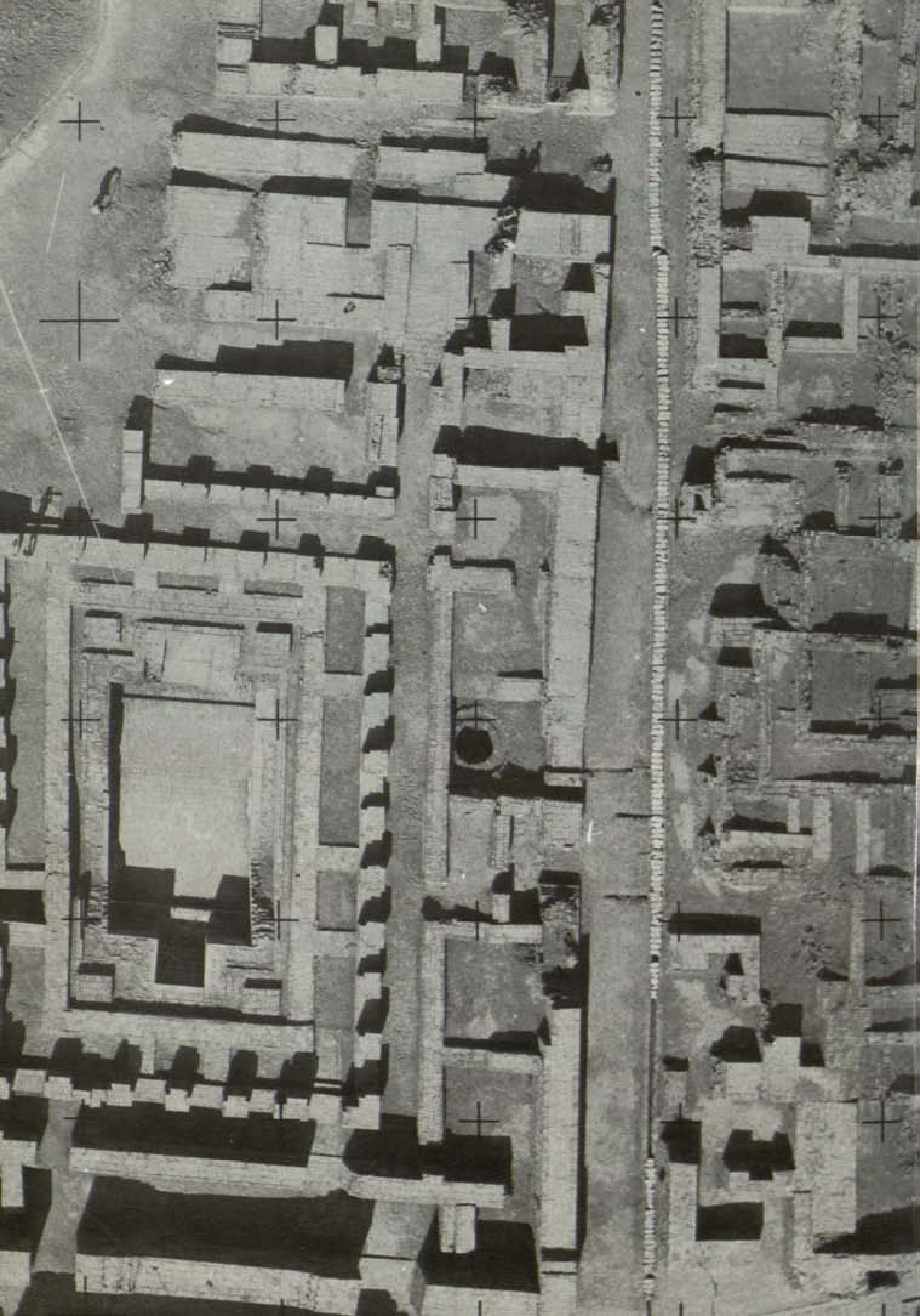
Interim Reports Vol.1

It is with deep sorrow that we remember the death of Johanna van Lohuizen de Leeuw and Giuseppe Tucci. This publication is dedicated to both of them.



Reports on Field Work
Carried out at Mohenjo-Daro

INTERIM REPORTS Vol. 1

Pakistan 1982-83
by the IsMEO-
Aachen-University Mission

edited by
M. JANSEN and G. URBAN

GERMAN RESEARCH-PROJECT MOHENJO-DARO
RWTH AACHEN
*
ISTITUTO ITALIANO PER IL MEDIO ED ESTREMO ORIENTE
ROMA

The Great Bath aerial photograph taken from hot air balloon ca. 100 m height.
German Research Project 1983.

This volume is a joint publication of the German Research-Project Mohenjo-Daro, Department for History of Architecture and Architectural Preservation, RWTH Aachen and the Istituto Italiano per il Medio et Estremo Oriente (IsMEO), Rome in Cooperation with the Archaeological Survey of Pakistan.

EDITORS: Michael Jansen, Günter Urban
EXECUTIVE EDITOR: Irmgard Leinen
EDITORIAL STAFF: Andrew Holdsworth and Máire Mulloy

Forschungsprojekt „Mohenjo-Daro"
Schinkelstraße 1
D- 5100 Aachen

ISSN 0174-6375

Contents

Concerning the contradictory spellings of the name "Mohenjo-Daro"

For this publication, the editors decided not to standardize the spelling of the name *"Mohenjo-Daro"*, but rather to accept the different versions submitted by the authors. We therefore apologise for what at first sight appears to be an unsystematic way of writing. While the German Research Project uses the traditional form of *"Mohenjo-Daro"*; as can be found in Marshall , Mackay and Wheeler, other contributors favour a different spelling, such as *"Moenjodaro"*, *"Moenjo Daro"* etc.. According to our Pakistani archaeologist, G.M. Shar, the meanings of the different spellings are as follows (Source: *Sindhi-English Dictionary, Second Edition, 1976*): Daro(daro) – دڙو – noun, in all cases meaning a heap or mound. Mohenjo – مهنجو – or Mohonjo – موهن جو دڙو – possessive pronoun, mine or my. Moen/Moan – موئن – past participle plural of to die, dead. jo – جو – preposition, of, mark of the possessive case. Mohan – موهن – noun, also Hindu name meaning one who fascinates. Epithet of Krishna. We thus have such possibilities as "My mound" or "The mound of the Dead" or "The mound of Mohan". According to the Sind Dictionary, the *Moen-jo-daro* form, with its variations of *"Moenjodaro"* or *"Moenjo Daro"*, seems to be the most appropriate.
We feel it is necessary that one generally accepted spelling be adopted and used by all scholars in future works.

Preface THE ITALIAN CONTRIBUTION OF ISMEO TO THE MOHENJO-DARO RESEARCH-PROJECT

The IsMEO participation in the Moenjodaro Project, jointly with the RWTH, is aimed at expanding some aspects of the scientific project initiated at the end of the sixties with the excavations of Shahr-i Sokhta, the main protohistorical center in Iranian Sistan. Both initiatives are motivated by the same determination to en'arge the study of early Indo-Iranian civilizations of the third millenium BC, incorporating the Middle Asian Bronze age urban cultures recently brought to light. The discovery of these pristine state formations across the oases belts of eastern Iran, southern Turkmenia and Afghanistan has opened up a much deeper historical perspective, defining the cultural complexity that the emergence of the greater religious and political movements underwent in this part of Asia. Such expansion into the prehistoric period can only be based on the integration of a broad spectrum of disciplines in long-term research programmes. The experience gathered at Shahr-i Sokhta has highlighted how fruitful such a multidirectional approach can be to a critical understanding of early urbanism and its cultural implications. This type of strategy has become quite a standard procedure of IsMEO in its tackling of the evercomplex problems involved in the study of Asian civilizations. More institutionalized forms of international cooperation are corollary to such a policy of long term investments. The agreement IsMEO and RWTH signed in Rome on December 14th 1983 to cooperate on the exploration of Moenjodaro represents the first milestone in such a direction.

Quite obviously, at the present initial stage the Italian contribution is still primarily channelled into those aspects best developed in the course of the Shahr-i Sokhta programme. The surface evaluation of craft activity areas at Moenjodaro that we here present for the first time in a more formalized fashion, represents a direct development from experiences gathered at Shahr-i Sokhta, Tepe Hissar and Shahdad between 1972 and 1977. The present aim is to move from a descriptive-functional stage of objects and contexts to a more interpretative one, attempting a first definition of allocative forms of labour division and early patterning of corporate craft activity across an Indian society. Whatever results our research will produce in terms of socioeconomical analyses, it is certain that our knowledge of Harappan technology will experience a great elan. The studies of J.M. Kenoyer on shell working and of A. Halim and M. Vidale on such particular manufacturing procedure as that of stoneware bracelets in closed containers are two remarkable examples of the scale of detail we are going to attain. The geophysical survey by Mauro Cucarzi has also seen its timid beginnings within the multidisciplinary frame of our research programmes in Swat and in Sistan. Between 1975 and 1978 various magnetic and electrical resistivity surveys allowed the detection of prehistorical burial complexes at Aligrama and Shahr-i Sokhta, thus proving the high resolution of this standard method in the Middle Asian context. At Moenjodaro the tasks of the geo-physical survey are certainly of a magnitude rarely encountered in former projects. To establish the underground configurations of the Moenjodaro „iceberg" will require the testing and the adaptation of various techniques and the parallel development of proper software to interpolate the great number of measurements that will be collected. This question of adaptation is indeed a general one. Moenjodaro is one of the greatest archaeological monuments in the world and it could by no means be approached without an extensive adaptation to its particularism of the methods developed elsewhere. The actual preparatory stage we are experiencing calls for a broad and somehow unbiassed collection of data, before any overselective development is impressed on our future research. On a smaller scale of definition, Moenjodaro remains a largely unexplored universe and to minimize the damages excessive confidence is always producing in science, we propose a long-lasting investment firstly finalized to the construction of a solid data base, in the same pattern as the RWTH documentation project that has undoubtedly been the driving force behind this renaissance of research work at Moenjodaro.

Our scientific activity can only have a purpose if it strengthens the traditional ties of cooperation and friendship IsMEO has had with Pakistani colleagues and authorities. The almost thirty years IsMEO has been working in Pakistan witness the importance of this relationship and the new venture initiated at Moenjodaro should be regarded as a further expression of this solidarity. In presenting this first volume of preliminary reports, we wish to express our heartfelt gratitude to the Director General of Archaeology and Museums of Pakistan, Mr. M. Ishtiaq Khan, for having entrusted in the combined hands of the German and Italian teams such relevant aspects of the most important protohistorical site of the country.

Gherardo Gnoli — Maurizio Tosi

Rome, July 1984
Aachen, July 1984

THE CONCEPT OF INTERDISCIPLINARY RESEARCH AT MOHENJO-DARO

It is with great pleasure that we present here the first in a series of Interim Reports which we plan to publish periodically with the cooperation of our colleagues from the Archaeological Survey of Pakistan and ISMEO, Rome.

The need for such a series arose from the fact that we wanted to make available for immediate discussion the preliminary results already gained in the various subsidiary research programmes within our Project. In this way an organ has been provided not only for a rapid flow of information on the latest research results but also for a running critical commentary on our work in progress. Each issue of the Interim Reports, which will appear at regular intervals, will cover the results of a single field season, though not necessarily to the exclusion of outside contributions not directly linked to our Project's work in Mohenjo-Daro.

Mention may be made here of a further series, Data Collection, which will likewise make its appearance before the end of 1984. The Data Collection will comprise complete corpora of factual information, e.g. the entire body of registered finds made in the different areas excavated, or systematic house lists with all the accompanying data on room size, proportion etc. These series of preliminary results are intended as a complement to the monograph which will contain the overall report of the Project's findings in Mohenjo-Daro. A guide to our future publications is given in an appendix to Interim Reports I.

With these publications we are pleased to meet the express wish of the Director General of the Archaeological Survey of Pakistan, to see the results of our work in print at an early date.

In order to make these results accessible to as large a readership as possible we agreed, after due consultation with the Archaeological Survey of Pakistan and ISMEO, to publish them in English.

We were further influenced in our decision by our desire to add our voice to all those at national and international level who, together with UNESCO, are trying to draw the world's attention to Mohenjo-Daro and the imminent extinction it must suffer unless immediate financial assistance is forthcoming. A concerted rescue operation involving all the relevant scientific disciplines is the only option left open to us if this extraordinary city of the third millennium BC is to survive into the third millenium AD.

When the German Research Project Mohenjo-Daro began work at the Technical University of Aachen in October 1978 we were not setting forth into unknown territory. Years before our appearance on the scene, we had already undertaken a systematic reappraisal of Harappan architecture both in the Indian Union and in Pakistan, thus enabling us to draw up clear working and time schedules for the modern recheck of the Mohenjo-Daro material to which the Pakistani Government gave its approval in 1979.

We were faced with the formidable task of documenting in detail some 100,000 sqm with about 300 house units in the space of five years. As this meant an average period of only two days per unit, special working methods had to be devised which would be precise enough to provide us with the required detailed information. In practice, this resulted in our wide use of photography and photogrammetry, techniques which guarantee speed and precision in on-the-spot documentation but also entail lengthy processing afterwards in Aachen.

Besides rechecking the structural groundplans, all the walls were levelled and systematically recorded by means of photographs of their side views. One of the more spectacular highlights of our operation was the hot-air balloon specially designed and constructed in Aachen for aerial photography in Mohenjo-Daro. Altogether, over 600 photos were taken with the camera attached to the balloon, of which the majority is suitable for photogrammetric processing. The photo of the Great Bath taken from an altitude of about 100 m shown on the frontispiece is a typical example.

Nevertheless, the redocumentation of Mohenjo-Daro could not have been completed without the original photos of the excavations. In the course of the past six years we were kindly permitted to study and make copies of some 5,000 original photos now kept in Mohenjo-Daro, Karachi and Delhi. This excellent pictorial record made it possible to make a critical reassessment of the present state of the structural remains.

Further excavation records generously placed at our disposal were the original fieldbook entries of the excavations carried out between 1924 and 1938. The 12 fieldbooks containing approximately 38,000 registrations in all were of invaluable assistance in our architectural analysis and interpretation, which without them would have been merely a descriptive exercise. By consulting the fieldbooks it is possible to relocate up to 600 registered finds per architectural unit, thus providing concrete clues as to the function of the latter in daily life. By now, most of the fieldbook entries are stored in the computer data bank and will be available for study shortly as an issue of our Data Collection series.

An extremely useful addition to all the secondary material dating from the 20's and 30's was the largely complete and still unpublished collection of plans of Wheeler's 1950 excavations at Mohenjo-Daro, procured for the Project by Professor Norman Hammond in 1982. The photos accompanying the plans, likewise largely unpublished, were also supplied by Prof. Hammond and in part by the Archaeological Survey in Karachi.

Even today, it is obvious that only a mere fraction of the enormous mass of data recently made available can be evaluated and interpreted in full with the present means of our

Project. Therefore we are particularly pleased to be able to justify the faith in the Project by making also the data entrusted to our care available to the interested public.

In 1982 the German Research Project Mohenjo-Daro was joined by Professor Tosi and his team from ISMEO, Rome. From this significant expansion to the scope of our operation grew an independent joint project under the auspices of the Technical University of Aachen and ISMEO with the objective of investigating scientifically the archaeological surface of the site. Once it was officially sanctioned by the Pakistani Government this project soon got underway.

In accordance with the conditions laid down by the Pakistani Government and UNESCO that no further excavation may be carried out at the site until agreement is reached on how the city can be saved, non-destructive working methods had to be developed by the ISMEO - Aachen University Team which would yield results without damaging the site. Among the methods used are geophysical surveying, study of air photos, random sampling and surface cleaning.

By also examining the remaining 'archaeological pockets', i.e. undisturbed corners within the already excavated parts of the city, the latter can be integrated in the surface analysis. Of particular importance in these pockets are any botanical or zoological remains, organic, datable residue and drain sediment which can be analysed scientifically in the laboratory. Besides work on the actual analysis, the German-Italian partnership offered the opportunity to formulate concepts for future research which would take into account the combined body of data collected to date.

Complementary analyses such as these are needed if the enormous potential of the fieldbook registrations is to be exploited to the full as part of a modern archaeological concept which reduces the amount of excavation necessary to an absolute minimum.

On a broader level, there are still many questions open concerning the appearance of the city, its layout and subsequent alterations, the vertical extent of the habitation levels below the surface, and the general environment. The ultimate question mark still hangs over the human element in the history of the city, its citizens' lifestyles, the social and economic basis which created such a complex phenomenon as Mohenjo-Daro in the first place. In view of these gaps in our knowledge this publication marks the first small step which, we hope, will encourage further ideas and discussion.

Finally, a word on our use of a computer, which provoked raised eyebrows from some of our colleagues on being introduced to the Project. By now it is being used both by our Italian colleagues for storing data directly at the site and by ourselves for processing the 38,000 fieldbook entries, and we feel confident that our coming publications will justify its use even to the more sceptical of our critics.

We are deeply grateful to the Government of Pakistan, represented by the Ministry of Culture, Sports und Tourism and the Director General of the Archaeological Survey of Pakistan for their generous support.

Without the financial assistance of the "Deutsche Forschungsgemeinschaft", who always reacted to our financial worries with sympathetic understanding, this research programme could never have been realised. Our special thanks are due to Siemens (Pakistan) and Hoechst (Pakistan) for their friendly support during the field seasons.

We are deeply indebted to our Pakistani colleagues and friends from the Survey, especially those based at Mohenjo-Daro, for their constant friendly interest and unfailing helpfulness.

Last, but not least we thank all our colleagues in Pakistan, Aachen and Rome who contributed to the success of the Project and this publication.

Günter Urban Michael Jansen

Aachen, July 1984

Craft Activity Areas and Surface Survey at Moenjodaro
Complementary Procedures for the Evaluation of a Restricted Site

Luca Bondioli
Soprintendenza Archeologica
dell' Abruzzo, Chieti

Maurizio Tosi
Massimo Vidale
Istituto Italiano per il Medio ed Estremo Oriente,
Roma

Acknowledgements

This paper may be regarded as an assemblage of different contributions from a large group of closely interacting scholars. S. Pracchia, M. Tosi and M. Vidale are actually responsible for the data collected on the field, together with J.M. Kenoyer of Berkeley University, but some relevant indications for the method applied have been provided at an early stage of the fieldwork, in January 1982, by Michael Jansen, Sandro Salvatori and Geraldina Santini. Some of the introductory considerations have been developed through several discussions carried out over the past few years in Moenjodaro, Aachen and Roma with M. Jansen and several members of his team, notably A. Ardeleanu-Jansen, U. Franke and T. Urban. The last paragraph is an original contribution of L. Bondioli, although some inital steps have been developed by the critical contribution of Alfredo Coppa, Institute of Anthropology, Rome University. We gratefully acknowledge the farsighted support of M. Ishtiaq Khan, Director General of the Department of Archaeology and Museums, Government of Pakistan, who has made possible the whole Italian participation to the Moenjodaro Project. Dr. Michael Jansen has been the energy behind the whole work and his generous aid has nursed our timid beginning in the face of the magnitude of the task involved.

Thanks are due to the President of IsMEO, Prof. Gherardo Gnoli, for having brought this prestigeous institution to sponsor the project from its first confused steps. Finally, we wish to express our gratitude to Prof. Giovanni Scichilone, Soprintendent for Archaeology of Abruzzo, for having expanded the capacities of the project with the rich laboratory infrastructures at the National Musem of Chieti.

We thank the assistence of those who have carried out with skill and patience the technical work accompanying this preliminary presentation: Geraldina Santini for drawing tables 1 - 4 and fig. 1; Vincenzo Labianca for painting the AICA distributions in the Moenjodaro plan; Loredana Ricci for typing the first version; Ian McGilvray for editing the English text.

Introduction

The preservation of Moenjodaro should no longer be confined to a question of the physical maintenance of its bricks and buildings, but extended to cover all its archaeological implications. Reproposing it as an object of direct scientific investigation, we should return this great monument to its principal role in the study of early civilizations.

When in 1964 excavations were suspended in order to avoid further deterioration, the exploration of Moenjodaro was still at its very beginning. While granting protection to the buried structures from indiscriminate exposure, the excavation ban somehow severed the most important site of the Indus Civilization from later developments. Indeed, these twenty years have seen a radical rethinking in archaeology, at a general as well as at a regional level. As a scientific discipline it has experienced important innovations in its theoretical attitudes and methods of investigation, involving among other things a discrete use of excavations as testing procedure. No less significant are certain reconsiderations of the historical perspective in which the Indus Civilization is viewed. A flood of fresh fieldwork has shed new light on the Chalcolithic and Bronze Ages all over the belt of countries surrounding the Indus plains: in Baluchistan and eastern Iran, in Central southern Asia, along the Hakra-Ghaggar dried alluvium, in the Kathiawar peninsula, in Oman. The emerging picture is a highly dialectical one: polycentric developments and cultural interdependence are conjugated in the parallel evolutionary trends towards urbanism and forms of social stratification that developed almost everywhere in Middle Asia from the end of the 4th millennium BC. The Indus Civilization can no longer be regarded as an isolated case of „*urban revolution*" linked to another riverine plain. It emerges instead as the dominant superstructure of a much larger region, which by the end of the 3rd millennium BC was powerfully aggregating the experiences of a mosaic of peoples spread between the Caspian and the Arabian Sea.

In the light of this pivotal role Moenjodaro still stands as the most promising of all sites, a rich bank of data with which archaeological research has succeeded in its quest to penetrate the mature stages of the transformation from the chessboard of late Chalcolithic cultures to the Indo-Iranian societies of the earliest historical records. The Indus Civilization stood at a turning point, which was both geographical and temporal. Moenjodaro stands before us not as just another destroyed site, but with the magnitude and complexity of the largest protohistorical site of South Asia, strategically located between the Kirthar Range and the Ocean and facing the critical Western borderlands of the Subcontinent. Nowhere else is a similar opportunity to be found: major efforts should be made to continue the exploration of a site, of which the physical preservation of its excavated structures might hinder the very development of new methods of conservation. Too little is known of the geomorphic processes and the natural environment of Moenjodaro to be able to determine the direction and scale of the future interventions without further intensification of a broad spectrum of observations. Moreover, to restore Moenjodaro to the place of preeminence it deserves means soliciting increasing investments for its preservation.

To call for a new generation of studies does not necessarily mean demanding new excavations. Until such time as a procedure has been agreed upon to protect the exposed structures from salt outgrowth and other erosion agents, no excavations should be undertaken. Yet the study of Moenjodaro should be continued and expanded with other no less effective means of investigation.

We need only to design a strategy that while ensuring the postponement of any displacement of primary undisturbed deposits, provides the new information we need in a systematic operational frame.

This paper presents a first suggestion in this direction. The Surface Evaluation Project initiated at Moenjodaro in January 1981 with the combined efforts of the Rheinisch-Westfälischen Technischen Hochschule Aachen (RWTH) and the Istituto Italiano per il Medio ed Estremo Oriente of Rome (IsMEO). The present formulation responds to the requirements of two independently developed lines of study: on one side there was the demand for a critical review of the architectural remains, representing the largest exposed complex of protohistorical buildings in the whole Middle East still awaiting reconsideration; on the other the analysis of craft activity and labour organization initiated during the seventies in various 3rd millenium BC sites of eastern Iran and southern Turkmenia *(Tosi 1977; 1984; Bulgarelli 1979)*. Here, conditions of surface observation were ideal due to the combined effect of intense wind deflation and recurrent shiftings of river systems. Between 1972 and 1977 more or less systematic observations on some of the largest proto-urban settlements in the Turanian lowlands, e.g. Altyn depe and Shahr-i Sokhta had suggested that selective allocations of workshops and factories had developed through the first half of the 3rd millenium BC, possibly as a function of increasing centralization and elite control of craft production *(Tosi 1984)*. True craftsmen quarters sprang up on the outskirts of the earlier settlements, extending over 20 to 30 % of the present surface. In general their distribution seems to conform to recurrent patterns of allocation *(Mariani 1984)* , although to develop the proper methods of evaluation observation had to be organized around a very large collection of data according more formalized procedures. To this end Moenjodaro could provide an ideal testing ground, given the size, complexity and prestige of the site. A large-scale surface evaluation analysis of its craft manufactures might provide information on a previously unrecorded scale, while ensuring a form of preservation for previously unrecorded classes of data. The surfaces excavated by wind and water are as much a source of information as the buildings brought to light by Sir J. Marshall and E.J.H. Mackay. To work on the undisturbed surface of Moenjodaro means to move inside an enormous excavation trench, where the extensive erosional processes may be regarded as the methodical work of various agents, whose features and patterns we may learn to read. The characteristics of a site surface are directly related to *„the natural and cultural processes that have occured since its original occupation"* *(Kirkby and Kirkby 1976: 229)* and the operational rules followed by various geomorphic processes under conditions are quite well known. *Kirkby and Kirkby* have provided some of the basic guidelines for a formalized procedure of interpretation to relate the actual spread of artifacts to the destroyed context of their primary deposition *(Kirkby and Kirkby 1974; 1976. See also for a critical review of their models Kohlmeyer 1981.)*.

While systematic surface surveys are no novelty in field archaeology and several authors have stressed their utility in the arid zones of Southwestern Asia *(e.g. Redman and Watson 1970)*, they have so far developed very little beyond small scale tests. In general their implementation has been sporadic, limited and subordinate to the selecton of promising lots for excavations. Such a limited strategy would be rather ineffectual at a site like Moenjodaro. To cope with its extension and complexity the only approach has to be founded on assuming the undisturbed surface as a context by itself to be treated independently from the promise of future excavations.

The Surface Evaluation Project represents a step towards combining two research courses converging on Moenjodaro: for the documentation work it expands its context of observation by including the sections of the site that connect the various blocks of architecture; the craft research will achieve its ultimate target at the largest and most complex site of the entire Middle Asia.

First Outline of a Research Strategy

Apart from those studies aimed at achieving a better understanding of the natural setting of the site, the alternative or integrative methods of intervention the archaeologists might implement at Moenjodaro fall into the following three categories:

1. PROSPECTIONS AND TOPOGRAPHICAL RE-RECORDING:

All the procedures to improve the standards of mapping, detailed ground morphology, elevation variability and the structural configuration of exposed buildings.

2. SURFACE EVALUATION OF ARTIFACTS AND PEDOLOGICAL COMPONENTS

It encompasses all methods to describe and analyse the effects of erosion on the archaeological deposit, resulting in the spreading of artifacts and the related geomorphic processes.

3. REMOTE-SENSING TECHNIQUES OF GEOPHYSICAL PROSPECTION

They include all procedures to measure the earth's variability by recording different types of physical response (magnetic intensity, electric resistivity, sismic wave, gravimetric measurements, etc.). Several methods will have to be employed to cope with the size and diversity of the compound: Moenjodaro is part of the sedimentary complex of a large alluvial lowland. On the other hand if we consider that not even the true dimensions and the configuration of the compound are known, the geophysical prospections must be given priority.

Our revisitation of Moenjodaro is conceived as a combined approach moving from all three courses of analysis in an effort to pattern surface and underground surveys in a single testing procedure.

The recovery of the earlier data would have been the essential precondition for a programme grounded on the assumption that the surface of Moenjodaro is a vital archaeological resource. This function has been undertaken by the German Research Project initiated by the RWTH in 1978 and representing from now on the core of any new generation of studies on Moenjodaro. The recollection of all original drawings and photographs, the first photogrammetric restitution of the site plan, the reconnaissance of the architectural structures by ground and low-altitude aerial survey, the replacement of finds in their context of provenance through the re-edition of the original registers represent a higher level of physical control of the site, rarely attained on any other protohistorical center of the Middle East *(Urban and Jansen 1983)*.

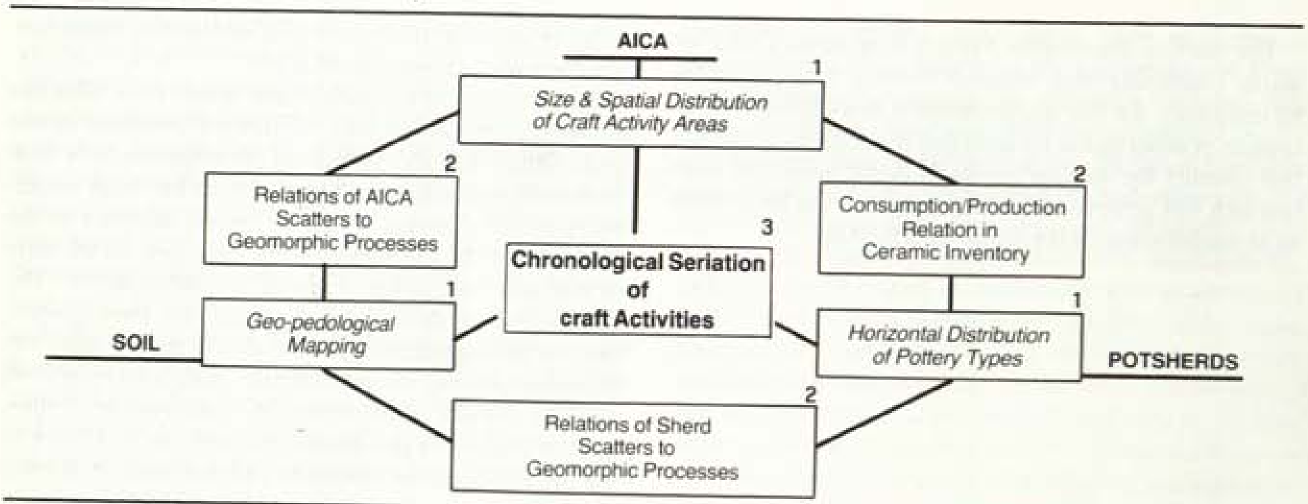
The IsMEO-RWTH Surface Evaluation Programme (SEP) is partitioned into three distinct research procedures according to the processing of the following classes of data:

1. Archaeological indicators of craft activity (AICA).
2. Ceramics and the related manufacturing installations.
3. Morphological surfaces in their pedological and sedimentological configurations.

First aim of the SEP is to map the distribution of craft indicators over the entire data of the Moenjodaro compound in order to determine the forms of labour allocation within the regional center. The ceramic and pedological analysis will be performed subordinately to the craft evaluation, as they are essentially to provide parameters for a chronological seriation of the various techniques of data recollection. Preliminary tests were carried out in two field seasons (2). This paper and the outlined strategy of approach are based on the preliminary results of this work.

The information retrieval of craft indicators is conveyed on two distinct lines of evaluation: a *locational* one, to detail by pinpointing and ranking the clusters of items, the spatial allocation, a *processual* one, oriented to the reconstruction of the manufacturing processes by means of different methods of investigation. In our opinion this second aspect will ultimately produce the most profitable results for the wealth of information it will provide on Harappan technology. The distribution of craft indicators, while allowing a first definition of the functional division of urban space, continue to be debatable for many owing to the limited reliability of their contextual definition in chronological terms.

Tab. 1 *Operational stages and levels of integration to correlate independent evaluation procedures on surface materials.*



The three different classes of data to be mobilized at Moenjodaro will be related according to scaled concurrence, working at two different levels of integration *(table 1)*.

At first each class will be independently processed with the same scheme of operational phases, including *positioning, identification* and *classification*, each according to its specific taxonomic criteria. For the archaeological indicators of craft activity (AICA) the classification should include the determination of its position in the relative manufacturing process. Potsherds will be evaluated by percentual occurence of types on given units of space, still to be standardized. The reconstruction of geomorphic processes of alluviation and accumulation affecting slope decline will be strictly context-dependent, confined to surfaces related to spreading of artifacts and states of degradation of wall structures.

The first level of integration is established on the binary correlation of each class with the other two. The recorded distributive patterns of AICA and potsherds will be literally superimposed on the soil maps to determine relations between scatters and various geomorphic processes. Relations between potsherds and AICA bear a dual order of results: on one side by confronting type percentages among sherds spread as wasters from ceramic manufacturing areas with the total inventory of shapes recorded at Moenjodaro, there is a procedure to evaluate relations between production and consumption per typological class; on the other their contextual relation represents the only means to chronologically seriate craft activity areas. As mentioned above this second aspect remains the most controversial of the whole project. Dating is only possible at conditions of spatial continuity determining, mostly within a single archaeological spread, changes in manufacturing work over the same surface, given that a surface sequence derives from a broken down strategraphical superimposition. The perception of such overlappings requires punctual recording of items' distribution, on a 1 : 10 : 20 map base detailing 20 cm contour lines. Since spatial allocation for craft activity seem to have been persistent through time, in spite of changes in the kind of activity performed, this painstaking approach has provided the most promising result. We are dealing anyway with a very relative seriation, bearing little relation to the history of the site. To seriate distant activity areas in a consistant chronological frame we have little other than ceramic variability to relay on. Models of slope regression as those suggested by Kirkby & Kirkby to relate geomorphic processes and horizontal pottery spreads might be rather unsuitable outside their context of primary observation *(Kirkby & Kirkby 1974; 1976)*. Their method, developed for mounds in Oxaca and Deh Luran, would be of limited reliability at Moenjodaro through the interference of the abundant bush vegetation.

The chronological ordering of the activity areas will be possible also as part of a second level of integration among the three classes of data, relying on the spatial relation of artifact spreads and a more general understanding of the soil configuration and the systematic parcelling of all its undisturbed surfaces (3). In any case this will be no immediate resolution. The taxonomy of the protohistorical Indus pottery is still at a crude stage of seriation and also not yet represents a suitable dating device for the scale of time variability required by the craft evaluation. Salination will be a further problem, because of its destructive effects on surface materials. Nevertheless the potsherds are part of the information spread over the surface on the site and they could hardly be ignored. Sampling bias will be counteracted by increasing detail in the recording of variability.

A final word of caution should be said to emphasize the limits of surface data for quantitative estimates of craft production. AICA is a generic denomination, encompassing the most diversified types of artifacts. In our case common factors of archaeological preservation combine with the peculiarities of each manufacturing activity. While there are processes based on radical physical transformations resulting in the stockpiling of great quantities of diagnostic residues, others require minimal space allocations and in an archaeological context they leave barely a few broken tools behind. AICA scatter along a continuum between these two extremes. To tackle this variability our sampling and recording strategies have to be diversified, while the implementation of archaeometrical techniques might rescue a comparable information on the least conspicious activities. Of course the information AICA carry will remain too biased to allow an estimate of relative commodity output. However, combining extensive observations, multiple sampling strategies and accurate recording with geomorphic and architectural evidence, we might estimate variance of workshop configuration relative to each manufacturing process at Moenjodaro. These figures if accurate may be further processed and eventually utilized for ethnoarchaeological testing procedures.

Aspects of Craft Evaluation on Protohistorical Sites.

In any urban center on the Indus Civilization we may expect an extremely well established system of corporate management of labour. At Moenjodaro we observe a state of craft industries that in aspects of technology and social organization are at least 2000 years old. Selective allocation of the same crafts in activity areas incorporating most of the technological solutions normally recognizable as typically Harappan, have been found fully standardized at Mehrgarh in period III, as early as c. 4000 BC *(Jarrige 1981; 1984)*. High economic integration is a character of developed urbanism, but according to the evidence from its early center on the borders of Baluchistan, the growth of commodity production in the forms of a centralized function was not an effect, but an agent of social stratification.

A great antiquity and the continuity of a successful tradition are not enough in themselves to explain the elevated standards reached by Harappan craftsmanship. However, what has mostly intrigued scholars from the very beginning is the consistency of this quality across a broad variety of settlement types and ecosystemic conditions, spreading over a territory larger than any other protohistorical civilization of the world. Even the most ordinary Harappan products, whether utilitarian or ornamental, are found in every settlement, regardless of size, location or complexity, to facilitate the archeologist's identification on the cultural complex. It might well be that focussing on a more detailed scale of evaluation we might circumscribe aspects of regional variance, but to a great extent this variability will rarely be of immediate perception. It would be wiser to suggest an explanatory frame that could be used to develop a set of testable propositions. Given the vastness of the territory involved, we may immediately dismiss any explanation grounded on the hegemony of a few production centers for the greater part of the circulating commodities unless we are prepared to admit they were served by a gigantic supply network. There is still no reliable evidence that camels and equids were widely used as pack animals before 2000 BC *(Compagnoni and Tosi 1977; Meadow in Jarrige et al. 1974; Meadow s.d.)*. Conversely, almost every Harappan site from Kathiawar to the other end of Shortugai in Bactria and in Baluchistan had their specialized workshops processing local resources.

The long-span ductility of the Harappan craft is an aspect of high efficiency that emerges once we compare its widespread distribution with the most advanced systems in contemporary Turan, confined to a small regional scale notwithstanding the imposing size of their centers furnished with the extensive craftsmen quarters. Such high standards might conceal the inner reality of a society ideologically equipped for the control of its distant segments. Our research strategy should be directed towards the organizational aspects of the Harappan craft most congruous to the archaeological record.

Division of labour is inherent in any social system and should be treated as a continuous variable. What distinguishes the organization of craft in the urban context of a stratified society, whether redistribution- or market-oriented, is on the one hand its subordination to elite policy for the control of rural production, on the other the corporation of specialized workmanship. Whatever their dependance on the primary producers or the rules governing them, craftsmen would tend to arrange their internal organization in their own way, according to a stringent set of rules and traditions to the benefit of their own leadership as much as of the physical efficiency of the manufacturing process they control. The matter-energy flow is patterned with man-to-man relations of hierarchy and comradeship. This corporate structure is the essence of any division of labour: it determines the efficiency of the whole production system and its response to innovation or social change, it stores and promotes the know-how of an entire civilization, it might survive beyond the latter's ultimate collapse.

The consistently spread qualities of Harappan craftmenship were the effect of a social organization still elusive across the archaeological record. The absence of any readable record and the insignificant number of burials excavated so far exclude for the time being at least two of the relevant sources in evidence. The only other perspective we may enter to approach the social organization of Harappan labour division is the spatial allocation of craft. The larger centers are to be evaluated first, and Moenjodaro is the first among these.

Once conveyed towards more general problems of this kind the SEP at Moenjodaro will rise above the threshold of a conservation project, and take on the configuration of a true historical approach.
A few conceptual definitions and classificatory criteria will be introduced before discussing the suitability of Moenjodaro to this type of analysis, together with some results of the first two seasons of work. In general the field method is derived from a simple cluster representation of the functional organization of space, conceiving craft allocation as a system of chess board variance across the undisturbed areas of the site. Our observation can be more easily formalized for all kinds of computer-generated surface-trend analysis.

The data base of a craft allocation programme does not differ from that of other locational studies: entered in an *„inventory of archaeological resources"*, indicators are individually seriated, accompanied by a short coded description and the coordinates of their provenance. Next to be included is the information more specifically relevant to craft evaluation. Each item has to be ranked according to its reliability and assigned to a phase in the manufacturing process of a given commodity. Degrees of reliability are directly related to classes of indicators as detailed below and can be further defined from morphological and locational parameters. Conversely, phase definition depends on the state of analytical and replicative studies, often not immediately available at the time of first coding. Processes are then grossly partioned, and we may assume further specification with the expansion of technological studies. An interactive process of this kind is in fact the expected result of the whole project.

Returning now to the question of reliability, we introduce a specific classification to serve as a system of screening. By summarizing in an earlier work the evidence from the Turanian centers *(Tosi 1984)*, AICA have been grouped in the following six classes:

1. FACILITIES. Permanent installations built for the processing of any product or raw material. They include pottery kilns, metal-smelting or glass-making furnaces, dyeing ponds, etc.

2. RESIDUES. Nonutilized remains after the processing of commodities, including wasters, disposed defective products and the broken sections of certain tools.

3. TOOLS FOR MANUFACTURE. All portable artifacts made or adapted to produce other commodities.

4. SEMIFINISHED PRODUCTS. Rough-hewns or masses of raw material prepared in a suitable form for further processing.

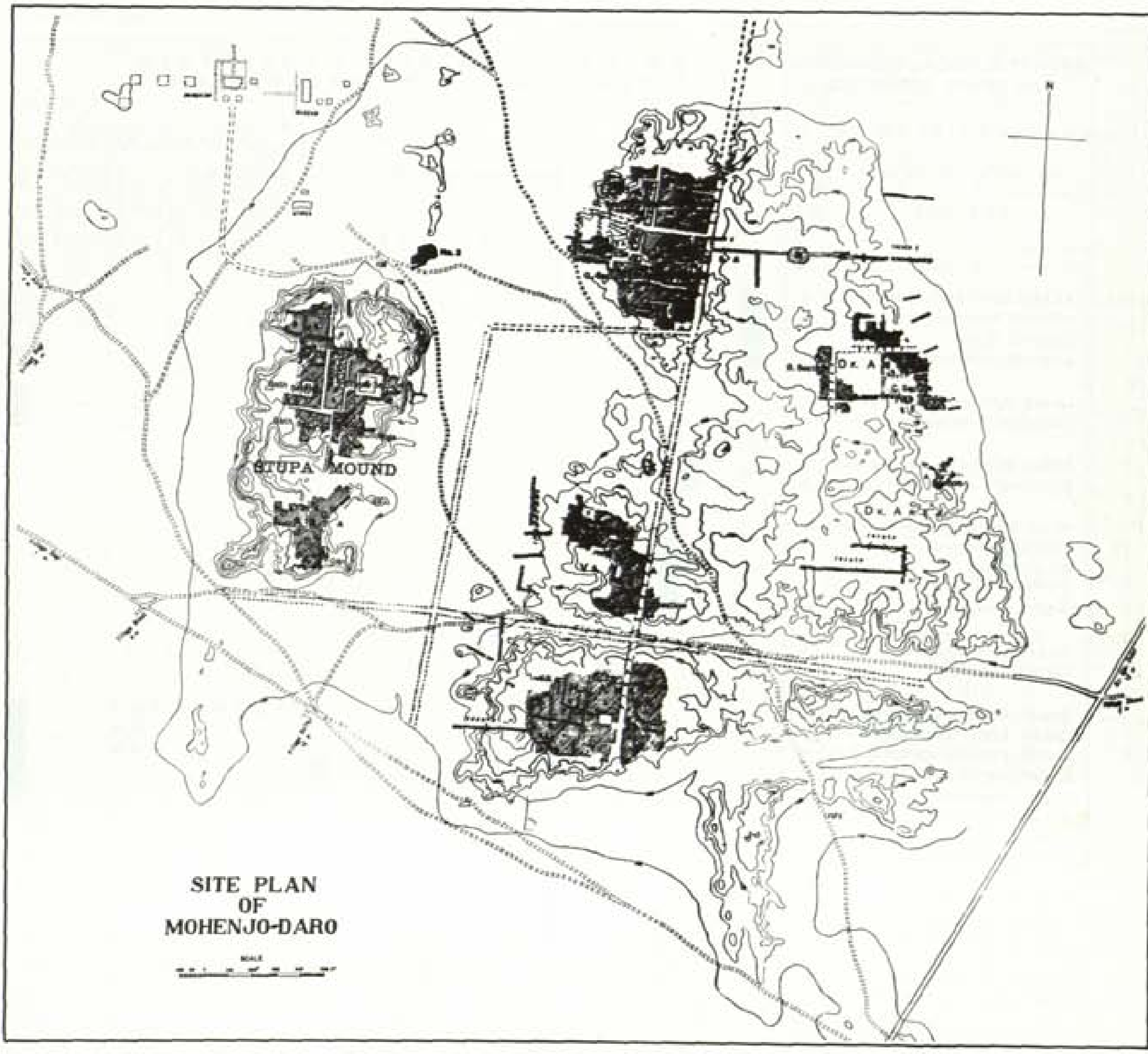
5. STOCKED AND UNWORN PRODUCTS. Supplies of finished commodities held in reserve awaiting distribution, with no deterioration from use or transport.

6. MATERIALS FOR RECYCLING. Intact or fragmented end-products obsoleted for further processing.

In evaluating size and intensity of craft activity these six classes rank of course at different levels of reliability. While density of installations or concentrations of tools and residues provide the most reliable measure of craftwork intensity, the presence of hoards of stocked or recycable products is of low incidence, especially in cases of isolated occurence or in a surface context. At Moenjodaro only the first four classes have been utilized for the surface evaluation survey *(Table 4)*.

Across the surface of a site craft activity areas are best determined by higher densities in a variable distribution of indicators. Our operational definiton has to account for both *intensity* (quantitative parameter) and *complexity* (qualitative parameter) of AICA occurences. *Intensity* is measured as percentual frequency of AICA per unit of space. *Complexity* is ranked with an index of spatial concurrence of items related to different stages in one or more manufacturing processes. By relating these parameters it is possible to develop an index of craft attitude to illustrate the variability according to each physiographic trait, architectural structure or unit of space.

