60 guns; *pala*, smaller than *fragata*, 2-3 masts, 40 guns; *pataxo*, patterned like the *nau*, but much smaller; *galveta* (gallivat), smaller than *pataxo* and *pala*, 15 guns; *machua*, 1 or 2 masted, 10 guns; *patmari*, messenger boats, *tona*, flat bottomed passenger boat for river navigation, 12 or so passengers; *sando*, *manqueri*, *batelo*, were also large passenger or cargo ships which could be quickly changed to a kind of small warships with a couple of guns mounted.

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Before Professor B.S. Shastry, Head, Department of History, Goa University could send his full paper the hand of death took him away in July 1991. The Society for Marine Archaeology intends to bring out Prof. B.S. Shastry commemoration volume soon.

– Editor

Section 5

Sea Level and Environmental Parameters in Marine Archaeological Studies

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Sea Level and Environmental Parameters in Marine Archaeological Studies

Bio-Indications of Sunken Ships and Ship Wrecks

A.H. PARULEKAR

An evaluation of bottom fauna of ship-wreck sites in estuarine and coastal waters of Goa, revealed an exceptionally high biotic enrichment. In terms of number of species, faunal dispersion, faunal diversity, biomass and productivity, in space and time, the values for richness and heterogeneity in benthic macrofauna were generally higher at ship wreck sites than at close proximity natural sites. Rationale of using biotic factors as indicators of modification of submarine biotopes due to ship-wrecks and other man-made objects is discussed.

INTRODUCTION

Habit and habitat preference in marine biota, both sedentary and mobile, has a direct dependence on the type, location and environmental set-up of an ecosystem. Since the biota of the seafloor, technically referrred to as benthos, is largely dependent on the local topographical characteristics, the distribution, abundance, diversity and productivity exhibit changes as the nature of submarine topography is modified (Heirtzler 1982). In the subtidal realm, it has often been observed that besides the natural topographic features like sea mounts, banks and ridges, the man-made structures e.g. artificial reefs, jacked-up platforms, and sunken ships, often support unusually rich and diverse biota (Ranasinghe 1981).

OBSERVATIONS

The causes for extraordinarily high enrichment of subtidal ecosystems have not properly been understood. However, many instances of such modified habitats, both in the inshore and oceanic waters of the Exclusive Economic Zone (EEZ) of India, as elsewhere in the world oceans, are on record.

While studying the bottom fauna of the Arabian Sea Parulekar (1976) reported the unusually high benthic biomass in the environs of continental islands of Karwar group (Lat. 15°43′ 15°55′; Long. 74°00′–74°10′E) and St Mary Isles (Lat. 13°15′ – 13°25′N; Long 74°40′ – 74°47′E). However, the factors causing such an enrichment, could not be properly understood.

Recent surveys on submerged banks in the Arabian Sea, further highlighted the significance of submarine topographical features in the ecology, richness of biota and biological processes. A dredging survey of the Angria Bank (Fig. 1) revealed the high enrichment of flora and fauna at depths of 20-73m in an oceanic environment, with water column of 820m. While the total number of floral species were 57 (Untawale et al 1989), the faunal species, excluding finfishes and other nektonic forms, but including rich representation of sponges, corals, worms and shells, were 89. Similarly, in surveys on other submerged banks in the Arabian Sea (Fig. 2), 73 species of algae (Untawale – personal communication) and 115 species of unique fauna, have been recorded from Sassostris (Lat. 12°59′ – 13°13′N; Long. 71°51′ – 72°05′E); Bassas de Pedro (Lat. 12°31′ – 13°38′N; Long. 72°16′ – 72°46′E) and Cora Divh bank (Lat. 13°33′ – 13°52′N; Long. 72°04′ – 72°15′E). The ecological characteristic of these oceanic banks, in the Arabian Sea, have less varying to stable conditions of temperature, salinity and dissolved oxygen (Nair et al 1966).

A comparison of faunal richness of the oceanic banks, continental islands (Parulekar,*op. cit.*) and submerged rocky basement (Parulekar 1981), with the benthic fauna of the environs of such ecosystems, revealed (Parulekar et al 1982), the magnitude of enrichment, which was manyfold more in the modified substratum than in the natural bottom deposits.

A CASE STUDY

Recently, while going through a publication (Rao and Gudigar 1988) on the underwater cultural heritage of the Indian Ocean islands, an illustration showing the sites of ship-wrecks in the coastal waters of Goa (Fig. 3) prompted, the author, to make an attempt to evaluate the ship-wreck sites from a biological angle and to ascertain whether a ship-wreck induced changes in benthic substratum results in the enrichment of biota.

Data, from published (Parulekar 1973; Parulekar and Dwivedi 1974; Parulekar et al 1975; Parulekar et al 1980; Harkantra and Parulekar 1981 and Parulekar et al 1982) and unpublished sources are used here to compare the distribution, abundance, diversity and productivity of benthic or seafloor fauna at and around ship-wreck sites with the clean or natural sites in close proximity. All the ship-wreck sites are indicated (A), (B), (C), (D), and (E) as in Fig. 3, and

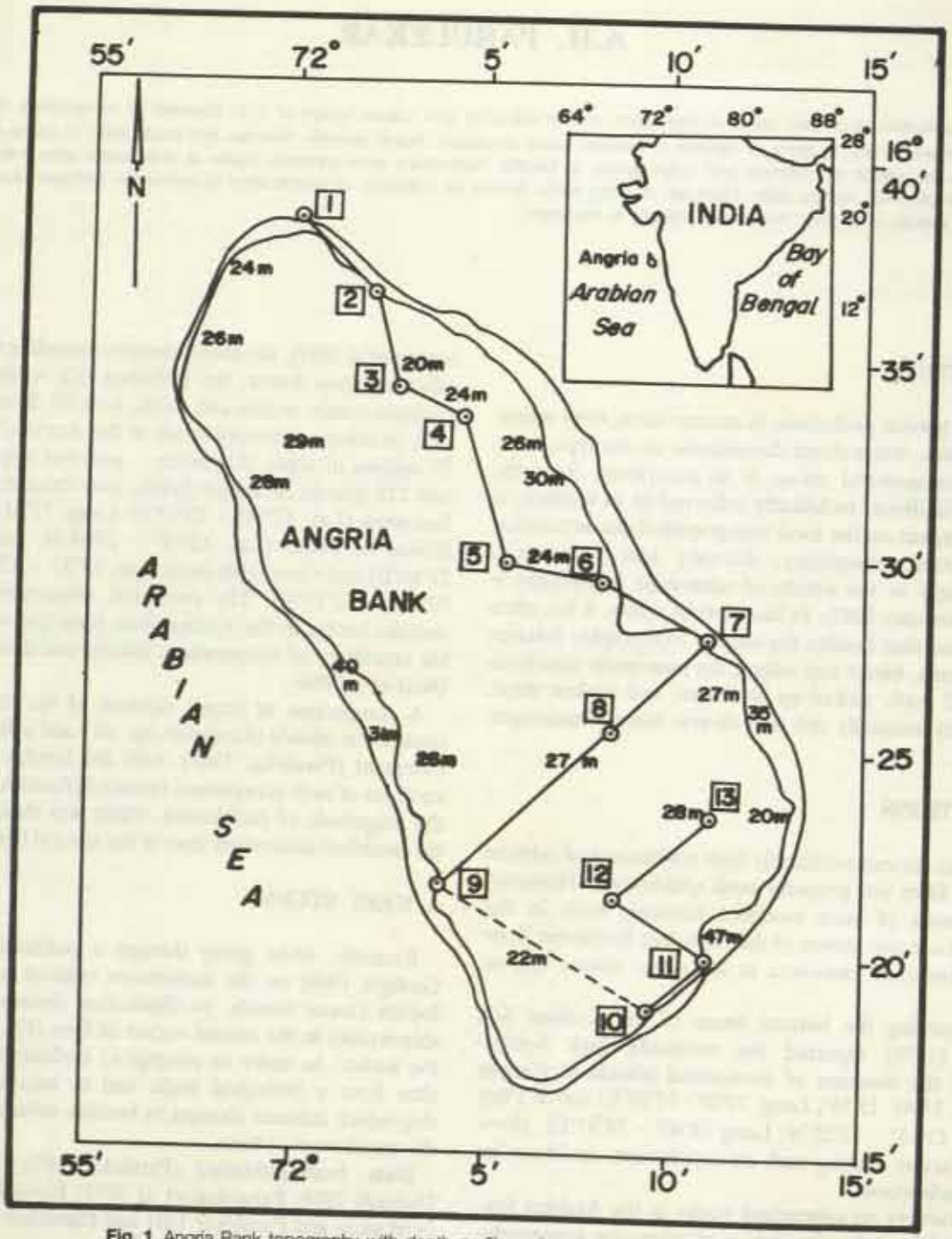

Fig. 1 Angria Bank topography with depth profile and sampling track with stations (box).

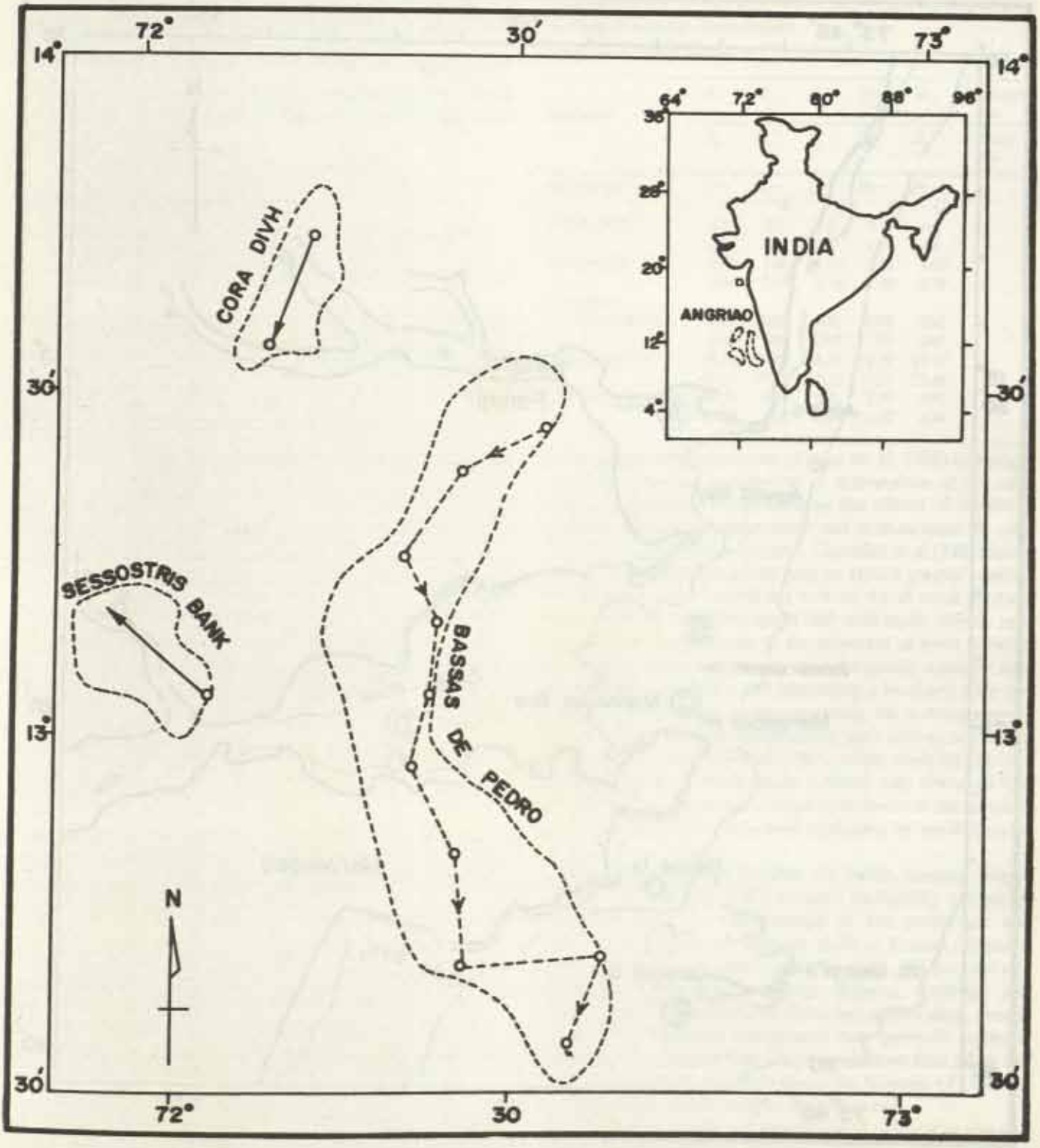

Fig. 2 Location and sampling track at submerged banks in the Arabian Sea.

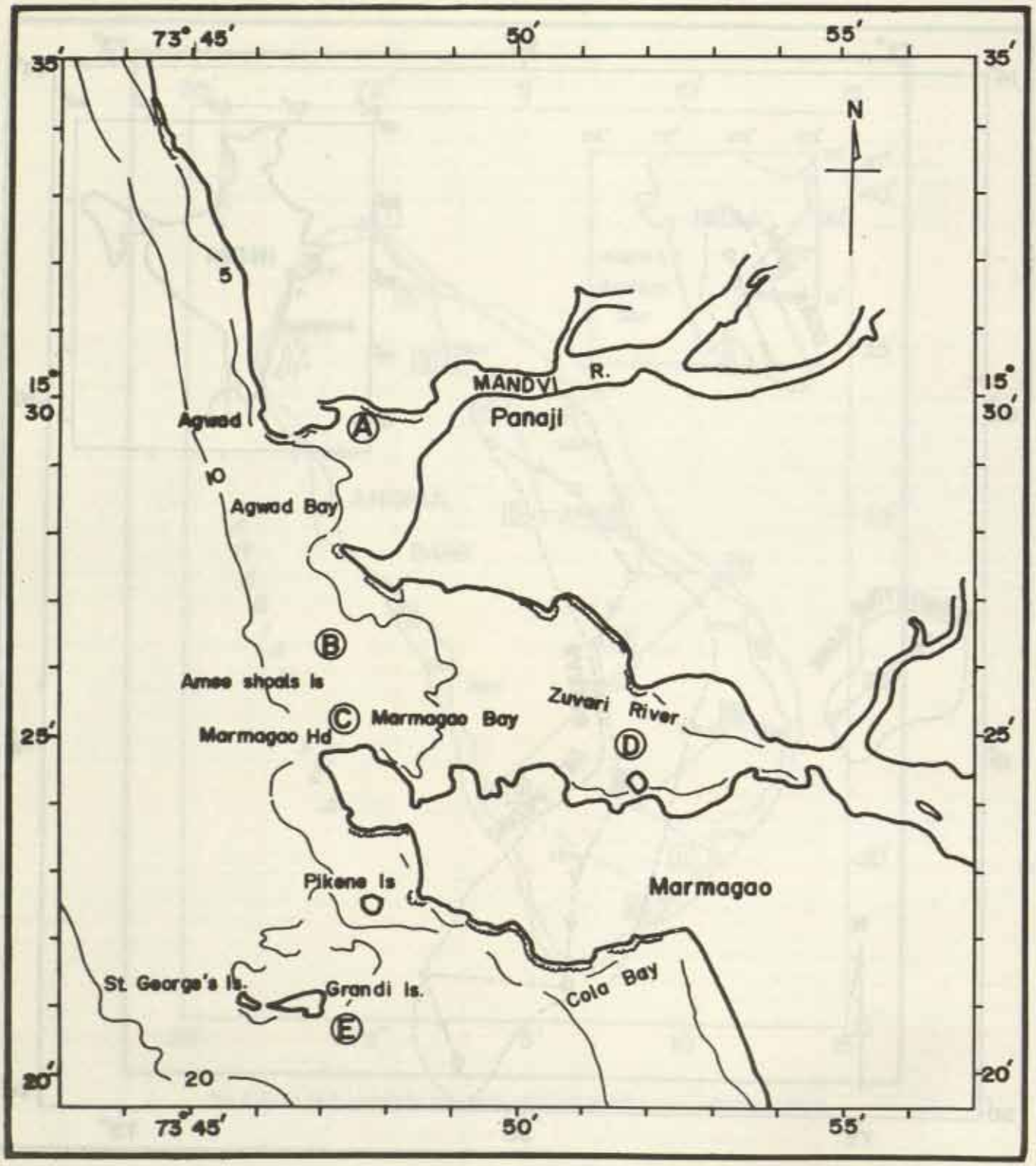

Fig. 3 Observation points (A to E) in Goa waters.

the natural sites denoted as A1, B1, C1, D1 and E1 (Table 1) were less than 750 m in one or other direction from the shipwreck site. Thus, A1 was 500 m east of (A); B1 was 650m north of (B); C1 was 600m west of (C); D1 was 500m west of (D) and E1 was 700 m east of (E).

The comparison (Table 1) was made by evaluating the annual mean at ship-wreck site and adjoining natural sites in respect of the following biological parameters pertinent to benthic macrofauna:

- Total number of species in space and time
- Dispersion of species and biota in space and time
- Diversity of macrofaunal species
- Population density of macrofauna in space and time
- Biomass or standing crop in space and time
- Rate of production of macrofaua in unit area and in unit time

A perusal of data in Table 1, reveals that at ship-wreck site, the biotic enrichment, as measured in terms of distribution, dispersion, diversity, abundance and productivity of benthic or bottom macrofauna is many times more than at clean sites, where presumably, the submarine features are in their natural and unaltered state. On all counts of six parameters taken for comparison (Table 1), the sites with modified substratum due to the sitting of ship wreck can distinctively be delineated on the basis of biological indications relevant to richness, heterogeneity and productivity of bottom living macrofauna. The preference for submarine substratum, as assessed from the dispersion values, which explains the distribution, similarity and association of biota, was more specific in relevance to ship-wreck sites than the natural sites. The spatial variability in the availability, abundance and variety of benthic macrofauna, as observed at ship-wreck site (Table 1), further reflects on the importance and significance of substratum in natural and modified benthic ecosystems.

Table 1: Comparison of biotic Enrichment, Between ship-wreck site (A to E) & Natural sites (A1 to E1) In respect of Distribution, Dispersion, Diversity, Abundance and production of Bottom Macrofauna.
(Annaul Mean Values)

Parameter	A	B	C	D	E	Shipwreck site
	A_1	B_1	C_1	D_1	E_1	Natural site
Species (nm^{-2})	47→	45→	23→	20→	29→	
	16	18	8	6	12	
Dispersion (I)	4.9	2.3	6.8	3.1	4.8	
	2.1	1.4	3.8	1.7	2.7	
Diversity (d)	6.46	4.82	4.13	3.76	3.09	
	3.76	2.47	2.78	1.81	1.78	
Population Density (nm^{-2})	3901	2211	4382	1350	2242	
	1169	1201	2242	523	1087	
Biomass(gm^{-2})	170.19	30.02	138.17	32.57	34.16	
	44.50	17.11	34.16	17.97	22.64	
Production (gCm^{-2})	12.20	3.18	6.61	2.87	3.01	
	5.40	1.95	2.54	1.92	2.54	

RELEVANCE

What attracts marine organisms to natural and man-made submarine topographical features still remains unanswered, inspite of numerous studies (Ransinghe *op. cit.*). Some of the earlier studies assumed that it is the food production which acts as an important factor for aggregation and overall biotic enrichment. However, habitat enhancement is one of the important causes of biotic enrichment of submarine substratum (Walton 1962).

A wide variety of environmental factors play an important part in attracting biota to submerged structures such as sunken ships, artificial reefs and jacked-up offshore platforms (Okamoto 1983). Many factors like light, temperature, water motion, sedimentation, substratum size and rugosity, depth, sand scour, presence of microflora, species composition and cover of the attached community, grazing/cropping by herbivores and omnivores (Carter et. al. 1985) can singly or jointly cause the enrichment or defaunation of the submarine substratum. While studying the effects of substrate rugosity, percent substrate cover and vertical relief on resident fauna of varying substrates, Chandler et al (1985) inferred that midwater structures help to attract greater number of species than the natural sea bottom. Small coral patches, rocky outcrops or oyster rocks and man-made objects provide structural complexity to the substrate as wave patterns get altered, redirecting waves into ecologically sensitive sites (Burchmore et al 1985) and generating a localized eddy circulation, which helps in concentrating the nutrient supply and thus supporting an exceptionally high biological productivity. Buckley and Hueckel (1985), while studying the rate of development of biota on an artificial reef observed that the algal colonization was a major contributor to the physical structure followed by increased habitation by small invertebrates.

While the submarine features, viz. banks, mounts, ridges, natural and artificial reefs increased availability and abundance of biota, no enhancement in net production was observed in studies on artificial reefs in France (Begueny 1974). Similarly, Barchmore et al *(op. cit.)*, did not find any significant difference in species richness, evenness and heterogeneity between the artificial and natural sites, though values for richness and hetrogeneity were generally higher at artificial sites. Walton (*op. cit.*) found about four times the population density and nine times the biomass of biota on artificial reefs relative to open bottom areas.

In the present study, the magnitude of richness as assessed from number of species, dispersion pattern, diversity index, abundance, standing crop or biomass and rate of production

was twice as high in shipwreck than at the natural sites. Conclusively, it can be recorded that modification of submarine substratum due to sunken ship, induces and supports biotic enrichment.

A point that emerges from the results of the present case study is whether, the biotic enrichment can serve as a valid indicator of shipwreck sites and, if yes, how precisely?

ACKNOWLEDGEMENTS

Thanks are due to many a colleagues, especially Dr. A.G. Untawale, and Mrs. Prita Ramani, for being gracious in permitting the use of some unpublished data.

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DISCUSSION

Q: Dr. Gangadharam: Biota are nutritionally dependent and temperature dependent; to what extent can these two factors interfere in projecting backward their relative population and applying it to wreck identification and location?

A: Parulekar: The biota is definitely food dependent. They always display different food habits and a preference for particular food, but as regard the temperature dependence, specially in the tropical marine biota, they seem to have an upper limit of withstanding temperature variations. They can withstand 24-34° temperatures but the upper critical limit is 42°c. The reasons which we want to give for enrichment of submarine ridges, banks, seamounts and shipwrecks with that particular structure, in a particular environment is that it alters the natural physiochemical set up and gives rise to local eddy circulation wherein all organic matter comes into a small gyre. This concentration of organic matter is manifested in high values of C that we find. Daily productivity 450mg/day when in the near vicinity and less 30mg C/day. Trigger fish and Scorpion fish cannot eat this phytoplankton but they feed on herbivores which feed on the phytoplankton; otherwise these animals are only found in pockets. This is a cursory observation without much scientific thought. Future data collected should provide indicators for biological phenomena.

Q: In the 1st Marine Archaeology Conference a paper on the 'Risdan shipwreck', pictures were shown of timbers taken

from the same wreck in which the timbers were perforated by wood borers but the tusks were not perforated by wood borers. Within the same wreck there was a difference could, you explain it?

A: Parulekar: Dr Shantakumaran (Wood Preservation Group N.I.O.) could explain it better. Perhaps in some tusks the activity was at a minimum because conditions for the wood borers to operate were not optimum.

COMMENTS

Shantakumaran: In the same wreck if some timber is damaged i.e. if some timbers are attacked and others are not, it only indicates the pressure of larger organisms on the timber. Or the timber may be buried in some silt.

Sila Tripati: Has the use of seaweed for medicinal purposes been mentioned in ancient literature?

A: Parulekar: The main objective of our underwater studies is application to the biomedical field, Now as history goes I am not so sure about the seaweeds. As early as 3000 years ago the Arabs used a Nereid worm as an efficient anti-helminth (round worm). This impairs human health though. Secondly in Japan the seaweeds are eaten especially the variety which is rich in protein. It has an abnoxious taste. They are however rich in halogenated compounds. Iodine controls proper function of thyroid and deficiencies can be controlled.

Littoral Processes and their relevance to the submergence of ancient ports along Andhra Coast, India.

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Dona Paula, Goa 403 004. India.

The study of environmental parameters along the coast of Andhra Pradesh, India reveals that the area during December to March experiences mild waves (H_s = 1 m, T_s = 6 sec) predominantly from N.E. Modification of wave parameters takes place in April and high waves (H_s > 2m, T_s > 8 sec, dir. 180-270) prevail during May – September. Qualitative picture of littoral currents also vary with the changes in the prevalent wave parameters. These currents were from NE for the waves from 90° and from SW for 120° – 210° wave approaches. Rip currents were also observed in these patterns. The observed currents were from NE (intensity 0-40 cm sec) in February whereas they were from SW (magnitude 20 – 70 cm sec^{-1}) in September.

Based on sediment budget between February 1981 to September 1982, it is found that about 117 m sediment deposits in a storm to swell cycle. The average rate of sediment deposition was 58 to 65 m for swell to storm profile transformation. The bivariant plots of size measures suggest that the source of the sediments is through river source. The dominance of depositional processes leading to the accretionary nature of the coast and their relationship with the submergence of ancient harbours in this region is discussed.

INTRODUCTION

The sediment dynamics in the littoral zone is governed by the prevalent environmental conditions of an area and sediment input (Chauhan 1986, 5; Anamymous, 1977). The prevalent morphodynamic processes which are the net result of sediment input and intensity of geomorphic agents thus determine the nature of a coast. The dominance of accretionary processes over a long period of time would lead to emergent type of coast and tend to migrate the coast line seawards. Higher input of sediments in a favourable physiography may lead to the dominance of accretionary processes. Magnitude and direction of the littoral currents determine the quantum of sediment transfer along a coast and in depth knowledge of this process is essential for understanding the nature of a coast.

Condition of navigational channel of any harbour determines its utility. A deep unobstructive natural channel is *sine qua non* for the efficient movement of the vessels. The maintenance of navigational channel, to a large extent, depends upon silting of channels and this in turn is related with the sediment dynamics in the littoral zone.

The littoral currents generated within and beyond the surf zone are the most important sediment transporting agents and state of a beach (Wright 1984, 93–118) at any given time represent a dynamic equilibrium among various prevalent morphodynamic processes and sediment input. As "Present is the key to the past" and the nature of a beach is the reflection of the morphodynamic nature of an area, the study of sediment dynamics along a coast will help in understanding the physiographic evolution an area has under gone in the recent past.

Present work has been carried out at Machilipatnam (Fig.1) and aimed at determining the nature of the coast. To establish this, the prevalent wave parameters (based on over 10 years of ship borne observations) has been obtained. Patterns of littoral currents based on wave refraction studies for most prevalent wave approaches and wave periods have been obtained. These patterns have been validated by the field measurements. Sediment budget, based on the profile measurements in time and space, has been obtained and source of the sediments to the area is determined based on bivariant plots (Friedman, 1977, 3-32).

AREA

The study area is constituted of sandy beaches which are bordered landwards by some creeks (Fig. 1). The Machilipatnam harbour is located deep inland, and the creek acts as its navigational channel. The beaches are open and directly exposed to the Bay of Bengal. The detailed physiography of the area based on the Naval Hydrographic chart Number 355 is shown in Figure 1.

METHODOLOGY

About 25 km area of Machilipatnam coast has been monitored between February 1981 – September 1982. Five transects extending from berm to 2 m water depth below low tide level were monitored. The location of each transect is shown in Figure 1. To obtain the variations in the beach profiles under different environmental conditions, observations were made in February of 1981 and 82, April of 1981 and September of 1981 and 82. The variations in the beach profiles in

time and space have been utilized to obtain beach states[5] and to determine sediment budget in time and space under different environmental conditions, i.e. swell to storm cycles, following the methods described by Chauhan. The net sediment budget between February 1981 to September 1982 has been obtained. The details of beach profile measurements, determination of wave steepnes (H_∞/L_∞), wave energy ($\bar{E}$) and beach slope have been described in Chauhan (1988, 60).

The wave parameters for the study area have been obtained from daily published weather reports of the India Meteorological Department, based on shipborne observations between 1978-1985. The percentage occurrence of swell wave parameters, i.e. wave height (H_∞), period (T_∞) and prevalent directions were obtained after statistical analyses of these data (Kenny p.348).

The qualitative picture of coastal circulation was obtained by wave refraction studies following the numerical methods on the ND 570 computer based on the detail assumptions.

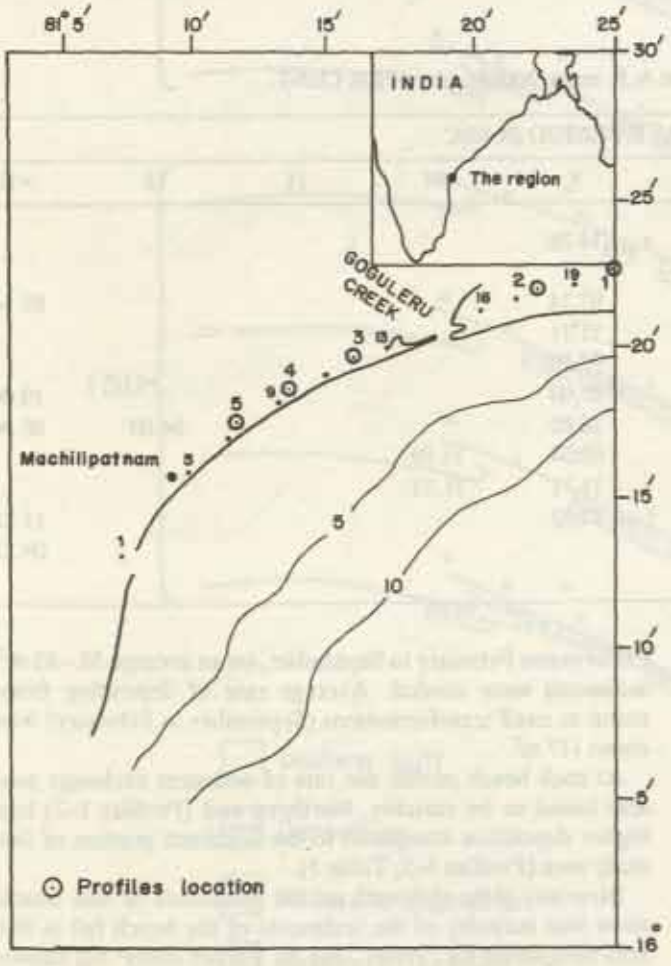

Fig. 1

(Ananymous 1977). Bathymetry for the wave refraction studies has been obtained from the Naval Hydrographic Chart Number 355. Wave orthogonals were drawn at 50 m intervals so as to obtain detailed refraction patterns. As the coast has NE-SW orientation, the wave approaching from 90–210° only will influence the coast directly, and hence, wave refraction patterns were observed for these directions for wave periods 6,8,10 and 12 sec. The patterns of littoral currents were also obtained in February of 1981, 82 September of 1981 and April of 1981 following the standard methods i.e. release of Rhodamine B dye and float observations methods.

About 150 sediments samples were collected from the upper 5 cm of beach surfaces, along and across the beach profiles, and were analysed for various size measures following standard method[15] on the ND 570 computer. The bivariant plots for the size measures[13] were obtained to demarcate the environment of deposition.

RESULTS AND DISCUSSIONS

The prevalent environmental conditions along A.P. coast vary within wide range. Table 1–3 present the wave parameters for the coast. The prevalent waves are generally mild and have low periodicity during December to February ($H_\infty \simeq$ 1m, T_∞ 5 sec). The most prevalent wave direction during this period is from NE (30 – 60°). The shift in the direction of wave approach takes place in March to April (H_∞ 1–4m, T_∞ 5–10 sec, direction 30–210°) and during May to September high wave environment prevails (Table 1) The general direction of wave approach also changes from NE to SW (180–270°, 210–240 for > 60% time) during this period. These parameters again change in October (Tables 1–3). The area experiences cyclonic storms/depressions in May and late October to early December. The frequency of their occurrence is high in November.

The detailed patterns of littoral currents and the area of wave energy concentration obtained through the wave refraction studies (utilising refraction and direction functions) are presented in Figures 2–3. The patterns of the littoral currents obtained based upon dye and float movements under different hydraulic conditions (Fig.4) validate the results of the refraction studies. The patterns of littoral currents appear to be more complex for the SW waves having high periodicity (T_∞>10 sec). The area prone to erosion has also been identified for different wave directions and periods (Figs. 5–6). The magnitude and directions of the measured littoral currents show contrasting changes. Mild to moderate currents (0–40 cm sec^{-1}) from NE prevail in February, whereas the moderate/strong (20 – 70 cm sec^{-1}) currents from SW were observed in September. In April, magnitude of the currents was mild to moderate and they have variable directions.

The beaches of the area respond to the changes in the prevalent environmental conditions (Fig. 7). The variations in the beach slope and other parameters of beach profile in time and space under different environmental conditions are presented in Table 4. The beach profile was "swell type"[10] in February, 81 and 82. With changes in the prevalent hydraulic

Table 1. Deep water wave height H_s (PER CENT) for different months long the A.P. coast.

MONTHS	WAVE HEIGHT IN M						
	1	1.5	2.0	2.5	3.0	3.5	4.0
Jan	60.80	26.08	13.04				
Feb	71.40	07.14	07.14	14.28			
Mar	73.30	06.66	06.66	06.66	06.66		
Apr	88.88		11.11				
May	33.33	23.80	19.04	09.50	09.52		04.76
June	09.52	09.52	42.80	33.30		04.76	
July	22.70	31.80	18.18		18.18		09.09
Aug	06.25	25.00	25.00	12.50		87.00	12.50
Sep	12.50	25.00	25.00	25.00	12.50		
Oct	62.50	37.50					
Nov	55.55	33.33			11.11		
Dec	46.15	30.76	15.38		07.69		

Table 2. Deep water wave height (T_s) for different months long the A.P. coast. Values are in PER CENT.

MONTHS	WAVE PERIOD IN SEC								
	5	6	7	8	9	10	11	12	>12
Jan	85.71		04.76		14.28				
Feb	69.56	30.43							
Mar	78.57		07.14		07.14				07.14
Apr	55.55	11.11	11.11	11.11	11.11				
May	22.85	22.85	19.59	40.00	05.70				
June	20.00	15.00	20.00	30.00	05.00				10.00
July	08.00	20.00	12.00	36.00	12.00			04.00	08.00
Aug	15.09	15.09	32.07	15.09	07.54	15.09			
Sep	44.44	11.11		22.22	11.11	11.11			
Oct	73.68				10.52				15.78
Nov	80.95			09.52					09.52
Dec	76.92	07.69	15.38						

conditions in March, beach profiles modify and were characteristically "storm type" in September. The change in the direction of wave approach from NE to SW during this period had pronounced effects on the beach profiles. The concentration of wave energy due to wave refraction along the coast (Figs. 2–3) and high wave energy density of prevalent waves lead to the profound effects on the beach (Figs. 5–6).

The magnitude of sediment budget in time and space along the coast shows marked variations (Table 5). The study of erosion – depositional cycles during the course of the present study suggest the dominance of accretionary processes over the erosional component. The budget of sediment at different profiles clearly demonstrate that from swell to storm profile, i.e. between February to September, on an average 58 – 65 m^2 sediments were eroded. Average rate of deposition from storm to swell transformations (September to February) was about 117 m^2.

At each beach profile the rate of sediment exchange was also found to be variable. Northern end (Profiles 1–2) has higher deposition compared to the southern portion of the study area (Profiles 3–5, Table 5).

Bivariant plots obtained on the sediments of this beach show that majority of the sediments of the beach fall in the area designated for "river" (Fig.8). Earlier study[2] has shown that the sediments of this beach are predominantly bimodal and have high silt contents. These results confirm that the sediments to the beach are contributed through fluvial sources.

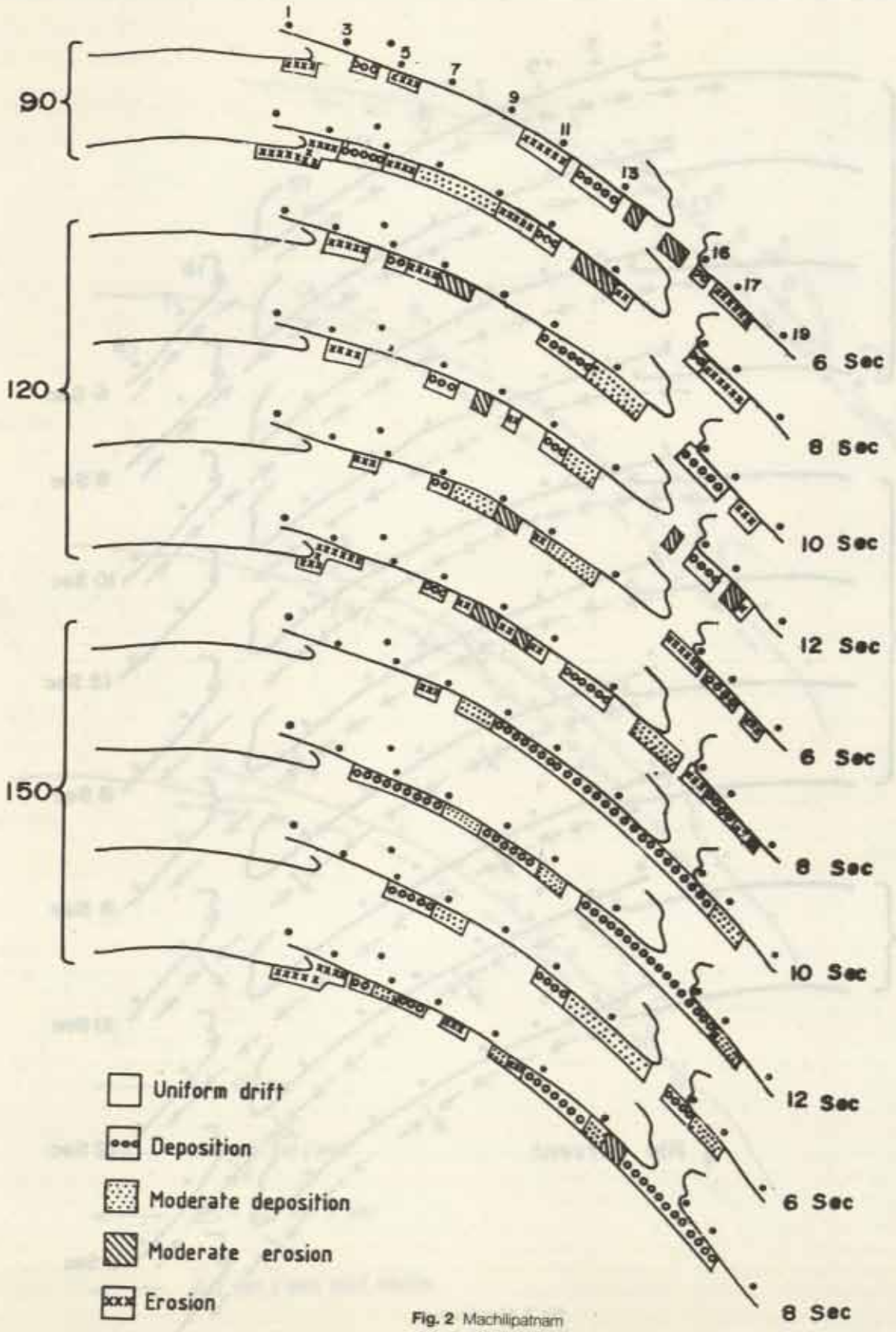

Fig. 2 Machilipatnam

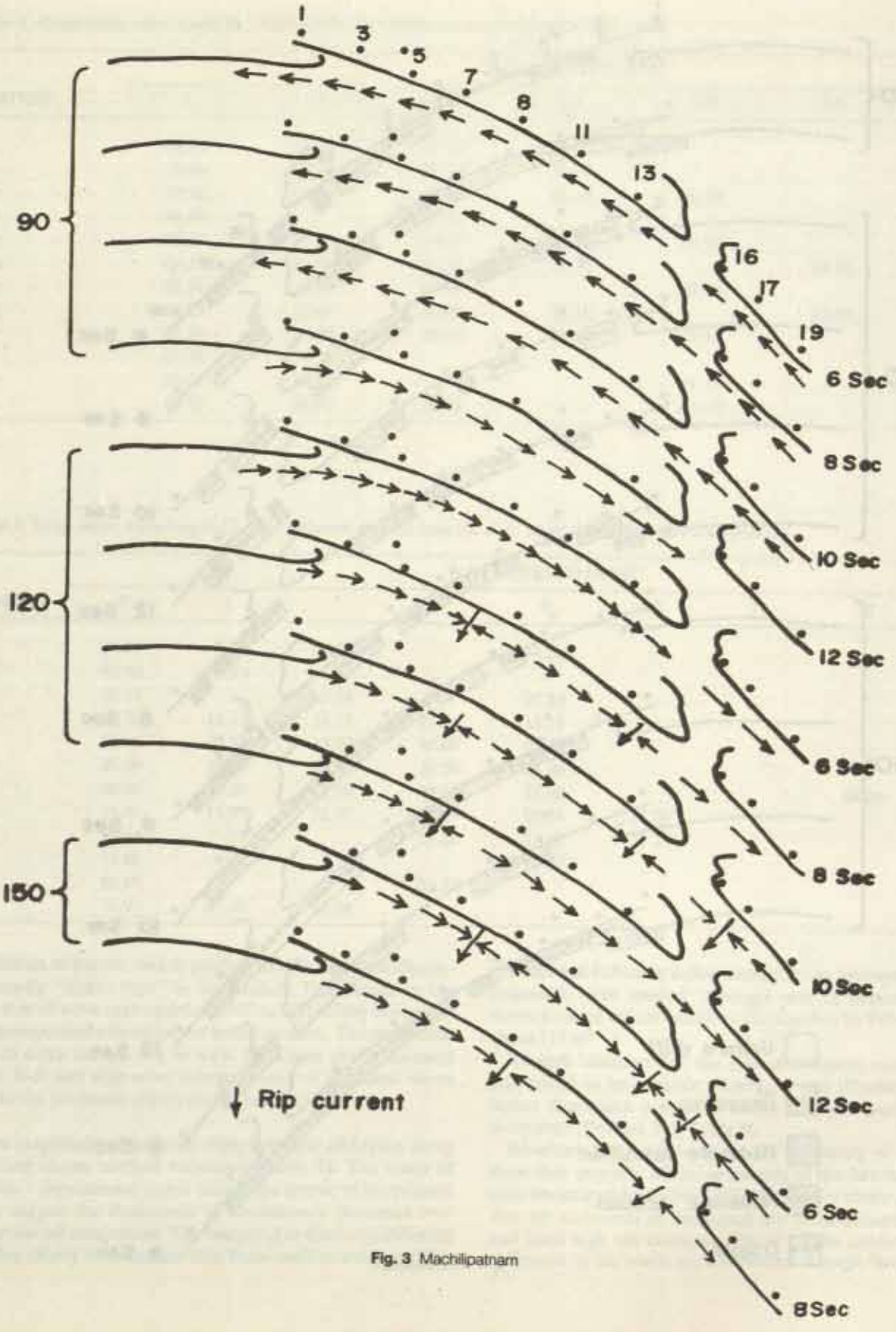

Fig. 3 Machilipatnam

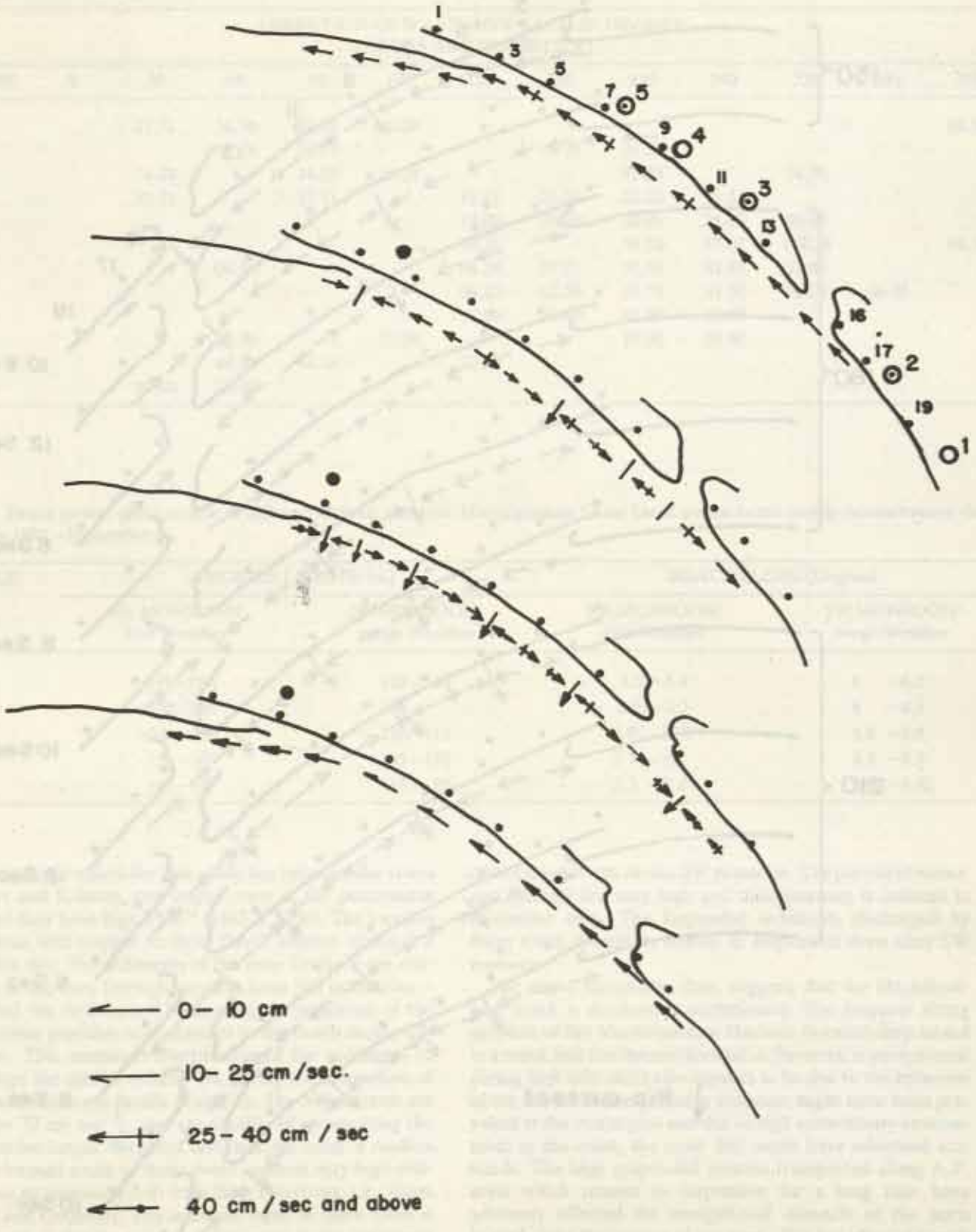

Fig. 4 Machilipatnam

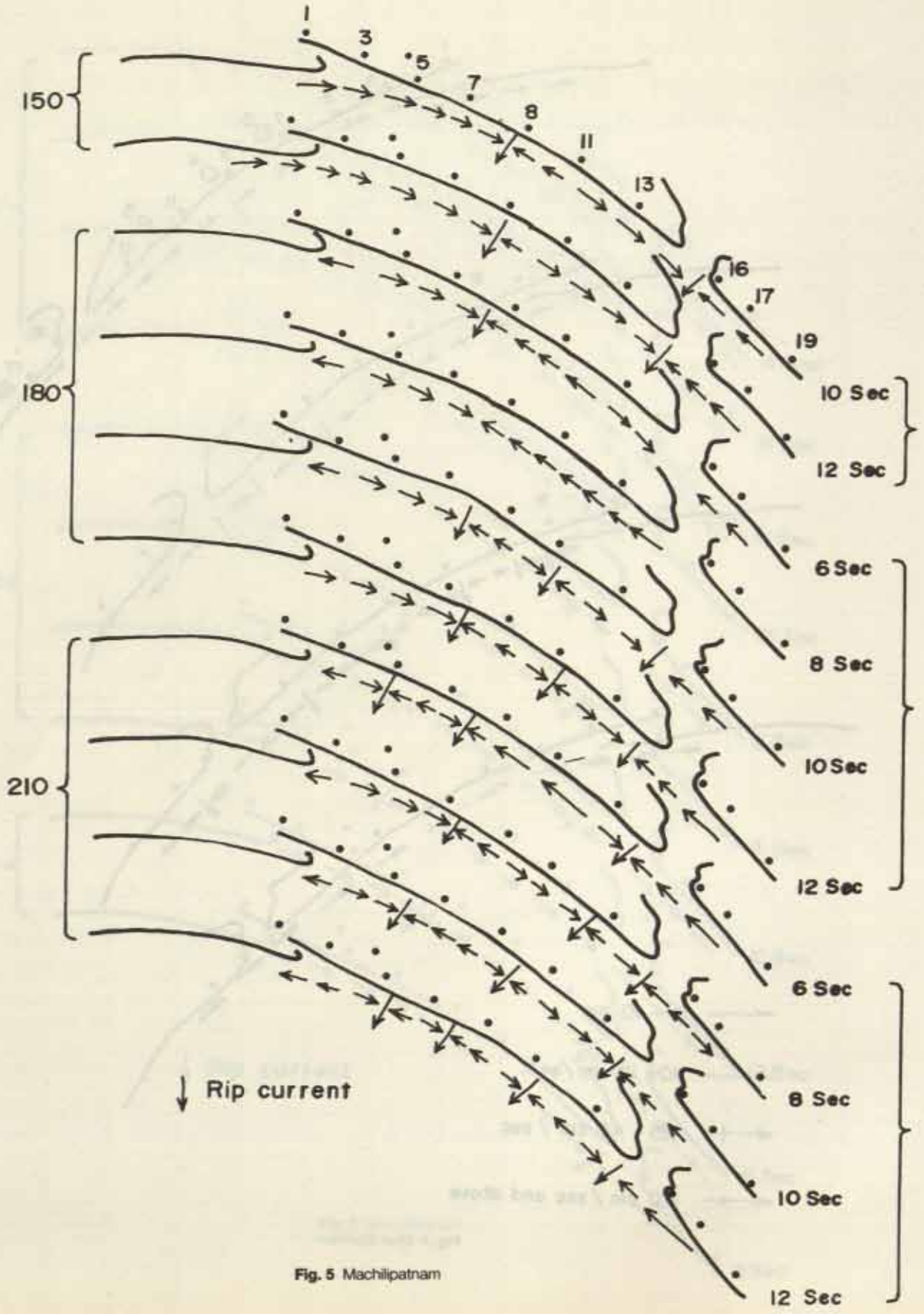

Fig. 5 Machilipatnam

Table 3. Deep water wave approaches for different months along the A.P. coast.