Fig. 1 *The so called „Francis Map", clearly indicating the position of a series of low, small mounds radiating from the main complex.*

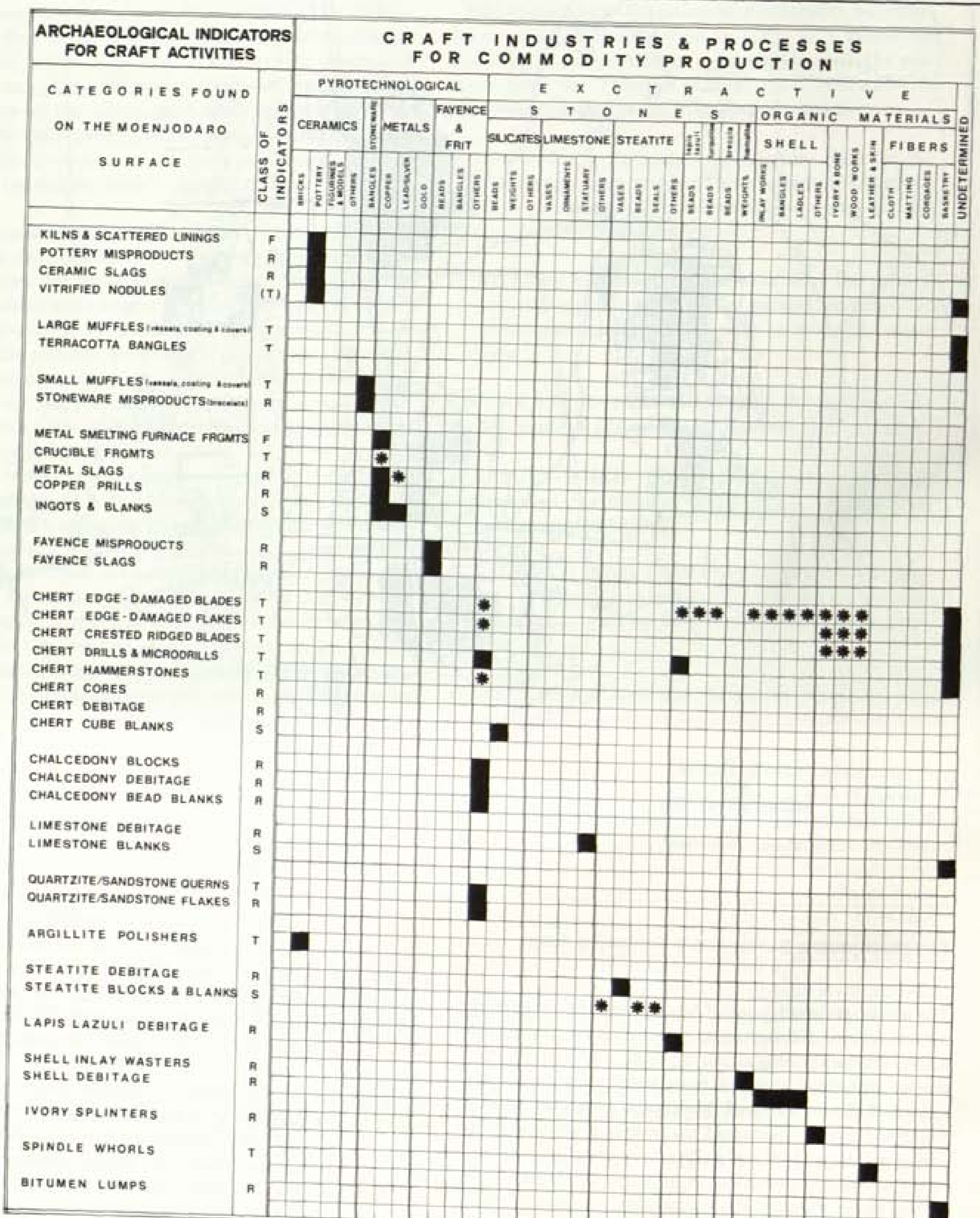


The Moenjodaro Surface as a Sampling Area

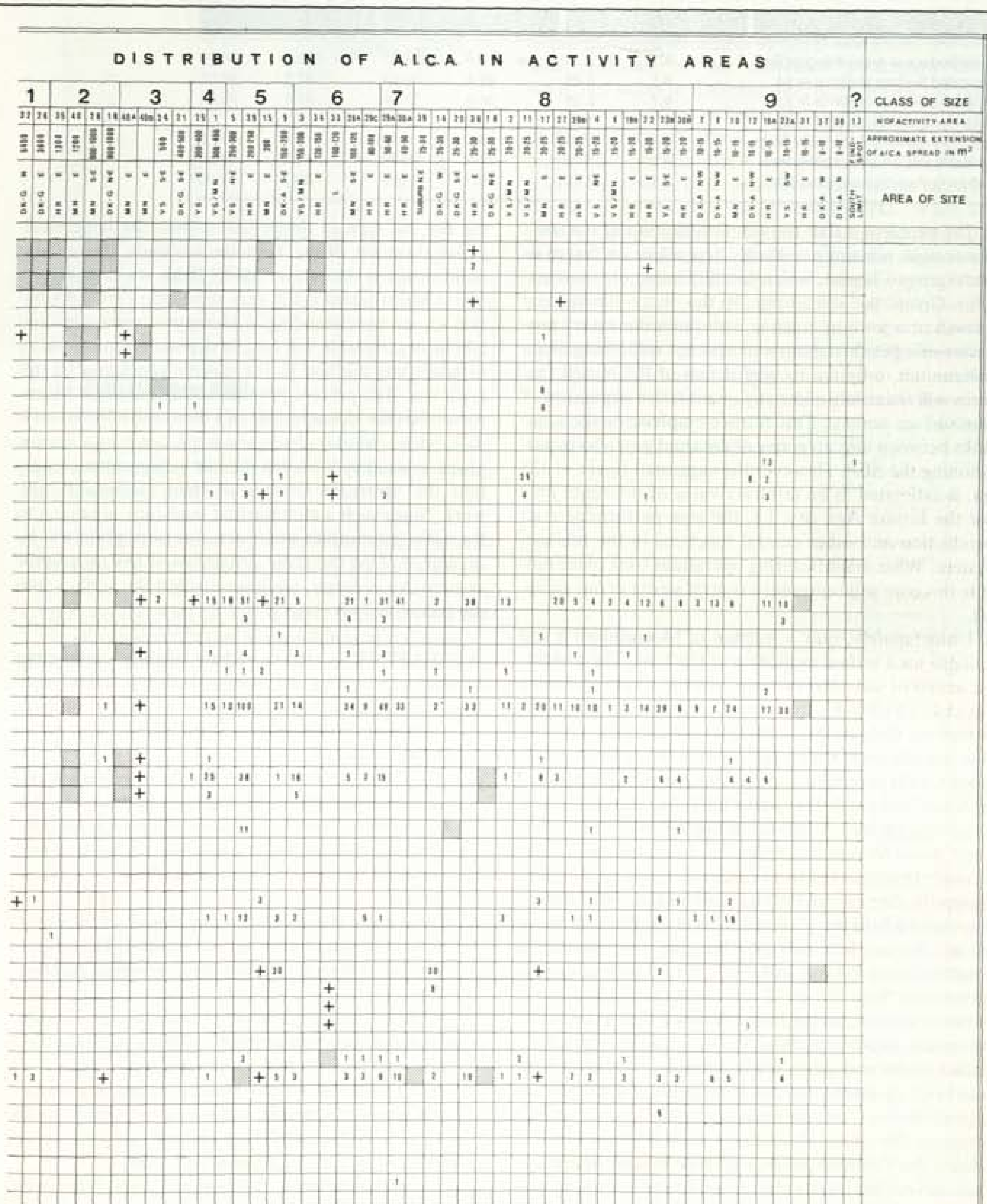
The above-ground layout of Moenjodaro has at present a total area of 125 hectares: a figure encompassing the whole of mounds rising above the 48 m. a.s.l. contour line, where artifactual remains have been most frequently recorded. Today most of this area is protected against floods by earthen dams and has been recently encircled with a drainage canal and a ring of pumping units as part of the UNESCO preservation programme *(Master Plan 1972)*. In its entirety the archaeological compound is probably much larger, including various suburban entities as well as the predecessors of the Harappan city and the still unlocated graveyards. Quite interestingly, one of the first topographical plans of the site ever made, the so-called *„Francis Map"*, recorded a whole series of minor mounds radiating from the main compound *(fig. 1)*.

Not all the mounds belonging to the peripheral system were later reported in the final reports. In general they conform to the 155 feet contour line (= 47.25 m.) of the elevation layout of the plain. A random survey carried out by S. Pracchia and M. Vidale in December 1982 revealed substantial traces of Bronze Age occupation on each of the peripheral mounds. Future investigations should establish whether this altimetric feature is the effect of the protohistorical settlement in relation to the alluvial risk.

Tab. 4 *Moenjodaro: general distribution table of surface AICA after the 83 SEP campaign.*



21


DISTRIBUTION OF A.I.C.A. IN ACTIVITY AREAS
1
2
3
4
5
6
7
8
9
?
CLASS OF SIZE
N° OF ACTIVITY AREA
APPROXIMATE EXTENSION OF A.I.C.A. SPREAD IN m²
AREA OF SITE

Tab. 2 *Types of surface at Moenjodaro for areal definition of residual space available to Surface Evaluation Programme.*

TYPES OF SURFACE	CITADEL MOUND				LOWER TOWN				TOTAL			
Total Surface of Archaeological Site	ha	**8.1**	%	5.18	ha	**116.9**	%	94.82	ha	**125.0**	%	100.00
Mounded Surface at 48m a.m.s.l.		**8.1**		6.48		**49.4**		39.52		**57.5**		46.00
Mounded Surface at 50m a.m.s.l.		**6.7**		5.36		**38.3**		30.64		**45.0**		36.00
Total Surface of Excavated Areas		**2.3**		1.84		**7.2**		5.67		**9.5**		7.60
Earth Dumps Near Excavated Areas		**1.8**		1.44		**5.0**		4.00		**6.8**		5.40
Left for Surface Survey above 48m		**4.0**		3.20		**37.2**		29.76		**41.2**		32.90
Left for Surface Survey above 50m		**2.6**		2.08		**26.1**		20.88		**28.7**		22.96

The problem is that the actual definition of the site's dimensions remains necessarily dependent on that of its underground layout, which is still completely inaccessible. Given the dynamism of the three-dimensional growth of a town interacting with the sedimentary processes of a perifluvial environment for something like a millennium, only the reconstruction of the buried features will ultimately allow any quantitative expansion of our surface survey. This further emphasizes the close links between the categories of data and procedures partitioning the SEP. However the suggested figure of 125 ha. is estimated as an arbitrary value of reference only for the bronze Age city, i.e. the area performing craft production and other central functions in the regional system. What manufacturing operations took place outside this core will represent a central aspect of our analysis.

Unfortunately, only a fraction of Moenjodaro is still suitable for a surface evaluation of this kind. The combined action of salt efflorescence, alluvial silting and slope breakdown excludes the lower flatlands from direct observation. Only the areas rising above the 50 m. contour line are safe from silting and provide the optimal conditions for the recollection of surface spreads. As detailed in *table 2* and *fig. 2*, they make up 45 ha., barely 36 % of the entire surface. Of these, between 6 and 7 ha. are on the Citadel Mound and little over 38 across the *„Lower Town"*. Disturbances from earlier excavations and their dumps further reduce the available surface of 13.86 ha., i.e. over 16 % of the total and 36 % of the mounds above 50 m. We are left with 28.7 ha., the equivalent of a fourth of the total size and 63.77 % of the mounded region above 50 m.

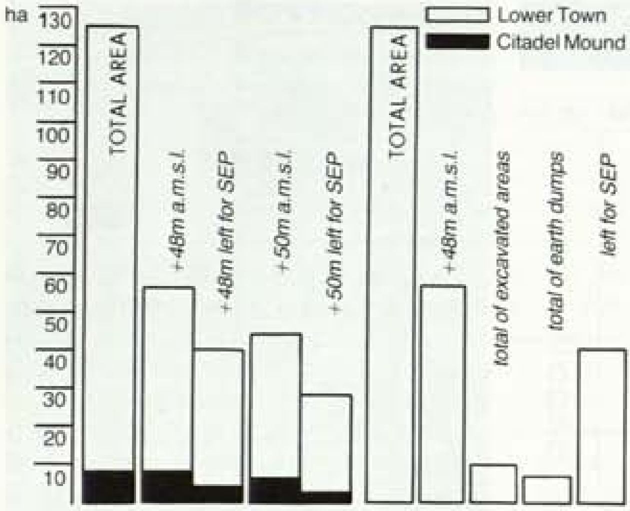
Quite a sizeable part of this surface will thus be excluded by minor factors of disturbance, such as vegetation, camel tracks and valley ways, emerging wall structures and brick platforms. In conclusion only a small percentage of Moenjodaro can be studied in terms of its surface remains. The situation recalls the most heavily disturbed sites in the Turanian plains, e.g. Tepe Hissar, where surface surveys have had to be carved between earlier excavations and other anthropic disturbances *(Tosi in Dyson et al. s.d.)*. Although it may be considered less rewarding for this type of investigations than the large wind-deflated centers of the Turanian lowlands, the amount of information stored over the 15-20 ha. we may still rescue at Moenjodaro is still very substantial. Its contribution to our understanding of Harappan technology and labour organization will largely depend on our capacity to adapt any method to the specific conditions of this great site. The present physical configuration of Moenjodaro has the characteristic of a dissected hilly countryside, where tabular elevations slope down into narrow plains, crossed by V-section riverine valleys cutting deeply into the upstream sections of their catchment network. Since such a miniaturized landscape is subject to the same geomorphic processes, our perception will be organized along the same definitions of any orographic system. Accordingly, we have divided the surface into the following four classes:

1. PLATEAUS, the levelled, slightly undulating surfaces topping the mounded regions. Here vegetation is thickest: twigs and dried vegetal remains cover a good deal of the ground, hiding most of the topsoil evidence.
2. RIDGES, the narrow, steep, strongly graded elevations, usually marking residual structures of eroded plateaus. They follow lines of higher ground resistance, determined by massive brick structures and tend to provide little information on artifacts' spreads.
3. SLOPES, the gently sloping flanks of all elevations collapsing under natural erosion. They represent the areas most susceptible to surface recollection.
4. VALLEYS, any section of a runoff system draining the plateaus in the plain. In terms of information provided they are best subdivided in:

   4.1 Upstream: lateral gullies cutting the slopes and usually producing a crowding of artifacts from the nearby spreads. They include both the upper and mid sections of a runoff network;

   4.2 Downstream: the bottom plains filled with finer alluvial sediments, with very inconsistent information on surface spreads.

Fig. 2 *Extension in hectares of main site area at Moenjodaro according to their percentual incidence.*



In the areas covered by our survey in the eastern and southern sections of Moenjodaro, five basic types of surface have been recognized:

1. CONOIDS, formed by aeolian deposition around the base of bushes and trees. They are found on plateaus as well in downstream valley sections, where they deposit wide dejection fans. These deposits cover all types of surfaces and interdict observation.
2. AEOLIAN-ALLUVIAL SURFACES, formed by small depressions capturing wind and water deposition. This second type of sediment is found only on the flat plateau sections.
3. CONOIDS, formed by the outcropping and consequent decay of baked bricks in strictly localized aggregates, ranging from the still assembled wall or platform to the loose heap in collapse. These denser aggregates are spread all over the mounded region of Moenjodaro and once isolated form the ridges. Inside the valleys they are more usually found as exposed walls working as dams until cut and made to collapse by water.
4. PRIMARY SILT SURFACES, produced by the erosion of the large mudbrick platforms and walls. Like the previous ones these relocated elements interdict observation along the gradients of ridges and in downstream valley sections.
5. EXTENDED PAVEMENTS OF SECONDARY DEPOSITION, aeolian and alluvial in genesis, of a highly altered silt, mostly originating from the breakdown of baked bricks and adobe. These sediments are probably the most frequent of the whole Moenjodaro surface and their formation is related to salt migration, as detailed below.

In a ruined city like Moenjodaro forms are created in relation to buried structures of bricks and adobe: the variable resistence of the man-made substratum drives wind and water in different directions, giving the basic instructions on the extension, depth and general outline of the natural excavations. It should be recalled how different Moenjodaro is from any other site of the Middle East in the texture of its deposits along with the extensive use of baked bricks in construction works. Walls and platform shape outcropping lines of resistance into slope profiles, thus increasing the density of the deposit and affecting direction and shape of the surface spreads. As a result, architectural remains become at Moenjodaro, more than anywhere else, a significant aspect of a surface survey. The dominant interplay in shaping the surface of Moenjodaro seems largely restricted to the relation between run off discharge as a factor of breakdown and relocation, and the baked brick structures as the main factor of density and resistance.

Effects of Salinization on Surface Survey

Slope regression is the prevailing geomorphic process affecting the physiography of the site and the movement over the surface. Despite the arid climate of Sind, with precipitation averaging 200-300 mm/yr, rainfall remains the major single natural factor of surface breakdown. Outgrowing salt migration from the very high water-table intensifies pulverization of topsoil, causing the rapid disintegration of bricks and potsherds, but has a smaller effect on slope erosion. While primary and redeposited silt fill all lower components of the Moenjodaro landscape, redeposited particles of baked clay from flaked terracotta are the dominant components on plateaus and slopes. Wetting and drying cycles combine with rainfall in accelerating on the uppermost levels with salt and carbonates to form the characteristic swollen crust of Moenjodaro.

Tab. 3 *Observed grades of resistence to salt crystallization in pedogenetical processes on the surface of Moenjodaro, for the different types of materials and objects relevant to AICA Evaluation.*

CLASSES AND TYPES OF ARTIFACTS		GRADES OF SALT-RESISTENCE		
PYROTECHNOLOGICAL PROCESSES		LOW	MEDIUM	HIGH
CERAMIC	- Sherd and Other End Products	□		
	- Slags & Kilns			□
STONEWARE	- Bracelets			□
	- Misproducts			□
	- Firing Containers			□
METAL	- End Products		□	
	- Crucibles & Furnaces Fragments		□ —	— □
	- Slags			□
	- Prills			□
FAYENCE & FRIT	- End Products		□ —	— □
	- Slags			□
EXCTRACTIVE PROCESSES				
STONES	- Silicates (Chert/ Jasper/Chalcedony)			□
	- Lapis Lazuli			□
	- Limestone	□ —	— □	
	- Carbonates	□		
	- Quartzite			□
	- Sandstone			□
	- Soapstone	□		
ORGANIC MATERIALS	- Shell			□
	- Ivory & Bone	□ —	— □	
	- Bitumen		□ —	— □

Fig. 3 *Moenjodaro Moneer South-East Area (AA.40): removal with vacuum cleaner topmost pulverized clay formations.*

Salinization has a dual effect on survey work: it swells the topsoil, cementing artifacts and finer particles in a hard crust resistent to wind erosion, and flakes potsherds and other ceramic objects. Both processes prevent the development of an aeolic deflation pavement, representing an essential resource for surface evaluation on archaeological sites in the arid zones. Any sampling technique designed for the detection of horizontal variability in the distribution of artifacts at Moenjodaro and lowland Sind will have to take into account the biasing effects of salinization on both their movement and conservation.

Considering that we are not dealing with an aeolic pavement, the surface of Moenjodaro should not be conceptualized as a bi-dimensional plain, but treated as a composit geomorphic formation. At times over 10 cm thick, it is articulated in three pedogenetic phases by the salinization process: at the bottom the *eroding tegument* of the archaeological deposit, irregularly covered by a *pulverized clay sediment* storing most of the humidity, both evenly topped by a saline crust. Archaeological materials are moved vertically between the original surface of the site and the saline crust, where they become cemented.

The main consequence on the evaluation of artifacts scatter is that the objects cemented in the saline crust represent only a fraction in the original scatter, since only part of them have migrated to the surface, while the rest „float" in the loose sediments underneath. It has been observed that rainfall accelerates vertical movement of the smaller objects. In late March 1982, once the first surface collection campaign had been completed at Moneer-South-East, over a c. 2000 m^2 sampling area made interesting by a spread of small chalcedony rejects and related chert debitage from a bead manufacture (AA.4OA), a day of strong rain produced the effect of a diffuse salt efflorescence. On close inspection on the next day, M. Vidale could estimate that the number of AICA that had emerged to the surface through the softened crust was roughly equivalent to the number of the items already collected.

Collection of artifacts cemented in the salinized topsoil means cracking and pitting the crust, leading to its rapid destruction. Immediately below the saline crust we encounter the coarse-grained clay sediment, mostly originating from decayed mudbricks, where conditions of observation can be very poor. To detect the pedological configuration of the clean site's surface and the architectural layout, the pulverized clay deposit has to be removed. This has been accomplished with the most outstanding results by the extensive use of compressed air from vacuum cleaners and air-guns. *(fig. 3)*.

The biasing effects of the salinization process can be counteracted by a three-stage collecting procedure. To consider as complete the surface evaluation of artifacts spread over a given area, recording and collection will have to be repeated separately for each *„stratigraphic"* unit of the topsoil formation. The salt crust will be removed in small slabs, checked on both sides, the pulverized sediment by compressed air. Geo-pedological observations and mapping will be carried out as a third stage on the clean surface of the archeaological deposit.

The effects of salinization on the physical state of artifacts varies according to the type of material. In general, ceramics and clay, certain carbonates and all kinds of soapstones deteriorate rapidly as soon as they emerge and are cemented in the saline crust. On the contrary, silica stones, slags and shell have been seen to be highly resistant. *Table 3* summarizes our observation, listing the main classes of materials processed at Moenjodaro and present in the archaeological record with their relative degree of salt resistence.

The greatest deviation from other sites in the Middle East is caused by the destruction of all ceramic products, particularly potsherds. Consequences on craft evaluation are minimal, because ceramic production is generally evaluated from vitrified wasters and permanent firing installations, but such a radical breakdown of potsherds on the ground will hinder any chronological setting of surface variability developed exclusively from topsoil distribution of pottery types. No appropriate sampling strategy has yet been developed to cope with such an extensive phenomenon. The only possible approach would necessitate a better understanding of the processes leading to salinization. In spite of the high salt content, surface potsherds only a few centimeters below the ground are still unflaked and might complement the topsoil information once the pedogenesis related to their vertical migration is properly defined. On the surface of Moenjodaro there are still plenty of potsherds and a more selective recollection might still bring us some relevant information. At present no other procedure can be foreseen other than a broadening of our data base. Unless a number of geological studies are directed towards specific archaeological problems, there is still little chance of achieving a sufficient degree of control so as to expand our analysis of Moenjodaro and most protohistorical sites of lowland Sind.

Methods of Field Recording

In order to produce a first picture of the AICA distribution at Moenjodaro, during the first two seasons the systematic survey was confined to the most remarkable of activity areas, where the concentrations were evident enough to be detected. Given the preliminary character of our work no sampling strategies have been yet devised, on the assumption that they would have been more consistently implemented once the general conditions of occurence had been portrayed. Along the same lines the collection of artifacts has been largely restricted, except for general identification of the manufacturing process involved, not to compromise the potential information capacity of the activity areas.

Our efforts have been directed toward developing methods of recording the AICA disribution on the uneven surface of the site. As a standard procedure, once possible activity areas have been detected and before any artifact is collected, the overall configuration of the spread is sketched on the 1 : 1000 plan sheets and numbered according to a preliminary list of activity areas *(hereafter AA. 1-n)*. Since the definition depends on the relation between density and ratio of craft functions concurrence, this list can be regarded as an early stage in the evaluation process.

To provide maximum detail a high level of accuracy has to be attained not only with regard to the position of the objects, but also to the ground morphology. Contour lines at 1 m. distance are photogrammetrically determined within the general survey of Moenjodaro carried out by the RWTH Project. A more detailed topography is to be developed in the activity areas of more complex configuration, mostly on upstream valleys intersecting slope spreads, by means of optic level to map contours at 20 cm isocurves. Relative distance between objects and points is recorded by theodolite or by oblique imagery of terrestrial photogrammetry, so far still in the testing stages. A further level of detail is to be reached by low-altitude vertical photogrammetry from a hot-air balloon. However, most craft indicators are too small to be properly recorded by photogrammetric imagery. Their location has to be visually detected from an average eye distance of 30-50 cm. To avoid footprints and the rapid deterioration of the salt crust, a 3 x 5 m platform of bamboo frames and stands was devised; it stood at an average height of 30 cm from the ground *(fig. 4)*. Passageways to and from the platform were simply made of wood planks. Observation could be carried out from a comfortable position, resting on movable planks laid between the bamboo scaffoldings: even the smallest

Fig. 4 *Moenjodaro Moneer South-East Area (AA.40): use of bamboo movable platform for non-destructive surface observation.*

Fig. 5 *Moenjodaro Moneer South-East Area (AA.40): use of small flags pinpointing artifacts' individual position.*

items could be easily detected with minimal damage of the salinized surface. Once pinpointed on the ground and signaled with a coloured flag on a bamboo stick or another marker, each item is numbered and placed in a sealed polythene bag. Flags and bags are left on the spot *(fig. 5)* until the following plotting phase, in order to label coordinates before removal. Coordinates are given as the distance of points from axes of 5 x 5 grid squares. The most suitable mapping scale are the very small ones, 1 : 10 and 1 : 20.

This very simple and painstaking method provides the highest level of detail by means of cross-checking between direct and photogrammetric means of measurement. Being an extremely time-consuming procedure, its utilization should be restricted to areas characterized by overlapping spreads of small indicators on a dissected ground morphology, where accurate correlation with hydro-pedological soil variability is an essential instrument of analysis. These conditions are satisfied at Moneer South-East (AA.40), the very first activity area identified at Moenjodaro by the RWTH team in January 1980 just to the south-east of Moneer excavations.

Where the ground surface was flatter and soil morphology more uniform a simple recording procedure was adopted. The spread was first transected by a 5 x 5 m grid of white string, with the same orientation as the whole system. AICA were located and marked with flags or other means. Recording was carried out directly on graphic paper using a 1:10 scale, using as reference a 1 x 1 m aluminium frame partitioned into 10 x 10 cm squares, moved along the string grid. Although standard accuracy should fall within 10 cm, an area of 100 m^2 can be recorded by two persons in half a day, against the week required by three-coordinate theodolite recording.

An indeterminate degree of accuracy may be attained by using low-altitude vertical photography from a hot-air balloon. This method has been tested with promising results by S. Pracchia and M. Vidale on the southern portion of Moneer-east, for an area of great complexity: a dissected slope with strong concentrations of ceramic wasters and other AICA *(fig.6)*[1]. Grid intersections and other points of reference are marked on the ground for inclusion in the photographic imagery.Coloured 6 x 6 slides are painted in scale 1:10, 1:20, and 1:50 (Cibachrome process). Such larger objects as kiln wasters, or warped potsherds can be immediately identified on the photo print and drawn on a superimposed sheet of transparent paper. Smaller AICA are first located and numbered on the ground according to the usual procedure, then recorded on the same sheet by relocating them after visual check directly on the photograph. By developing a more specific marking system for smaller indicators this third procedure may be further extended to the whole site, provided that a contextual use of the low-altitude orthophotography will be possible for a prolonged period of time.

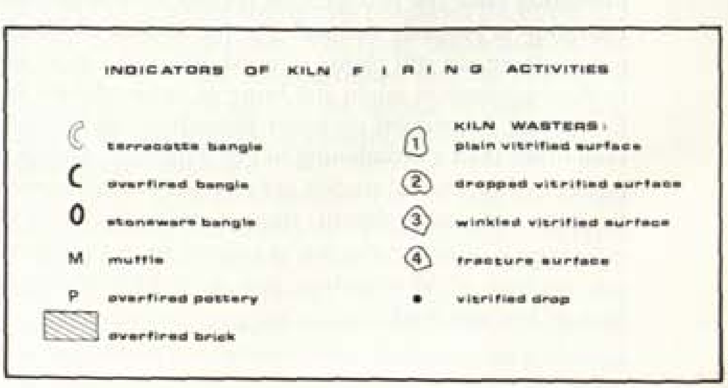


Fig. 6 *Moenjodaro Moneer South-East Area (AA.40): distribution of kiln-firing indicators along a slope (see also footnote 1).*

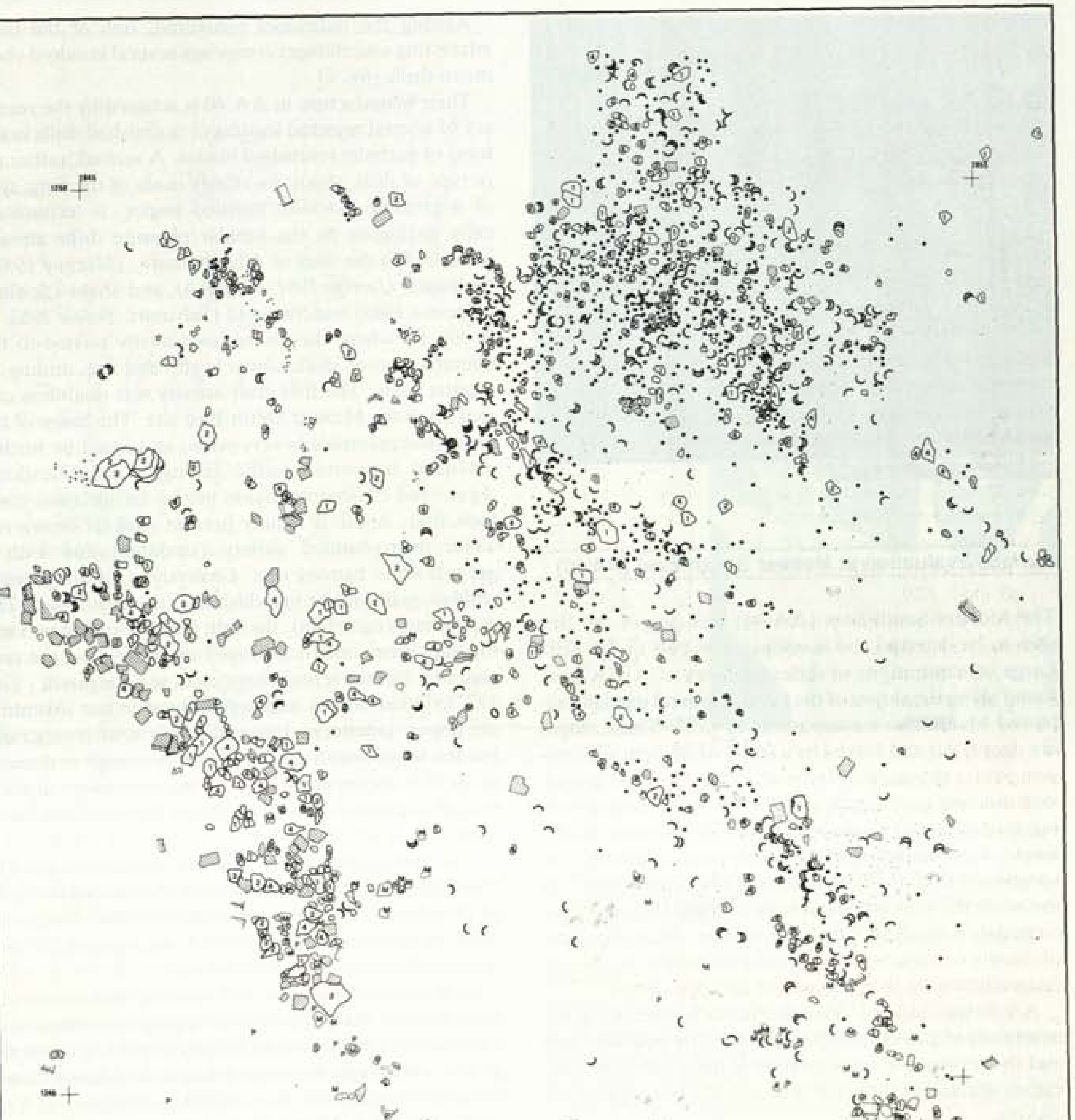
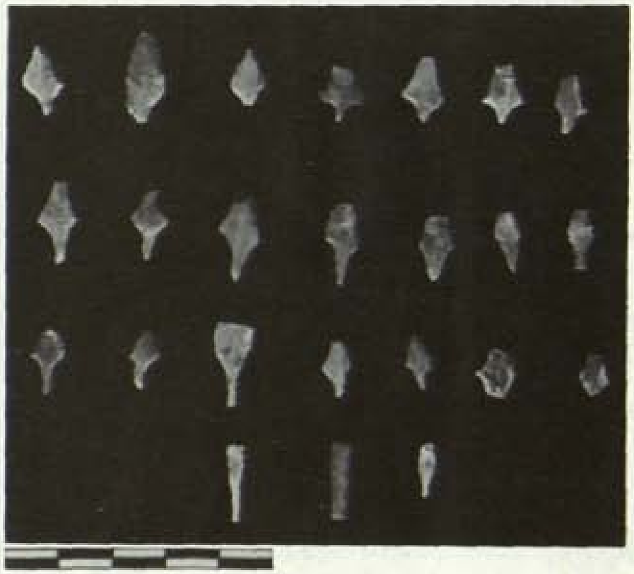


Fig. 7 *Moenjodaro Moneer South-East Area (AA.40): chert micro-drills.*



Surface Evaluation at Moneer South-East (AA.40)

The Moneer-South-East (AA.40) was one of the first sites to be detected and investigated as part of the SEP. Large concentrations of different types of AICA were found along the slopes of the tabular mound partially explored by Moneer's excavations in 1937. These slopes are deeply cut and carved by a series of four parallel erosion gullies debouching eastward into a silt-filled depression running north-south and most probably corresponding to the axis of an ancient road. To the south-east a single, large valley running north-south separates the compound from the flat mounds of the *„lower town"*; to the north the site turned out to be bounded by one of the large debris mounds of the old trenches. A careful check of the site conditions led to the elimination of all the surfaces affected by the presence of dumped debris.

AA.40 was deemed to be a particularly interesting site as a result of two outstanding features: its extensive size and the presence of large clusters of quite different indicators situated in different but partially overlapping locations.

The northern section of AA.40 was littered with thousands of lithic residues, comprising a wide range of different AICA: chert bladelets and blades, mostly unretouched; chert drills and hammer-stones; a large number of chert debris; agate, chalcedony and other semiprecious stone debris; flakes and chips of sedimentary or metamorphic rocks such as limestone, sandstone, quartzite. Fragments of rods and sheets suggested the employment of copper/bronze tools.

Among the indicators recovered, one of the most interesting assemblages comprises several hundred chert micro-drills *(fig. 7)*.

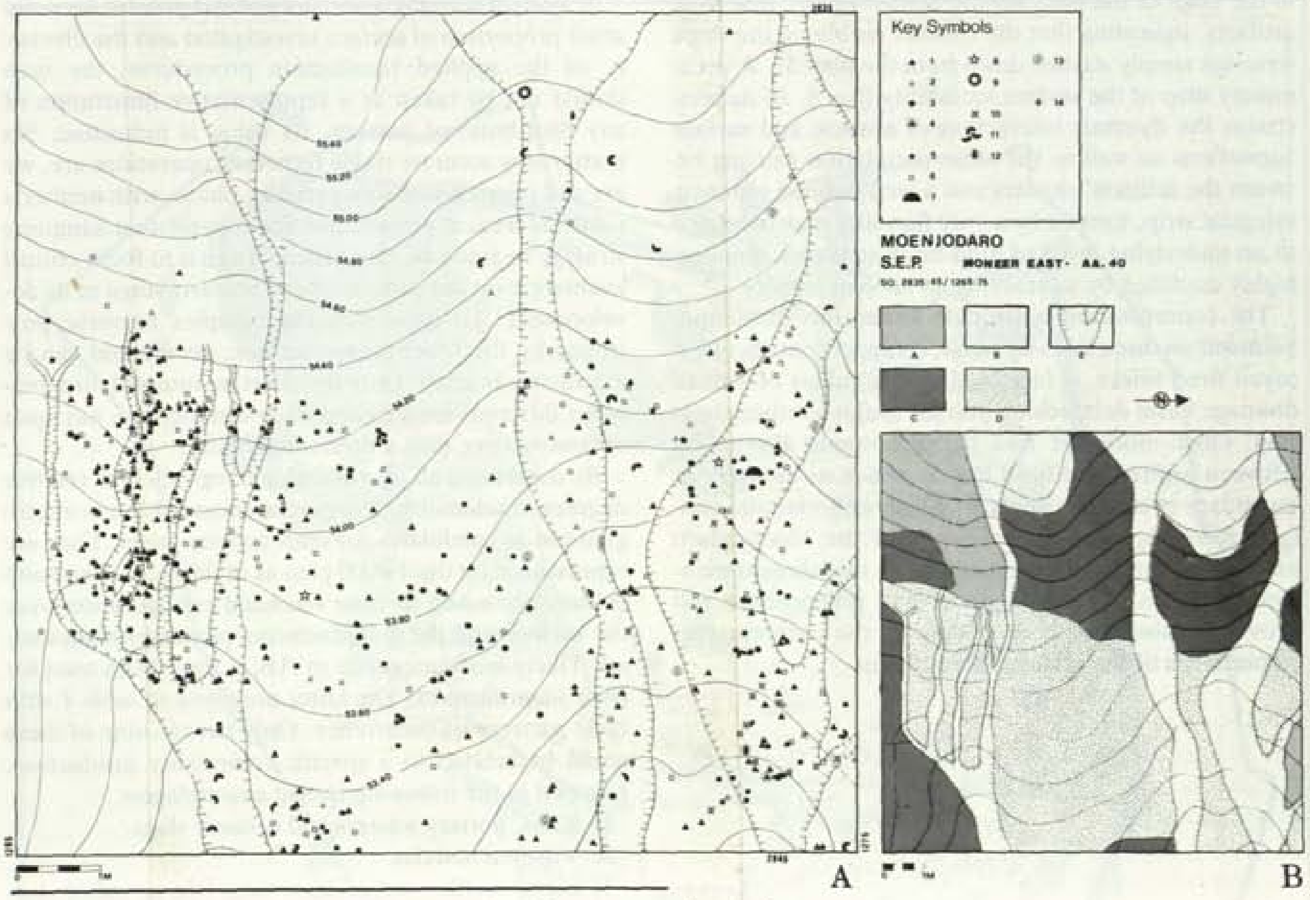
Their manufacture in AA.40 is attested by the recovery of several rejected wasters or unfinished drills in the form of partially retouched blades. A second, rather rare type of drill, almost invariably made of the same type of a greenish-blacklish mottled jasper, is technologically analogous to the tubular phtanite drills already identified in the sites of Chanhudaro , *(Mackay 1937)*, Mehrgarh *(Jarrige 1981: 99, fig. 6)*, and Shahr-i Sokhta, *(Piperno 1983)* and Shahdad *(Salvatori, Vidale 1982: 8-9, fig. 3)*, where they were functionally related to the manufacture of chalcedony beads and the drilling of steatite seals. The first craft activity was doubtless carried on at the Moneer South-East site. The range of the processed materials is very wide, and could be further extended by more specific geological identifications. Agate and chalcedony flakes are by far the most common find. Agate is mainly present with its brown-red white micro-banded variety (sardonix) and with a greyish/white banded one. Chalcedony, in its greyish, whitish, yellowish or brownish hues is well attested. The red variety (carnelian), the light green (chrisoprase) and the dark green one (heliotrope) are present but not very common (for the terminology used, see *Bulgarelli , Tosi 1977*). Other stones well represented in our inventory are jasper, jadeite, rock crystal. Lapis lazuli is very rare, but the single rough-out recovered is enough to demonstrate the employment of a cutting technology already well documented from the eastern Iranian lapis lazuli workshop *(Tosi, Piperno 1973)*.

The greatest majority of this debris may be referred to the chipping of lumps or geoids into rough-outs for further processing. Rejected rough-outs or small blocks are much more common than ground, unperforated blanks or beads broken during perforation.

In the southern section of AA.40 the distributions of lithic wasters are partially overlapping with remains of kilns exposed by erosion and slowly crumbling inside the gullies. The heaps of overfired materials include kiln wasters and linings, flows of overfired TC bangles and fragments of muffles *(fig. 6)*. These materials seem to spread from a series of deposits roughly corresponding to the 52 m isocurve. All the indicators mentioned are functionally grouped in two separate manufacturing processes for the production of ceramic materials fired in muffles. These topics are more widely discussed in a separate contribution (see *Halim and Vidale in this volume)*.

Up to 1983 AA.40 has been surveyed for a total extension of 3700 m^2. Using the discribed methodologies of identification, recording and collecting, more than 7000

Fig. 8 *Surface Evaluation at Moneer-South-East*



artifacts were entered in our inventory, all of them accompained by centimetric coordinates. By including sections of the plateau, the complete extension of the valleys as well as their deltaic regions debouching into the lower depression, the surface assemblages could thus be treated as isolated closed units. While the aim of the SEP at Moenjodaro was to reconstruct forms of labour allocation in the urban context, the Moneer East operation was designed to test the same line of approach within the restricted context of a single craft activity area. Furthermore, by means of highly detailed data collection it was intended to allow the building and the testing of hypotheses on the stratigraphic, areal consequently, chronological setting of the different surface assemblage.

The locational aspect of the research (i.e. the spatial variability of AICA) and the processual one (their insertion in the sequential chain of the manufacturing process) are then matched with the sedimentological variability of the surface. *Fig. 8* shows a square with a medium-high concentration of artifacts grouped in 14 categories. The AICA appear strongly concentrated immediately below the 55.40 m isocurve. The erosion gullies in the more elevated part of the square (corresponding

Key to A

1 Chert bladelets
2 Chert flakes
3 Chert drills
4 Chert hammerstones
5 Agate/chalcedony flakes
6 Other stones flakes
7 Anvil stones
8 Finished beads
9 Fragment of marble lingam
10 Overfired sherds
11 Terracotta bangles
12 Terracotta figurine
13 Shell fragments
14 Copper/bronze fragments

Key to B

Sedimentological variability in sq. 2835:45 / 1265:75

A *Dejections from conoids formed by retention of aeolic material under bushes and trees.*

B *Conoids produced by collapse and disintegration of fired bricks, whose powdered particles form not less than 80 % of the sediment.*

C *Deposits analogous to B, but characterized by an increase in the silt percentage.*

D *Soft silty deposits, highly reelaborated, produced by the decay of mud bricks or adobe surfaces, strongly affected by aeolic activity.*

E *Bed of erosion gullies, very often excavating the surface down to the outcropping of fired bricks structures.*

to the edge of the plateau) are almost totally free from artifacts, indicating that the clusters visible on the slope were not simply washed down from the plateau. A preliminary map of the surface variability *(fig. 8, B)* demonstrates the dynamic interaction of erosion and surface formations as well as the close correlation existing between the artifacts' clusters and a well defined sedimentological strip, formed by a very fine silty matrix related to an underlying layer of mud-brick structure remains, highly modified by weathering an aeolian activity.

The concentration is stronger where this formation, bounded on three sides by small, compact conoids of decayed fired bricks, is furrowed by the gullies of a small drainage basin debouching into the major southern incision. Once more, we find the dichotomic alternation between unfired and fired bricks, which, in primary or secondary context, in vertical as well as horizontal contact, form the structural skeleton of the Moenjodaro mounds. A proper understanding of this three-dimensional process of growth, decay and redeposition will provide a substantial body of data for the contextual interpretation of the surface assemblages.

A Few Considerations on the First Results

The SEP testing procedure for craft evaluation postulates a direct relationship between allocative forms of commodity production and spatial variance in the distribution of relevant indicators across a settlement system *(Tosi 1984)*. To determine its present consistency as a source of information the surface of Moenjodaro has been inspected in a series of random reconnaissances, transecting the least disturbed sections of the site, along its northern limits and to the east of Street 1. These rather unsystematic observations were immediately recorded on sheets of the 1:1000 RWTH plan, while the collected artifacts have been entered in the provisional activity areas file. By the end of the 1983 season the recorded AICA spreads were reported on an 1:2000 RWTH plan, summarized in the first map of craft indicators over the Moenjodaro surface *(fig. 9)*.

A word of warning mandatory at this point. Given the small proportion of surface investigated and the diversity of the applied recollection procedures, the map should not be taken as a representative illustration of any distributional pattern. Its value is indicative. No matter how accurate single recording operations are, we are still restricted to a preparatory phase, with neither a solid theoretical proposition nor a consistent sampling strategy to guide us. Our principal aim is to focus critical evaluation on our programme at an early stage of its development. To cope with the complex universe portrayed by the Moenjodaro surface, no method can be exhaustive in itself. Only the constant interpolation between different lines of approach can increase our span of control over such a diversified realm.

By combining all identifications, regardless of relative degrees of reliability, fourty-nine spreads have been singled out as candidates for craft activity areas. They are represented on the 1:2000 plan as of different shape and colour, according to their recorded configuration over the surface and the manufacturing processes represented. Thirty-nine categories of AICA have been used for their identification. The latter are given in *table 4* with their patterns of occurrence. Only twenty-nine of them could be related to a specific commodity production, grouped in the following twelve assemblages:

1. Kilns, pottery wasters and ceramic slags.
2. Vitrified nodules.
3. Large muffles and ceramic rings (the so called „terracotta bangles„)
4. Small muffles and wasters of stoneware bracelets.
5. Copper slags, prills and metal-smelting crucibles.
6. Faience misproducts and slags.
7. Chert implements, cores and debris.
8. Chalcedony bead blanks, pebbles and cores, debris.
9. Limestone debris and presumed blanks.
10. Steatite bead blanks, preparatory small blocks and debris.
11. Lapis lazuli bead blanks and debris.
12. Shell blanks and debris for inlay works, bangles, ladles and other products.

The remaining ten categories include either more rare indicators, predominantly those of frail structure (ivory debris, bitumen lumps) and complete artifacts doomed to be rapidly collected (e.g. spindle whorls, but also still unreported tools of metal or bone, more conspicuous than lithics), or those frequent ones have not yet been able to be related to any manufacturing process, such as the greater part of the lithic industry. *Table 4* incorporates all the specific associations, while questionable functions are entered as dubious or UNDETERMINED.

Fig. 9 *Preliminary map of craft activity areas at Moenjodaro.*

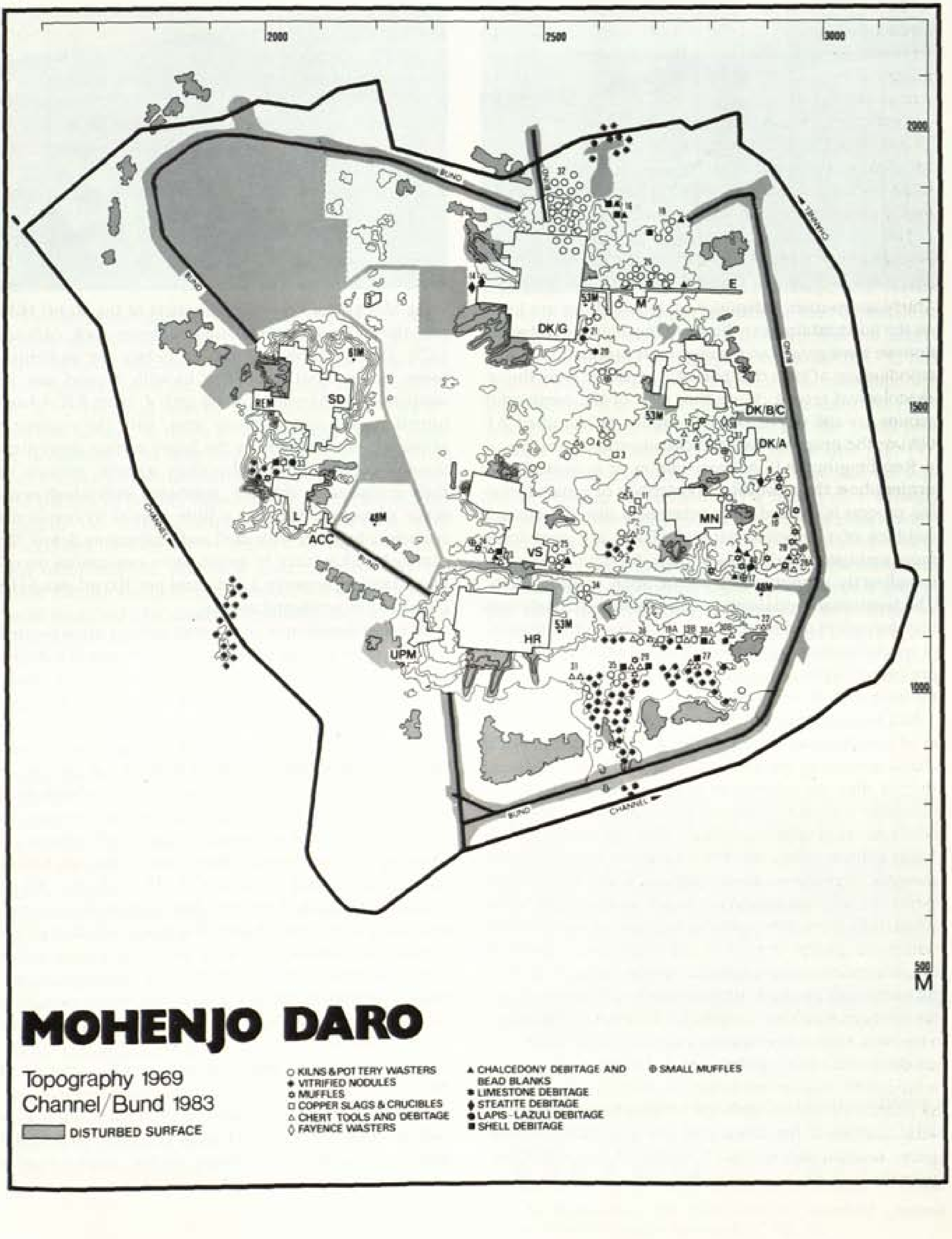


Fig. 10 *Moenjodaro, DK-G North (AA.32): heap of kiln linings and other overfired wasters marking the position of a pottery kiln.*

Fig. 11 *Moenjodaro, HR-South (AA.35): step hummock entirely formed by ceramic misproducts.*

Thirty-seven main categories of commodities are listed on the horizontal axis to illustrate the degree of information we have gained so far over craft production at Moenjodaro, or at least that part of it expected from the archaeological record. More than half of the commodity groups are still unpresented in the list of identified AICA, or the proposed associations are still uncertain.

Recalling our AICA classification, it is immediately evident how the most direct perception of a manufacturing process is derived from permanent installations and residues of processed material. Tools are generically more ambiguous indicators or their discriminatory value is indirectly proportionate to the span of utilizations. The functional specialization of a tool kit is strongly context-dependent and is unrelated to the level of professional specialization reached by a given population, since in pre-industrial societies craft is still stored more often in the man than in the implement.

In a technocomplex still extensively lithic the inventory of standard tool types is highly limited by the physical characteristics of the stones. In the end it will be found shorter than the number of required functions encompassed in the total of operations utilized for commodity production. Harappan culture, like any other Middle Asian culture during the 3rd millennium BC, presents a complex, very contradictory picture. While fully mature in its urban configurations, it still retained the same standardized inventory of lithic implements as its Neolithic predecessors, in spite of the much larger spectrum of commodities they produced and consumed. As a result, relations between the few types of lithic tools and the great number of specific manufacturing processes have only been determined in cases of concurrence with residues of the processed material. However, we expect to overcome this contradiction, at least to some extent, by more elaborated methods of investigation, such as wear analysis of functional surfaces and different replicative studies, planned for a further stage of our programme.

At Moenjodaro the nodular chert of the Rohri Hills was the most commonly used siliceous rock *(Allchin 1979: 180-81)*: tools and related debris are an ubiquituous surface find presenting us with a good case of sampling bias. As evidenced on *table 4*, chert AICA have turned up on every activity area, with the exception of the pavements made by the heavy surface concentrations of ceramic kilns and pottery wasters, because of their conspicuous visibility, combined with a high resistence to weathering and a little appeal to occasional collectors together with shell and chalcedony debris. To diminish redundance in quantitative evaluations occurences ranging between 1 & 5 items per 100 m^2 should be dismissed as accidental events.

Size and distribution of the craft activity areas located so far may be related for a first order of general considerations. The recorded AICA clusters are rather small: 25 out of 49 extend over less than 30 m, while only 6 of them range beyond the 1000 m.

With the relevant exception of the chalcedony workshop at Moneer South-East (AA.40A), all the larger spreads are consequent to permanent pyrotechnological installations and their wasters. These very prominent features are located on the outer edges of the present archaeological compound, north and east of DK-G (AA.18,26,32) and south-east of HR (AA.35). All of them are articulated between a low-lying section, containing the 2-3 m broad cluster of vitrified kiln linings approximately aligned on a E-W axis, and a steep dune-shaped hummock, 3-5 m high *(fig. 10)*. On closer examination hummocks display a structure made of tightly packed potsherds, mostly misproducts. Most impressive are the hummocks of AA.32 and AA.35 *(fig. 11)*: on the front side of this last one a relevant number of vitrified nodules soldered together in bunches were found in contextual relation, proving some kind of association with pottery firing operations. Here as well was collected the only ceramic burnisher found so far, made from a smooth pebble of black argillite *(fig. 12)*.

Fig. 12 *Moenjodaro, HR-South (AA.35): black argillite ceramic burnisher.*

Fig. 13 *Moenjodaro, HR-East (AA.36): remains of isolated kiln.*

The estimated number of kilns in the largest of the pottery manufactures, AA. 32 at DK-G ranges between 7 and 10 units. Mackay refers to other six or more kilns, one of them found in the middle of Central Street *(1938:33, Pl. X, d)*. He dated them to *„the end of the Late Period"*, and was inclined to relate their installation to the phase of decadence. Our impression is that the distribution was not an exceptional one but responded to the allocative pattern of pottery manufactures. Surface evidence suggests the contemporary activity of several small workshops, denounced by clusters of overfired bricks and other wasters, produced apparently by very few kilns. Pottery was fired also by individual kilns, set in the small backyard of a standard residence unit, as best exemplified by one found in House VII, Block 2 of HR-A. The horseshoe structure is resting with its back against a wall to close the southern side of First Lane, between House VIII and House VII. Because of this single kiln, Sarcina has suggested that House VII related to artisanal activities *(1978-79: Pl. XXXVI)*.

The assumption is contextually right, but we suspect this kind of cottage manufacture as quite a diffused custom among Moenjodaro residence, as a non-competitive form of segmented manufactures.

All the domestic firing installations found so far would add up a rather modest volume of pottery output compared to the demand expected for a city like Moenjodaro and its dependant rural population. Ceramic might have been a minimally centralized commodity production or the largest manufactures were located further away from the town's center, in the outer ring of minor mounds crowning the site beyond the present limits of the archaeological compound.

There is evidence anyway that a relevant amount of certain pottery types might have been produced by very small activity areas, represented on the surface by minor spreads of slags (e.g. AA. 4, 15, 24, 34) or even isolated kilns like those occuring along the workshop row in HR East *(fig. 13)*.

Part of the answer might lay with the kind of pots these smaller units produced and in this direction our analysis is going to move. Although in the larger AA. 32 and AA. 35 pottery misproducts indicate the contemporary manufacture of several types, one of the recurrent characters observed in the smaller units in the *„mass production"* of the distinctive *pointed goblet type (fig. 14)*. An alternative explanation might indicate that the supply of ceramic did conform to a model of a strongly segmented commodity production, such as evidenced by other manufacturing processes detected at Moenjodaro.

Allegedly, we would be dealing with a diffused system of small scale production units, spread over a greater part of the main N-S and E-W depression transecting the eastern half of Moenjodaro. Whether this kind of occurrence is the biased result of the better visibility of sloping or is related to the early road system is still premature to state.

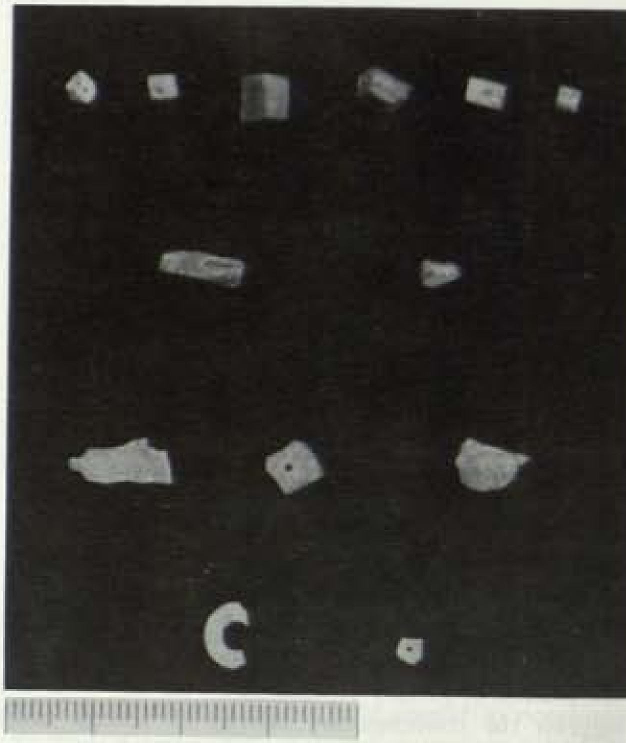
Fig. 14 *Moenjodaro, HR-South (AA.35): overfired „pointed goblet" from the wasters hummock (cf. Fig. 11).*

Steatite and faience working seem to conform most strikingly to this kind of small workshop system. A strong concentration of tiny steatite wasters, including small lumps, small perforated square blocks and microscopic flakes, was found by J.M. Kenoyer under the foundations of excavated structures at the westernmost limit of DK-G. The wasters suggest *(fig. 15)* a manufacture of small disk-shaped beads of steatite extending over 25-30 m (AA. 14). A second concentration of small steatite blocks and small plates has been located. About 25 m to the north we have been able to locate for the first time the tiny slags produced by faience smelting (AA. 37). The wasters were associated with a sherd of a straw-tempered container, possibly square-mouthed, with attached drops of the same glassy material *(fig. 16)*. Both sites might be of particular interest: the first in the perspective of the identification of a seal-cutting workshop, the second because technology of faience production in the Indus Civilization is still one of the least known.

Directly relevant to a better understanding of the general pattern of work distribution might be the result of a more accurate survey, carried out over a two-week period in January 1983, along the southern perimeter of the 400 m-long ridge extending straight east of HR. This orographic structure is one of the most outstanding features on the unexcavated part of Moenjodaro: its steep sides rise up to 55 - 56 m and the whole of its base seems to be made of a gapless series of mudbrick platforms. Along its southern flank the ridge is bordered by an E-W depression. Both the depression and the HR-east ridge lie at the center of a 12 - 15 ha. area representing the largest undisturbed portion of the site. Both sides of the depression and particularly the southern foothill of HR-east, have turned up to be covered by a continuous strip of AICA clusters, confined between the 50 and 52 m isocurves. The immediate suggestion is that they represent rows of workshop flanking a large valley way on both sides. The manufactured commodities include ceramics, shell bangles and inlays, chalcedony beads. At least six spreads (AA. 22, 27, 30B, 31, 36, etc.), ranking between 10 and 25 m, were made of chert tools with no significant association with any residues, suggesting the processing of organic materials.

A small spread of copper slags, prills and crucibles, just over 10-12 m in extent (AA. 19A), has been detected on the northern edge of the depression. Quite likely it was just a small refining unit connected with a non-metallic manufacture: the slags are spread in a small fan on the eastern side of a low hummock and none of them has the weight or shape of wasters produced by primary smelting operations *(fig. 17)*.

Fig. 15 *Moenjodaro, DKG-West (AA.14): steatite wasters suggesting the presence of a bead-making manufacture.*



In any case this small assemblage and the one of slags and prills from AA. 11 are the only activity areas with evidence of metal working found so far. It is another puzzling aspect of the craft evidence from Moenjodaro, considering that copper smelting is usually one of the most conspicuous activities on surface survey. All the observed eastern Iranian sites present extensive occurrences of copper slags, reaching as in the case of Hissar up to one tenth of its total surface *(Tosi 1977; 1984; Bulgarelli 1979; Salvatori and Vidale 1982; Dyson, Howard s.d.)*. The lack of evidence from Moenjodaro opens up to another question to be answered by future research.

Similar alignments of workshops have been observed along the N-S axis, between VS and Moneer, and east of Moneer on the limits of the site. On the first one the detected AICA include ceramics, chalcedony and the metal-smelting slags' spread of AA. 11. The picture east of Moneer is probably the most interwoven of the whole of Moenjodaro. The area is a rather undisturbed plateau modified by rainfall in a rolling landscape of gently sloping elevations. The percentage of optimal surfaces of observation is here very high and survey work has yielded results. Chalcedony and ceramic productions in closed containers are the most frequented activities, as best attested by AA. 40 with its spreads of almost 1200 m^2 representing the largest non-pottery production area of the whole site so far detected *(Halim and Vidale 1984; Halim, Vidale s.d.)*.

Fig. 16 *Moenjodaro, DK-A West (AA.38): faience smelting slags.*

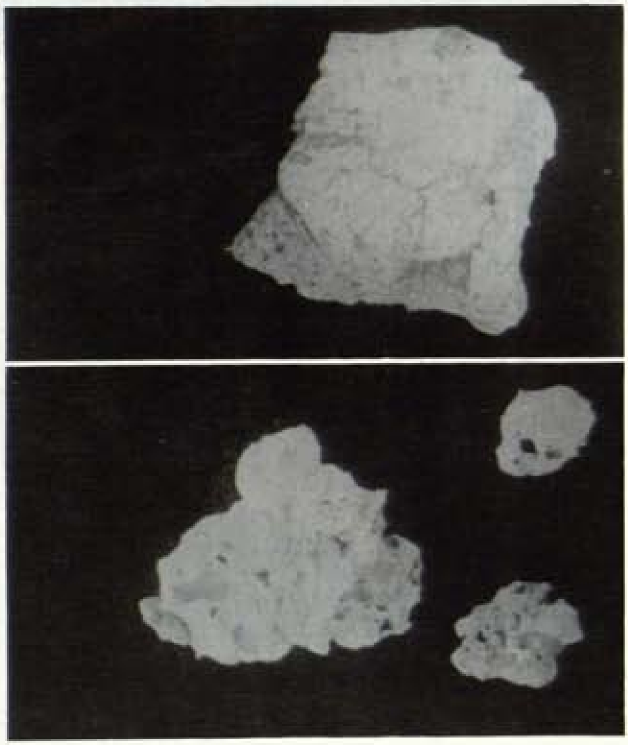
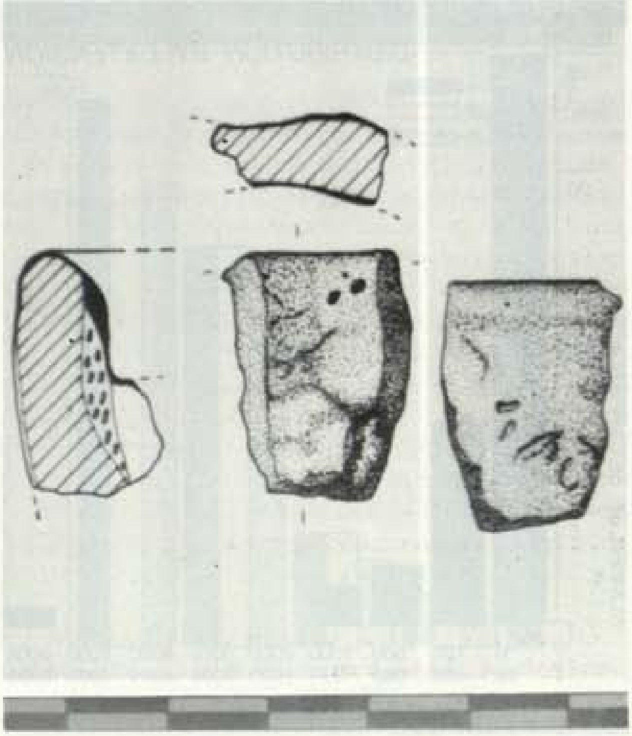


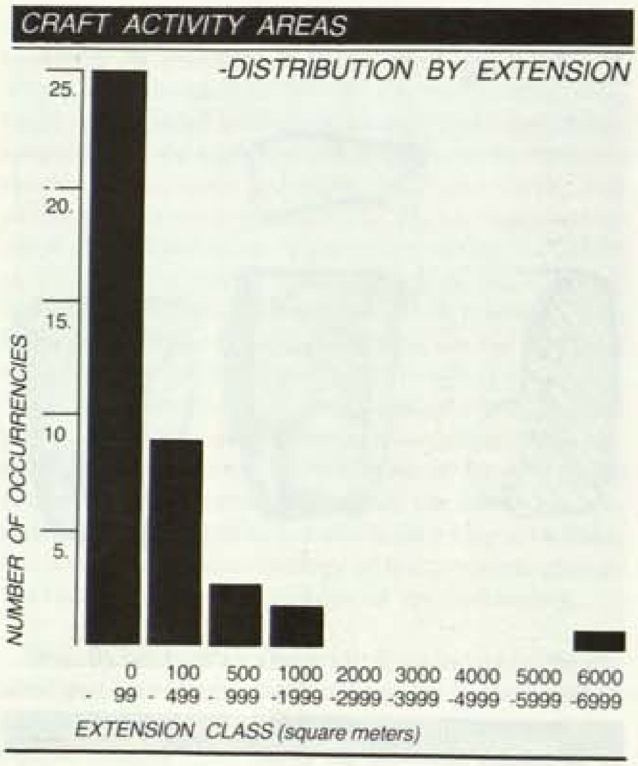
Fig. 17 *Moenjodaro, HR-East (AA.19A): remains of refining crucible.*



The whole south-eastern quadrant of Moenjodaro, south of DK-A and east of Street 1 would indeed conform to our idea of a *„craftsmen quarter"*, allocating across a mosaic of small workshops a broad spectrum of services and commodity productions. Nowhere at Moenjodaro we seem to face a factory-like situation; with large structures dependent on the manufacture of a small spectrum of commodities, such as was presumed for the ceramic and metal-working areas related to the Turanian sites of the 3rd millennium BC *(Tosi 1977; 1984; Mariani 1984)*. All these assumptions point in the same direction: our programme needs to develop a better understanding of the suburban configuration of Moenjodaro. We may expect in fact to detect quite a different picture on the outskirts of the site, where such relatively conspicuous industrial debris are more likely to have been concentrated. J.M. Kenoyer's discovery in February 1983 of a suburban shell-working area (AA. 39), specialized in a single operation of conch tip-chipping, c. 500 m north-east from the edge of *„Lower Town"* preludes to some kind of radial model of segmented production units, physically dispersed but still governed by the central institutions of management *(Tosi 1984: fig. 1)*. This type of craft allocation is identified by relatively high concentrations of a limited number of AICA on the suburban entities. However, peripheral production entities of these kind might have been also rather complex compounds, combining with a broad span of functional activities aspects of administrative control. A significant indication in this direction comes from one of the very few excavations of such a suburb undertaken so far in the Middle East: those of TUV mound on the south-eastern outskirts of Malyan, the largest protohistorical site of southern Iran *(Nicholas 1981)*. In this three hectares area, dated to the end of the 4th millennium BC, has been detected a multiple-functional pattern of manufacturing activities. Not only is there the evidence through its stratigraphic of different craft, including copper-smelting, chert/chalcedony chipping and shell-working, but these industrial refuses were associated with various classes of information-processing artifacts, such as sealed bullae and tablets.

Moenjodaro was probably less complex in its interrelation between craft production and administrative control. The incorporation of information-processing devices in its industrial activities went well beyond the use of inscribed marks, considering the recent discovery of the carefully sealed bullae locking the still undetermined content of the large muffles during the firing operation, in AA.40 B *(Halim and Vidale* in this volume). Craft activity represented an essential contribution to be control of urban elites over the rural population. From the analysis of its spatial patterning we expect to discover some of the aspects of institutional system that governed the agricultural wealth of Sind during an earlier expression of the Indian civilization.

Fig. 18 *Distribution of Craft Activities Areas according to surface extension classes.*



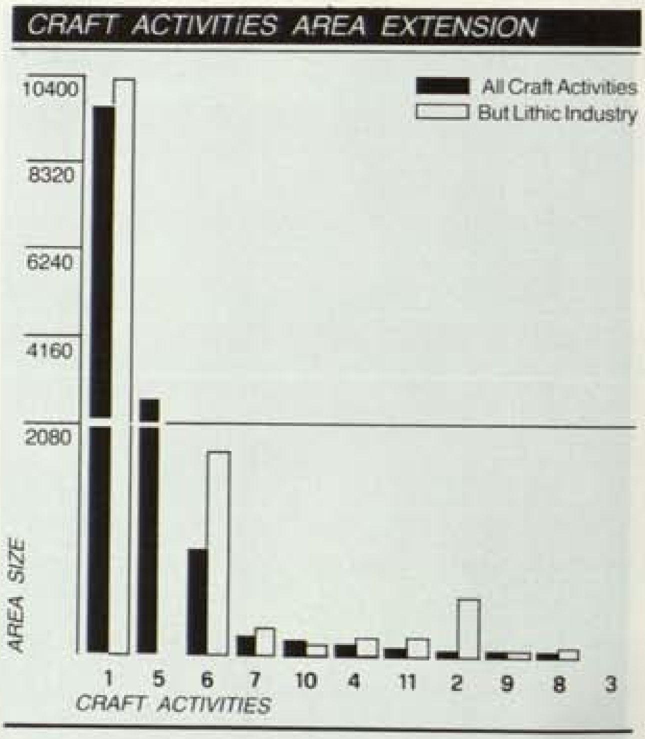
Towards a First Definition of an Analytical Strategy

A preliminary analytical approach to the surface survey data referring to Moenjodaro is based on three parameters: the sites of the areas, the manufacturing processes identified inside the latter, and the demonstrable working stages as a function of the complete theoretical process.

The approach to this analysis is linked to an approximate scale since the identification of the manufacturing processes and the working stages are the result of a fairly highly formalized synthesis that has no measurable physical characteristics. During the synthesis process the data already undergo a reduction of their information load with respect to the simple series of topographically identified AICA. However, the choice of this data base is dictated by the need to convey the analysis towards the verification of hypotheses which will form the basis of subsequent, more refined, locational analysis.

A first clue to the non-homogeneous nature of the manufacturing processes comes from the distribution of the surface areas *(fig. 18)*. More than 60 % of the areas are smaller than 100 sq.m and more than 80 % less than 500 sq.m. Conversely the remaining areas are very large and lie outside this range of variation. A distinction can

Fig. 19 *Evaluation of the total surface occupied by each Craft Activity in the system (1 = Pottery, 2 = Stoneware Bracelet, 3 = Faience Beads, 4 = Copper/Bronze, 5 = Lithic Industry, 6 = Chalcedony, 7 = Steatite Beads, 8 = Steatite Seals, 9 = Lapis Lazuli, 10 = Shell Inlays, 11 = Shell Bracelets and others).*



immediately be made between two different types of organization, roughly corresponding to the terms workshop and factory.

This distinction is reflected also in the absolute predominance of ceramic wasters in the larger areas (except for AA.40 which was given over to chalcedony bead production and the exact position of which in the range of production activities will form the subject of specific studies) while the smaller ones absorb all the remaining types of activity.

An approximate calculation of the surface area occupied by each single craft activity can be made using several generalizations: assuming that each manufacturing process in a given polyfunctional zone occupies the same area as the accompanying ones, the overall development of each individual production type can be calculated *(fig. 19)*.

Pottery thus accounts for most of the active area and its predominance is overwhelming. Next comes the lithic industry, followed by the remaining activities, which are concentrated in a fairly small area.

The histogram in *fig. 20* shows how the vast majority of areas are characterized by a single craft activity, while the maximum is 5 activities per area. The frequencies of the individual manufacturing processes in the area *(fig. 21)* indicate that the lithic industry differs from the others in the large number of finds involved. Lithic industry introduces noise into the data, since its role cannot

Fig. 20 *Overlapping degree of specific Craft Activities in the system.*

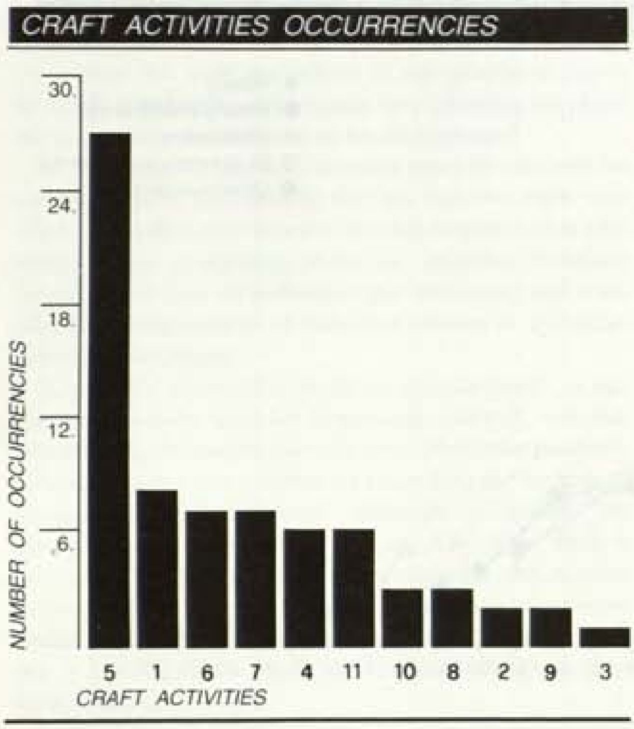
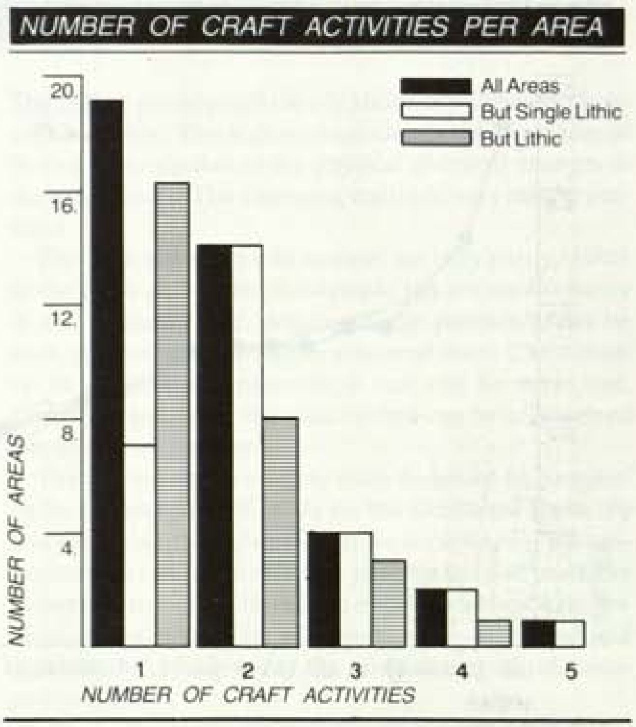


Fig. 21 *Total number of occurrences of each Craft Activity.*



be compared with that of the other productions. In all probability, it cannot be considered representative of any particular craft activity, but rather of the production of tools connected with various different manufacturing processes performed directly on site.

Fig. 20 shows how the elimination of area given over to stoneworking alone means that areas with two craft activities become dominant, on the other hand, if it is neglected completely, a decreasing gradient of 1 to 4 activities per area is obtained, as is perhaps only to be expected.

It was thus decided to neglect lithic industry in this preliminary stage of the analysis.

Recalculating the total area of each activity, the difference between pottery and the other industries becomes even more evident, while it is interesting to note how the production of stoneware bracelets *(No. 2 fig. 19)*, occupies an important position after chalcedony processing *(No. 6 fig. 19)*.

This result leads us to consider how, at least during the early stages, it was not possible to take account of the average per capita space allocation relative to each manufacturing process. The production of ceramic bracelets, although restricted to fairly small areas *(fig. 21)*, nevertheless occupies a total area of more than 500 sq.m., probably as a result of the particular facilities used (depuration, firing) which increased the ratio between wasters and items produced.

The second stage of the analysis consisted of characterizing each area by means of a coefficient that takes into account the three parameters: number of activities in each area, the spread of rarity of each production and the size of each area. It was thus possible to obtain a complexity/specialization coefficient defined as:

$$Si = \ln\left(\frac{\sum_{j=1}^{Ni} \frac{1}{F_j}}{Ei} + 1\right)$$

in which

Ni = Number of activities located in the i-th area,

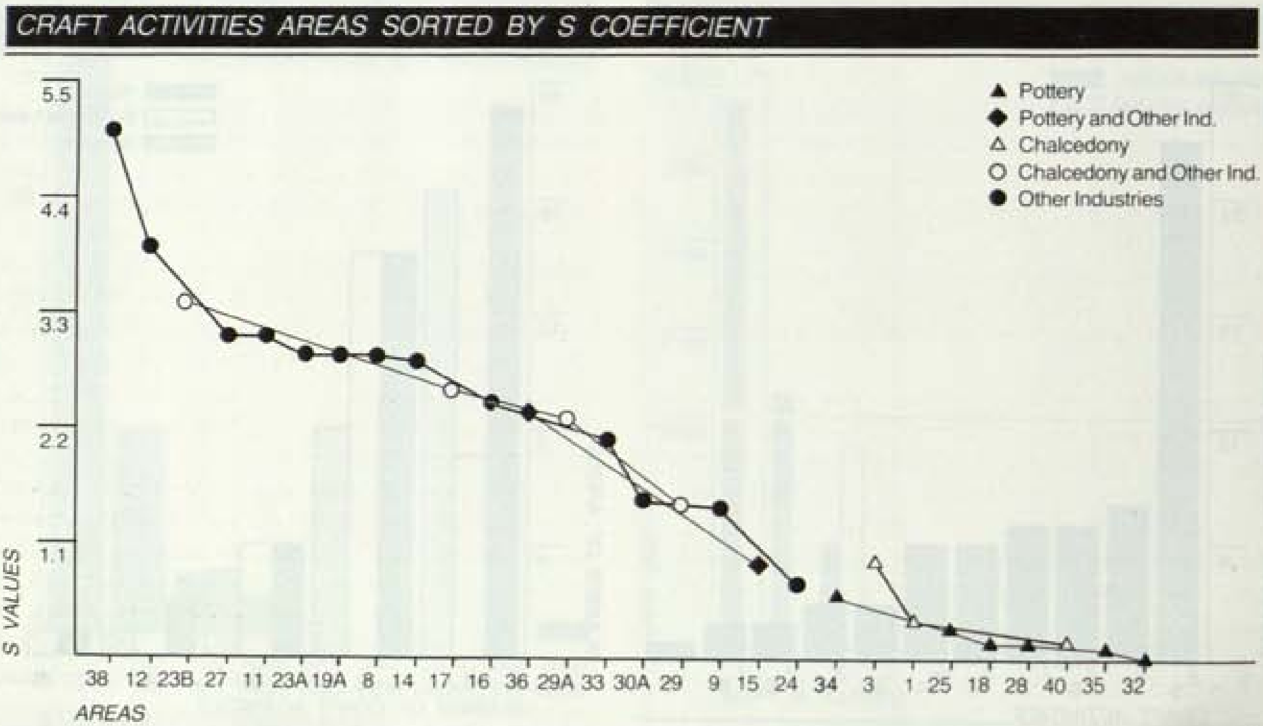
$\frac{1}{F_j}$ = inverse of general occurrence of the j-th production,

Ei = size of i-th area.

Natural logarithms were used to reduce the range of variation of the coefficient and for clearer graphic representation of results.

In *fig. 22* the areas have been arranged in decreasing order of S value. In the graph, the areas have been divided into five categories (pottery, pottery associated with other industries, chalcedony, chalcedony associated with other industries, other industries) since the number of combinations was too large and it was desired to focus attention on the more obvious contrasts and co-occurences,

Fig. 22 *Craft Activity Areas, sorted by decreasing values of S, according to specific types of production attested in the single area.*



neglecting others that could not be considered at the time either significant or capable of immediate interpretation.

It is immediately apparent that values are lower in the areas with only pottery and chalcedony bead production, while as S increases in value, the areas with chalcedony and pottery production mixed with other productions begin to appear. The highest S values are almost entirely associated with polyfunctional areas having a high degree of specialization (the maximum corresponds to faience production in AA.38) not related to the chalcedony and pottery cycles.

This subdivision confirms the differences between the latter productions and reveals a number of difficulties that cannot be solved at the present level of analysis.

Despite the high degree of specialization/complexity displayed by the polyfunctional areas, the internal nature of the spatial subdivision between productions will be clarified only by locational analysis of the AICA topographical data.

The results obtained are fairly comforting even though many data patterns still remain to be explained. Nevertheless, it is already becoming clear that there is a latent structure of the overall production of the areas which, once the data base has been further filtered and understood, will yield material for fairly exhaustive models of corporated labour at Moenjodaro.

Ground Survey Using Hot-air balloon *1)*

The southern sector of Moneer South-East (AA.40), which was analysed during the '83 season, is characterized by the massive presence of kiln wasters. The latter are distributed with varying concentrations over an area of about 200 m^2 and display a high degree of typological and size variation. The total number of wasters is in the order of several tens of thousands.

One of the preliminary operational phases of the SEP calls for a ground survey to be carried out to identify and document in the field the information segments belonging to a craft activity process. The method involving the direct topographic measurement of the indicators and their areal marking using coordinates has encountered some difficulty in this area owing to the length of time required for the operation. The estimated time increased considerably if account had to be taken of the contextual aspect, which consisted mainly of the horizontal stratigraphy sedimentologic variability of the surface and emerging structures, and of the large quantity of potsherds: these classes of data, although not directly related to craft activities, represent an indispensable factor in the overall evaluation of the area. Furthermore, with a view to carrying out a large-scale analysis of other

1) The following observations have been collected and written by S. Pracchia as part of his contribution to the 1983 season at Moenjo Daro.

areas, the need had long been felt, on the basis of available resources and time, to test a method that would streamline the slow operations of topographical survey as much as possible, at the same time allowing the maximum number of evidences to be documented.

In choosing the method, account must be taken of the various factors, particularly the fact that two main variables were taken into account in analysing indicator allocation in the processing phase i.e. intensity (absolute frequency of class of indicators per unit area) and complexity (configuration of indicator classes in co-occurrence relationships).

A possible alternative to direct measurement, a system traditionally used for large-scale analysis, was that of collecting indicators per unit area. However this method did not solve the problem of recording the horizontal stratigraphy. Furthermore, although it allows the quantitative relationships of area intensity of the finds to be retained with fairly good approximation, the method radically alters the relationships of spatial co-occurrence inside the units analysed. It was thus decided to carry out a test survey using low-level aerial photography from a hot-air balloon.

Method Used

An area of 10 x 10 m. with the same general alignment as the grid system was selected. Surveyor's stakes were laid horizontally in correspondence with the grid pickets to allow optical distqrtion to be checked later. Located at the centre of the square with the help of a theodolite, the balloon operated at a height of 40 m. The field of view of the photogram was wide enough to cover the square chosen with a fairly large margin.

The „*perspective*" of the 10 x 10 m. square thus obtained on the photogram has an irregular polygonal shape owing to the variations in height. For the purposes of topographic viewing, side distortion was corrected in the dark-room by making the four corners of the polygon coincide with a square having a side length of 20 cm. „*Straightening*" was achieved simply by inclinating the projection plane of the enlarger. The photographic print reproduces the grid square with a scale of 1:20.

There is still a certain degree of error in the position of the indicators inside the square owing to the large variations in height caused mainly by the presence of numerous small erosion channels.

The capacity for detecting the presence of, or for recognizing, the category of individual indicators depends on the nature, size and colour of the objects.

Horizontal Stratigraphy

The colour photograph clearly shows the sedimentological variability. The higher zones clearly display traces of buried masonry due to the physical chemical changes in the saline crust. The emerging walls are very clearly outlined.

The dark-coloured kiln wasters are only partly visible in the black and white photograph, but are much clearer in the coloured one. Medium-large potsherds can be seen, particularly the lighter coloured ones. Chert tools up to about one centimeter in size can be made out. Generally speaking, the class of find can be ascertained but never its typology.

The photographic imagery must therefore be completed by a ground check made on the individual finds. To this end, it was found sufficient, to superimpose a transparent sheet of paper over the photograph and mark the indicators according to the pre-established typology. Indicators not visible on the photo were identified and placed on the map using the visible ones as reference points *(fig. 6)*.

Advantages and Disadvantages of the Method

Advantages

A) SPEED AND EASE OF OPERATION: The range of materials recorded increases much more quickly than when direct measurement survey techniques are used, reducing to a minimum and selectivity in the choice of find classes to be documented.

B) INTEGRITY OF FIND FREQUENCY PER UNIT AREA: The overall view of the absolute frequency of finds per unit area required to evaluate the typological clusters remains unchanged.

C) INTEGRITY OF SPATIAL CO-OCCURRENCE RELATIONSHIPS: The overall view of the reciprocal locational relationship between indicators with an expansion contained within a decimetric range of error remains unchanged.

Disadvantages

A) Impossible to exert easy control over distortion occurring inside the margins and due to optical distortion. This error, in our case contained within a maximum limit of about 30 cm, can only be detected by means of a well-known series of photogrammetric steps and operations that are difficult to perform in the field.

B) System's incompatibility with direct measurement. In the same area the comparison between classes of indicators measured directly and classes recorded by means of aerial photography entrains a loss in the true spatial co-occurrence relationships.

Every graphic or photogrammetric survey of an archaeological surface area, no matter how carefully it is performed, only gives an approximate representation of the deposit data and a certain percentage of the information referring to the overall potential evidence is lost.

The main advantage of the low-level aerial survey method is that it is quick and easy to perform (the map was drawn up in about eight hours, compared with the 40 actually employed for direct measurement). These characteristics make it particularly suitable for analysing large surface ares. The overall picture quickly provides a preliminary tool for selecting the sectors in which to operate using methods better suited to the research problems to be solved.

Even though errors of less than a few centimeters cannot be checked, the method has considerable advantages over the rapid square grid collection methods which, while standardizing the error inside a common spatial limit, nevertheless alter all the area co-occurrence relationships inside the unit analysed.

Bibliography

ALLCHIN (B.) 1979, Stone-Blade Industries of Early Settlements in Sind as Indicators of Geographical and Socio-economic Change. In: *M. TADDEI (ed.), South Asian Archaeolog y 1977*, Naples, pp. 173-211.

BULGARELLI (G.M.) 1979, The Lithic Industry of Tepe Hissar at the Light of Recent Excavations. In: *M. TADDEI (ed.), South Asian Archaeology 1977*, Naples, pp. 39-54.

BULGARELLI (G.M.) 1977, TOSI (M.), La lavorazione ed il commercio delle pietre semipreziose nelle città dell'Iran protostorico. In: *Geo-Archeologia 1–2*, pp. 37-50.

COMPAGNONI (B.) 1977, TOSI (M.), The Camel: its Distribution and State of Domestication in the Middle East during the Third Millennium B.C. in Light of Finds from Shahr-i Sokhta. In: *R.H. MEADOW, M.A. ZEDER (eds.), Approaches to Faunal Analysis in the Middle East (Peabody Museum Bulletin 2)* Cambridge/Mass. 1978, pp. 91-104.

DYSON (R.H.), HOWARDS (S.) (eds.) s.a., Preliminary Reports of the Tappeh Hesar Restudy Project, 1976, (Monografie di „Mesopotamia" 2), Firenze s.a.

FINKBEINER (U.) 1983, Uruk-Warka XXXV: Survey des Stadtgebietes von URUK. Vorläufiger Bericht über die erste Kampagne 1982. In: *Baghdader Mitteilungen 14*, pp.1-9.

HALIM (M.A.), VIDALE (M.) s.a., Ceramic Manufactures in Closed Containers at Moenjodaro. Paper presented at the 7th Conference of the Association of South Asian Archaeologists, Brussels 4-8 July 1983, forthcoming publication.

JARRIGE (J.F.) 1981, Economy and Society in the Early Chalcolithic Bronze Age of Baluchistan. New Perspectives from Recent Excavation at Mehrgarh. In: *H.HÄRTEL (ed.), South Asian Archaeology 1974*, Berlin, pp. 93-114.

JARRIGE (J.F.), ENAULT (J.F.), SANTONI (M.) 1974, Fouilles de Pirak, Vols. I-II, Paris.

KENOYER (J.M.) 1983, Shell Working at Moenjo Daro, Pakistan. Paper presented at the 7th Conference of the Association of South Asian Archaeologists in Western Europe, Brussels, 4-8 July 1983, forthcoming publication.

KIRKBY (A.), KIRKBY (M.J.) 1974, Surface Wash at the Semi-arid Break in Slope. In: *Zeitschrift der Geomorphologie (Supplementband 21)*, pp. 151-176.

KIRKBY (A.), KIRKBY (M.J.) 1976, Geomorphic Processes on the Surface of Archaeological Areas. In: *P.O. DAVIDSON, M.L. SHACKLEY (eds.), Geoarcheology*, London, pp.-29-253.

KOHLMEYER (K.) 1981, „Wovon man nicht sprechen kann." Grenzen der Interpretation von bei Oberflächenbegehungen gewonnenen archäologischen Informationen. In: *Mitteilungen der Deutschen Orientgesellschaft (MDOG) 113*, pp. 53-79.

MACKAY (E.J.H.) 1937, Bead Making in Ancient Sind. In: *Journal of Asiatic Oriental Society (JAOS) 75*, 1, pp. 1-15.

MACKAY (E.J.H.) 1938, Further Excavations at Mohenjo-Daro, Vols I-II, New Delhi.

MARIANI (L.) 1984, Craftmen's Quarters in the Protourban Settlements of the Middle East: the Surface Analysis. In: *B. ALLCHIN (ed.), South Asian Archaeology 1981*.

MASTER PLAN 1972, Preservation at Moenjo Daro's Master Plan (Unesco Document No. 9/4/72-Arch.), Karachi

MEADOW (R.H.) 1983, The Equids of Mehrgarh. Sibri and Pirak and Osteological Evidence for the Introduction of the Horse to South Asia. Paper presented at the 7th Conference of the Association of South Asian–Archaeologists in Western Europe, Brussels 4-8 July 1983, forthcoming publication.

NICHOLAS (I.M.) 1981, Investigating an Ancient Suburb. In: *Expedition 23*, pp. 39-47.

PIPERNO (M.) 1983, Bead-Making and Boring Techniques in 3rd Millennium Indo-Iran. In: *M. TOSI (ed.), Prehistoric Sistan I*, (IsMEO Re.Mem. XIX, 1), Rome, pp. 319-325.

REDMAN (C.L.), WATSON (P.J.) 1970, Systematic Intensive Surface Collection. In: *American Antiquity 35*, 3, pp. 279-291.

SALVATORI (S.), VIDALE (M.) 1982, A Brief Surface Survey of the Protohistorical Site of Shahdad Preliminary Report. In: *Rivista di Archeologia VI*,pp. 5-10.

SARCINA (A.) 1978-79, A Statistical Assesment of House Patterns at Moenjo Daro. In: *Mesopotamia XIII-XIV*, pp. 155-199.

TOSI (M.) 1977, The Archaeological Evidence for Protostate Structures in Eastern Iran and Central Asia at the End of the 3rd Millenium B.C.. In: *J. DESHAYES (ed.), Le Plateau Iranienne et l'Asie Centrale des Origines à la Conquetē Islamique*, Paris, pp. 45-66.

TOSI (M.) 1984, The Notion of Craft Specialization and its Representation in the Archaeological Record of Early States in the Turanian Basin. In: *M. SPRIGGS (ed.), Marxist Perspectives in Archeology*, Cambridge.

TOSI (M.), PIPERNO (M.) 1973, Lithic Technology behind the Ancient Lapis Lazuli Trade. In: *Expedition 16*, pp. 15-23.

URBAN (G.), JANSEN (M.) (eds.) 1983, Forschungsprojekt DFG Mohenjo-Daro. Dokumentaion in der Archäologie. Techniken, Methoden, Analysen. Veröffentlichungen des Geodätischen Instituts der RWTH Aachen, Nr. 34, Aachen.

VIDALE (M.) 1983, Outline of a Strategy for the Archaeological Analysis of a 3rd Millennium B.C. Pottery Production Centre in the Indo-Iranian Region. In: *G. URBAN, M. JANSEN (eds.), Forschungsprojekt DFG Mohenjo-Daro. Dokumentation in der Archäologie. Techniken, Methoden, Analysen. Veröffentlichungen des Geodätischen Instituts der RWTH Aachen*, Nr. 34, Aachen, pp. 109–118.

Theoretical Aspects of Structural Analyses for Mohenjo-Daro

Michael Jansen
German Research-Project Mohenjo-Daro Aachen

Some Theoretical Aspects for an Architectural Analysis

Attempts have recently been made, above all by American ethno-archaeologists[1] in, for example the settlement area of Mesopotamia, to carry out architectural analyses which go beyond the traditional limits.

With such sophisticated questions as social organization and its alteration in time, the analysis of architectural structures entered a new dimension, in which the established results could no longer provide satisfactory explanations. *E. Stone (1981:19)* could thus write:

„Although Mesopotamian archaeologists spend much of their time clearing buildings, determining construction techniques and identifying architectural modifications, relatively little attention has been paid to the social and cultural implications of these structures. Domestic architecture reflects the social needs of its inhabitants and as such is a sensitive indicator not only on variations in wealth but of variations in social organization...".

Similar considerations were the foundations for the research work, running since 1978[2], into the excavations carried out mainly in the 1920's in Mohenjo-Daro, Pakistan *(Marshall, 1931; Mackay, 1938)*[3].

A method of analysis was developed parallel to the architectural redocumentation, based on the following topoi:

- a new understanding of the ground-plans through a critical examination of the present day architectural condition in the light of original documents such as unpublished plans and original photos
- a renewed levelling of all structures (direct and indirect)
- a photographic record of wall prospects using normal photographic techniques
- documentation of the unpublished inventory lists.

The following catalogue of research work was drawn up on the basis of these data:

- investigations into horizontal and vertical structural expansion, i.e. the structural[4] changes through time
- an examination of constructional technology in relation to materials and the way in which they were produced, as well as modification processes through time
- an examination of the architectural access system[5] and its temporal modification
- investigations into a formal room evaluation and the development of a room-grouping concept dependent on size and position
- investigations into a formal room classification by size and proportion (size-proportion-diagram)

The ideal aim of the investigations was:

- a qualitative-quantitative description of the structural-functional architectural modifications
- derived from this a reconstruction of living conditions and their temporal modifications divided into:
  - house types as indicators of social groups and their distribution within the settled area
  - the function of areas in- and outside the houses, their interior and exterior position as well as temporal modifications
  - population density and social behaviour.

The following methods were developed to help us in our work.

1. Patterns of Three-Dimensional Expansion

Vertical dividing gaps in the masonry were taken as main indicators of horizontal expansion. Because the bricks were bonded each interruption, addition or alteration is immediately noticeable. In this way a *'relative structural chronology'* can be determined, such as is already normal in masonry analysis. Due to a lack of recorded cross-sections, concepts of vertical growth can only draw upon the still existant decayed walls themselves and/or corresponding illustrations in the publications.

In order to determine homologous layers, horizontal alterations visible in side-views of the decayed walls can be taken into consideration, such as levelling layers or a change of brick bonding in connection with thresholds, drainage outlets and brick platforms inside houses[6]. For a comprehensive analysis of this horizontal-vertical modification process, one should not from the start view a part of an expansion structure as an isolated *'house'*[7], which would lead to a static interpretation disregarding other important factors, but rather the whole expansion structure, here called a *'cluster'*[8], should be included in the analysis and can thus guarantee an optimal interpretation of the relative stratigraphy of each cluster.

2. Access System

A graphic layout, quite popular for architectural planning, was chosen for a comparative description of the first general types of living conditions. In such a scheme the designer arranges the roughly determined room units in an orientated spatial concept according to size and proportions, and this plan is then the predecessor of the later drawn ground-plan. The areas are here already arranged according to compass-points and function, and connected in accord with the access system. In doing this the designer follows certain design prerequisites which are determined by:

a) the true function of the structure
b) the respective cultural conventions and specific living behaviour which determine the socio-functional ground-plan[9]
c) the respective climate which determines the climatic-functional ground-plan
d) the building materials, which are influenced not only by their relative occurence and physical properties, but also by functional, social and climatic factors.

The more segmented the ground-plan, then the more mono-functional the single areas, i.e. larger areas can be used for a greater variety of functions. This type of planning scheme can be used just as well in subsequent analyses of ground-plans in order to describe specific living behaviour. If the living concept inside a house changes in time then this alteration can also be accordingly described.

3. Evaluation of Rooms

Because we do not know which compartments were used for which functions in the Harappa Culture, a room evaluation system had to be developed which was independent of such cultural conventions as *'private'*[10] or *'residential building'*[11]. Thus three categories of compartments were defined as a first method of approximation:

I Compartments directly accessible to the public transport network (streets etc.), hall and entrance in the above case.
II Transit rooms having more than one entrance.
III Terminal rooms with one entrance only.

That the toilet and bath are terminal rooms, and the dining- and living-room transit rooms in modern European houses, may be characteristic only in our culture. We know for example that public toilets with no partitions existed in Roman times, an idea quite unimaginable for us, and at most found nowadays only in military camps.

The definition of „private" and „non private" or „public" in our model is therefore based on the concept of the access system which shows rooms of category I as being directly accessible to the general traffic lines (lanes, streets etc.) and therefore being most „public" within this hierarchy, while rooms of category III are the remotest ones and therefore most „private". Therefore this definition of „private" has not necessarily the connotation of a cultural definition.

4. Size-Proportion Diagram

A size-proportion diagram was drawn up so that not only the access systems could be compared, but also the compartments themselves. All rooms and their respective access systems were recorded on this diagram, which showed on its y-axis the proportions a/b of each room and on the x-axis the proportions a x b. In this way a size-porportion pattern appeared, with an accumulation of certain compartment types in certain size-proportion areas.