	DIRECTION OF WAVE APPROACH IN DEGREE VALUES ARE IN PER CENT											
MONTHS	0	30	60	90	120	150	180	210	240	270	300	330
Jan		31.81	36.36	18.18	09.09							04.54
Feb			57.14	28.57			14.28	28.57				
Mar		14.28		14.28	14.28			42.85		14.28		
Apr		11.11		11.11		11.11	33.33	22.22	11.11			
May						10.00	35.00	30.00	25.00	05.00		
June						04.76		38.50	47.61	144.28		04.76
July			04.54			04.54	27.27	31.81	31.81	31.81		
Aug						06.25	12.50	31.75	31.50	06.25	06.25	
Sep						12.90	50.00	02.50	12.90			
Oct			25.00		12.90			27.50	25.00			
Nov			44.44	44.44		22.22						
Dec		30.00	70.00									

Table 4. Beach profile characteristic at different stations along the Machilipatnam Coast based on the beach profile measurements during February 1981 – September 82.

PROFILE NO.	PROFILE LENGTH (m)		BEACH SLOPE (Degree)	
	NE MONSOON/ Fair Weather	SW MONSOON/ rough Weather	NE MONSOON/ Fair Weather	SW MONSOON/ rough Weather
1	150 – 155	120 – 130	3.01 – 3.6	6 – 6.5
2	150 – 160	136	2.21 – 2.3	4 – 4.5
3	– 145 – 150	110 – 115	2.07 – 3.07	4.6 – 5.9
4	155 – 165	145 – 150	2.3 – 3.1	4.3 – 4.9
5	140 – 145	110 – 120	2.3 – 3.2	4.09 – 4.62

The area undertaken for this study lies between the rivers Godavari and Krishna, two major rivers of the penninsular India and they have high TSM[14] (1845 & 1158). The location of this area with respect to these fluvial sources makes it a favourable site. The sediments of the river Godaviri are contributed to the area through currents from NE in October – April, and the drift from SW carrying the sediments of the river Krishna provides nourishments to the beach during SW monsoon. This continual contribution of the sediments to coast keeps the rate of erosion low during transformation of swell profile to storm profile (Table 5). The SW currents are strong ($\simeq$ 70 cm sec^{-1}), and are capable of transporting the sediments for longer distances, and thus, the coast of Andhra Pradesh located south of these rivers receives very high sediments due to combined drift from these two rivers, i.e., rivers Krishna and Godavari. The sediment input of these rivers is also at peak at this time due to heavy rains in the catchment area of these rivers during SW monsoon. The prevalent waves and currents are very high and their intensity is reduced in December only. The suspended sediments discharged by these rivers therefore, remain in suspension even after SW monsoon.

The above discussion, thus, suggests that the Machilipatnam beach is dominantly accretionary. The frequent silting problem of the Machilipatnam Harbour (located deep inland in a creek and the channel located in the creek is navigational during high tide only) also appears to be due to the influence of the fluvial sources. Similar situation might have been prevalent in the recent past and due to high accretionary environment at the coast, the coast line might have advanced seawards. The high suspended matters transported along A.P. coast which remain in suspension for a long time have adversely affected the navigational channels of the ports located along this portion of the coast. This has affected severly

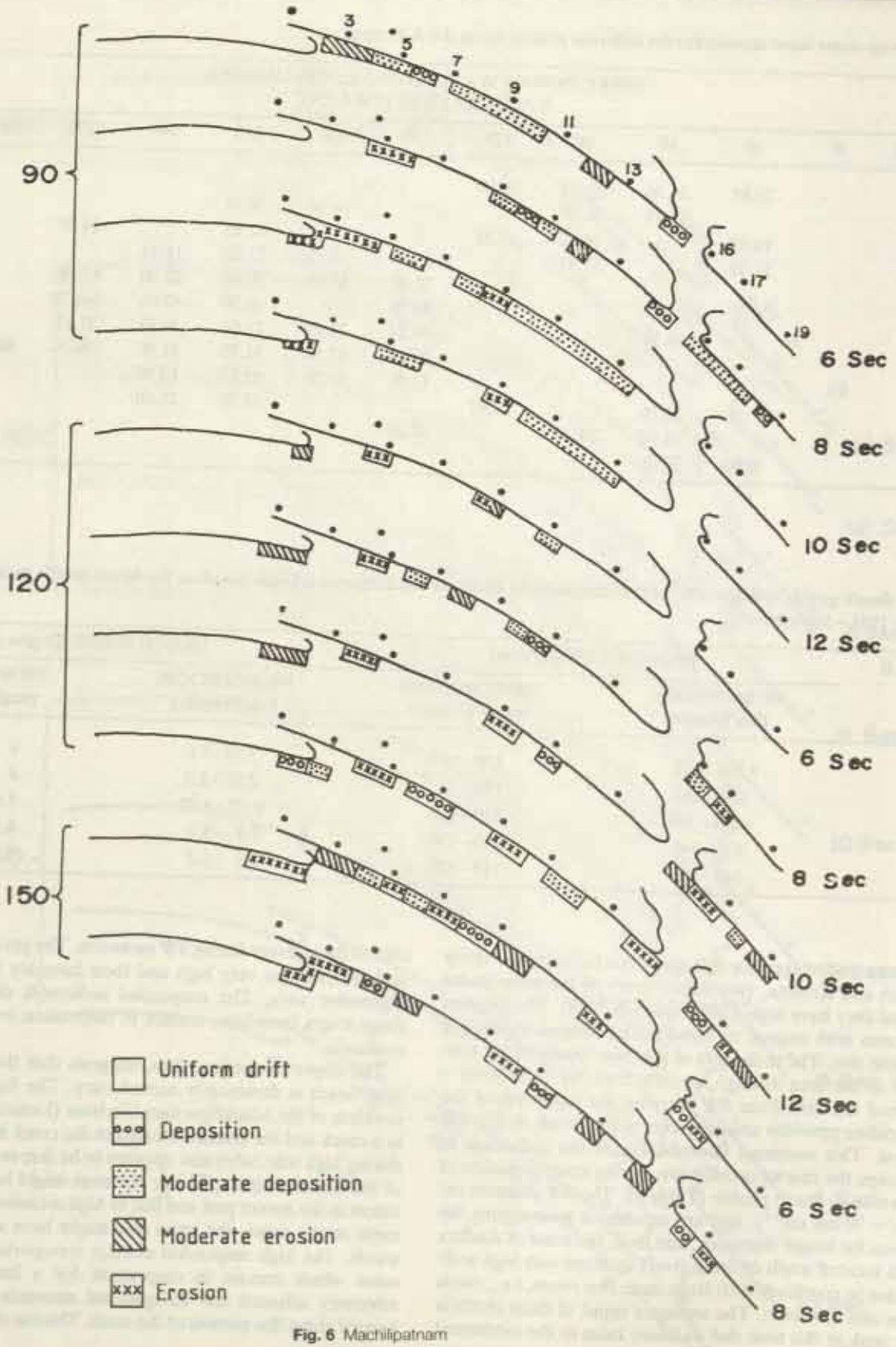

Fig. 6 Machilipatnam

Table 5. Budget of sediment exchange at different stations along the Machilipatnam Coast obtained from the comparison of beach profiles in time and space during 1981 – 1982 (Values are in m^2).

PERIOD	AVERAGE LENGTH OF BEACH PROFILE (m)	PROFILE NUMBERS					
		1	2	3	4	5	AVERAGE
Feb.81 – Apr.81	150	+ 14.117	+ 11.72	+ 19.05	+ 17.21	+ 24.64	+ 15.15
Feb.81 – Sep.81	110	– 67.35	– 68.50	– 59.57	– 60.18	– 74.06	– 65.93
Sep.81 – Feb.82	150	+136.72	+121.73	+ 98.69	+109.10	+120.15	+117.27
Feb.82 – Sep.82	110	– 78.82	– 70.21	– 52.73	– 41.45	– 47.50	– 58.16
Range of Sediment deposition in one cycle		(+)57–69	+51–52.8	+39–45	+48–67	+6–72	+51–59.11

(+) indicates deposition, (–) indicates erosion

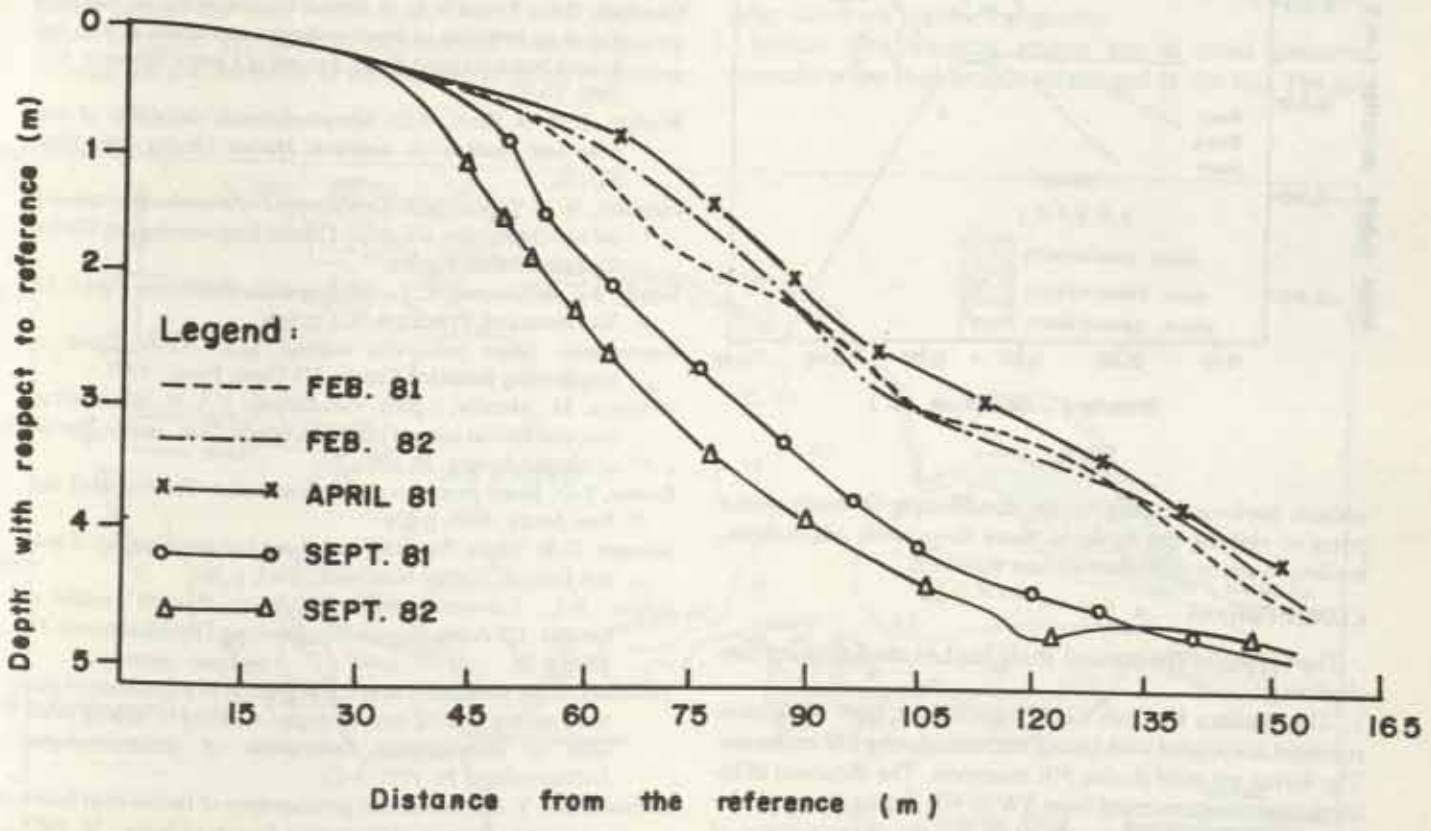

Fig. 7

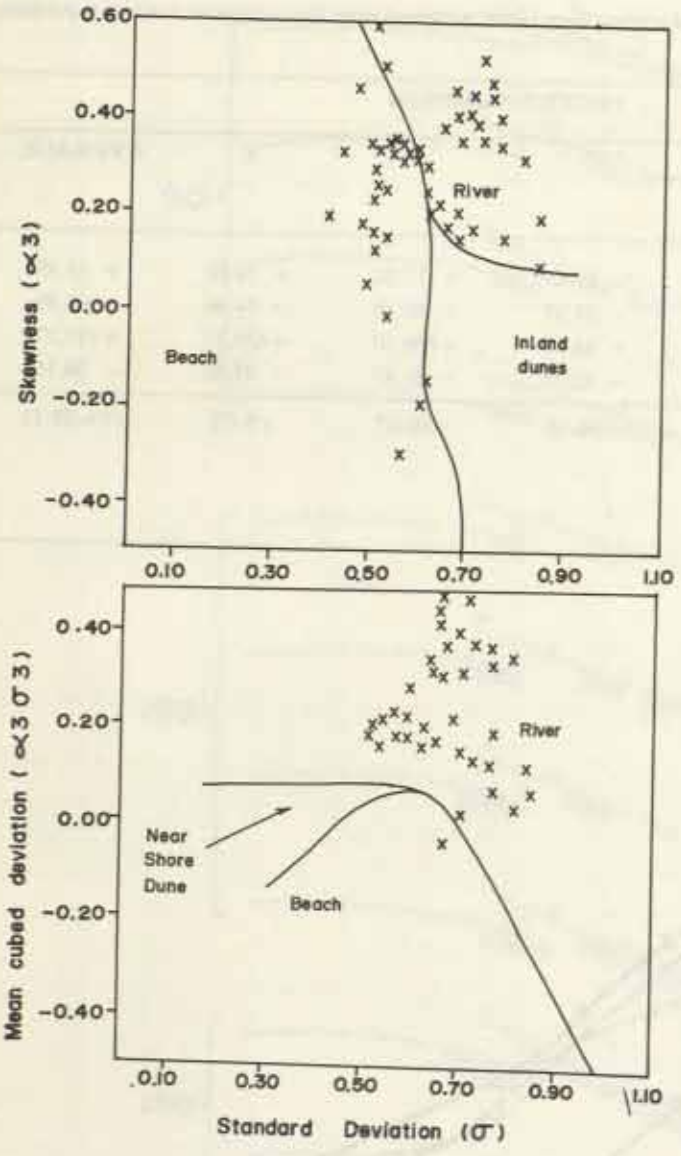

Fig. 8

ancient harbour leading to the abandoning of many minor ports or shifting the trade to more favourable alternatives, leading to sharp reduction in their numbers.

CONCLUSIONS

The results of the present study lead to the following conclusions:

1. The Andhra Pradesh Coast experiences high wave environment associated with strong currents during SW monsoon. The waves are mild during NE monsoon. The direction of littoral currents is reversed from SW to NE during this period.
2. Sediment budget along the coast and the characteristics of sediments in the bivariant plots confirm a high input of sediments to the area. The northern portions get very high input due to combined contributions by two major rivers.
3. The high input of the sediments leading to either migration of coast line or silting of navigational channels of ports, appears to be contributing factor for abandoning of ancient harbours.

ACKNOWLEDGEMENTS

The author is thankful to the Director, National Institute of Oceanography, Dona Paula, Goa for providing facilities. He is thankful to Mr. R.R. Nair for encouragement and comments on the manuscript. Thanks are also due to Mr. N.P. Sukumaran and Mr. F. Almeida for the timely help in preparation of the manuscript.

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Topography and surface sediment distribution around Amee shoal Mormugao

N.V. AMBRE

The general topography and sediment distribution in the Amee shoal has been studied where the ship wreck was recently discovered in the water of 3 m. The area consists of rocky shoals and reef extending in a north-south direction across the entrance of the bay, separates the bay from the Arabian Sea. The rocks are exposed in the bay all along the northern side except near the Dona-Paula point. There is a patch of coarse sediment extending from the north-western end of the bay in a NW-SE direction into the bay which indicates the incoming and outgoing of currents and prevent finer sediments from accumulating and sitting up in the bay. The coarser material mainly consists of sand which is moderately sorted and is confined to the bay margin of high energy area. The fine sediment poorly sorted and consisting predominantly of silts and clays is present in the central bay of low energy area. The bathymetric contours indicate that the area has a gradual slope towards the west. The area to the northern and eastern sides of Amee shoal consist of shelly-sand and rock outcrops. The low-lying rocky sub-bottom appears to be the main cause for the ship-wrecks. However, due to absence of fine sediments - such as silt and clay in the area, the ship is expected to suffer least from corrosion and biofouling.

INTRODUCTION

It is well known that ancient civilizations had their origin mainly around the river banks, channels and other places of water resources. The mode of international trade was mainly through the sea. Majority of the shipwrecks occur in shallow waters. The marine records show that more than 75% of the shipwrecks were in shallow waters. One of the main reasons for the shipwreck in the shallow water was inadequate knowledge about sea bottom topography.

Marine archaeological objects are at times preserved naturally when they remain submerged in the sea. The pre-

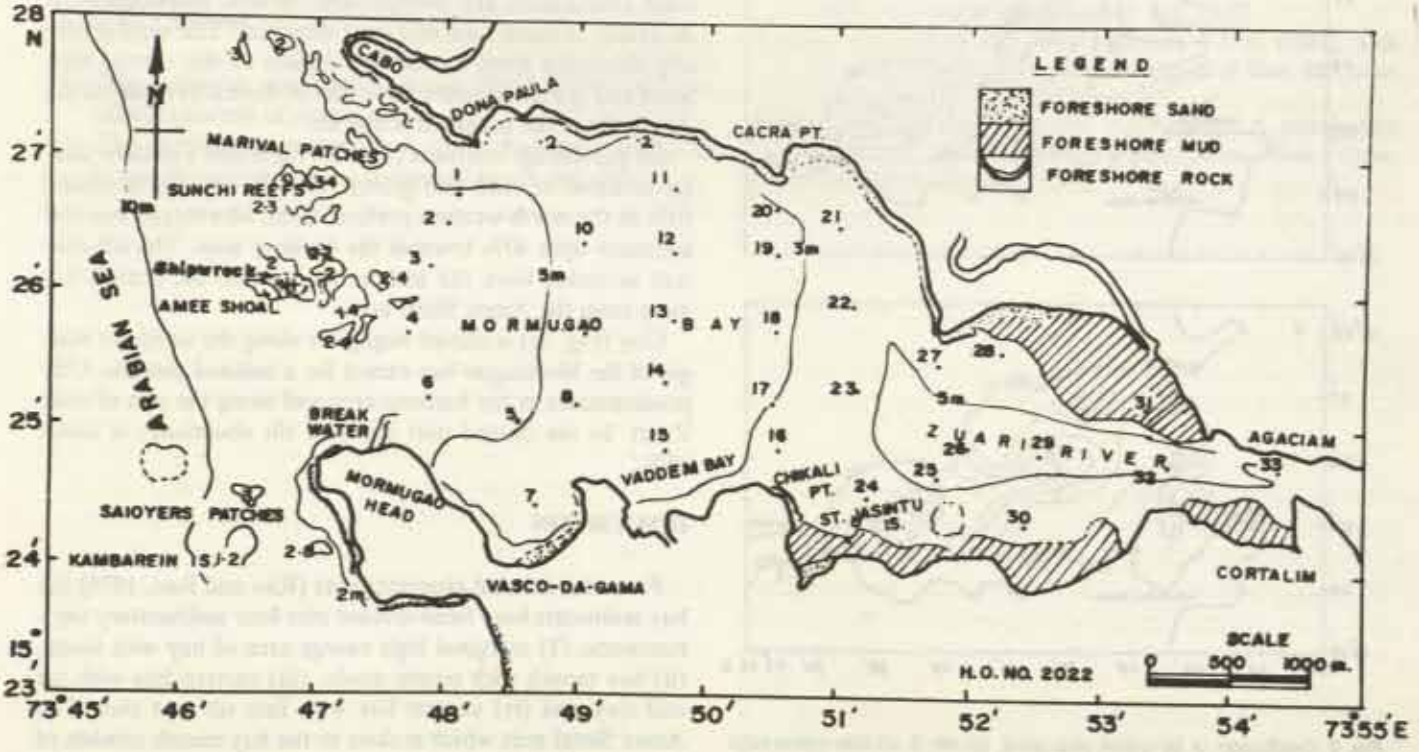

Fig. 1 Sample location and topographic contours of the Marmugao Bay (after Rao & Rao, 1974).

servation of archaeological objects depends upon the type of sediments (Rao, 1987). The geomorphic features that favour a high degree of preservation includes the sites covered by the sediments in low energy environment. Water depth, waves, currents, tides, sea bottom topography, sediment suspension and movements and sediment texture are important factors at the site location (Nayak, 1987). In the present case, the geology around the Amee Shoal - Shipwreck, Mormugoa has been studied to understand the extent and potential of the shipwreck.

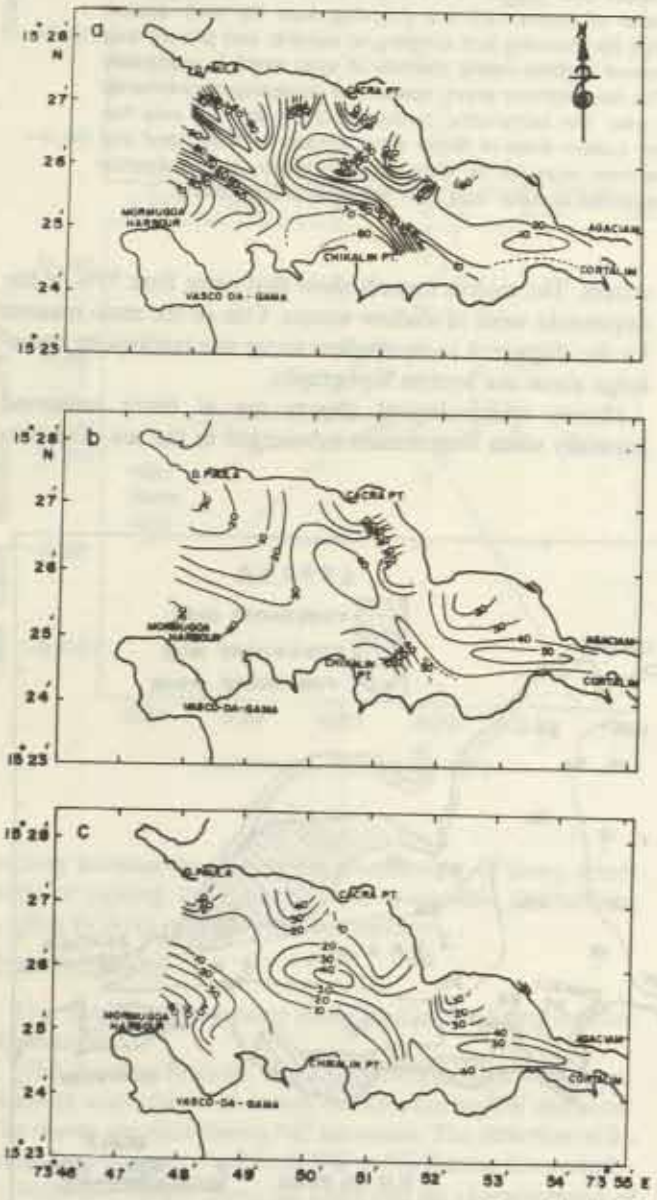

Fig. 2 Distribution of (a) gravel plus sand, (b) silt, & (c) clay percentage (after Rao & Rao, 1974).

GENERAL GEOLOGY

The Amee shoal is located between Mormugao and Cabo (Fig. 1) headlands. It is bordered by Sunchi reef in the north and Mormugao bay in the east. The river Zuari has its opening to the sea near the Amee shoal in the west. The geology around Amee shoal has been described by Rao and Rao (1974). Wagle and Rajamanickam (1980), Veerayya et al. (1981), Kidwai et al. (1981). The area consists mainly of Precambrian ferruginous quartzites covered by laterites of variable thickness.

The Zuari river mouth is about 5.5 km. wide and narrows down upstream to less than 0.5 km. The water flow is regulated by tides of semidiurnal type. The river drains mostly the metamorphic terrain of quartzites, phyllites, banded hematite quartzite, gneisses and granite gneisses. This river is the main supplier of sediments to beaches and to nearshore and offshore areas. The Mormugao bay (14 km length and 5.5 km width) extends in east-west direction. The rocky shoal and reef extending north-south separates the bay from the Arabian Sea. The area, sample locations and topographic contours are shown in Fig. 1.

RESULTS

Details about sampling and sediment texture are discussed by Rao and Rao (1974). Sand predominates in the inshore region (Fig. 2a). Along the northern and southern sides, the sand abundances are 60-90% and 70-90% respectively. It decreases towards east and west direction. The sand gradually decreases from the inshore region to the central bay. Sand and gravel contours show that in the eastern part of the Amee Shoal the sediment is coarser.

Silt percentage contours (Fig. 2b) represent a pattern similar to those of sand and gravel. The silt content is around 10% in the north-western portion of the Mormugao bay and increases upto 40% towards the harbour area. The silt content increases from the inshore region into the central bay away from the Amee Shoal area.

Clay (Fig. 2c) is almost negligible along the northern margin of the Mormugao bay except for a isolated patches. Clay predominates in the harbour area and along the axis of river Zuari. In the central part clay and silt abundance is about 45%.

DISCUSSION

From the textural characteristics (Rao and Rao, 1974) the bay sediments have been divided into four sedimentary environments: (1) marginal high energy area of bay with sands, (ii) bay mouth with coarse sands, (iii) eastern bay with silt and clay and (iv) central bay with fine silt and clay. The Amee Shoal area which is close to the bay mouth consists of coarse sand environment.

The sediments along the northern and southern margin of the bay are predominantly sands which are well to moderately sorted. A patch of coarse material extends into the bay from its mouth in a NW-SE direction. The Amee Shoal area is therefore of high energy zone suggesting predominance of sand deposition. Sandy patch indicates strong current in NW-SE direction, winnows the fine sediments such as silt and clay and carries it away from the Amee Shoal leaving the coarse sediments. The transport and mixing of the sediments is brought about by wave action. Fine sediments accumulate in the central bay due to littoral currents from northern and southern sides and maximum wave heights near Dona Paula and Cabo Raj region (Reddy, 1970). These currents might have been weakened by the shoal and reef present at bay mouth.

In the eastern bay sediments are mainly clay associated with fine silt and are poorly sorted. This is affected by the sediment brought by river Zuari that enters into the eastern bay through a narrow constrictoin at Agaciam and Cortalim. The deposition of fine sediment gradually decreases towards the central bay as the river Zuari meets the salt water of higher salinity, which flocculate the silt and clay.

The Amee Shoal area thus shows predominance of coarse sand. Comparatively, the porosity of sand is more than silt and clay. Therefore any archaeological objects (such as ship, etc.) buried in the sand will have more exposure to the sea water thereby increasing the chances of corrosion and heavy encrustation.

CONCLUSIONS

1. The sediment around the Amee Shoal-shipwreck area consists mainly of coarse sands.
2. The preservation potential of any archaeological objects in coarse sand is poor as compared to silt and clay.
3. The chances of heavy encrustations, corrosion and contamination with chlorides are more in the Amee Shoal area.

ACKNOWLEDGEMENT

The author is extremely thankfull to Dr. B.N. Desai, Director and Mr. R.R. Nair, Project Leader for encouragement and valuable guidance and permission to publish this paper. Thanks are due to Miss Flavia Sandra Fernandes for typing.

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Consequences of sea level rise due to Greenhouse effect for coastal Archaeological monuments

RAJIV NIGAM, PATHAK M.C. and N.H. HASHIMI

It is evident that the fluctuating sea level and related climatic phenomenon were responsible for extinction of many ancient port - cities and places of cultural heritage. Lothal, Kaveripatnam and Dwaraka are the glaring examples of destruction due to sea level rise in the past and thus became the well known objects of modern marine archaeology.

It is well known that sea level is on the rise for the last 11,000 years (Holocene sea level changes) and there are evidences to believe that there will be an accelerated rise in sea level in near future due to greenhouse effect. The increased concentration of greenhouse gases in the atmosphere will be responsible for thermal expansion of sea water and the melting of ice from high latitudes. Consequently the sea level will rise. It has been infered that the sea level rise will vary between 23.8 cm to 116.7 cm by the year 2050 and 56.2 cm to 345.9 cm by the year 2100. Such a rapid rise in sea level will cause inundation of many modern ports and cities and also monuments of cultural importance and thus become a subject of study for future marine archaeologists. The seriousness of the problem may be explained with a case study, for example, the famous shore temple at Mahabalipuram in Tamilnadu which was built far from the coast. In course of time sea has gone up and now shoreline is touching the base of the temple. This has caused severe problem of erosion. In the past To check further damage to the temple due to erosion a protection wall was constructed (1944-45). Now it will again face a fresh danger due to future sea level rise. The gradient of land in this region is 1:500. Therefore, the anticipated rise of 1 or 2m may cause the shore line retreat by 0.5 to 1.0 km. This may put the temple right into the sea and thus get subjected to damage from all the four sides. This all may happen in the next few decades. Therefore, a precautionary measure has to be planned immediately and implemented.

This is only one example, there may be many more cases of this type all along the west and east coasts of India. Geologists are already on the job to identify the 'danger zone' along the Indian coasts which is going to face consequences of sea level rise due to greenhouse effect. The need of the hour is that archaeologists should come forward to join the geologists to catalogue the monuments of archaeological importance falling in the 'danger zone' and plan the strategy in advance before the disaster occurs.

INTRODUCTION

Marine Archaeology is the study of human interaction with the ocean environment. Unfortunately for archaeologists, 18,000 years age world sea level was was much lower and the coast line was located many kilometres out towards sea from its present locations. The continental shelf was a part of the terrestrial environment. Thus most of the evidences of the origin and early development of marine culture is submerged (Flemming, 1985). It is evident that the fluctuating sea level rise and related climatic phenomena were responsible for drowning of many ancient port-cities and places of cultural heritage. Lothal (Nigam, 1988), Kaveripatnam (Rao, 1990) and Dwarka (Rao, 1988) are the glaring examples of destruction due to sea level rise in the past and thus became the well known subjects of modern marine archaeology. References to consequences of sea level fluctuation are available in religious, archaeological and oceanographic records (Nigam, Hashimi and Pathak, 1990). Figure 1 shows the generalized curve for the sea level rise which indicates that about 11,000 years B.P. sea level was 60-90 m below the present one (Nair, 1974; Nair and Hashimi, 1980) along the west coast of India. If we assume the same trends (i.e. rise in sea level) will continue in future also, anticipated sea level will submerge the low lying areas of present coast alongwith valuable monuments of archaeological importance. But considering the natural trend by this rate, 1 m rise will take about 1000 years.

However, these estimates for natural trend are under threats due to man's indiscriminate interference with the environment. As Goddy (1982) said "This is a unique time, when one species, humanity, has developed the ability to alter its environment on the largest (i.e. global) scale and to do so within the life time of a single species number". In view of this, whatever natural changes are likely to happen in the next 1000 years may happen now in only 100 years. For example, Scientists predicted that sea level may rise upto 1 metre by 2050 (Hoffmann et al., 1983). The phenomena responsible for this alarming situation is known as "Greenhouse Effect". The objective of this paper is to bring the facts about likely climatic changes to the notice of the archaeologists and indicate the consequences of such changes in the field of archaeology.

WHAT IS GREENHOUSE EFFECT

Over the last couple of years, the Greenhouse Effect has become one of the world's hottest topics.

Since the mid of nineteenth century there have been warnings about how increased level of Greenhouse gases [Carbon dioxide (CO_2), Methane (CH_4), Nitrous Oxide (N_2O) and

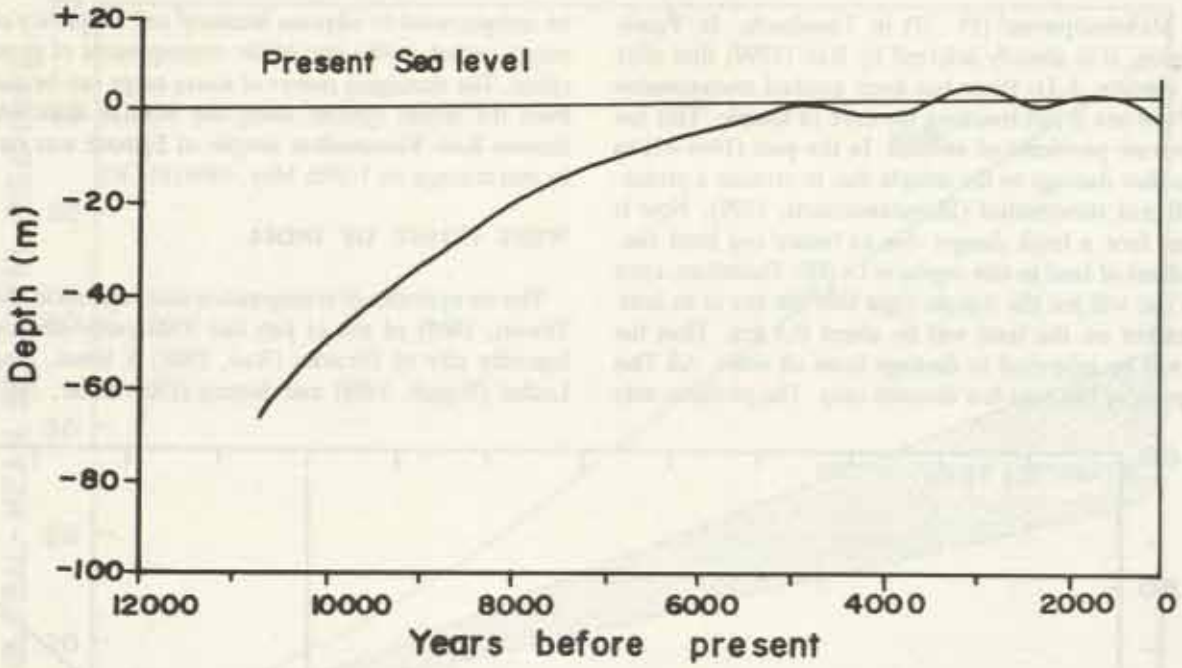

Fig. 1 Generalized sea-level curve for Indian region.

Chlorofluorocarbons (CFC)] in the atmosphere can effect our climate. These gases in the atmosphere act in a similar way, as the glass walls and roof of a greenhouse, in trapping heat from the sun that would otherwise be radiated back into the space. Any departure from equilibrium of these gases in atmosphere (natural or man made) creates problem. Too little greenhouse gases in atmosphere and we freeze, and too much we get overheated.

In the last 100 years the earth has warmed up by more than half a degree centigrade (Jones et al., 1986). This warming (0.4–1.1°C) is compatible with what might be expected to have resulted from the increase in atmospheric concentrations of carbon dioxide and other greenhouse gases Some 65-90% of the increase of carbon emissions in the atmosphere today is believed to come from the burning of "fossil fuels" (coal, oil, gas) (Bolin et al., 1986; Warrik et al., 1988).

The net result of warming is thermal expansion of sea water and melting of ice on polar regions. As a consequence of these, sea level is also rising (Report by Common Wealth Group of Experts, 1989). The best estimates is that the global mean sea level has risen by 10-15 cm over the past century. There are reasons to believe that these trends will continue in future also. There are a range of estimates of future warming and related would be sea level rise based on different modelling assumption. Figures 2 and 3 give the most recent projections drawn for 2030 AD. Another set of estimates was given by Hoffman et al. (1983) for a period upto 2100 AD by which as per high scenario, sea level may go upto 3.45 metres.

While there is a reasonable agreement about global average increase, there is much less agreement about what these could mean for the climate of particular regions, let alone individual countries. Here in this paper we are concerned about the consequence of accelerated sea level rise for India in general and for archaeologist in particular.

CONSEQUENCES FOR INDIA

Nigam (1989) indicated the possible implications of sea level rise for coastal zone management for Indian region. Such implications include inundation of low lying coastal areas and some islands, migration of human population, loss of agricultural and forest land, destruction of industries, buildings in coastal areas and tourism, problem of drinking water due to salt water intrusions, change in precipitation pattern etc. Shetye et al. (1989) presented a general scenario which shows that east coast of India is more vulnerable as compared to the west coast (Figure 4). One thing is certain that whatever be the scenario, rapid rise in sea level will cause inundation of many modern ports and cities and also monuments of cultural importance and thus become a subject of study for future marine archaeologists. To show the seriousness of the problem two case studies are given below, one each from east and west coasts of India.

EAST COAST OF INDIA

The immediate victim of accelerated sea level rise on the east coast will be the famous shore temple of Rajasimha's

time at Mahabalipuram (Pl. 37) in Tamilnadu. In Tamilnadu region, it is already inferred by Rao (1990) that after 11-12th century A.D. there has been gradual transgression of sea. Now sea is just touching the base of temple. This has caused severe problems of erosion. In the past (1944-45) to check further damage to the temple due to erosion a protection wall was constructed (Shivaramamurti, 1978). Now it will again face a fresh danger due to future sea level rise. The gradient of land in this region is 1 : 500. Therefore, even 1 metre rise will put the temple right into the sea as its horizontal extent on the land will be about 0.5 km. Thus the temple will be subjected to damage from all sides. All This may happen in the next few decades only. The problem may be compounded to increase intensity and frequency of storm surges, which is also one of the consequences of greenhouse effect. The damaging power of storm surge can be visualized from the recent cyclone along the Madras coast when the famous Kasi Viswanathar temple at Ennore was destroyed by storm surge on 7-10th May, 1990 (Pl. 38).

WEST COAST OF INDIA

The six episodes of transgression and regression (Negi and Tewari, 1988) of sea in just last 3500 years destroyed the legendry city of Dwarka (Rao, 1988) 6 times. Decline of Lothal (Nigam, 1988) and Sopara (Dhavalikar, 1988) ports

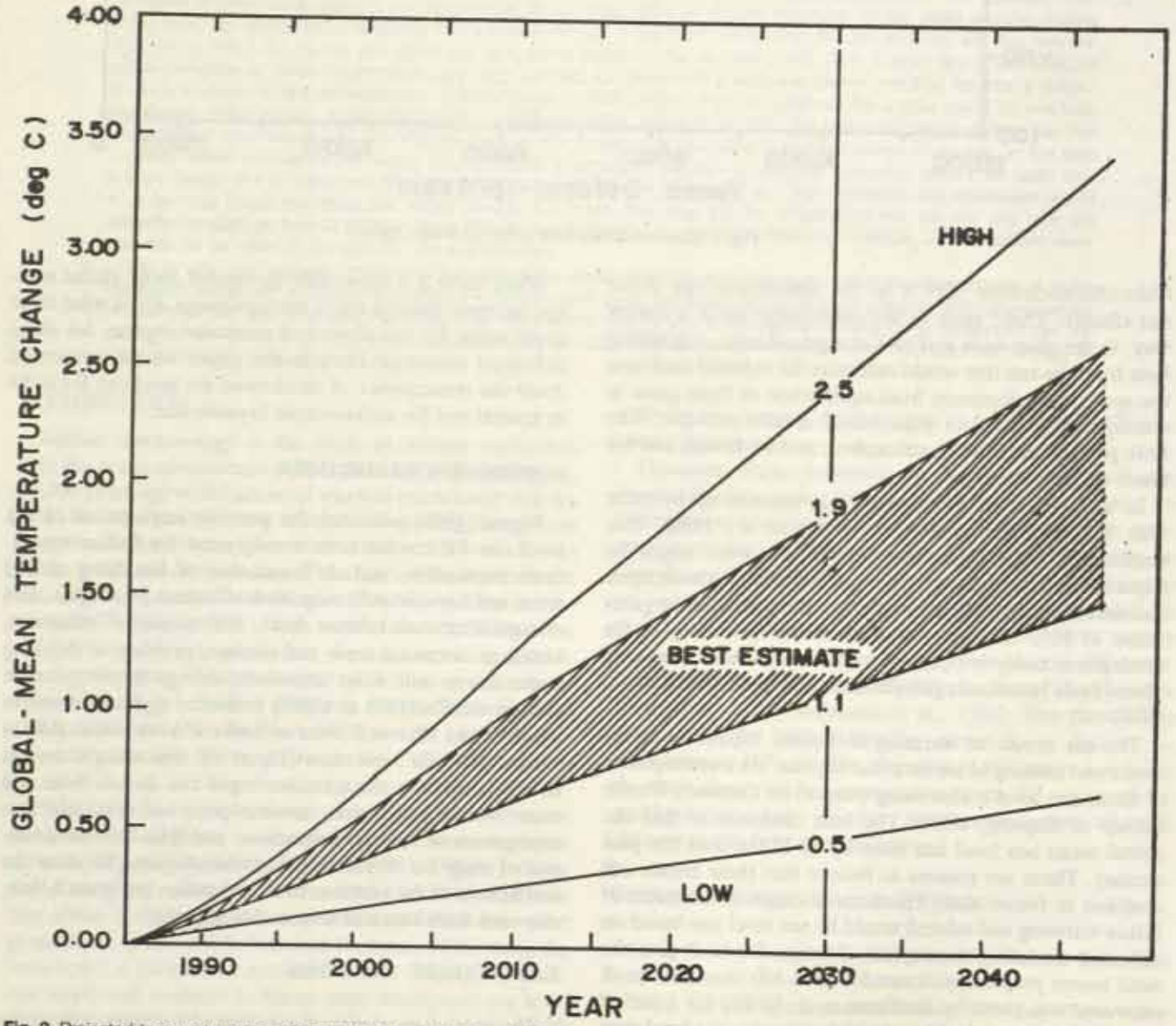

Fig. 2 Projected temperature rise, 1985-2050 (After T. Wingley 1989 in Commonwealth Secretariat Report Climate Change: Meeting the Challenge, 1989).