With the research methods described here each structure can now be described in such a way that a quantitative-qualitative comparison of the results is possible. Certain types of houses can be defined through the determination of an increasing number of similarities. These give the first indications as to the relative utilization with respect to:

1) public accessibility (streets etc.)
2) internal arrangement (spatial)
3) climatic physical constructional factors

However, all these experiments would remain formal were it not possible to relocalize artifacts in their relative structural context. Only when all available information has been studied can an adequate interpretation of the living behaviour be proposed. In the case of Mohenjo-Daro, this means the evaluation of the unpublished inventory books, containing more than 38.000 entries, and their relocalization in the structural context. Hopefully certain groups of artifacts can be isolated in certain types of houses, which will give us more information as to the functional use of the structure. It is hoped that the example presented here will be seen as a contribution in this direction.

Supplement to the Introductory Remarks

After the aforementioned concept for an architectural analysis of Mohenjo-Daro had been completed the article by *Elizabeth F. Henrickson (1981)* was brought to the authors attention. Because this article deals with a very similar subject in the sphere of the Late Early Dynastic of the Diyala Region, thus probably contemporary with our own research area and touching upon a parallel research attempt, the author thought it necessary to give a brief mention to it in this discussion.

Henrickson defines the following aims and operations as her starting point:

„– *Establishment of units of continuous occupation through time resulting in delineation of the occupational history of each house and the definition of the occupational phases for the subsequent functional analysis.*
– *Examination of the individual house plans as the context for domestic activities.*
– *Examination of patterns of house size and major divisions within houses for indications of family type and wealth differences.*
– *Analysis of data on patterns of artifact distribution within the various rooms of each house for indications of repeated correlation." (ibid: 44).*

Henrickson expressed her research objective as follows: *„Establishment and documentation of these kinds of intracommunity patterns should increase our understanding of the developments which were taking place during this period in regional inter-community settlement organization and intra-community socio-political organization." (ibid: 45)*[12) 13)]

Without wishing here to further elucidate her stratigraphic reinterpretation of Khafajah and Asmar , it seems important to note that the analysis does not go beyond the limits of the architectural structures, which must serve as the sole framework for the artifacts found therein. Thus the attempt at a structural cluster analysis as primary source of information is further validated.

After completion of the stratigraphic analysis[14)] Henrickson carries out a functional analysis, characterised by the following operations:

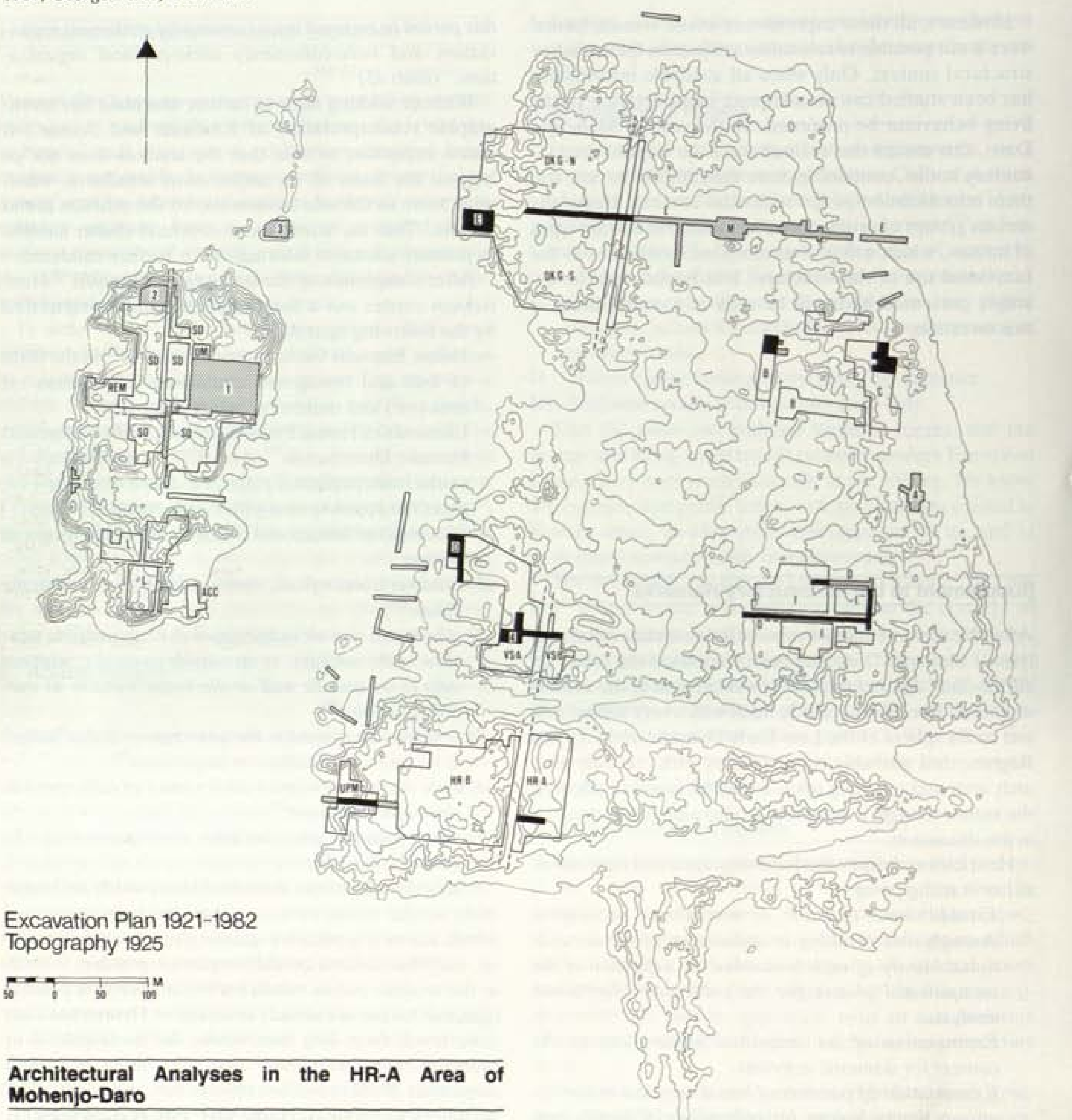
– House Size and Gross Internal Division[15)] in the form of lists and histograms containing information on area (m^2) and number of suites *(ibid: 52f)*.
– Elements of House Plans Correlated with Object and Feature Distribution[16)]*(ibid: 57f)*. Here Henrickson works from published plans in as much as she investigates the access system (inter-connection of rooms)[17)] of connected houses and classifies the single rooms as follows:

„*1) whether it was a front, centre or back room within the house*[18)]
2) whether it was an inside room (i.e. no possible window to the outside), or an outside room (i.e. with access to an outside wall or the house window to outside possible)[19)]
3) whether, compared to the other rooms in that house, it was a small, medium or large room[20)]
4) how many doorways to other rooms or to the outside the room possessed[21)]
5) what features and facilities were present in the room." (ibid: 58)

Using the operations described here, which are essentially similar to our own, a method has been developed which allows a qualitative-quantitative structural analysis, and thus makes a critical comparison possible. Whereas the analysis and its results for the architecture of Khafajahand Asmar are already available in Henrickson's article, it will be a long time before the investigations in Mohenjo-Daro, with more than 250 house units and more than 38.000 recorded objects, are completed. The preliminary analysis of House VIII, HR-A Area presented here shows the enormous potential of the available information.

But one point can already be made; a fresh revision of previously excavated settlements brings to light a whole new set of data, which leads to a more sophisticated description of settlement behaviour and socio-economic concepts, both within the community and on an intercultural level.

Fig. 1 *Topographic plan from 1925 of Mohenjo-Daro showing all excavations up to the present (Nomenclature see Fig. 1A).*
Most recent excavations = 1950 Wheeler, REM-site, ACC-site; 1964, George Dales, UPM-site.



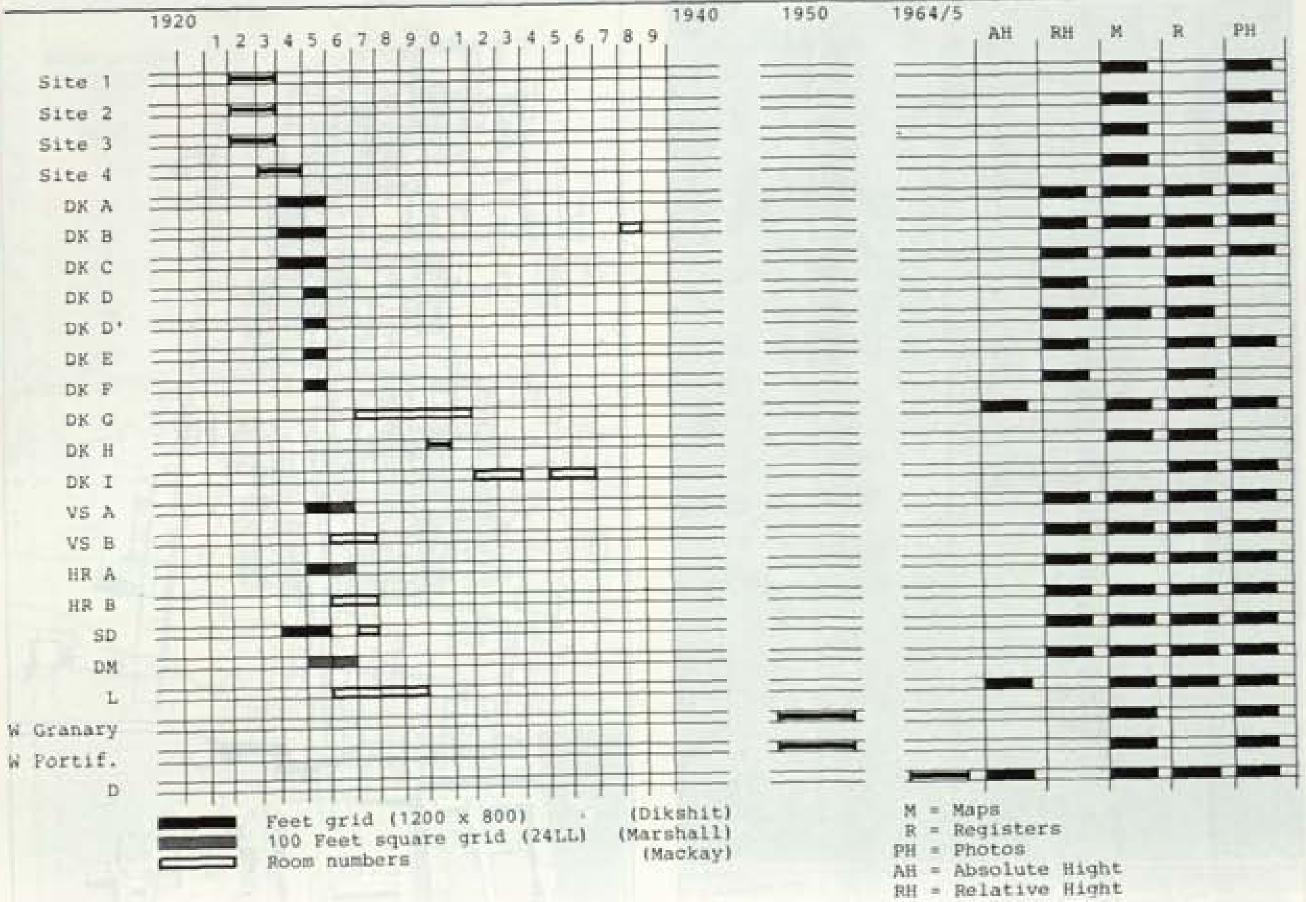
Architectural Analyses in the HR-A Area of Mohenjo-Daro

The HR-A area (Fig. *1)* was uncovered in the winter of 1925 - 26 by H. Hargreaves[22], hence the name HR given to the site.[23] Altogether an area 7,800 m^2 was cleared in the period from 15.12.1925 to 27.2.1926[24], about a third of the entire HR area.[25]

The published plans *(Marshall 1931: XXXIX)* show no evidence of the general system of coordinates which were used for horizontal location in the fieldbooks.

The allocation system used here refers to the Block-House-Room system *(Marshall 1931:176ff, Jansen 1983:24)* applied uniformly to all the excavated areas of Mohenjo-Daro with this publication in view.[26] According to the coordinate point system introduced by the Mohenjo-Daro Research Project[27] *(Wanzke 1983:71f)* the HR-A area is bounded by the following points:
N: 1070 m, S: 1180 m, E:2520 m, W:2330 m.

Fig. 1A *Representation of each single excavation and available data in table-form.*



Extent of the Excavation Area

The HR area *(Fig.2)* takes up the western portion of a wedge-shaped ridge running W - E for some 700 m, narrowing from 180 m in the W to some 20 m at its eastern end, at the same time reducing in height from about 10 m above the plain (57 m above MSL) to 2 m (49 m above MSL) in the E.

The HR area is bounded in the N by the E - W depression already mentioned, which up to now was assumed to have originally been one of the E - W street axes which was subsequently broadened to its present width by the flood waters of the Indus. This theory may not be pursued further here; however, the latest structural analyses do at least show plainly that at the same time in the southern part of the VS area immediately to the N of HR-A the structural fabric piled up in terraces from about 50 m above MSL[28] to 53 m above MSL *(Fig.3)*. Thus it becomes apparent that the depression formed part of the ancient topography of the town and that – at least in this area – the architectural substance expanded terrace by terrace and not in horizontal layers as suggested by the stratigraphy of the excavators *(Marshall 1931: 9, Mackay 1938:XIVf)*.

A similar pattern of contemporary structural growth with differences in height of up to 3 m is found in the southern part of the HR-A area[29] (*Jansen 1983*, unpublished, VII International Conference of South Asian Archaeology, Brussels) and also along First Street *(Fig.4)*[30]. These few examples suffice to show that the dating of artifacts and structures on the assumption that urban growth took place horizontally at a constant rate is no longer tenable and needs to be revised completely. The topography in the HR area of the ancient town proves to have been very uneven with height differences of up to 5 m between parts inhabited simultaneously. As the section along first Street *(Fig.5)* shows, the HR area was bounded on the N and S by this depression and therefore would appear to have belonged to a portion of the town which formed a precinct apart from the rest.

Fig. 2 *Aerial photo of HR- and VS-Areas (1928).*

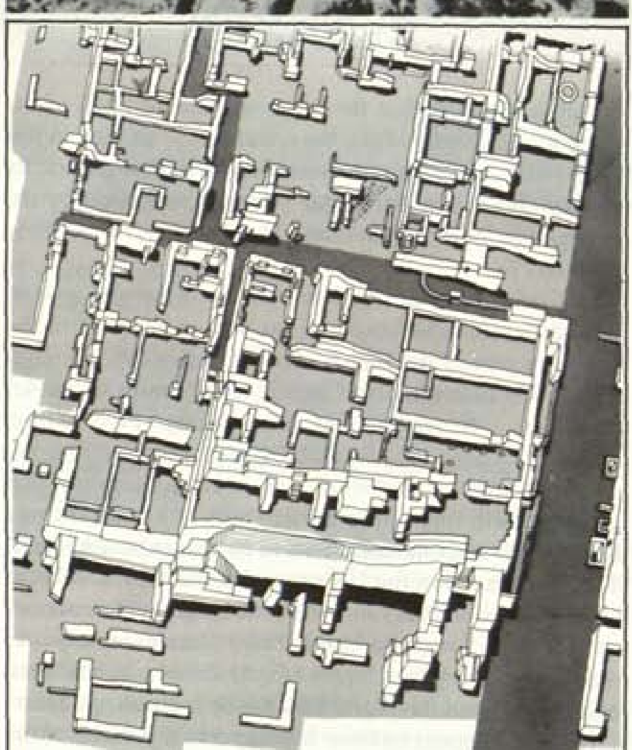


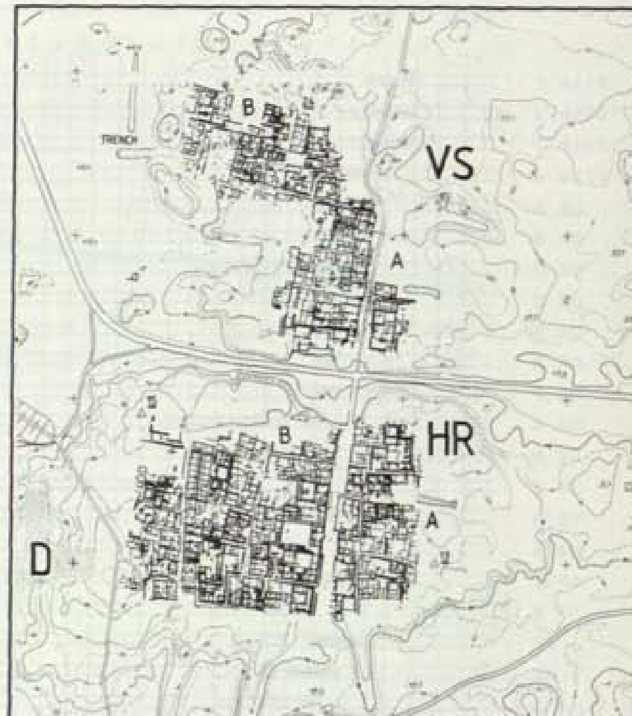
Fig. 3 *Isometric plan of southern VS-Area showing terraced construction.*

Upper

Fig. 3A *Topographic map of the present day state of HR- and VS-Area*

Middle

Fig. 4 *Isometric plan of HR-A Area with Dead man Lane.*



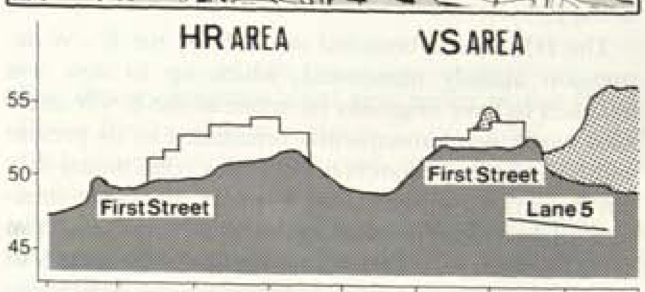


Fig. 5 *Section along First Street, HR-, VS-Area looking west, tenfold the height scale.*

Fig. 6 *Plan of HR-A, 1925-26.*

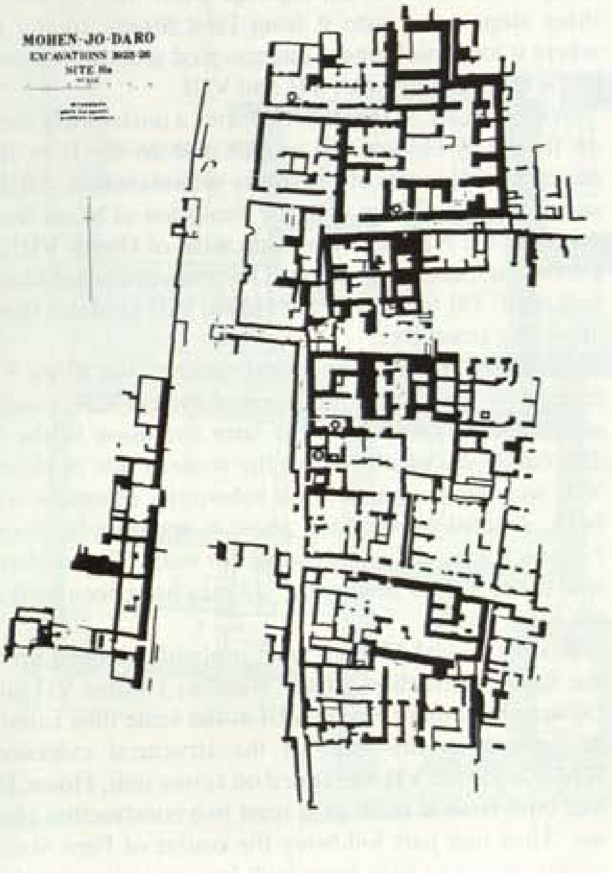


Fig. 7 *Aerial photo of HR-A, 1983.*

History

According to the rediscovered fieldbooks *(Ardeleanu 1981)*, H. Hargreaves began excavating in this area in mid-December 1925 by digging a trench 10' wide from W to E which, for identification purposes, he divided into 10' sections labelled alphabetically with capital letters. This excavation produced such important finds as Nr. HR 163, *„a headless seated image in the round of alabaster (frag.)"*, discovered on the surface in Square I-J exactly on the site on the upper western staircase of House I (as transpired later).

Very soon (19.12.1925) however, this horizontal orientation system proved inadequate for the exact registration of the quantity of finds now being made. On 31.12.1925 Hargreaves finally introduced a new orientation system later to be applied to all remaining excavation areas in Mohenjo-Daro. This was a 100' grid system based on magnetic N which was further subdivided into 25 20' units.[31] But as this horizontal orientation system is applied only in the fieldbooks it proved extremely difficult to correlate the data assembled in them with the architectural plans *(Ardeleanu 1981)*.[32] As *Fig.6* shows, the HR-A area was largely cleared to its present extent by the end of the winter season on 27.2.1926.

The western limit of First Street as far as Lane 2 where the spectacular skeleton find was made in what was later to be called Room 74 of House V (HR-B) was already recognizable; here it is interesting to note that only the northern portion of its eastern limit had been investigated. House VIII in the N of HR had been excavated completely by then, and will be dealt with here in more detail.

House VIII (HR-A Area)

Together with the Great Bath and the Granary, House VIII is one of the most well-known structures in Mohenjo-Daro as it has been described not only by the excavators *(Marshall 1931: 17)* but also in much of the secondary literature as typical of the upper middle class of Mohenjo-Daro[33] and was depicted with an isometric drawing in the excavation reports *(ibid: Pl. IV)*. In fact, this house is here described twice, once by Hargreaves *(ibid: 182f)* in his excavation report on the HR-A area and again by Marshall *(ibid. 17f)* in his general introduction as editor. There is little to add to their very graphic account of the architecture, beyond contradicting Hargreaves' remarks *(ibid: 183)*:

„Finds in this extensive building were few, and only one seal No. 224 (Pl. CIX), was recovered in the exterior passage of Room 17. Room 12 yielded HR 2445, a small shell spoon, Room 9 a small faience ram, HR 2013 (Pl. XCVII, 1) and Courtyard 18, HR 1797, a small wavy ring with white dots on a red ground (Pl. CLVII, 10) and HR 2045, a terracotta ball with an incised pictograph like the letter H. Ashes, charcoal and some carbonized grain were also found in this courtyard and in several of the rooms."

Our study of the fieldbooks shows that more than 200 objects were found in this house, not just five as he reports.

The second part of this paper is devoted to an attempt to evaluate these finds.

Methods of Investigating House Forms in Mohenjo-Daro

Structural Chronology

In the N of HR-A area which is separated from HR-B by First Street lies an architectural cluster marked on the plan as Block 3, comprising Houses VII, VIII and IX. Block 3 is reached from Block 2 via High Lane, a street about 3 m broad which zig-zags from the W, where three steps open onto it from First Street, to the E, where it loses itself under unexcavated ground. It provides access to Houses V, VII and VIII.

Within Block 3, House VIII forms a nucleus adjoined on the W by Houses VII and IX and on the E by the structural fragments of a house as yet unlabelled. All the surrounding buildings with the exception of house fragments in the NE use the outside walls of House VIII as part of their enclosing limits. This observation led Marshall *(ibid: 18)* to suspect that House VIII predates these adjoining structures.

As shown in *Fig. 8*, the actual nucleus[34] of Block 3 is formed by the northern portion of House VIII, clearly separated by joints from the later extension to the S. The cul-de-sac which ends at the western side of House VIII may have continued on before the extension was built. A third construction phase is apparent in Room 17, which was subdivided by interior walls. The southern wall in the NW of *„courtyard"* 18 may have been built at the same time.

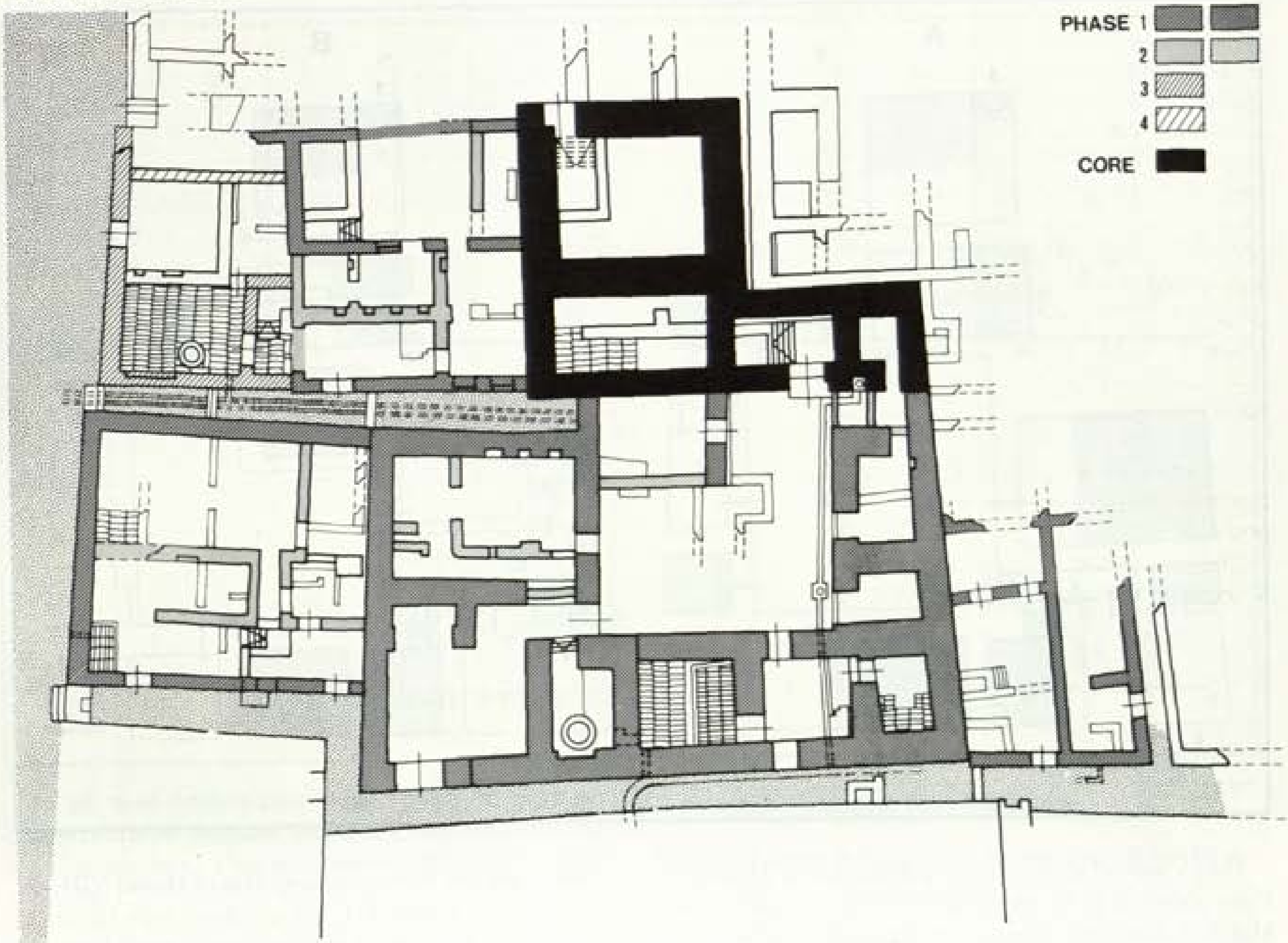
Rooms 12 and 13 were most probably blocked up in the final construction phase. Whether Houses VII and IX were built on to House VIII at the same time cannot be proved on the basis of the structural evidence. Whereas House VII was added on as one unit, House IX was built from E to W in at least two construction phases. Thus that part following the course of First Street would appear to have been built last, an indication that this street line did *not* serve as an urban planner's orientation system for the structural expansion of the town but rather that the architecture was simply aligned along this axis.

This phenomenon, which can be supported by further evidence and is apparent also in other parts of the site, indicates that First Street was not a predetermined starting point in the sense of a dominating factor in the planning of the town layout but was incorporated in this manner in an already existing older urban structure (at least in in the HR area).[35]

The analysis of horizontal growth could not be complemented by an analysis of vertical growth as almost all the walls of House VIII were restored in the course of time and the original excavation photos here are inadequate source material

As regards the main settlement phase of House VIII, levelling[36] of architectural features such as thresholds, staircase bases, drain courses etc. showed an average settlement level of 54.25 m.[37] Only the two rear rooms 15 and 16 failed to produce clearcut figures, as the staircase in Room 14 ends at 55.33 m but walls inside the rooms apparently reached as high as 56 m.

Fig. 8 *HR-A Area, House VIII with horizontal additions.*



General Chronology

Influenced largely by the quality of the architecture, Marshall assigned House VIII to Intermediate II,[38] likewise House VII which was subsequently built *(ibid: 183)*. Whereas this dating may be supported by the relevant access levels in High Lane, it is no longer possible to date House VI, whose walls form the southern facade of High Lane opposite House VIII. Marshall *(ibid: 181)* assigned House VI to the Late Period, which seems justified at first glance as House VI is sited more than 3 m higher than House VIII.

Just how complex the stratigraphy of Mohenjo-Daro appears to be is shown by the fact that a vertical pottery drainpipe which starts at 57 m approx. in House VI joins a street drain in High Lane at 53.50 m approx., which in turn is connected up with the drainage system of House VIII. These interconnecting drains show plainly that High Lane served as a public access route at the level of approx. 53.80 m from which House VIII could be entered and which at the same time, was joined by the drain from House VI 3 m up from the ground, so that House VI must have been contemporary with House VIII despite this difference in base levels.

The Spatial Concept of House VIII

The original layout of House VIII *(Fig.9)* comprised a central unit formed by a row of small parallel rooms grouped around a large central area. The entrance area alone is somewhat complicated by the fact that a transit area separates it from the central space, which was thus not directly visible from the public access point.

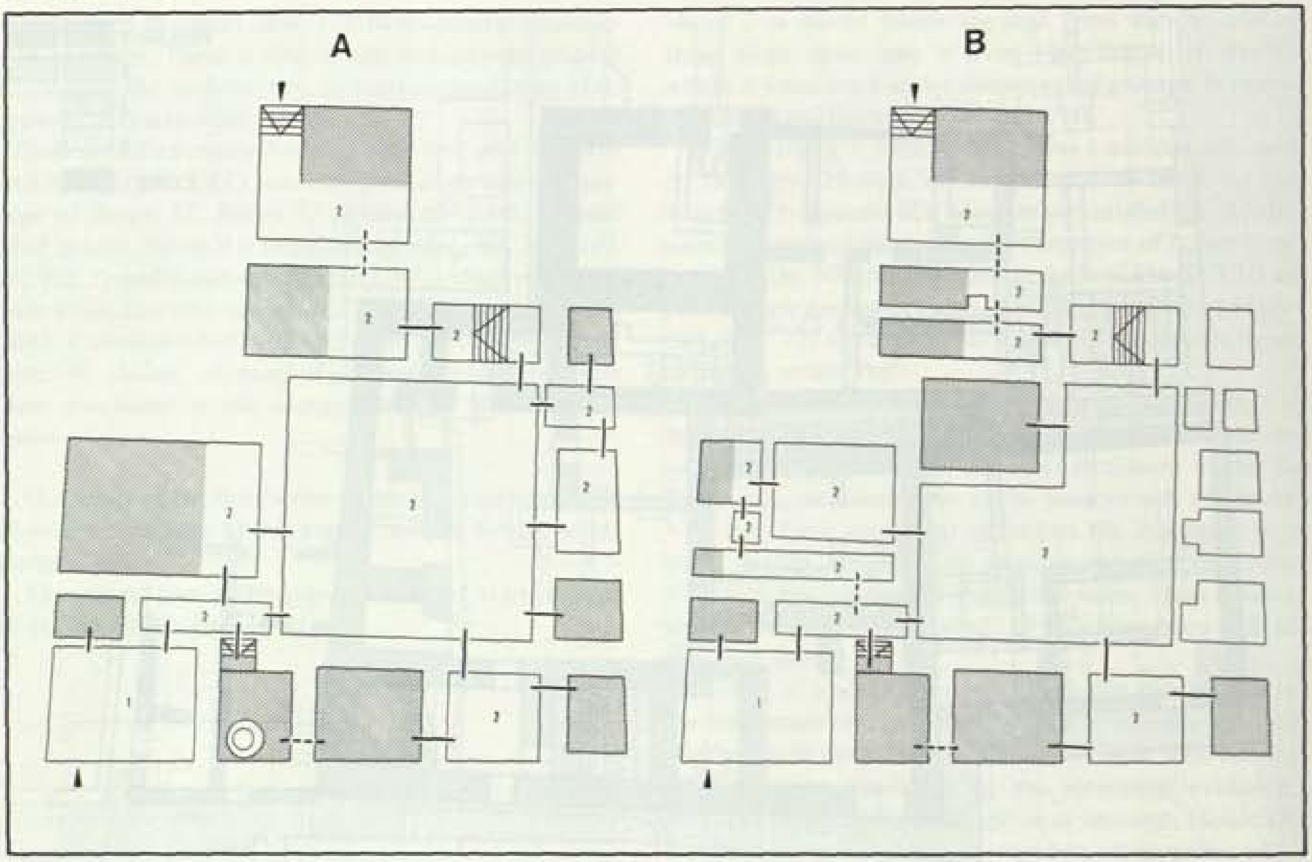
Marshall describes this house type as follows:

„And here, let me say parenthetically, that the principle of the open court encompassed by chambers was just as fundamental to house planning at Mohenjo-Daro as it was throughout the rest of prehistoric and historic Asia, and as it has continued to be in India until the present day" (ibid: 18).

Fig. 9 *HR-A, House VIII, Scale 1:200; the spatial concept of House VIII*

1 = Publicly accessible
2 = Transit room
3 = Terminal room

A Original condition
B Final condition



That a second glance at the architecture of Mohenjo-Daro shows it to be significantly more complex than Marshall described is proved in the analysis carried out by *A. Sarcina (1981)* where the position of the courtyard or central area is considered decisive for the classification of the house in question.

At least in the case of House VIII, not classified by Sarcina under any of the types she identified *(ibid: Pl. XXXIV)*, it is true to say that it is dominated by the central courtyard which provides direct or indirect access to all the other rooms and whose 100 m^2 correspond to about 30 % of the total usable area.

Before the access system could be analysed the following degrees of access were defined, as mentioned above:

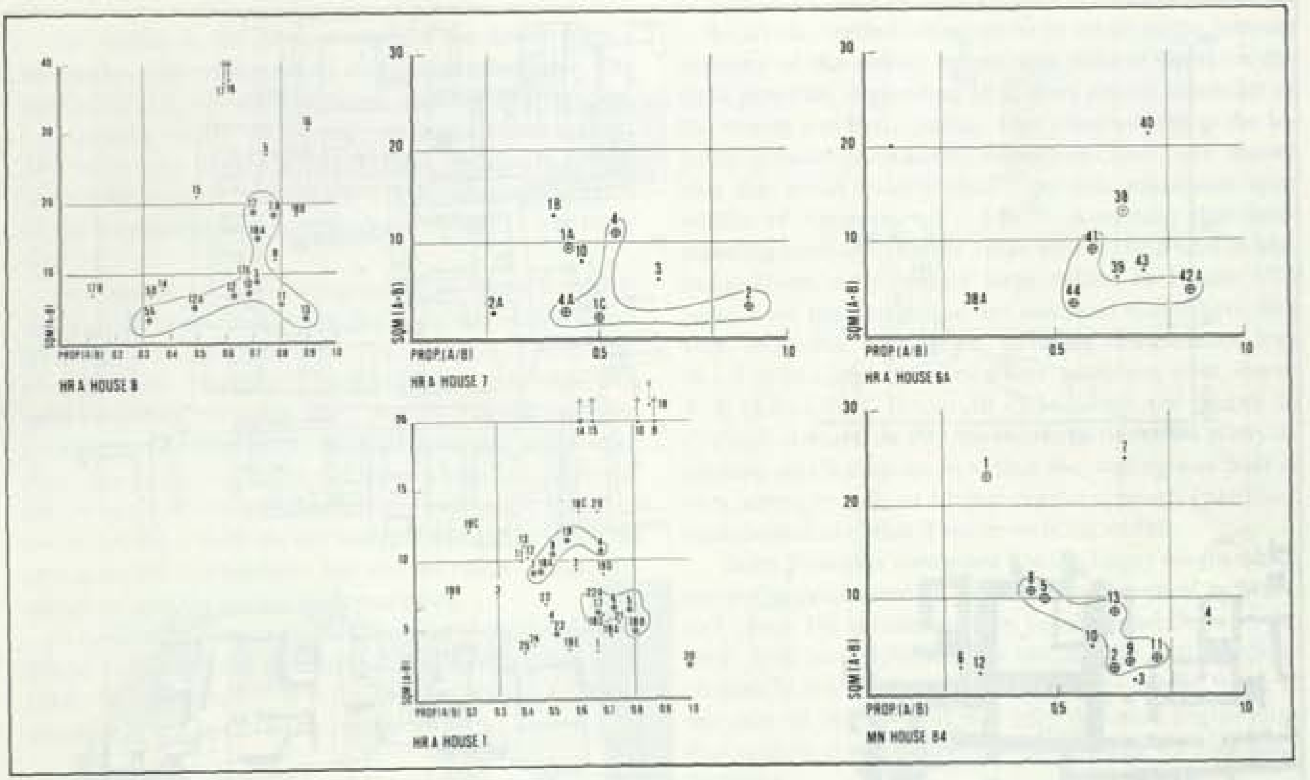
1. compartments directly accessible to the public
2. compartments with more than one entrance (transit rooms)
3. compartments with a single entrance only (terminal rooms)

The classification starts from the assumption that compartments of the first category are the most public in character and compartments of the third category the least public (with the highest degree of privacy)[39].

When applied to the access system of House VIII, we can assign to category 1 the entrance area (R 5), at 27 m^2 one of the biggest compartments, apart from the courtyard. Such a large semi-public area (8 % of the total usable space) is by no means unusual in Mohenjo-Daro houses. It may have been representational in character, though its size may also have been related to a more specific function.[40] Marshall *(1931:18)* identified a small room directly opposite the entrance as a guardroom from which the entire entrance area could be kept under observation. Originally 3 m broad, the entrance was later narrowed to 2.20 m by extending the eastern facing. There is nothing to indicate that doors once made it possible to close off this entrance effectively; anyway, it is so broad that closing it would have been impractically troublesome.

This entrance opens onto a transit room (category 2) or landing leading to the well room, Room 17 and Courtyard 18. If Courtyard 18 is considered as the central space accessible from all the other compartments and therefore as belonging to the private sector, the corridor means that the well room and Room 17 could have been used by the public without impinging on the privacy of the inner portion of the house.[41)]

Fig. 10 *Size-Proportion Diagram.*
The diagrams here show the room qualities of different houses. „Terminal Rooms" (Category III) are concentrated in the proportional areas 0,5-0,8 and in size up to 10 m². Only a small number of rooms, purely Category II („Transit Rooms") fall under the 0,3 proportion. Rooms more than 20 m², similarly Transit Rooms, fall usually in the proportion area above 0,5 (central distributor). House I and House VIII are clearly abnormal in their proportion distribution and are thus shown to be exceptional structures.



In all, four other transit areas branch off from the courtyard (most probably unroofed), each in turn providing sole access to a terminal room. Only one terminal room (R 11) could be entered directly from the courtyard. Room 9 at the S side of the courtyard acts as a transit area separating two terminal rooms whose tiled floors suggest were once areas where water was used, an identification which in the case of Room 7 at least is confirmed by a water outlet in the wall. A narrow channel leading from the well room (R6) to R7 is evidence of a water supply.

A staircase in the N leads to an upstairs section which the excavators presumed to have accommodated the bedrooms.

To the E of the courtyard a series of small chambers ends in the NE with a tiny compartment (R 13) of only 3 m². On the W side there is only a narrow doorway to R 17, but it may be later in date than the rest of the structure. Likewise unproven is the northern entrance to R 16.

The thickness of the masonry in Room 12A and the presence of a vertical pottery drainpipe in its northern wall was seen by the excavators as evidence for a second storey, reached via the staircase in Room 14. Signs of a further staircase were found in Room 9.[42)] They concluded that the owners of the house lived on the first floor, leaving the ground floor rooms to the staff.[43)]

The Access System in the Final Phase

Radical changes in the general layout concept can be deduced from the fact that Room 17 was further subdivided. The separation of the eastern portion from the rest of House VIII by bricking up the entrances must have taken place in the final habitation phase, when the living space seems to have been reduced to the courtyard and the areas where water was used.

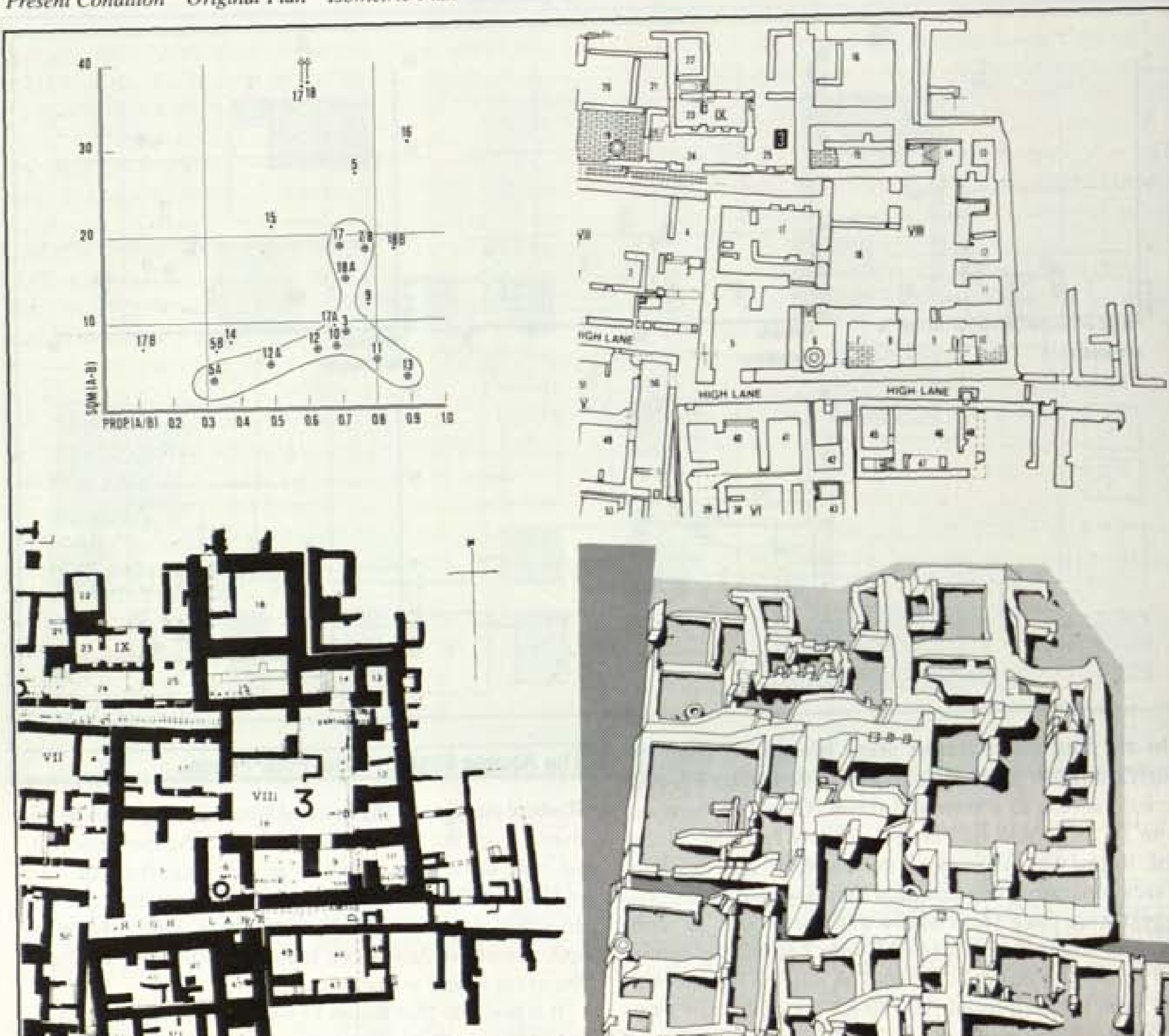
It is possible that Room 17 was transformed into an internal living unit comprising a small central room and adjoining terminal compartments.

Size – Proportion Analysis

Another method of analysis used for investigating architectural forms and functions is the size-proportion diagram, which throws light on the distribution of room sizes and proportions within each house.

The distribution pattern of House VIII differs from that of other houses *(Fig.10,11)*. Whereas the Category 3 rooms in the latter (except House I, HR-A) are all less than 10 m² in area with proportions between 0.4 and 0.8, in House VIII there are two groups of rooms belonging to this category, the first up to 10 m² in area and the second between 15 m² and 20 m² in area.[44)].

Fig. 11 *Size-Proportion Diagram HR-A, House VIII*
Present Condition Original Plan Isometric Plan



Summary of Formal Analysis of House VIII

The result of this analysis is a collection of data, in itself not much more than a framework of numbers, most of which can only be interpreted when studied on a comparative basis with further material.

Before a functional analysis can be carried out to supplement this formal analysis and its comparison with other houses, the inventories of the rooms must be studied and the findings related to the formal analysis. It is planned to investigate House VIII in this way with the help of the data provided by the fieldbooks and thus set the example for the study of other houses.

Nevertheless, even before comparative studies are carried out, first attempts can be made to interpret the data material as it is on a formal level.

As was seen from the access system, the house is divided into two access areas, i.e. rooms such as the well room and Room 17 which can also be reached by other routes than via the central courtyard 18, and rooms which can only be reached from the courtyard. This means that Rooms 17 and 6 were semi-public in character. Thus the well, for instance, could be used without intruding on the privacy of the household. This dual function of the well room, known also from other houses in Mohenjo-Daro, finds supporting evidence in the fact that water could be passed from the well room through a narrow opening into the private part of the house.

The rooms in the inner portion of the house form a hierarchy, with courtyard 18 as its supporting base. The courtyard can serve the greatest number of functions, e.g. passing traffic, recreation, production, storage etc. The next step in this hierarchy also comprises transit rooms of Category 2 which serve as distributing channels to the terminal rooms, e.g. Room 9, Room 12 and staircase 14.

The variety of functions possible in these compartments is naturally reduced by their size and shape. Transit rooms of proportions in the 0-0.1range, i.e. long, narrow corridors, were most likely access routes only, like railway carriage corridors. But Category 3 rooms also form a hierarchy in themselves, depending on size and shape. Here the range of possible functions is determined by the usable space necessary in each case, such as the length of an animal for a stable or the width of storage jars plus access space for a storehouse, but also the radius of space required by man for certain work processes.

A further limitation on the planning of the layout of a house is the natural qualities of the building materials used. In this respect it is easily explained why large courtyards are enclosed by small rooms.

As a rule, roofed areas are kept small as the bearing capacity of the ceiling beams sets natural limits on the span possible, depending as it does on the diameter of the beams and their quality. Our observations in the locality around present-day Mohenjo-Daro have shown that the wood quality used[45] permits maximum span widths of between 4.5 - 5 m[46]. Assuming that free-standing roofs over larger areas were to be found in Mohenjo-Daro, only certain large rooms in House VIII could have been roofed in this way, and would have thus been of special importance, including the entrance area No. 5 (6.0x4.5m), the area where water was used, Room 7, 8 (4.0x4.5m), Room 16 (5.5x5.5m) and Room 17 (5x8m). Room 16 is the only one longer than 5m in any direction, which may mean a) that the ceiling was built of very strong beams, or b) that central supports (partition) once existed or c) that it has never been roofed.