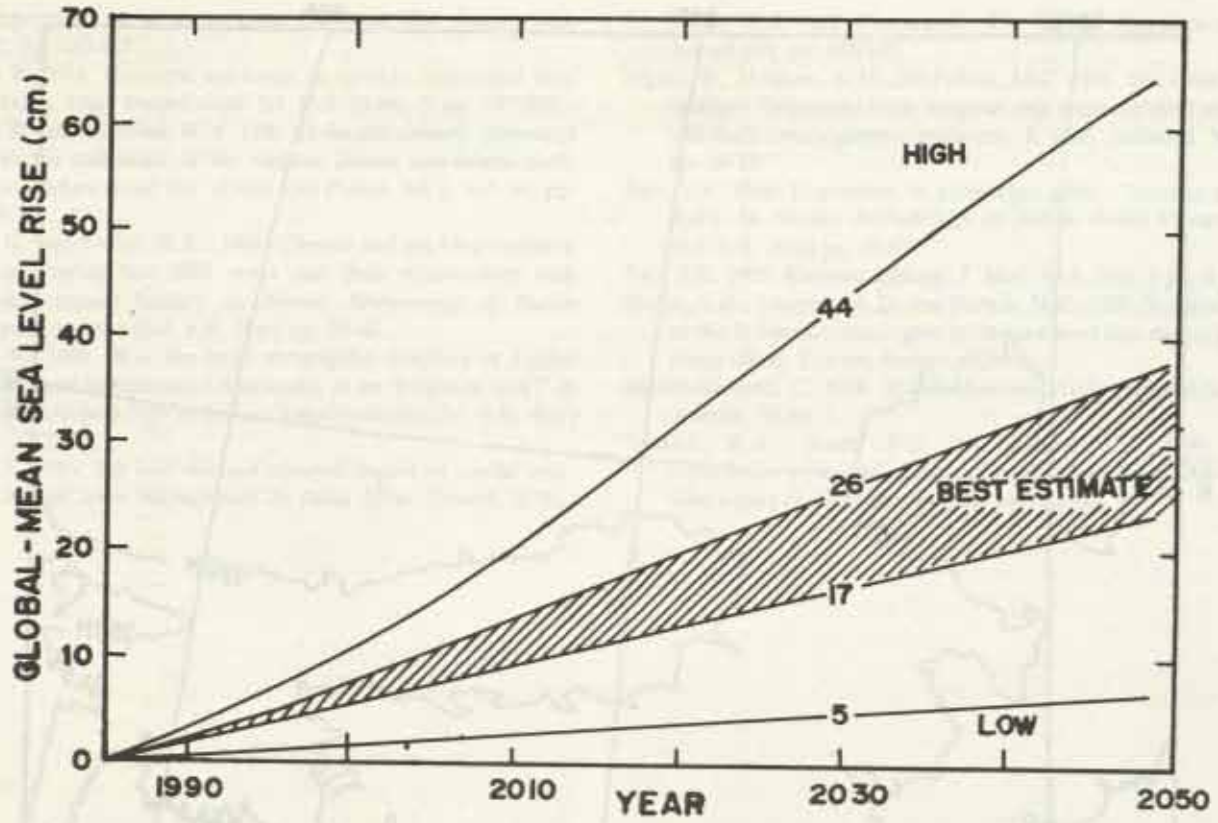

Fig. 3 Projected sea-level rise, 1985-2050.

were also attributed to fluctuations of sea levels. Now similar type of event will take place on shorter time span (few decades) and many establishments will be adversely affected. One such good example is the Samudra Narayana temple (Pl. 39) at Dwarka. The sea is touching the base of this temple and any further rise in level will be too costly to the survival of temple.

PLAN OF ACTION

We have discussed above, only two examples (one each from east and west) as case studies. There are many more cases of this type all along the west and east coasts of India. Since the visualised evantualities may happen in very short time, a precautionary measure has to be planned immediately and implemented.

Under the sponsored project of Ministry of Environment and Forests, Scientists are already on the job to identify the 'Vulnerable Zone' along the Indian coasts which is going to face consequences of sea level rise due to greenhouse effect. The need of the hour is that archaeologists should also catalogue the monuments of archaeological importance falling in the "Vulnerable Zone" and plan the strategy in advance before the disaster occurs.

ACKNOWLEDGEMENT

We are thankful to Dr. B.N. Desai for his encouragement and permission to publish this paper, we are also indebted to Sri. R.R. Nair for critical reading of the manuscript. We also acknowledge the financial help received from Department of Environment (Grant No. 21/6/89-RE). Miss Geeta Menon deserves thanks for typing the manuscript. Last but not the least we are grateful to Dr. S.R. Rao for giving an opportunity to present this work at IInd International Conference of Marine Archaeology of Indian Ocean Countries at Bangalore.

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Fig. 4 Showing idea about slope of Indian coastal areas.

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Impact of Climate and Sea Level Fluctuations in Historical Context

K. RAJAN

The recent study on paleaoclimate and the constant inflow of reliable data on sea level fluctuations help to understand the impact of climate in the historical context. The long survival and evolution of the biological ecosystem and its dependent human society are invariably influenced from time to time in a regular cycle by the erratic climatic changes.

The study of protohistoric and historic sites in India flourishing in the long historical matrix revealed one striking feature that each site seated in a different geographical zone had been disturbed or deserted at a particular time. The emergence of a new culture upon the old one with mutual assimilation and accomodation happened at a particular time throughout India.

Hence an attempt is made here to correlate these major cultural and historical events that took place in the 567 and 1134 years of astronomical cyclic period. The close observation made in the above choronological sequences clearly demonstrated that there was a rise and fall in human activities, both material and intellectual, in every 550 years. A bird view of the available data pooled together since prehistoric times gives a better and reliable picture to realise the cause of the events that happened in the long historical matrix and its close relation with environment.

The long survival and evolution of biological ecosystem and its dependent human society invariably influenced from time to time in a regular cycle by the erratic climatic changes or fluctuations, rise in sea level, episodic valcanism, tectonic movements and recurrence of physical bombardment of the earth by comots, particles and radiation. The paucity of the reliable data and uncertainty that prevailed in the relevant geological time scale fails to resolve these geophenomena either caused due to exogenetic factors or endogenetic factors.

However the recent studies clearly demonstrate the striking features and relations between atmosphere and the earth. The solar radiation impinging on the earth's surface effectively controls the terrestrial climate cycles. It is a also known that so called ice ages such as Gunz, Mindel, Riss and Wurm consisted of several regular intervals of maximum glaciation intervened or followed by non-glacial periods.

The impact of the sea level changes in respect to a particular region is based on multidisciplinary factors and phenomena that affect the ocean level such as the temperature and salinity, density of sea water, currents, long effects, meteorology, atmospheric pressure, different wind effects, evaporation and precipitation, hydrology, water discharge from rivers, geology, land uplift and land subsidence, astronomy, gravitation, tide generation forces, seismology etc.

Approximately 36000 years BP sea level stood at present day shoreline. From 36000 until 22500 BP there was a lowering of the sea between −10 and −20 m. The maximum low stand might have occurred at 18000 years BP (Blackwelder, 1979:618-620). The sea level had started rising systematically from 18000 years BP at an extra-ordinary rate and rose nearly 100-150 m at some places in the next 12000 years. These sea level changes slow down or rather we could say stabilized around 6000 BP (Negi and Tiwari, 1988:79-82). It is easy to understand that stabilisation of sea level is also associated with stabilisation of average global temperatures and climate in different regions. It is well known that agricultural era had started only after stabilization of global sea level and climate around 4000 BC.

These climatic changes occurred in both 567 and 1134 years astronomical cycle. Every 1134 years one major planetary conjunction took place and also one hemicycle in every 567 years sequence. Equally important, in all probablity, is the solar activity tidal cycle (King-Hele) of 178/179 years. The great mid-Holocone glacial readvance identified in world oceans with a 6 m drop in sea level coincides precisely with the fourth cycle back from 1433 AD that is at 503 BP. It also matches the 25th cycle back of the 178/179 years King-Hele cycle (Fairbridge, 1977:413-416).

The critical year 1433 AD was first brought to attention by Patterson who believed that it correlated with catastrophic tides and flooding. This 1433 AD is the all-planetary conjuntion, the so called zero check year. The year 1433 AD coincides with a remarkable high but short-lived period of sunspot activity and also a major rise in C^{14} flux. Historical climatic analysis shows that 1433 AD initiated a time of great instability throughout the world, culminating in the great medieval ice age, with its attendent human suffering. It seems that the conjunction time coincided with a high sunspot state and immediately followed by a low-spot condition which indicates a minor glacial event. Accordingly, taking 1433 AD as the base year, the major planetary conjunctions have been traced back through the Holocene by keeping the 567 years and 1134 years as a cyclic year. Going back from 1433 AD the turning points on the 567 and 1134 years

cycle were 866 AD, 299 AD, 268 BC, 835 BC, 1402 BC, 1969 BC, 2536 BC, 3103 BC, 3668 BC, 4235 BC, 4802 BC, 5369 BC, 5936 BC, 6503 BC, 7070 BC, 7637 BC, 8204 BC, 9348 BC, 9925 BC and so on.

An attempt is made here after studying the above data to correlate the major cultural and historical events that took place in the above said cyclic period. The close observation made in the above chronological sequences clearly demonstrated that there was a rise and fall in human activities, both material and immaterial, in every 550 years cycle (the round off of 567 year cycle). For instance, let us consider the period between 835 BC and 268 BC in which India had seen the birth of Buddhism, Jainism, Upanishadic Hinduism while China evolved Confusism, Taoism and Zorastrianism in Iran and classical Judaism in Middle East.

A bird view of the available data pooled together since prehistoric times gives a better and reliable picture to realise the cause of the events that happened in the long historical matrix and its close relation with environment. The palaeolithic tools, particularly the lower and middle, recovered from different altitudes of the river terraces in the valleys like Kottalaiyar Valley near Madras, Narmada valley in Maharashtra and Soan valley in Punjab help to determine its age (Sankalia, 1963).

One of the reasons for the formation of the river terraces is the sea level variation. The data of this fluctuation indirectly helps to determine the date of the particular prehistoric tool collected from particular river terrace. The succeeding phase of microlithic period also faced arid climatic condition in the early part of the Holocene period around 10000 BP in which most of these tiny tools were collected from sand dunes in the sites like Sawyarpuram in Tirunelveli Dt. (Zeuner, 1956).

Leaving these prehistoric data behind in which much precision could not be attained due to the paucity of the reliable data one could see the advent of agriculture from the neolithic site Mehrgarh dated back to 6000 BC exactly matching with the stabilization of the terrestrial climate.

The rise of civilization could be seen in India between 2300 and 1800 BC. The excavations carried out in the type sites like at Harrappa (Vats, 1941), Mohenjodaro (Marshall, 1931), Lothal (Rao, 1973) and Kalibangan (Lal, 1967) exposed the monumental architecture like granary, Great Bath, Dockyard and Citadel respectively to testify its glorified civic administration and cultural contact with the neighbouring world.

The technological advancement made in the field of art, architecture, town planning, civic administration, trade, shipping, dockyard construction, knowledge of writing, usage of seal and sealings, social hierarchy in the form of citadel and lower town, fortification wall used either for defensive or offensive purpose stands for the evolutionary nature of the civilization that prevailed between 2300 – 1800 BC. This great civilization was brought to an end around 1800 BC due to vast flood as the one noticed at Harappa and Mohenjodaro and the sea level change causing the disuse of the tidal dock at Lothal.

The rise and fall of this civilization directly moves with the fourth planetary conjunction back from 1433 AD. In 550 years it reached its peak and disappeared subsequently without any trace. The central Indian chalcolithic cultures like Banas, Kayatha, Malwa and Jorwe observed in the type sites like Ahar, Kayatha, Navdatoli and Nevasa respectively unearthed in the subsequent cyclic year also met with the same fate (Dhavalikar, 1979:229-269).

The post-Harappan phase dated between 1600 BC and 1000 BC saw the great intellectual activity that took place in the Gangetic plain. The vedic hymns and two epics emerged in the succeeding cyclic year of 567 years. The excavations carried out at Dwarka (Rao, 1988) Hastinapur (Lal, 1955: 31-32) and Hulas (Dikshit, 1970: 21-28) clearly indicate the cultural mileau that prevailed. The succeeding cyclic year saw the birth of Buddhism and Jainism, the emergence of 16 Janapadas, the Magadhan empire in the north and widespread megalithism in the south.

In Tamil Nadu, as the writer intends to restrict to a particular region, the next cyclic year of 268 BC – 299 AD. i.e. between 3rd century BC to 3rd century AD saw the proliferation of Sangam literature, advent of Brahmi writing, wide spread megalithism in the form of cairn circle and stone circle entombing a cist burial, urn etc., trade contact with the Roman world and other related activities. The availability of large amount of Roman coins at sites like Vellalur (Nicholson, 1887), Roman ceramics such as the Arrîtine ware, rouletted ware, Amphorae and the excavations at Arikamedu (Wheeler *et. al.,* 1946) and Kaveripattinam (Raman, 1968) provide data for the trade contact with the Roman world. Mention should be made of a sherd having graffito in Tamil-Brahmi bearing the name cattan at Quseir-al-Qadim or Ancient Quesir the Arab name of the Egyptian port called Laucos Limen or "White Harbour" in classical times. This Egyptian port is situated northeast of Ancient Coptos on the Nile and served as a Roman window opening to the East in the first and second centuries of Christian era (Whitcomb, *et. al.*, 1981).

Apparently this cyclic period is represented by the finds from Arikamedu (Wheeler, etal., 1946), Karur (Sridharan, 1984), Uraiyur (Gururaja Rao, 1972), Kaveripattinam, (Raman, 1968), Alagankulam (Raman, 1988:114-118), Kodumanal (Subbrarayalu, 1989) Tirukkampuliyur (Mahalingam, 1970), Alagarai (Mahalingam, 1970), Vallam (Subbarayalu, 1984), Adichchanallur (Rea, 1902-03:111-143) etc., in Tamil Nadu and Brahmagiri, Chandravali (Wheeler, 1948:181-310), T. Narasipur (Seshadri, 1971), Hallur (Nagaraja Rao, 1971), Karnataka and many other sites in other parts of India The striking feature common to all these sites is that in 3rd century AD the people abandon the site at particular time living in different geographical zone perhaps

due to environmental change. It is necessary to study the palaeo-ecosystem for better understanding of the very survival of the human society which depends on the environmental onslaught like sea level variation caused by planetary conjuction in a particular cyclic year.

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Section 6

Geophysical and Magnetic Surveys for Marine Archaeological Exploration

Section 6

Geophysical and Magnetic Surveys for Marine Archaeological Exploration

Marine Archaeological Surveys off Tranquebar, Tamilnadu Coast – Preliminary Results

T.C.S. RAO and K. MOHANA RAO

Preliminary investigations comprising of Echosounder, Magnetic and Side Scan Sonar surveys have been carried out in May, 1989 in the offshore regions of Tranquebar, the erstwhile Dutch Port on Tamilnadu Coast. The surveys were mainly confined between 5 and 15 m water depths where possible existence of sunken shipwreck and submerged structure is reported. Investigations were also undertaken along the beach and intertidal zone to get some possible indications of ancient culture in this region. The Chola, Pandyan and Dutch coins are found in abundance in the intertidal zone near Masalamani (Chola) temple and terrakotta ring wells of 3rd Century A.D.

The bottom topography is perfectly smooth and gentle covered with fine sands and muds. No single outcrop has been recorded between 5 and 15 m water depths. Incidentally there are no outcrops even on the coastline. The Side Scan Sonar recorded several interesting features opposite to Masalamani temple, Chinnavanigiri and Chinnakudi. Most of these features are present between 9 and 11 m water depth while very few objects were recorded at about 5 m water depth off Masalamani temple and Tranquebar Fort. Many of the objects recorded from 9 to 11 m appear to be arranged in a fairly systematic pattern either in semicircular and/or circular fashion. The absence of any outcrops on the coastline and the regular arrangement of the object at these depths suggest the possible existence of submerged structures. One or two objects recorded in this area closely resemble to the submerged ship wrecks but none of these objects could be confirmed by diving operations because of rough sea conditions and very poor visibility.

INTRODUCTION

Tranquebar situated on the eastern coast of India is about 25 km south of the celebrated port at Kaveripatnam, also known as Pumpoohar; which was a major trading port from the third century B.C. Pumpoohar had attracted traders from all parts of the world especially from the Roman empire. The history of Tranquebar (Tarangambadi) can be traced to the beginning of the Christian era. Ancient Sangam classics such as "Purananooru", "Natrinai" and "Agananooru" refer to Poraiyur which is a port town. It is likely that the sea which originally skirted Poraiyur receded after the second century A.D. Marine Archaeological Unit at NIO, Goa in association with Regional Centre of NIO at Visakhapatnam initiated the exploration and excavation in May 1989 off Tranquebar to throw some light on the pre-Tamil Sangam era civilization. During this period preliminary investigations comprising of Bathymetry, Side Scan Sonar and Magnetic surveys were carried out between 5 and 15 m water depth and about 15 km to the south and north of Tranquebar.

GEOLOGY

The offshore region of Tranquebar located between Karaikal in the south and Kaveripattanam in the north falls in the drainage basin of Cauvery river. In addition, several other small ephimeral rivers named Nandalar, Virasolanar, Kadalaliyar and Vadiyar which are some of the distributories of Cauvery river discharge into the sea near Tranquebar. The coast is almost trending north-south without any prominent bays and hills and is covered with recent alluvium. The total net work of Cauvery river system drains largely through the precambrian formation in Karnataka, Kerala and Tamilnadu. The study of LANDSAT imageries and space photography (Gemini II) revealed the presence of series of parallel to enecholon lineations in the drainage area of Cauvery (Srinivasan and Srinivas 1977) which fits into the tectonic setting of southern India as a whole (Katz 1978). The precambrian formation of the drainage basin of Cauvery river comprised of Dharwar system, peninsular gneiss, charnockite and the closepet granite (Krishnan 1968). The entire central zone of Cauvery drainage basin where the present study is undertaken is exposed with alluvium only, whereas the inland basin is running through the rock formations. The beaches and dunes in the study area look blackish as the sands comprise of heavy minerals with the dominance of opaque minerals of ilmenite and magnetite. The continuous vertical cross section of the sediments obtained from the borewell dug by ONGC reveal the succession of layers from Cretaceous to recent formation (S.P. Kumar 1987). Loveson and Victor Rajamanickam (1987) reported from their studies of satellite imageries and aerial photography that the southern coast has undergone prevalent emergence or regression of sea.

The bathymetric charts recorded in the shelf region of Tranquebar reveal gentle topographic variation with fairly smooth ocean bottom. The shelf gradient is slightly more upto 10 m water depth, remaining fairly gentle from 10 to 50

m depth and again becomes more steep upto shelf edge. The width of the shelf is about 32 km. A few sediment samples collected during our investigations indicate that the sea floor upto 5 m depth comprises of medium to fine sands between 5 and 10 m, silty clays from 10 to 15 m and silty clays and clays beyond.

RESULTS

The echograms obtained during the present surveys between 5 and 15 m water depth did not record any major undulations of the ocean bottom or any outcrops except one or two submerged river channels. The magnetic data recorded in this region is also fairly smooth and devoid of any significant anomalies. However, the Side Scan Sonar (SSS) records show the presence of several objects of varying sizes in the ocean bottom and also revealed the existence of a series of disjointed structures between Tranquebar and Chinnavanigiri. Some of the features recorded in the sonographs and their possible implication to Archaeological investigation are described in this paper.

The Side Scan Sonar surveys were carried out parallel to the coast between 5 and 15 m water depth and about 15 km along the coast covering the area to the south and north of Tranquebar (Fig. 1). The profiles were placed at about 1 m water depth interval and the scanning range was 100 m either side of the boat. All the surveys were carried out on a mechanised wooden hulled fishing trawler (SONA). There were no navigational aids except the magnetic compass and the locations were noted by visual observations with reference to the objects available on the coastline. During the survey period the sea was rough. As such we could not get the correct plan view of the objects and the noise content of the records is fairly high. While the objects recorded off Masalamani temple near Tranquebar were recorded around 5 m water depth, to the north of Tranquebar i.e., off Sinnarpet and Chinnavanigiri, the objects were recorded between 9 and 11 m water depth.

A long linear feature extending from the coast into the sea (Pl. 40) has been recorded at about 5 m water depth off Masalamani temple near Tranquebar Fort. Near to the north of Masalamani temple disjointed structures (Pls. 41-42) that resemble the fragments of a linear structure parallel to the coast is recorded at about 7 m water depth. These objects each of about 25 m in length extend for more than half a kilometer in length along the coast. The disturbed objects are more or less of equal size with a semitwist in the shape. The arrangement of these objects suggests the presence of a submerged wall which might have been disturbed and the pieces are either thrown apart or got buried under the sediments causing the discontinuity in the main structure.

Off Chinnakudi which is about 7 km north of Tranquebar fort, several objects of varying sizes are recorded (Pls. 43-44). They are mostly concentrated between 9 and 11 m water depth. In general, they appear to have been scattered objects. But a close look at the records suggest that they are arranged mostly in a semicircular pattern scattered over an area of about one kilometer long. These objects are recorded off a temple near Chinnavanigiri. In the absence of any rock outcrops on the shoreline and beach and the echosounder records being devoid of any outcrops it is tentatively concluded that the objects recorded in the sonographs may correspond to some manmade structures that are subsequently submerged.

In between Chinnakudi and Chinnavanigiri large isolated bodies and patches of small objects are recorded. Off Chinnavanigiri the sonographs revealed presence of several large isolated objects (Pls. 45-46). Some of these objects from their size and shape are suspected to be sunken ship wrecks. The magnetic anomalies over these objects would normally be of very low amplitude. The rough weather conditions prevailed during the surveys produced large background noise which might have possibly masked the low amplitude anomalies produced by these objects.

To the south of Tranquebar, there are not many objects but some submerged river channels associated with some objects are recorded. These river channels are also recorded in the echograms.

Along with these surveys, investigations were also undertaken along the beach and the intertidal zone to get some

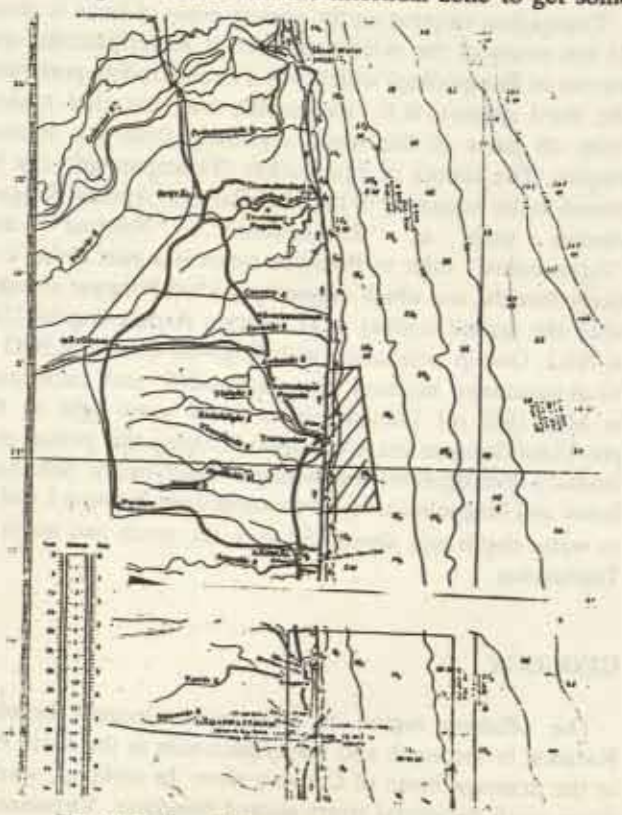

Fig. 1 Location of Survey area off Tranquebar.

possible indications of ancient culture. Pre-Chola, Pandyan and Dutch coins are found in abundance in the intertidal near Masalamani (Chola) temple and there are terrakotta ring wells of 3rd Century A.D. None of the objects recorded in the geophysical surveys could be confirmed by diving operations because of rough sea conditions and very poor visibility. However, from these preliminary surveys it is suspected that many of the objects recorded could be of Archaeological importance which could throw more light and evidence after conducting more detailed and systematic surveys supported by diving operations. Dr. S.R. Rao opines that the submerged structures from 9 to 11 m depth may be of the early historic period while those recorded at 5 to 7 m depth may be of medieval period. The present surveys also revealed the possible existence of one or two sunken ship wrecks off Sinnarpeta.

ACKNOWLEDGEMENTS

Authors express their thanks to Dr. B.N. Desai, Director, NIO, Goa, and Dr. S.R. Rao, Emeritus Scientist for their encouragement and permission to associate us in these investigations. We are also thankful to Shri M.K. Premkumar of NIO, Visakhapatnam and our colleagues at the Marine Archaeological unit of NIO, Goa for their valuable assistance during the surveys.

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Application of Acoustic, Magnetic and Electromagnetic Systems in Marine Archaeology

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The importance of integrated geoscientific studies is reiterated for underwater archaeological exploration. Geophysical systems applied for the detection of artefacts, ancient places and underwater sites/objects are explained and detailed with applications of case histories. Sampling alongwith various geological analysis and datings are suggested for their precise identification interpretation.

INTRODUCTION

In India, a good amount of integrated geoscientific studies for underwater archaeological exploration is already contemplated for transforming the latter from its nascent stage to adolescence.

At the conference of "Marine Archaeology of Indian Ocean Countries" organised by National Institute of Oceanography (Rao, 1988), it is brought to limelight that latest geoscientific techniques have been adopted and sophisticated equipments are deployed for target search, documentation and retrieval of wrecks. To strengthen the marine archaeological activities in the country, the Tamil University and Andhra University are taking steps to undertake geoscientific surveys of their respective coasts (Gangadharam, 1989; Rajamanickam, 1989) for exploration of marine archaeological remains.

MARINE GEOSCIENTIFIC METHODS

Underwater Archaeology is the study of ancient shipwrecks, ports, harbours, submerged towns and other underwater sites or objects associated with history, folklore and local traditions. Marine geoscientific studies have come in handy for the identification of underwater strata/artefacts. Systems that can be applied for their detection are divided into three categories viz. 1) Acoustic, 2) Magnetic 3) Electromagnetic, followed by sampling by deploying snapper/grab, corer & vibracore etc.

1. Acoustic System

Instruments such as echosounder, side scan sonar, mud penetrator and subbottom profiler are used invariably to have the seabed topography, horizontal plan view of the seabed and thickness of the various subsurface layers in which any archaeological artefacts are sandwiched. The principle and usefulness of these instruments with reference to the underwater archaeology are reiterated.

a. Echo Sounder

This is useful for obtaining the profile of the seabed and its depth. Apart from this, the nature of the bottom and in some favourable geological regions, even subbottom can also be recorded. At times, it becomes difficult to identify a wreck resting on a rocky terrain. When the echosounder passes over the object, the latter is recorded in the echogram as a sharp rise/pinnacle. It is possible that even the hardformations with sharp pinnacles may be interpreted as ship wreck. If any structure/ship wreck is recorded in the echogram, it is advantageous if a systematic grid survey across the exposed one is carried out to confirm its continuation and to delineate its boundary. A suitable combination of the power and frequency of the signals optimally improves the resolution of the recorded object and the information about the seabed which probably gives bright scope to the correct interpretation of the desired object on the seabed. This system is useful to pinpoint a site rather than searching large areas at a time provided an accurate position fixing system is used.

b. Mud Penetrator

If an object/site of archaeological importance is buried in the soft sediments like clays and silty clays, and the echosounder is not able to record, the same may be recorded with the help of mud penetrator. Having the power for penetration and resolution for demarcation in the sediments, mud penetrator improves the signal to noise ratio for recording the details of the buried parts of the objects through the selection of proper frequency and power (Pls. 47 & 48) Reverberations can be removed by time varying gain facility. At shallow depth, power between 15 and 2.5 kw with a frequency of 350-500 kHz can give good results. Palaeo-channels which are existing beneath the clayey seabed in some offshore areas and assumed to be the continuations of the present rivers/rivulets flowing in the adjacent coast can even be delineated effectively with this system (Subba Raju et al., 1991).

c. Sub-Bottom Profiler

Objects/sites buried in compact sediments like sands can be identified with a high power profiler by using boomer or sparker as an energy transmitting source. The signals from these sources induce deeper penetration in the sediments and may help in identification of the buried objects. Lower frequencies are used for obtaining the better penetration in the sediments of the sub-bottom formations and those buried inside the unconsolidated sediments thus providing useful information for locating the underwater buried sites of even archaeological interest, such as palaeo-channels even in the sandy formations (Stright, 1986; Rajamanickam and Subba Raju, 1988). Often scarps (Pl. 49) in the subbottom rock terrains can be recorded (Subba Raju, 1991) with this system.

The above instruments give only on-line recording of the bottom and sub-bottom formations and the features are recorded only when the concerned instrument passes directly over the same. These instruments can also distinguish the geological interfaces between the sediments and the rocks which enable the marine geoscientist/archaeologist to chalk out a plan about the silt and sand movement against the rock formations and the chances of ship wreckages and their burial in these environments.

d. Side Scan Sonar

This is quite useful in obtaining a horizontal and broad plan view of the sea floor. This can also locate split up underwater archaeological sites. When wrecks or features protrude above the seabed, this system offers as an effective tool. In this system, the towed transducers, located in a 'fish' enclosure, on either side, transmit and receive the sonar signals from the seabed. As the transducer moves forward through the water, successive strips produce a map of the seabed on either side of the recorded track of the sonar. The back scattering property of the sea floor returns the signals which are recorded in the form of tonal differences. Because of the angle of the sonar that strikes the objects on the seabed, there will be a delay beyond the object before the sound strikes the seabed. This causes a white shadow behind the strong signal, allowing the height of the object above the seabed to be calculated. Nearer the transducer to the seabed, better is the imagery. This is extremely sensitive and pictures of even deeper water shipwrecks will be obtained with sufficient details depending upon the sweep range. The extent of pipeline exposures, scouring areas, ripples and ridges formed due to the currents and wave action can also be identified in the sonograms (Subba Raju and Vora, 1987).

2. Magnetic System

The magnetometers used in this respect are Proton Precession Magnetometers which measure both absolute and differential magnetic fields working on the physical principle of proton precession in aromatic liquids such as kerosene, hexane or aviation fuel etc. which is filled in the sensor and towed behind the vessel. As it is known, the frequency of the precession of the protons in the liquid depends on the intensity of the local magnetic field. When the protons are subjected to a magnetic field induced by a momentary electric current transmitted through a coil, they are polarised and realigned uniformly in a new direction. When the current is stopped abruptly, the protons orient themselves randomly as before. In this process, they precess generating within the coil, a current of the same frequency as their frequency of precession, which is amplified, counted and recorded. The frequency of precession, of course, depends on the intensity of the local magnetic field.

As the sensor passes over the ferromagnetic object, an anomaly in the earth's magnetic field is recorded. Generally, iron ship wrecks or rocks containing ferruginous formations create magnetic anomalies (Anonymous, 1981; Breiner, 1975). Neither a huge bronze statue nor a wooden wreck can disturb the magnetic field since they are non-magnetic. Iron fittings in the wooden wreck can create the anomalies. It is generally expected that the magnetometer can detect an anomaly of 5 nT safely depending upon the distance between the sensor and the object. According to the theoretical formulae (Hall, 1966), an object having a weight of 10 tonnes, can be detectable from a distance of 45 m. The same way, 10,000 tonne ship can be detected from a distance of 450 m. 10 kg cannon ball and 2 ton cannon can be detected from the distances of 3 and 27 m respectively.

It is theoretically calculated that the signal increases nearly eight times if the distance between the sensor and the object is reduced to half the original. This gives a meaningful idea for surveying the target if the theoretical distances are known (Fig. 1). If a point source is assumed for the cause of the magnetic anomalies, it is possible theoretically to assess the size and mass of the object producing the same (Subba Raju, 1987). Both operation-wise and manufacture-wise, instruments measuring absolute field are more widely used because of their versatality and wider range of applications.

3. Electromagnetic System

Another common and effective instrument is underwater metal detector (Foster, 1970; Green and Martin, 1970). The metal detector uses the pulse induction techniques and is very simple for use by divers holding it with the hand like a torch but within a range of not more than 3 to 4 m from the target (Personal communication, LSE brochure) to get detectable signals. As soon as the diver dips it in the water, it switches on automatically and triggers the pulse, generating a signal and receiving the return signal from the objects. Of course, the size, shape and composition of an object in

addition to its orientation to the search loop, affects the detection range. However, this is used to pinpoint the objects on the seabed or buried within permissible depth range. These instruments detect both ferrous and non-ferrous objects e.g., 1 m length steel pipe and 1 kg gold bar can be detected from the distances of about 3 m and 0.8 m resply. By and large, this system appears to be useful for salvage operations, offshore debris search, lost well heads, pipeline burial surveys etc.

So far, whether all these three systems are used simultaneously for underwater archaeologial exploration in India is not well known. But the application of acoustic and magnetic systems in both the coasts are evident through the surveys conducted off Tamilnadu in the east coast (NIO Tech. Rep., 1984) and off Maharashtra in the west coast (Siddiquie et al., 1982, Subba Raju et al., 1991) by National Institute of Oceanography. East coast surveys were conducted in a bid to explore the possibilities of discovering the ancient submerged port city which is evident through the great epics of Tamil literature like *Silappadikaram* and *Manimekalai* and continuously heard through the folklore and traditional songs of the region (Subba Raju, 1987; Vora, 1987) while the west coast surveys were conducted in connection with exploration of placer deposits (Rajamanickam, 1983) and for installation of underwater structures (NIO Tech. Rep. 1989). In the latter surveys, the buried palaeochannels have been observed beneath the clayey seabed which are important due to the fact that the river/channel banks were the ancient habitat sites.

APPLICATIONS

a. Submerged structures off the east coast

Poompuhar was a flourishing port in the first century B.C. on the east coast of India, at the confluence of river Cauvery with Bay of Bengal. It had lost its glory and eminence as it is reported to be swallowed by the transgression of the sea. Local fishermen have reported household articles that have been netted by them and also apparent temple-like structures, where shoals of fish occured abundantly.

Alongwith the smooth topographic nature of the seabed, echograms have recorded strange conspicuous features as peaks/pinnacles in water depths of about 18-19 m. The features have at times broad and slender bases on the seabed having considerable heights in water layer. Some of these features have even twin peaks with blunt and sharp nature and single peaks with one side sloping and other side straight (Vora. 1987).

Sonograms have also revealed interesting linear, rectangular, circular, oval and irregular shaped features having the diameter of 20 m and even more. These features, associated with shadow zones in the sonograms, represent considerable heights of the objects and appear as three dimensional. Magnetic records have shown a number of anomalies and as such it is difficult to interpret these anomaly sources as natural geological ones. However, the sources causing the anomalies are likely to be man made and due to i) the single body with a single peak. ii) the shallow and wide bodies appearing with two or more peaks, and iii) the bodies spread irregularly or haphzardly on the sea floor (Subba Raju, 1987). It is inferred that both acoustic and magnetic surveys tend to represent the submerged structures and/or shipwrecks.

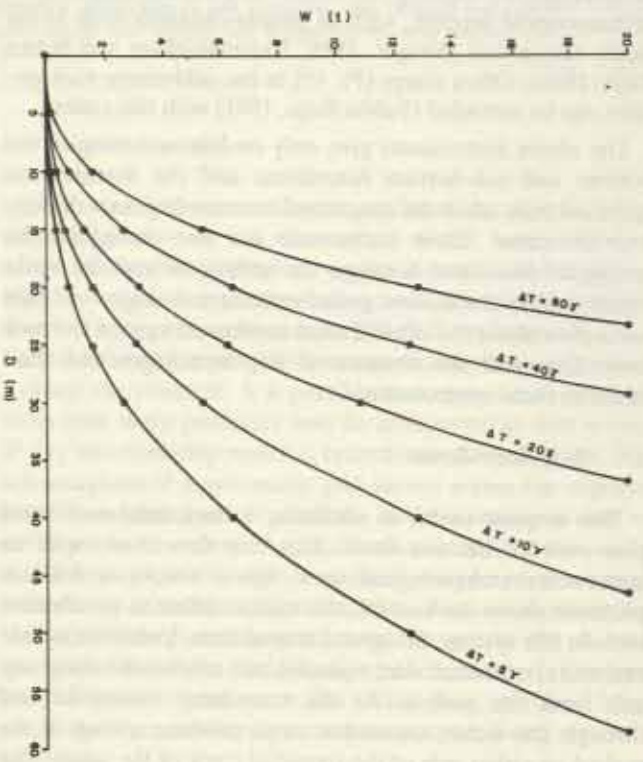

Fig. 1 Theoretical curve illustrating the relationship between the weight of the source (W) and the distance between the sensor and the source (D) for creation of different magnetic anomaly values (ΔT).

b. Palaeo-channels off the west coast

The period of the last 11,000 yrs B.P. is quite interesting in view of cultural heritage and early human civilisation. However, it is reported that the ancient civilisations were active in the last 6,000 yrs B.P. The estimates of the sealevel about 12,000 yrs B.P. on the west coast gives rise to the water depths of 138 m which compares well with the global findings (Merh, 1987). Kale and Rajaguru (1985) have also postulated a rise in the sea level from 12,000 yrs B.P., the rate being very rapid and about 18 mm/yr during the late Pleistocene and early Holocene. According to them, the sea level along the west coast reached very close to the current

level during 5,000 to 6,000 yrs B.P. Since then it seems to have oscillated to the position both above and below the present level.

It is evident that earlier civilisation had its habitat sites along the river banks or channel courses. Consequently, the attention of marine archaeologists is drawn to these palaeo-rivers/courses, that are better preserved in the seabed as the earlier extensions of the existing rivers on the adjacent land. Buried below 12 m subsurface, fluvial creeks were observed off Vengurla in 30–38 m water depths (Subba Raju et al., 1991). The creeks were also observed below the seabed in the sandy and clayey formations off Jaigarh and Batye in shallow waters (Rajamanickam and Subba Raju, 1988) and in the areas of previous sea level stands around Bombay High (NIO, 1977).

SAMPLING

After analysing the recorded data, sampling should be conducted to find out the nature and geology of the surface and subsurface layers and to bring out a composite evidence leading to accurate identification and interpretation which is the ultimate concern of the marine archaeological studies.

Sampling can be done with the help of snapper/grab, corer and vibracore depending upon the desired depth at which the sample is to be collected to verify or confirm the ancient habitat sites.

i) Snapper/Grab

For collection of surficial samples, a snapper/grab can be operated from the forward/aft derrick according to the convenience.

ii) Corer

A piston gravity corer can be used for collection of subsurface sample. The corer 3.3 m long with an inner diameter of 50 mm with acrylitic tubes of inner diameter 44 mm with the weight of 132 kg will be useful with a free fall of 3 m (NIO, 1977). The sampling sites may be decided after an examination of the echograms, sonograms and shallow seismic records.

iii) Vibracore

This consists of an impacting bin vibrator working by deploying the pneumatic pressure and mounted on top of a core pipe made of 4-in standard pipe which contains a 3.5-in interior-diameter tubular plastic liner for carrying the core. A check valve at the top of the core barrel and a springleaf core retainer at the bottom are fixed to retain the core sample in the plastic liner during withdrawal and raising of the vibracore. Usually, a mast consisting of a steel H-beam supported in vertical position by a base consisting of four legs attached to the mast, was fixed on the sea floor. The vibrator and the core pipe were spring mounted to a slide attached to the mast and thus were set free to move vertically, guided by the mast, with weight of the slide exerting a constant pressure on the core pipe. The core barrel was designed to be driven into the sediment and pulled back along with the core into the frame before lifting from the seafloor. Power was supplied to the pneumatic vibrator by an air compressor on the support vessel through a flexible wire-reinforced hose. A strip-chart record provides the depth of penetration achieved by the vibracore (Pearson et al., 1986). When the vibracore was sent to the seafloor, the weight of the vibrator and core tube alone normally drives the core through considerable depth in the sediments. The pneumatic vibrator is activated till the desired depth is achieved.

Any identified features or geological strata depends much on the results of the number of analyses through which these collected samples were scrutinized. These analytical techniques such as grain-size analysis, point count analysis, geochemical analysis (Pearson et al., 1986), foraminiferal analysis (Nigam, 1988) and radiocarbon dating (Agarwal and Kusumgar, 1974) allow a specific assessment of the sample but together bring an integrated evidence leading to precise and accurate identification and interpretation. This ultimately paves the way to confirm or reject whether the sample has an archaeological site/deposit or not.

Along with the above systems, optical systems can be used for confirmation of the location of the archaeological objects/sites in various places (Bass and Katzev, 1968; Rao, 1988).

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Relevance of Topography and Sediment in Ship Wreck Exploration – Examples from Goa waters

M.C. PATHAK, N.H. HASHIMI and RAJIV NIGAM

Ship wrecks are the tools to open the secrets and to decipher the mysteries of the past. A number of ship wrecks of historical importance have been reported along the Goa coast viz. Amee shoals, Aguada bay, Calangute. To assess the state of preservation of these wrecks, topography and type of sediment are found to be the vital parameters.

The technique of comparing the bathymetric profiles of the surveys separated in time (1881 – 1976) of Goa coast provided information about the environmental impact and estimation of sediment movement. Thus it can be useful to visualise the environmental set up in ancient time and provide a scientific explanation to the condition of the ship, once she ran aground. Furthermore, this study indicates a strong correlation between bathymetry and the type of sediment in the model areas of Marmagoa and Aguada bays. In these areas it is observed that the high energy shallow water region are dominated by sandy sediments while the topographic low areas with low energy conditions have muddy sediments.

The recent discovery of the ancient guns once carried by a ship which wrecked on Amee shoals in Marmagoa bay shows that the region having high energy shallow water topography covered with sand and shells is not conducive for the preservation of the wreck, whereas the low energy region of deeper depth such as off Calangute area is conducive for the preservation of the ship wrecks.

This study may be used as a model for understanding the relevance of topography and the nature of sediment for the state of preservation of the ship wrecks.

INTRODUCTION

India with her vast coastline had a very vital role in the maritime trade from ancient time. Through these maritime activities the great cultures of the old world were interacted. Archaeological evidences of maritime activities dated back to middle of the third millinium BC onward are available in the form of docks and ports (Joshi, 1987). The history of maritime activity of the past is lying underwater in the form of historical relict features known as ship wrecks. Long experience has shown that these artifacts are the best source of information and may be studied as primary documentary evidence in reconstructing the past. The Marine Archaeological Unit of the Institute has compiled the vital information pertaining to more than 200 ship wrecks on the Indian Continental Shelf (Rao, 1983).

Before prospecting for such a large number of shipwrecks the most important step is to visualise the environmental set up of prospective locations. Topography and the sediment distribution of a particular area plays a potential role in the preservation of a ship wreck.

In order to provide the meaningful basis for making extrapolation and interpolation concerning the ship wreck preservation, the present study from the location of Goa waters where the environmental and historical data is available can serve as a model for other areas. The chosen study area can be divided in the three geographical sites of different environment models. The resulting data have been analysed to define the effects of the topography, sediments, currents and wave characteristics for the state of preservation of ancient ship wrecks.

The purpose of this paper is to provide technique for identifying the state of ship wreck and related finds to assist marine archaeologists in assessing the state of ship wrecks in similar environment.

MATERIAL AND METHOD

This paper is based on the bathymetric surveys carried out by using the Atlas Deso-10 Echosounder with dual frequencies of 30 KHz and 210 KHz. The 210 KHz frequency gives better resolution and 30 KHz provides the sub-bottom information. The mini ranger MRS III system was used for position fixing with accuracy of ± 3 m. The positions were recorded at every 15 sec interval and the corresponding event marks were put on all records. During the evaluation of the record these event mark positions were used as a descriptive unit. The tidal corrections were applied by using the oscillations recorded at every 30 minutes on a tidepole/guage installed at Panaji and Mormugao Harbour.

Bathymetric profiles based on available charts of 1881 and 1976 surveys were compared for understanding the erosional or depositional condition. Textural sedimentary data was used for studying the topography v/s sediment correlation.

RESULT AND DISCUSSION

Rao (1983) has published prospective locations of ship wrecks along the west coast of India. In order to test the environment v/s preservation of ship wreck concept, three different types of areas i.e. Aguada bay, Amee shoals in Mormugao bay, and Calangute areas were chosen from Goa waters. These areas are categorised as Site 1, Site 2 and Site 3 (Figure 1).

Site 1: Aguada bar

The Aguada bar referred to in Portuguese hydrographic map as Barra de Agoada and in recent hydrographic charts as Aguada bar is a coastal fixture (Fig. 1). The bar is having a least depth of 2.8 m and is being navigated by shallow draft vessels with a local knowledge of the navigation channel. The Mandovi River may be classified as a Ria which is defined as a river system which is partly or wholly drowned by the sea due to Handrian Pleistocene Glacial Transgression or Subsidence of land areas (Ahmed, 1972). Coastal processes have created a narrow entrance which is being kept open by river flow and tidal circulation. Formation of sand bar has narrowed down the river mouth. The river carries a mixture of fine sand and flocculated fine cohesive sediment. The suspended sediment load (surface) is about 30 mg/litre in fair weather 100 mg/litre in the monsoon season (Murty and Das, 1972, Murty et al., 1976).

Visual observation during monsoon indicates a line of breakers near the bar. The wave breaking phenomenon may be associated with the strong ebb current from the river opposing the wave advancement, and thus the waves steepen and break more easily.

The bathymetric charts of these areas show that the isobaths (line joining points of equal depth) are fairly parallel to the shore line in the Miramar area. Typically the isobaths are tending towards the Aguada bar in the area. These isobaths are converging and giving rise to a saddle at the head of the Aguada bay where the river flows into the bay. In general, water depth in this area is 5.4 m bay ward side of bar to 10 m river side with minimum 2.8 m on the bar, whereas river mouth is very steep (Fig. 2). However, it slopes gently towards the bay side and it appears that the flow area is decreased considerably at the throat area thus causing an increase in current velocities. The increased velocity has greater scour capability (Escoffier and Walton, 1979). The comparison of pre – and post-monsoon surveys shows that the freshwater outflow in the monsoon season has a flushing and scoring effect (Pathak et al., 1988), but during the lean season the channel returns to its original depth. Comparison of bathymetric profiles shows that there is no significant topographic change during the last 100 years. Dredging was carried out to deepen the navigation channel but subsequent surveys showed that the channel in between the bars (Aguada bay in the south and Reismagos bar in the north Fig. 1) silted upto its original depth. In spring low water both the bars are visible during fair weather season. It appears that the tendency of the waves is to align themselves parallel to the bottom contours.

There is greater movement of sand from Aguada bar side. The Reis Magos bar consists of rock reef. The considerable turbulence and the river outflow prevent the sediment deposition in this area. The material transported by river outflow is being deposited in greater depth. The topographically high area with considerable activity may be defined as high energy area. This high energy area, is all along covered with sandy bottom associated with the gravel. Recent dredging activity resulted in the recovery of an old anchor probably belonging to a ship wreck; except the anchor no other object of archaeological interest was recovered from the area. The shallow uncharted depth on the bar channel could be the cause of wrecking most of the ships.

Site 2: Amee shoal in Mormugao bay

The Marmugao bay is referred to in Portuguese hydrographic map as Baia de Mormugao and in recent hydrographic chart as Mormugoa harbour. The entrance of Mormugao bay lies in between two promontories Cabo in the north and Mormugao in the south (Fig. 1). The Southern side of Mormugao bay is mostly a bold and rocky rising island to table land from about 30 to 80 m in elevation. The Zuari River flows into the head of Mormugao bay through a constricted passage. Amee shoals, a site where the information about ship wreck is available, is located northward of the Mormugao Harbour approach channel and nearly in the centre of the bay. The rocky shoals and reefs extending north-south across the entrance of the bay act as a barrier at the approaches.

The river discharge is modulated primarily on the seasonal time scale. Increased level of river discharge during the monsoon months promotes erosion and suspended sediment transport. The isobaths in this region indicate a gradual slope towards the west. The water depth in the Amee shoal area is ranging from 1.8 to 11 m. The minimum depth recorded in the middle of the Amee shoals is 1.8 m. The bay floor is characterised by prominent submerged rock outcrops. In between these shoals the bathymetric lows are also noticed. This may be the combined effect of the current and topography. The comparison of the bathymetric chart of year 1881 with that of the year 1976 shows that the area is not conducive for sediment deposition.

The sea bottom in this area is covered with shelly sand, lithified sediment or a rocky bed thinly covered by sediment (Wagle, 1988). The ebb currents are of the order of 3 knots, the flood currents are 1.5 knots during the spring tide. In the Amee shoals region the wave heights are maximum in the southwest monsoon season. The sea breaks heavily along

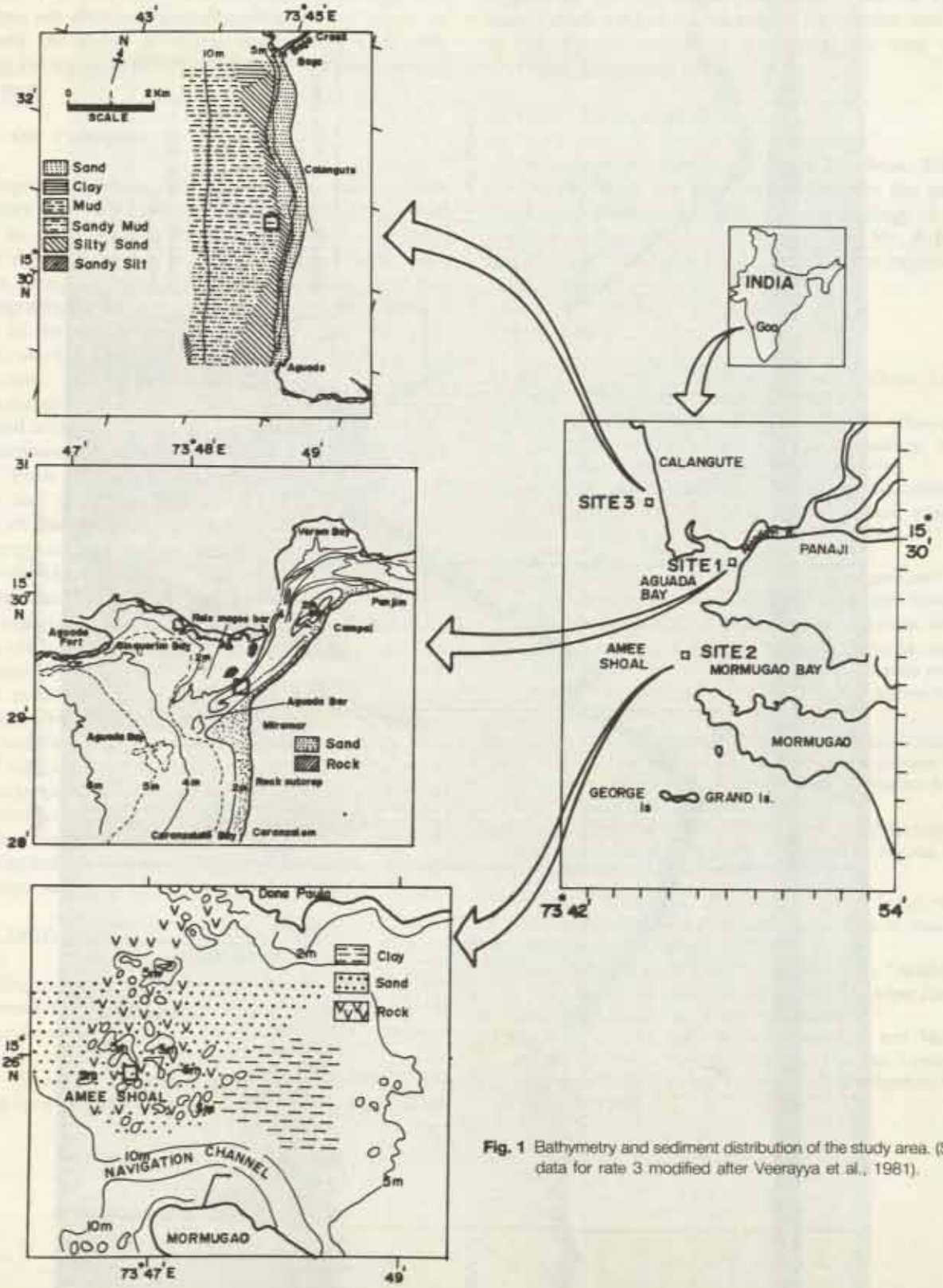

Fig. 1 Bathymetry and sediment distribution of the study area. (Sediment data for rate 3 modified after Veerayya et al., 1981).

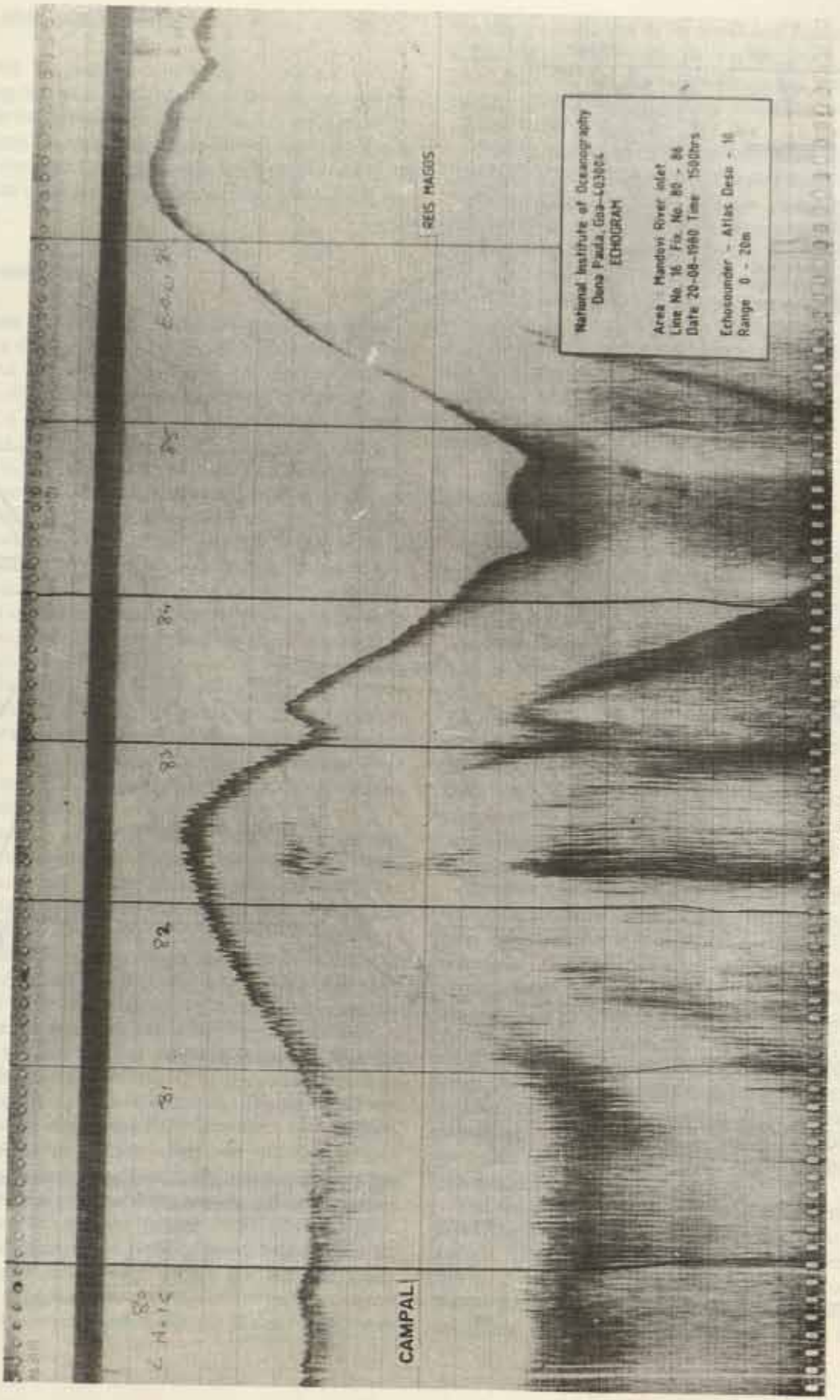

Fig. 2 Echogram across Mandovi River inlet.

this track. The area may be defined as high energy area which does not allow sediment deposition.

Recently the divers of Marine Archaeology Unit while searching for the ancient ship wreck found the heavy guns of ancient time.

Site 3: Off Calangute

The topography of the area is very smooth. The isobaths of the area are fairly parallel to the shoreline (Fig. 1). In general the water depth in the ship wreck area is fairly large being in the range of 7-10 m. The sea floor is covered with soft mud. Comparison of the bathymetric profiles shows that the topography in the area is stable. The reported wreck is situated in the clay covered area. It seems that due to the weight of the ship with cargo caused a part of the ship to sink into the clay.

The selected regions corresponding to the different topographic and sediment regions are observed from Site 1 and 2 which correspond to the high topography and incompressible bottom. From these locations only heavy artifacts such as anchors and guns were located. This indicates that the chances of damage from the direct lift and drag forces in high energy area might have resulted poor preservation of the ship wreck. The experimental evidence (Castial et al., 1979) indicated that the objects located on the hard bottom surface experience the maximum force. In Site 3 the topography is smooth and the bed is covered with soft mud. This topographically low area is a low energy zone covered with the soft mud providing a cushion like effect to the ship wreck. The ship wreck is reportedly preserved in this zone.

The resulting data shows that the high energy area covered with sand is not conducive for the preservation of ship wrecks and the low topographic area covered with soft mud is conducive for the preservation of the wreck. It also shows that the potentiality for preservation of ship wreck is also controlled by the degree of slope, nature of the material in the slope and ground conditions.

CONCLUSIONS

The discussion above has shown the usefulness of the environmental study methods as a systematic approach for better understanding of the complex inter-relationship of topography, sediment and preservation of ship wreck. This method allowed a systematic analysis for identifying the potential areas and information can be used as a part of the exploration and excavation programme. Thus the environmental study method can be used as a predictive tool and as an investigative method in determining the state of ship wreck in a prospective area.

ACKNOWLEDGEMENTS

The authors are grateful to Dr. B.N. Desai, Director, Mr. P.S.N. Murty for permission to present this paper in the Second Conference on Marine Archaeology of Indian Ocean Countries. We are also thankful to Mr. R.R. Nair and Dr. S.R. Rao for their suggestions in the improvement of the paper.

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Section 7

Diving and Underwater Photography

Section 7

Diving and Underwater Photography

Photography for Marine Archaeology Projects

C.T.C. DOBBS

Any project in the sphere of marine archaeology may require photographs for a wide range of different needs. Some of these needs will be archaeological such as record photographs of finds in position underwater or just after raising to show their state of preservation. Other needs will have more to do with public relations and involve glossy pictures for magazines or books. Further needs will be a cross archaeological conference like this. This lecture and paper are intended to outline these needs and then concentrate on giving practical examples of a range of techniques and items of equipment that should enable better photographs to be taken underwater. The paper does not involve ALL aspects of underwater photography, but rather it is intended to illustrate the additional thought and procedures required of an underwater ARCHAEOLOGICAL photographer.

To take pictures underwater that will be of use to a project, a photographer needs a combination of both equipment and techniques. The one is of little use without the other. Items of equipment that will be considered include; wide-angle lenses, cameras and lighting equipment. Techniques to be mastered include both diving techniques, particularly buoyancy control, and photographic techniques, such as composition, positioning of light sources and photomosaics. Finally, documenting the contents of record photographs taken underwater must be done as soon as possible as such details can quickly be forgotten.

Video equipment is rapidly becoming more accessible to archaeological projects and if time and space allow, some notes on the techniques and equipment required for good results in this medium will also be discussed.

BRACKETING EXPOSURES

When using colour film, and particularly for important shots, the technique of bracketing is recommended. Take the picture at the f.stop you think is the optimum and then repeat the shot, first over-exposing by a stop and then under-exposing by a stop. Although filrh is expensive, it is perhaps cheap when compared with all the other factors of an underwater project and it is often good to use up a whole film on a dive so that the camera can be opened up and checked after the dive and so that you don't have an annoying short end on your next dive.

DOCUMENTATION

If photography or video is to be used as a recording technique on a site it follows that the photographs are part of the site record. This means the photographs should be backed up by full documentation and should ideally be kept with all the other site records. Just as with excavation dive log records, a record of all the photographs taken on any dive should be made on a log sheet or index card. (See page for an example). This is essential as many details of pictures will often be known only by the photographer and may easily be forgotten. Experience has shown that it is best to make brief notes about the photographs whilst still underwater, and then write up the log sheet soon after the dive. The documentation must then be finished when the film has been developed and the exact frame numbers and results are known.

An example of a photo log sheet is included here which might act as a basis for your project. Naturally the most important information is the subject matter of each shot but the angle it is viewed from and the area or object number are also needed for cross-referencing. Extra information on technical aspects can be added in other columns which are particularly useful for recording the results of exposure tests made on the site. Processing details should be included and the film number should also be clearly marked on the negative sheets. Transparencies are sometimes numbered purely on a sequential system rather than a film/frame numbering system but the details must still be recorded soon after the dive.

INTRODUCTION

This paper is submitted to the Second Indian Conference on Marine Archaeology as a written introduction to a number of techniques, disciplines and items of equipment that should enable better results over the range of photographic requirements on a marine archaeology project. The lecture at the conference will differ, being an illustrated talk that shows examples of many of the aspects outlined here. The paper is an edited extract from Mr. Dobbs contribution to the handbook entitled Nautical Archaeology, A Practical Guide, which is being published by the Nautical Archaeology Society in 1990. It contains chapters on most aspects of underwater archaeology and will be a useful handbook for all those working in this field.

Photography has the potential of being one of the most useful recording techniques for the archaeologist on underwater sites, as well as being objective and cost-effective. It can be a very efficient recording method in terms of that most valuable commodity – diving time. Yet this potential has rarely been fully exploited by underwater archaeology projects. Although this is partly due to the high cost of equipment, a lack of technique and discipline is often equally to blame. Although some basic factors will be discussed in this paper because they are absent from other publications, any complete newcomer to underwater photography

will also need to refer to specialized books and to experienced underwater photographers. This paper is mainly intended to illustrate the additonal thought and procedures required of an underwater ARCHAEOLOGICAL photographer.

PROJECT PHOTOGRAPHY (Pls. 49-50)

Although the underwater archaeologist's prime use for under water photography is to record features of the site, a project as a whole will require photographs for a variety of different purposes. One common fault on projects is that a large number of pictures may be taken of the interesting items or the personnel at work but without a clear impression of what each photo is intended for. There will usually be a distinct difference between 'record', P.R., press, and lecture photographs, and the composition of the photo will probably be different in each case. It is rare for one picture to adequately cover the entire range of requirements.

To take an example, a complete wooden bucket or jug is found on a site. Record photographs are taken preferably in B & W as well as colour to show how it lies in relation to other objects, packing material, or hull structure and these photographs include a scale. It is fragile and many photographs will be needed if it is to be dismantled on the seabed. Transparencies are taken to illustrate this artefact at lectures and conferences and perhaps also to show how it was excavated or raised. An underwater photograph is needed for Press, P.R., and fund raising purposes especially as this is the most interesting object found so far. For this, the inclusion of a diver rather than a scale will add some extra interest for the general public. Finally a journalist from a colour magazine wants a picture of a diver surfacing clutching the item above his head and bursting through the surface as if he has just made a buoyant ascent! He is refused as the object is far too fragile and it comes up carefully packed in a suitable container. The journalist photographs the shore-team and the diver checking the packaging before transport to the conservation laboratory.

This paper primarily concerns the underwater photography required on a project, and record photographs taken underwater of fragile finds prior to lifting are vital. However, the importance of further record photographs soon after raising and before packaging, or conservation cannot be overlooked. Sometimes such photographs become the best record of the objects, particularly if they have to be dismantled for conservation. A project photographer has a responsibilitiy to ensure that photographs of all aspects of the project are taken and it is worth making a list near the beginning of the work of the types of photographs needed so that no area is left out. In this way many of the publicity photographs can be fitted in around the needs of the record photographs.

A system should also be devised before the diving period starts so that both project and the photographer know where they stand in relation to the material. In an ideal world the project would supply all the film and equipment and expenses and would keep all the developed film but this involves a great deal of expenditure for small projects. In many cases the photographer may be supplying very expensive equipment of his own in which case the project budget should certainly allow for such a person to have selected duplicates or prints for his own portfolio.

EQUIPMENT

It is unfortunate fact that underwater photographic equipment is extremely expensive as the market is still quite small. However it is important to use the right equipment where possible and even more important to use it correctly as will be outlined further in 'techniques'. One essential item that is often overlooked and costs very little is a photographic scale.

Scales

Cheap, square section, plastic rulers about 300 mm long are ideal for adapting into a scale. Decide what size metric divisions you would like and then mask the divisions and spray or paint the ruler. Insulating tape or permanent marker could be used but matt black paint gives a better finish. It is a good idea to cut off any part of the ruler extending beyond the measured part so that a scale of an exact total length is achieved. Yellow or orange rulers are ideal to use as a basis because they produce less flare in the photographs than when using white rules. For ease of use it is worth drilling a hole in one or both ends of the rule which can be plugged with a small piece of lead. This reduces the annoying habit of the scale drifting around as you are about to take a picture. A larger lm scale can conveniently be made from a folding plastic ruler, and many other materials can also be used as the basis for a scale. A scale should be carried by the photographer on all dives with a camera and a small scale can easily be tucked inside the knife straps when not in use. You should not have to resort to using your knife as a scale! Another advantage of using a scale is that if there is more than one photographer on the site, and the scales are painted differently, it is easy to know who should be credited with the photographs and also who should be chased up to obtain the documentation! In clearer waters, and particularly when photographing structures, another useful basis for a scale is a painted lm long spirit levels as it is easy to lay these to show the horizontal or vertical. These types of scale are adquate for most uses but if many measurements are to be taken from the photograph a scale shaped like a square or cross or even a cube is needed.

Lenses

The major problems facing underwater photographers in Europe are poor visibility and low light levels. However, even in the tropical waters around India these factors can be important. To obtain good pictures, the subject should be no further away than one third of the visibility, and one quarter would be a better rule of thumb for record photography. This means that either close-up or wide-angle lenses will give better results. As close up systems usually give too small an area for archaeological purposes a wide-angle lens or attachement must be the first item of expenditure for an underwater archaeological photographer or project. In conditions of poor visibility, (1-4m) a 15mm lens or equivalent attachment is required for the best results, but in better conditions especially in tropical waters a 20 mm focal length may suffice. The use of a wide-angle lense even in clear waters is recommended because it still reduces the lens to subject distance and hence increases the clarity of the photograph. The high cost of the 15 mm wide-angle lenses mean that most projects can only consider cheaper wide-angle attachments. In Indian waters a lens like the Sea and Sea 20 mm would be a good compromise between results and price. For those using a camera in a housing rather than the Nikonos system, a dome part is highly recommended.

The Table of lens coverage is useful for comparing the degree of coverage of underwater lenses with land systems you may be familiar with. Present UK costs in rupees are included as some items are far too expesive and this has to be borne in mind when deciding the ideal equipment. Note the significant gain in angle made by a dome port which restores the focal length attained by the lens on land. The 90 degree angles of 15 mm lenses or wide-angle attachments enable you to photograph an entire diver from a distance of 1m. This gives the same angle of view underwater as a 50 mm lens gives in air. If buying second-hand be aware of the lack of spares and that the older Nikonos 15 mm lens and the older Sea & Sea, 17 and 18mm lenses do not allow 'through-the-lens' metering with the Nikonos IV and V whereas the newer 15mm Nikonos lens and the Sea & Sea 15 & newer 17mm lenses do allow it.

Cameras

One frequently asked question is 'Should I buy a Nikonos or should I buy a housing for my SLR camera'. If the housing is well made and has a good viewfinder system, the housing solution should give more accurate viewfinding and focusing for close-up work. However the Nikonos system will give you an extra camera and is quicker to reload and change lenses. Whilst the housing will often be better for the professional photographer going down to do nothing on his dive except take photographs, the Nikonos is much smaller and less cumbersome to dive with and so more practical as an archaeological tool. Flexible housings and cheaper amphibious cameras are not serious contenders for recording work around Britain, but may have some use in the clearer tropical waters if all other equipment is too expensive.

Lighting

As well as reduced visibility, other problems with underwater photography are those of low light levels and a reduction in colour at depth. Even though tropical waters are much brighter than around Britain, artificial light will still considerably improve definition and contrast as well as return colour to otherwise dull photographs. However the timing of a photography session should not be ignored as diving in the middle of a bright day rather than in the morning or late afternoon can make all the difference in terms of the penetration.

Usually an artificial light source will be a flash gun (strobe) but some projects have the use of mains cable lights which are equally effective. When using these an earth trip must be used and tested before each dive and if using colour film, it should be the 'tungsten type' or the colour balance will be affected. The advantage of mains lights is that the desired lighting can be clearly seen whereas flash photography relies on experience and judgement. The position of any light source is perhaps the most crucial factor in underwater protography and this is discussed below under techniques.

Film & Developing

The film and developer combination is a very important factor in underwater photography especially in murky water, and serious photographers must master their own techniques of developing. Projects should have a dark room available, for if photography is being relied on as an important part of the documentation process, it is vital to check the results of any shots as soon as possible. Although colour will be needed for PR, lectures and some of the record photography, B & W is most accepteable for the majority of the recording. Whilst some people advocate the use of colour print film, the expense of obtaining quality prints and the problems with trying to cope with three types of film outweigh any advantages, especially as copying to another form gives less satisfactory results.

There is not a great deal of difference between the various makes of E6 colour slide films around, and their use will enable quick results to be obtained either by yourself in the darkroom or with an E6 laboratory. Whilst the slower 100 ASA is recommended for the finer grain when artificial light is being used or in bright waters, the 200 or 400 ASA versions will give good results in gloomy water. If light levels and budget allow, Kodachrome 64 will give the finest results and is significantly better than its E6 counterparts. A new

Kodak 200 ASA film has been developed recently and is extremely useful for most underwater photography – but at a price.

With black and white film, again the 125 ASA Plus-X or FP4 will give better results if artificial lighting is being used but the 400 ASA films will be more practical in deeper or darker waters and they allow shorter exposures to minimise camera shake. The new TMX films from Kodak (125 and 400) are probably the best compromise available on the market at the moment. One great advantage is that you can underexpose them one stop (ie use at 250 or 800 ASA) without changing the development times; so you can mix normal and unexposed shots on the same roll of film.

Equally important as the type of b&w film is the developer and darkroom techniques you use. Your temperature control, timing and agitation techniques should be standardized for consistent results and you should find a developer combination that works well for you and the particular conditions you are working under and then stick to it. Developers such as Microphen and Promicrol will increase film speed with fairly acceptable losses of grain. It is important to realise that any development time is a guide and if you find you need more contrast or the negatives for your test film are thin, then increase the development time accordingly and vice versa.

TECHNIQUES

Diving

Whilst an expensive wide-angle lens and flash gun may make great improvements to the clarity of photographs taken on a site, an equal improvement can often be made by changing diving techniques, and a flashgun is useless unless properly positioned. Poor but acceptable visibility on archaeological sites is often made unworkable by divers with their knees and fins by kicking up the silts. Perfect buoyancy and fin control by a phtographer are essential skills and if it is the other divers that are causing the problem, they should be re-educated.

In some circumstances it may be impossible for divers not to disturb the visibility in which case a period of the day exclusively devoted to photography may have to be considered. This might be the first thing in the morning before silts are stirred up or during slack water especially on 'excavation sites' or around mid-day when the light levels may be at their best. It is far better to have such a period set aside for all but the most urgent photography than to waste metres of film and hours of diving time creating milky pictures that are of no use either for P.R. purposes or as an archaeological record. In certain circumstances it may be beneficial for the photographer to remove his fins but this should only be done with the approval of the diving supervisor and on sites where it does not prejudice safety.

Lighting

Along with acquiring a wide-angle lens or converter, correct positioning of the flashgun is the most important factor likely to lead to better photographs. I believe that the flashgun should never be used with the bracket still attached to the camera except for close-ups. This is because even slight backscatter considerably affects a photograph. By holding the light source well above the camera and away from the lens, a much more even coverage is obtained and backscatter is minimised. Think of the flashgun as mimicking the sun. An added advantage of this method is that it also gives a wider coverage of light which is needed for the wide-angle lens. Remember also that it is the flash-to-subject distance that determines the exposure for flash photography, not the lens-to-subject distance.

There is no substitute for experience and analysing your mistakes when it comes to flash photography but try to imagine where you want the light and where the shadows will lie. For more experienced photographers, the use of extra slave flashguns should be considered. These extra flashguns are triggered by the light of the first flash but require no extra cord. The inclusion of a light source, for instance in the near background of a scene to be used for publicity purposes, will add considerable depth to the photograph.

Composition and Cleaning

Composition is an often neglected photographic skill for underwater scientific projects but it is as important to record photographs' as it is to spectacular P.R. shots. Care should be taken to obtain the best angle to show the subject, and oblique shots are often the most effective. The scale should be placed close (but not too obtrusively) and next to the object, perhaps horizontally just in front of it or vertically next to it. The scale should obviously not obscure important detail. The subject needs to be as clear as possible and if this means several minutes of work to remove light overlying sand or silts, this should be done. This is particularly important when photographing wood, as joints, treenails and grain are very easily disguised even by very light coverings of silt. A wide, soft paintbrush is very useful for cleaning in this situation.

Some objects may have to be photographed because it is felt they are too fragile to raise whole and discussion may be needed between the photographer and the archaeologist. Uncovering of a fragile object will make the photograph clearer, but may also make the object less likely to survive during raising. On the other hand if it is not recorded photographically and is still damaged then information is again lost.

If objects or structures are fully exposed and cleaned for photography, then even more care than usual must be taken

TABLE TO SHOW THE APPROXIMATE DEGREE OF COVERAGE OF VARIOUS LENSES

Make	*Focal length*	*lens f.no*	*In Air*	*+ Flat Port*	*+ Dome Port*	*U.W. Contact*	*Cost Rs. (12/89)*
Nikonos	15	2.8	–	–	–	94°	32,200
	20	2.8	–	–	–	78°	11,600
	28	3.5	–	–	–	59°	6,740
	35	2.5	62°	–	–	43°	3,120
	80	4.0	30°	–	–	22°	6,740
Sea & Sea	15	3.5	–	–	–	96°	9,340
	17	3.5	–	–	–	86°	s/h
	18	2.8	–	–	–	84°	s/h
	20	3.5	–	–	–	79°	7,540
,, SWL16	*	*	–	–	–	91°	3,720
,, SWL24	*	*	–	–	–	63°	3,540
SUBAWIDER	*	*	–	–	–	91°	3,830
NOVATEK 28	*	*	–	–	–	74°	(USA)
20	*	*	–	–	–	95°	(USA)
SLR: NIKON	20	2.8	94°	66°	94°	–	9,350
:OM–ZUIKO	21	3.5	92°	65°	92°	–	5,930
:OM–ZUIKO	24	2.8	84°	60°	84°	–	3,500
:OM–ZUIKO	28	2.8	74°	54°	74°	–	2,500
:OM–ZUIKO	35	2.8	62°	46°	62°	–	2,500
:OM–ZUIKO	50	1.8	46°	34°	46°	–	1,550
VIDEO-ZOOM	8.5 mm		52°	39°	52°		
at	10 mm		50°	37°	50°		
	12 mm		48°	35°	48°		

8.5 mm with 0.7 × converter 74° 54° 74°
8.5 mm with 0.48× converter 108° 80° 108°
12mm with 0.48 × converter 100° 73° 100°

* Supplementary lens designed to fit over the Nikonos 35 mm lens
# Prices are guide prices for December 1989 in the UK.
NB Degrees of coverage are generally calculated in relation to the diagonal of the image, NOT the width.

to re-bury or otherwise protect them against renewed degradation.

Photo-Mosaics

Underwater visibility will seldom be good enough to photograph large objects, structures or areas in one frame with good detail, and even if it was good enough, the lens would not give a true plan over the whole structure because of distortion. Photomosaics are a way of obtaining a similar end-result by taking overlapping photographs and joining the prints together. Theoretically this can be done simply by 'flying' over the site which may help to make up a pictorial view. However a lack of precision or of any control information will not give accurate information for the site records. For a simple 'aide memoire' a few oblique photographs would give a better result. For a real photo-mosaic it is far better to do the job properly and enable the mosaic to contribute significantly to the survey and other recording methods used on the site.

Although it is useful on some sites, there is often no need to have a heavy frame or a system of rails over the site to run the photo-tower along. However there are a number of advantages to using a lightweight photo tower which can easily be made out of 22mm plastic pipe or conduit see. These advantages include:

The square frame at the base of the tower can act as a scale when printing. For instance, if the frame is one metre square and you draw lines forming a 10cm square on your enlarger easel and line up the squares when printing, you will

obtain a 1:10 image of any structure level with the frame. The fixed camera to subject distance also gives consistent magnification making the printing easier.
The tower holds the camera and film plane parallel to the subject so that a true plan or elevation view is obtained.
A tower holds the camera steady allowing slower speeds and hence smaller apertures with better depth of field and lens performance.
The tower base provides easy reference points for determining the overlap between taking each shot.

The height of the tower of 'flying height' required for a particular coverage can either be calculated by trigonometry or by a simple formula pointed out to me by Jeremy Green of the Western Australian Maritime Museum. The formula is then applied here to 35mm photography, where the image size on the film is 36mm × 24mm. Don't forget that the focal length must be the real focal length in water, not the focal length in air that the manufacturer has engraved on the lens!

For instance, the focal length of most '15mm' lenses or adapter combinations is in fact 20mm underwater. The table given earlier will again help you estimate the real focal length of your lens, or you can multiply by 1.33 which is the refractive index of water.

Formula

$$\frac{D}{H} = \frac{W}{f}$$

where D = Distance of cover needed in m
H = tower Height in m
W = width of film in mm
f = focal length of the lens in mm

For horizontal cover where width of film = 36mm

$$\frac{D}{H} = \frac{36}{f}$$

and hence horizontal cover $D = \frac{36}{f} \times H$

so for a 15mm (ie 20mm) lens,

$$\frac{D}{H} = \frac{36}{20}$$

So horizontal cover D = 1.8 x H

This means that with a 15mm (20mm!) lens, a tower height or flying height of 1m will give a horizontal coverage of 1.8m and a vertical coverage of 1.2m (if you do the maths again for a the film width of 24mm). This is quite suitable for a 1m grid as it allows some leeway alround. Although a rectangular grid frame can be used, remember that there would then be more distortion in one direction - after all the lenses are circular, it's just the image that is rectangular.

DISCUSSION

Manavi Thakkar: With a slow shutter speed do you sometimes get a shake?
A: Dobbs: By only lighting the background with subtle and the foreground by the flashgun which is on for only 10 sec. the foreground is sharp and the background is far away. Therefore the slight shake that occurs in 1/30 does not matter for things in the distance.
Gangadharam: One aspect that was not touched upon is under water photogrammetry. I know it is very complex. I have seen it in Australia and when I was at Dehradun Institute of Photography. There are experts on land photogrammetry. I tried to convince them to undertake such work in the sea and gain experience so that when Marine archaeologists like Dr. S.R. Rao need it we can get expertise.
A: Dobbs: Photogrammetry is important and I have not introduced it in this talk because it would be going into too much detail. The idea is that if you have enough controlled information in the picture or you take aerial photographs you can actually get measurements from the photographs.

Guidelines to Amateur Divers Working on Archaeological sites Reconnaisance and Excavation in water

MANAVI THAKKAR

Working in a three dimensional fluid environment where you are virtually weightless and often in low visibility but still expected to carry out a range of skilled tasks, can often get tricky. This paper outlines a few basic techniques such as search patterns in different water conditions, the use of simple natural navigation and recovery techniques. Rigging and lifting of objects with lift bags along, bouyancy calculations to provide a successful lift are literated. In archaeology it is important to emphasize that however scattered the contents of a site may appear the distribution is due to a logical sequence of events/forces that have acted on the material. It is also essential to know the relative positions of all objects. The need for good navigation and planned search activity and good communications are essential for a successful excavation.

INTRODUCTION

Ever since man first saw the sea he has been enthralled by it. He swam in it, he built boats, constructed ports from which to run foreign commerce. Eventually a large extent of his civilization revolved around the use of the sea. Today the most prosperous cities of the world are coastal cities. This great biomass of marine life feeds us. The endless reaches of the waves give us a cause to wonder. Yet in all this pre-history, we had no knowledge of what was below the thin layer of surface tension. Tidal waves, sea level rises and other natural phenomena devoured many a civilization and after man's attempts to breathe compressed air we are now in an age in which we can come in contact with the ocean floor and even explore our past. The paper is a series of facts that promote practical working knowledge and experience on search and recovery underwater.

DIVE PLANNING

Adequate dive planning involves two components
- Familiarization
- Assessment

Familiarization is collecting enough information about the diver and the dive site to make a valid assessment. For making an assessment you need to be familiar with your divers, their capacity, the dive site location and prevailing weather conditions. Dive site familiarity comes about with prior experience, on site orientation dives, making of maps with significant features above and below water including contours of underwater terrain. Entry and exit locations need to be marked and colour coded bouys which mark different locations, need to be put on so that relative positions can be plotted from land. Planning will probably allow a more controlled tour and enable efficient management and search in the event of an emergency. It would also develop general awareness and navigational skills.

Assessment of the environment i.e. factors that constitute acceptable conditions are relative and dependent on the experience level of the group. It is firstly essential to get weather information from TV, radio and newspapers. Most weather conditions are due to the interaction of warm and cool air masses which are affected by the earth's rotation. At the sea surface the pressure is 29.92 inches of mercury (1013.2 millibars). The variations in this pressure are due to cold air sinking and creating high pressure areas and the warm air rising to create a low pressure region. As pressure rises it is able to hold large amounts of invisible moisture and as the pressure decreases the air condenses into moisture, clouds and fog. The point here is that high pressure areas are settled weather zones and low pressure areas signal unsettled weather.

The onshore winds develop as a result of temperature/pressure imbalances. As the land heats faster than the sea the hot air rises and the cool air from the sea is pulled in. This sea breeze intensifies into the late afternoon. As the land begins to cool this sea breeze will drop and dissipate at night. This phenomena is important for dive planning in mornings when calm wind conditions are encountered. Diving should not be attempted until weather, tides, currents, sea state, and visibility are studied. Currents which usually affect divers are localized and caused by tidal exchange. As a general rule high tide yields the best visibility. On days when there is a great variation between high tide and low tide, logically speaking, on these days vast amounts of water are exchanged and the local current will be stronger. Tidal changes in bays can cause significant current problems and poor visibility. Sediment is stirred up by an outgoing tide.

The best visibility is at slack tide – high or low – or an incoming tide. At the same time never assume that the current will go only in one direction, this is particularly true with longshore currents which interact with major oceanic currents. Like on the East Coast of the U.S. the Gulf stream flows from South to North it might seem logical to assume that all currents on the East Coast flow in this direction at all times but this is not true because major oceanic currents are not the only cause of localized currents, in fact localized eddies can develop in the direction opposite to major currents. Local physical features will also affect all this when diving in currents and emphasize working together. Also major patterns of oceanic circulation interact with wind driven waves and are further altered by local conditions. If local guidance can be sought it would help plan for the unexpected. Always have a safety line at the stern, for an incoming diver, specially when there is a current.

Take a high observation point and watch the floatsum and boats at anchor to determine the relative strength and direction of the current. Also the direction of the sub-surface current can be inconsistent with surface currents. The divers can usually sight a maximum current of one and a half knots and that too for a short distance. Therefore, it is important that the current be used as an aid, specially towards the end of the dive. This is an important consideration in selecting entry and exit points. Also if, for instance, a diver is caught in a strong current he must not try and swim against it but maintain positive buoyancy and float with it till help is signalled.

Like a lot of people I consider visibility to be the single most important factor in dive planning.

The factors which affect visibility are
- Weather
- Seasonal variation
- Bottom composition
- Wave action or surge and currents
- Time of day
- Location

Each of the above basically affects the amount of suspended particulate matter in the water column and therefore, light penetration. Rain can stir up the bottom and if it is made of fine silt this will remain in suspension; therefore, hard packed gravel bottoms are usually more desirable. Also run off from rivers contribute high nutrient levels specially in cold waters which would result in plankton blooms. Thermal stratification of water brought about by changes in air temperature can also affect visibility. Usually the interval between 10.00 hours and 14.00 hours offers the best visibility because at higher incidence angles the sun's rays have more penetration; generally angles less than 48° tend to deflect most of the light thereby reducing penetration.

The final thing about dive planning is, be practical about logistical considerations for remote areas; such as transport,

Fig. 1

total self sufficiency and contingency emergency procedure and medical first aid. A planned expedition always has a greater chance of success.

COMMUNICATIONS

Good simple reliable communications save time and add to security. Line signals i.e. number of pulls on the line can convey the status of the recovery operation. Other hand signals are as illustrated.

Signals are usually performed in an exaggerated manner to prevent confusion and all signals must be acknowledged by the receiver to indicate that a signal has been received and understood.

Whistles are also used sometimes, they are reliable and effective limited range devices for surface signalling. A diving whistle should be non-corrosive and attached to the diver in a readily accessible way and used only in an emergency. Whistles work really well when there is a fog or at night when surface visibility gets limited. The big advantage of a whistle is that a considerable amount of noise can be generated with very little energy, and sound carries well over water. Five short blasts is the international distress signal.

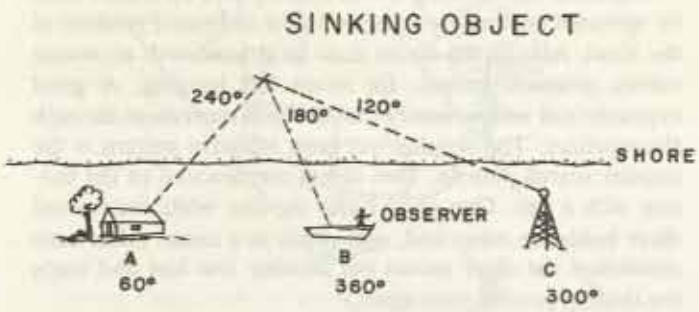

Fig. 2

Long range surface signalling devices are smoke emitters and flares. Flares and emitters don't light underwater but once they are lit they function well even if accidently submerged.

Surface signalling devices such as strobes, flares, smoke emitters or mirrors are recommended whenever divers are diving in currents that could sweep them past the intended point of exit.

Audible signals have limited use under water. Frequently a rap on the tank with a dive knife is used to get attention. This is usually the signal to say that a diver is surfacing. Underwater slates are the best means of communication. A simple ordinary lead pencil and slate fit into the BCD pocket or on a instrument console. This is the best way of recording and conveying information to a group.

Tactile signals such as line pulls are useful if previously agreed upon.

There is no doubt that the most sophisticated method of underwater communication is by means of electronic transmitters and receivers. These devices use radio waves and allow complete conversations to take place between divers. When precise communication is required there is no better alternative than actual voice communication. Such gadgets are expensive and usually need to be housed within a casing. Whatever your methods of communications are, agree on them before hand. Talk to your buddy who may be from a different geographical location as to what signifies what for the particular dive and please, keep it simple.

PINPOINTING LOST AND FOUND OBJECTS

Shore Triangulation

Look straight ahead at the sinking object then turn your back and find a permanent object directly in front of you. Run down 100 yards to another object repeat the above procedure call this object 'b'. Go back to 'a' plus 50 yards in the opposite directior to 'c' Preferably the objects chosen have a more distinct object behind them. Bearings are taken 'a' 'b' 'c'. The diver needs to swim out from 'a' until 'b' and 'c' are reached. This would be a bearing directly opposite from the one taken from the shore. Now with the known reciprocals the diver can swim directly out until two points on the shore cross. To double check when the diver sights over his compass along 120° and 240° the sunken object should be directly below him.

SEARCH PATTERNS AND NAVIGATION

Natural Navigation

It is important specially in a three dimensional fluid environment where you are weightless and in limited visibility references are seldom available and a certain amount of sensory deprivation also can contribute to disorientation. The use of natural surroundings for reference increases awareness and sense of direction. Proper navigation can avoid long surface swims, help buddies stay together and maintain a common course. Natural navigation techniques consist of

(i) Dive Patterns
(ii) Distance Estimation
(iii) Use of Natural References

Dive Patterns allow the diver the freedom to explore but at the same time enable him to maintain an awareness of relative position. The basic concept here is to roughly follow a general heading and make distinct right hand turns and remember where each turn places 'you' relative to the end of the dive destination.

Some common patterns that work most efficiently and are simple are out and back techniques, go down one side of a rock ledge formation, reef. Turn back towards the starting point after crossing to the other side of the formation.

Other dive patterns are as outline in Fig. 3. The triangle pattern at 120° turns is recommended only when a compass is used. It is important to discuss the dive patterns with your buddy; visualize them in your mind. After this it is alright to wander of course as long as you know where you are in relation to your course; otherwise find something that you can reference so that you can return to your course heading. It is also important to know your distances for relocating sites or searching. The natural way for doing this is watching tank pressure. Your tank pressure times your dive segments and will give you the air used. Basic physics relationships of time

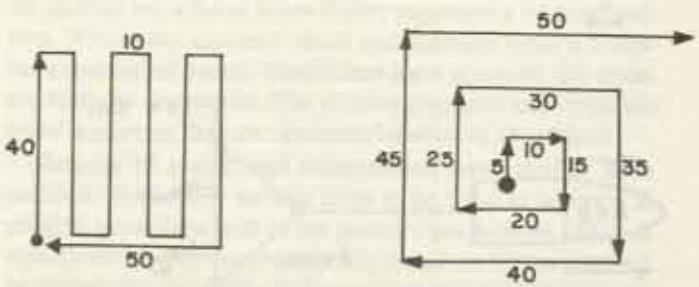

Fig. 3

distance and velocity (d = vt) can also be used. Counting kick cycles or arm spans is another basic method. As you move along it is important to note light shadows, the position of the sun at that time. Water movements surge. Surge intensity will always increase shorewards and surge is always perpendicular to the shore. If you watch sea fans they grow perpendicular to the current and sandollars are found parallel to the shoreline. Sand ripples which are a fascinating sight to watch are parallel to the shoreline. There is a lot of controversy how these are formed, basically it is from rip currents.

The divers begin their search pattern where the lost object is said to be. It is important to begin at a known point over a known area and end at a known point. The area must be marked by surface markers. They then begin swimming a series of U's either by timing each length or counting kick cycles. If time is used then usually I swim each leg of the pattern for 60 seconds. When counting kicks each leg is at least 40 kicks. The series of U's is also easier with a compass.

HOLDING ON TO A TOWED ANCHOR

One simple and efficient way of being towed underwater is simply to hold onto the flukes of the boats anchor. If the boat goes too fast there is a tendency for the anchor to float up, the diver would then have to swim it down. If the boat operator is a novice and goes too fast the anchor can be brought to the surface by inflating your BCD. If the boat moves too slow then the anchor will float along the bottom. If the boat moves faster than 2 knots it would be hard to keep your mask and regulator on. Sometimes it is easier to be towed by a line with a loop like shown below.

The U patterns mentioned earlier can be performed by the boat on the surface.

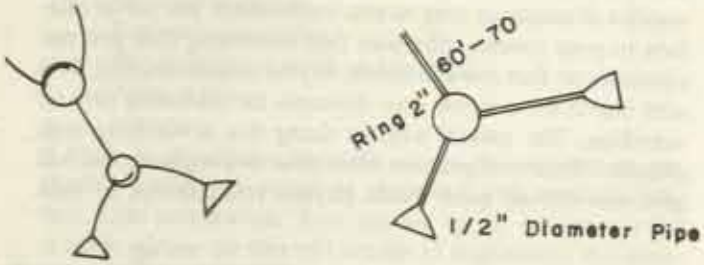

Fig. 4

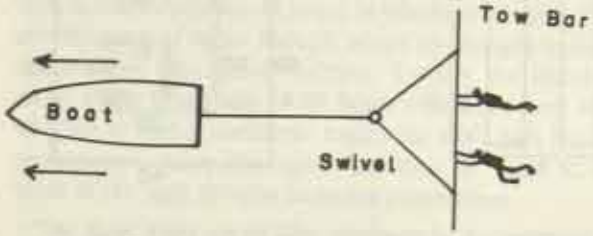

Fig. 5

Whenever one is being towed a safety pick up zodiac must be operated on a course adjacent to the estimated position of the trawl. Also all the divers must be streamlined, no rescue valves, pressure gauges, fin straps left hanging. A good exposure suit will be handy due to rapid movement through thermoclines. The simplest yet most effective pattern is the circular search pattern. Two divers can descend to the bottom with a line. One diver holds the line while the second diver holds the other end, and swims in a circle. After each revolution the diver moves out another few feet and starts the circling process over again.

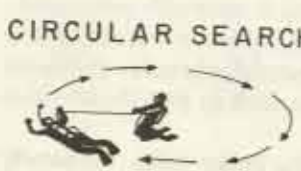

Fig. 6

Fig. 7

Sometimes it becomes necessary to control the search from the surface. Divers descend to depth and move out, all communications are through tugs.

In excessively murky water this could be modified to include a surface tender instead of surface divers. One diver is in direct contact with the shore by holding the line. The divers proceed towards the object; if they move away from the direction they are given a tug in the right direction from the surface tender.

BLACK WATER SEARCHES

In such waters the divers are diving blind and must rely on the tender and standby divers for guidance and safety. One must understand that divers are precision tools in the hands of a good tender. These tools never work needlessly and avoid being distracted by anything except what they are looking for. They never surface with items in hand. Hands are for stability and control.