Seen from this viewpoint it is the larger rooms which are not normal-sized and not the smaller ones, as Marshall *(ibid: 19)* surmised when he allocated them to the staff. It is very possible that neither the entrance area (Room 5) nor Room 17 were originally roofed over. In the case of Room 17 it was only the later partitioning that made it at all possible to roof this area without much difficulty.

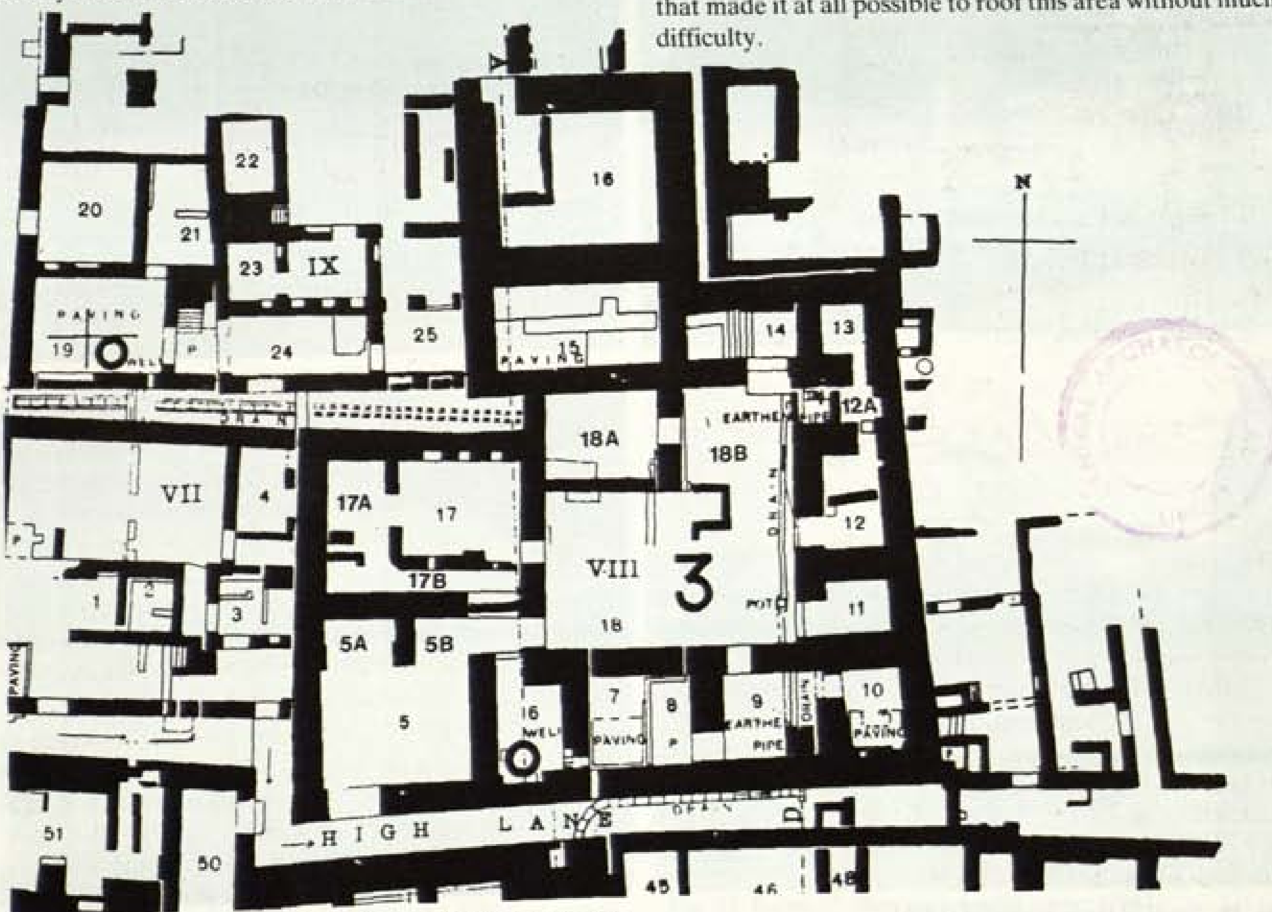


Fig. 13 *HR-A, House VIII. Original plan with partially completed room numbers.*

Upper
Fig. 14 *High Lane showing entrance to House VIII (1925).*
Middle
Fig. 16 *Inner courtyard of House VIII (1926).*

Upper
Fig. 15 *Same view as Fig. 14 (1980).*
Middle
Fig. 17 *Same view as Fig. 16 (1980).*

Fig. 18 *Detail of inner courtyard (1926).*

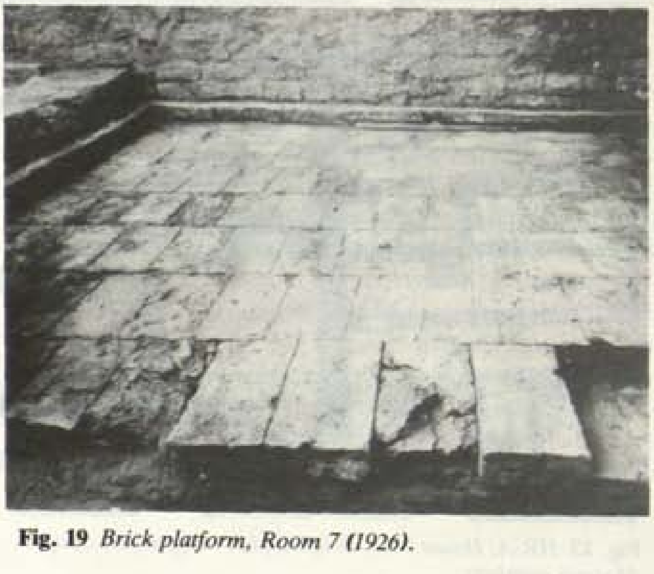


Fig. 19 *Brick platform, Room 7 (1926).*

Fig. 20 *Hatch between Well Room and Room 7 (1926).*

Fig. 21 *Well Room (R6) (1926).*

Fig. 22 *House drainage channel in Room 8 (1926).*

Fig. 23 *Room 17, showing rounded corner (1982).*

Relocalisation of the Artifacts Registered in the Fieldbooks in their Architectural Context

The rediscovery of the fieldbooks opened up the new possibility of studying the relationship of the artifacts not only to each other but also to their architectural context.

However, initial difficulties meant that the data could not be analysed directly. The main problem was that the horizontal-vertical allocation system used in the fieldbooks was not the same as that in the subsequent publication *(cf. Jansen 1983)*. The work of correlating the fieldbook system with that of the publication *(Marshall 1931)* had already been carried out for the HR-A area by A. Ardeleanu *(1981)*. This correlation revealed that the fieldbook system was based on a 100' grid for the HR area, subdivided into 25 20' squares *(Fig.12)*. In the HR-A area therefore, the allocation system was not based on architectural association (e.g. room-by-room as in the HR-B area) but on small 20' grid squares, which makes the attribution to architectural units especially difficult.

Vertical orientation in the HR area consisted of measurements given as *'below surface'*, i.e. purely relative data without any reference to an absolute altitude level. By levelling the tops of the walls and with the added help of unpublished altitude plans it was eventually possible to reconstruct the absolute heights above MSL.

The nature of the fieldbook entries presented a further difficulty, as they cannot be considered as forming a scientific analysis but merely as a personal descriptive record. Here it was (and still is)[47] necessary to exercise discrimination in gauging the degree of probability as objectively as possible by means of textual analysis.[48]

The fieldbook entries can be correlated with the architecture after the architectural indicators of settlement levels (thresholds, staircase bases, floors etc.) have been determined by levelling and also by means of vertical frequency tests in the individual grid squares. When an unusual accumulation of objects is found in association with one of the architectural indicators just mentioned they are presumed to be contemporary. As no stratigraphic records of any kind exist, the results of this method can only be deemed approximate. Possible disturbances in the horizontal layers can be compensated by statistical means.

The entire procedure stands and falls on the sufficiently large amount of data to be compared. Although this study comes nowhere near a substitute for further excavation, the results to date provide us with far more critical information than had been previously available. Especially in the light of the ban on further excavation in Mohenjo-Daro the work of revising the available data according to modern scientific standards becomes a top priority.

As shown on the plan *(Fig.12)*, House VIII is covered by the following 20' grid squares:
36X 1, 2, 3, 6, 7, 8; 36W 11, 12, 13, 16, 17, 18, 21, 22, 23; 35X 4, 5; 35W 20, 24, 25 – in all, 20 squares each $20'^2$ (37.12 m^2) in area.

Of these squares only the following cover the house almost completely and have therefore been chosen for this analysis:
36X 1, 2; 36W 16, 17, 21, 22 and 35W 20, 24, 25.[49]

Square 35X 1 covers Room 17 almost completely. Only in the N does it overlap by about 1 m into the cul-de sac outside the house. The first fieldbook entry *(Appendix 1)*, dated 27.1.1926, is find No. HR 1027 – a faience bead discovered at a depth of 3'. No surface finds whatsoever are recorded. The altitude coordinate in the SW corner of the room was calculated to be 56 m above MSL. Basing calculations on the thresholds in the entrances to the room, the settlement level was tound to be 54.30 m. As shown in the table in Appendix 1 a concentration of 25 objects from a total of 52 was found at 4'9" (– 1.49 m) and 5'4" (– 1.65 m). In all, 26 objects were included in the investigation of this settlement layer, whose average level is 54.40 m ± 10 cm.

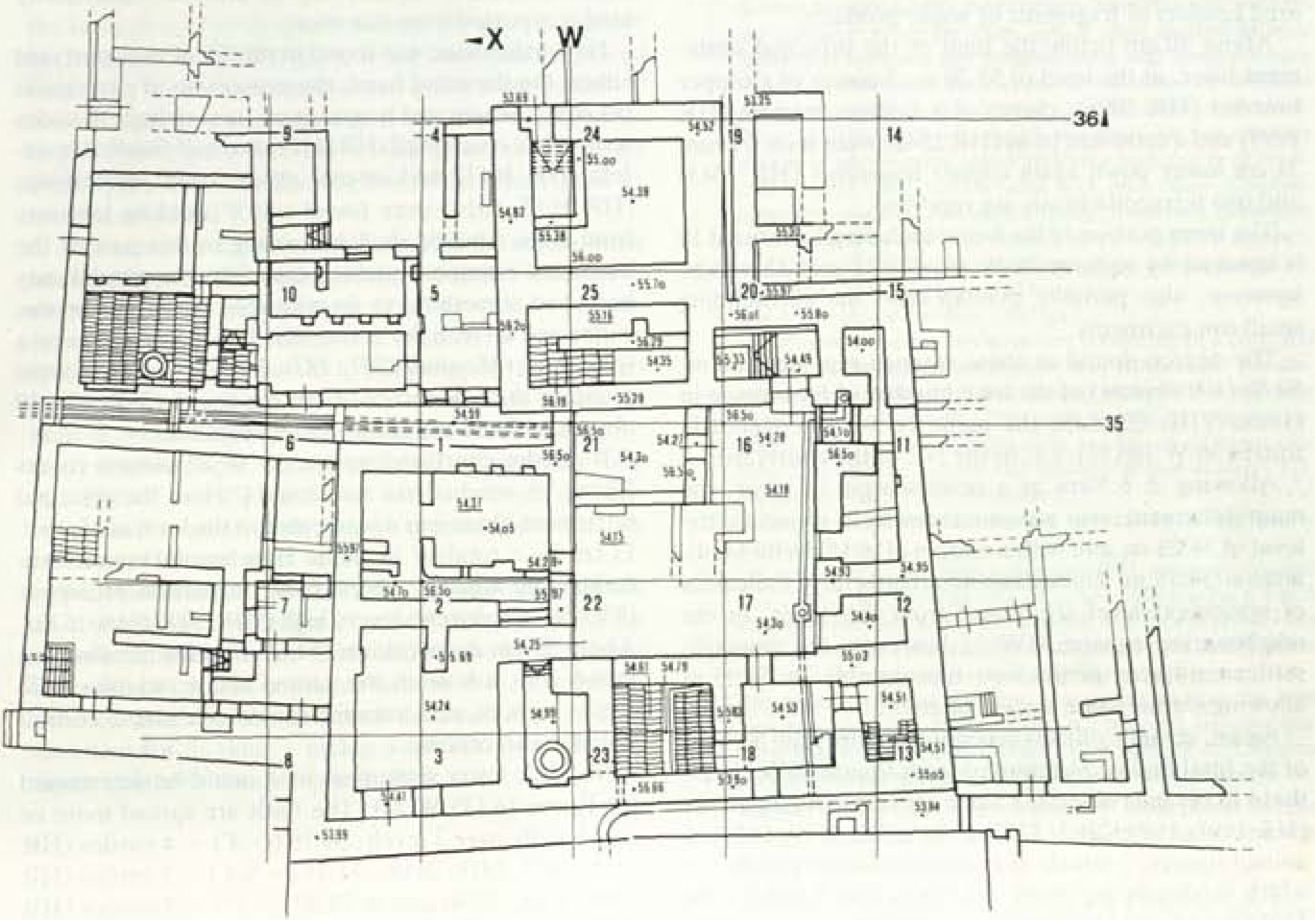
The material make-up of the objects is as follows, in order of quantity:
ceramic – 38.5 %, copper – 7.7. %, stone – 11.5 %, gastropods – 7.7 % and *white paste* – 34.6 %.

Almost 54 % of the objects found were termed *beads* and a further 16 % is made up of miniature vases not more than 4 cm high. A female terracotta figurine (HR 1976) was also found in fragmentary condition.

Only a few objects are reported from the layer above, which is about 1.7 m thick. They consist mostly of stone fragments, which are probably stray finds.

In square 36X 1 digs were made down to a depth of – 2.75 m, i.e. a further 1.10 m deeper than the presumed lower settlement limit. This excavation produced a further 22 objects, of which a concentration of 13 was found at 53,3 m ± 15 cm. A similar analysis of their material make-up gives the following results:
ceramic – 53.9 %, faience – 7.7 %, copper – 7.7 %, stone – 23 % and gastropods – 7.7 %. When sorted into beads (30 %) and miniature vases (23 %) the main components thus ressemble those of the layer just examined. Altogether, 2 figurine fragments were found in this layer, one female and the other possibly representing a dog.

Fig. 12 *HR-A. House VIII showing old excavation grid and present day levelling.*



Although it is not possible to make a more precise classification of the objects according to their finding-places, yet the overall result of the investigation indicates a certain homogeneity in the material make-up of both clusters of objects.

Square 36X 2 cannot be assigned unequivocally to any one room, even though it lies entirely within House VIII. As the floor of Room 6, which is partially covered by this square, is about 0.7 m higher than the passage and Room 17, a settlement level valid for the square as a whole cannot be reliably calculated. Given the reconstructed surface level of 56.50 m, a high concentration of 20 objects from a total of 32 was found at a depth of 2.26 – 2.44 m. This gives us an average lower settlement level of 54.15 m ± 9 cm, which is tolerably close to the level of the passage. As a brick floor was unearthed at 54.99 m in Room 6, which therefore was not dug up any further, the objects noted above as having been found at a depth of – 2.35 ± 9 cm must have come from the passage area.

The proportion of earthenware, 47.6 % of the finds,[50] is again larger than that of any other material, and in this square also two animal figurine fragments (HR 1420, HR 2026) turned up; on the other hand, gastropods are completely absent. Nothing was found to indicate that the enlarged entrance area was used for production or storage of products on a commercial scale.

About 1 m higher, at the level of 55.28 m, a set of antlers (HR 2111) was found; its tines, which were cut off, could have been used as percusion tools for striking flakes off stone by the indirect hammer-and-chisel method. Apart from the antlers, other finds made at this level were a fragment of a stone[51] bracelet (HR 1349), a fragment of a shell bracelet (HR 1350) plus a further object made of shell (HR 1351).

31 cm higher up, at the level of 55.59 m, only two objects are reported to have been found, a gastropod core piece[52] (HR 923) and a fragment of a faience bracelet.

From the statistical point of view ceramics, which at lower levels account for about 50 % of the objects found, no longer feature. The only earthenware discovered consists of fragments or waste products.

About 40 cm below the limit of the principal settlement layer, at the level of 53.76 m, 3 pieces of a copper bracelet (HR 2098), pieces of a faience bracelet (HR 2099) and a carnelian bead (HR 1542) were found. From 51 cm lower down again copper fragments (HR 2043) and two terracotta beads are reported.

The inner portion of the house including Courtyard 18 is covered by squares 36 W 16, 17, 21 and 22 which, however, also partially overlap onto the surrounding small compartments.[53)]

The objects found in these squares represent about 50 % (100 objects) of the total number of finds made in House VIII. Of these the majority was discovered in square 36 W 16 (42), i.e. in the NE of the courtyard.

Allowing ± 6.5 cm as a small margin of error, the main settlement layer is documented by 21 objects at the level of 54.23 m, and with a margin of ± 15 cm by 34 objects at 54.15 m. Unmistakable architectural indicators of settlement level are absent from this layer. In the neighbouring square 36W 21 however, the principle settlement layer is likewise recognisable at 54.15 m allowing for the same margin of error.

Again, ceramic objects account for more than 50 %[54)] of the total find of 34 reported from square 36W 16. Of these 18 ceramic objects, 8 alone are terracotta figurines (HR 1697, 1699, 2269, 2272, 1794, 1796, 1799, 1823), 4 animal figures, 3 female representations and another of which no details are given. Two cups with handles (HR 1701) apparently show that food and drink played a role here. The proportions of objects made of stone (14.7 %) and faience (8.8 %), and of gastropods (8.8 %) are likewise within the average range. Only copper (3 %) is under-represented in this square. Somewhat below the limit of the principal settlement layer, at the level of 53.90 m, the shattered ceramic figure of a bird (HR 2040) and a red-painted ceramic ball with written characters on it (HR 2045) were found.

Square 36W 21 is the only one completely within Courtyard 18. It covers the NW corner, where the kitchen of the house is suspected to have been. Here also the principal settlement level, represented by more than 12 objects, is at 54.15 m ± 15 cm. A remarkable feature of this square is the complete absence of ceramics at this level. Instead, objects of stone make up 58.3 % of the total, including a millstone (HR 1536), a piece of chalcedon (HR 1692), a jade bead and a cube of *white stone* (HR 1691).

A noteworthy find was carbonised wheat grains (HR 1616) which, together with the millstone (HR 1536) may well point towards food preparation. Nevertheless, it remains difficult to explain why no ceramic ware of any kind is reported from this area.

No earthenware was found in the SE of the courtyard either. On the other hand, the proportion of gastropods (61.6 %), whole and fragmentary, is very high. Besides a complete *conch shell* (HR1610), two half-finished bracelets (HR 1611) and several other *conch shell objects* (HR 1613, 1614) were found which could be leftovers from some kind of shell processing in this part of the house. A ceramic container sunk into the ground may have had something to do with this activity, as it was connected up with the drain; Marshall believed it to be a soak shaft *(Marshall 1931: 183)*. Very few objects were found in the SW corner of the courtyard (36W 22 - 10 objects at 54.10 m), most of them ceramic.

N of the courtyard square 35 W 25 almost covers Room 15, reached via staircase 14. Here the principal settlement phase was documented at the level of 55.16 ± 11 cm by a total of 18 finds. Here again ceramics are completely missing, whereas the proportion of copper (83.5 % - 15 objects) is very high (HR 1537, 1618, 1620). About 50 cm deeper down (54,67 m) a faience disc was found with a hole in the centre and a swastika (HR 1287), as well as 3 ceramic *toy wheels* and 2 conical objects, also ceramic.

No clear lower settlement limit could be determined for Room 16 (35 W 24). The finds are spread more or less equally over 3 levels: 54.78 (– 4') – 4 entries (HR 2416, 2417, 2418, 2419); 54.35 (– 5.4') – 3 entries (HR 2257, 2258, 2274) and at 53,87 (– 7') – 3 entries (HR 2612, 2614, 2615). Except for a single painted sherd (HR 2419) no earthenware turned up.

Concluding Remarks

This initial and very general analysis of the distribution of finds in relation to architectural structures has shown that the nature and function of particular parts of a house can be determined much more precisely by studying the type and combination of associated objects. Although the limitations set by the data input must be taken into account, this does not mean that new detailed studies of objects and groups of objects cannot be carried out in order to clarify any existing stylistic features. Admittedly the various strata in House VIII are not yet so clearly recognisable as to allow gradual changes in form and material make-up of finds to be simply read off in chronological sequence; however, the planned investigations in the DK-G area where the promising material is more than 6 m deep will certainly provide us with more useful information.

A major obstacle to the horizontal relocalisation of the finds proved to be the very rough 20' grid introduced by Marshall in 1925 *(Fig. 1)*, which was soon replaced (1926) by Mackay's compartment numbering system.[55] This system in combination with Mackay's use of absolute altitude figures to show vertical position will greatly simplify the work of evaluating more than a third of the total data available.[56].

This tentative analysis of House VIII did not produce answers to such detailed questions as to the function of the small rooms; nevertheless, it did provide enough information about the *courtyard* to make it possible to identify certain sections of it according to the activities apparently carried out there, e.g. the section where the finds of ceramic figurines were concentrated or where the many scattered signs of gastropod shell working were located. Similar investigations into the finds made in other houses will most certainly help to round off this first impression of life and work in House VIII.

With this analysis therefore, the first step has been taken towards the evaluation of an enormous mass of data, as in all some 38,000 fieldbook entries for 250 house units can be studied in similar fashion. Not only the ban on excavation but the fieldbook documentation itself – excellent for its time – makes a revision of all the currently available data a top priority.

Footnotes

1) *Henrickson, E., 1981; Stone, E., 1981; Eaton-Francis, M., 1974.*
2) *ARP (Aachen University Project, Mohenjo-Daro).*
3) *Jansen, M., 1983.*
4) By *'structural'* is meant purely the architectural state.
5) By which is meant the system of accessibility to the rooms.
6) Mackay *(Mackay, 1938)* had already used this method correctly. He came, however to the false conclusion, namely that all zones at the same depth in different houses belonged to the same period, from which he developed his chronological layer model, which was rightly criticised by *Wheeler (1961: 69). Delougaz et al., 1967*, writing about Khafajah and Assmar had this to say: *„The separation of occupation levels into strata presented difficulties peculiar to the houses. The continuity of occupation of the area was unbroken by any general destruction to mark a division into periods. Rather, each house had its own history, not necessarily paralleled by that of its neighbours. The problem was further complicated by the custom of founding new walls on the remnants of earlier ones, which often resulted in level differences between two neighbouring and contemporary houses... Obviously the elevations could not be taken as guides to stratification... Instead, the coordination of rebuildings in different houses had to be based on two separate groups of observation, which yielded a high degree of probability when they corroborated with each other. Contemporaneity could be established firstly, from such continuity of rebuilding as could be traced from one limit to another, and secondly, through comparison of the objects found within them." (Henrickson, 1981: 44-45).*
7) See for example *Sarcina, 1981.*
8) By *'cluster'* is meant any structure consisting of a core and its extensions, which are in some way connected. The cluster is both defined by and limited within the composite structural construction. Thus each cluster can only be examined on its own. Comparitive studies of different clusters can only be carried out through object analyses *(cf. Delougaz et al., 1967: Footnote 1).*
9) Take for example the contrast between a Hindu and a Moslem house.
10) The term *'private'* as used by *Sarcina, 1981*, or even *Delougaz et al., 1967*, has connotations of socio-cultural aspects which should be the final aim of the analysis. The idea of privacy can differ in various cultures. These differences can mostly be reflected in the house concepts of the different cultures.
11) The term *'residential building'* is as problematic as the term *'private'*, as it is also determined by our customs, and combinations like living-administration, living-working or living-representation are not sufficiently differentiated in this term.
12) It is not exactly clear what is meant by *'house'* here. But the concept of identification of limits could be compared with our concept of *'clusters'*.
13) In her analysis of the structures in Khafajar and Assmar she came up against the same sort of problems which we experienced in Mohenjo-Daro, which consisted of replacing each housing unit in an new chronology.
14) Designated *'formal'* or *'structural'* analyses by us.
15) She refers here to *B. Triggers, „The determinants of Settlement Patterns"* in: *Settlement Archaeology, 1968.*
16) In this operation two steps are combined which were carried out separately in our analysis, whereby the purely structural analysis of room size and position was not seen to be *'functional'* in the first step of the analysis.
17) This analysis is represented in our work as the access system.
18) These rather vague, unquantitative specifications are represented in our room evaluation system by the Categories I, access from public, II, transit and III, room with one access (see section on evaluation of rooms).
19) The problems of quantification arising from the segregation of room sizes into small, medium and large, such as Henrickson does, are eliminated by the size-proportion diagram developed by us (see section 4 on size-proportion diagram).
20) c.f. Footnote 18.
21) c.f. Footnote 18.
22) H. Hargreaves, 1925 Officiating Director Archaeology, was Sir John Marshall's successor in the office of Director General (8.10.28-29.7.1931).
23) *Marshall, 1931: 176ff*

24) The register entries in the field-book end on the 20.3.1926 (HR 2686) and was signed on 3.4.1926 by R.B.D.R. Sahni.
25) The HR-B Area was excavated by R.B. Daya Ram Sahni between 1926-27, approx. 14.000 m².
26) For a discussion of classification problems see *Jansen, 1983: 24.*
27) See Preface by Urban/Jansen.

28) House I.
29) House I lower courtyard at 51 m, joined by a double staircase to the upper courtyard 54 m above MSL.
30) A soakaway at a height of 52 m in First Street, is connected by drains in Deadman-Lane to structures at a height of 55 m, and to a vertical shaft which rises to a height of 57 m above MSL.
31) The classification consisted of a letter for the 100ft. east-west direction and a number for the 100ft. north-south direction, with the respective subdivision of the 20' units from 1-25 e.g. 35x/25.
32) This correlation is now possible. A computer program is running in Aachen to evaluate the field-books.
33) As *A. Sarcina (1981)* could prove, House VIII is in no way typical of the general house types in Mohenjo-Daro.
34) Shown in black.
35) Axial investigations in HR have shown that First Street at least, in its present orientation, is a product of a later development phase, whose direction of axis overlies an earlier construction.
36) German Research Project Mohenjo-Daro 1979-1984.
37) The following rooms are exceptions: Room 6; 54, 99, Room 7; 54, 79, Room 8; 54, 53.
38) *Footnote 2, 182: „Built probably in Intermediate II, slightly modified in Intermediate I and subsequently burnt down."*
39) c.f. Section 3 in the text on the evaluation of rooms and Footnote 10).
40) This could have been the sales area for a shop building. This area could just as well have been the public visiting room in the house.
41) The public use of the well is in this case conceivable.
42) This structure in Room 9 is now known not to be a staircase.
43) Because there is not enough archaeological proof for this assumption, it will not be further discussed in this article.
44) A similar distribution can be seen in House 1, HR-A Area.
45) According to *Marshall (ibid: 19)* remains of *Cedrus deodora* and *dalbergia sissoo* were found, which must have been used as ceiling joists.
46) By a ceiling weight of approx. 380 kp/m, a good quality wood must have an average thickness of 18-24 cm, with a supporting length of 5 m.
47) The program of textual analysis has not yet been completed.
48) With the aid of the field-book numbers and original photos, the objects in the different museums can be better defined.
49) Additional investigations are necessary for the partly covering squares, which will not be carried out for our example.
50) 10 out of 21 pieces.
51) According to latest investigations *(Vidale, unpublished; Franke, personal information)* it concerns a very fine ceramic, possibly a purposeful stone imitation.
52) Probably *Xancus pyrum.*
53) The disadvantage of this area notation method is obvious here. However, there exists for more than 50% of the data contained in the whole of the field-books an exact room indication (DK-G, HR-B, VS-B).
54) 52,3% (18 objects).
55) Due to the problems encountered it is advisable not to use a grid, but rather a point coordination system.
56) DK-G Area with approx. 13,000 registrations out of a total of 36,000.

Bibliography

ARDELEANU-JANSEN (A.) 1981, Kleinfunde aus dem Bereich der Harappa-Kultur in Relation zur Architektur, Aachen (unveröff. Manuskr.)

ARDELEANU-JANSEN (A.), FRANKE (U.), JANSEN (M.) 1981, An Approach Towards the Replacement of Artefacts into the Architectural Context of the Great Bath in Mohenjo-Daro. In: *URBAN (G.) / JANSEN (M.), Forschungsprojekt DFG Mohenjo-Daro. Dokumentation in der Archäologie, Techniken, Methoden, Analysen. Veröffentlichungen des Geodätischen Instituts der Rheinisch-Westfälischen Technischen Hochschule Aachen,* Nr. 34, Aachen, S. 37-42.

DALES (G.) 1965, New Investigations at Moenjo-Daro. In: *Archaeology 18,* No. 2, pp. 145-150.

DELOUGAZ (P.), HILL (H.D.), LLOYD (S.) 1967, Private Houses and Graves from the Diyala Region. In: *Oriental Institute Publications,* Vol. LXXXVIII, Chicago, pp. 143-144.

EATON-FRANCIS (M.) 1974, Mesopotamian Building Materials and Techniques of the Early Dynastic Period. In: *Marsyas. Studies in the History of Arts.* Vol. XVI, 1972-1973, New York, pp. 1-28.

HENRICKSON (E.F.) 1981, Non Religious Residential Settlement Patterning in the Late Early Dynastic of the Diyala Region. In: *Mesopotamia. Revista di Archaeologica Epigraphia e Storia Orientale Antica,* Vol. XVI, Firenze, pp. 43-140.

JANSEN (M.) 1983, Preliminary Results of Three Year's Documentation in Mohenjo-Daro. In: *URBAN (G.) / JANSEN (M.), Forschungsprojekt DFG Mohenjo-Daro,* Aachen, pp. 21-35.

MACKAY (E.J.H.) 1938, Further Excavations at Mohenjo-Daro, Vol. I-II, New Delhi.

MARSHALL (Sir J.) 1931, Mohenjo-Daro and the Indus Civilization, Vol. I-III, London

SARCINA (A.) 1981, A Statistical Assessment of House Patterns at Mohenjo-Daro. In: *Mesopotamia. Revista di Archaeologica Epigraphia e Storia Orientale Antica,* Vol. XIII-XIV, Firenze, pp. 155-199.

STONE (E.) 1981, Texts, Architecture and Ethnographic Analogy: Patterns of Residence in Old Babylon Nippur. In: *Iraq,* Vol. XLIII, Spring, pp. 19-33.

WANZKE (H.) 1983, Geodätische Konzepte in der Archäologie am Beispiel Mohenjo-Daros. In: *URBAN (G.) / JANSEN (M.), Forschungsprojekt DFG Mohenjo-Daro*, Aachen, pp. 71-80.

WHEELER (Sir M.) 1961, Archaeology from the Earth, London (first ed. 1951).

Appendix 1

Key to Computer Print-Out:

1 = Computer number
2 = Field-book number
3 = Museum number, place of custody
4 = Date of excavation
5 = Excavation square
6 = Depth of excavation
7 = Number of objects
8 = Description of object

1	2	3	4	5	6	7 8
1069	1027		27.1.26	36 X /1	3'	1 faience bead
1196	1147		29.1.26	36 X /1	4'9"	1 stone bead (damaged), 1 T.C. bead
1312	1259		30.1.26	36 X /1	2'4"	1 rect: lime-stone piece 14" X 8"
1762	1673	M	8.2.26	36 X /1	4'9"	1 T.C. vase min: ht: 1 1/2"
1763	1674	M	8.2.26	36 X /1	4'9"	1 T.C. vase min: ht: 1 6/8"
1765	1676		8.2.26	36 X /1	4'9"	1 rectang: piece of stone L: 2 1/2"
1766	1677		8.2.26	36 X /1	4'9"	1 sq: piece of conch shell side: 3/2" ; 1 unfinished bead of conch shell
1830	1736		9.2.26	36 X /1	4'6"	a frag: of worked stone L: 4 7/8" , B: 2 2/8"
1831	1737		9.2.26	36 X /1	4'6"	a lump of rock crystal
1880	1784	5	9.2.26	36 X /1	5'8"	1 complete copper bangle
1881	1785		9.2.26	36 X /1	5'8"	1 frag: of flint
1882	1786		9.2.26	36 X /1	5'6"	1 white paste bead
1971	1865		10.2.26	36 X /1	5'4"	2 frags: of copper
1972	1866		10.2.26	36 X /1	5'4"	1 frag: of alabaster pottery
2007	1900		10.2.26	36 X /1	5'6"	1 T.C. obj: (conical in shape + spiraled) ht: 3"
2031	1922		11.2.26	36 X /1	7'8"	1 paste bead L: 5/8"
2034	1925		11.2.26	36 X /1	7'	4 frags: of copper
2035	1926		11.2.26	36 X /1	7'	1 faience end bead of a necklace sq: 7/8"
2070	1961		11.2.26	36 X /1	7'	1 paste knob-like obj: ht: 3/8"
2084	1974	M 7	12.2.26	36 X /1	5'4"	2 T.C. toy-cart-wheels dia: 2 1/2" + 1 7/8"
2085	1975	1	12.2.26	36 X /1	5'4"	2 T.C. beads
2086	1976		12.2.26	36 X /1	5'4"	1 frag: T.C. fig: of a female
2091	1978b		12.2.26	36 X /1	5'4"	1 T.C. vase ht: 2"
2095	1982		12.2.26	36 X /1	8'6"	1 lime-stone cube + 1 frag: stone-cube
2104	1990	M	12.2.26	36 X /1	8'6"	1 frag: T.C. fig: of a female
2105	1991		12.2.26	36 X /1	8'6"	1 frag: of an alabaster bead
2106	1992		12.2.26	36 X /1	8'6"	1 min: T.C. vase ht: 1 1/2"
2107	1993	M	12.2.26	36 X /1	8'6"	1 frag: T.C. fig: of a dog
2119	2005	M	12.2.26	36 X /1	8'	1 T.C. bead
2122	2008		12.2.26	36 X /1	8'	1 T.C. tumbler (damaged) ht:4"
2129	2015		12.2.26	36 X /1	8'	1 frag: of copper L: 3 1/2" B: 2 1/2"
2173	2056		13.2.26	36 X /1	8'6"	1 T.C. min: pot ht: 1 5/8"
2211	2093		15.2.26	36 X /1	8'10"	1 cylin: faience bead L: 1 1/8"
2215	2097		15.2.26	36 X /1	8'10"	1 conch shell disc dia: 1"
2234	2116		15.2.26	36 X /1	8'10"	1 T.C. bead
Total number of items= 35						
963	923		25.1.26	36 X /2	3'	a conch shell cone, ht: 1 3/8"
964	924	21	25.1.26	36 X /2	3'	frag: of a faience bangle
1409	1349		2.2.26	36 X /2	4'	1 fragmentary stone bangle
1410	1350		2.2.26	36 X /2	4'	1 fragmentary conch shell bangle
1411	1351		2.2.26	36 X /2	4'	1 frag: of a conch shell obj:
1485	1419		3.2.26	36 X /2	7'6"	1 frag: of a copper obj: L: 1 1/2" + a black stone disc dia: 5/8"
1486	1420		3.2.26	36 X /2	7'6"	frag: T.C. fig: of an animal
1487	1421	M	3.2.26	36 X /2	7'6"	1 T.C. lid dia: 1 1/2"
1615	1542		5.2.26	36 X /2	9'	1 carnelian bead
2032	1923		11.2.26	36 X /2	7'4"	4 stone discs + 2 frags of copper
2039	1930		11.2.26	36 X /2	7'4"	1 T.C. vase ht: 2 5/8" (damaged)
2053	1944		11.2.26	36 X /2	8'	1 T.C. min: vase ht: 1 7/8"
2141	2025a		13.2.26ɇ	36 X /2	8'	2 T.C. toy-cart-wheels dia: 2 6/8"
2142	2026		13.2.26	36 X /2	8'	1 T.C. frag: fig: of a dog
2143	2027	M,2	13.2.26	36 X /2	8'	2 T.C. beads
2144	2028		13.2.26	36 X /2	8'	painted potsherd
2148	2032		13.2.26	36 X /2	8'	2 frags: of faience bangles + 1 frag: of faience pottery
2160	2043		13.2.26	36 X /2	11'	frags: of copper
2164	2047		13.2.26	36 X /2	11'	2 T.C. beads L: 2 6/8" + 1 1/2"
2216	2098		15.2.26	36 X /2	9'	3 frags: of a copper bangle
2217	2099		15.2.26	36 X /2	9'	1 frag: of a faience bead (painted)
2226	2108	6	15.2.26	36 X /2	9'	1 T.C. pot ht: 4"
2229	2111		15.2.26	36 X /2	4'	antlers of a stag
Total number of items= 23						

1	2	3	4	5	6	7	8
1339	1285		1.2.26	36 W /16	3'		2 frag: of copper obj: + 1 frag: of conch shell obj:
1407	1347		2.2.26	36 W /16	4'6"		1 frag: of a conch shell bangle
1790	1697	13	9.2.26	36 W /16	5'6"		1 frag: T.C. female fig: L: 3 1/4"
1791	1698		9.2.26	36 W /16	5'6"		2 T.C. beads
1792	1699		9.2.26	36 W /16	5'6"		1 frag: T.C. female fig:
1793	1700		9.2.26	36 W /16	5'6"		2 frags: of a faience bead + 1 faience potsherd
1794	1701	M	9.2.26	36 W /16	5'6"		2 painted bottom T.C. cups with handles dia: 1 7/8"
1795	1702		9.2.26	36 W /16	5'6"		1 cir: stone obj: like a wheel dia: 1 6/8" , ht: 4/8"
1824	1730		9.2.26	36 W /16	5'11"		a frag: of a conch shell
1825	1731		9.2.26	36 W /16	5'11"		1 black stone obj: (like a chessman) ht: 1/2"
1826	1732		9.2.26	36 W /16	5'11"		3 frags: of a paste obj:
1827	1733		9.2.26	36 W /16	5'11"		a faience potsherd
1828	1734		9.2.26	36 W /16	5'11"		a frag: of rock crystal
1899	1801	M	9.2.26	36 W /16	6'6"		1 T.C. lid, dia: 2 1/2"
1900	1802		9.2.26	36 W /16	6'6"		1 black stone lid with a groove round it + 1 frag: of flint
1922	1823	6	9.2.26	36 W /16	6'6"		1 frag: T.C. animal fig:
2157	2040		13.2.26	36 W /16	7'		1 min: T.C. fig: of a bird (fragmentary)
2159	2042	10	13.2.26	36 W /16	7'		1 T.C. bead
2162	2045		13.2.26	36 W /16	7'		1 T.C. ball painted red + 1 pictograph on it (scetch in the register)
2199	2081	M	15.2.26	36 W /16	4'		a sq: piece of copper sq: 1 1/8"
2394	2267		18.2.26	36 W /16	6'		frags: of copper
2395	2268	8	18.2.26	36 W /16	6'		frags: of conch shell bangles
2397	2269		18.2.26	36 W /16	6'		frags: of T.C. fig: of a female
2398	2270	13	18.2.26	36 W /16	6'		1 T.C. bead
2399	2271	21	18.2.26	36 W /16	6'		1 T.C. min: vase ht: 1 1/2"
2400	2272		18.2.26	36 W /16	6'		1 T.C. frag: fig: of a bull (head only)
Total number of items= 26							
1194	1145		29.1.26	36 W /17	4'6"		1 conical faience obj: ht: 2 2/8" decorated with parallel lines
1195	1146		29.1.26	36 W /17	4'6"		3 frag: of copper
1604	1531		5.2.26	36 W /17	6'5"		1 frag: of painted pottery
1605	1532		5.2.26	36 W /17	6'5"		1 frag: of T.C. bangle
1688	1610		6.2.26	36 W /17	4'8"		1 complete conch shell
1689	1611	2	6.2.26	36 W /17	4'8"		2 unfinished conch shell bangles + 1 frag:
1690	1612		6.2.26	36 W /17	4'8"		1 frag: white paste bead
1691	1613	1	6.2.26	36 W /17	4'8"		2 conch shell objs: + 1 frag:
1692	1614		6.2.26	36 W /17	4'8"		1 frag: conch shell obj:
Total number of items= 9							
1250	1200		30.1.26	36 W /21	4'4"		1 copper coin-like obj: dia: 1 2/8"
1274	1221	M	30.1.26	36 W /21	3'		1 T.C. lid dia: 1"
1328	1274	22	1.2.26	36 W /21	3'6"		1 frag: of a conch shell bangle
1329	1275	8	1.2.26	36 W /21	3'6"		1 T.C. ball
1330	1276		1.2.26	36 W /21	3'6"		1 painted pot sherd
1331	1277	M	1.2.26	36 W /21	3'6"		frag: of a T.C. obj: L: 3 1/2" B: 2 1/8"
1390	1332		2.2.26	36 W /21	5'4"		1 frag: of a conch shell bangle
1606	1533		5.2.26	36 W /21	6'4"		many white paste beads
1607	1534		5.2.26	36 W /21	6'4"		1 frag: of a copper obj:
1608	1535		5.2.26	36 W /21	6'4"		1 frag: of alabaster
1609	1536		5.2.26	36 W /21	6'4"		1 grinding-stone
1611	1538		5.2.26	36 W /21	6'4"		1 conch shell disc, dia: 7/8" + 1 faience bead
1693	1615		6.2.26	36 W /21	6'		a lot of white paste beads
1694	1616		6.2.26	36 W /21	6'		charred wheat grains
1695	1617		6.2.26	36 W /21	6'		1 jade bead + a piece of soft stone
1783	1691	22	8.2.26	36 W /21	5'6"		1 white stone cube , side 7/8"
1784	1692	2	8.2.26	36 W /21	5'6"		1 alabaster bead ; 1 conch shell disc + 1 piece of chalcedony
1785	1693		8.2.26	36 W /21	5'6"		1 frag: of a faience obj: of light blue colour + 1 piece of copper
1884	1788		9.2.26	36 W /21	7'4"		2 frags: of faience
Total number of items= 19							
1240	1190	M	29.1.26	36 W /22	4'6"		1 T.C. vase
1241	1191		29.1.26	36 W /22	4'6"		1 T.C. toy-cart-wheel dia: 3"
1340	1286	11	1.2.26	36 W /22	4'10"		5 disc beads 1 frag: of conch shell obj: 1 T.C. long bead + 1 T.C. round
2161	2044		13.2.26	36 W /22	7'5"		white paste beads
Total number of items= 4							
858	825		22.1.26	35 W /20	3'		a cylin: stone ojb:, l: 1 2/3", dia: 3/8"
1613	1540		5.2.26	35 W /20	3'		1 conch shell disc-like obj:
1821	1727	M	9.2.26	35 W /20	7'10"		1 min: T.C. vase ht: 1 1/2" (damaged)
1822	1728		9.2.26	35 W /20	7'10"		1 copper bead
1823	1729		9.2.26	35 W /20	7'10"		a lump of chalcedony
1883	1787		9.2.26	35 W /20	7'		1 frag: of stone
2262	2140		16.2.26	35 W /20	5'6"		1 frag: of carnelian bead L: 1/2"
2263	2141		16.2.26	35 W /20	5'6"		1 frag: of corroded copper
2264	2142		16.2.26	35 W /20	surf:		1 fragmentary T.C. fig: of a dog L: 4 1/4"
2265	2143		16.2.26	35 W /20	surf:		1 frag: of a faience bangle
2317	2196		17.2.26	35 W /20	4'		2 faience discs dia: 1" + 1/2"
2319	2198		17.2.26	35 W /20	1'10"		1 frag: faience nose ornament dia: 1/2"
Total number of items= 12							

1	2	3	4	5	6	7	8
2384	2257		18.2.26	35 W /24	5'4"	1 frag: carnelian bead L: 1"	
2385	2258		18.2.26	35 W /24	5'4"	a frag: faience bead	
2402	2274		18.2.26	35 W /24	5'4"	frags: of copper	
2547	2416		20.2.26	35 W /24	4'	frag: of copper	
2548	2417		20.2.26	35 W /24	4'	2 paste beads	
2549	2418		20.2.26	35 W /24	4'	frag: of conch shell	
2550	2419		20.2.26	35 W /24	4'	a painted potsherd	
2758	2612		25.2.26	35 W /24	7'	1 bead of conch shell	
2760	2614		25.2.26	35 W /24	7'	1 frag: of an ivory obj: L: 2 2/8"	
2761	2615		25.2.26	35 W /24	7'	many frags: of copper + 1 key-shaped obj:	

Total number of items= 10

Appendix 2

Key:
1 = Relative height below surface in metres
2 = Number of objects
3 = Absolute height above MSL

Height number distribution in metres

1 (m)	2 (number)	3 (m)
1) 36X/1 Absolute height 56,5 m above MSL		
0,73	1	55.77
0.91	1	55.77
1.40	2	55.10
1.49	15	55,01
1.65	10	54.85
1.70	2	54.80
1.77	2	54.73
2.13	6	54.37
2.44	3	54.06
2.65	7	53.85
2.74	3	53.76
2) 36X/2 Absolute height 56,5 m above MSL		
0.91	2	55.59
1.22	4	55.28
2.26	7	54.24
2.32	4	54.18
2.44	9	54.06
2.74	3	53.76
3.25	3	53.25
3) 36W/16 Absolute height 56,0 m above MSL		
0.92	3	55.08
1.22	1	54.78
1.40	1	54.60
1.70	10	54.30
1.83	5	54.17
1.83	6	54.17
2.01	10	53.99
2.14	3	53.86
4) 36W/17 Absolute height 56,0 m above MSL		
1.40	4	54.60
1.46	9	54.54
1.71	2	54.29

1 (m)	2 (number)	3 (m)
5) 36W/21 Absolute height 56,0 m above MSL		
0.91	1	55.09
1.10	4	54.90
1.22	1	54.78
1.34	1	54.66
1.65	1	54.35
1.70	6	54.30
1.83	4	54.17
2.01	6	53.99
2.26	2	53.74
6) 36W/22 Absolute height 56,5 m above MSL		
1.40	2	55.10
1.46	8	55.04
2.29	1	54.21
7) 35W/20 Absolute height 56,5 m above MSL		
0.32	1	56.18
0.92	2	55.58
1.22	2	55.28
1.64	2	54.86
2.15	1	54.35
2.35	2	54.15
8) 35W/20 Absolute height 56,0 m above MSL		
1.22	5	54.78
1.65	3	54.35
2.13	4	53.78
9) 35W/25 Absolute height 56,5 m above MSL		
0.92	3	55.58
1.22	1	55.28
1.34	11	55.16
1.43	5	55.07
1.83	6	54.67

Appendix 3

Compilation (Figures in %)

	TC	FA	Cu	ST	SH	OT
1) 36 X/1 A.	38.5	–	7.7	11.5	7.7	34.6
1) 36 X/1 B.	53.9	7.7	7.7	23.0	7.7	–
2) 36 X/2	47.6	14.3	14.3	23.8		
3) 36 W/16	52.3	8.8	3.0	14.7	8.8	
4) 36 W/17	–	8.7	26.1	–	61.6	
5) 36 W/21	–	16.6	16.6	58.3	16.6	
6) 36 W/22	40.0	–	–	–	50.0	
7) 35 W/20	16.4	30.0	16.4	30.0	7.2	
8) 35 W/24	10.0	10.0	30.0	10.0	20.0	20.0
9) 35 W/25	5.5	5.5	78.0	5.5	–	5.5

Classification of Object Distribution according to Classes of Material

1. **TC** = Terracotta
2. **FA** = Faience
3. **Cu** = Copper
4. **ST** = Stone
5. **SH** = Gastropods (Shell)
6. **OT** = Other

Kilns, Bangles and Coated Vessels
Ceramic Production in Closed Containers at Moenjodaro

M. A. Halim
Department of Archaeology and Museums of Pakistan, Karachi

Massimo Vidale
Istituto Italiano per il Medio ed Estremo Oriente, Roma

Acknowledgements

We are particularly grateful to M. Ishtiaq Khan, Director General of the Department of Archaeology and Museums, Pakistan, for his interest in our research and his continuous support. Much assistance was given by all the members of the Department, in Karachi as well as in Moenjodaro. We are especially indebted to Miss. Salma Sultana Begum, Conservator of Moenjodaro for the '82 campaign, and to Mr. Saddiqi, Conservator in the following season: on several occasions their help was invaluable. The bulk of the fieldwork and of the laboratory research has been carried out with the help of Michael Jansen; his continuous and tireless assistance was determinant for our research. We would also like to thank M. Tosi, who was a constant source of information and encouragement. In Italy we are deeply indebted to G. Maura and P. Matias of the Rome University; their work readily granted the chemical analysis and interpretation of the recovered material.