Swinging Arc Pattern

Divers enter the water where the item is expected to be. The current is used in keeping the line taut. With the tender observing the divers' bubbles and watching the progress of the arc, he will turn the diver with a predetermined number of pulls. Some line is let out by the tender as the divers swim in the opposite direction. This procedure is repeated until the area is searched. If the item is located the divers give five

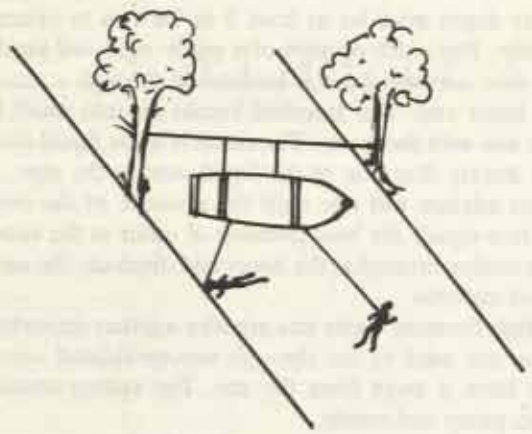

Fig. 8

tugs to signal this. The tender will allow slack so that a marker buoy can be attached. Sometimes a weighted bar is attached after the item is found so that the weighted bar can be used as a platform to achieve negative buoyancy.

A weighted line is used if the current is too strong; this allows negative buoyancy for the divers to stay on the bottom and move downstream at regulated rate. When the divers drift to the end of the line they signal and surface. The boat then transports them upstream to repeat the procedure.

ACOUSTIC SURVEYS AND PHASE MEASUREMENTS

This is a sophisticated method of underwater survey which is the direct equivalent of trilateration. In the simplest form three transponders are placed at known locations. They are interrogated regularly from within their established grid and the time delay for each response is measured and recorded. The velocity of sound in seawater is known accurately once temperature and salinity are measured. The time delays for the three responses are related to the distance between the interrogator and transponders by the formula (Dist = vel × time). The interrogator gets a digital readout of the time delay. If the geodetic location is not important and only the relative position and motion within a site are to be measured, the acoustic grid is appropriate.

Phase Survey Measurement can be used when the area to be surveyed is large. Three receiving elements are precisely located on the underside of the craft. A diver places a transponder on the object where position is to be determined and an interrogator is located on the ship which queries the transponder. A phase analysis is performed on the receiver which displays as a deflection angle and line of range sight to the object with respect to the receiver element... Small transponders, if strapped to the divers tank, can also continuously monitor his position. If continuous communication is available the diver can be directed through a survey pattern that can be geodetically fixed knowing the ships position.

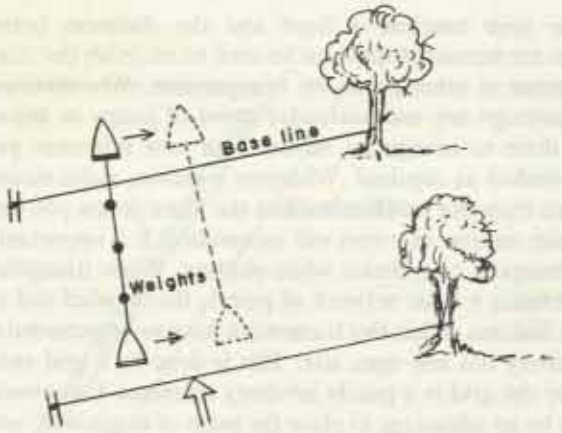

Fig. 9

These sophisticated survey patterns are obviously an indication of the strong interaction that is needed between marine engineers and archaeologists. The field of underwater bottom surveys and recording is moving into a technological era of sophistication and accuracy.

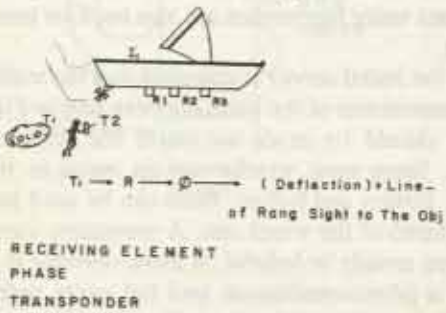

Fig. 10

EXCAVATION AND RECOVERY TECHNIQUES

Excavation is not just the process of recovering objects but deducing facts have to be seen in context with the environmental matrix and their association with neighbouring finds and existing facts. Recording during an excavation is important. Every detail, however trivial it may seem, could be a part of the puzzle. However scattered and random the sequence of events/objects may seem, unless these distributions are plotted we will not know if they represent a relevant pattern. Within the apparent chaos and disorder there is a logical sequence of events /forces that have acted on the material since its deposition. The relative positions and strata are more important than the absolute location of the objects.

Methods of search and triangulation have already been outlined. A baseline termini need to be fixed as securely as possible since these will be the primary points from which all subsequent site measurements will be taken. Often climbers or pistons are fixed into rock outcrops with Self locking eye bolts. In muddy bottoms steel rods are used and secured with ballast. The design of the baseline should be at least 10 m

Once your baseline is fixed and the distances between them are measured they can be used to establish the relative positions of other points by triangulation. Whenever rocks or outcrops are encountered a series of jumps or bypasses are done to triangulate further with new reference points established as required. Wherever possible, make measurements from the baseline because the more jumps you have a greater number of errors will accumulate. It is important not to transpose co-ordinate while plotting. While triangulation establishes a basic network of points, the detailed and complex features within this framework have to be recorded on a relatively flat and open site. This is done by a grid system. Since the grid is a purely arbitrary reference framework, it may be an advantage to place the point of origin well outside and below the actual origin of the grid, this allows possible extensions in these directions. Unless the site is flat, slopes and fissures need to be accounted for. If the slope is nearly flat ignore it and introduce corrective factors later. Sometimes rough levels can be taken using a depth gauge which has been calibrated against a suitably measured shot line. Levels are taken at a depth below mean low water tide. Sometimes water barometers are also used for more accurate levelling.

Once the initial survey is complete and the visible features and characteristics of the site have been mapped in detail, an attempt should be made to locate the extent of buried deposits. Since most wrecks contain metal in the form of fastners, fittings and ballast, these can be used to locate the general trend of the wreck site. A systematic metal detector survey can usually be helpful. A metal detector is good when used as a prereconnaissance tool but every detected piece must not be dug out haphazardly without an assessment. Probing can of course damage buried objects. Surveys with probes must be carried out systematically with soundings made at fixed intervals. The advantage is that probing can often delineate large objects. Core sampling is a useful technique for obtaining stratified samples for analysis.

Excavation Tools

Excavation tools must perform two main functions.

(i) provide a means whereby archaeological deposits are revealed.

(ii) dump the spoil in a suitable damp area so that it will not spill back into the excavation site or further areas to be excavated. The best method is fanning sediment with one's hand; however, when it comes to transporting spoil by hand even the most vigorous fanning will not work. A suction pipe is needed. The water dredge provides light effective suction. The dredge is not used to dig directly into deposits but rather as a receptacle into which spill can be fed in. Care should be taken so that it has sufficient water to breathe. A much heavier excavation tool is the airlift. The water depth must be at least 8 m for this to operate efficiently. The airlift consists of a partly rigid and partly flexible tube into which air is introduced through a manifold at the lower end. The manifold breaks air into small bubbles that mix with the water. The result is a gas liquid mixture of less density than that of the liquid outside the pipe. The air water mixture will rise until the pressure of the column of mixture equals the base pressure of water at the same level. The suction created at the lower end displaces the unconsolidated material.

High Pressure water jets are also another important tool; these are used to cut through unconsolidated overburden and force it away from the site. The system consists of a hose, pump and nozzle.

Recovery procedures are outlined in the buoyancy discussion but it is important to bag small finds. Large objects are stored in boxes individually with a label. Before extraction is attempted a suitable transfer container must be prepared.

Buoyancy

There are several methods of providing buoyancy to raise sunken objects ranging from the historical method of displacing water with air, either by filling the object with air held in a container or the filling of a vessel with plastic foam. The choice of method depends on several factors.

1. Location of the sunken objects, its attitude on the sea bed.
2. Identification of the object. In the case of a ship, the available plans can give an indication of the capacity fixtures, displacement weight and the centre of gravity.
3. Depth of water will give you an idea of bottom time and the amount of air needed to provide buoyancy.
4. Nature of the sea bed, its load bearing capacity, if the wreck has sunk, the contact area to the bottom and breakout force needed.
5. Sediment cover to be cleaned by necessary airlifting operations.
6. Structural integrity of the structure; whether its condition is compatible with the chosen method of lift.
7. Attachment points and their structural integrity.
8. Material of which the object is constructed and extent of biofouling on it.
9. A complete plan of action along with feasibility and availability of water communication.
10. Safety of divers in the area.
11. Tidal information and sea state.
12. Laws relating to the wreck, and arrangements for storing as well as disposing of the object when it is at the surface.

Salt water weighs 64 lb/ft^3

Fresh water weighs 62.37 lb/ft^3

Air weighs so little compared to an equal volume of water that it lifts virtually the same as it displaces.

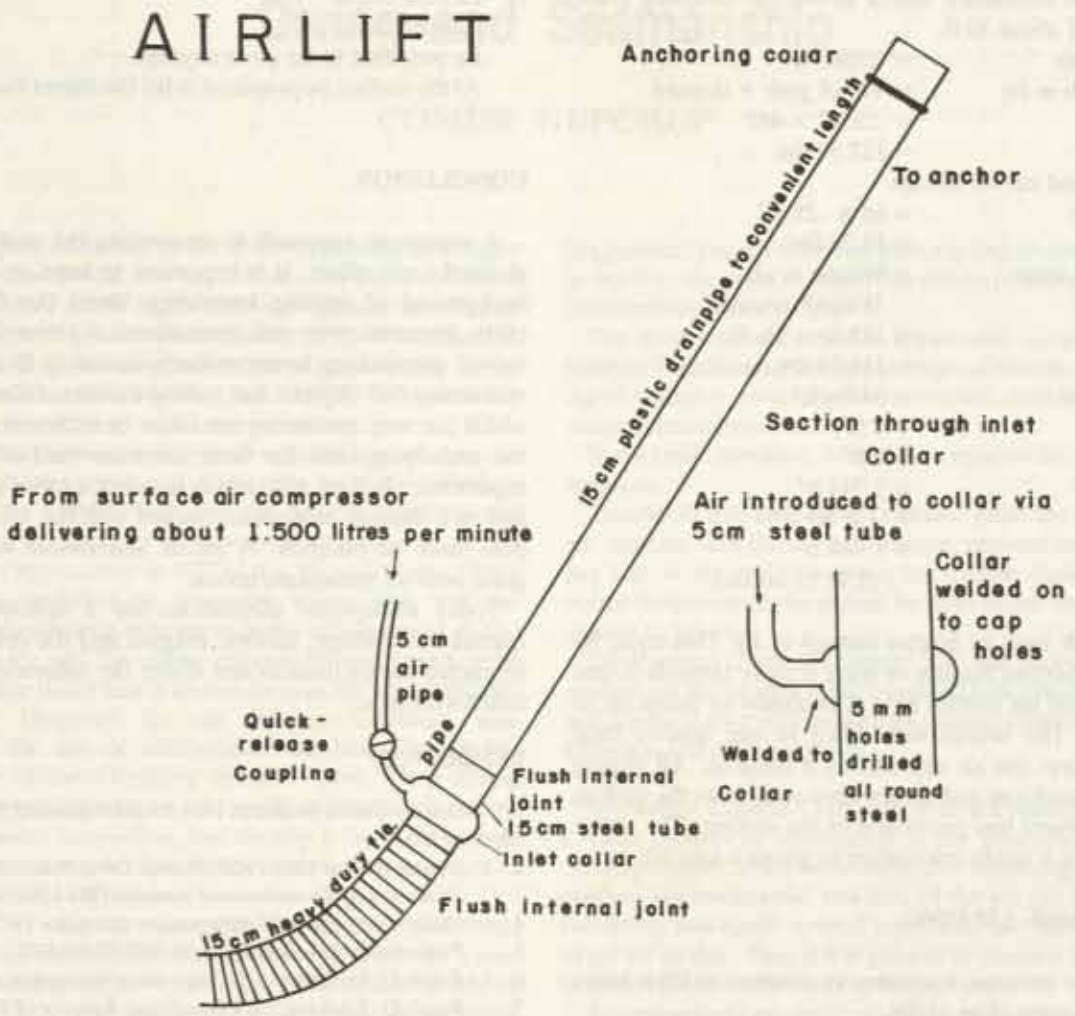

Fig. 11

As we all know that when we get into the water we weigh less, equipment that was once bulky and unrealistically heavy is suddenly maneuverable. The diver himself will loose almost 100% of his weight in water because the body's density is nearly the same as that of water. Then why is it that the lead weight this diver carries is still heavy and helps him sink? Lead does not become significantly lighter underwater because it is very dense (708 lb/ft^3).

d = mass/vol

so mass = density × volume

Sunken objects are lifted off the bottom in many ways depending on sizes, weight and floatation capability.

Common methods are:

1. Lifting with a floating crane, or from salvage pontoons equipped with multiple winches: This method would require straps to be passed on either side of the object.
2. Air lift bags (see fig. Dive maker) which would then be inflated under water. Variations of this may be to place airbags within the structure or secure submersible salvage pontoons alongside the object which would then be pumped with air from the surface.
3. Sometimes the main compartments are pumped with a light floating material like 'Syntactic foam'. 'Eccofloat' is also used; it consists of hollow epoxy fiberglass spheres.

LIFTING CALCULATIONS

Archimedes principle is the backbone for salvage operations but theoretical figures on paper do not always reflect what happens in the field. On a research expedition off the Bahamas the following points had to be taken note of:

Location 26°57'N 76°06'W
Memory rock in the Bahamas
Boat anchor is set in hard rock
Steel = 485 lb/ft^3

Object thrown overboard was a geological sampling grab, water depth of about 30 ft.

Volume of grab	= .25567 ft^3
Weight of grab in air	= Vol of grab × density
	= .25567 × 485
	= 123.99 lbs
Due to slots and curves 128 lbs	
Bouyant force	= 64 × .25567
	= 16.36 lbs.
Wt. of grab in water	= Weight in air – Weight in water
	= 128 lbs – 16.36
	= 111.64 lbs.
Density of S.W.	= 64 lbs/ft^3
64 lbs	= 1 ft^3
111.6 lbs	= ? ft^3
	= 1.744 ft^3
1 bottle	= .135 ft^3
? bottles	= 1.744 ft^3
	12.91 13 bottles

The final lift took 14 bottles instead of 13. This could be attributed to bottom friction or what is more tangible is that the open ended list bottles have a tendency to dump air as they surface. The bottles were filled to one quarter their capacity because the air expands as it surfaces. All rigging was in good condition and divers were away from the grab as it rose. The object was controlled at the surface. The above calculation was a safety calculation to gauge a safe lift.

RIGGING AND LIFTING

a) Never use personal buoyancy as a means to lift a heavy objective more than 15 lbs.
b) When using a lift bag be sure the size is appropriate for the object.
c) Be prepared to secure the bag to the object.
d) Test Rigging before inflation.
e) Inflate the bag
   i) Use alternate air source.
   ii) Be careful not to entangle the regulator in the rigging.
   iii) Add a little air at a time.
   iv) Be prepared to expel air from the bag at any time.
f) Lift the object
   Remain clear.
   Be prepared to let go at anytime.
   At the surface be prepared to lift the object from water.

CONCLUSION

A systematic approach to uncovering the past requires a planned team effort. It is important to have as complete a background of existing knowledge about the find, plans, plots, previous trails and excavations; a trained team, and lots of painstaking hours towards deducing facts, not just recovering the 'objects' but testing the site. Often decisions which are very instinctive are taken in archaeology, though the underlying basis for these are from hard evidence and experience. Before any action is taken proper precautions and well thought procedures backed with the necessary support must be outlined. A lot of underwater work entails good positive immediate action.

Today underwater excavations are a delicate blend of marine archaeology, history, religion and the determination to pursue the excitement and revive the memories that haye faded with time.

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ACKNOWLEDGEMENTS

I would like to acknowledge PADI for Fig.2 and Fig.4 through 9 taken from their *search and Recovery*. And Fig.1 and Fig.3 from the *open water Dive Manual*. A special thanks to SUBMEX For Fig.10 and 11.

Diving and Seamanship

COMDR GUPCHUP

1. History gives no record of the date when diving first began or who the first divers may have been, but there are many records of man's effort to breathe and operate underwater and of diving having taken place, mainly in naval warefare, as early as 400 B.C. It is recorded that Alexander the Great descended in some form of diving bell in 333 B.C. Most of this diving was carried out without special equipment. What equipment there was consisted of a breathing tube to the diver's mouth, the upper end of the tube being supported on the surface by a float. Not until the Middle ages was any attempt made to supply air to a man over a century old, beginning with the appearance in 1837 of the 'Closed' Diving Dress and Helmet invented by Augustus Siebe. This was the greatest single advance ever made in the development of diving equipment, and this dress, essentially unchanged, is in world-wide use today and is known to us as the Standard Diving Dress. However, it was Jacques Cousteau who popularised the use of selfcontained air breathing by the introduction of the Cousteau demand valve. Deep diving employing breathing mixture of oxygen and helium is a comparatively recent innovation, but already it has been proved that man can live and work in depths considerably in excess of 400 metres for days at a time.

2. Diving is not a straight forward engineering, mathematices, or a branch of medicine. It is basically a seamanship evolution helped by all these fields of science and in our efforts to go to deeper depths for larger periods we would be wrong if we do not consider the most important factor, the diver himself, that man at the end of a rope or air pipe, on the bottom of the sea, feeling all alone and cold. Without his courage, dedication and determination we would all be wasting our time.

3. The effects of diving on the human body are caused by the operation of certain physical laws, in particular the physical properties possessed by liquids and gases. The human body underwater is operating in a completely different environment, in which it is exposed to much greater pressures than it experiences at the surface. It is necessary, therefore, to consider carefully the meanings of the terms force, pressure and density as applied to liquids and gases. Some of the factors affecting divers are listed below:

(a) *Oxygen Poisoning.* This is brought on by breathing oxygen at too high a pressure. The exact cause is not known, but is thought to be the intoxication of the breathing centres of the brain. The symptoms are unreliable and the on set varies both from individual to individual and from day to day. It generally occurs at any depth where oxygen has a partial pressure greater than two bars abs and so diving is limited in depth to the point at which this occurs (depending upon the mixture being breathed).

The most frequent order of appearance of symptoms is as follows: Twitching of the lips, vertigo, dizziness, nauses (feeling of sickness); twitching of extremities; drowsiness; convulsions; unconsciousness.

Some times however, convulsions may be the one and only symptom.

Treatment is to reduce the pressure, place the diver in fresh air, restrain him during convulsions, prevent self injury and gag him to prevent him biting his tongue. Loss of memory occurs frequently so he should be kept under observation for at least 12 hours.

(b) *Hypoxia (Lack of Oxygen)* This will occur if the partial pressure of the oxygen being breathed falls below 0.2 bars abs and is nearly always caused by an excess of nitrogen; it is then known as Dilution Hypoxia.

(c) *Carbon Dioxide* Carbon dioxide is a poisonous gas. It is a waste product of combustion in the production of energy and its presence in the body stimulates breathing. A diver will produce approximately, one litre of the gas per minute while swimming and under normal conditions the body is well able to get rid of this. Thus if it is present in excess it is always due to some failure of the diver or his equipment.

At atmospheric pressure, up to about 3% of carbon dioxide can be breathed with no effect on the body. As the percentage is increased, the stimulation of the respiratory centres of the brain increases, resulting in an increased pulse rate and heavier breathing. At about 0-1 bars abs the pulse rate slows down and the blood pressure drops. Resulting in unconsciousness and, in extreme cases death. Thus the onset of carbon dioxide poisoning can be recognised by the increased breathing rate followed by breathlessness and exhaustion. On return to fresh air the symptoms soon disappear however, the person may experience head aches; may also vomit for a while.

(d) Carbon Monoxide Under normal conditions, this gas will not be present in any breathing apparatus. It is produced mainly in the internal combustion engines and forms part of the exhause gas. The two most likely sources of it that concern the diver are a ship's engine and the air compressor itself. Thus care must be taken on the siting of the compressor's fresh air inlet with regard to the exhaust outlet. Also, although the inlet may not actually be near the exhaust fumes, the wind may blow some carbon monoxide into it. Thus 0-00001 bars abs is taken as the upper safety limit.

Carbon monoxide when inhaled combines with the haemoglobin in blood to form carboxy-haemoglobin, which is pink in colour and restricts the intake of oxygen into the bloodstream.

The onset of carbon-monoxide poisoning gives rise to the following symptoms; increasing weakness; exhaustion with breathlessness; dizziness; fainting; general pallor but with a noticeable pink tongue.

Immediate treatment is required and consists of administering oxygen at a partial pressure of two bars abs, artificial respiration if the diver is unconscious and the attention of a medical officer as soon as possible.

(e) Hyperventilation. Divers without breathing apparatus are known to practise hyperventilation to increase their endurance underwater; it is done by taking rapid deep breaths for a short period immediately before entering the water. This method doesnot, however, increase the oxygen content of the body as supposed but merely reduces the level of carbon dioxide; the result is a delay in the stimulation of the respiratory centres of the brain, which produces the impulse to seek more air.

The diver, because of the pressure he then experiences, uses up much more of the oxygen in his lungs, and when the carbon dioxide eventually builds up sufficiently to force him to surface the oxygen drops and the diver is likely to suffer hypoxia, followed by loss of consciousness and drowning.

Thus the practice of hyperventilation in an attempt to increase endurance cannot be recommended.

(f) Nitrogen Narcosis When a diver descends using air, at about 30 to 50 metres he starts to experience nitrogen narcosis; this is thought to be due to the absorption of nitrogen into the cells of the central nervous system.

The initial effect is a feeling of light headedness with increasing self confidence. As depth is increased the diver will become more jovial, will have dizzy spells and his power of concentration will drop; he will not be able to do simple tasks and will pay less attention to personal safety. At about 80 metres he will probably go into a state of depression and will be incapable of clear thought.

These effects are very similar to those of alcohol and the taking of the latter just previous to diving will increase the effect and the onset of the narcosis will occur at shallower depth. Another predisposing factor is the condition of the diver; for instance, anxiety may bring on the narcosis much earlier.

The only method of prevention is by continued practice, i.e. continual deep diving, so that the diver becomes accustomed to narcosis and remains in control of himself.

SALVAGE

1. There can be no doubt that the success or failure of a salvage operation in which underwater operations are to play an important part is very largely dependent upon the ability, intelligence and integrity of the divers. The salvage diver must always bear in mind that he is the 'eyes' of the salvage officer and that upon his accurate reporting of underwater damage etc. will depend to a very large extent the method the Salvage Officer will adopt in planning the operation. Too much emphasis cannot be given to the fact that accurate, concise and unembellished information is required from the diver.

2. Since most of the work will depend on his skilful use of slings, straps, shackles etc., it is essential that the salvage diver be a sound, practical seaman of considerable experience. He must be well versed in the use of all underwater tools, such as the Temple Cox Bolt Gun, underwater welding and cutting gear, pneumatic drills, saws, hammers, etc., also in the use of demolition explosives.

WRECK LOCATION AND MARKING

3. In deeper waters, and where underwater visibility is suitable, the use of underwater television cameras may be considered. The cameras may then also be used for a preliminary survey of the wreck.

4. When the wreck has been located, a Datum Mark Buoy should be secured, to a prominent part of the ship structure, where the mooring wire will not chafe. To guard against the possibility of the buoy being lost, the position of this datum should, if possible, be fixed by shore marks, two transits being the simplest and most sure form of fix. At times the Marker buoys cut. To overcome this, and in the event of a valuable underwater object being located underwater locator beacons are utilised so as to assist subsequent location by divers.

PROCEDURE

5. The diver should see that no detail is overlooked, and, as he proceeds, he should mark the wreck structure by the most convenient method. This procedure is preferable to marking with pellets, which are liable to foul and to be lost. In the same way, he will need to mark any point at which he ascends so that upon resumption he can pick up the survey where he left off. Any damage discovered is assessed and reported over the intercom system to the Salvage Officer, who will record the information received. Any attempt by the diver to memorise this data and to report on surfacing should be discouraged, although, when the diver has returned to surface and has had time to collect his thoughts, he may be asked to enlarge upon any particular point in the survey. Any further detail that the Salvage officer may then require can be made the object of the diver's next visit to the wreck.

METHODS OF REPORTING DAMAGE

6. If a diver is to report on the condition of a ship, he must know how to name all the various parts of the structure which together form a ship, and since a ship consists of steel plates inter-connected by steel structurals, it is not sufficient to report damage to a particular area of plating. For the Salvage Officer to fully grasp the extent of damage and its location in the ship, the name of the particular area of plating and its

structural connection must be given relative to some easily defined portion of the ship.

AIR LIFT

7. The air lift is used to remove the material excavated and prevent silting up of the excavations. In its simplest form, an air lift consists of a pipe immersed in water, into which compressed air is introduced at its lower end. The air rising up the pipe expands rapidly as the pressure decreases and so displaces the water, carrying it up and out at the top end. Thus a flow of water is set up in the pipe and loose material is carried in suspension with the flow and discharged on the surface. It must be emphasised that only loose material will be removed and an air lift alone will not dig except in fluid mud or very soft sand. For efficient use, it must be fed by the diver. Air lifts of sizes varying from 100 to 450 mm are employed on tunnelling, silt removal and bulk cargo recovery.

BEHAVIOURAL PATTERN OF SHARKS

1. Whilst diving in shark infested areas alongwith the Calypso divers, the following general behavioural patterns of sharks were learnt from experience by our naval divers.

(a) Sharks are the scavangers of the ocean. They eat the fish that are sick or are in disstress. The shark recognises such fish by the splashes or underwater shock waves created by them. A diver swimming on surface creates splashes and simulates a fish that is sick or is in distress and hence attracts sharks in the vicinity. In such eventuality when the shark approaches the diver should either climb into the boat/Gemini immediately or if the boat/Gemini is not nearby then the diver should hold his breath and go below the surface of the water to face the shark and look at it. There is bright chance that the shark will inquisitively look at the diver and then go away.

(b) While swimming/snorkling on surface, one should be very close to the Gemini (holding it with one hand) as the sharks are timid by nature and they avoid all foreign objects.

(c) when a diver plunges into the water and if sharks are already in the closeby waters they will rush towards the diver at their maximum speed and stop 2 to 3 meters away from the diver. One should not panic at this juncture and should stay underwater for some more time and look towards the shark. The shark will retreat from that area after observing the diver.

(d) While diving in shark infested areas cage should always be lowered with an additional diving set and push rod (a rubber tipped aluminium rod) inside it. The diver should also carry a push rod alongwith him. When the shark comes too close to the diver inquisitiely, he should be pushed back with the push rod. Never attack them with knife as bleeding them will attract other sharks in the vicinity.

(e) The shark generally circles a diver when he is under water, first in larger circles and then in smaller circles. At times they become very inquisitive and want to see the diver who is not a normal inhabitant for them. If it comes too close, the shark should be pushed with push rod. Before attacking a shark generally gives one or two brushes to the diver with his body. When these brushing advances of the shark start, the diver should enter the cage or slowly go away from that area keeping a continues watch on the shark. This happens also when a shark feels that the object is a competetion for food.

(e) The sharks have their own territories. Some sharks do not like intruders. So when a diver happens to intrude into their territory they put their side fins down and come towards the diver, in order to show that it does not like the intruders. In such an eventuality the diver should slowly retreat from that area while keeping a watch on the movements of the shark. The shark will make advances which will indicate that it is trying to catch/hold the extreme portion of the diver, i.e., the fins, till the diver is out of its territory.

(f) The baby sharks are not reliable. They are like small puppies on land and like to nibble at anything playfully that is near them or new to them. Since they have immense power compared to divers, they should be pushed away if they come close, lest they hurt the diver.

(g) One should never corner the reef shark as it can become aggressive in order to protect itself.

(h) Diving in open and deep waters with sharks is dangerous as one encounters bigger sharks much larger then the size of the diver himself. The diver then becomes the size of food/prey of bigger sharks. Also the sharks in deep ocean some time remain hungry for days together, say 7 to 15 days at a stretch and they eat anything that they encounter. So while diving in such waters one should dive with the cage and remain inside it or if outside the cage then the back of the diver should be resting on the cage in order to watch the shark in a better way, or two divers should dive with back to back next to the cage.

(j) While diving near reefs the divers should dive back to back or their back should be against the reef in order to have a good watch on the shark. The reef sharks are generally smaller in size say upto 3 meters. The diver with his fins is generally of 2 meters and does not pose as a prey/food for them. Hence it is quite safe.

(l) One should not throw anything overboard during the time that the divers are down as this would attract sharks.

Section 8

Conservation and Dating of Underwater Archaeological Objects

Section 8

Conservation and Dating of Underwater Archaeological Objects

The Saga of the Shipworms in early Navigation

L.N. SANTHAKUMARAN

Shipworms as destroyers of timber, par excellence, in the marine environment are well-known from very ancient times. They attacked the wooden hulls of ships in such intensity that the weakened bottom planks broke up even due to a mild impact caused by hitting on a rock or any floating objects. This leads to catastrophic leaks resulting in the ultimate disappearance of the ship even in comparatively calm seas.

The paper presents an account of the unhappy encounters between early navigators and marine wood-borers and some interesting anecdotes, compiled from a survey of literature up to the nineteenth century. As many as 17 references have been cited. The seriousness with which early mariners faced the problem of biodeterioration and the scare the wood-borers created in their minds have been brought to light, with, in some cases, excerpts from their journals and books. The instances referred to are, among others, the voyages of Christopher Columbus, Sir Richard Hawkins, Sir Francis Drake, Francois Cauche, Dampier and Captain James Cook. The anxiety and concern for protecting the ships from the ravages of wood-borers and for their own safety, as evidenced from their accounts, are discussed. Based on the information gathered from recorded history, it is suggested that marine borers were instrumental in inducing early ship-wrecks, thereby enriching the materials for marine archaeological excavations and studies.

INTRODUCTION

The marine wood-borers of the molluscan families Teredinidae and Pholadidae and the crustacean families Sphaeromatidae and Limnoriidae, bring about rapid destruction of timber used for various marine structures. Known to them as 'shipworms' or 'broma', all the ancient navigators had invariably a taste of the ruthless destruction caused by these borers to the hulls of their wooden boats. The mariners were well aware of this hidden danger lurking in the underwater portions of their boats and they shuddered at the very thought of these organisms. Recorded history of early navigations is full of instances of unpleasant encounters between the mariners and the marine wood-borers. More often than not, the borer-ravaged bottom planks of the boats broke up even due to a mild impact caused by hitting on a rock or any floating objects. This leads to catastrophic leaks resulting in the ultimate disappearance of the ship even in comparatively calm seas.

In this paper an attempt has been made to compile information from literature upto the nineteenth century on the role played by marine wood-borers in causing ancient shipwrecks. The seriousness with which early sailors faced the problem of biodeterioration and the scare the wood-borers created in their minds have been brought to light with, in some cases, excerpts from their journals.

MARINE BORER HAZARDS DURING ANCIENT MARITIME ACTIVITIES

The injurious marine organisms were known even in the Roman times as evidenced by the following verse of the poet Ovidius Naso (43 BC-17 AD): "Estur ut occulta vitiata teredine navis" (= "For as the ship by hidden shipworms spoiled") (Cnippingius, 1670) and Pliny, the Elder (23-79AD) wondered and wrote "What teeth, too, has she inserted in the teredo, to adapt it for piercing oak even with a sound which fully attests their destructive power! while at the same time she has made wood its principal nutriment... The followers of Alexander, the Great, have left a statement that, at Tylos, an island in the Red Sea, there are trees, of which ships are built, the wood of which has been found uninjured at the end of two hundred years, even if it has been underwater all that time..." (Vol. 3 of 1855 edition by H.T. Riley).

In his letter to the King and Queen of Spain, written from Jamaica on 7.7.1503, Columbus describes the havoc caused to his ships by marine borers. "On the last day of April, 1503, we left Veragua (Province of Panama), with three ships, intending to make our passage homeward to Spain, but as the ships were all pierced and eaten by the teredo, we could not keep them above water; we abandoned one of them after we had proceeded thirty leagues, the two which remained were even in a worse condition than that, so that all the hands were not sufficient with the use of pumps and kettles and pans to draw off water that came through the holes made by the worms. In this state with the utmost toil and danger we sailed for thirty five days, thinking to reach Spain, and at the end of this time we arrived at the lowest point of the island of Cuba...." (Major, 1847). Bishop (1913) states that "of the four caravels of Christopher Columbus on his fourth voyage (1503), the "Gallego" and "Biscaena"

were left behind at Puerto Bello (Portobello, Panama, on Carribean), the remaining two "Capitana" and "Santiago de Palos", bored through and through by the teredo, proceeded to Jamaica". In fact, the borers were so popular in the early sixteenth century that they were ignorantly connected with the generation of geese. It was believed that when wood is exposed in the sea, "many worms generate in it and finally develop into geese with wings and feathers" (Boece, 1527). Oviedo Y. Valdas (1547) states that "Shipworms (broma) generate in wood... and honeycomb the planks so that they become like a sponge and do not hold water".

According to the work of Roger of Hovenden, translated to English by Riley (1853), the ships belonging to King Richard I of England were badly mauled by marine wood-borers during the third Crusade when he met King Philippe II of France at Messina, Sicily in 1190. "The King of England in the meantime, while he was staying at Messina caused all the ships of his fleet to be hauled ashore and repaired, as many of them had become damaged in consequence of being eaten away by worms. For in the river Del Faro there are certain thin worms, which in the language of the people are called 'Boem', whose food is every kind of wood. Whenever these have once adhered to any kind of wood, they never leave go thereof, except through main force, until they have, pierced right through; they make narrow straight holes when they have effected an entrance, and then from gnawing away the wood become so increased in size and bulk, that in coming forth they make wider holes" (Page 173-174, Riley, 1853).

Another instance of considering marine borers a real danger is available in Adams (1599). While narrating an early voyage to Russia, it is stated that ".... for the merchants, they get very strong and well seasoned plankes for the building, the Shippewrights, they with daily trauaile, and their greatest skill doe fitte them for the dispatch of the shippes: They calke them, pitch them and among the rest, they make one most stanch and firme, by an excellent and ingenious inuention. For they had heard that in certaine parts of the ocean, a kinde of wormes is bredde, which many times pearceth and eatheth through the strongest oake that is: and therefore that the mariners, and the rest to be imployed in this voyage might be free and safe from this danger, they couer a piece of the keele of the shippe with thinne sheetes of leade..." (Page 270-271 of the 1809 edition).

While discussing the destructiveness of the "arters" (shipworms) on his ship, Sir Richard Hawkins (1622) writes that "...we found her all under water covered with these wormes, as bigge as the little finger of a man, on the outside of the planke... In little time, if the shippe be not sheathed, they put all in hazard... most of their plankes under water have beene like honey combes..." (P. 119-120 of the 1987 edition). According to Moffett (1634), Francis Drake's ship "Golden Hind", when returned to London in 1581, after the voyage around the world, had been rotten and spongy due to attack by teredo.

Perhaps the maximum number of shipwrecks in one single incident, with marine wood-borers as the main culprits occurred during the debacle of the Spanish Armada in 1588 at the hands of the British Navy. By the time the mighty Spanish warships reached the English Channel, they had been rendered 'unseaworthy' by the wood-borers and eventually sank as wrecks (Bitz, 1967). After this defeat, the naval power of Spain was so much crippled that in 1590 the King had to order his merchant ships to winter in the West Indies for fear of further assaults from the British Navy. But when the Spanish ships attempted to return in late summer of 1591, nearly a hundred of them have already been converted into wrecks on account of intense borer damage and sank to the sea bottom (Monson, 1682).

In the journal of Robert Boners, Master of the "Dragon", about this voyage to the East Indies in 1611-1614, it is mentioned that "I doe thinke that the Gulfe of Cambaya is the worst place in all the Indies for wormes, and therefore the ships which goe for Surat must have good provision". (Purchas, 1625) (Gulfe of Cambaya is Gulf of Cambay). Similarly, in Captain Walter Payton's journal on his second voyage to the East Indies, in 1614, it is remarked that "The double sheathing of ships which goe to Surat is of great purpose: for though the outermost sheathing be eaten like a honey combe with wormes, yet the inner is not perished. It were also requisite that the Rudders were sheathed with thinne copper, to prevent the wormes eating off the edges thereof...." (Purchas, 1625).

In the description of William Dampier's voyage around the world (1679-1691), one can see yet another example of how the borers had terrorised the early navigators. On his experience at Mindanao (S. Philippine islands) he writes "About the middle of November we began to work on our ships bottom, which we found very much eaten with the worms: for this is a horrid place for worms. We did not know this till after we had been in the River a month, and then we found our Canoas bottoms eaten like honey combs; our Bark, which was a simple bottom, was eaten through, so that she could not swim. But our ship was sheathed, and the worm came no further than the Hair between the sheathing plank and the main plank.... We were told that in this place where we now lay, a Dutch ship was eaten up in 2 months time... We had no worms until we came to this place..... The Mindanayans were so sensible of these destructive insects, that whenever they come from sea, they immediately hale their ship into a dry dock, and burn her bottom and there let her lye dry till they are ready to go to sea again" (Page 362-363 of the 1698 edition).

In his "essay on the marine of the ancients, particularly on their warships", Deslandes (1768) has mentioned that the ship belonging to Francois Cauche during his voyage from France to Madagascar (Indian Ocean), was attacked by worms and was made unseaworthy. Count D'Estrees lost 6 of his 9 ships on a voyage from Brest (W. France) to

Curacao (West Indies) and the remaining three returned with heavy worm attack. Similar accounts on problem of biodeterioration are available in Captain James Cook's journal of his voyage in the *"Endeavour"*. A literal transcription of the original manuscript was brought out by Wharton (1893). The following citations will show how the borers with their depredations kept the Captain and his crew preoccupied. "May 24, 1769, at Otaheite. Having found the long boat leakey for these few days past, we hauld her ashore today to stop the leakes, when, to our great surprise, we found her bottom so much eaten by the Worms that it was necessary to give her a new one, and all the carpenters were immediately set to work upon her" (P. 74). June 25, 1770, Queensland, Australia: Having run aground on a coral reef, the bottom of the *"Endeavour"* was so damaged that some of the sheathing was stripped off. This alone will be sufficient to let the worm into her bottom, which may prove of bad consequence" (P. 281). November 9, 1770, at Batavia:.... and found her bottom to be in a far worse condition than we expected, the false kiel was gone to within 20 feet of the sternpost, the main kiel wounded in many places very considerably, a great quantity of sheathing off, and several planks much damaged, especially under the main channel near the kiel where 2 planks and $^1/_2$ near 6 feet in length; were within $^1/_8$ of an inch of being cut through; and here the worms had made their way quite into the timbers, so that it was a matter of surprise to every one who saw her bottom how we had kept her above water, and yet in this condition we had sailed some hundreds of Leagues, in as dangerous a Navigation as in any part of the world, happy in being ignorant of the continual danger we were in" (page 359). The sheathing given to *"Endeavour"* is probably of wood.

Narrating his experience in the examination of ships in the Dockyard of Plymouth, England, Willcox (1827) reports that His Majesty's Ship *"Scepter,* after leaving Bombay, India, for England in 1807, was obliged to return on account of a serious leak caused by teredo attack in a place where the copper sheathing had been damaged." This ship was constructed of teak. The leak would have proved disastrous had it been developed in mid-ocean. Seymour (1855) remarks that "no Russian ship in the Black sea lasts more than ten years not only on account of the bad wood of which it is built, but also because of the worm *(Teredo navalis)* which infests Sevastopol and the southern coast of Crimea and commits great ravages among the ships" (P. 92).

Details on marine wood-borers in early navigation furnished above, are to be considered only a fraction of events that might have been recorded in history. There may be numerous instances that might have gone unrecorded. In the five years from 1864-1869, ten thousand sailing ships insured in England were lost in various parts of the world and Portuguese lost 130 ships between 1555 to 1650 on the route to Indies (Throckmorton, 1970). As mentined by Santhakumaran (1988), these ships might have fallen prey to the destructive activities of marine wood-borers. Whatever little information, available from recorded history, is sufficient to illustrate the harrowing experience of our ancient navigators on account of their unseen animal foes in the sea and also to highlight the glaring inadequacies and utter futility of all protective devices contrived by man during his relentless war against the borers from time immemorial. (For details on protective measures, see Santhakumaran (1988) and Clapp and Kenk (1963) from which material for this paper was also taken). The severity of the problem is as acute today (Figs. 1 to 4) as it was in yesteryears.

No doubt, the marine wood-borers, being instrumental in causing ship-wrecks, might have enriched the sea bottom with materials for archaeological studies. However, the same organisms will continue their depredations on sunken ships as well converting them into irretrievably useless junks. Marine archaeological work should be initiated without delay at known ship-wreck sites to unravel the mysteries of early voyages and to unearth valuable historical data before the wrecks are 'consumed' by the marine wood-borers (Pls. 51-54).

ACKNOWLEDGEMENTS

The author is grateful to Dr. V.V. Srinivasan, Director, Institute of Wood Science & Technology, Bangalore, and to Dr. B.N. Desai, Director and Dr. A.H. Parulekar, Head, Biological Oceanography Division, National Institute of Oceanography, Goa, for their keen interest during the course of this study.

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Conservation of Antiquities

S. SUBBARAMAN

I INTRODUCTION

Conservation, Preservation and Restoration are the different terms commonly employed for describing the various treatments given to an antiquity or work of art with a view to improving its condition and preventing its deterioration. It may be useful here to try and define these terms.

While Conservation and Preservation are more or less synonymous, Conservation is the accepted term at present and has a definite scientific connotation. It is a composite term applied to a set of procedures aimed at prolonging the life of an object to the maximum extent possible, within the limits of its present physical extent i.e. without adding anything new. Restoration, on the other hand, definitely implies addition e.g. of missing parts etc. and hence does not form part of Conservation in the strict sense.

Conservation has three broad aims : (i) removal of the causes of deterioration, (ii) bringing the object back to its original condition as much as possible and (iii) preventing future deterioration. The second objective viz. bringing the object back to its original condition often involves cleaning for the removal of overlaying accretions of different kinds and is important both from the aesthetic and the archeological points of view. The removal of the disfiguring accretions not only restores the original appearance of the object but may also reveal hidden details and, in rare cases, even inscriptions. In this limited sense of bringing back the original surface and hidden details etc., the process may even be termed 'Restoration' but should be carefully distinguished from the commonly understood meaning of the word given above.

In this country, even in the case of paintings, restoration by means of repainting the missing parts, is not permitted. The treatment aims only at the conservation of the painting as it is.

II CAUSES AND MODES OF DETERIORATION

When an object is first buried in the soil, it reacts with its environment and undergoes rapid change in the initial stages but, after some time, the change slows down and a state of equilibrium tends to be established between the object and its surroundings. If left undisturbed, the object remains in a more or less stable condition. Once it is excavated and brought out, however, the object now exposed to an entirely different environment may again start undergoing rapid change and deteriorate fast. This particular phenomenon may be noticed in an even more drastic degree in the case of marine objects. For instance, water-logged wood, unless proper precautions are taken, may warp and crumble rapidly when exposed to air.

The changes in an object leading to its deterioration may be physical or chemical, though often it may be more accurate to describe them as physico-chemical.

The main factors causing the deterioration of objects and monuments are: (i) Heat, (ii) Moisture, (iii) Light, (iv) Biological agents and (v) Atmospheric polutants.

(i) Heat :

(a) In the case of stone monuments, particularly in hot regions and in summer, owing to the expansion of the stone surface during the day and its contraction during night to a much greater degree than the interior of the stone, the surface tends to peel off in layers. Another factor in similar deterioration is the differential thermal expansion of different minerals in the rock.

b) When a heated stone surface is suddenly cooled by rain, cracking may take place.

c) Heat increases the rate of chemical reactions and hence can speed up chemical deterioration.

d) The effects of heat on sensitive surfaces such as paintings can be drastic even in the short range.

(ii) Moisture :

a) Rain water, over a period of time, can cause physical erosion of even stone surface. Moisture can cause distingeration of sensitives material like paper, textiles, wood etc.

b) Over-dry conditions can render paint media brittle and cause the paint layer to crumble.

c) In the cold regions, the action of frost viz. conservation of water into ice within the pores of the rock (which involves a 10% increase in volume) can cause gradual disintegration of the rock.

d) Water can bring in soluble salts into the pores of the rock through capillary action and the repeated crystallization, dissolution and re-crystallization of salts within in pores can subject the rock to tremendous strain, resulting in its disintegration.

e) Changes in the Relative Humidity of the atmosphere can cause damage. For instance, in canvas paintings, the canvas responds to the changes in R.H. much more than the paint layer and becomes taut and relaxes in turn subjecting the paint layer to strain, resulting in cracking. Such changes can take place also in paintings on paper.

f) No chemical change will take place unless some moisture is present, which is thus a prime condition for chemical deterioration.

g) Relative Humidity of the atmosphere, exceeding 75%, is favourable for the growth of micro-organisms such as moulds and fungi.

(iii) Light:

Sun light causing the fading of dyes in textiles is well-known. The reaction caused by light is known as photo-chemical reaction and is an important factor in the deterioration of dyes and pigments. The ultra-violent component of the light is known to play a major role in this reaction although visible light beyond a certain level i.e. itensity of illumination also plays a part. Apart from fading of dyes, excessive illumination can even cause weakening of textile fibres.

(vi) Biological agents :

a) When conditions are favourable, organisms like moulds, fungi mosses, lichens, algae etc. grow on objects and monuments. Apart from disfiguring the object, they can cause physical disintegration. Some of them secrete acidic substances causing drastic chemical change.

b) Bacteria, such as the Thio and Nitrifying Bacteria have been found to play an important part in the weathering of rocks.

c) Objects of organic origin are susceptible to attack from various types of insects.

d) Birds and bats are sometimes a serious problem in monuments, their droppings causing considerable damage to objects.

(v) Armospheric pollutants :

Due to industrialization, harmful effluents entering the atmosphere at an ever-increasing rate have their effects also on monuments and museum objects.

(i) Carbon dioxide (Co_2), forming the weak Carbonic Acid (H_2Co_3) with water reacts with marble forming the soluble Calcium bicarbonate which is gradually leached out, eroding the marble surface.

(ii) Sulphur dioxide (So_2), the gas constantly entering the atmosphere due to the burning of coal and petroleum and in a variety of industrial activity, is perhaps the most harmful from the conservation point of view. It quickly converts itself into Sulphur trioxide, So_3, which with water forms the strong acid, Sulphuric Acid, H_2So_4.

Its action on marble and a variety of museum material is extremely harmful.

The recent controversy about the setting up of the Mathura Refinery within the 'danger' zone from Taj Mahal is well known.

(iii) Oxides of Nitrogen are other harmful gases present in the atmosphere in traces, which can adversely affect museum objects.

(iv) Traces of Chlorine (Cl_2) and Hydrochloric Acid gas (Hcl) which are always present in industrial and urban atmosphere are highly reactant and adversely affect a variety of museum material. In a marine environment, sprays of Sodium Chloride (Nacl) from the sea water is a serious cause of deterioration of monuments and objects.

(v) Apart from the adverse effects of atmospheric pollutants mentioned above, even normal chemical reactions such as Oxidation and reduction are often the factors causing deterioration of objects.

Metallic corrosion is a well-known phenomenon in this context. Iron rusts quickly in the presence of moisture. The process is basically oxidation and may be represented as :

$$2Fe + 30 + 3H_2O = 2\,Fe\,(OH)_3$$
$$2Fe\,(OH)_3 = Fe_2O_2 + 3\,H_2O$$

Ferric Hydroxide is formed first which is later converted to Ferric oxide, Haematite (Fe_2O_3).

Under sea-water the reaction taking place may be represented as :-

$$Fe + 2Nacl + 2\,H_2O = Fecl_2 + 2\,NaOH + H_2$$

When exposed to the atmosphere, the Ferrous Chloride is gradually converted to Ferric Oxide.

In the case of copper and its alloys, the first step is the formation of Cuprous and Cupric Oxides (Cu_2O) and CuO). Reaction with atmospheric Carbon di oxide leads to the gradual formation of the basic carbonates, Malachite $Cu\,Co_3\,Cu\,(oH)_2$ (green) and Azurite, $2\,Cu\,Co_3.\,Cu\,(oH)_2$ (blue). If the changes stop at this stage it will be well and good because the Oxide and Carbonate coatings do not harm the metal surface in any way and even act as protective coatings against further atmospheric corrosion. They also give a pleasing appearance to the object and hence are referred to as 'noble patina'.

What often happens, however, is that the traces of Hcl present in the atmosphere leads to the formation of Cuprous Chloride ($Cu_2\,Cl_2$) which in turn reacts with Oxygen in the presence of moisture leading to the formation of Basic Cupric Chloride, Atacamite, $2\,Cu\,Cl_2Cu\,(OH)_2$. The latter breaks out in the form of light green spots on the object and is commonly known as 'Bronze disease'.

If left unchecked, the process can ultimately cause the complete destruction of the metal.

III. METHODS OF TREATMENT

A. Antiquities of inorganic origin :

i) STONE

(a) After the removal of dust and dirt with the help of a dilute solution (say 1%) of a non-ionic detergent, such as Teepol, vegetation growths such as mosses, lichens etc. are removed with the help of 5% solution of Ammonia, assisted by detergent solution. Lime-wash and ochre coatings are removed with the help of 5% Acetic Acid solution.

The final step in the cleaning is thorough washing with distilled (or soft, salt-free) water to remove all traces of chemicals used.

(b) Soluble salts in the stone are removed by repeated immersion in distilled water, if the object is small, and by application of moist paper pulp in the case of large objects and monuments, repeating the process until the salts are removed completely.

(c) After cleaning and drying, the stone surface is treated with a fungicide solution (5% Zinc silico flouride or 2%

Sodium Pentachloro phenate in water) by brushing or spraying, for prevention of further vegetational growth.

(d) Finally the surface is preserved by application of two coats of 1% solution of Poly methyl methacrylate in Toluene.

(ii) METALS :

1. Iron : Before undertaking the treatment of an Iron antiquity, it is essential to ascertain first whether the mineralisation has proceeded to the extent of completely destroying the metal core. The presence or otherwise of the metal core may be tested by careful examination using needless and scrapers and also with the help of a magnet. In rare cases, X-ray may be necessary.

Where no metal core is present, the only treatment to be given to the object is immersion in dilute caustic soda solution (5% Na OH) a few times for the complete removal of any chloride present, followed by thorough washing with distilled water and careful drying. Finally the object may be given a wax coating by immersing it for a few seconds in molten Paraffin wax at 110°C.

Where a solid metal core is present, there are several possible methods of treatment.

(a) Electrolytic method

In this method, use is made of a direct electric current of about 10-15 ampere strength under a voltage of 6-12 volts. The requisite electric supply may be obtained either by using batteries or from the mains with the help of a transformer-rectifier.

The object to be treated is the Cathode, and the Anode is a sheet of Iron (preferably stainless steel). The electrolyte is a 5% solution of Sodium Hydroxide (NaOH).

The process may be allowed to proceed a few hours or even over night if necessary. Any accretions still remaining on the object at the end of the treatment may be brushed off and the object thoroughly rinsed under running water. After drying, a coat of 1% Poly methyl methacrylate (PMM) may be applied on the object.

(b) Electro-chemical method

In this method, the principle that when two metals are in simultaneous contact with an electrolyte, the baser of the two metals is sacrificed in preference to the nobler one, is made use of.

The mineralised Iron object is kept completely surrounded by Zinc granules and the ensemble immersed in 10-12% solution of Sodium Hydroxide in a suitable container. The solution is kept near boiling point for 1 to 2 hours, at the end of which the object is removed with the help of tongs, thoroughly brushed and washed. The process is repeated if necessary.

The cleaned and dried object is preserved with 1% PMM.

(c) Chemical methods :

For removal of rust from large objects, such as Cannons etc., as well as for removal of a thin coat of rust from smaller objects, 10% solution of Oxalic acid, or still better 10% solution of Rustodine (based on Phosphoric Acid) or EDTA can be used. The solution is applied on the spot and after a few minutes' reaction time, the rust is brushed off. The cleaning is completed with thorough rinsing with water.

(d) For cleaning of museum objects such as swords etc., having only some rusty spots, paraffin oil is applied to the spots for softening the rust, which is then brushed off by means of a brass brush.

2. Copper and its alloys :

(i) When patina can be sacrificed

Where an object is in an advanced state of corrosion and is covered with thick, mineralised incrustation, it is necessary to remove the incrustation completely not merely to restore the object to its original condition as far as possible but to save it from total destruction. In such circumstances, what are called stripping methods (implying complete removal of the incrustation) are employed.

These consist of (a) electrolytic, (b) electro-chemical and (c) chemical methods. While the first two are exactly same as those described earlier for Iron antiquities, the chemical method is as follows :

The object is immersed in an alkaline solution of Sodium Potassium Tartrate (Rochelle salt) prepared by dissolving 150 gms. of Rochelle salt and 50 gms. of Sodium Hydroxide in one litre of distilled water. The object may remain in the solution even overnight, if necessary. All the Cupric salts in the incrustation are dissolved by the solution, which turns blue as a result. The object may be immersed in a fresh solution the next day and treatment repeated, if felt necessary. This is followed by thorough brushing and washing under running water.

The pink-coloured deposit of cuprous salts still remaining on the object after the above treatment, is removed by immersion of the obect for $^1/_2$ hour in a 5% solution of Sulphuric acid followed by thorough brushing and washing.

The object is kept immersed repeatedly in changes of distilled water until any chloride present is completely removed. Each time the distilled water is tested with Silver nitrate solution and the washing is repeated until the wash-liquid no longer answers for chloride.

Complete elimination of chloride is essential for preventing further corrosion. A more effective method for removing the chloride is what is called the intensive washing technique in which the object is immersed in distilled water, which is raised to boiling point. The water is allowed to cool to the room temperature, the object throughout remaining immersed in it. The process is repeated until the water no longer answers for chloride. In this method, even the chloride remaining inside pores is removed. Next the object is dried either at room temperature or in an Electric oven at 105°C. Finally it is preserved with a coat of 1% PMM.

(ii) When patina has to be preserved

When an object has a noble patina but is covered only with spots of bronze disease, the aim of the treatment is to remove only the bronze disease spots, while preserving the noble patina in tact. The treatment consists of removing the undesirable corrosion products as well as the factors causing corro-

sion and to stabilize the patina. In fact, wherever a good patina is present, the effort should be to preserve it. (The stripping methods described above are applicable only when no coherent patina is present and the corrosion process has proceeded to such an extent that the complete removal of the mineralised incrustation is necessary for saving the object).

(a) Sodium Sesquicarbonate method

The object is kept immersed in 5% Sodium Sesquicarbonate solution (prepared by dissolving equi-molecular quantities of Sodium Carbonate and Sodium bicarbonate i.e. 28 gms. and 22 gms. respectively in one litre of distilled water). The object is periodically brushed under running water and replaced in the solution. At the end of a week, the object is placed in a fresh solution. The treatment (which may take a few weeks for completion) is continued until all the bronze disease spots are removed and the solution (tested each time for chloride) no longer shows the presence of any chloride. The object is now thoroughly washed, rinsed with distilled water, dried and finally preserved with 1% PMM solution.

b) Silver Oxide method

When only a few spots of bronze disease are present, they are scraped off and the spot excavated for complete removal of the corrosion products. The pits are filled with Silver Oxide (Ag_2O) moistened a little with spirit. The advantage of Silver Oxide is that it reacts with any chloride that may be still present forming the non-reactive Silver Chloride, thus arresting the corrosion process. Secondly the colour of Silver Oxide usually matches with the patina of the object and the treated spots remain inconspicuous.

Ultrasonic Cleaning

Brushing and washing are essential steps in all the methods of treatment for metallic objects. In the place of conventional brushes, it is sometimes advantageous to use an ultrasonic cleaner. The object immersed in the solvent in a suitable container is placed inside the tank of the ultra-sonic cleaner surrounded with water. The ultrasonic vibrations transmitted from the bottom of the tank to the cleaning liquid surrounding the object produce the effect of powerful brushing on the object. The method is especially useful for cleaning intricately carved objects. All the parts of such an object may not be accessible to ordinary brushing. However, the method has to be used with great caution in the case of fragile objects because the powerful vibrations may sometimes result in the breaking of such an object.

3. SILVER:

Sivler is sensitive even to traces of Sulphur in the atmosphere in the form of Hydrogen Sulphide (H_2S) and quickly turns dark in its presence. This process is usually referred to as tarnishing of Silver. The corrosion product is Silver Sulphide.

Oxidation with the formation of dark brown Silver Oxide, may also occur. In the presence of Hydrochloric Acid gas (Hcl) in the atmosphere, Silver chloride, white in colour to begin with but turning to dark grey due to the action of light, will be produced. In the case of base silver, (containing appreciable quantities of copper) copper, the less noble of the two metals, corrodes preferentially and the object is usually covered with bluish green corrosion products of copper. Sometimes the object itself may be mistaken to be a copper object because of this circumstance.

a) Base silver coins or objects are treated by boiling in 30% Formic Acid solution followed by thorough brushing and washing. The treatment is continued till all the corrosoin products are removed and the original surface of the Silver is restored.

b) When only dark grey silver chloride is present, the object is immersed in 10% Ammonia solution until the deposits disappear. This is followed by washing to remove the Ammonia completely.

c) When oxides and sulphides are present, the object is treated with a hot solution of 10% Thio-urea, followed by thorough brushing and washing.

In all the treatments described above, after the final washing and drying, the object is preserved with 1% solution of PMM.

4. LEAD:

Lead is very sensitive to corrosion and is readily converted into Lead oxide (light yellow in colour) in the presence of moisture and Oxygen and into Carbonate and basic Carbonate (white) when Carbon dioxide is present. The white pigment, which has been in use now for many centuries, viz. White Lead is the basic carbonate of Lead.

There are two important methods for the treatment of corroded Lead objects.

(a) Caley's method:

The object is kept in 10% Hydrochloric acid solution for a few hours until the effervescence completely ceases. (This treatment removes the carbonates). The object is next washed two or three times in near-boiling distilled water for complete removal of any Lead chloride present.

For the removal of the Lead oxide coating that may be present, the object kept in a warm 10% solution of Ammonium Acetate. At the end of the treatment the object is washed a few times with freshly boiled and cooled distilled water (to free it from dissolved Carbon dioxide).

The object is dried with the help of blotting paper (without touching the object) and by placing in a desiccator overnight.

The cleaned and dried object is given a coating of wax by immersing it in molten Paraffin wax at 105° C. For a few seconds.

(b) Ion-Exchange method:

In this method, for getting rid of the incrustation of corrosion products, the same principle as is usually used in water-treatment viz. exchange of ions, is made use of. The insoluble lead compounds are converted into other soluble ones by exchange of the anion and are leached out.

The object is kept completely surrounded and in close contact with heads of the Ion-exchange resin viz. Amberlite inside distilled water in a suitable container and kept in an Electric oven for a few hours at a temperature of 70° – 80° C until the incrustations completely disappear.

The object is dried and given wax coating. (In this method, even further washing after the treatment is not required.)

It is advisable to avoid storing treated Lead objects inside wooden almirahs since the small quantities of volatile organic acids emanating from wood may cause corrosion of the objects. They should be kept in steel almirahs. Similarly handling of the treated object, before giving it a wax coating, may also be avoided because Lead is so sensitive that even sweat may affect it.

B. OBJECTS OF ORGANIC ORIGIN

1. Wood

Objects of organic nature, being derived from living things, are succeptible to attack by various types of micro-organisms like moulds, fungi etc. as well as by insects.

The main constituents of wood are Cellulose and a protineceous material called Lignin. Being of a cellular structure, wood can imbibe large quantities of moisture. Being anisotropic in nature, its movements in different directions, due to expansion or contraction, are in different degrees. Hence the pronounced tendency of wood to warp and the need to season it properly before use.

a) Fumigation: Insect-infested wooden objects have to be fumigated. The object is placed in an air-tight cupboard and a dish of Carbon-di-Sulphide, CS_2, (a highly volatile liquid) is placed (at a higher level since its vapours are heavier than air.) The dish is replanished after 3 or 4 days. The object may remain in the cupboard for about a week.

Since mixtures of Carbon-di-Sulphide vapour and air are highly explosive, great care has to be taken. It will be much safer to use a mixture of Carbon tetra chloride (Ccl_4) and Carbon-di-Sulphide (CS_2) in the proportion 4:1 though the lethality of the mixture as a fumigant is somewhat less than pure CS_2. The period may be extended if necessary.

In sophisticated fumigation chambers, the fumigant used is Ethylene dioxide gas or a mixture of Ethylene dioxide and Carbon dioxide in the proportion 1:9 which is commercially available as Carboxide gas.

Some muesums abroad use even Hydrocyanic acid gas (HCN) as the fumigant but evidently strict precautions have to be observed in order to avoid tragic accidents.

b) Fungicidal treatment: Objects that have suffered fungal attack may first be cleaned with rectified spirit and treated with a 2% solution of Sodium penta chlorophenate in water.

c) Repairs and impregnation: While thin cracks can be filled with the help of 20% solution of Poly Vinyl Acetate (PVA), wider cracks may be filled with a paste of Fevicol and saw-dust.

Objects, which have been rendered fragile, are strengthened by impregnation with a wax-resin mixture. The object is kept immersed in a molten mixture of Bees' wax and Rosin (4:1) in an electrically heated tank. After removal from the tank, any excess wax on the surface is removed with the help of turpentine.

(d) Preservation:

Beech-wood creosote in Petroleum spirit (2 to 3%) is a good preservative for wooden objects. It may be applied by brushing or spraying.

Water-logged wood:

In an object, which has remained water-logged the Cellulose portion of the wood might have mostly disintegrated with only the tougher lignin remaining. If the object is exposed to air, due to the sudden evaporation of moisture from the cells, they may collapse resulting in the severe warping and disintegration of the object. It is, therefore, essential that an excavated water-logged wooden object should be kept wrapped in wet cloth and covered with Polythene sheets in order to prevent quick evaporation until the object can be given necessary treatment.

(a) Alum method:

This is the traditional method making use of the fact that Alum is much more soluble in hot water than in cold water. The object is kept immersed in a saturated solution of Alum at 90°C for a few hours or overnight and taken out. The Alum solution penetrates the wood and on being crystallised after cooling, strengthens the weakened cell walls. Any excess Alum crystallised on the surface is removed by brushing on hot water quickly.

(b) Alcohol-Ether method:

Small objects can be treated by repeated immersion in Ethyl Alcohol until the water is completely replaced by Alcohol, followed by immersion in Ether a few times till the Alcohol is replaced. Ether has a low surface tension and its final evaporation from the object has no adverse effect.

(c) Poly Ethylene Glycol Wax method:

This method is being used at present with much success. Poly Ethylene Glycols have the general formula $CH_2OH.(CH_2OCH_2)_n - CH_2OH$. While the earlier members of the Polymeric series are liquids and the intermediate ones have a vaseline-like consistency, the higher members with value of n greater than 35 are solids and wax-like materials. They have the unique advantage of being soluble in water. The particular material useful for the treatment of water-logged wood is Poly Ethylene Glycol (PEG) wax of grade 4000, which is a hard, white, non-hygroscopic solid with a melting point of 53° – 55°C.

The object is placed in a 12% solution of PEG at room temperature in a covered container, which is then placed in a ventilated oven and the temperature gradually raised until after a period of weeks it has reached 60°C. During this time the wax slowly diffuses into the wood, displacing the water in the wood and the supernatant solution slowly evaporates so that at the end of the operation the object is just covered with molten wax.

The object is taken out and cooled. Excess wax on the surface is removed by brushing on Toluene.

2. Paper

Paper, made up entirely of Cellulose, is highly succeptible to attack by micro-organisms and insects. Fungus or insect-infested paper objects should be first fumigated before undertaking any other treatment.

a) Thymol fumigation:

Fungus-infested objects should first be brushed carefully for removing the fluffy fungal growth completely. The objects are then placed on perforated shelves inside the fumigation chamber, the fumigant being Thymol crystals placed in a dish just above a 100 watt electric bulb fixed to the bottom of the chamber. The bulb is kept on for one to two hours. Thymol vapours fill the chamber. The obects may be inside the chamber overnight.

b) Fumigation against insect-attack:

The objects are placed in the fumigation chamber and crystals of Para di chloro Benzene (PDCB) are placed in suitable containers so as not to be in direct contact with the object. About 500 gms. of PDCB for every 20 cubic feet of space is the recommended quantity. The fumigation has to be continued for at least two weeks, replacing the PDCB, if necessary. The vapour has no effect on writing in ink. Therefore, even manuscripts can be fumigated by this method.

c) Cleaning:

i) Spots caused by fungal growths, fly marks and other stains can be removed by immersing the object in 1% solution of Chloramine-T. In the case of documents with writing in ink, the ink may first be protected by brushing on a coat of Poly Methyl methacrylate before undertaking the above treatment.

ii) For the cleaning of discoloured prints etc., an effective and safe method is the Chlorine dioxide method. The object is kept immersed in a 2% solution of Sodium Chloride in a tray inside a fume-cupboard and Formaldehyde solution (75 ml. for every litre of the Chlorite solution) is carefully added. The reddish brown gas, Chlorine dioxide gas is released, which is the effective bleaching agent. A close watch is kept on the object and as soon as the cleaning process is seen to be complete, the object is removed, on a glass-sheet support, and washed repeatedly (10 – 12 times at least) until all traces of the chemicals are removed.

This method has been found to be effective and safe and preferable to the old method of using Hypochlorites, which often tended to over-bleach the paper.

d) De-acidification:

Paper tends to turn yellow and brittle with the passage of time due to development and increase of acidity in it. This may be both because of inherent and manufacturing defects and due to external factors. Paper affected in this way has to be de-acidified.

After protecting the ink-writing with PMM as described above (wherever necessary), the document is kept immersed for a few minutes each, first in a saturated solution of Lime-water and next in a solution of Calcium bicarbonate.

Illustrated manuscripts, paintings etc., which can not stand treatment with water, may be de-acidified by immersion in a 5% solution of Crystalline Barium Hydroxide in Methyl alcohol.

e) Repairs and Lamination:

Paper objects and documents that have become fragile need reinforcement.

Where the writing is only on one side, the document can be given a support of acid-free hand-made paper using starch-paste (containing small quantities of fungicide and insecticide) as adhesive.

If the writing is on both sides, however, the reinforcement has to be achieved by attaching a support of transparent material on both the sides. The process is called lamination.

The commonly used method of lamination is by using Cellulose Acetate sheets with the help of a specially designed press, where the sheets can be attached to the paper document under pressure at the required temperature.

Where such an equipment is not available, the Cellulose Acetate sheet is attached to the document by using Acetone. The Acetone slightly softens the Cellulose Acetate which is then pressed on to the document with cotton swabs. The method is called the solvent lamination method and requires much skill and practice. The correct quantity of Acetone to be used is crucial. Too little may not effect attachment and too much of it may dissolve away the cellulose acetate.

3. Palm – leaf:

The problems of conservation of palm-leaf manuscripts are somewhat similar to those of paper.

Insect-infested palm leaf may be fumigated with Para dichloro benzene.

Brittleness with ageing is a common problem with palm-leaf. Elasticity can be brought back by rubbing in a suitable oil. Citronella oil or Cedar wood oil may be used.

For laminating fragile palm-leaf Chiffon silk has been used with starch paste.

4. Leather:

Leather is also highly succeptible to attacks by moulds and fungi as well as insects.

Leather that has suffered fungal attack may be treated with Santobrite (Sodium Pentachloro phenate) – 2% solution.

Fumigation may sometimes become necessary for which Carboxide gas may be used. (Carbon di Sulphide may be avoided).

Brittleness is a common problem with old leather objects, book-bindings etc. For restoring their suppleness and longevity, the British Museum Laboratory have developed a mixture, the ingredients of which are anhydrous lanolin, 200 gm; Cedar wood oil, 30 ml.; bees' wax, 15 gm; petroleum ether (B.P. 60° – 80°C), 330 ml. The mixture has a vaseline consistency and can be brushed on to the leather surface evenly, followed by polishing with soft cloth.

Thermoluminescence Dating: An Up-Date on Applications to Indian Archaeology

A.K. SINGHVI, B.P. AGRAWAL and K.S.V. NAMBI

In recent years TL Dating has offered possibilities of bridging the gaps in Archaeological chronology left despite more than 2000 C_{14} dates. Application of this method in dating aeolian and fluvial sediments also offer palaeolithic chronology. The firing temperature of the pottery also can be estimated through this method. Paper deals with basic terms used in quoting a TL date method, basic TL age equation, various techniques, parameters in dating analysis and the events dated by TL.

INTRODUCTION

In India, the archaeological chronology has relied principally on the radiocarbon method. However, despite the availability of about two thousand radiocarbon dates (measured principally by the Physical Research Laboratory, (PRL), Ahmedabad and the Birbal Sahani Institute of Paleobotany, Lucknow) important voids such as the chronology of megalithic burial pits still remain. The basic reasons for such chronological gaps are (i) the poor preservation of organic debri in a tropical environment and (ii) dating limit of ca 30 ka with the presently available technology in the country.

In the recent years, Thermo Luminescence (TL) has offered possibility of bridging the chronological gaps in Indian Archaeology. This method also offers to provide palaeolithic chronology by virtue of its applicability to the dating of aeolian and fluvial sediments. Besides the increase of TL signal with age, the TL method also offers to provide a date each to the various subsets of an archaeological context. Thus in principle - a burnt flint or pottery as also the depositional/burial event of the context can be dated (see Aitken, 1985, Singhvi and Chawla, 1986, Chawla and Singhvi 1989). Efforts at Bhaba Atomic Research Centre (BARC) have shown that in suitable circumstances, it is also possible to routinely use TL method to estimate the firing temperature of the pottery (Sunta and David, 1983) and the research at Oxford/PRL has indicated the potential use of TL in provenance studies. In this brief contribution a survey of the TL based chronological work in India is presented along with a brief outline defining the basic terms used in quoting a TL age. It may also be appropriate to mention that TL dating is by no means a routine dating method and a physics back-up is desirable. Also important is a realization of actual dosimeteric conditions in the field in dose-rate calculation as also of a realistic assessment of the depositional and post depositional environment of mineral grains of the sediments.

THERMOLUMINESCENCE DATING

Thermoluminescence is thermally stimulated emission of light from a substance in addition to its incandescent emission. This phenomena is induced by exposure to ionizing radiation and is exhibited by a variety of non-conducting materials including minerals and organic compounds. The intensity of emitted light bears a proporitonal relationship with the amount of irradiation received by the sample and this fact is exploited for age estimation. In nature, minerals such as quartz, feldspars, etc. are continually exposed to radiation emanating from the environmental radioactivity viz Uranium-238, Thorium-232, K-40 as also from the cosmic rays.

Irradiation to ionizing radiation results in a production of an avalanche of freed electronic charges some of which wander-around in the crystal lattice and get trapped at a lattice defect. Depending on the binding energy of a trapped charge its residence time in a trap (i.e. at the lattice defect) varies from 1 sec - $10^{7\text{-}8}$ yrs. However a thermal stimulus (heating upto 300-500°C) can cause a thermal release of trapped charges some of which radiatively combine at a luminescence or recombination centre to produce luminescence. The proportional dependence of luminescence intensity of the total cumulative amount of irradiation received since last heating (or like) paved the way for dating applications. This is because the rate of irradiation from the environmental radioactivity is the same thereby causing a steady increase of trapped charges concentration i.e. the stored luminescence continues unabated till excavation and the TL intensity of a sample on heating can be related to its age via the equation:

$$\text{TL age (yrs)} = \frac{\text{TL acquired}}{\text{TL acquisition/year}}$$

exploiting propositional relationship of luminescence with age.

$$= \frac{\text{TL acquired}}{\text{(TL/rad. dose) x (rad. dose/year)}}$$

$$= \frac{ED_\beta + I}{aD_\alpha + D_\beta + D_\alpha + D_c}$$

This is the basic TL age equation. Here $ED^\beta + I$, represent the equivalent radiation dose (expressed in Greys (Gy) – the amount of energy absorbed/gm) that is needed to generate the observed TL level in a virgin sample. Where D's are the component of radiation dose arising due to various decay modes of various radionuclides. Thus D^α is the alpha dose arising due to alpha particles emitted in the radioactive decay of U and Th radionuclides, where as D^β comprises the contribution from beta particles in the decay of U, Th and P. These contributions also get scaled depending on the grain size of the minerals contributing to TL. Thus for example fine silt size grains receive full alpha dose, the medium sands size grains only have their skin affected by alpha irradiation. Similarly it is important to assess the role of internal radioactivity, especially in respect of alpha and beta irradiation, which travel only to a distance of ~ 20 um and 2mm respectively in minerals. Various techniques such as fine grain method (utilizing only the fine silts (2-8 μm size) extracted from a sample) and mineral inclusion method (utilizing > 100 μm fraction) have been developed for applications.

In TL dating analysis there are several parameters, that need a proper evaluation. These include:

1. *The alpha efficiency factor* – relating to lower efficiency of TL induction by alpha particles compared to beta particles or gamma rays.
2. *The anomalous fading* – which is non-thermal loss of TL on storage and can lead to a severe age underestimation. This is generally observed in some of the volcanic feldspars, but a routine check for its presence is essential.
3. *Supralinearity correlation (I)* – as a sample dependent parameter that accounts for a non-linear TL growth at low doses and is readily estimated in the laboratory.
4. *Radon Escape and Radioactive disequilibrium* – arising due to escape of radon from the radionuclide chain. This effect is easily detected and a check for radon escape is a must for any dating analysis. This is normally presented as sealed/unsealed alpha-count rate ratio. Similarly for sample in contact with water, there could be finite possiblity of leaching and migration of some of the radionuclides and such effects have to be guarded against

Site: SRINGAVERAPURA (Allahabad)
Location: 25°31'N, 82°E
Grid ref.: as given below
Site description: A Ramayana site

Locus	*Material*	*Date (BP Yrs)*	*Lab. ref.*
Tr SVP-1, Sq YA-3 Qd-3 L-17	RW-Pre-NBW	2660±280	PRL-TL-21
L-17	B&RW-Pre-NBW	2769±400	PRL-TL-24(1)
L-17	B&RW-Pre-NBW	2690±280	PRL-TL-24(1)
L-18	Black slipped ware Pre-NBW	2743±300	PRL-TL-29
L-19E	Ochre colour Pottery OCW	2900±380	PRL-TL-33(1)
L-19E	Ochre colour Pottery OCW	2885±270	PRL-TL-33(2)
L-19E	Ochre colour Pottery OCW	3015±280	PRL-TL-38(1)

Samples by: Samples collected by A.K. Singhvi B.B. Lal and K.N. Dikshit. Archaeological.
Evidence: Charcoal samples from L-18 and L-19 are radiocarbon dated to 2700±130 yrs. BP. (PRL-669) and 2855±280 Yrs. BP. (PRL-670) and show excellent concordance.
Comments: Archaeologically the TL dates have been taken to suggest the antiquity of the Ramayana epic to about 750 B.C.
Reference: (1) D.P. Agrawal, N. Bhandari, B.B. Lal and A.K. Singhvi (1981), Proc. Ind. Acad. Sci. (E) 90E, 161.
(2) D.P. Agrawal, N. Bhandari, B.B. Lal and A.K. Singhvi (1981), Ancient TL 14, 10.

5. *Water content* – the presence of water results is the attenuation of radiation exposure to minerals and cause significant underestimation if this presence of water is not accounted for. Information of burial depth, rainfall and groundwater tables can help assess the amount of moisture content through the burial history of the sample.

EVENTS DATED BY TL

Basically any event that results in the erasure of previously acquired thermoluminescence (during the geological antiquity of minerals) can be dated by this method. Three types of events can be identified:

1. The most recent thermal event that resulted in a heating of the constituent minerals upto 500°C. This could be the kiln firing event of the pottery, or samples hearth lining. Burnt clays, and flints are also amenable to dating.
2. The insitu crystallization of minerals such as calcites, gypsum etc.
3. The most recent sun exposure event, such as in the case of sediments transported over long distance – e.g. desert sands, loess and fluvial deposits.

The solar illumination results in a photo eviction of charges resulting in a resetting of the TL clock. Often archaeological impliments are found insitu in such deposits and thus the chronology of the context provides a dating of lattice cultures. Thus the chronology of the Neanderthal man in W. Germany (Singhvi et al, 1986), the chronology of geometric microliths in Srilanka (Singhvi et al, 1987), and the paleolithic chronology in W. India (Singhvi et al, in press) have been established.

In the following a upto-date summary of Indian TL dating effort is presented. The first set TL dates were by the BARC group (Nambi et al, 1979) and subsequently the TL ages on pottery by the PRL group have also been provided. Sites dated by the TL method include the Ramayan site at Sringaverapura, Upper paleolithic site at Kurnool, and the megalithic burial. An overview of the TL dates is provided in Fig.1.

Site: SANGHOL (Ludhiana, Punjab)
Location: 30°20′N, 75°15′E
Grid ref.: as given below
Site description:

Locus	*Material*	*Date (BP Yrs.)*	*Lab. ref.*
SGL-II Tr.Ex-1, L-40	Late Harappan Bara ware	3120(± ±270)	PRL-TL-1
SGL-II Tr.Ex-1, L-31	G.W.	2100(± ±180)	PRL-TL-6
SGL-II Tr.Ex-1, L-45	Late Harappan Bara ware	3220(± ±450)	PRL-TL-7
SGL-II Tr.Ex-1, L-35	Upper level of Late Harappan	3110(± ±270)	PRL-TL-9 Bara ware
SGL-II Tr.Ex-1, L-46	Lower level of Late Harappan	4030(± ±330)	PRL-TL-10
SGL-II Tr.Ex-1, L-33	Painted GW	1760(± ±210)	PRL-TL-14

Site: MAHAGARA (Allahabad)
Location:
Grid ref: as given below
Site description: Neolithic site

Locus	*Material*	*Date (BP Yrs)*	*Lab. ref.*
Depth 0.95 mbs L-8	Neolithic Brown pottery	4243	TL/AU/MGR/ 77-2
Depth 1.12-1.5 mbs	Neolithic Brown pottery	3604	TL/AU/MGR/76-1

Samples by: Samples supplied to BARC by Archaeological Survey of India.
Archaeological
evidence: Radiocarbon age of a charcoal L-8 from depth 1.15 m is 1400 ± 150 BP (RPL -409)
Comments: TL age of MGR/77-2 is substantially older and not in stratigraphic sequence.
Reports: (1) M. David and C.M. Sunta (1980) BARC report No. 1074.
(2) G.R. Sharma (Ed) (1980) Beginning of Agriculture P-198. Abinash Prakashan, Allahabad.

Site: MUCHCHATLA CHIRTTAMANU GAVI
Location: 15°21′N, 78°8′E
Grid ref.: as given below
Site description: Upper paleaolithic occupation level

Locus	*Material*	*Date (BP Yrs.)*	*Lab. ref.*
Fire place 1.65 to 1.8 mbs	Burnt clay	17390 (± ±1740)	

Samples by: Dr. M.L.K. Murty, Dept. of Archaeology, Decan College, Pune.
Archaeological.
evidence: (1) C.25000 BP based on a C-14 (PRL-293) age from Mandipalle, Cuddapah.
(2) Site also yielded lithified burnt fragments.
Comments: The date provides chronology to upper palaeolithic occupation in the region. C-14 dates for upper palaeolithic dates ascribed to C.3000 BP. to 10,000 BP.
Reports: (1) K.S.V. Nambi and M.L.K. Murty (1981), Current Science 50, *21*, 945.
(2) K.S.V. Nambi and M.L.K. Murthy (1983), Bull. Deccan College Res. Inst. *42*, 110.

Site: BAGOR (Rajasthan)
Location: 25°21′, 74°23′E
Grid Ref:
Site Description:

Locus	*Material*	*Date (BP Yrs)*	*Lab. ref.*
0.41 to 0.55 mbs	Sand dune which yielded microliths.	2060 (± ±210)	PRL-TL-42

Samples by:
Archaeological evidence:
Comments:
Reports: Y.P. Sharma, A.K. Singhvi and D.P. Agrawal (1981) Ancient TL No. 15, *8*.

Site: BHAGWANPURA
Location:
Grid ref: as given below
Site description:

Locus	*Material*	*Date (BP Yrs)*	*Lab. ref.*
A. *C-2 Baulk*			
0.30 mbs L-3	GW	3830 (± ±500)	BPR-1
0.55 mbs L-4	RW	4038 (±160 ±520)	BPR-4
0.55 mbs L-4	GW	3814 (± ±530)	BPR-5
0.55 mbs L-4	RW	2716 (±260 ±420)	BPR-6
0.55 mbs L-4	RW	1344 (± ±170)	BPR-7
B. *C-1 Qd. 2*			
0.80 mbs L-4	GW	311 (± ± 50)	BPR-2
0.80 mbs L-4	GW	2710 (± ±440)	BPR-3
0.90 mbs L-5	GW	1235 (± ±180)	BPR-8
1.10 mbs L-6	GW	2649 (± ±400)	BPR-9
1.15 mbs L-6	RW	4742 (± ±440)	BPR-10
1.18 mbs L-6	RW	2434 (± ±410)	BPR-11
1.30 mbs L-7	RW	4868 (± ±580)	BPR-12
1.40 mbs L-7	RW	3241 (±290 ±410)	BPR-13
1.60 mbs L-8	RW	3532 (±140 ±420)	BPR-14
2.10 mbs L-9	RW	4141 (±500 ±620)	BPR-15
2.25 mbs L-10	RW	5460 (± ±820)	BPR-16
2.40 mbs L-10	RW	2696 (±140 ±700)	BPR-17
2.45 mbs L-10	RW	3024 (± ±450)	BPR-18

Samples supplied by: The Archaeological Survey of India Delhi to the TL Laboratory, Health Physics Div. BARC, Bombay.
Archaeological
evidence: Bhagwanpura is an Indus valley site having yielded Harappan ware.
Comments: Some of the samples do not exhibit a stratigraphic correlation. See the discussion in the report by the Authors.
Reference: BARC report No. 1013 (1979) published by the Bhabha Atomic Research Centre, Bombay.

Site: HULAS
Location: 29°15′N, 74°40′E
Grid ref: as given below
Site description: A Harappan site

Locus	*Material*	*Date (BP Yrs)*	*Lab. ref.*
1/2 baulk, L-3	PGW	2300 (± ±)	PRL-MSL-TL-1
3 pit, L-5	L-Harappan	3100 (± ±)	PRL-HLS-T1-10
3, L-35	L-Harappan	3200 (± ±)	PRL-HLS-TL-79
1, L-7	Harappan	3650 (± ±)	PRL-HLS-T1-17
3, L-4	Harappan	3800 (± ±)	PRL-HLF-TL-1

Samples by: Dr. K.N. Dikshit, Archaeological Survey of India, Delhi and Dr. A.K. Singhvi, PRL, Ahmedabad.
Comments: PRL-HLS-TL-79 see the published report for more details.
TL-dates show a good concordance with the available Harappan chronology based on radiocarbon dates.
Reports: A.K. Singhvi, Y.P. Sharma and D.P. Agarwal (1983) Pact. J.9, 365.

Site: KUMARNAHALLI
Location: 40°19′N, 75°43′E
Grid ref.: as given below
Site description: Megalithic burial pit

Locus	*Material*	*Date (BP Yrs.)*	*Lab. ref.*
Pit II 2.0 mbs	BW/RW	3420 ± 290 3080 ± 260	PRL-TL-50
Pit III 1.7 mbs	BW	3110 (± ±500) 2910 (± 470)	PRL-TL-49
Pit IV 2.0 mbs	RW	3360 (± ±300 3180 (± ±280)	PRL-TL-47
Pit V 2.0 mbs	BW	3300 (± ±400)	PRL-TL-46

Samples by: Dr. Nagrajarao, Archaeological Survey of India, Delhi.
Archaeological
Evidence: Burial pit pottery associated with skeleton.
Comments: The TL dates suggest somewhat older antiquity of the megalithic burial than considered so far.
Reports: A.K. Singhvi, Y.P. Sharma and D.P. Agrawal (1983), Pact J.9, 365.

Site: MATHURA
Location:
Grid ref.:
Site description:

Locus	*Material*	*Date (BP Yrs)*	*Lab. ref.*
AZ Qd 3g & 3b 1.9 mbs L-6	RW	1688(± ±136)	M-1 MTR-9
XA-1 Qd3, 2h & 2g 2.65 mbs	R/GW	1811(±126±307)	M-2 MTR-8
BA Gd2, 1e & 1f 3.5 mbs L-11	RW	1420(± ±127)	M-3 MTR-8
A1 Qd2, 5e & 5f 1.3 mbs	RW	3018(± ±513)	M-4 MTR-8
A1 Qd3, 4e & 4f 2.45 mbs L-5	RW	1682(± ±235)	M-5 MTR-8
AT A1-Qd4, 2h & 2g 0.33 mbs	RW	2227(± ±422)	M-6 MTR-8
XB-1 Qd4, 3e & 3f 3.60 mbs L-13	Black polished	2262(±113±294)	M-7 MTR-8
5g & 5h 1.75 mbs	Brick	1335(± ±226)	M-8 MTR-5
4g & 4n L-6	RW	2175(± ±346)	M-9 MTR-4

Site: NAPCHIK (Wangu Manipur)
Location: 24°26'N, 94°50'E
Grid ref.: as given below
Site description:

Locus	*Material*	*Dates (BP Yrs.)*	*Lab. ref.*
Tr. 2 fourth soil layer 1.09 mbs.	Corded ware	3600 (± ±350)	PRL-TL-77

Samples by:
Archaeological
Evidence: Samples were found associated with lithic impurities and suspected to be Hoabinihian culture.
Comments: TL-dates too young to be of Hoabinihian origin perhaps indicating contamination of young pottery in a slope wash depth.
Reports: A.K. Singhvi, J.P. Sharma and D.P. Agrawal (1983) Pact J. 9, 365.

Site : DHEGAM
Location: 21°42′N, 72°55′E
Grid ref: as given below
Site description: Lower Narmada valley

Locus	*Material*	*Date (BP Yrs)*	*Lab. Ref.*
Burial soil about 2 mbs	$CaCO_3$ nodules overlain by alluvial Silt and halocane black soil	22890(± ±1830)	BARC

Samples by: Prof. K.T.M. Hedge, M.S. University, Baroda.
Arch. Evidence:
Comments:

1. Kankar analysed to assess feasibility of thin dating for palaeolithic chronology.
2. The radiocarbon age of the sample is 22452±550. The concordence of C-14 and TL dates is of importance in view of possible implication in the extension of the tree ring based calibration of radiocarbon ages.
3. Disequilibrium of radioactive series in $CaCO_3$ nodules not accounted for.

Reports: K.S.V. Nambi and K.T.M. Hedge (1982) Natural Radiation Environment Eds. K.S. Vohra et al, p.664. Wiley Eastern, New Delhi, India.

Antiquity of Iron at Gufkral

A.K. SHARMA

Excavations at Gufkral in Jammu and Kashmir had brought to light five periods of occupation. Period II, the Megalithic period is associated with the erection of Manhirs, introduction of cultivation of rice (Oryza saliva Linn) and millet (Eleusive coracana) and use of iron. Wheel made dull red pottery also made its appearance during this period. The 14C dates for this period show that megalithic people flourished here between 1570 B.C. to 1130 B.C.

The site assumes importance for the fact that the antiquity of iron in Indian sub-continent has been pushed back to middle of the 2nd millennium B.C. These dates point out the possible link to Iran-Afganistan area from where iron with approximately similar dates have been reported.

In order to firmly establish the new dates it is necessary to have more excavations at Gufkral and one or two more Megalithic sites in the valley. In the light of Gufkral finds it becomes necessary to re-examine the finds from Burzahom.

Gufkral (34°54'N, 75°10'E) is situated 41 km. south-east of Srinagar near Tehsil town of Tral in Dist. Pulwama of Jammu and Kashmir. It is located on an extensive upper karewa terrace. The site was excavated by Prehistory Branch of Archaeological Survey of India in 1981 and 1982. Excavation has brought to light five periods of occupation from Aceramic Neolithic to Historical period with time bracket as revealed by a series of 14 C dates (uncalibrated).

Period IA – Aceramic Neolithic – 2420 – 2000 B.C.
Period IB – Early Neolithic – 2000 – 1700 B.C.
Period IC – Late Neolithic – 1700 – 1550 B.C.
Period II – Megalithic – 1550 – 1100 B.C.
Period III – Historical

Period II; The megalithic period is associated with the erection of Menhirs on the site. The period marks the arrival of a new wave of people sometime during the middle of the 2nd millennium Neolithic occupation. These new migrants brought with them, iron, rice *(Oryza saliva* Linn), millet *(Eleusive coracana)* and knowledge of erecting huge memorials.

Wheelmade dull red ware pottery made its appearance during this period. Jars having shapeless rims, long necked jars, bowls, basins, dish-on-stand and medium sized globular jars are the pottery types that occur during this cultural phase. Vessels with channeled spout were also introduced.

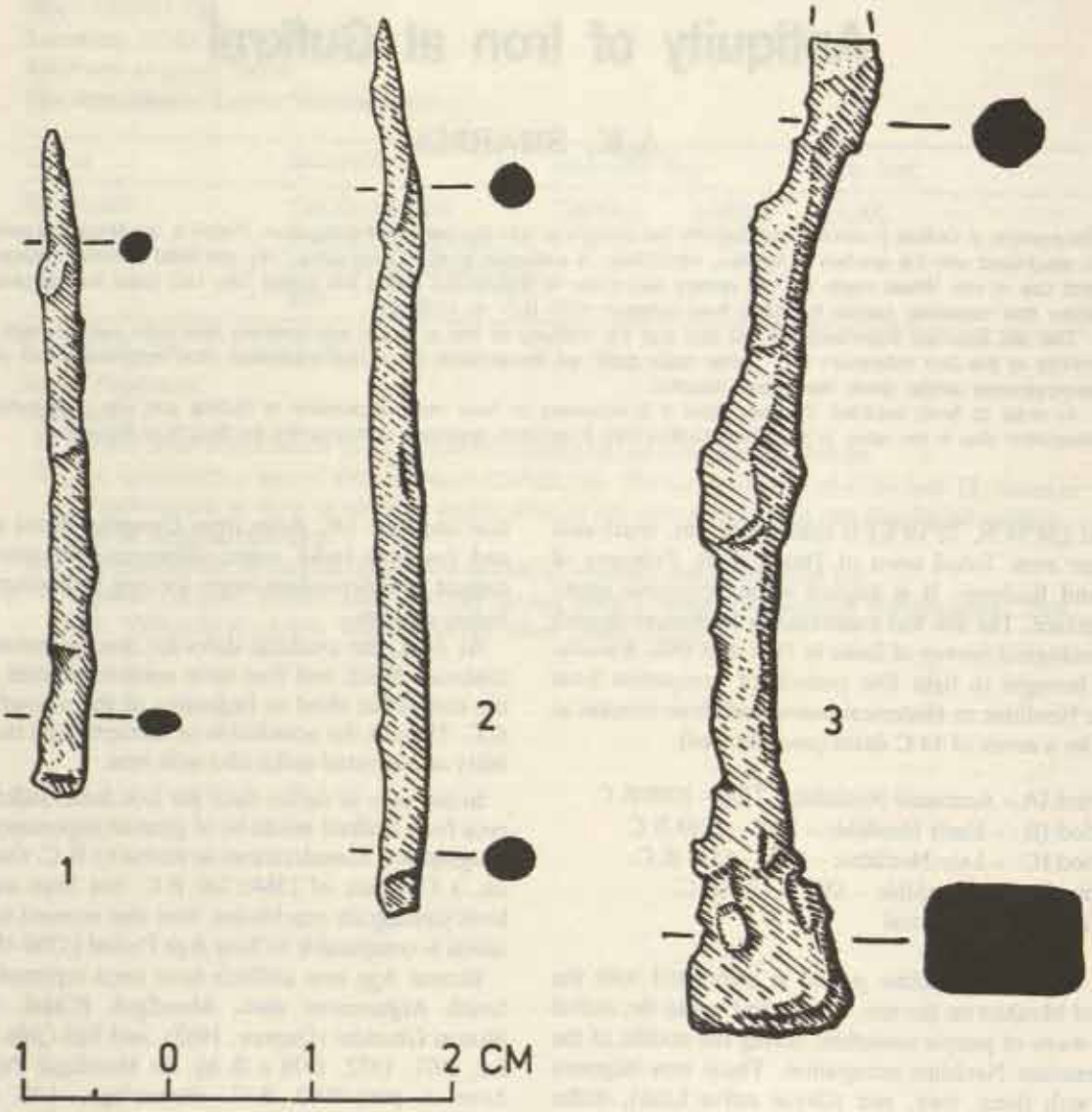
In the present paper I would like to focus attention on the antiquity of iron in the valley. At least three 14c dates available (BS 431, BS 433 and BS 434) clearly indicate that the antiquity of this metal goes back from *1570*B.C. to nearly 1130 B.C. These dates push back the dates earlier than so far known from other sites in the plains. Though Dilip Chakrabarti has indicated that the date of the megalithic with black, red and black and red pottery at Kumaranhalli goes back to 1380/1200 B.C. (PRL-TL-47) and 1440/1100 B.C. (PRL-TL-50), we after examining results of recent excavation and new 14C dates from Gangetic Plains and Central and Southern India, reject diffusionist interpretations and suggest an independent origin for iron technology within the Indian context.