The different topics involved in the subject have been widely discussed on many occasions with colleagues and scholars. We are deeply indebted to R. Mughal, Director of the Exploration Branch of the Department, for his helpful observations and comments. Prof. F.R. Allchin suggested us a more proper terminology for our specialized ceramic containers (see footnote 1).

Other suggestions, comments and constructive criticism have come from J.F. Jarrige, G. Dales, J.M. Kenoyer, G. Weisberger. Although, given the novelty of the subject, it was sometimes difficult to reach a general agreement, every comment or critic has been and shall be most welcome.

Finally, this work being a partial result of the Surface Evaluation Program in Moneer South-East, we express our gratitude to all the colleagues that contributed in several ways to the field and laboratory activity, namely: S. Salvatori and G. Santini; G.M. Sher Baloch, for his constant contribution to the surface recording and his sharp criticism; U. Franke, A. Ardeleanu-Jansen, S. Pracchia and J.M. Kenoyer for their help in the surface recording, M. Karner, W. Dames, M. Jacobs, responsible for the installation of the famous grid in Moneer site; T. Urban, who provided an invaluable help for the topographical mapping of the site. The English version was edited by I. Mc Gilvray; many thanks are due to Loredana Ricci for typing the paper.

Introductory Note

In analyzing and processing the materials recovered from the excavations of the DK-G North Area, E. Mackay found a group of ceramic items of anomalous nature. In the 1938 report, such items are grouped under the term „Muffles and Crucibles " with a question mark for uncertainty *(1938: 178)*[1].

Being well aware of the degree of sophistication of Harappan technological know-how, and having a sharp and bright interest in the logic of technology and production, he hypothesized that the observed anomalies could be explained in this direction.

Fifty years later, during the '83 season of the German-Italian Joint Project at Moenjodaro, in the framework of the Surface Evaluation Program, we had the chance to retrace Mackay's steps independently with the result of confirming the substantial exactness of his intuitions and particularly of corroborating his interpretation of a small, subcylindrical pottery type *(Mackay 1938: 178)*[2].

The first word in the title of this paper is „kilns". However, owing to surface approach constraints, kilns as primary technological contexts are conspicuous by their absence in our study, their remains nevertheless provided, in the form of secondary surface assemblages, the starting point for the research. The heaps of kiln wasters, distributed in different concentrations in different sections of the site, are so evident on the surface of the mounds that they become famous to the public at large as the ultimate proof of the theory of the „atomic destruction" of Moenjodaro.

Wandering around such wasters, we encountered large concentrations of sherds belonging to two quite different pottery types, which shared the anomalous feature of being coated with a thick layer of chaff-tempered clay rich in cereal seeds. One of these pottery types clearly corresponded to the item described by Mackay.

In this initial phase of the research, the strange vessels could simply be considered as defective products. We hypothesized, perhaps rather arbitrarily, that the coating device could be explained by the need for insulating and protecting the vessels during firing operation, and that the vessels could have been used to bake particular types of inorganic matter under controlled conditions. The lack of metal prills and the analysis of the slags ruled out the possibility of a metal smelting activity.

Upper
Fig. 1 *Moenjodaro, Moneer South-East Area (AA.40): view of the site from south. An erosive gully filled with kiln wasters is visible in the foreground. The white triangle marks the bush under which the complete Coated Carinated Jars were found.*
Middle
Fig. 2 *Moenjodaro, Moneer South-East Area (AA.40): view of erosive gully with kiln wasters. The gully is discharging in a N-S depression probably corresponding to an ancient street.*

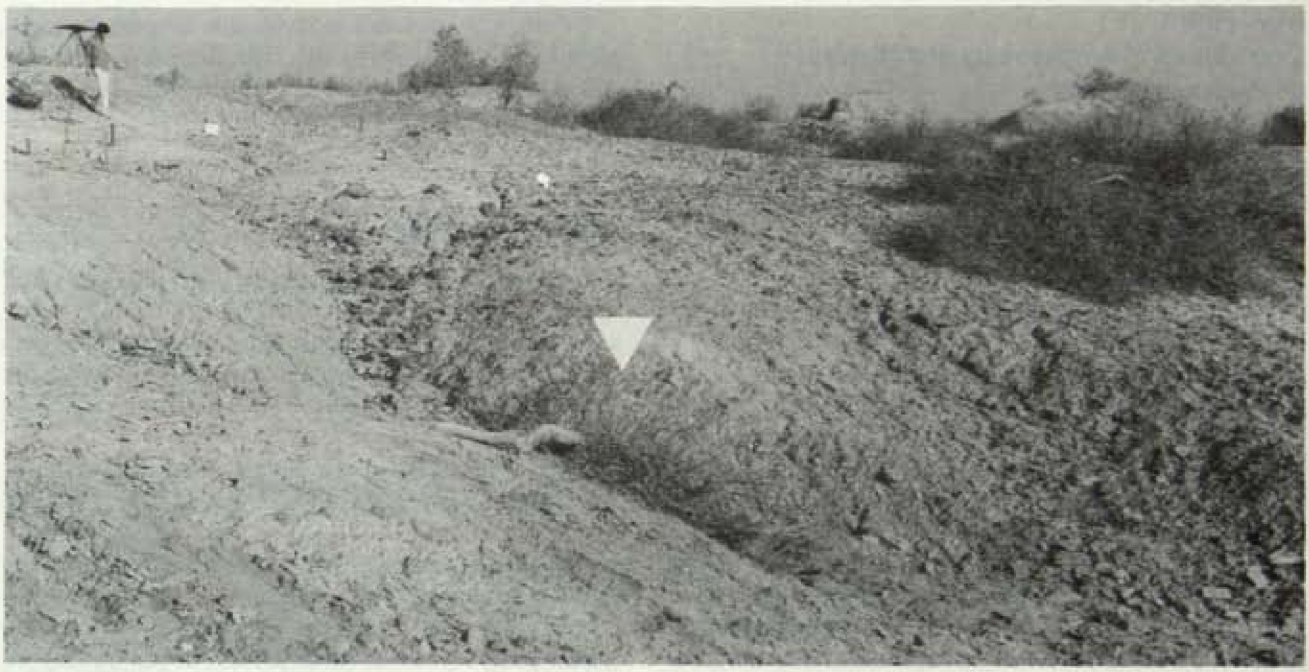


Fig. 3 *Moenjodaro, Moneer South-East Area (AA. 40): close view of a Coated Carinated Jar fragment on the surface of the site.*

We were thus left with the most probable hypothesis: the vessels could have been used to bake earth, rocks or clayish compounds in different possible stages of transformation. In other words, they could have been used as true saggars.

The subsequent steps of the research gave progressively more evidence to support the initial working hypothesis.

The Coated Carinated Jars

The Moneer South-East Area (AA 40) occupies an important place in the schedule of the SEP, owing to its size and the co-occurence of several classes of indicators relative to quite different manufacturing processes.

Among the most evident processes, shell working is well attested; isolated clusters of overfired sherds point to the probable existence of small-scale pottery making activities; in the site, furthermore, thousands of flakes of agate and chalcedony, chert drills and other specialized tools form the largest assemblage of indicators of semiprecious stoneworking so far identified at Moenjodaro. All the southern section of the site is covered with overfired and partially melted kiln wasters, such as bricks, kiln linings, glass-like drops, and hundreds of warped fragmentary terracotta bangles. The available evidence suggests the presence of at least two or three kilns.

Probably due to the weight and the irregular sharp contour of these wasters, made unperishable by vitrification, the erosion gullies capturing them are particularly deep and overloaded with remains *(Figs. 1-4)*.

Fig. 4 *Moenjodaro, Moneer South-East Area (AA.40): particular of surface littered with overfired terracotta bangles, vitrified drops, fragmentary kiln linings.*

These collapsing heaps of wasters did not seem consistently associated with normal overfired pottery. They contained, instead, large amounts of grayish-greenish sherds of large size, bearing the above-mentioned chaff-tempered coating *(Fig. 5)*. The two different layers of the vessels were even and thick enough to allow us to speak of a „*double vessel*" composed of:

(a) an „*inner vessel*", made with a heavy pottery of a very homogeneous texture, free from macroscopic inclusions. Exposure to high temperature gave this pottery a grès-like appearance and produced cracking, warping, bubbling and internal lamination. Thickness of the base fragments varied between a minimum of 2 and a maximum of 4 cm.. The external surface of the inner vessel was covered with an uninterrupted series of horizontal grooves, 2-3 mm. deep and 3-4 mm. wide, very carefully executed in the wet clay. This expedient, through an absolute increase in the available external surface afforded the best adherence to the second layer.

(b) an „*outer vessel*" made with a heavy chaff-tempered clay. Overfiring produced dilation and vitrification of the thin sections of clay among the straw particles. This rendered the outer vessel very fragile, so that it often appeared almost completely decayed. The average thickness was 2-3 cm., and, in some cases, sherds retained circular imprints on the coating, particularly on the external surface on the base. In one case, two superimposed bangles were found still sticking to the bottom of the vessel *(Figs. 6-7)*.

All the sherds clearly belonged to the same pottery type: a medium-large size sub-cylindrical jar on a truncated-cone shaped base, whose inner vessel had a round everted rim. We adopted for this ceramic type the name „Coated Carinated Jar" (hereafter CCJ).

Upper
Fig. 5 *Moenjodaro, Moneer South-East Area (AA.40): overfired CCJ sherds found on surface (MNSE/82/636).*
Middle
Fig. 6 *Moenjodaro, Moneer South-East Area (AA.40): overfired CCJ fragment, bearing on the outer coating of the base the circular imprint of a terracotta bangle (MNSE/82/638).*

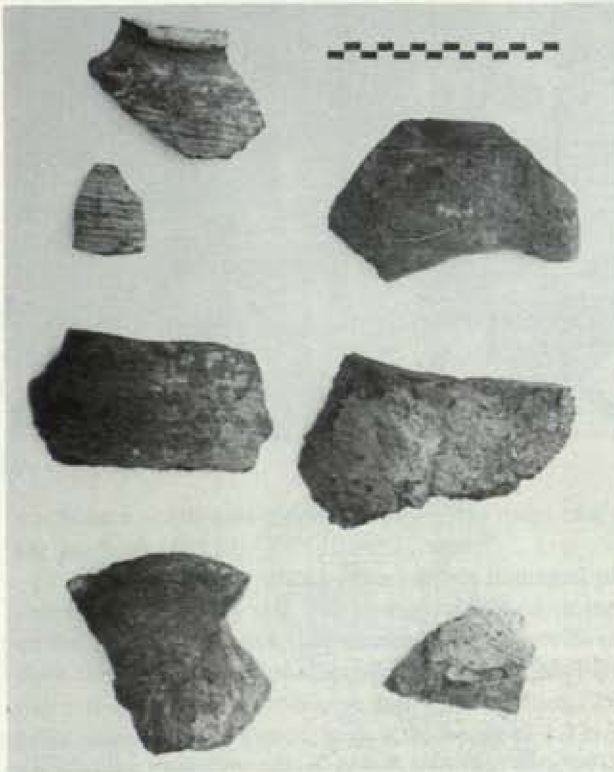


Fig. 7 *Moenjodaro, Moneer South-East Area (AA.40): side view of an overfired CCJ base fragment, bearing two superimposed terracotta bangles on which the vessel was suspended. The lower bangle retains particles of overfired clay possibly belonging to the outer coating of a second CCJ (MNSE/82/641).*

Fig. 8 *Distribution of coated containers on the surface of Moenjodaro, after the '83 SEP campaign: 1, primary concentrations of Coated Carinated Jars (CCJ); 2, isolated finds of CCJ sherds; 3, primary concentrations of Coated Sub-cylindrical Bowls (CSB); 4, isolated CSB finds.*

Fig. 9 *Moenjodaro, Moneer South-East Area (AA.40): the first complete CCJ specimens emerging from the slope surface at the moment of the discovery.*

Fig. 10 *Moenjodaro, Moneer South-East Area (AA.40): the first complete CCJ specimens after the removal by vacuum cleaner of the topmost eolian formations.*

The identification of large amounts of this very specialized pottery type in close association with macroscopic indicators of kiln-firing led us to a preliminary survey of the adjacent areas, subsequently extended to the surface of the whole site. As a final result, we were able to ascertain that only three sites presented assemblages of kiln wasters substantial enough to suggest the presence of primary firing activities (AA. 17, 28, 40: *see Fig. 8)*, meanwhile isolated finds were distributed in different sections of the town. The three primary areas cluster in the south-eastern corner of the so-called „lower town". No CCJ sherd, to date, has been recorded from the surface of the peripheral mounds.

The attention paid to this admittedly rather unattractive pottery was fully rewarded when, during normal survey activity in Moneer South-East, just under the branches of a bush, five complete containers were found emerging from the surface, clearly belonging to the same type identified in the heaps of kiln wasters. *(Fig. 9)*

The jars were found in the southern section of AA. 40, inside the zone selected for our SEP test, at the point marked by the 2852 (Long) and the 1236 (Lat.) coordinates of the RWTH grid system.

Here one of the larger erosion valleys of Moneer South-East, running in a W-E direction, cuts the archaeological deposits, forming to the south a slope with an average gradient of 35°. At this point, as well as in large sections of the whole site, the surface is formed by the soft layer of eolic sediment originating from redeposited fractions of fired bricks and other ceramic materials. This layer is covered by an uneven crust of salt (or halocement) 2-5 mm. thick.

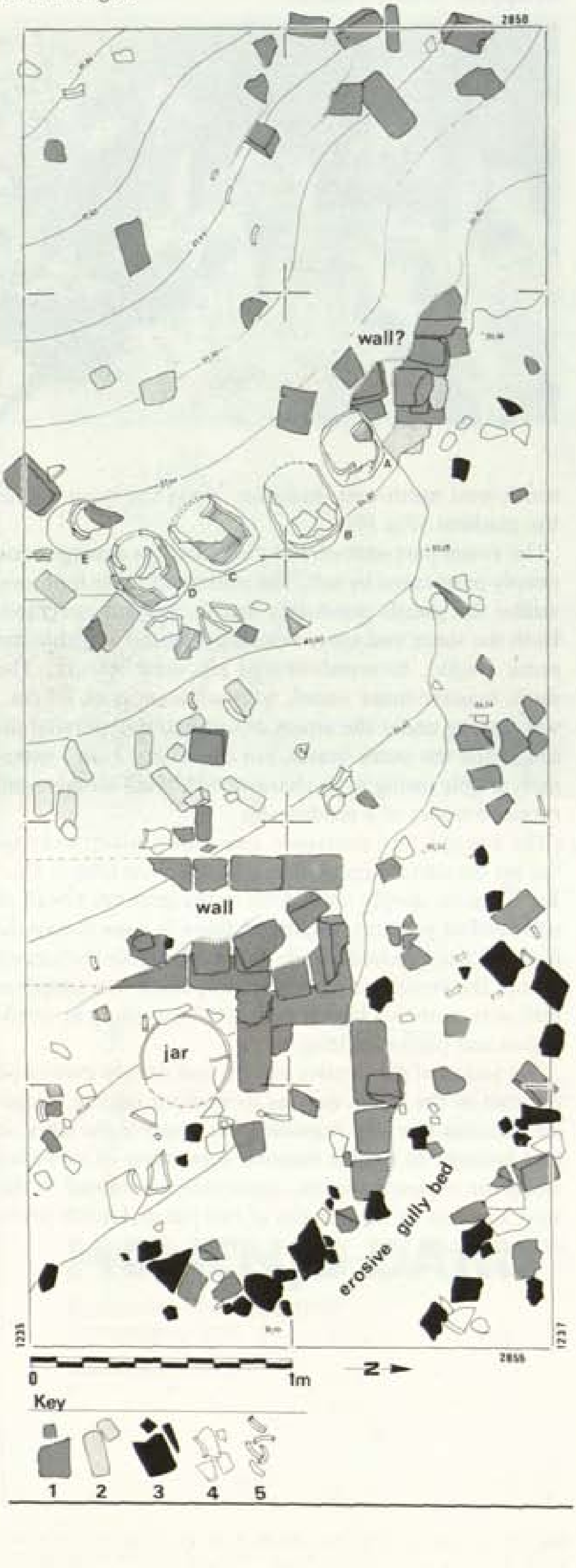
The first four containers (labelled A-D in a clock-wise direction) emerged from this surface covering about 1/3 - 1/2 of their volume. Lying in a crescent-shaped row, some 5-10 cm. apart, they appeared to be sliding in a south-west north-east direction, along the main axis of the gradient. *(Fig. 10)*

The vessel part uncovered by erosion was damaged and deeply permeated by salt. The pottery of these four jars, unlike the sherds previously found, was not overfired. Both the inner and outer vessels presented a lighter and more fragile, brownish-orange coloured texture. The more massive inner vessel, with a thickness of 2-3 cm., was flaking under the attack of salt into thin parallel slices, while the outer vessel, not exceeding 2 cm., extremely fragile owing to its characteristic chaff temper, still retained traces of a reddish slip.

The rim of a fifth container, apparently intact, was visible on the surface immediately to the West *(Fig. 9, E)*. Jar E, more deeply embedded in the ground, rested in sub-vertical position, slightly inclined in a north-east direction. The exposed rim showed that, unlike the former group, the vessel had undergone exposure to a temperature very probably higher than 1000°, resulting in vitrification and partial melting.

The action of the erosive stream had deeply excavated the foot of the slope, carving its contour into an irregular, sinuous line. By removing the upper eolic layer, it had brought to light a massive deposition of silty clay along the exposed section, apparently contained to the west and east by the remains of two parallel north-south oriented walls.

Fig. 11 *Moenjodaro, Moneer South-East Area (AA.40): map of the area cleaned by vacuum cleaner. Note the position of jar A, resting against the possible western wall, and, at east, the badly preserved remains of a corner, with a jar in situ (see also Fig. 12). The bed of the gully, at north, cuts the structures depositing overfired kiln wasters captured from the upper sectors of the slope. 1, bricks and fragments; 2, mudbricks and fragments; 3, overfired bricks and fragments, kiln wasters; 4, potsherds; 5, terracotta bangles.*



The Rescue Operation

Promptly reported to the Moenjodaro Conservator, Miss S.S. Begum, the discovery was considered with interest by the Director General of Archaeology and Museums, Mr. M. Ishtiaq Khan, who decided to effect a small-scale rescue operation. M.A. Halim, of the Excavation and Exploration Branch, the senior author of this report, was appointed to direct the work; the second writer was very kindly invited to cooperate.

In order to gain more information on the deposition context of the jars, as well as on their relationships to the visible structures, we used a vacuum cleaner to strip the area lying between the 2850:2855 (Long.) and the 1235:1237 (Lat.) coordinates (*Fig.11*).

The topmost eolic layer previously described contained the almost complete contour of jars A-D, for which it was possible to confirm the hypothesis of a secondary context of deposition. Acting like a miniature dam, the row of vessels had retained a fan of silty clay on the upper slope with traces of water trickles, bearing a scatter of fired and unfired brick fragments. A similar sediment, strongly affected by weathering, with fragments of bricks and other remains embedded in an uneven silty matrix, was brought to light in the lower part of the slope. These altered surfaces appear to have been created by the same erosional processes that had shifted the containers downhill away from the primary place of deposition. On the other hand, given the good state of conservation of the vessels and their regular arrangement, their primary place of deposition should have been very close.

Along the eastern side of the gradient the silty layer turned out to cover the poorly preserved remains of a north-south oriented wall of fired bricks, of which only two courses survived. The wall was associated with an eroded floor, retaining the lower half of a jar in situ (*Fig. 12*).

Container A was resting directly against the western structure *(Fig. 13)*. As seen from the section exposed by the gully, the structure appeared to be part of a wall or a platform constructed with irregularly alternating courses of mud bricks and fired bricks, part of which were disconnected or already collapsed.

To remove jars B, C, D we deepened the excavation into a strip of 2 m. Under the weathered layer, no more than 5 cm. deep, we met the head of the massive silty deposition seen in section. It was a very compact and thick deposit of the well-known light gray silty clay produced by the decay of mud brick structures. On the surface of the layer complete and fragmentary fired bricks were visible, as well as the bright outline of several sections of mud bricks. Both types were chaotically arranged *(Fig. 14)*. With the base embedded in this collapsed layer, B,C,D, rested directly on the scattered bricks.

At the base of the vessels and bricks the depositional level was marked only by a slight increase in the consistency of the silty sediment and by a discontinuous horizon of calcium carbonate. This surface was more evident in the southern extension of the trench, less affected by erosion. We found no clear trace of a structural floor.

To unearth jar E we had to enlarge and to further deepen the excavation, down to a maximum of 40 cm. In the course of this operation, we discovered jar F, which led to jars G and H. Jar I, at this point was left in place as it ran no immediate danger of damage. Altogether, out of the 8 jars, only E and F turned out to be overfired *(Fig. 15)*.

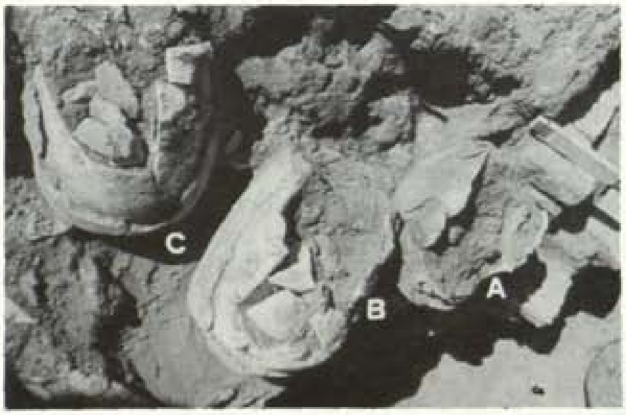
Containers E, F, G, H formed a second, distinct group with its own depositional features. All around this group the context of the collapse was almost unaffected by erosion. It was possible to observe clearly how the containers had suddenly been knocked down and sealed by the collapse of a wall constructed with fired and unfired bricks, originating from south-west, most probably from the western wall itself.

The inclination of jars E and G followed the direction of the collapse, while F and G were diagonally opposed, inclined according to a north-west/south-east axis. Jars E, F, G suffered no damage in the collapse. Container H, on the contrary, already being cracked, had been crushed by a brick, and had to be reconstructed in laboratory *(Fig. 17)*.

A remarkable feature of the collapse was noted in the southern extension of the trench. It was seen that the heap of fallen bricks had protected from erosion the traces of a very distinctive sediment characterized by a high degree of anthropic re-elaboration. The matrix of the sediment was very uneven, mainly due to the presence of irregular lumps and particles of silt and clay in various stages of alteration, not sorted by gravity or water. This formation, sealed by the collapse may be related to the features of the contemporary surface. Some lenses genetically related to this sediment have been recognized in the internal filling of jars D, G, H.

All around container G, the described sediment embedded a downpour of fragmentary terracotta bangles, particularly concentrated around the mouth, which was hermetically sealed by a crushed mud brick *(Figs. 16, 17)*.

Upper
Fig. 12 *Moenjodaro, Moneer South-East Area (AA.40): view of the cleaned area from east, showing in the foreground the eroded remains of a brick-constructed room (cf. Fig. 11) and the row of the CCJ.*
Middle
Fig. 13 *Moenjodaro, Moneer South-East Area (AA.40): particular of jars A, B, C, during the rescue excavation; jar A rests directly against the bricks.*



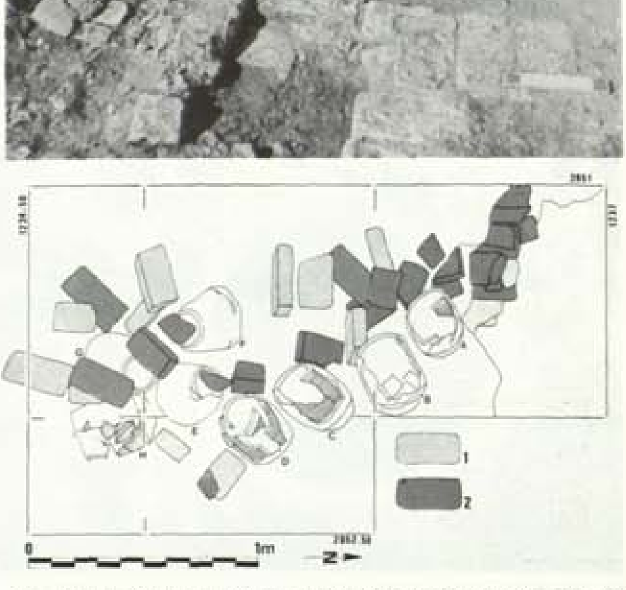


Fig. 14 *Moenjodaro, Moneer South-East Area (AA.40): position of the 8 CCJ in the bricks' collapse. 1, mudbricks; 2, fired bricks.*

Several other fragments of terracotta bangles were recovered in the small trench. Fragmentary specimens of a second typical Harappan artifact, the so-called „terracotta cake", were recovered in close proximity to jar G. Jar H lay on the top of a crushed round terracotta cake (*Fig. 18*). Other specimens of the same artif..ct, again fragmentary, were found in other points of the trench (*Fig. 19*).

Fig. 15 *Moenjodaro, Moneer South-East Area (AA.40): jars C, D, E, F, G, H, during the rescue operation.*

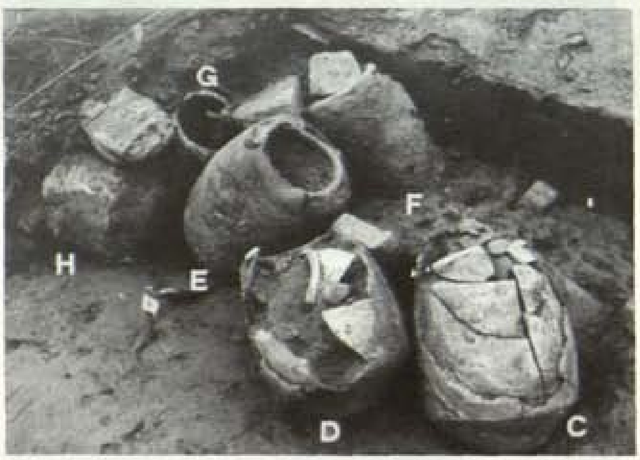


Fig. 16 *Moenjo Daro, Moneer South-East Area (AA.40): close view of jar G, with the mouth surrounded by a collapse of terracotta bangles fragments.*

Fig. 17 *Moenjodaro, Moneer South-East Area (AA.40): jars G and H at the end of the rescue excavation, before removal.*

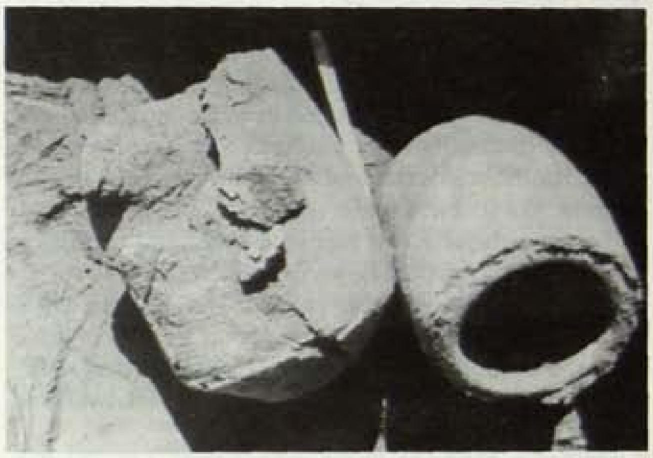
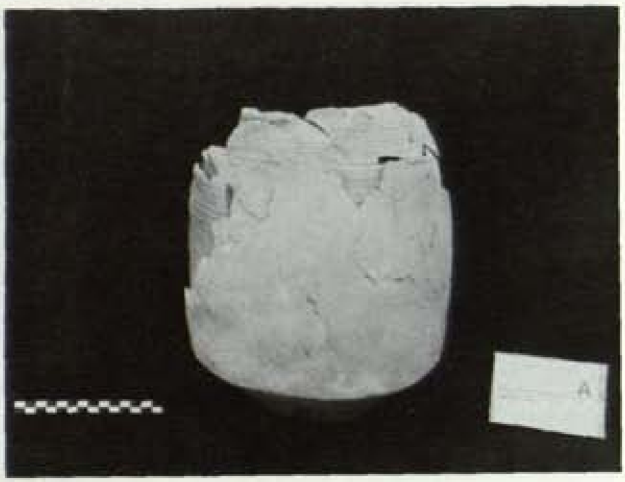


Fig. 18 *Moenjodaro, Moneer South-East Area (AA.40): particular of jar H, lying over a crushed round „terracotta cake".*

Fig. 19 *Moenjodaro, Moneer South-East Area (AA.40): fragments of round and triangular „terracotta cakes" recovered in the rescue trench (MNSE/82/615, 614, 626, 612, 621, 613, 632).*

Fig. 20 *Moenjodaro, Moneer South-East Area (AA.40): Jar A (MNSE/82/593).*



Excavation of the Internal Filling

After removal, the 8 jars *(Figs. 20-27, 28-35)* were taken to the project laboratory to be internally excavated[3)] and to undergo preliminary restoration. The 6 non-overfired specimens turned out to be so deeply permeated by salt that we decided to clean them in dry conditions, carefully scraping the clay, flake by flake, with a pointed wooden stick. It was thus possible to avoid damage produced by the efflorescence of salt crystals.

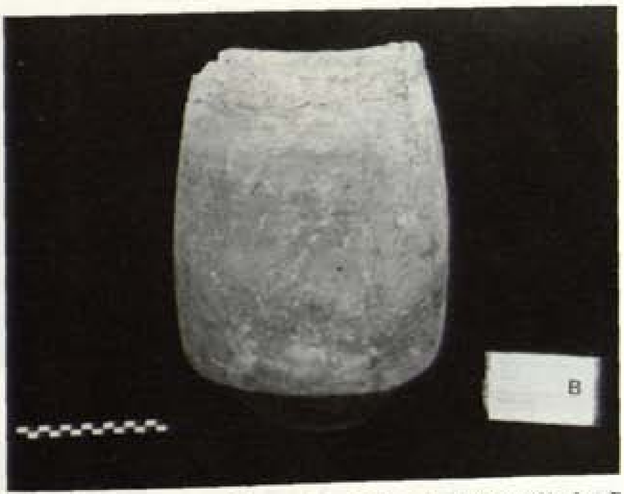
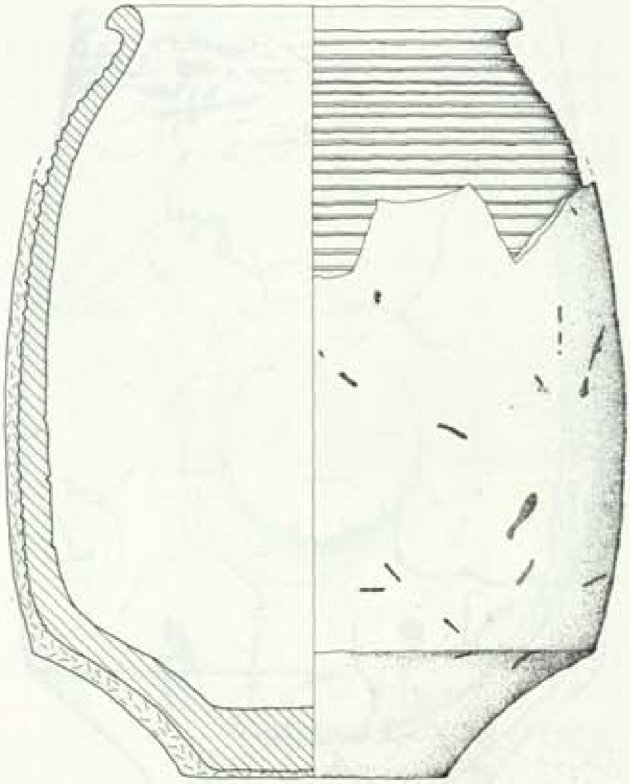


Fig. 21 *Moenjodaro, Moneer South-East Area (AA.40): Jar B (MNSE/82/594).*

Fig. 28 *Moenjodaro, Moneer South-East Area (AA.40): Jar A (MNSE/82/593).*



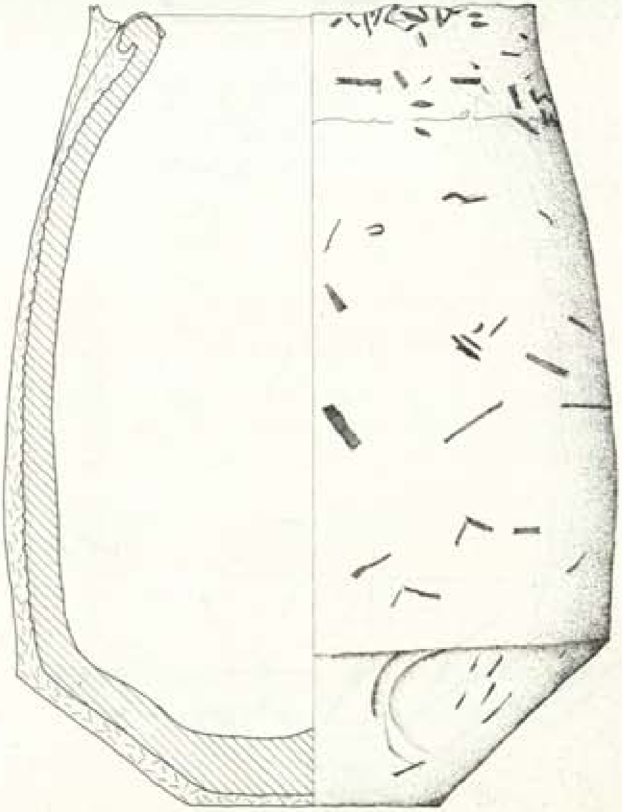


Fig. 29 *Moenjodaro, Moneer South-East Area (AA.40): Jar B. Note the concave impression on the outer coating, over the rim, and the bangle impression on the lower section (MNSE/82/594).*

Fig. 30 *Moenjodaro, Moneer South-East Area (AA.40): Jar C. Note the double bangle impression on the lower section (MNSE/82/595).*

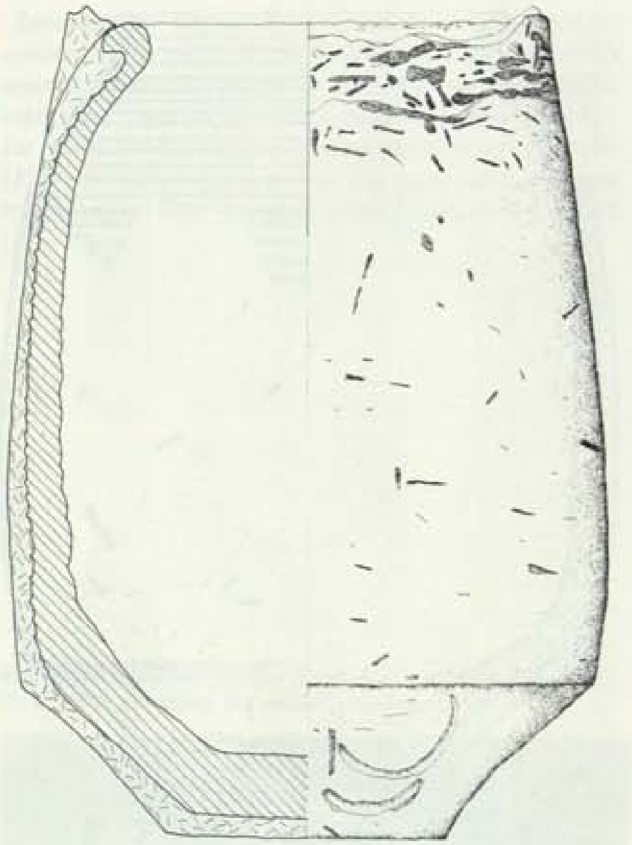


Fig. 22 *Moenjodaro, Moneer South-East Area (AA.40): Jar C (MNSE/82/595).*

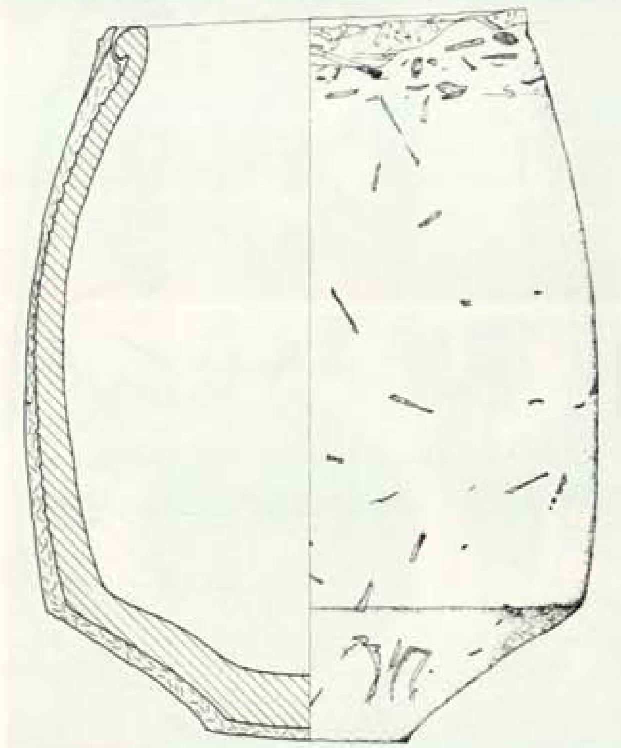
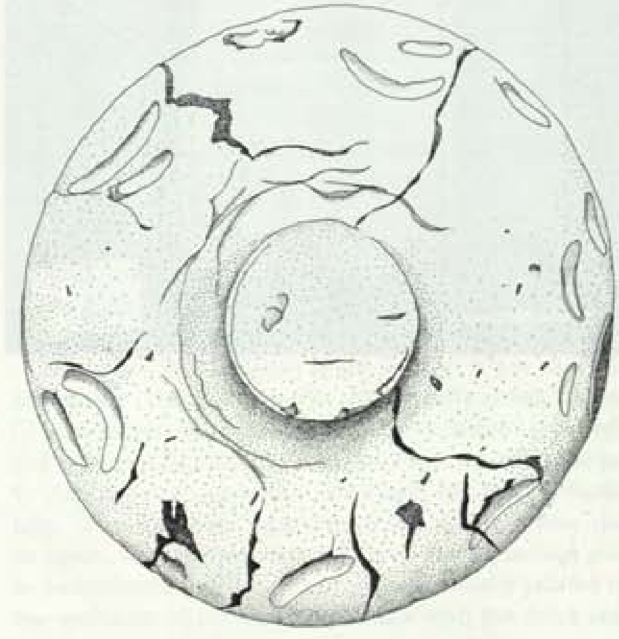
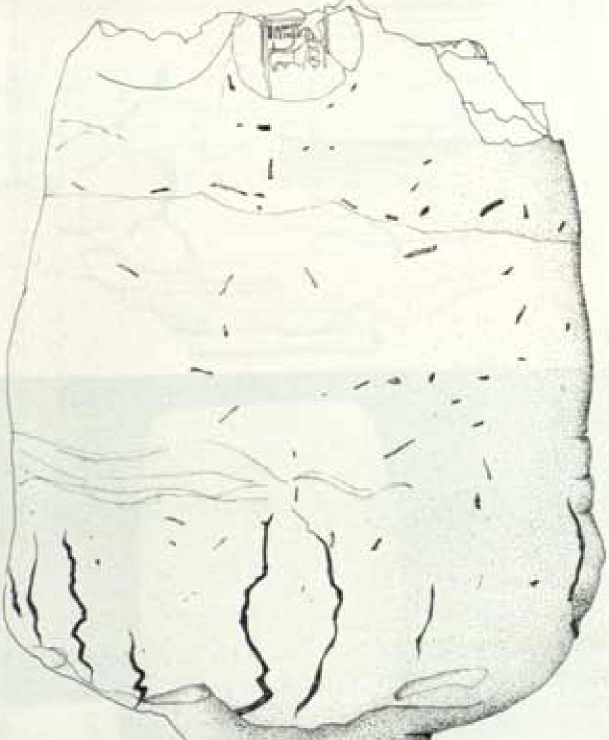


Fig. 23 *Moenjodaro, Moneer South-East Area (AA.40): Jar D (MNSE/82/596).*

Fig. 31 *Moenjodaro, Moneer South-East Area (AA.40): Jar D (MNSE/82/596).*

Fig. 24 *Moenjodaro, Moneer South-East Area (AA.40): Jar E (MNSE/82/597).*





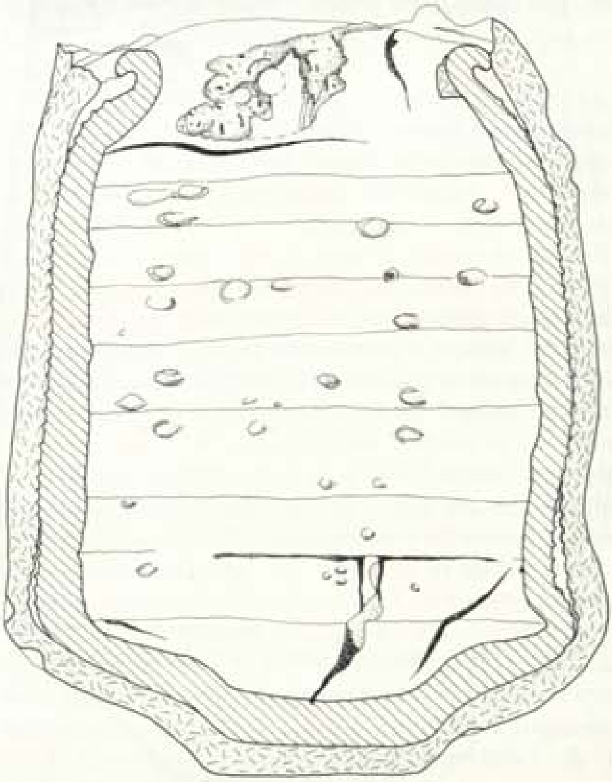


Fig. 32 *Moenjodaro, Moneer South-East Area (AA.40): Jar E, 32, a: frontal view, 32, b: section. Note internal cracks and bubbles; remains of the supporting cones are visible under the mouth. 32, c: lower section, with imprints of terracotta bangles (MNSE/82/597).*

Fig. 33 *Moenjodaro, Moneer South-East Area (AA.40): Jar F. 33, a: note cracks and bubbles, the twisted mouth and the sealing remains. The jar was suspended over two overfired terracotta bangles. 33, b: lower section: note the two central complete bangles and the radial bangle imprints (MNSE/82/598).* ▷

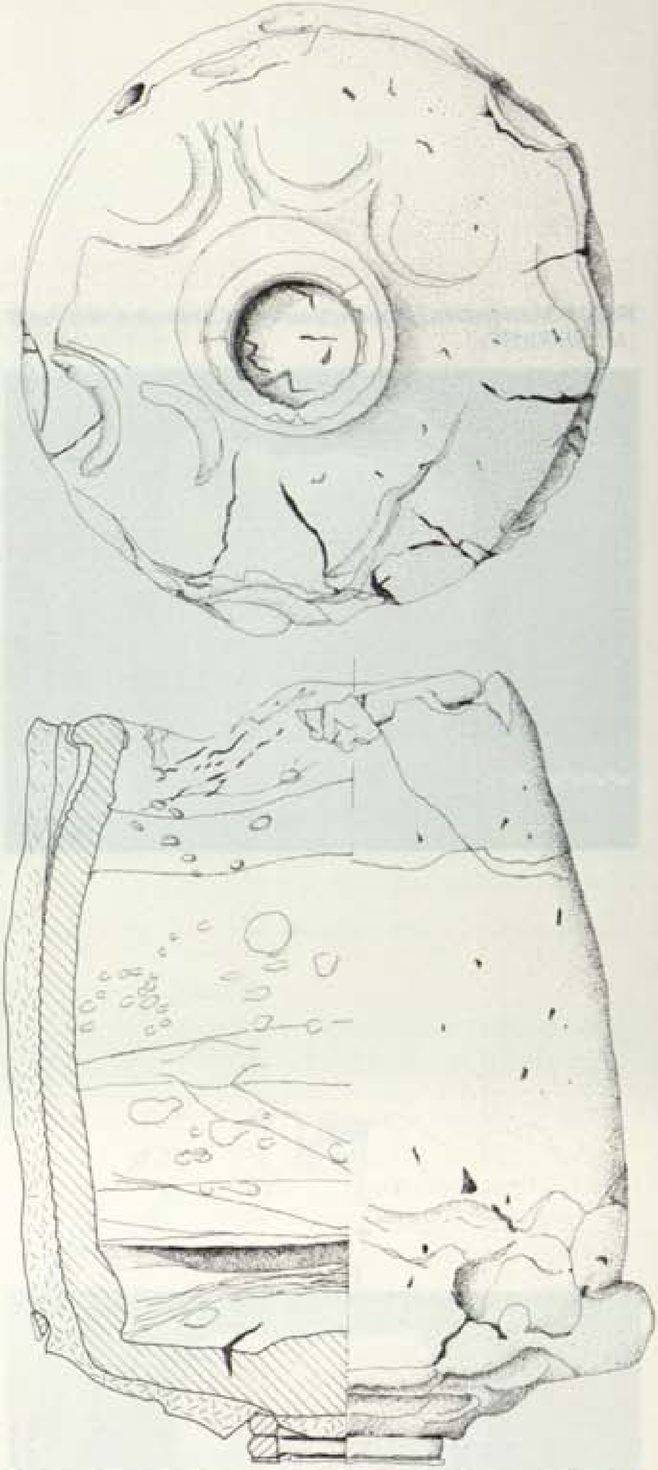


Fig. 25 *Moenjodaro, Moneer South-East Area (AA.40): Jar F (MNSE/82/598).*

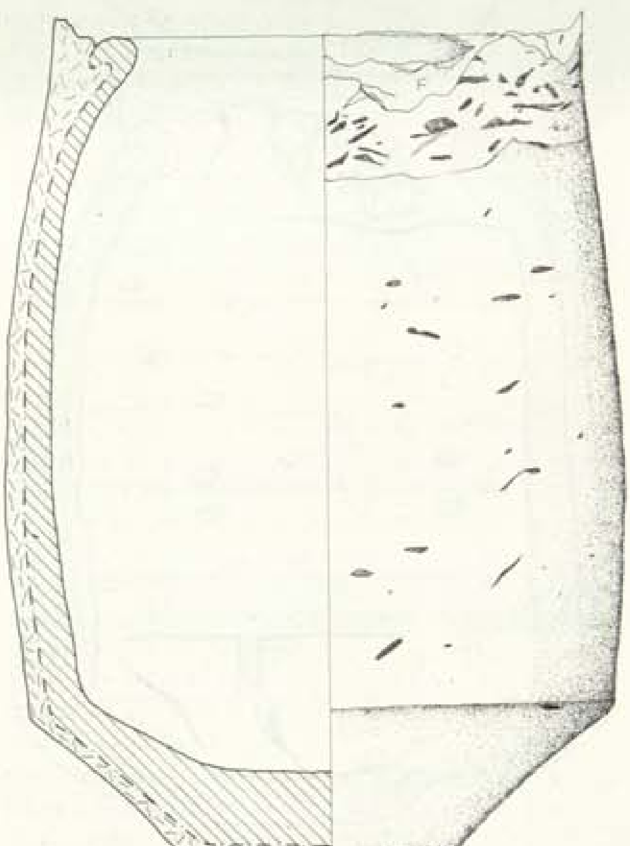


Fig. 34 *Moenjodaro, Moneer South-East Area (AA.40): Jar G (MNSE/82/599).*

Fig. 26 *Moenjodaro, Moneer South-East Area (AA.40): Jar G (MNSE/82/599).*

Fig. 27 *Moenjodaro, Moneer South-East Area (AA.40): Jar H (MNSE/82/600).*

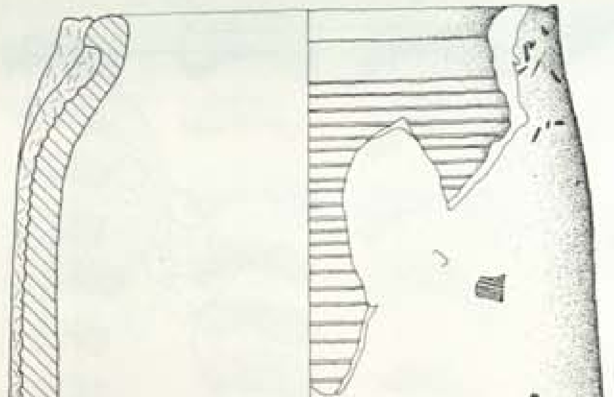


Fig. 35 *Moenjodaro, Moneer South-East Area (AA.40): jar H (MNSE/82/600).*

The first elements to fall inside jar C (*Fig. 36*) were large fragments of broken mud bricks △ associated with an intrusive sherd △ . Subsequently, the vessel was slowly filled with a sequence of micro-layers [illegible] ③ , a series of silty-clayish lenses with variable texture and ceramic micro-inclusions with a maximum diameter of 5 mm. The dynamics of the filling seems to indicate that at the time of the collapse which deposited the mud brick fragments, jar C was already lying at an inclination of 45°. Subsequently, the inclination of the axis of deposition slowly rose to 75°, reflecting the ongoing shifting of the vessel along the slope. Layer ② , with matrix partially affected by eolic phenomena, anticipates the formation of the upper episode ① , a dark-coloured, strongly oxidized lens produced by surface erosional processes.