At Ahar, the available dates for iron recovered from Protohistoric Black and Red ware context indicate a date from the end of the third to beginning of the second millennium B.C. There is the association of domesticated rice and possibility of cultivated millet also with iron.

In the wake of earlier dates for Iron from Gufkral, the evidence from Gufkral would be of greatest importance because of geographical considerations as stated by R.C. Gaur. At Marlik, a C14 date of 1364±100 B.C. has been assigned to a level yielding six iron blades. Iron also occured at Galighai V which is comparable to Iron Age Period (1330-1000 B.C.).

Bronze Age iron artifacts have been reported from three South Afghanistan sites, Mundigak (Casal, 1961), Deh Morasi Ghundai (Dupree, 1963), and Sail Qala Tepe (Shaffer, 1971, 1972, 1978 a & b). At Mundigak Periods III-IV have a post–3000 B.C. chronology. 14C dates from Sahri-Sokhta 11(7), (6), (5), III(4-3), IV(2-1) and IV(O) which could be equated with Mundigak IV in respect of indigenous ceramics indicate that Mundigak IV might be assigned to 2300-1900 B.C. The material remains from Said Qala Tepe I-IV are nearly identical to those of Mundigak III-IV. The 14C dates available are for Period I-1775±220 B.C., Period II-1868±90 B.C., Period III- 1960±220 B.C.

From Gufkral at least three identifiable artifacts of iron were recovered from Period II. Two are needles (5.6 cms. & 4.5 cms. long) which are highly encrusted and third one appears to be a nail (7.5 cms. long). 14C dates ranging from 1550 to 1100 B.C. of the Megalithic Period which had yielded iron indicates possible diffusion from Iran-Afganistan area to Kashmir valley. The migration from East and North East through the Pamirs and the Hindukush could be dated to a little before the middle of the 2nd millennium B.C.



But before anything could be said with certainty further excavations should be conducted at Gufkral and other Megalithic sites (e.g. Baramulla and Dwi-ekam-Pura) in Kashmir valley to obtain more positive evidence. It also becomes necessary to re-examine the finds from Burzahaom.

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Section 9

Marine Art

The Buddha and Bodhisattva as Rescuers of Seamen

NALINI RAO

This paper examines the visual depiction of the Buddha and the Bodhisattva as rescuers of seamen as it occurs in the sculptural reliefs and paintings of ancient India. It concentrates on the nature and method of representation, the relation between text and imagery, the iconographical tradition, the design and type of ships and its historical context. It also deals with the protective function of the Bodhisattva and the uses and functions of the imagery in relation to the monastic establishment at Ajanta.

One of the earliest sculptural depictions of the protective role of the Bodhisattva Padmapani for seafarers can be found in the caves of Kanheri. In this second century A.D. representation of a scene of a shipwreck on sea are seen two men praying for rescue to the Bodhisattva, who sends two messengers. This is the oldest representation of sea voyage in art when India's maritime trade had reached far and wide to Rome, Egypt, Afghanisthan and China. The importance of trade to the economy was increasing as did the dangers at sea for traders who were mainly Buddhists. The above scene might be a specific sea voyage or a generic one though it is hard to establish one or the other in the absence of any written or oral evidence.

However, it is in the paintings at Ajanta that we find three important scenes of shipwrecks in the context of Jataka stories. One of them fills the whole section of the center section of the right aisle in Cave XVII consisting of panel about 29 scenes depicting the Simhalavadana Jataka. The story deals with a king named Simhakesarin. There lived a merchant named Simhaka, who had a son called Simhala. Simhala went on a sea voyage and was shipwrecked and washed ashore on an island inhabited by witches who had the ability to transform themselves into beautiful women. The witches led the traders to their city and allured them by their beauty. But Simhala came to know about the fate of all those who had been captured by the witches and of their greed to devour people. Next morning, Simhala went to the north and managed to escape alone to India on the back of a magic horse, Balaha (Pl. 55); the witches followed him to India and there devoured the king Simhakarin and his ministers. The people installed Simhala as their king who conquered the Copper Island of the witches. In the painting, the artist has depicted the *Mūlasarvastivādin* version of the story as he portrays the conquest of the Copper Island which appears only in this version. He has represented all the important events in the story that appear in the text, though there is no rigid faithfulness to the text: the motivation for narration seems to be on the progress of the action of the story. The first scene depicts two ships stranded on the shore. Above is a gateway leading to the witches' city and a number of scenes in which the flying horse appears. The upper part of the middle of the pictures is Simhala's native city. The palace complex with its *antahpura* (inner chambers) can be seen. The whole planning of the city seems compitable with ancient Indian city structures. The entire narration is a stylized pictorial composition with no difficulty in following the sequence. It starts from the bottom right, proceeds to the middle of the picture, then Simhala's house on the left, and around the royal palace; from here to the right again towards the events in the lower half of the middle section of the picture, where with the crossing of the ocean and defeat of the witches, the story ends. In this continuous method of narration (wherein the figure occurs again and again), even the size and scale of the figures complies with the importance given to them in the story – thus it is more conceptual than realistic. The numerous figures are bigger in scale than the buildings, shops, chariots and animals which are smaller in proportion to the people. In regard to the illustration of the ship on the same wall in Cave XVII is a second ship depiction; it shows the merchant, Simhala stranded on the coast of the witches' Island. Here, the artist has reproduced the hull, so the vessel as usual is disproportionately small; he has also suggested rigging by drawing three masts. However, in relation to the actual depiction of the Buddha or Bodhisattva, the painting conforms to the aniconic representation during the early Hinayana tradition and is more conceptualised as can be seen in the visual representation of the *Jātaka* story of Kalyanakarin and his brother found over the right cell door in cave XVII.

The Story of Kalyanakarin is not found in the Pali *Jataka* but often occurs later in Buddhist literature. It was included in two *Vinaya* collection – the *Vinaya* Dharmagupta and in the *Mulasarvatvavada Vinaya* version which it follows. The story goes that a certain king had two sons; the elder named

Papakarin was wicked. Once the two set off on a voyage to acquire wealth. On their way back the ship sank and everyone except the two brothers were drowned. In order to obtain the riches that Kalyanakarin had obtained, Papakarin put out his brother's eyes while he has asleep, robbed him and left him. As a blind musician, prince Kalyanakarin arrived at the royal court in a foreign land. The king's daughter fell in love with him and chose him to be her husband. The prince soon regained his sight and returned to his father's kingdom with his wife and ruled over the kingdom. The first scene of the story is set on the ocean with Kalyanakarin seated in a pavilion in the center of the ship and wearing a crown; to his right is Pápakarin wearing a smaller crown. On the upper right hand, are two men seen again carrying a cask probably full of jewels. To the left, the ship is sinking while to the right, a drowning man is stretching out his arms for help. To the left under the stern, another man is clinging to the trunk of a sea monster. Two more sea monsters are approaching the man. To the above, is a drowning man receiving help; he must be Kalyanakarin pulling out his brother out of water. To the right of the ship wreck scene, the two brothers are seated, while to the left below, the two appear again. Kalyanakarin is tired and his head is resting on his brother's lap. The rest of the story is damaged but at the bottom of the picture is the park where the princess chooses Kalyanakarin to be her husband. To the left is the court scene where the princess and Kalyanakarin are seated and he is now wearing the crown again. In the last scene is seen the father blessing Kalyanakarin and giving his permission for the marriage and his return to the country.

The whole progress of the story is very well recorded in a flexible manner, the primary purpose being to explain the idea that virtous men are helped in moments of danger when they appeal for help – though the Bodhisattva is once again not figurely represented. However, it is the ship which is of great interest to the maritime historian. The boat in which Kalyanakarin and his brother undertook a voyage is depicted twice on the wall of the left aisle in Cave I – first time sailing and the second time as sinking (Pl. 56). As in many maritime illustrations not only the part of the ship above water but also the part below the surface appear in the painting. Seen as a whole the hull is cresecent shaped with a high bow and stern and a curved bottom. In contrast with other Ajanta vessels, the planks have been shown and probably only the two ends of the ship should be imagined. There are eyes painted on both the bow and stern, probably intended to make the boats seem like living creatures of the sea. Instead of the usual rigging and structures on deck the painter has drawn a pavilion in the middle of the ship. It resembles those found in royal gardens. However, such a hull could not have supported structures on deck. But the painter also has painted realistic elements (despite the artificial pavilion) – he used the free space above to suggest the tackle. Three masts with sails loosely attached to the yards are discernible. He has also included two crew members – an oarsman in the bow and a steersman, in the stern of the ship. The steersman is standing on a ladder wielding a single steering oar in the water on the Star board side of the boat. To understand such an unusual picture, we have to know that one ancient method of steering the ship consisted of attaching oars that pivoted on their own axes to both sides of the stern. When the helmsman moved the tiller so that it rotated the blade of the oar in the flowing water, the current created pressure on the blade and caused the ship to turn. This type of steering mechanism only functions when the boat is in motion and the water is flowing along the two sides (hence the boat had to be towed to the shore).

Another interesting example of a maritime scene depicted in Ajanta can be found on the wall of the right aisle in cave II. The painting represents the *Puṛṇāvadā Jātaka*, a story about a merchant ship that picks up a cargo of costly sandal wood from an island and is then threatened by the demon to whom the ship belongs. The vessel's owner Ḍarukarnin calls on his brother Purna, a Buddhist monk for help and the monk flies down through the air to pacify the demon. The painting shows a broad vessel that is not floating in the water but resting on it like Kalyanakarin's ship. The line of the deck exhibits a similar steer, i.e., it is lowest in the middle and curves slightly upward towards the stern. This kind of steer is common also in Roman trading vessel and improved the ship's navigability. An additional protection is provided on the boat by two planks mounted on the stern and bow; the ship also has a decorative eye on the prow. In this panel the structures are given importance, in contrast with other pictures of Indian ships. They are reproduced in their entirety because only one person Darukarnin in the story had to be depicted in the boat. At the stern is a flag-pole with a flag while at the back of the ship is an open shelter underneath which are pots filled with water. In the middle of the boat is a cabin. While the three masts of the ship bend forward, the more number of masts being in contrast to Roman trading ships. Another interesting aspect of the narration is that a Buddhist monk is here represented figurally in contrast with other two representations mentioned above – probably serving an exemplary image to the monks in the monastery.

It is essential to understand the religious background of the portrayals of the Buddha Avalokiteswara (conceptually and figurally) as savior from dangers. In the 24th chapter of the *Saddharmapundarikasutra* is found the evidence wherein Buddha answers a question from a Bodhisattva about the meaning of Avalokiteswara. He explains the protective functions as one who delivers men from the *Astabhayas* or the eight dangers of life, namely, suffering, fire, flood, sword, chains, demons, enemies and distress at sea. It mentions that when sailors are driven on to the witches' island by a storm

Kalyanakarin was able and charitable, while the younger and call upon him, he resecues them from the island. The eight dangers correspond to the representation on the left front wall of the verandah in Cave XVII and on the front wall of the sanctuary in Cave II which is badly damaged. However, there is a close similarity between the text and the pictorial representation in the case of the distress at sea. At the same time the artist has modelled his representations in a relatively flexible iconographical tradition and sequence of the dangers is not rigidly adhered to. This was perhaps because the primary purpose of the artist or patron was to express the idea that the Bodhisattva Avalokiteswara redeems all those who pray to him for help in times of need and he was one who was full of compassion to those in danger. Distress at sea was one type of danger that could be represented in a concrete form and the experience of which was a reality. To the monks in the monasteries the picture of Avalokiteswara served as a guiding image and an object of meditation who wanted to follow the path of the Bodhisattva.

PART III

Miscellany

PART III

Miscellany

Factors Affecting the Preservation of Underwater Archaeological Sites

Ian Oxley

The last four decades have seen great progress in the practice of underwater archaeology, especially in the development and use of equipment and techniques to locate and excavate wreck sites. There has been remarkably little concern with the investigation of the underwater environment itself.

The existence of any archaeological site is the result of the interaction of two main factors: the natural element and the non-made (or non-modified) element. It is obvious that to understand the latter we should assess the former.

Therefore, the process of archaeological investigation must include an assessment of the natural environment of a site. Such an assessment should identify the processes which contributed to the formation of the site, particularly the preservation or degradation of the materials or deposits that compose it (MacLeod, 1987). The information gained may also be useful in predicting the types of information source, for example metal as opposed to wooden artefacts, which will be preserved on the site (Brown *et al.*, 1988).

The environment of a site also dictates the techniques and methods that will be most effective thorughout the archaeological investigation, from the pre-disturbance survey to the post-excavation analysis. Consequently, objective and quantified data on parameters such as temperature, depth, current patterns and visibility are fundamental to the formulation of an effective research design (MacLeod *et al.*, 1986).

Chemical (pH, salinity, corrosion potential) and biological (marine flora and fauna) data will contribute towards an understanding of the processes of degradation of the wide range of materials found on archaeological sites underwater. In addition, the discipline of conservation science will benefit from an increased knowledge of the burial conditions of objects and more effective conservation treatments will be developed (Ferrari *et al* 1990, Kenchington *et al* 1989, Oxley 1984).

The topics outlined above represent the subject of research for an MSc. (part-time) being undertaken at the University of St. Andrews. Contact with other workers in similar fields of research would be warmly welcomed. Correspondence should be sent to:

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Ancient Ports of Kalinga

SILA TRIPATI

The The ancient Kingdom of Kalinga mentioned in the Hathigumpha inscription of Kharavela (Ist century B.C.) extended from the mouths of the Ganges to the estuary of Godavari river on the East Coast. Ptolemy (100 A.D.) mentions that Paluru (District Ganjam), Konark, Puri (both in district Puri) and Kosambi (district Balasore) were flourishing Ports. Besides the inscriptions and other archaeological finds the *Brahmanda Purana* (10th century A.D.) also refers to the ships in the Chilika Lake and those which plied between Kalinga and south east Asian countries. Nanda raja, is said to have attacked Kalinga with the intention of getting access to the sea for the landlocked Kingdom of Magadha (Bihar). The ancient text *Artha Sastra* (3rd - 4th century B.C.) refers to Magadhan trade. The exports from Kalinga included elephants, cotton, salt and silk. The inscriptions of the Sailendra dynasty found in the Malayan Archipelago refers to overseas trade between Kalinga and south Asian countries. An attempt is made in this paper to highlight the rise and decline of Kalingan Ports and their contribution to the development of overseas trade and spread of Indian culture.

SILA TRIPATI

The literature shows that there have been flourishing ports along the 600 km long line of Orissa in the past which have played an important role in the maritime history of ancient India. Kalinga, as the present Orissa was known extended from the mouth of Ganges to the estuary of Godavari river in the south (Banerjee, 1931:3). The present paper information is gathered from the literary sources, archaeological evidences, and travellers accounts to throw light on the ports of Kalinga and their contribution towards the spread of Indian culture.

In Kautilya's *Arthaśaśtra* (3rd-4th century BC) the maritime activities of India especially the rules regarding sea trade, and construction of ports have been described (Mookerji, 1962:73-75). The Hathigumpha inscription of King Kharavela (1st century BC) indicates that the Magadhan Emperor invaded Kalinga to acquire sea ports of Kalinga, as Magadha did not have any sea ports of its own (Mahatab, 1959:174). Kalidas's reference in *Raghuvamśa* to the King of Kalinga as lord of the sea "Mahodadhi Pati" speaks of the maritime power of Kalinga (Das, 1977:115).

Sylvain Levi discovered Pithuṇḍa port (district East Godavari in Andhra Pradesh) on east coast of India and the Hathigumpha inscription reveals that Pithunda port which was deserted then was renovated by Kharavela (OR, 1964:19). *Jaina Uttarādhyāna Sūtra* also says that Pithuṇḍa had trade relations with Champa (present Kampuchea) even in the days of Mahavira (Sarma, 1981). Adzeitta (Ajita) another port on the Kalingan coast had active trade relation with Burma and was contemporary with Pithuṇḍa port.

Ptolemy's (100 AD) *Geography of Ancient India* describes Kalinga's major and prosperous ports like Nanaigam (present Puri) and Konagar (Konark) both in district Puri, Kosambi (district Balasore), Pālur (district Ganjam) in Orissa, Kalinganagar (district Srikakulam) in Andhra Pradesh and Tamralipti (distric Midnapur) in West Bengal. The *Brahmāṇḍa Purāṇa* (10th century AD) also refers that Chilika lake (district Puri) was a big harbour, providing shelter to the sea-going vessels. From this harbour vessels which sailed to Java, Malaya, Sumatra, Bali, Burma, China, Thialand, Ceylon and other places could the carry thousands of passengers (Das, 1975:7).

Among them Pālur, identified by S. Levi was one of the important and flourishing ports from the time of Ptolemy to Hieun-Tsang.

Ptolemy the Greek geographer has mentioned Pālur as an international maritime emporium further to the south-west, most likely at the Rishikulya estuary or nearby on the southern elongation of Chilika lake. Even today in this area a village bears the name Pālur. The presence of Apheterion, the point of departure for ships bound to Charyse or Golden land *(Suvarna Dvipa)* and the prominent hillock south of present village Pālur which during Portuguese period (16th century) was known as Serra de Palura and served as a landmark for early sea farers in the Bay of Bengal proves that Pālur was a port.

The *Mahaparinirvana sutta* and *Datha-Datu-Vamsam*, a Pali work by Dhammakitti of Ceylon tell that Brahmaduatta (543 BC) the King of Kalinga raised a stupa where he kept the sacred tooth of Buddha given to him by the Buddhist Arhat, Khemather by name for worship and the place where the stupa was built came to be known as Dantapura/Pālur.

The excavation branch of the Archaeological Survey of India, Bhubaneswar which had undertaken exploration near Pālur recovered sherds of bowls, dishes and jars of red ware alongwith a terracotta dabber and a wheel. Over an area of half a km these red ware sherds are extensively scattered in the midst of sand dunes and the habitational mound bisected by the road leading to Prayasi. On ceramic evidence the site may be assigned to the 12th century AD and it deserves a systematic excavation (IAR, 1984-85:56-60).

The Sailodhbavas migrated to South-east Asia through the port Pālur after the 7th century AD and established there a Sailendra dynasty. The Sailodhbavas were ruling over the land which extended from Mahanadi to the Rishikhilya river. This kingdom is known as Kangoda or Kanyadha (modern Ganjam) with its capital on the bank of the river Salima. Some scholars have identified Salima river with Sali which joins the Chilika lake. The lack of good relation with the Bhaumakaras of Utkal and Gangas of Kalinga, the Sailodhbavas might have taken the advantage of port Pālur to migrate to Malaysia. For this migration a favourable route was already created by the traders of Kangoda from Pālur. The Sailendra of Suvarna Dvipa are supposed to be the Sailodhbavas, emigrants from Kangoda. The discovery of certain stone inscriptions and copper plate grants both in Indian Peninsula and Malayan Archipelago, has revealed that they built some Buddhist temples in South-east Asia, and by the end of the 8th century AD all the rulers of Bali, Java, Sumatra, Malaya and Borneo owed their allegiance to the Sailendra dynasty (Mahatab, 1959:108-9).

Manikapatna (Adigrama) in district Puri located near Chilika lake is believed to have been a port as evidenced from a palm leaf manuscript. It probably flourished during the medieval period. Recently the Orissan Institute of Maritime and South-east Asian studies, Bhubaneswar excavated Manikapatna which revealed some Chinese celadon and procelain wares along with indigenous grey and red were pottery. The Roman rouletted ware and the Ceylonese coins found here suggest trade contact with foreign countries. Besides pottery, the terracotta and semi-precious stone beads, earrings, glass and decorated glass bangles were also recovered. Abul Fazl (in 1595-1596) mentions Manikapatna was a 'large port' where salt tax was collected and Mughals invited the Dutch to found a factory at Manikapatna. Other ancient ports of Kalinga could not be identified on account of changes in names. However, the exploration undertaken by scholars has revealed some of the ancient ports like Boitakuda, Banijpur on the coast of district Puri in Orissa (Prachi, 1931:15).

The Kalingas had a sound knowledge of materials such as varieties of wood required for boat-making in ancient times. According to the principles of *Yukti Kalpataru* of King Bhoja of Dhara (11th century AD) Kalingan people also divided sea-going vessels into two categories on the basis of dimension, (a) Sāmānya (ordinary class) and (b) Visēsha (special class) (Singh, 1962: 548-50). This fact clearly indicates that the Kalingas had a large fleet of boats for inland and overseas trade, namely the Bhelaka, Bariratha, Nauh, Tarikah, Plavah, Tarandhuh, Vahanah and others. Some boats had many sails and masts with the capability of carrying two hundred people as described by Fahien (Majumdar, 1973:12). A small vessel was attached to the main boat which can be called as a life boat to save human lives in case of damage to the main one. Although the boat motives are not profusely depicted in Kalingan art, they can be visualised from the boats depicted in the Bhoga-mandapa of Sri-Jagannath temple Puri and a small medallion of Lingaraja temple Bhubaneswar.

The accounts of Megasthenes and Kautilya's *Arthasāstra* as well as Hiuen-Tsang's *Si-Yu-Ki* speak of the transaction of Kalinga during ancient times. The chief export commodities were rice, bajra, cotton, silk, salt, elephant, gems, pearls, ornaments, fine cloth, ivory and diamond (Das, 1978:48). The diamond obtained in Sambalpur was famous especially in countries like Persia, Egypt and Greece. Similarly, the elephants and tusks of Kalinga were appreciated in the neighbouring provinces. R.D. Banerjee opines that Kalinga had trade contact with the coastal regions of Africa and with Mexico and Peru by sea (Banerjee, 1931). For the safety of this extensive trade the people of Kalinga maintained a naval force escorting and protecting the merchants in the Indian Ocean.

The recovery of foreign coins of 3rd and 4th century AD besides the roulletted ware, clay bullae and iron caltrops during excavation at Sisupalgarh has confirmed trade relation of Kalinga with Rome (AI-5:62-105).

The *Deepavamsa* and *Chulavamsa* (Buddhist religious books) state that during the reign of Ceylonese King Agrabudhi-II (592-602), the Kalinga king and his queen visited Ceylon. It also mentions that King Vijayabahu of Ceylon (1054-1109) married a Kalinga Princess named Triloksundari.

The history of Burma tells that Kalinga had good relation with Burma and Buddhist preachers from Kalinga came to Burma through the sea route and preached Buddhism in Burma. The 'Dharakshetra' in Burma was a prominent settlement of Kalinga. In course of time the Kalingas occupied the throne of the Prome Kingdom and ruled there for many years (*Prachi*, 1931:31).

The Maritime relation of Kalinga with China and Arabian countries is brought to light by the excavations at Khalkata Patna near coastal areas of Puri on the left bank of the river Kushabhadra, where the Chinese celadon ware along with the egg white glazed and glazed chocolate ware of Arabian origin were found with the indigenous dark grey pottery. The discovery of Chinese copper coins with the characteristic square perforation in the middle bearing legend in Chinese character on both sides proves that Khalkata Patna was a Port town during 12th century having maritime trade both with the east as well as the west (*IAR*, 1984-85:56-60). The depiction of a giraffe on the Konark temple suggests Kalinga's contact with Arab and African countries.

Raghavaraja Chola captured the islands of Kalinga in the high sea in the conflict between the Cholas and the Sailendras which continued throughout the 11th century AD, and caused a setback to the maritime trade of Kalinga. Later on due to the Arab interference in the Indian Ocean the maritime trade was again disturbed. The Gangas, however,

could not protect the trade interests of Orissa as they had a weak naval force (Das, 1978-48). The Muslim and Mughal rulers raised the commercial taxes from the rulers of Orissa.

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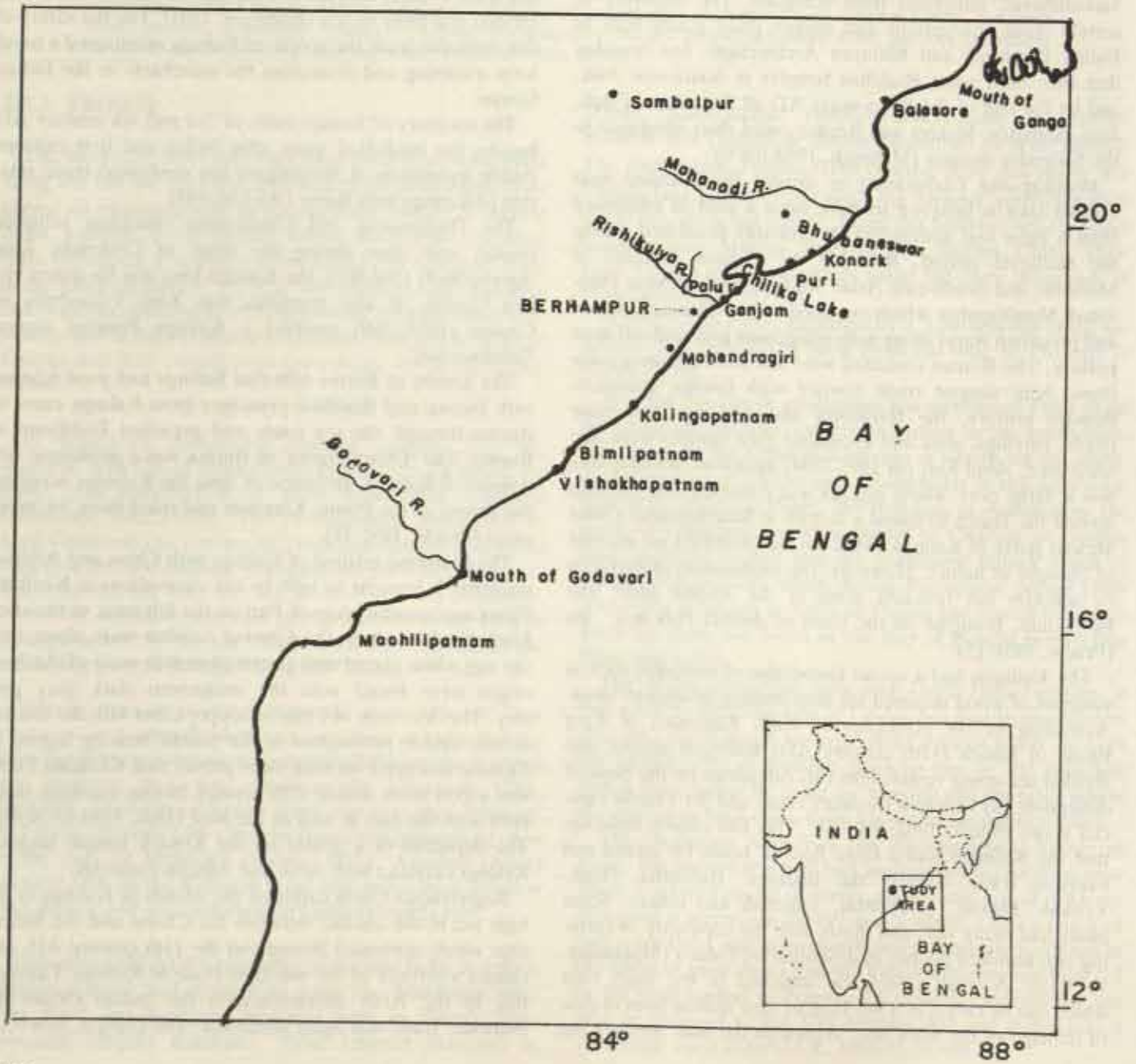


Search for Shipwrecks in Goa Water

MANAVI THAKKAR

Amee Shoal

After a local tipoff describes the possiblity of a wreck in Amee Shoal area, the Marine Archaeology Unit, (MAU), of the National Inst. of Oceanography started under Dr. S.R. Rao's direction exploration in a water depth of about 3.7m. The water depth in the centre of these shoals is less and gradually increases in the Northwest direction. There are two other locations on these rocky shoals which are marked on Naval Hydrographic charts as probable shipwreck points both in shallow waters of 5.7 m and 3.7 m suggesting that the vessel's must have run aground on the rocky shoals. There are bottom eddy currents or gyres in this area which constantly churn up sediment. The fine sediment is poorly sorted and consists predominantly of silts and clays which are present in the central bay area of low energy. The eastern part and also the area we explored has coarser sediments.

Exploration of the site by MAU in December 1989 revealed large and well dressed granite blocks ranging in length from 30 inches to 86 inches and width of 15 inches to 42 inches. The orientation of these is random. The highlight of this are was the discovery of two five prong anchors. Anchor ‡1 had a shaft length of 80 inches and a diameter of 24 inches and was lying in the North-south direction. Anchor ‡2 lay in almost the same orientation some 12.8 inches apart facing Northwest with a shaft length of 98 inches and a diameter of 24 inches. The climax of the survey was the discovery of three cannons (Pl. 29) of which only the barrels survived. Cannon piece 1 oriented North South with a length of 77 inches; cannon piece 2 oriented North East with a length of 75 inches and a diameter of 4.11 inches and cannon piece 3 lay at 30° to piece 1 with a length of 77 inches. A few small blocks of 18 × 5 inches lay in between the cannons. The exterior is encrusted with calcareous materials and muscles. The sand in the area (medium grain) does not favour preservation. Obviously if more details could be worked out it would give an insight into how ships worked, where they were going, what kind of artillery they were carrying. After comparing the barrel to several cannons we feel it might be a Drake (commonwealth Culverin). Drake is a term used to describe guns which were shorter though not always lighter than ordinary guns and the barrel did not taper. But the culverin drakes are usually lighter. The cannon we found is an alloy of metals which could account for its being lighter. Also according to Robert Norton drakes require a paves charge of 1/3 to 1/2 of ordinary go as of the same calibre. Therefore even in that period weight and price were a major criterion and large calibre low weight composite cannons must have been favoured. Our cannons also showed a distinct cascable button slightly rounded at each end which was unfortunately not measured but confirmed that the objects at our site were indeed parts of cannons. Typical lengths of the commonwealth barrels are around 75 cm and lengths averaged around 76 cm. The barrel construction is usually one piece construction. Before any more definite conclusion can be drawn a detailed u/w survey map of the area needs to be prepared and some of the cannons need to be lifted and treated so that the alloy is determined and if there is a seal or marking of the manufacture we can determine the details of shipboard use, vessels of artillery. A propeller was also reported N.E. of this site. We are excited at the prospect of what this site has to offer and are looking forward to further excavations in the future.

Portuguese literature is rich in its reference to wrecks along the Goa coast, which obviously suggests strong maritime activity and important trade links that Goa had with Portuguese and neighbouring ports. In the 15th and 16th centuries spices such as pepper were valued higher than gold. The great route for spice was Malacca to Aden via the Malabar or Gujarat (Dabhol Chaul, Goa), Red Sea and the Persian Gulf. The Portuguese needed a secure base from which they could patrol western India and Goa is located on the crucial NW Sector of the Arabian Sea, midway between key economic areas of Malabar and Gujarat. Fleets could attempt to control trade of both the areas. In the 15th century Goa was the main port of trade for both Bahamani and Vijaynagar kingdoms. Besides spices horse trade was another key factor in the Goan economy. At least a 1000 horses came through Goa each year and there were import taxes on them. The Portuguese also tried to centralize the entire horse trade through Goa so that any ship coming from S. Arabia with horses for the Indian market could come only to Goa. Their main aim was to take over the trade in spice and horses from the Muslims.

The spice trade mainly took place in Old Goa where the Portuguese had forts and factories. The vessels left Lisbon by March end and reached Malabar by September end. Annually about 1500 ships plied between Portugal and India. 70% of these would carry back spices (pepper, ginger, cinnamom, cardamoms, tamarind, cotton seedling and wax) and the rest were sent for guarding the Malabar coast and as security vessels to escort the spice vessels.

The coastline of Goa consists of a narrow strip of sandy plains and beaches. This sandy shore is interrupted by estuaries and at other places by laterine plateaus of the central sector which jut-out to form headlands. The promotones of Baresh and Sashti created estuaries of the Mandovi and Zuari which give a fine natural harbour and two anchorages;

Marmugao in the South and Aguada in the North. Marmugao is sheltered even during the south-west moonsoon and serves as an all-weather port. Aguada was a one time fuel and water supply point which is currently not being used as a harbour. The seasonal port of Panaji where Goa-Bombay steamers, fishing trawlers, ferries and country craft dock, require a continuous dredging as a natural sand bar makes it unapproachable. Also the ports of Betul, Talpona, Chapora and Terekhol are seasonal. Goa is gifted with islands such as Chodan, Tiswadi, Kumbarjuve, Anjediva. The islands are of two types (1) alluvial and (2) rocky. The latter are protrusions of drowned topography separated from the mainland by faulting. The basic Geology of the area is Schistone and gnossone rocks of the Dharwar supergroup. However twothirds of the territory is covered with laterites. The hydrographic survey map shows reefs at Aguada head around Rai Magus, Cabo, Sunchi reefs and Amee Shoals, Odshel and Kankona; all in shallow waters (0.9m–3.4m). The reefs are dying out probably due to global warming or siltation from the dredging in the surrounding areas. An ever increasing global warming trend causing accelerated sea level rise and increase in sea surface temperature has affected the marine community specially the corals because they are close to the shoreline and in shallow water. During the Holocene period when the sea level began rising and conditions for coral reef survival such a water temperature of 25–29°C and clear shallow waters were not available the corals migrated and moved towards the shore. Thus successive rises in the sea level kept requiring the coral community to migrate closer to shore. The signatures of sea level rise are therefore entrenched within this fragile ecosystem. The present day reefs along Amee shoals and Sunchi reefs are fringing reefs.

The Amee shoal reef extends in a North-South direction across the entrance to the bay and separates the bay from the Arabian Sea. There is coarse sediment extending from the North-West end of the bay to inflow and outflow of currents and fine material is not allowed to settle here. The coarse material predominantly silt and clay along with the calcareous sand does not favour preservation of archaeological material because such an environment is highly susceptible to biofouling.

Wrecks shown in hydrographic chart.

Type	Lat.–Long.
Wreck with hull intact	15°29′30″, 73°47′07″
Wreck with hull intact	15°29′16″, 73°47′32″
Wreck of which exact depth	15°26′15″, 73°46′35″
is not known but is thought	15°26′08″, 73°46′50″
to be 30 m or less and	15°26′02″, 73°46′50″
dangerous for surface navigation	15°25′42″, 73°46′54″

Besides the wrecks in the Amee Shoal area a few wrecks listed by P. Gudigar on the basis of the information available in the Marine Records are worth noting.

It is said that twelve Portuguese ships which were to go to Calcutta sank owing to a severe storm near Aguada and seven smaller ships were also lost in Nerul river; the loss is being estimated at one million xerofins. The date of the disaster is put at 24th April, 1648 (Ref: *Subsidos para a historia Militas Maritima da India*, by Botelho de Sousa).

Five Portuguese wooden sail vessels namely *St. Helena, S. Joao, Evangelista, St. Francisco* and *St. Thome* set sail from Portugal to Goa. Only two managed to approach the Goa coastline and they were also wrecked in a storm. The *S. Cristovan* and *Santo Andre* both being Portuguese wooden sail vessels were lost due to natural calamities. The latter was sailing from Lisbon to Goa (Ref: *Anees da Mannha Portuguesa*, I *Parte Quarta Memoria)*.

The Portuguese relied on sea power and trade and ceased internal expansion as it would not yield any additional economic profits. The desire to acquire products from the African coast and crush the Arab power and trade, to discover the extent of the Muslim territory and spread christianity were also some of the driving motives besides their love for adventure. The commercial motives were that exotic spices and aromatic goods spices, pepper, cardomom, indigo, saffron, pearls, ivory, silk, muslin, alum, carpets fetched good revenue. The Portuguese profited from parasitic activity, they skimmed off money without providing reciprocal advantages or engaging in trade themselves. The profits derived from customs duties were sent to Goa for general state needs. Therefore Goa can be viewed as the centre of Portugal's seaborne empire getting revenue not from its own economic activity so much as its dominance (political and military) in Asian waters.

The large number of shipwrecks on the coast makes us wonder at the kind of maritime technology that the Portuguese possesed. A lot of these shipwrecks are due to old ships sailing on long voyages. The greed for profiting by building cheap vessels and overloading of ships, buying of ports in the Portuguese armada, lack of spare sails and not enough provisions and spares are perhaps some of the reasons for so many disasters. Overcrowding and overloading of heavy goods on top for easy offloading were also dangerous practices. A lot of the teakwood was immature and unseasoned and it would shrink and split. The dampness of the water on the outside and the heat of the pepper inside made the timber rot. The lack of repairs such as refitting of timbers and nailing and stiching of sails was never finished properly. It resulted in concealed defects showing up on a voyage.

Grandy Island (Pl. 27)

At this site the ship is located about 6 km west of Marmugao harbour (Fig.1). Hydrographic chart and information from fishermen helped the Marine Archaeology Unit to search for the wreck at the proper station and exploration was undertaken in November, 1987. This seems to be a steel-hulled cargo vessel with a cabin, hatch, bridge and accomodation. It is more than 32 m long. Though the cabin is ransacked, its lower deck and hull which lie covered by 1.5 to 2.0 m thick layer of sediment seem to be intact. The vessel lies tilted towards the star board side and a small portion of the

edge of deck covered by coral is visible. The mast and ladder are lying on the sea floor. The cabin of the ship, visible during the low tide is 9 m in height, 5 m in length and 4 m in width. According to S.N. Bandodkar, Diver-Photographer, this ship might have sunk in a storm after it lost anchor and drifted towards the rocks near the shore. This wreck can be an excellent training base for marine archaeologists.

Baga Shipwreck:

The Deputy Inspector General of Police, Panjim was informed by local fishermen near Baga village that some artifacts from a wreck were being removed stealthily. He informed the Marine Archaeology Unit and showed the spot which is 15 km north of Mormugao harbour. Exploration was carried out 200 m seaward of the Baga beach in water depth of 3 m to 6 m and diving was undertaken on24th November, 1990 after anchoring the survey vessel *Sardadevi* in 2 stations. Divers of MAU explored the area within 100 m radius of the vessel, but were unable to locate the shipwreck. At a water depth of 3m the seafloor is rocky and thickly covered with sponge, while in 5 to 6 m there is coarse sand. During exploration divers recovered a two-holed stone anchor, which is rectangular in plan and section with a square socket on the top. This anchor *in situ* was photographed and lifted. The Marine Archaeology Unit is planning further exploration of the area to-locate the shipwreck.

Participants in Exploration

S.R. Rao, P. Gudigar, M. Thakkar, Sundaresh, S. Tripati, S.N. Bandodkar, A.S. Gaur, S.B. Chitari, Y.D. Sharma

The Lost Temple for Vaisakheswara off Visakhapatnam, Andhra Pradesh, India

E.V. GANGADHARAM

Local oral tradition, some inscriptions and old maps suggest that there probably existed a temple on the western shore of the Bay of Bengal at Visakhapatnam (Long. E 83° 15'; Lat. N17° 40'). until about the middle of last century. One version of local history says that the temple may have been built by Kulottunga Chola in the 11th Century A.D. while another suggests that it may have been built by an Andhra ruler much earlier. The presiding deity of the temple is said to be Vaisakheswara, also known as Karthikeya or Kumaraswamy (son of Lord Shiva), the Hindu god who is regarded as the ruler of the planet Mars, and who is traditionally identified as the Lord of War.

A study of old coastal topographic maps of the Survey of India and old Naval Hydrographic Charts indicates intense erosion of the coast in the region of Visakhapatnam in the last century. The landward recession of shoreline gives credence to the possibility of any temple that may have been built on the shore atleast 1100 years ago to have become submerged. The slope of the near-shore continental shelf suggests that the ruins of the temple and its foundation consisting of blocks of rock could not have been completely washed away upto the continental slope, but likely to remain within half a kilometer of the original site. The local coast is highly rocky without crops of country rock jutting out of surf zone even now. Severe bi-annual monsoons characteristic of the region are likely to keep the sandy shore shifting its sediment alternately northwards and southwards. This suggests the possibility that atleast some of the sculptured and unsculptured blocks of the collapsed temple and its foundation could be either, projecting just above the sea-bed or concealed just underneath it.

The experience gained during the preliminary diving operations commenced by the Eastern Naval Command for the Vaisakheswara Temple Project of this Centre in October 1989 has resulted in the formulation of a systematic search plan to be undertaken in the immediate future. The paper gives details of the background information on the Temple, its coastal geological environment, the diving operations, equipment used and discusses the search plan evolved.

Pl 1. Justice Mr. M. Rama Jois delivers the Inaugural Address. From left, Dr. A.H. Parulekar, Mr. C.T.C. Dobbs, Prof. G. Venkatasubbiah, Justice Mr. M. Rama Jois, Prof. U.N. Roy, Dr. S.R. Rao, Dr. B.U. Nayak.

Pl 2. Chief Justice (Retd.) Mr. E.S. Venkataramiah delivering the Valedictory Address of the conference.

Pl 3. Participants in the conference.

Pl 4. Participants and observers

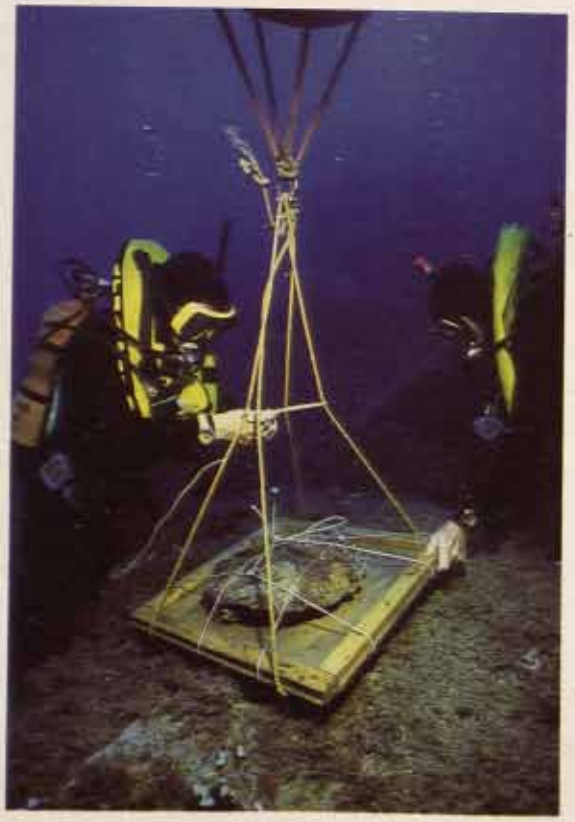
Pl 5 & 6. Terracotta seals from Bangarh and Chandraketugarh.

Pl 7. Terracotta seal from Chandraketugarh.

Pl 8. Intaglio from Peddavegi

Pl 9 Diver examines an antiquity, Giglio.

Pl 10. Bronze helmet, Giglio.



Pl 11. Lifting antiquities, Giglio.

Pl 12A. Un Sommozzatore dell'équipe subacquea di Oxford University MARE al lavoro con la sorbona sul fondale marino antistante Punta del Lazzaretto.

Pl 12B. La basca di Oxford sulla navi di Punta del Lazzaretto.

Pl 13A. The helmet from the Giglio wreck as it was when found.

Pl 13B. The helmet from the Giglio as it was when found.

Pl 14A. Corinthian aryballos with painted ram pitch on neck. Olivepip in pitch – Giglio ship.

Pl 14B. Giglio wreck: An Etruscan aryballos painted with boats; a jug (perhaps from corinth); an slack-dipped aryballos from Spata.

Pl 15A-B. Frammenti di anfore greco-italiche recuperati dal relitto naufragato a Punta del Lazzaretto databili al II sec. a.C.

Pl 16. Frammenti di anfore greco-italiche recupesati dal relitto naufragato a Le Scole databili fra fine IV-inizi III sec. a.C. Le anfore di questo pesiodo appartengono alla prima fase della produzione greco-italica e si distinguollo pes un corpo più corto e più largo.

Pl 17. MARE Group unloading equipment.

Pl 18. Bet Dwarka: Offshore Wall

Pl 19. Bet Dwarka: Masonry

Pl 20. Dwarka: Bastion

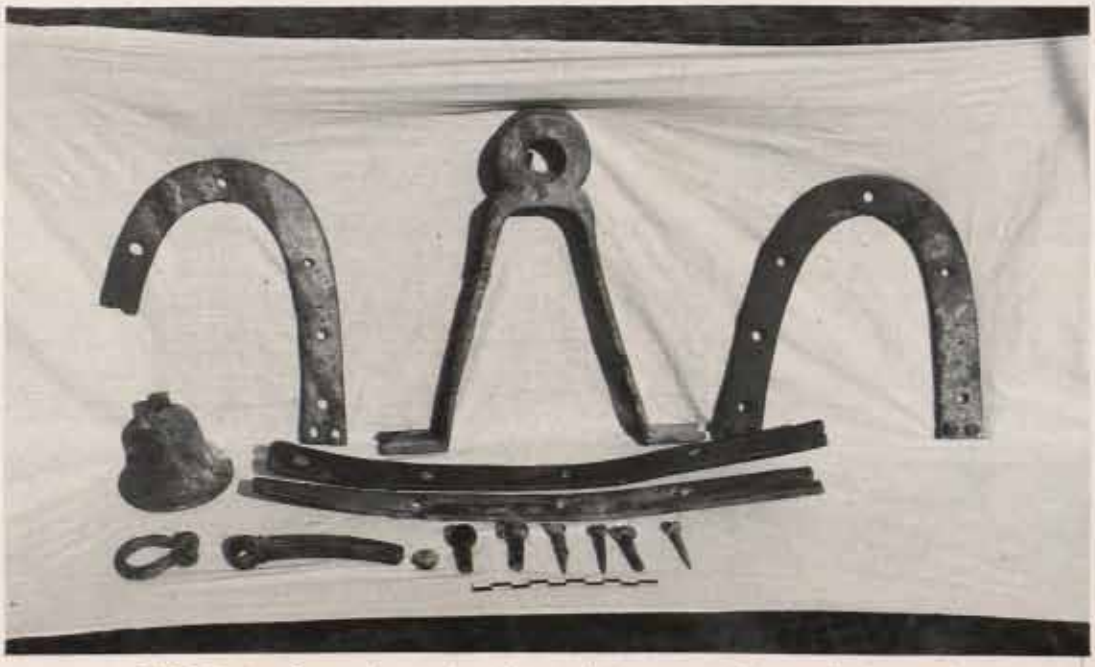
Pl 21. Dwarka: Wall

Pl 22. Dwarka: Diver plots the corner of a protection wall in the sea.

Pl 23. Ms. Manavi Thakkar, diver uses Aquazepp, an underwater scooter for survey of submerged buildings of ancient Dwarka.

Pl 24. Crescentic and L-shaped joints in a massive bastion of ancient Dwarka city submerged in the sea.

Pl 25. The Diver-archaeologist plots a massive building of Dwarka in the sea.



Pl 26. Dwarka: Brass arches, nails and copper bell – recovered from sea-bed excavation.

Pl 27. The Marine Archaeological expedition team surveys a sunken steel-hulled ship near Grandi Island, Goa.

Pl 28. A diver archaeologist plots the excellent masonry of submerged buildings of Dwarka.

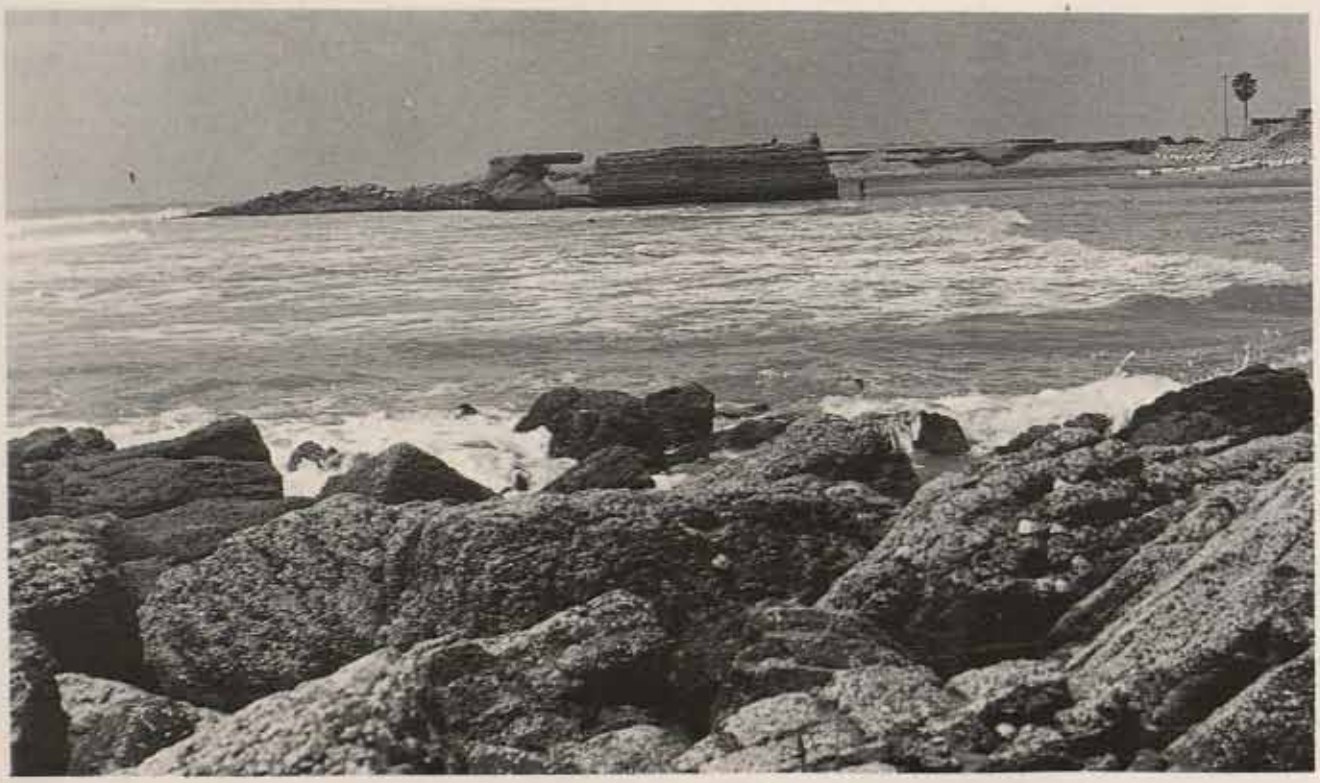
Pl 29. A diver archaeologist measures one of the three cannons in the shipwreck of Amee Shoals in Goa waters.

Pl 30. General view of Haigunda Island, Dt. Uttara Kannada.

Pl 31. Sculpture of Surya flanked by Buddha sculptures, Haigunda.

Pl 32. Yaksha figure, Haigunda.

Pl 33. Sculpture of Vishnu, Haigunda.

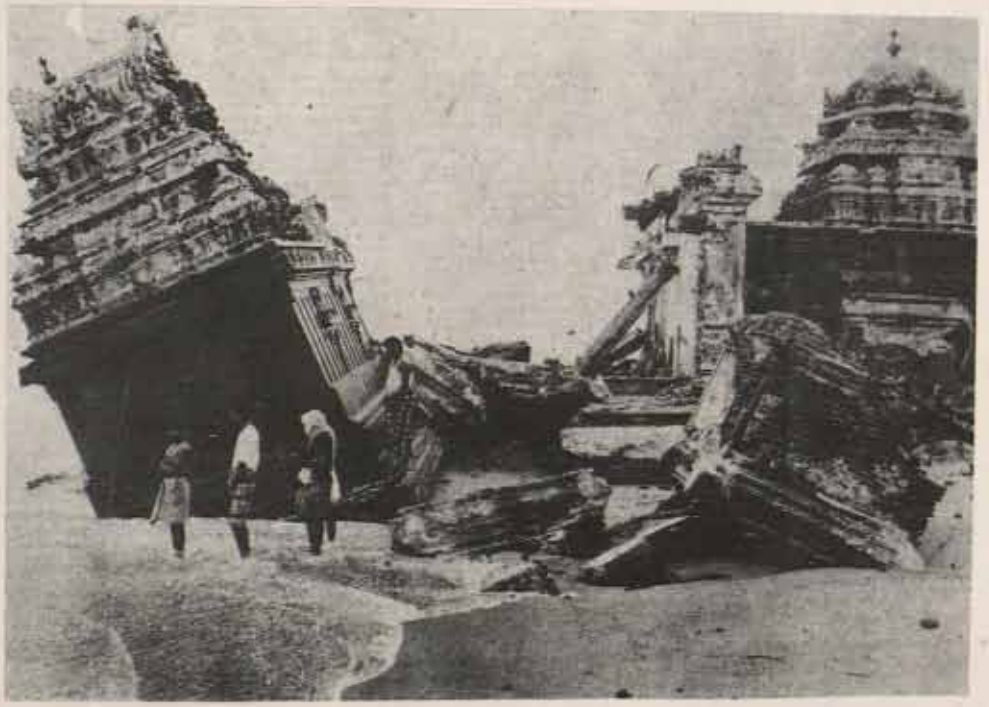


Pl 34. Havoc wrought by the sea on the Danish Port-installations (in the sea)

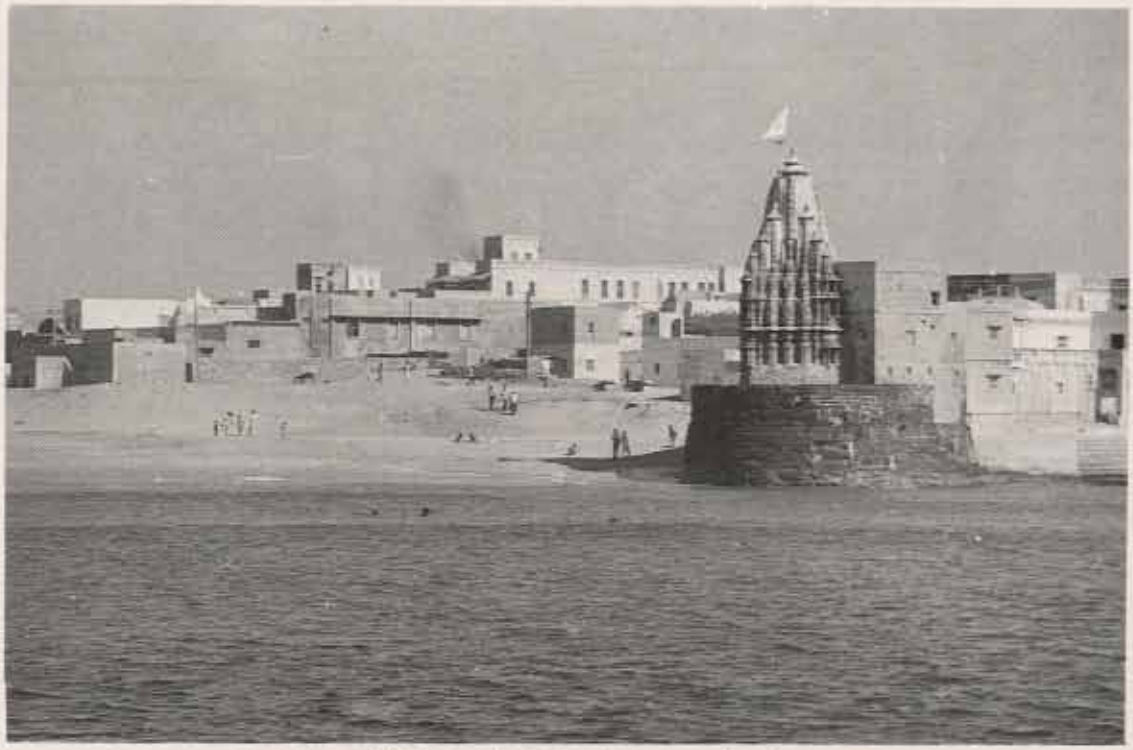
Pl 35. Tranquebar : Masalamani Temple.

Pl 36. Tranquebar : Local fishermen collecting coins in the intertidal zone.

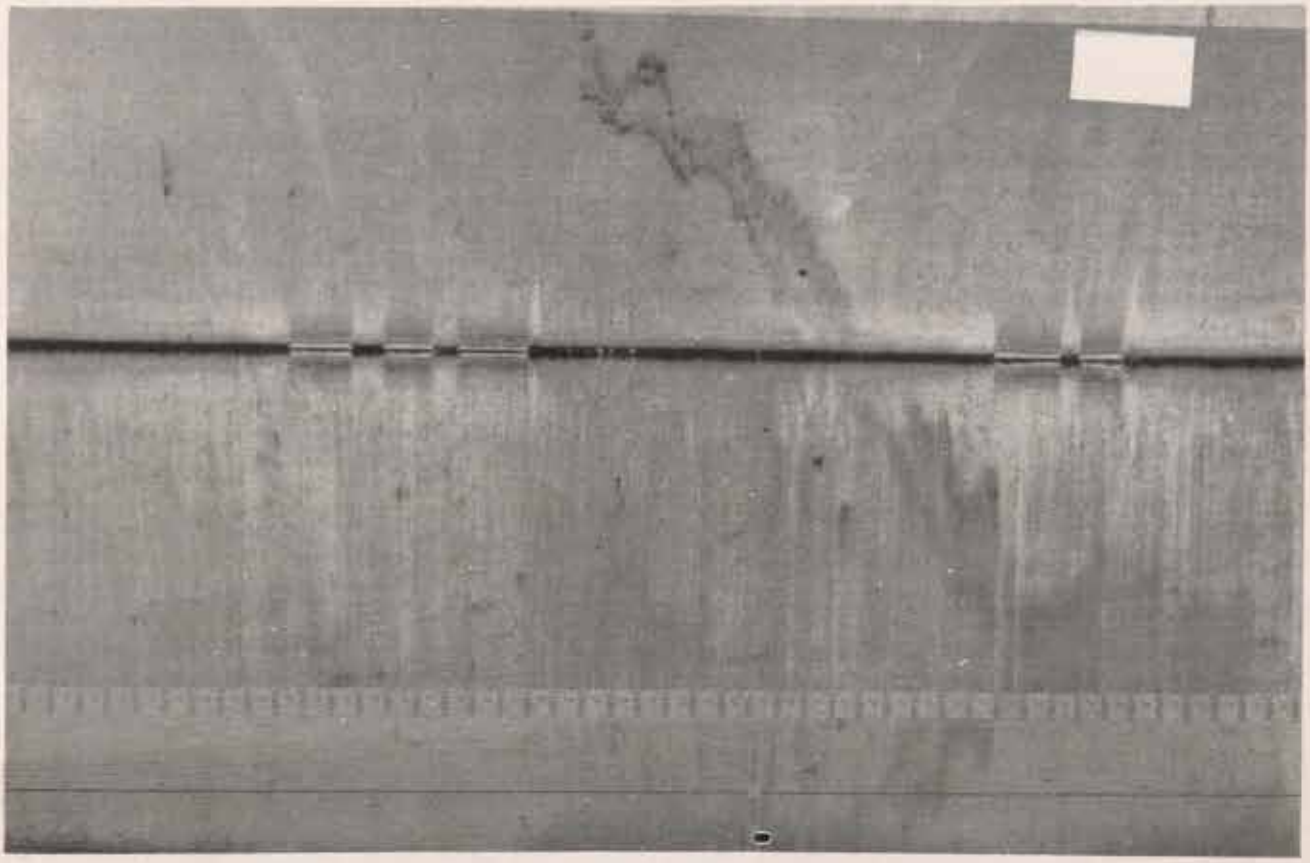
Pl 37. Shore temple, Mahabalipuram.



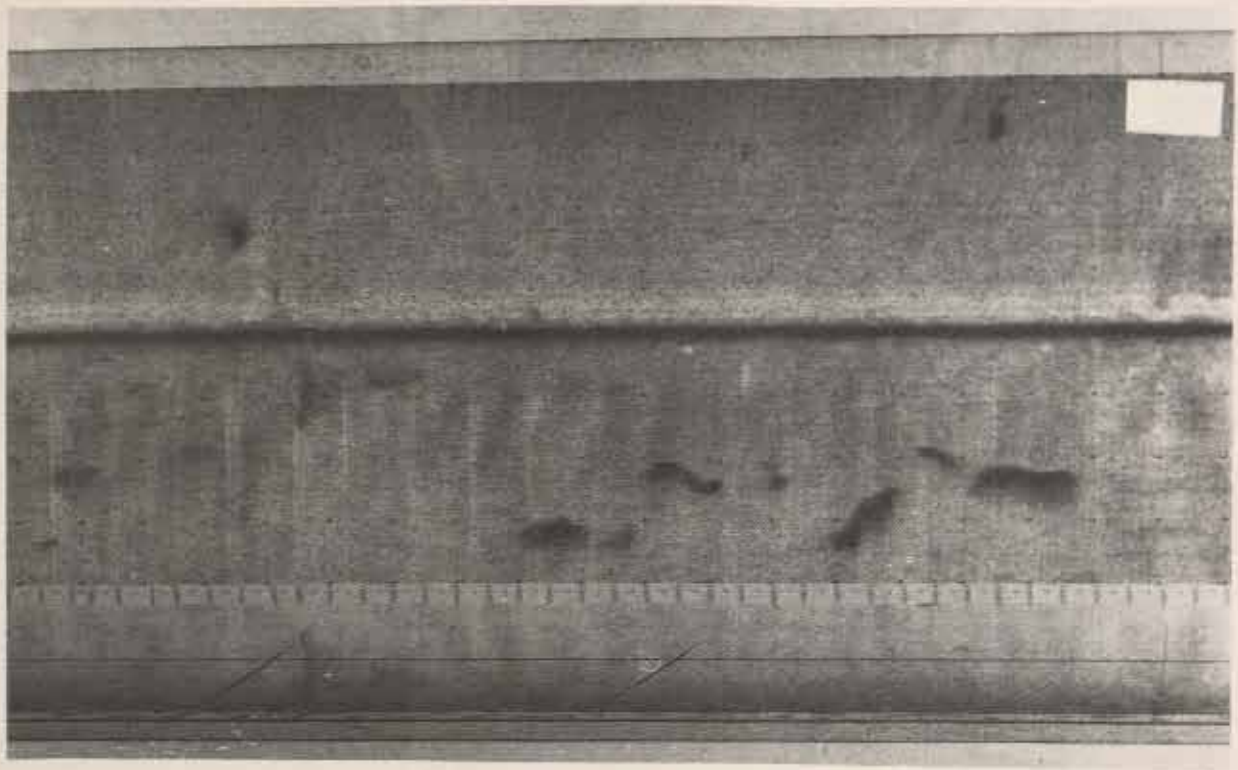
Pl 38. Kasi Viswanatha Temple, Ennore.



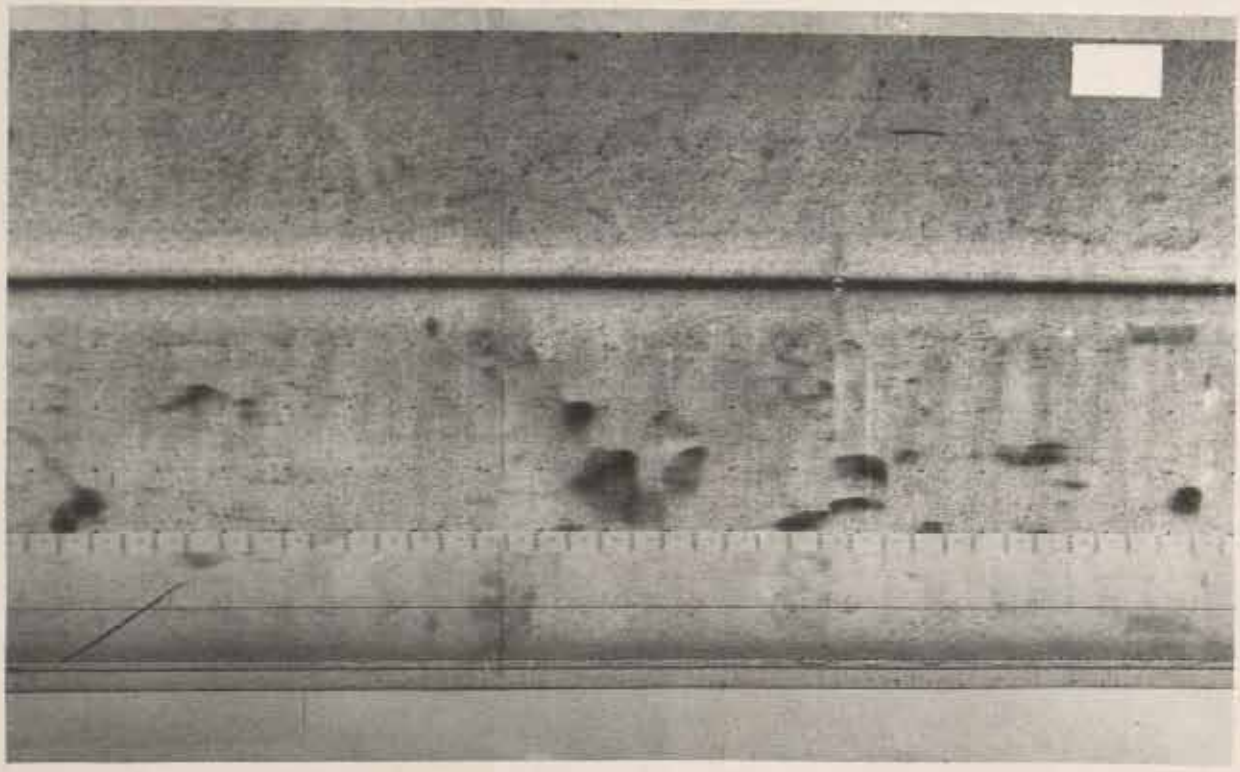
Pl 39. Temple of Samudranarayana, Dwarka.



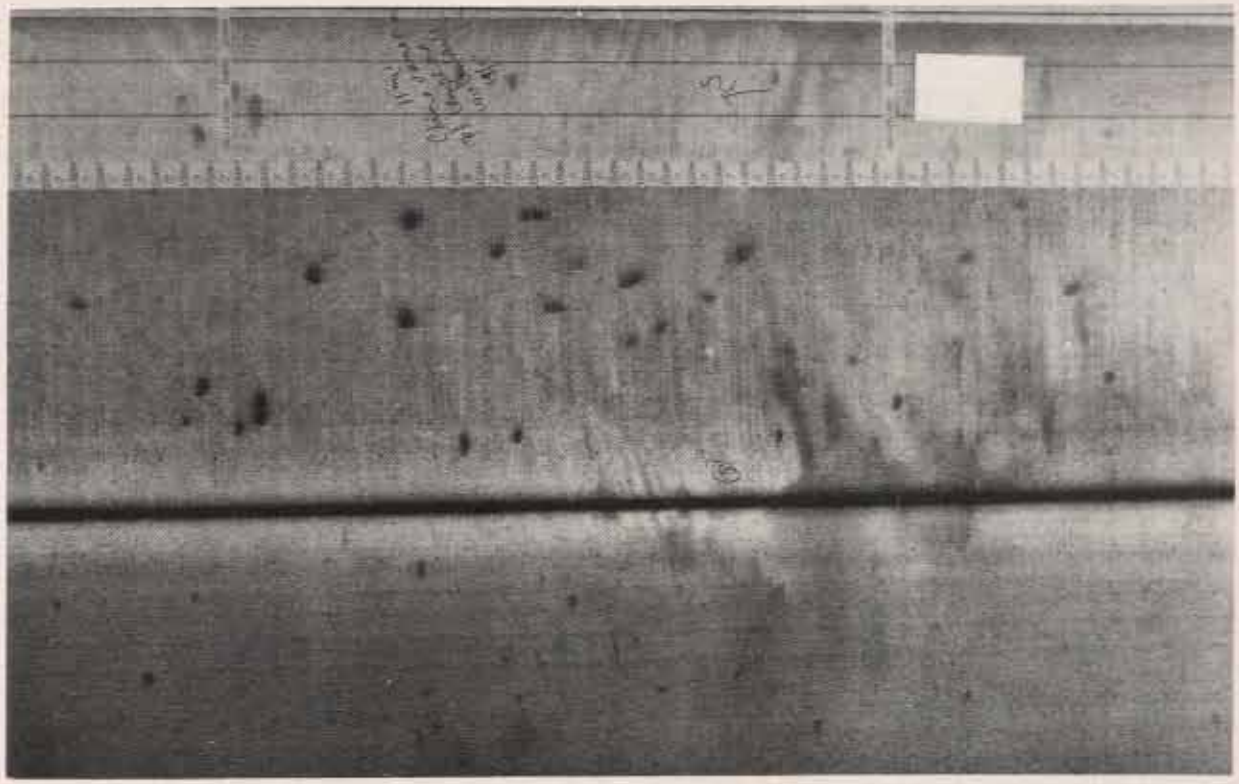
Pl 40. Long linear structure extending from the coast into the sea at 5m water depth.



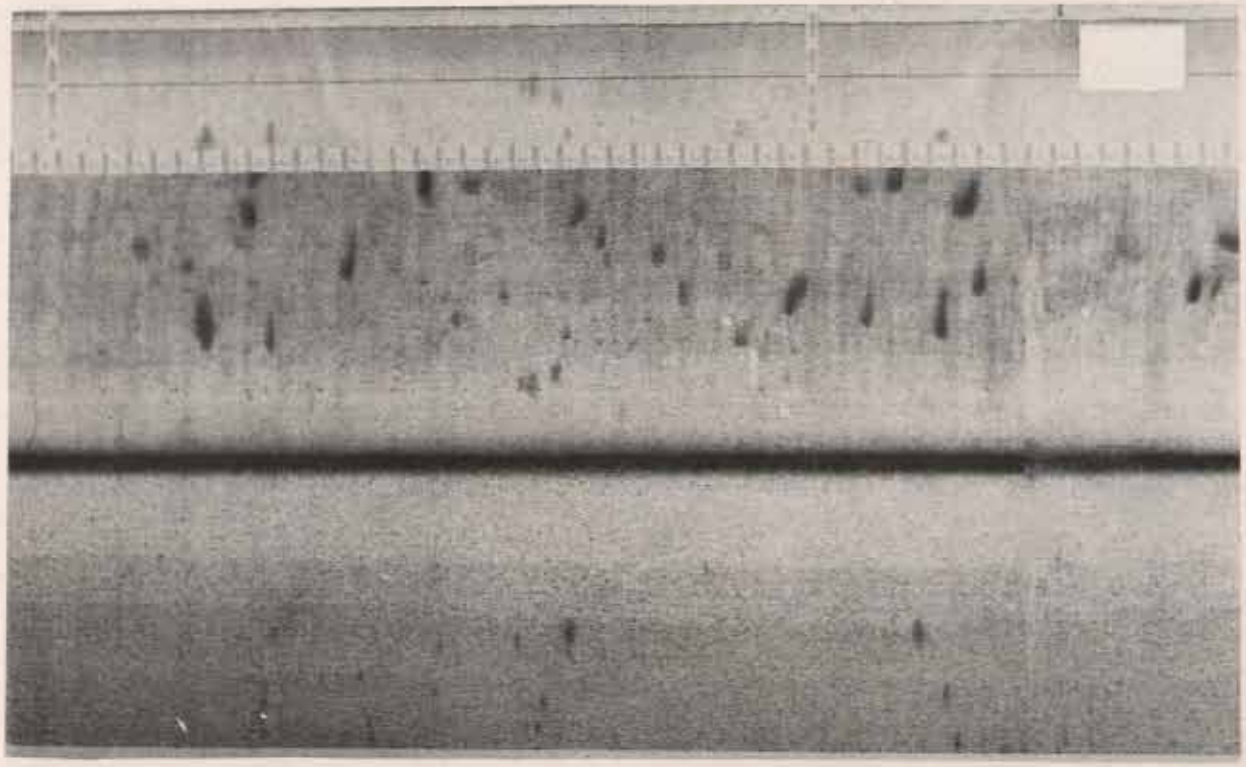
Pl 41. Disjointed objects of a linear structure extending parallel to the coast at 7m water depth.



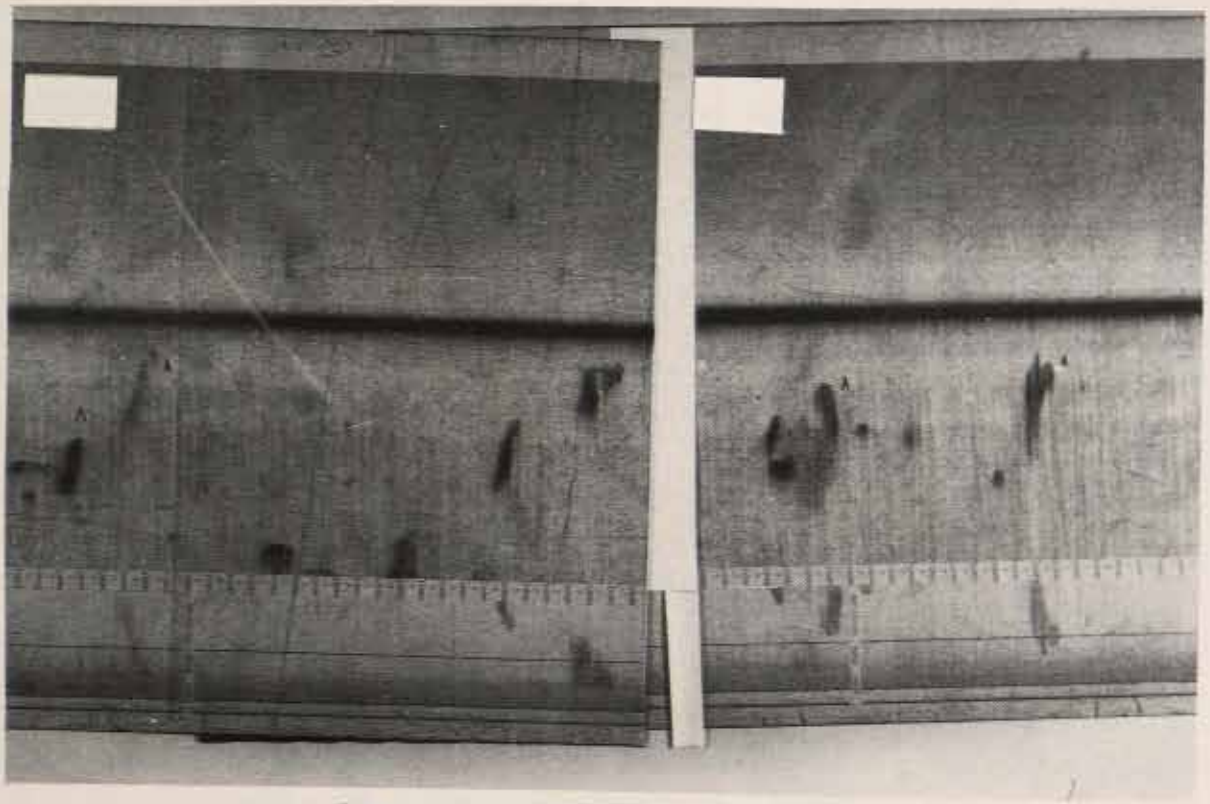
Pl 42. Disjointed objects of a linear structure extending parallel to the coast at 8 m water depth.



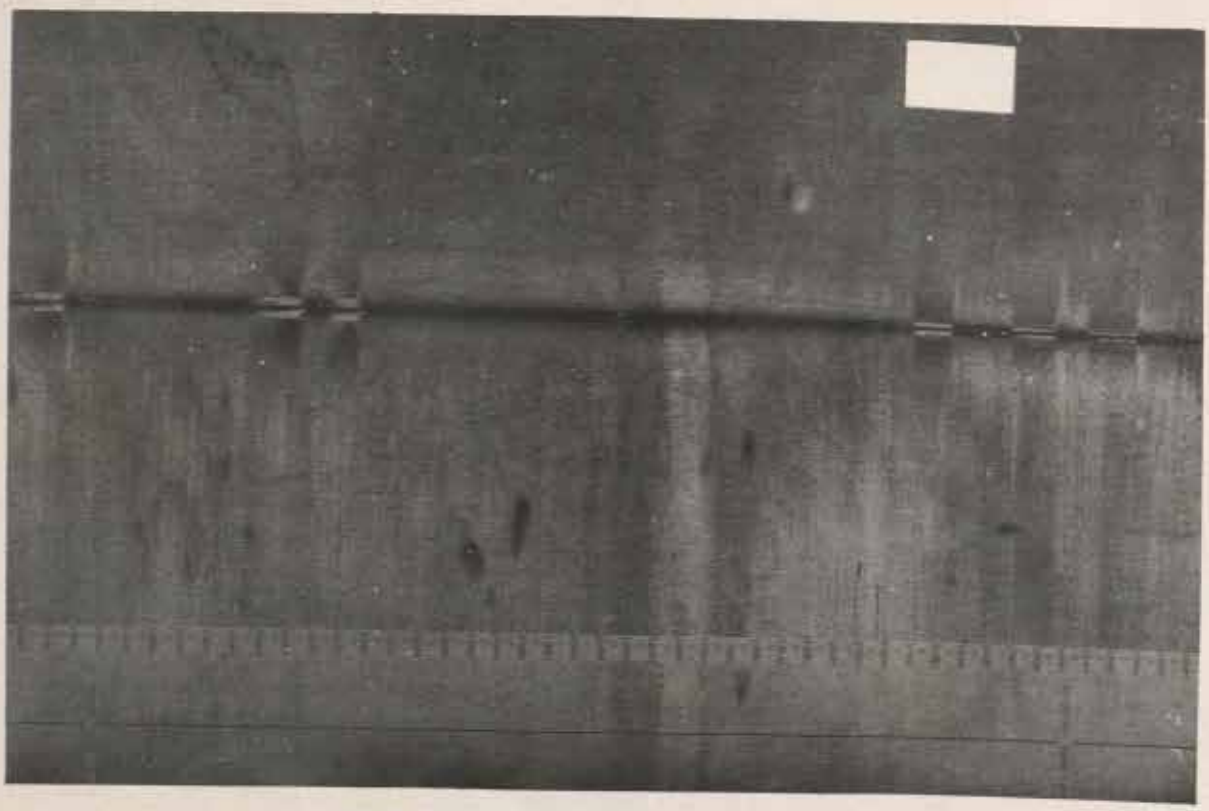
Pl 43. Scattered objects arranged in semicircular pattern at 11m water depth.



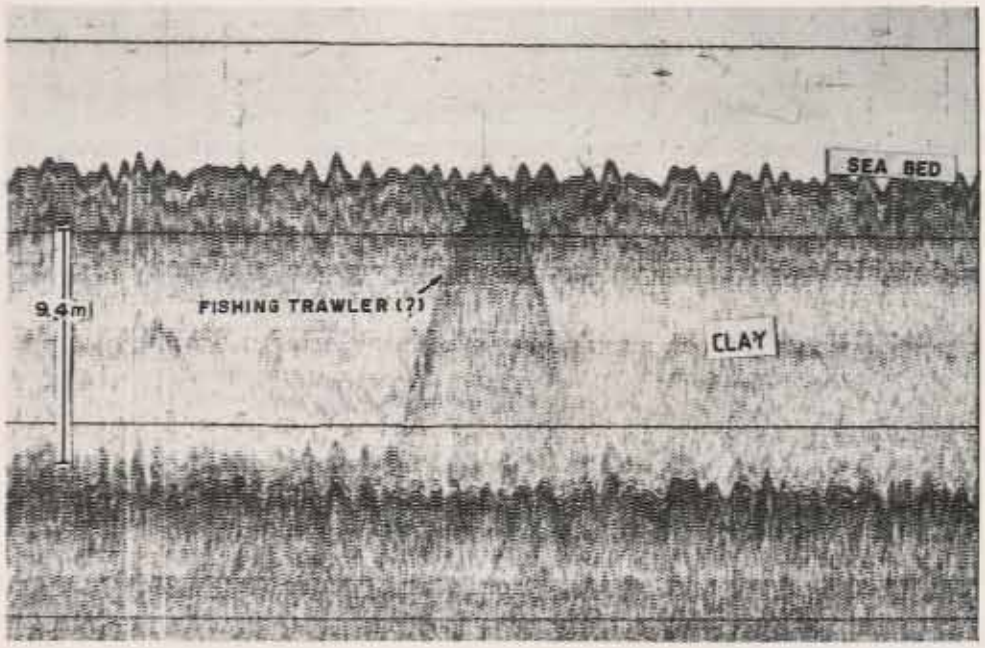
Pl 44. Scattered objects at 10 m water depth.



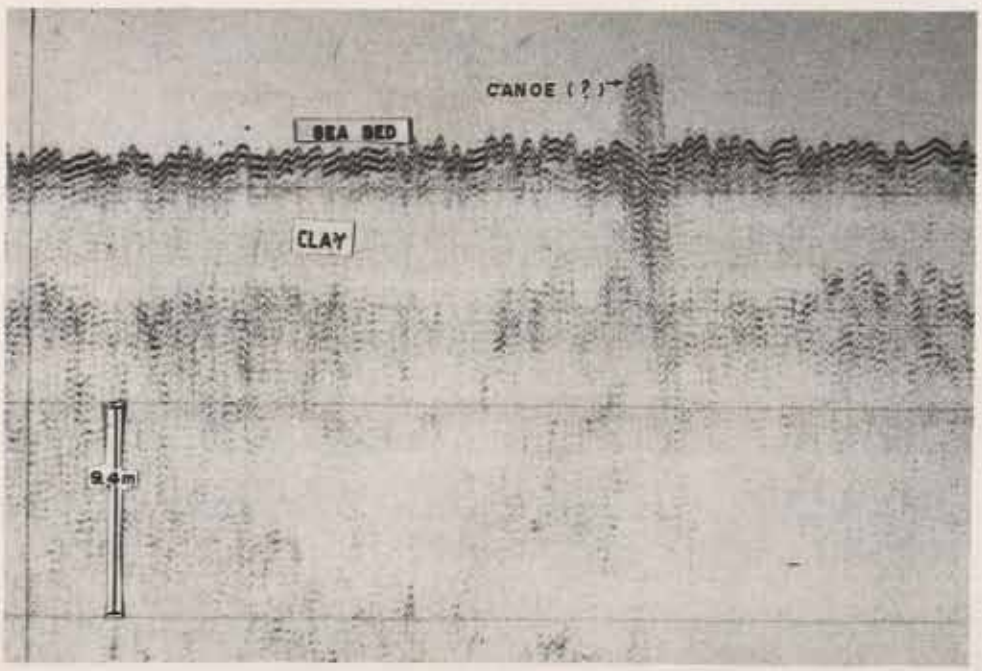
Pl 45. Suspected shipwreck at about 10m water depth.



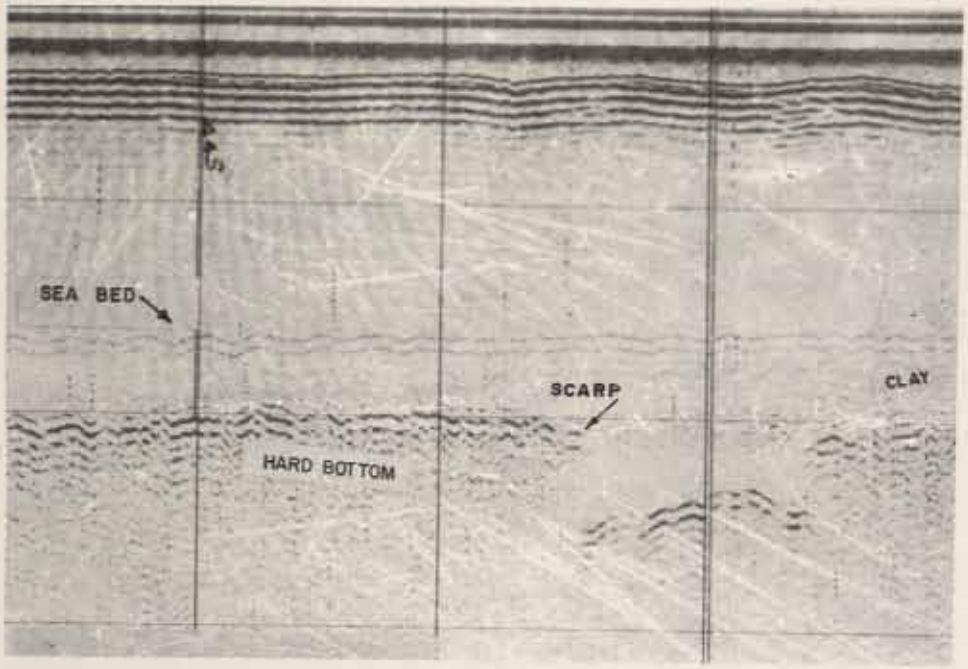
Pl 46. Submerged river channel and isolated objects.



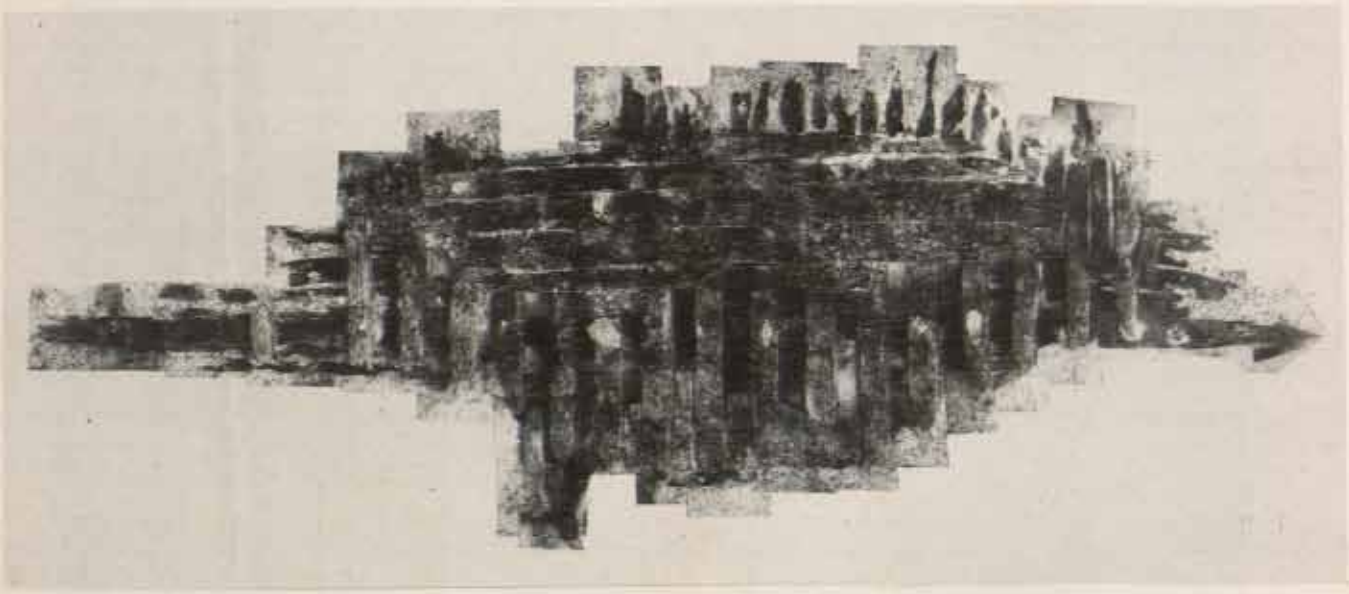
Pl 47. Mud Penetrator record showing the vessel (fishing trawler buried under the seabed and sandwiched in the unconsolidated sediments off Vengurla.



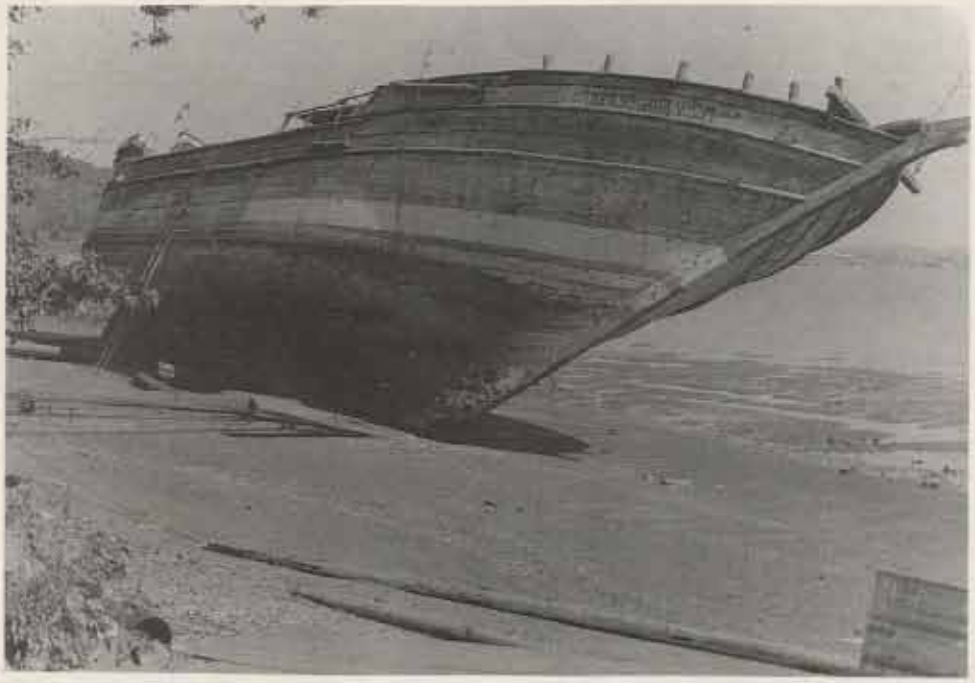
Pl 48. Mud penetrator record showing a small country craft (canoe ?) submerged off Mormugao.



Pl 49. Shallow seismic record showing the scarps in the hard bottom terrain off Redi point.



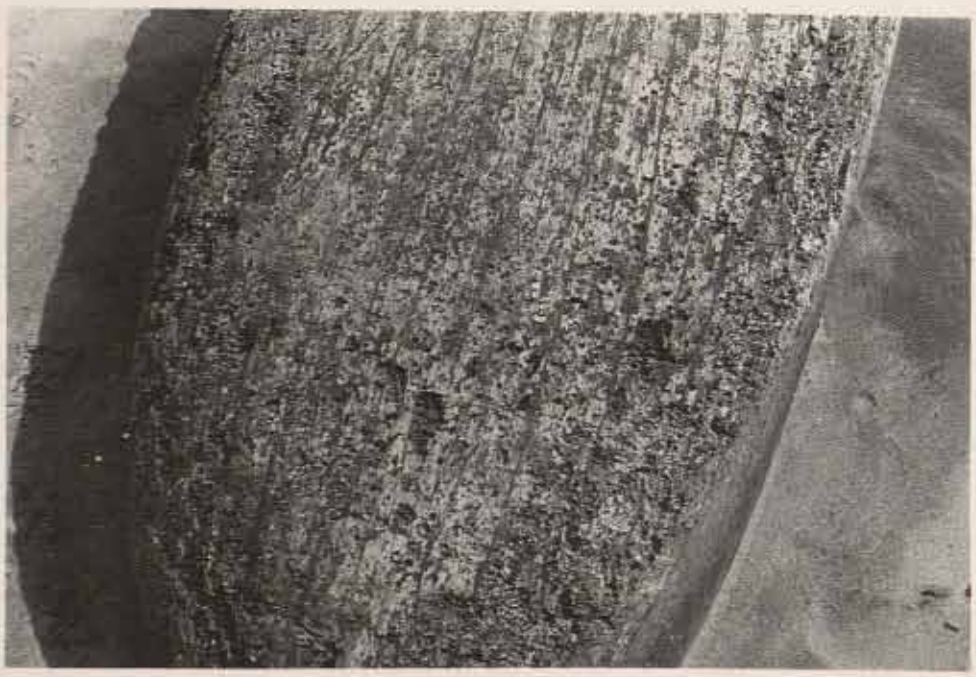
Pl 50. Photographing a shipwreck.



Pl 51. Damage caused to modern wooden boat.

Pl 52. Damage caused to wood by wood borers.

Pl 53. Damage caused to wood by wood borers.



Pl 54. Damage caused to wood by wood borers.

Pl 55. Bodhisathva comes to the rescue.

Pl 56. The Bodhisathva rescues the shipwrecked Purna.

Pl 57. 11-headed Avalokitesvara.