The section of the filling of jar D (*Fig. 37*) is partially analogous. The first deposits are two silty lenses ⑤ and ④ , the latter carrying down fragments of fired and unfired bricks △ △ , corresponding to those found inside jar C. At that time, apparently, the vessel was lying horizontally. The following episodes of the filling show, once again, the progressive shifting of the deposition axis to an inclination of 75°. Lens ③ is genetically related to the sediment in primary connection with the brick collapse; it deposited in the vessel about 10 fragments of unbaked and deformed terracotta bangles, △ , only slightly affected by fire in oxidizing atmosphere *(Fig. 38)*. Layers [illegible] ② ① form a sequence parallel to the one encountered in jar C (*Fig. 36*: [illegible] ①).

Quite different are the filling dynamics of jar G *(Fig. 39)*. When we removed the brick crushed on the mouth we saw that the brick had formed an airtight seal, preventing any kind of secondary infiltration. The vessel had been half filled by a deposit which, free from later contaminations, may be deemed as relative to the sediment found among the bricks and inside jar D *(Fig. 37:* ③ *)*. The collapse had hit the standing vessel from the south-west, pushing and shifting it onward, while its base worked as a fulcrum. The strength of the push completely reversed the inclination of the internal deposit, which consisted of a considerable number of the same fragmentary bangles which were found around the jar in the context of the collapse(△ ; *Figs. 16, 40)*. On the whole, no less than 83 fragments were recovered in association with jar G *(Fig. 41)*. Although we had no time to attempt systematic restoration work, it was our impression that the fragments belonged to different specimens not broken in situ. As in the preceding cases, the heaviest elements of the filling were recovered in direct contact with the base of the jar: some mud brick fragments (△), a shapeless lump of partially fired clay (△), and a fragment of terracotta cake (△).

Fig. 36 *Moenjodaro, Moneer South-East Area (AA.40): section of the internal filling of jar C.*

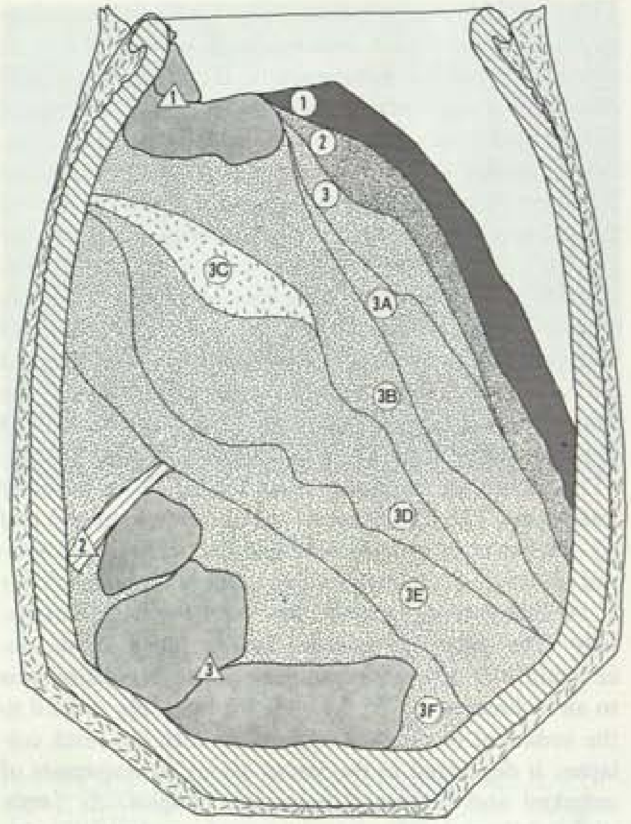


Fig. 37 *Moenjodaro, Moneer South-East Area (AA.40): section of the internal filling of jar D.*

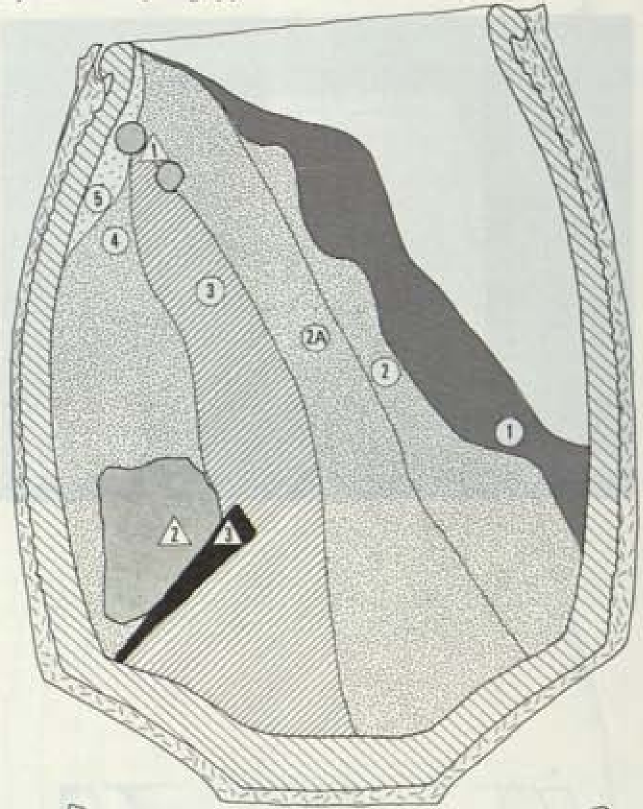


Fig. 38 *Moenjodaro, Moneer South-East Area (AA.40): fragments of unbaked clay bangles recovered in the filling of jar D (feature △). (MD82/607).*

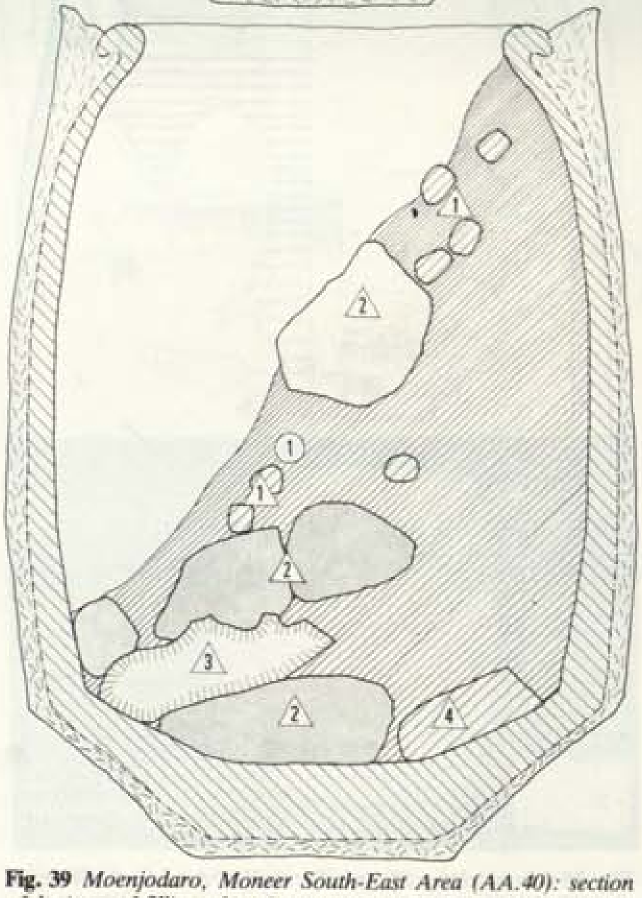


Fig. 39 *Moenjodaro, Moneer South-East Area (AA.40): section of the internal filling of jar G.*

Fig. 40 *Moenjodaro, Moneer South-East Area (AA.40): fragmentary terracotta bangles in the filling of the jar G during the internal excavation (MNSE/82/614).*

Fig. 41 *Moenjodaro, Moneer South-East Area (AA.40): group of fragmentary terracotta bangles recovered in association with jar G (MNSE/82/613,614).*

Jar H laid in a horizontal position, unaffected by erosion and displacement. Its cross-section recorded in great detail the sedimentological evolution of the slope and it is worth a more detailed description *(Figs. 42, 43)*.

LAYER ① Brownish-reddish lens, very soft, with eolic matrix, containing disintegrated remains of pottery, large percentages of powdered and redeposited fired bricks, small particles of charcoal. It cuts all the underlying episodes with an erosive limit.
LAYERS ② (2A) Formed by a thick deposition of silty clay particles originating from decayed crumbled mud bricks, redeposited by gravity. These layers contain a large percentage of eolic material, analogous to the one present in ① Layer (2A), in particular, contains fragments of fired bricks with diameters of up to 1 cm., and particles of clay of different colours in various stages of alteration.
FEATURE △ Some mud brick fragments penetrating (2A) with strength and subsequently eroded by ①.
LAYER (2B) Contact surface between feature △ and layer (2A), altered by pressure and subsequent contamination.
LAYERS ③ (3A) Two superimposed lenses of a deposit genetically related to ② – (2A) but more homogeneous in texture, due to water action selecting and re-depositing micro-stratified lenses of light-coloured silt. Such deposits have, as internal limits, a series of thin brownish levels, probably attesting periods of stasis in the sedimentation underlined by eolic surface alteration. The silty lenses become more and more evident in correspondence with the basal limit of layer (3A)
LAYER ④ A homogeneous layer of light-coloured silt which can be considered the basal episode of the sequence ③ – (3A).
LAYER ⑤ Brownish layer of silty-clayish matrix strongly affected by eolic alteration, which, in the described dynamics of alternate depositions of eolic/ silty episodes corresponds to ④.
LAYERS ⑥ (6A) Two other very pure, homogeneous layers of light-coloured silty clay deposited by water.
FEATURE △ Fragments of jar H, fallen over the surface of ⑦ at the moment of the breaking of the vessel, most probably as a consequence of the wall collapse.
FEATURE △ Two superimposed fragments of overfired terracotta bangles melted at the point of contact, embedded in layer ⑦.
LAYERS ⑦ (7A) Uneven depositions with sandy-silty matrix, strongly re-elaborated containing small lumps of silt and clay with different degrees of exposure to fire, bits of charcoal, fragments of bones. They are related to the sediment in sub-primary context among the collapsed bricks, as well as to the corresponding layers of the fillings of jars D and G *(Fig. 37: ③ ; Fig. 39: ①)*.

The vessel, lying horizontally and affected by strong internal cracking, was partially filled by ⑦ and (7A). At a later stage, the jar was hit from above by a brick of the collapsing wall and broken. The collapse marked the end of the depositions with strong anthropic re-elaboration and the beginning of the series (6A) – ④. This sequence is characterized by alternate depositions of silt originating from mud brick weathering and of eolic micro-layers forming on the exposed surfaces in phases of stasis. These alternating trends, which are very pronounced in the first episodes (6A) - ⑥, ⑤, ④, are less evident in the sequence (3A) – ③, and come to an end in layers (2A) – ②. These latter episodes document the stabilization of the slope, with the formation of the surface now visible in the area.

The other containers presented conditions of internal filling closely resembling the one we have described, with an absolute prevalence of series of silty lenses: Jar E was the only one to retain the surviving evidence of an internal deposition which can be considered a primary one. After the removal of a thick series of silty layers, we identified an anomalous layer, no thicker than 2 cm., of a dust-like, brownish-greenish material, resting just on the bottom of the vessel. This layer, permeating the large cracks in the base of the overfired vessel *(Fig. 44)*, had been sealed and protected by some ceramic fragments belonging to the system of closure of the mouth. These topics shall be discussed in detail in the following sections.

At this point, let us try to correlate the two different sources of information on the setting of the containers (the external context of deposition and the internal context of filling) and attempt an interpretation.

The containers laid in a row over a sub-horizontal floor, inside a room or within an open space bounded by structures. This irregular floor was immediately adjacent to a wall made of fired and unfired bricks situated to the south-west. The arrangement of the containers in the row was rather irregular. Some of the jars were in vertical or subvertical position (E, F, G), while others were overturned, laid horizontally (D, H) or were inclined (C).

The original arrangement of the vessels was clearly intentional. It is interesting to note that the majority of the jars were already damaged before the collapse, either by significant internal cracking, or by overfiring: they could well have been displaced and re-arranged in anticipation of some kind of re-use.

The episodes of internal filling are equally rather variable, and cannot be directly connected with the main collapse phase (see *Fig. 45*). While jar E retained an internal primary deposition, the other reversed or inclined containers had already been partially filled when the bricks fell down. The collapse, although sudden, and, to judge from the small trench, rather massive, knocked down the vessels without destroying them.

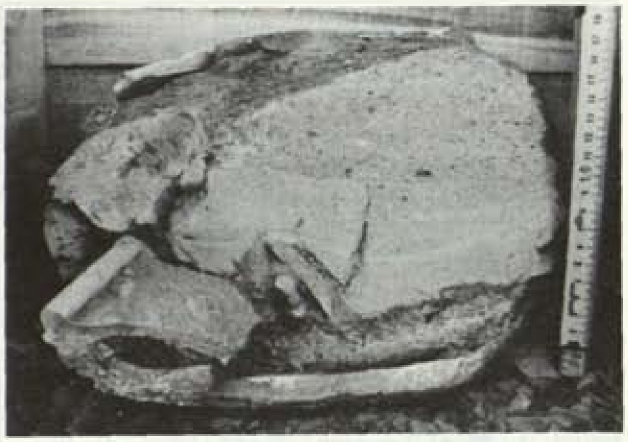
The sediment in sub-primary context within the collapsed bricks and the jars gives us an idea of the main features of the surface surrounding the jars at the moment of the collapse. Strongly re-elaborated by human activity, rich in clay and ceramic particles exposed to fire, this sediment was associated with the impressive concentration of terracotta bangles of jar G, to the fall of unbaked specimens of the same artifact recovered in the filling of jar D, as well as with the scattered terracotta cakes.

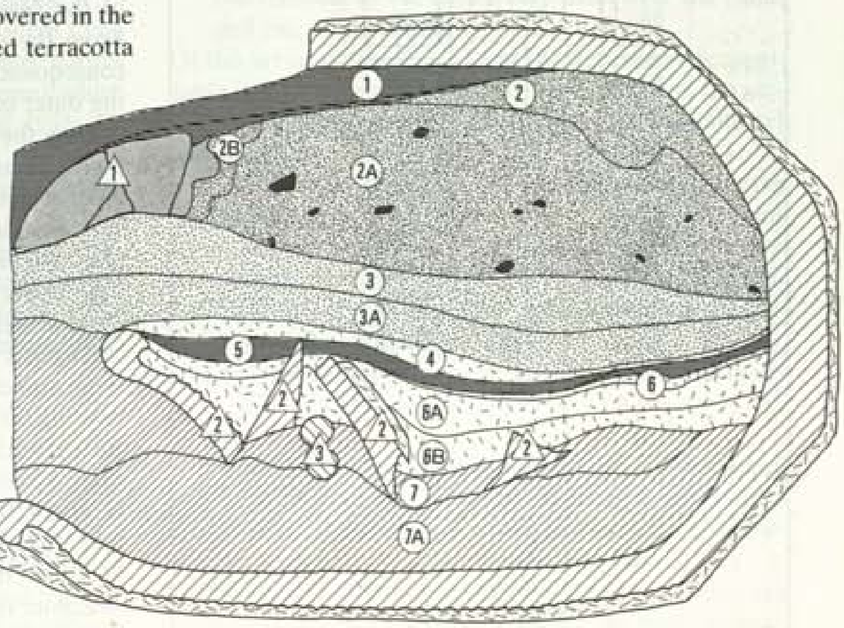
On the whole, this evidence suggests the presence of a surface strongly affected by intensive pyro-technological processes in which the firing of clayish mixtures played a major role, and the making, utilization and breaking of terracotta bangles, and, perhaps, of terracotta cakes had a specific functional meaning. Such observations fit in very well with the available surface evidence.

After the collapse of the wall (possibly indicating the abandonment of the area?) erosion started to excavate the new deposits. The northern group of jars (A, B, C, D) started to move, slowly shifting the axis of deposition. Slope erosion took place mainly by weathering, with periods of stasis marked by eolic activity. The evolution of a surface covering more closely resembling the one nowadays active on the slope, coincided with the extinction of the sedimentological variability at this point of the site.

Fig. 42 *Moenjodaro, Moneer South-East Area (AA.40): section of the internal filling of jar H.*

Fig. 43 *Moenjodaro, Moneer South-East Area (AA.40): section of the internal filling of jar H.*





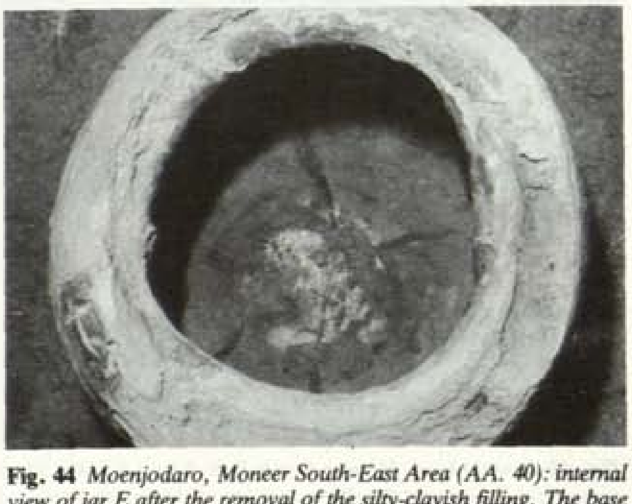


Fig. 44 *Moenjodaro, Moneer South-East Area (AA. 40): internal view of jar E after the removal of the silty-clayish filling. The base of the vessel and the large cracks retain a micro-layer of a brownish-greenish dust-like material apparently in primary context of deposition (MNSE/82/610).*

Fig. 45 *Diagram of stratigraphic units encountered in the internal excavation of the 4 CCJ.*

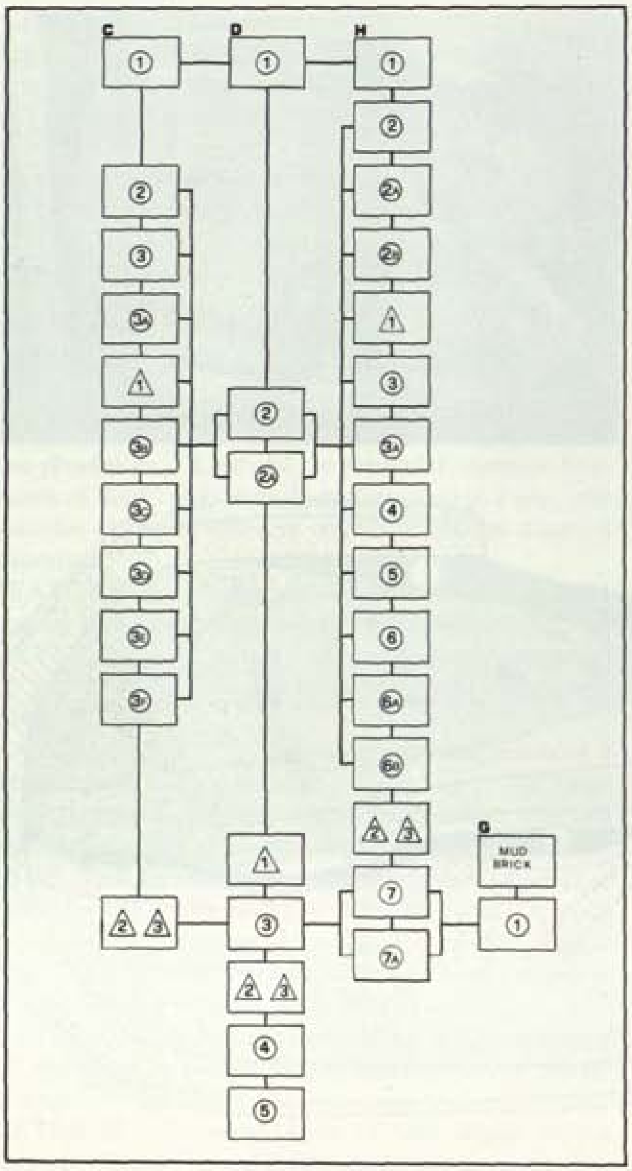


Fig. 46 *Moenjodaro, Moneer South-East Area (AA.40): close view of jar F, showing the strong twisting of the mouth produced in overfiring conditions (MNSE/82/598).*

Morphology

Out of the 8 containers recovered (*Figs. 20-27, 28-35*), 6 (A, B, C, D, G, H) were well enough preserved to yield substantial information on the morphological features of this ceramic type. In the other two cases the contours of the vessels had been deeply altered by overfiring. From the morphological point of view, E and F, as a consequence of the expansion and partial detachment of the outer coating, had lost their original sharp contour, shifting the maximum width to the height of the corner point, assuming a heavy, roughly pear-shaped profile. Furthermore, jar F during firing underwent strong pressure from above, resulting in the twisting of the mouth (*Fig. 46*) and in a noticeable shift of its central axis: in Fig. 33 the phase-displacement between the inner and outer vessel is visible.

Analysis of the other 6 specimens allows us to define some aspects of the internal variability of the type. Considering the contour of the two sections of the body (the sub-cylindrical upper section, and the truncated-cone shaped lower section) we may observe that jars A and D (*Figs. 28,31*) present a base with a slightly concave contour, supporting a slightly convex upper part. On the other hand, the bases of B, G, H, (*Figs. 29, 34, 35*) have a straighter trapezoidal contour and a more clearly cylindrical upper section. Container C can be placed somewhere in between the two groups (*Fig. 30*). The described differences in contour do not seem to be a function of the dimensional variability. Tab. 1 shows that the most variable dimensions are respectively the diameter at the corner point and the total height. Very homogeneous, on the contrary, are the mouth diameter and the height of the lower section, with only 1-2 cm. difference between the widest and the narrowest values.

Jars C and D (and, possibly E), share an everted rim whose downward-oriented central axis forms an angle of 45° with the tangential plane of the mouth. In all the other vessels, the same angle is close to 30°.

Lastly, it may be observed that jar D, with a strong inclination of the mouth plane and the consequent asymmetrical arrangement of the central axis, differs from all the other vessels.

Tab. 1: *Dimensional variability in the 8 recovered CCJ. Jars E and F are deformed by overfiring. Thickness values refer to inner vessel.*

	A	B	C	D	E	F	G	H
Height (total)	32.9	34.9	35.0	32.6	33.7	33.3	31.9	33.2
Height (lower section)	5.4	5.8	6.6	6.0	7.4	6.0	5.9	6.0
Mouth ∅	14.6	13.6	13.6	14.6	13.2	14.0	14.4	14.0
Maximum ∅	26.4	26.0	27.6	26.0	28.0	27.5	24.1	23.8
Corner point ∅	24.0	24.8	26.7	24.5	28.0	27.5	22.8	22.2
Base ∅	11.4	12.0	11.3	9.0	9.7	11.0	10.2	9.5
Wall thickness	1.3	1.5	1.5	1.3	2.0	1.8	–	1.5
Base thickness	2.7	2.7	2.6	2.4	2.0	4.0	–	2.5

On the whole, in defining the CCJ as a type, we can say that the attributes which, in our assemblage, express the morphological variability, do not cluster to form the abstract entities canonically defined as „sub-types".

Cylindrical medium or large-sized shapes seem to be rather uncommon at Moenjodaro . In the whole corpus published by Mackay there is only one vessel which could be deemed similar to CCJ (*Marshall 1931: Pl. LXXXII,12*). Mackay, classifying it under the group „Miscellaneous shapes", gives the following description:

„This jar is most unusual. It is a large vessel, whose inner surface is heavily finger grooved and outer surface very rough. The curiously abrupt slope away on the base should be noted (...). It is coated with a cream slip". (1931: 306)

The cylindrical body of CCJ may be compared with a single specimen recovered in the DK-G excavations (*Mackay 1938: Pl. LXI, 37*). Equally rare appear to be all the vessels with external groovings (*Marshall 1931: 309; Pl. LXXXIII*, Type Y, 1, 2; Type AA, 6-8). An important exception, the so-called „scored pottery": the small goblets with a pointed base and a grooved band on the shoulder, the most common ceramic type on the surface of the site. Similar is the picture available from the Harappa report (*Vats 1940: 279*).

Manufacture of Inner and Outer Vessel

The first step in the construction of CCJ was to form the lower section by moulding it inside a reverted truncated cone-shaped chuck fixed on the wheel. This type of tool for pottery making, often defined „jar-stand" in the archaeological literature, is a characteristic artifact of the Late 3rd millennium assemblages in the Turanian basin (*Hlopina 1974; Tosi 1983: Fig. 9*). Its employment in the forming process may be detected in the product by a set of very distinctive attributes, namely:

(a) the „curiously abrupt slope away on the base" noticed by Mackay;
(b) the absence of turning and trimming traces on the external surface of the moulded section;
(c) the presence, always on the external moulded surface, of the traces left by the thin sand coating often applied to prevent the clay sticking to the chuck during the volumetric decrease in the drying phase;
(d) some irregularities in the relative wall thickness of upper and lower sections, this latter often being thicker;
(e) the presence, immediately over the sharp corner point, of a band of rough, deep groovings, left during the removal of the excess clay from over the rounded rim of the chuck.

Of this set of attributes, (a) and (b) were easily recognizable in all the jars, attribute (d) was evident in the section of the inner vessel of jar B (*Fig. 29*); attribute (e) was shared by A, B, H (*Figs. 28, 29, 35*).

To judge from the published specimens, this forming technique seems to have been used at Moenjodaro for the production of a wide range of different shapes (see for example *Marshall 1931: Pl. LXXXI, 4, 5, 12, 30; Pl. LXXXIV, 20, 23; Pl. LXXXV, 5*). Although in the jar-stand published a true truncated cone-shape is missing, it is not impossible that some specimens were actually used for a similar purpose (see *Pl. LXXXIII, Type AE, 44-60*).

It may be observed that the group of CCJ recovered had been formed very probably by using a set of different chucks, differing in contour and maximum diameter, but with fairly constant height (see *Tab. 1*).

The second step in forming the inner vessel was the construction of the upper section over the base, probably still assembled with chuck and wheel. This task was accomplished using the so-called „ring building" technique, combined with fast wheel turning. A total number of 10-12 rings were employed, resulting after firing in a series of superimposed bands with an average height of 2-3 cm. Such a pattern is revealed by the overfired specimens, whose dynamics of deformation and cracking are closely related to the weak points of the vessels' structure (*Figs. 32, 33*).

The described ring-building and throwing technique seems to be particulary suitable for the fast production of cylindrical shapes. It was used, for example, at Shahr-i Sokhta, during the second half of the 3rd millenium, for the intensive production of small ogival jars *(Tosi 1969: Fig. 115)* a very common type, close to some Moenjodaro specimens *(Marshall 1931: Pl. LXXXIII, Type Z, 3)*.

Lastly the horizontal groovings were traced on the external surface of the vessel. The tool employed was a small comb, probably made of wood, with no more than 5-6 teeth 3-4 mm large. The zone of the inner vessel affected by the treatment extended from the base carination over the whole of the available surface of the vessel, even covering the very base of the rim.

After a first drying phase, the volumetric reduction of the vessel allowed the detachment from the chuck. The subsequent step was the application of the outer coating. This task could be accomplished with the inner vessel in leather state of hardness or after a first firing, two alternative possibilities to be experimentally tested.

The very even, symmetric, structure of the coating and the absence of any trace of junction on its surface indicate that it was applied by turning. The heavy inner vessel was placed on the wheel which was used, this time, as a lathe. As the coating was always applied to the base of the inner vessel, we have to assume that during this operation it was in an upside-down position, with the mouth centered on the wheel. The coating operation started from the base and the lower section, and was then extended to the whole body of the container.

At the height of the shoulder, the coating was noticeably increased; in some cases it was found to cover the rim of the inner vessel, thus further underlining the cylindrical contour of the upper section. The conclusion of this operation was necessarily followed by a final drying phase, during which the vessel had to retain its reverted position.

The CCJ had to be reverted for the third time to proceed to the application of the slip, the third and last step in the construction of the double vessel. The internal surface of the inner vessel, the zone of the rim, the outer vessel, with the exception of a 2 cm. wide band just over the base, were coated with a thick layer of red-orange slip. On these sections of the vessel are clearly visible irregular bands of oblique streakings, crossing with alternate angles of 45^0 / 135^0, from which large vertical drops often depart which are sometimes no less than 4 mm thick. For this operation flocks of vegetal fibres were apparently employed.

In the interior of the shoulder some containers have evident finger-prints left at the end of the slipping, during the removal of the vessels.

Figs. 55 , 56 *Moenjodaro, Moneer South-East Area (AA.40): ellipsoidal sealing with impression of „unicorn" stamp seal on the mouth of jar E (MNSE/82/597).*

The Upper System of Closure.

From this point onward, the reconstruction of the technological assemblage to which CCJ belonged is based almost exclusively on the analysis of containers E and F, and of some other artifacts recovered in association with the group of jars. The overfired CCJ E and F retained a much higher degree of diagnostic evidence than the other specimens. This is partly due to the semi-fluid state of the vessels inside the kiln, which allowed the retention of precious information in the form of imprints, and partly to the greater potential of preservation of all the overfired clay elements. Furthermore, this circumstance perhaps also conforms to a general rule in the study of prehistoric technology, according to which the greater labour-force is crystallized in the wasted, unfinished product (i.e. the more ruinous the error for the artisan , the more evidence is available to the archaeologist).

Jar E, in particular, which retained, in first place, the beautiful and unexpected sealing (*Fig. 55, 56*) has perhaps been the basic source of information. It follows that our data are now comparable only to a fairly less extent, and that the whole approach shall be necessarily biased in an analogical direction, with the proposed interpretations being given a probabilistic character.

On the whole, the available evidence seems to indicate the existence of a system of mouth-closure articulated in three different parts: (a) Lid and supporting elements, (b) Intermediate chaff-tempered coating, (c) Sealings and upper capping

Lid and Supporting Elements

We were lucky enough to recover in the context of jar E all the elements necessary to outline a first hypothesis of reconstruction. These elements are:

1) The fragments of a small pottery lid, somewhat less than 1/2 the body of which was preserved (*Fig. 47, Fig. 48 c*) found inside the vessel, on the bottom, where it covered the described micro-layer of greenish material. With a slightly bell-shaped contour and a thick rounded rim, it was made of compact, sand-tempered pottery with a buff shadow, quite different from the clays employed in the making of the jars. The lid was formed by moulding, with a quick and carefree execution as though the artisan was not concerned with correcting the cracking and holes that would spread during drying. The inner surface, rougher and irregular, retains a band of parallel thin impression and other imprints that could have been produced by the contact, in pressing, with a vegetal structure (*Fig. 48,6*). The maximum diameter of the lid was 13.2 cm..
2) Two fragments of terracotta bangles of the common type, bearing on one distal extremity fragmentary remains of conical elements made with the same half-tempered clay of the outer vessel (*Figs. 49; Fig. 48,d,e*). The base of the cones coincides with the breaking surface of the bangles' sections, forming a single functional surface. These elements were found in stratigraphical association with the lid sherd (*Fig. 48*).
3) The well-preserved remains of 3 lumps of the same clay, symmetrically arranged, sticking to the internal surface of the vessel at the height of the shoulder (*Fig. 32*). Flattened and shaped in roughly ellipsodal slices (with maximum lengths of 8, 5, 7 cm.) they have a central conical raised portion bearing visible imprints of the bangle fragments.

Upper

Fig. 47 *Moenjodaro, Moneer South-East Area (AA.40): top view of fragmentary bell-shaped lid recovered inside jar E, in stratigraphic association with the basal brownish-greenish layer (cf. Fig. 44). Note the cracks indicating a carefree moulding (MNSE/82/609).*

Middle

Fig. 48 *Moenjodaro, Moneer South-East Area (AA.40): jar E: ceramic elements belonging to the system of closure of the vessel a-c, bell-shaped fragmentary lid (cf. Fig. 47), d-e, fragments of supporting cones (MNSE/82/609).*

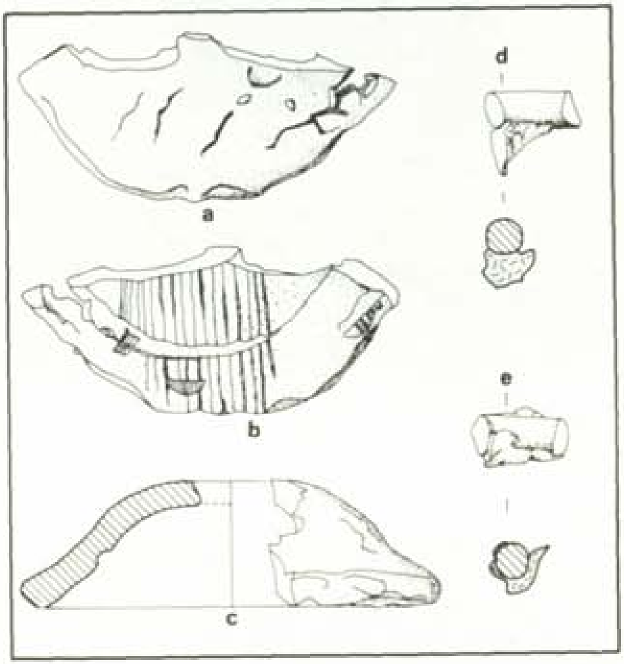
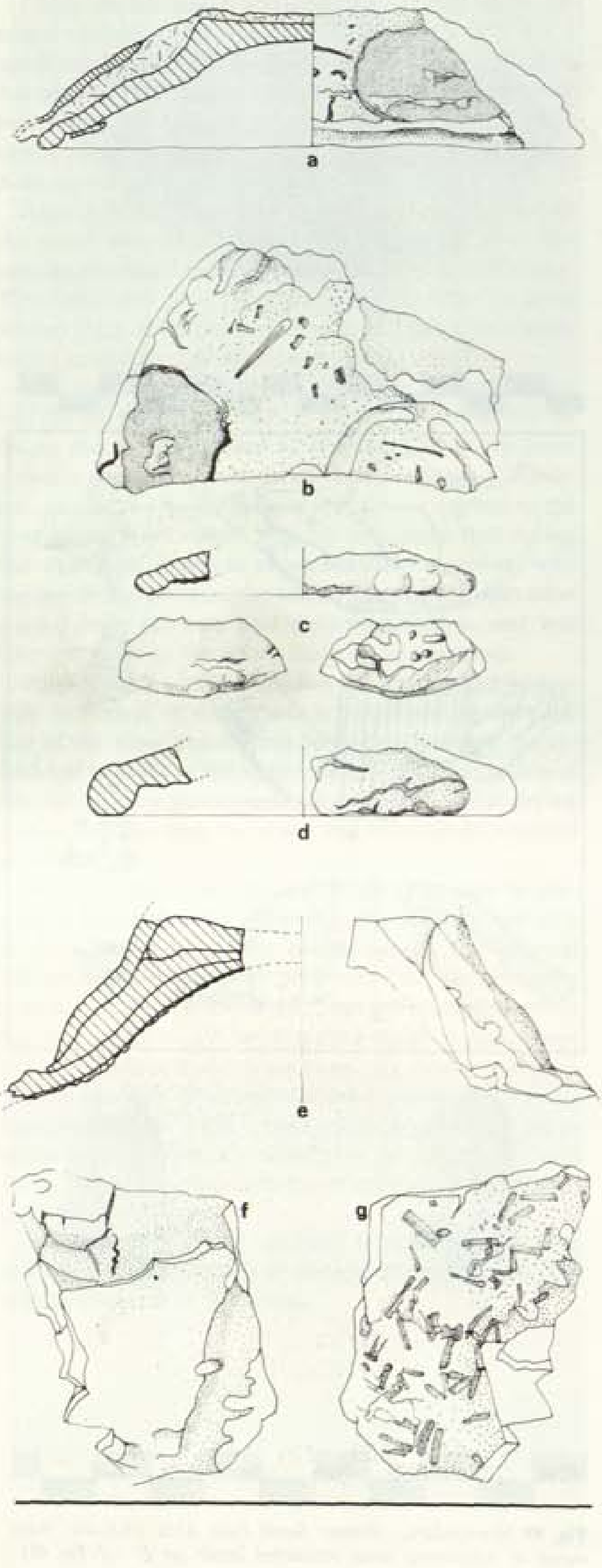


Fig. 49 *Moenjodaro, Moneer South-East Area (AA.40): fragments of supporting cones recovered inside jar E (cf. Fig. 48) (MNSE/82/609).*

Fig. 50 *Moenjodaro. Ceramic elements belonging to CCJ system of closure a, b, AA.28: fragmentary wheel-thrown lid with chaff-tempered outer coating, and circular imprints probably left by a terracotta bangle (cf. Fig. 7) . c, AA.40: fragment of moulded lid; d, AA.17: fragmentary lid; c-g, AA.40: fragmentary handformed upper capping (MNSE/83/1092; 83/1101, 83/1107; 82/634).*



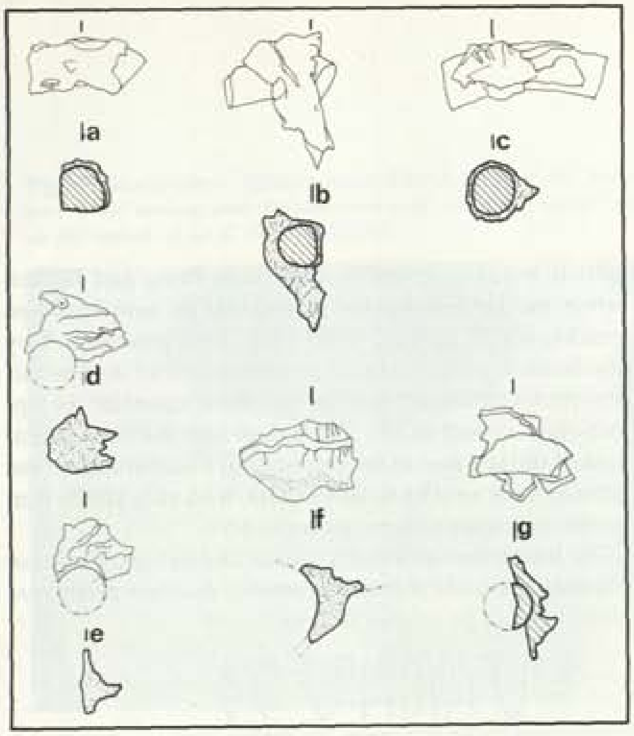
The correlation of these three different sources led us to the following interpretation: fragments of terracotta bangles were re-utilized by inserting them in small supporting cones made of the chaff-tempered clay of the coating. The cones were applied under the mouth of the jar to hold the pottery lid in place. The supporting device seems to have been rather fragile, and not intended to stand any substantial weight. The cones had been broken by pressing or knocking the closure system from above.

What was the functional logic of such a complex device? The diameter of the lid corresponds to the mouth diameter of jar E, but the estimate is not very reliable, as the mouth of the vessel was strongly warped. The average value of mouth diameters of the non-overfired specimens is 14.1 cm.; the total average values is 14.0 cm.. We may assume therefore, that lids of this type were intentionally produced with small diameters, and that, as a consequence, they needed the delicate supporting system to be held in place. A second specimen of this type of lid, morphologically and technologically very similar, was recovered in close proximity to jar H *(Fig. 50, c)*.

If this is the picture suggested by the analysis of jar E, we have to stress that we have evidence of an alternative and perhaps simpler type of lid.

As a matter of fact, specimens of more regular and larger lids were noticed on the surface of AA. 40 and 29; one of them *(fig. 50 a, b)*, evidently thrown on the wheel, still retained remains of the intermediate chaff-tempered coating, as well as the trace of a badly damaged sealing applied to it directly. A very interesting point is that the larger diameter of this second type of lid matched with the jar's mouth diameter and thus ruled out any need for a supporting cone system. This evidence would agree with the concave imprint of a large lid visible on the rim of jar B *(Fig. 29)*.

The evidence of employment of supporting cones is restricted to jar E and to some scanty traces visible under the mouth of jar F. More evidence, however, was recovered by re-analyzing the materials recovered in the excavation. We found 6 fragments to be related to the described closing devices. *Fig. 51 a - c* are fragments of bangles with traces of chaff-tempered clay, comparable with the analogous items contained inside jar E, which were recovered from the collapsed bricks around the CCJ; d and e, found in the filling of jar F, are part of supporting cones which still bear the cylindrical imprint left by the bangle. *Fig. 51 f,* finally, is a fragment of bangle with traces of an overfired clay closely resembling the pottery of the lid of jar E; it was found in the filing of jar C.



◁ **Fig. 51** *Moenjodaro, Moneer South-East Area (AA.40): ceramic fragments relative to CCJ system of closure (a, MNSE/82/605. b, MNSE/82/612. c, MNSE/82/624. d, MNSE/82/611. e, MNSE/82/611. f, MNSE/82/625. g, MNSE/82/606).*

Figs. 52 , 53 *Moenjodaro, Moneer South-East Area (AA.40): fragment of handformed upper capping (cf. Fig. 50, e-g) (MNSE/82/634).*

Intermediate Chaff-Tempered Coating

The existence of this second, very perishable, element of the closure system is attested to by the remains, visible on the shoulder of all the vessels, of a 5 - 8 cm. wide band of chaff-tempered clay, applied directly onto the outer vessel (see *Figs. 20 - 27, 28 - 35)*. The lighter colour and the rough surface of this band contrast strongly with the even, reddish surface of the slipped CCJ. Starting from the shoulder as a thin irregular film it becomes thicker towards the mouth where in all the specimens it is interrupted by a continuous breaking surface. The inference that such a layer was originally supposed to extend over the mouth and the lid of the jar seems to be quite reasonable, and is confirmed by the actual presence of the coating all over the mentioned wheel-thrown lid recovered from AA. 28 (see above; *Fig. 50, a, b)*.

Upper Capping and Sealings

The presence of an upper capping on some of the CCJ has been reconstructed from some overfired fragments recovered from AA. 40, the best preserved of which is reproduced in *Figs. 52 - 53,* and in *Fig. 50, e - g.* This roughly truncated-conical element appears to have been formed by simple hand application and superimposition of a series of slices of a very refined clay onto the chaff-tempered layer of the intermediate coating. No expedient was used to ensure adherence to the superimposed slices, which appear to have flaked according to the construction planes, and are fully visible in the breaking surfaces. In the course of the operation, the application of a thicker slice onto the centre of the raised portion changed the bell-shaped contour of the top into a sub-trapezoidal one.

The clay used underwent slight surface oxidation during firing resulting in a reddish surface film, while the interior assumed a dark violet-grayish colour. The application of this capping could have produced the two crescent-shaped depressions visible over the surviving lower part of the intermediate coating in jars Ξ and F (*Figs. 32, 33*).

In both cases, these depressions are found immediately on the left of the sealing remains. Being free from all traces of friction, the depressions could have been produced by the indirect pressure exerted in applying the upper capping onto the still plastic underlying coating. This would suggest that the capping sealed and hermetically closed the intermediate coating with the semi-lunate shaped sheets covering it down to the shoulder. The sealings, apparently made of the same clay, were probably alternated with the semi-lunate sheets when they were placed on the lower edge of the capping in order to ensure the integrity of the closing system.

On the other hand, as already stated, the fragment of lid with coating and sealing remains from AA. 28 has yielded no evidence of the described device. At the present state of our knowledge it is difficult to be sure whether these differences in the structure of the closing apparatus should be considered as expressions of systematic technological and functional divergences, or more simply referred to a set of secondary alternatives not affecting the basic functional logic of the system.

The actual remains of sealings are encountered only in jars E and F. They represent the last element to be assembled in the system of closure. The connection of the sealing with the upper capping, when present, had already been seen to be supported by the apparent identity of the used clay. Both containers retain the remains of two sealings. The sealings were originally arranged with a threefold symmetrical schedule. The sealings of jar F are badly damaged; of one only the outer border is preserved, while the other is attested by a small fragment of its left part. *(Fig. 54)*. In both cases there is no trace of the seal impression. We shall use the better preserved specimen of jar E as a descriptive model. The sealing *(Figs. 55, 56)* is an ellipsodal sheet of clay, with a maximum diameter of 6 cm., a minimum of 5 cm. and a thickness of 0.5-0.6 cm.. The carefully shaped sheet has been inserted in the plastic surface of the intermediate coating, with the center corresponding exactly to the height of the rim of the CCJ. In the center of the sealing the well-preserved impression of a square stamp-seal with unicorn, „brazier" and text is visible. The impression is deep and clear in the upper part, while it gradually disappears in the downward direction. The sealing is preserved for about 4/5 of its original extension. The upper part is missing, probably cracked in firing and broken when the jar was opened to recover its contents. The cracks, which partially follow the deep grooves left by the borders of the seal and the same figure of the animal, are probably responsible for the detachment of the upper right corner of the impression and the consequent loss of the last part of the inscription. Photographs of the sealing were sent to Asko Parpola, who very kindly sent us the following comment on the text:

„The inscription is not very visible (the rightmost signs in comparison to the left are uncertain); but I am pretty sure that it should be read as follows:

(underlining for uncertainty). For the four signs to the left, which form one whole, compare our inscription no. 1113 (= 113 in Marshall) from Moenjodaro:

and for the rest, compare seal 5064 from Chanhujo-Daro:"

(Letter addressed May 28, 1982 to M. Jansen).

The second sealing of jar E is preserved only in the rightmost lower part. Along the border of the breaking surface the lower remain of the seal impression are visible, with the legs and penis of the unicorn and the lower part of the „brazier" *(Fig. 57)*.

The analysis of this second impression seems to indicate that the same seal was used. The sealings remain visible on the specimen reproduced in *Fig. 50 a, b* are too badly damaged to give more information.

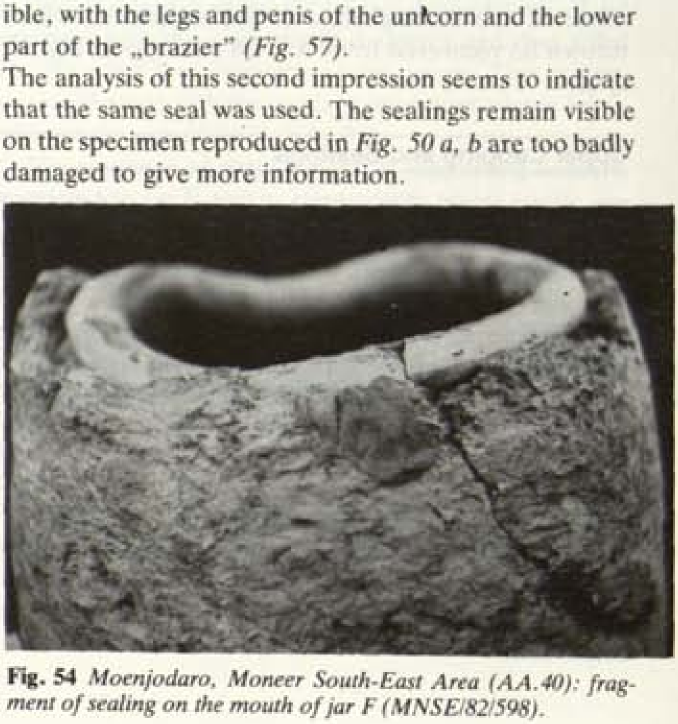


Fig. 54 *Moenjodaro, Moneer South-East Area (AA.40): fragment of sealing on the mouth of jar F (MNSE/82/598).*

Fig. 57 *Moenjodaro, Moneer South-East Area (AA.40): lower part of the sealing with the impression of „unicorn„ stamp seal on the mouth of jar E (MNSE/82/597).*

Fig. 58 *Moenjodaro, Moneer South-East Area (AA.40): fragmentary pile formed by 5 superimposed and overfired terracotta bangles (MNSE/82/1421).*

The Basal System of Support

As already stated, the surface evidence suggested the existence of a specific functional relationship between terracotta bangles and CCJ *(Figs. 4, 5, 7)*.

These observations were confirmed by the discovery of the complete specimens, in the first place E and F, bearing on the lower section a large amount of bangle imprints *(Figs. 32, 33)*. Jar F, furthermore, presented two complete superimposed bangles sticking to and partially embedded in the base *(Fig. 33)*. The strong pressure exerted on the jar from above, as well as the semi-plastic state of the overfired coating, seem to have maintained the two bangles in the original setting, in spite of the shifting of the vessel and the deformation of the base. The lower part of the basal bangle was covered with a regular film of sandy clay, 3 mm. thick, forming a greenish, incompletely oxidized lining. This was residual evidence of the surface on which the jar had been displaced inside the kiln. *(Fig. 33)*.

Overfired wasters formed by several superimposed sections of bangles are rather common finds in the areas mentioned. The specimen reproduced in *Fig. 58* belongs to a pile of 5 bangles, joined together by pressure and incipient melting. In firing, the pile underwent a strong excentric pressure, its central axis being twisted. The point of application of the pressure corresponds to the point of the pile in which the bangles are better preserved.

In view of the above evidence, the inference that the CCJ were actually suspended over a system of pillars of superimposed terracotta bangles during the firing process was fairly immediate. In some cases the system included two central bangles under the base, and a series of pillars radially arranged all around the circumference of the lower section. The analysis of the pattern of distribution of the imprints gave us more detailed information.

It is interesting to note that jar E, which warped and dilated in situ, retained a sub-primary relationship with the supporting elements; on the contrary, jar F, partially reversed, knocked down the pillars in a selective direction. The collapse allowed the preservation of the imprints in a restricted part of the lower section. The relationship, in this case, should be considered a secondary one.

The arrangement of the bangles was ideally reconstructed by analyzing the distribution of the imprints *(Figs. 59, 60)*. An inner circumference of imprints (dark circles in *Figs. 59, 60)* was characterized and referred to the basal bangles of the piles, which were less affected by secondary movement. Drawing the angles formed by connecting the center of the base with the center of the imprints, we were able to evaluate an average angle of 51^0 for jar E and 56^0 for F. This should indicate that the pillars were arranged according to a hexagonal-heptagonal schedule. The number of bangles in the piles may be inferred by comparing the average thickness of the bangles with the height of the corner point in the CCJ *(Fig. 61)*. In our estimate, we should have a pile of 7 - 8 bangles, with the uppermost excentric, for the CCJ with the two central bangles under the base, and a pile of 5 - 6 bangles in the other cases.

At this point, the information we have gathered on the technological unit may be assembled and expressed in the preliminary reconstruction illustrated in *Figs. 62, 63*. The reconstruction is conceived as an expression of the archaeologically defined connections between the different elements which have been recognized; at the present stage of the research, the extreme complexity of the system has not yet been fully explained by the available set of functional interpretations.

Fig. 59 *Reconstruction of the arrangement of supporting bangles, according to the imprints visible on the lower section of jar E (cf. Fig. 32).*

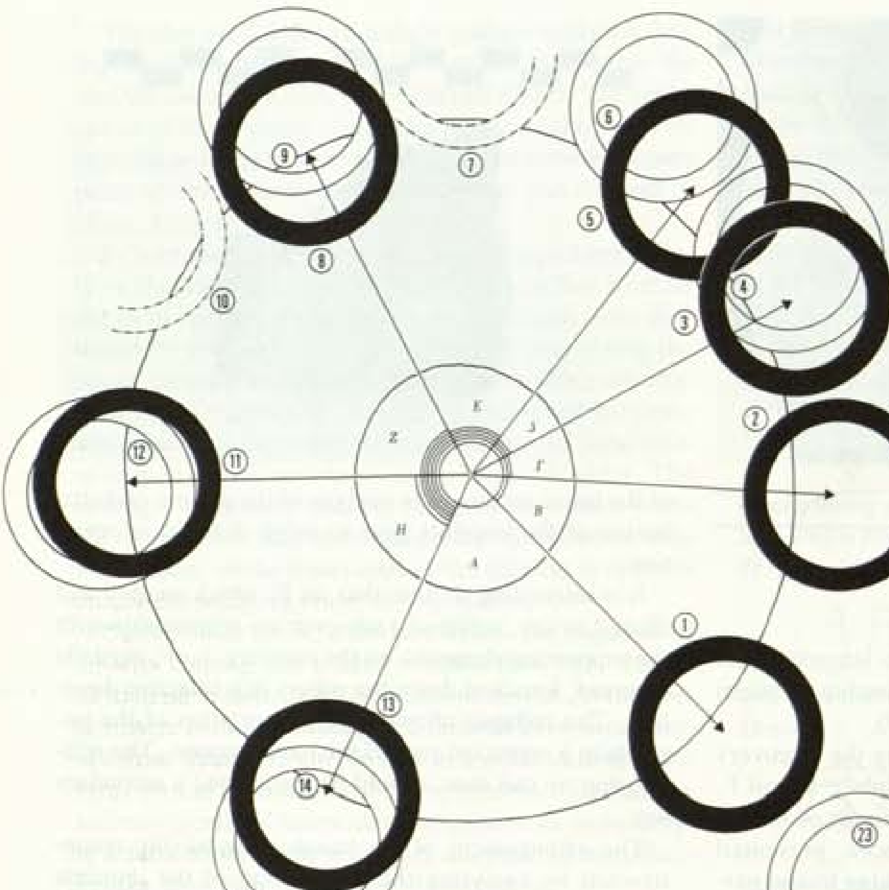
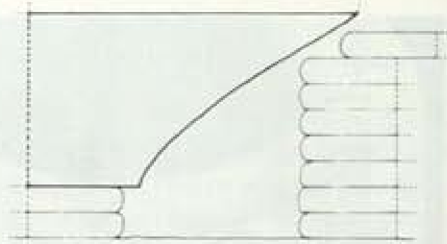


Fig. 61 *Reconstruction of the height of the bangles' supporting piles, according to the average dimension of CCJ lower section and bangles' thickness.*



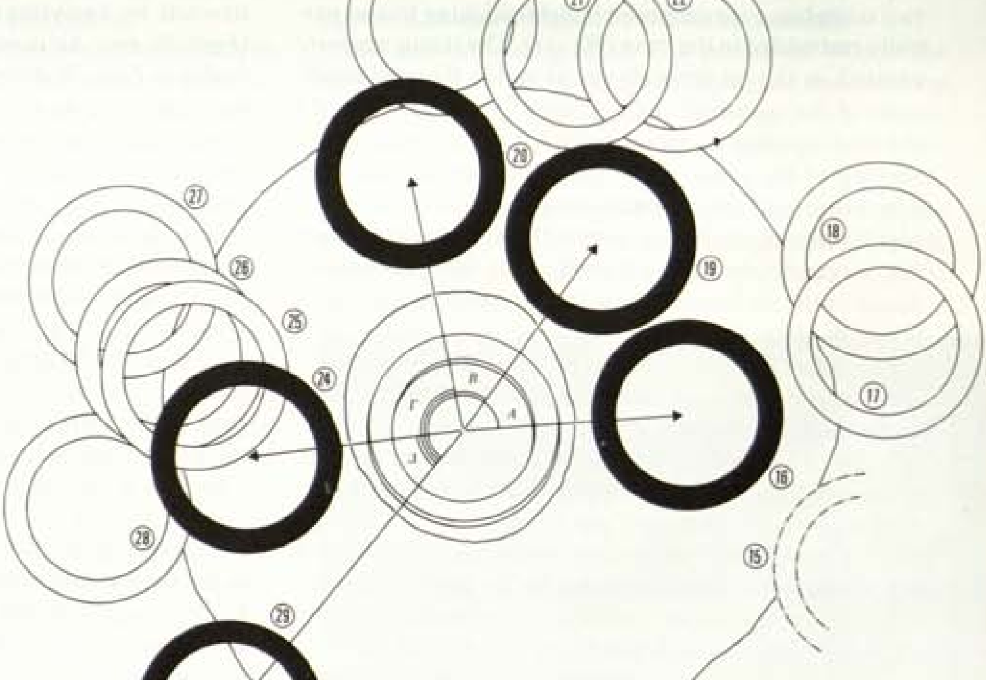
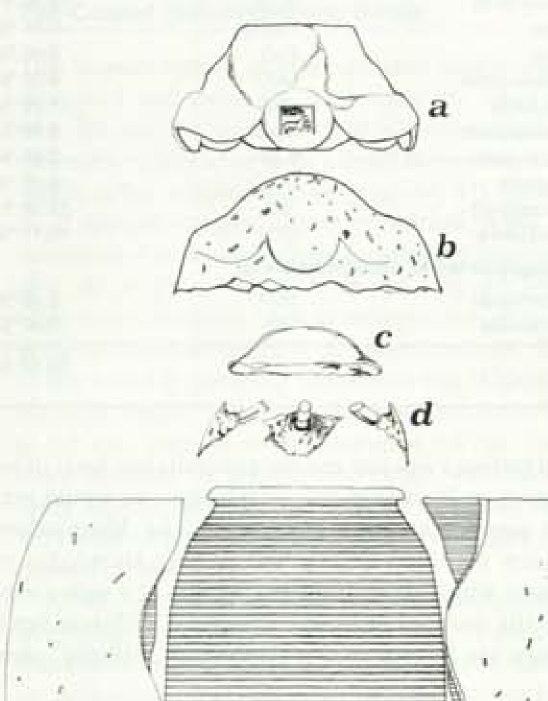


Fig. 60 *Reconstruction of the arrangement of supporting bangles, according to the imprints visible on the lower section of jar F (cf. Fig. 33).*

Fig. 62 *Reconstruction of the different ceramic elements to be assembled into a single CCJ ready for firing: a, upper capping and sealing; b, intermediate chaff-tempered coating; c, lid; d, supporting cones; e, inner vessel; f, outer vessel; g, basal system of support.*



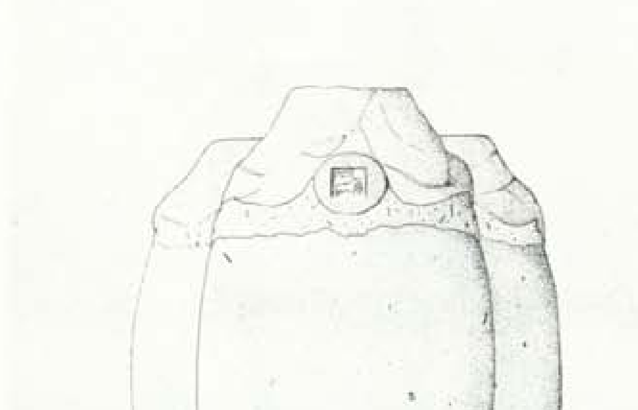


Fig. 63: *Conjectural graphic reconstruction of the whole system assembled inside the kiln.*

Function of Coated Carinated Jars

The hypothesis of a functional identification of CCJ as saggars was substantially supported by the proposed reconstruction of the mouth closure system. It appeared evident that skill and care were needed to avoid any kind of contact between the processed material and the hot gases circulating inside the kiln. The baking had to take place in very controlled, uniform conditions. The chaff temper in firing had to burn, forming inside the outer coating a network of cavities; in this way, the dilating coating could retain a film of hot gases insulating the inner vessel from the combustion chamber.

The exact function of the small lid and the relative supporting device remains difficult to explain. It is difficult, furthermore, to understand how the fragile cones could efficiently withstand the weight of the closure elements, unless we imagine that the cones were, in their turn, supported by the material to be fired in the saggar. Possibly, the complex closing device was planned to fulfill very peculiar conditions, somehow connected with the need to discharge the internal pressure, which increased during firing. As already stated, in some cases the closure was however somewhat simpler.

Again according to the „insulation" model, the basal system can be considered as a specific device to grant the most uniform heating around the saggars.

As we have seen, the sealings were arranged all around the mouth of the CCJ to prevent any unauthorized operation of opening and removing the processed material at the end of firing. If the present interpretation is correct, we are dealing with a very particular example of administrative control effected directly on an internal phase of a manufacturing cycle.

The thin layer of brownish-greenish material recovered in the cracked bottom of jar E was the only possible indicator for the identity of the baked material. Chemical determinations and X-ray diffractometric analysis were carried out by Prof. G. Maura and P. P. Matias, Facoltà di Ingegneria, Università di Roma *(Tab. 2, 3)*. According to their results:

„... in the diffraction spectrum are clearly evident the patterns of the following mineral components: quartz, cristibalite, feldspar, calcite, and clay minerals (illite, kaolinite, smectite, chlorite and others).

Quartz	10 - 15 %
Cristobalite	5 %
Feldspar	10 %
Calcite	10 %
Clay minerals	60 - 65 %

Tab. 2: *Determination by X-ray diffractometric analysis of the mineral components of the sample of brownish-greenish material recovered from CCJ E. The clay minerals present in the sample are, in order of decreasing percentage, illite, kaolinite, smectite and chlorite.*

The spectrum of the same sample, after 2 hours of firing at 1200° C., appears quite different. The structure of the material becomes almost completely vitreous: in spectrum remain only a couple of patterns due to the presence of residual quartz. The glass thus obtained is brownish-blackish (Fig. 64), with a violet shadow. Its hardness is high (Barkol hardness 80 - 90).

The presence of clay minerals, if we avoid taking into account the possibility of a secondary contamination, would indicate that the material did not undergo firing (in this case, the small percentage of cristobalite would be endogenic, and this component could have been mixed with the others in the formation of a natural sediment). On the whole, the material is quite similar to the mixture we employ today to obtain hard-textured ceramics or glazes. Normally these mixtures are obtained today by the intentional addition of feldspar (as a flux) and siliceous sands to the clay minerals in the required percentages."

In the absence of more detailed investigations on the depositional setting of our material, these data by defining the material as an unbaked one, would be in partial disagreement with the archaeological evidence (the deposition of the mixture inside the CCJ appears to be primary).

We are apparently dealing with a specific mixture, possibly destined to be further processed in the framework of a manufacturing cycle for the production of some kind of stoneware, grès or glaze. Given the present

Tab. 3: *Chemical determinations carried out on the same sample (previously dried at 105°C.).*

Aluminium oxide	Al_2O_3	18.56 %
Iron oxide	Fe_2O_3	0.71 %
Iron oxide	FeO	8.80 %
Manganese oxide	MnO	0.32 %
Calcium oxide	CaO	11.20 %
Magnesium oxide	MgO	0.40 %
Potassium oxide	K_2O	2.65 %
Sodium oxide	Na_2O	0.15 %
Silica, combined	SiO_2	29.38 %
Silica, cristalline	SiO_2	15.11 %
Thermogravimetric determinations:		
Water combined	H_2O	3.48 %
Carbon dioxide	CO_2	8.87 %
		99.63 %

lack of further evidence and the generally low level of information on Harappan pyrotechnology, we would prefer to avoid premature inferences. The Moenjodaro craftsmen mastered a deep and flexible knowledge of chemistry which allowed the production of a wide range of specific material including stoneware, different types of glazes, the faience group, glazed and „artificial" steatite.

Whatever this product might be, we are dealing with an independent manufacturing process characterized by high labour investment, whose quantitative output was strictly controlled through administrative devices. Its final identification depends on the possibility of extending the laboratory and field research.

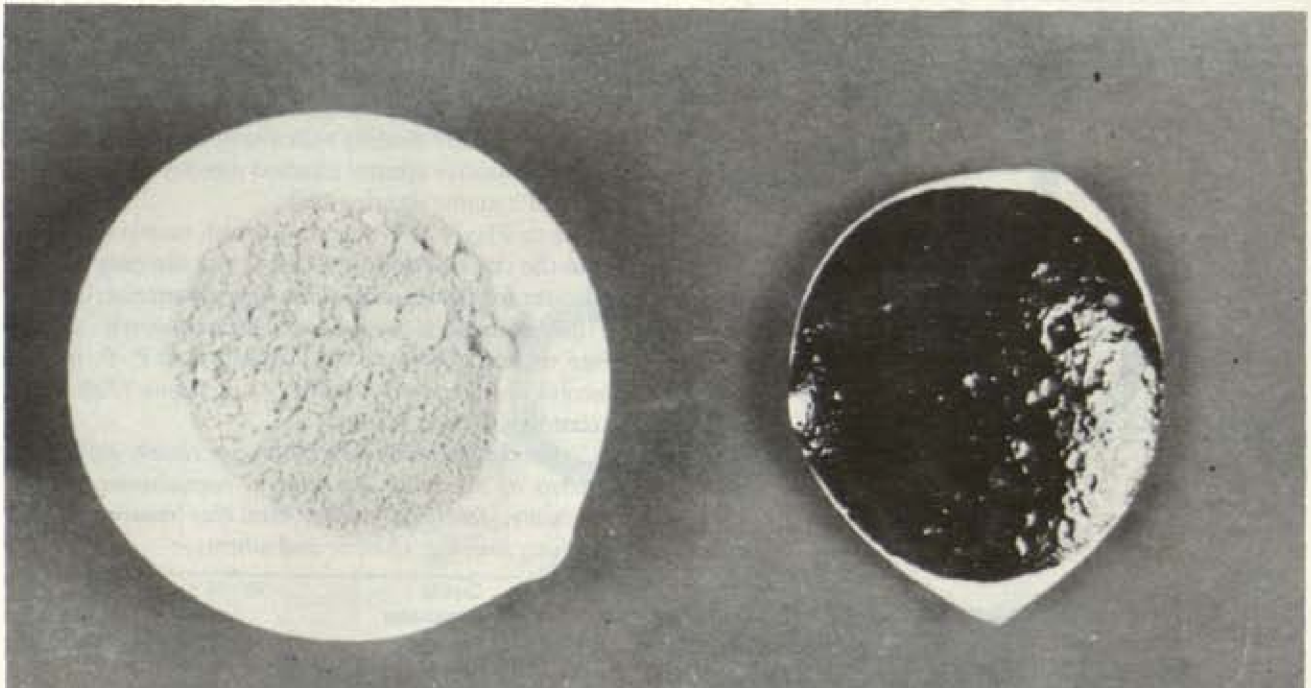


Fig. 64: *Moenjodaro, Moneer South-East Area (AA.40): sample of the brownish-greenish material recovered from the cracked bottom of jar E (cf. Fig. 44), left; sample of the same material, transformed into a brownish-violet glass after 2 hours of firing at 1200° C, right (MNSE/82/610).*

The Coated Sub-cylindrical Bowls

This second type of coated container had already been described and correctly interpreted by Mackay *(Fig. 65)*. We use the term „Coated Sub-cylindrical Bowls" (hereafter CSB) to indicate a small sub-cylindrical vessel with a rather variable contour (*Figs. 66, 67*). In some cases, it appears straight, almost cylindrical, while in other specimens it is inward-inflected, close to a truncated cone *(Fig. 67, d, f)*, or slightly S-shaped *(Fig. 67, i-l)*. Some CSB have a rounded, slightly enlarged rim, but a rim superiorly flattened seems to be more common. The base of the vessel is generally concave or flat. Equally variable is the height, ranging in the observed items from 2.5 to 5.2 cm., with an average value of 3.9 cm. The maximum diameter is around 10-11 cm., wall thickness is fairly regular, always close to 0.5-0.6 cm. All the CSB, very even in fabric, appear to have been very carefully thrown on the wheel.

All the recovered specimens were strongly affected by overfiring. The pottery, in every case, is dark-gray or blackish; it appears very homogeneous and fine-textured, with very rare macroscopic inclusions or air bubbles.

Fig. 65: *Moenjodaro: The „muffle" discovered in DK-G Area (after Mackay 1938: Pl. LXVI, 14)*

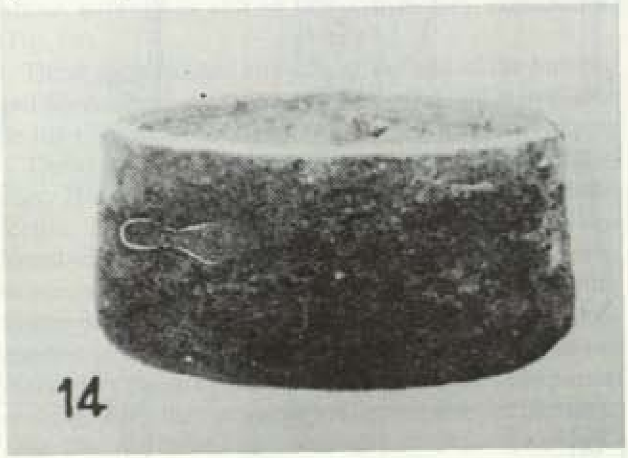


Fig. 66 *Moenjodaro, AA.28: stoneware bracelets' manufacturing wasters (top row) and coated sub-cylindrical bowls fragments.*

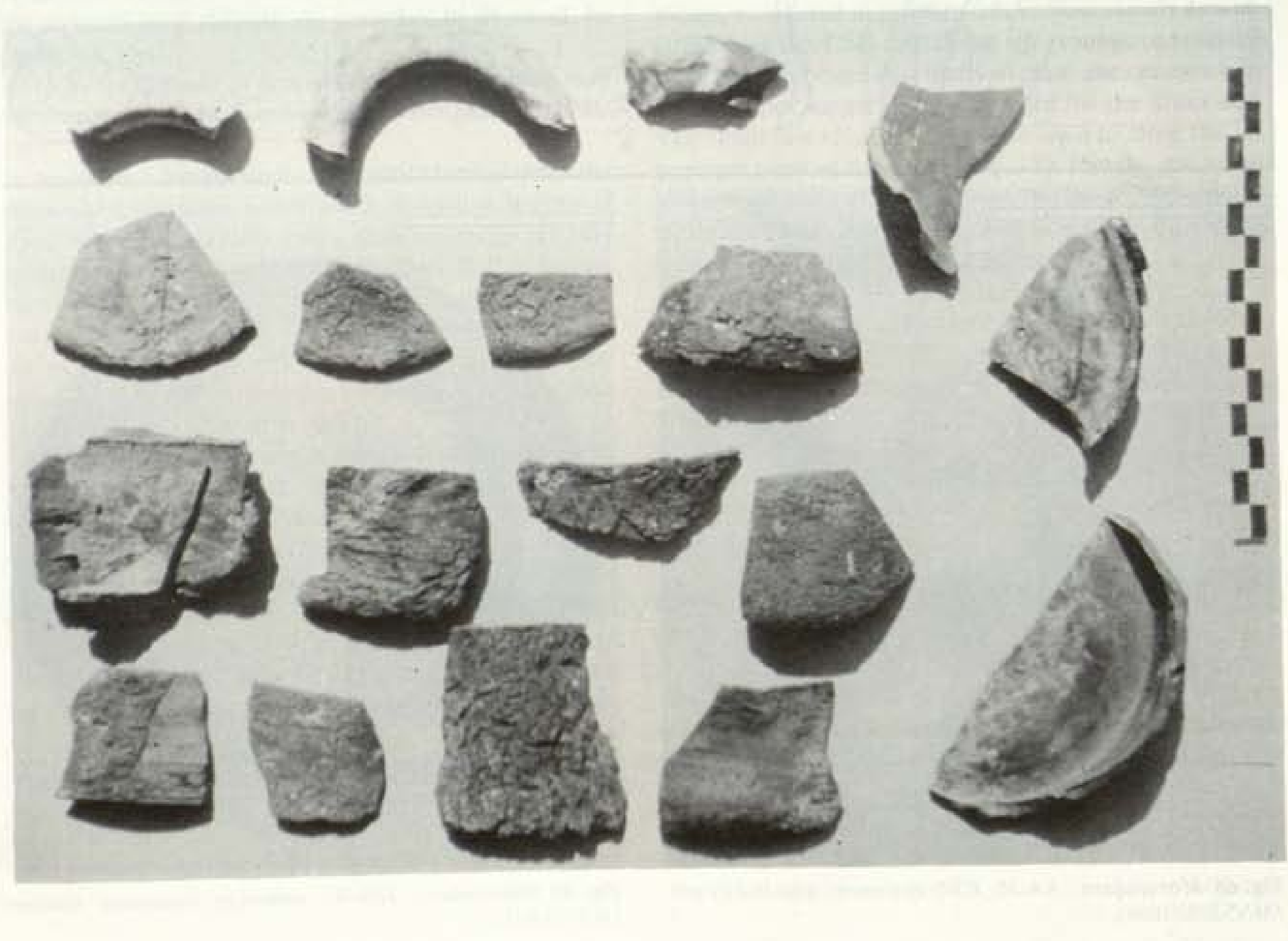


Fig. 67 *Moenjodaro, AA.28: Morphological variability of CSB (a, MNSE/83/1074; b, MNSE/83/1078; c, MNSE/83/1091; d, MNSE/83/1979; e, MNSE/83/1082; f, MNSE/83/1074; g, MNSE/83/1072; h, MNSE/83/1071; i, MNSE/83/1077; j, MNSE/83/1075; k, MNSE/83/1076; l, MNSE/83/1096).*

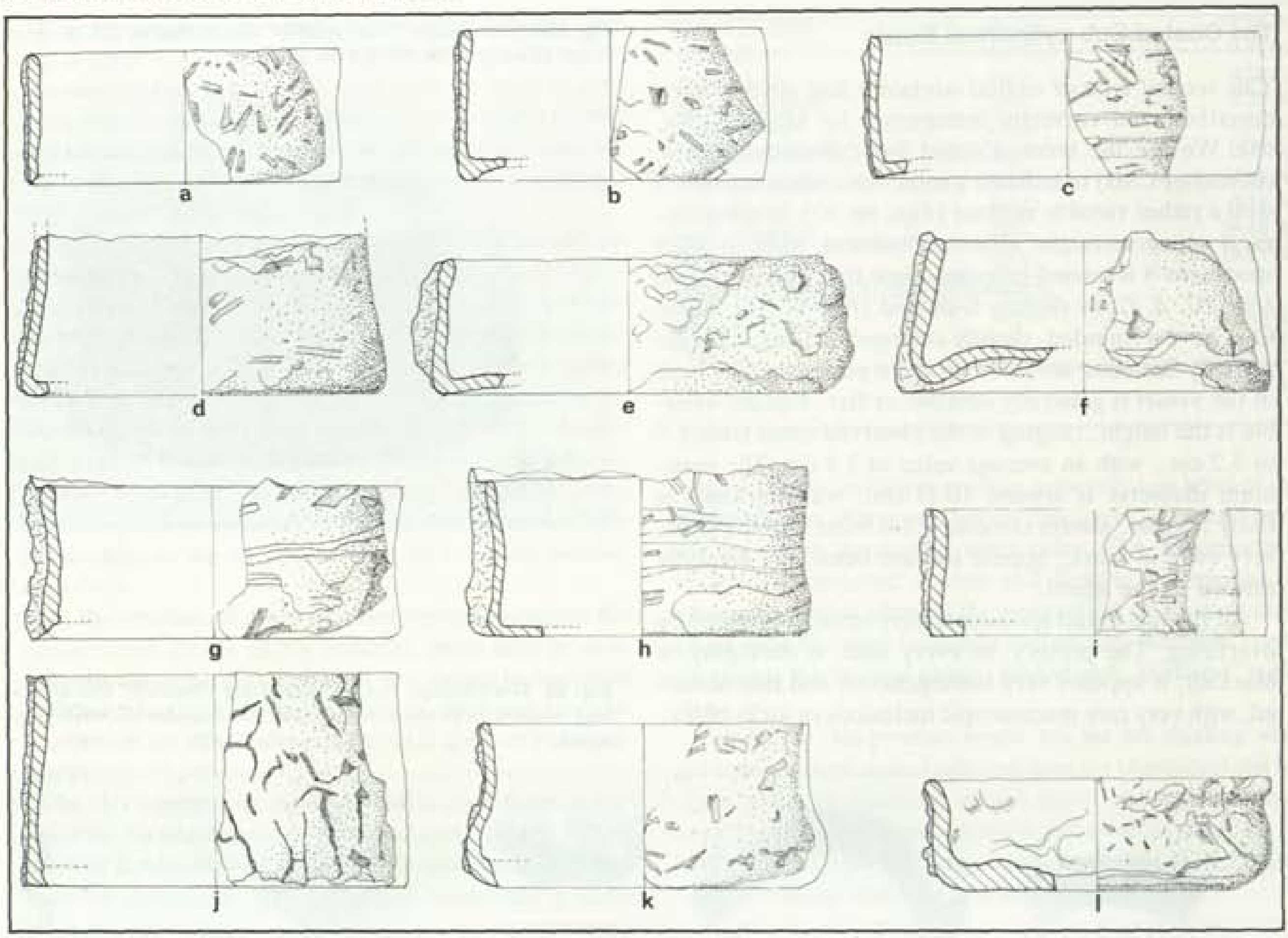


Fig. 68 *Moenjodaro, AA.28: CSB specimen attacked by salt (MNSE/83/1084).*

Fig. 69 *Moenjodaro, HR-W: unbroken stoneware bracelet (HW/83/621).*

Attacked by weathering and salt, this pottery flakes into small polyhedric fragments. The outer coating, apparently identical to that of CCJ, was probably applied using a similar technique (*Fig. 68*).

The CSB were endowed with small dish-like or bell-shaped lids, whose fragments, although not very common, were recovered in the surface survey.

The distribution pattern of CSB turned out to be fairly similar to that of the CCJ and partially overlapped it. Two primary concentrations allowed us to identify the CSB as saggars through the discovery of the wasted remains of the fired product: a very distinctive type of ceramic bracelet, well known in archaeological literature (*Fig. 69*). This artifact is described by Marshall as follows:

„*Another type of pottery bracelet was made with a heavily fired clay, dark brown or black on the outside and light gray inside, of a fine uniform texture, and free from blow holes. Indeed, these bracelets are so heavily burnt that they ring like metal when struck and in some cases they break with a glass-like fracture. Owing to their brittleness, they are practically always found in pieces...*" *(1931: 530)*.

A specimen from VS Area was analized by Sana Ullah, the archaeological chemist. As remarked by Marshall, he preferred

„...*to style this make of bracelet as stoneware rather than terracotta, for the former implies a better grade.*" *(1931: 530)*.

In Appendix I, furthermore *(1931: 686)* Marshall describes the whitish mottlings which are a distinctive feature of these bracelets. In some cases, such mottlings are very evident, and they look very attractive. If this feature should turn out to have been intentionally produced it could be very tempting to relate the close similarity of the mottlings to the veins of a fine-grained metamorphic stone (and, in our experience, these bracelets are often very deceptive at first approach).

Equally interesting are the morphological features of the „stoneware" bracelets. Their diameter appears to be strongly standardized, almost always close to 8.2 cm. Width and thickness, on the other hand, appear more variable. The widest range of variability is encountered in the shape of the section of the bracelets. The observed specimens include ovoidal, ogival and a large group of irregular triangular shapes, very often strongly asymmetrical. Round sections are conspicuous by their absence.

The surface of the bracelets is smooth and even. So far, we have not found a single fingerprint, nor any other of the traces which are so frequently retained by common pottery items in the plastic state.

The surface is always covered by a regular, fine pattern of microbands, extremely regular and parallel, whose nature has still to find satisfactory explanation (*Fig. 69*).

These sophisticated artifacts, at the end of the forming and finishing process, were carefully piled and placed inside the CSB to be fired.

This is clearly shown by the specimens reproduced in *Figs. 71* and *72, a, b*. As a consequence of the usual defective firing, fragments of stoneware bangles were found still adhering to the bottom of the CSB. This evidence, naturally, refers to the basal bracelet of the pile. Traces of piling are clearly visible on the surface of a large number of bracelets, where the original contact points are marked by the irregular circumference left by the partial melting and the subsequent incomplete detachment (*Fig. 70*).

According to our preliminary estimates, taking into account the average internal height of the saggars and the bracelets' thickness, an average number of three bracelets per saggar seems likely.

The fragment reproduced in *Fig. 72, c* is formed by the surviving inferior part of the CSB exactly superimposed over the rim of a second saggar. The two elements, recovered in primary connection, clearly demonstrate how the CSB containing the stoneware bracelets were superimposed in cylindrical piles, the concave base of the upper saggar serving as a lid for the lower one. The small lids (*Figs. 73, 74*) were used to close the uppermost bowl of the pillar (*Fig. 75*). Finally, the whole assemblage had to be coated with the usual chaff-tempered mixture; the points of conjunction between the saggars were sealed with additional coating layers.

The fragments of saggar's base shown in *Fig. 72, d* is an example of the technical solutions adopted to insulate the basal bowl of the pile.

The piles thus obtained were finally inserted into the kilns for firing.

Fig. 70 *Moenjodaro, AA.28: fragment of stoneware bracelet showing the characteristic regular pattern of parallel lines (MNSE/83/1098).*

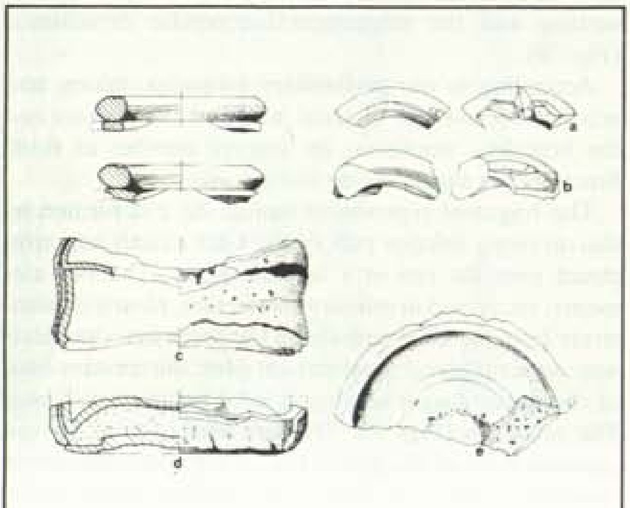


Fig. 72 *Moenjodaro, a, AA.28: section of stoneware bracelet with fragment of saggar's base. b, AA.17: section of stoneware bracelet with fragment of saggar's base; c, AA.28: overfired fragment formed by two superimposed CSB, showing the assemblage system of the saggars; d, e, fragment of CSB base with three different clay coating sheets, and the central trace left by the basal stoneware bracelet (a, MNSE/83/1093; b, MNSE/83/1100; c, MNSE/83/1083; d, e, MNSE/83/1095).*

Fig. 71 *Moenjodaro. Fragment of CSB base (cf. Fig. 72, d, e,), and stoneware bracelets retaining sherds of the saggar's base (cf. Fig. 72 a, b).*

Fig. 73 *Moenjodaro, AA.28: CBS rim (top, right) and fragments of dish-like lids (MNSE/83/1085, 1086, 1087).*

Fig. 74 *Moenjodaro, AA.28: CSB dish-like lids. Note the morphological variability in the four specimens and the inscribed sign on the outer coating of E (cf. Fig. 76) (a, MNSE/83/1087; b, MNSE/83/1097; c, MNSE/83/1103; d, e, MNSE/83/3404).*

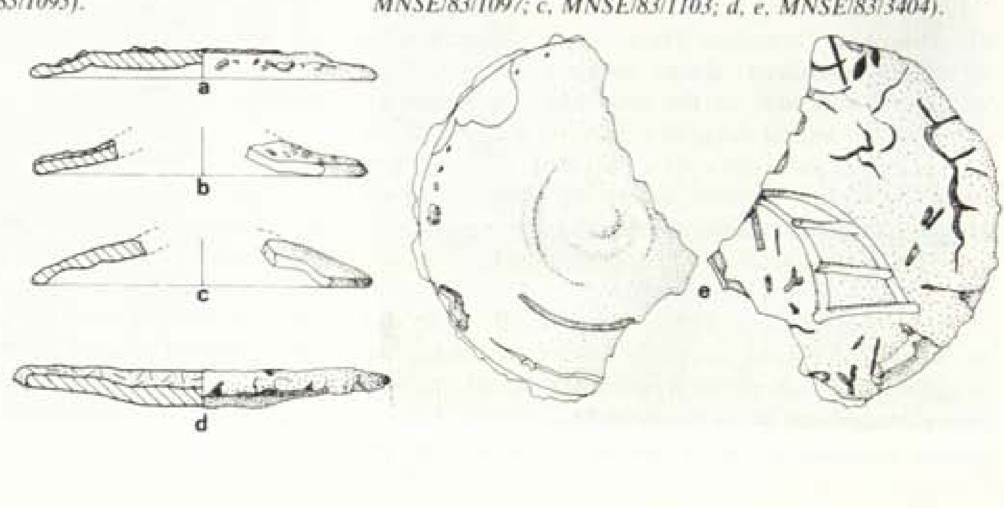


Fig. 75 *Reconstruction of the assembling of CSB and stoneware bracelets in cylindrical columns (the number of saggars is conjectural).*

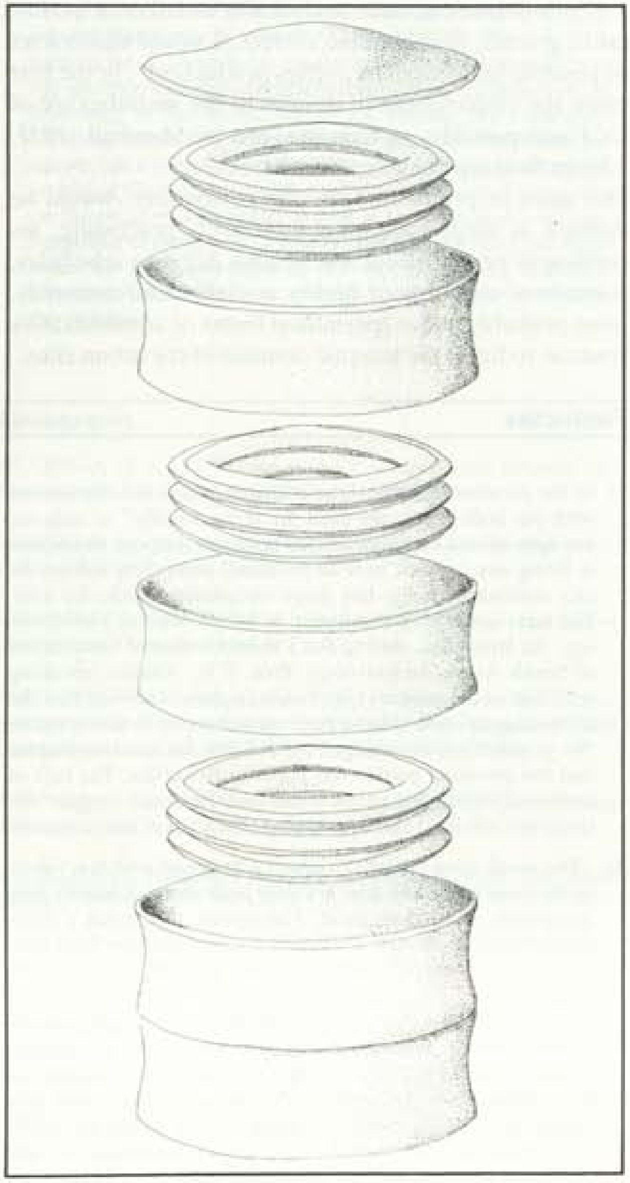


Fig. 76 *Moenjodaro, AA.28: inscribed sign on the outer coating of CSB lid (cf. Fig. 74) (MNSE/83/3404).*

Other Indicators of Information Processing

No sealing remains have so far been recovered in association with CSB. On the other hand, we have evidence that the piles of saggars, were in some cases, graphically denoted with inscribed signs. The outer coating of the lid visible in *Fig. 74, e* and *Fig. 76* retains a sign traced with a stick on the plastic clay.

The stoneware bracelets also bear inscriptions. This phenomenon had been already noticed by the early excavators. The inscriptions appear to have been traced onto the bracelets in a leather-like state of hardness, using a very thin-pointed tool. The thickness of the tract averages 0.2-0.5 mm.; the height of the characters is often close to 0.4 cm. The characters are thus very often elusive and difficult to identify. This circumstance, together with the tendency of the bracelets to break up into several fragments, as well as with the evidence of post-firing polishing in some of the specimens, suggests that writing on the stoneware bangles could be a rather more systematic and widespread practice than formerly thought. We are dealing with a strange kind of „invisible writing" directly denoting the single unit of production. The co-occurence of signs on the piles of saggars and inscriptions on the bracelets could indicate the presence of a „chinese boxes" structure of information processing inside a specific context of production.

Conclusive Remarks

The present paper seems to be more effective in raising good questions than in providing good answers.

A superficial run through the excavation reports of Harappa and Moenjodaro will demonstrate that the published corpus of Harappan material culture includes a wide range of products whose manufacturing processes are still poorly understood, and classes of possible tools whose functions are unknown. In other words, we could say that a proper understanding of Harappan technology is still forbidden by the dichotomy existing between products without archaeological craft indicators and classes of presumable indicators without identified products. In this perspective, our effort may be conceived as a further small step in the attempt to bridge these separate spheres.

Although a large amount of field and laboratory research will be necessary to test many of the proposed interpretations, the available evidence is substantial enough to give a picture of the puzzling degree of sophistication of Harappan pyro-technology. The manufacturing processes we have tried to outline and to reconstruct are characterized by the employment, for both tools and products, of artificial ceramic mixtures whose components had probably to be refined through other specific and laborious processes. Equally elaborated appear to be the schedules of assemblages of the saggar's elements. Although the function of part of the described device is not fully explained, we have enough elements to realize the high investment of labour-force involved in such an accurate control of the firing conditions.

The final products (whose identification for CCJ is still an open question) had to be highly valuable prestige items with a relatively high degree of standardization; in the case of the stoneware bangles their interpretation as personal ornaments could hardly be questioned.

The technological sophistication detectable in the manufacturing processes may be referred to an equally elaborated technology of administrative control on the production. The employment of sealings is a highly formal administrative act, indicating strict control over the quantity, and, perhaps on the quality of the production out-put. The use of writing on the bracelets is obviously a problematic but very promising topic of research.

In the light of these considerations, in artifacts such as the stoneware bangles we find not only the crystallization of impressive amounts of labour-force and specific know-how, but also the accumulated experience and skill needed to acquire and to master a wide and diversified knowledge of chemistry.

This knowledge must be considered as the fruit of lengthy observation and painstaking experimentation. We may think that this process of technological improvement took place side by side with the rise and structuring of new needs, such as the demand for more and more specific signs in the form of personal prestige items to be investigated in the dynamics of intra-social communication.

Given the chronological horizon under observation, at the present phase of the research we can only observe the final output of this evolution.

The Craft Activities Areas involved in the processes we have discussed would appear as small-scale manufactures acting within the boundaries of the urban compound. On the surface of identified areas, the concentration of pyro-technological indicators would appear substantial enough to meet the empirical standards for the label of „intensive production".

If this definition, once analytically tested on a quantitative ground, should prove correct, it would match a set of possible indications of „series production", in the first place the employment of moulds in the manufacture of CCJ and possibly, as hypothesized by Marshall *(1931: 530)* in forming the stoneware bracelets.
Our units of production, in this perspective, would be defined as small-scale units intensively processing, according to very efficient and flexible iterative schedules, substantial amounts of highly re-elaborated materials, most probably under specialized forms of administrative control, to fulfill the internal demand of the urban elite.

Footnotes

1) In the previous phases of the research and in the discussions with our colleagues, we used the term „muffle" to indicate any specialized vessel produced with the purpose to contain in firing any ceramic item or material, protecting it from direct contact with the hot gases circulating inside the kiln. The term „muffle" was adopted to follow Mackay's terminology. At Bruxelles, during the VII International Conference of South Asian Archaeology, Prof. F.R. Allchin, speaking with one of the authors (*M. Vidale*) rightly observed that the term „saggar" would have been more correct in this context. We gratefully acknowledge Prof. Allchin for his contribution and the attention paid to our paper at Bruxelles. The lack of uniformity in the use of the terms „muffles" and „saggar" reflects the still fluid and developing character of our research.

2) *„The small open vessel ..., which was found with two others of the same shape and size, is a gray paste that was heavily fired apparently more than once. This vessel, which has a fairly smooth interior though it is rough inside, may have been used as a kind of muffle" (Mackay 1938: 178; Pl. LXI, 72; Pl. LXVI, 14).*
This description, with the drawing and photograph, clearly concerns the ceramic container that in this article, was defined „coated sub-cylindrical bowl" (CSB). Our analysis of the surface finds demonstrated its actual employment as a muffle or, more properly as a saggar (see also *Mackay 1938: 203*). Mackay, moreover, came across specimens of lids used with saggars. His interpretation of the chaff-tempered coating as an indicator of specialized pyro-technolgical applications was substantialy correct:
„a thin pottery plate, 4.17 ins. in diameter and 0.2 ins. thick has a thick cement of mud and straw round the edge which shows signs of burning. This plate was evidently used to seal up the flue of a furnace, and similar plates with a similar cement are used for the same purpose in India at present day". (Mackay 1938: 178; Pl. LXVII, 15).
A third specialized ceramic item described by Mackay could be relevant for the purposes of the present study:
„the inside is perfectly smooth, but the outside which was purposely left very rough was coated with a mixture of sand and clay ... its great thickness which would certainly induce the slow cooling of its contents, a very necessary factor in the manufacture of glazes, suggests that it was used as a kind of muffle in a kiln, perhaps for the firing of faience". (Mackay 1938: 201; Pl. LIV, 23).

3) The observation we present on the internal stratigraphy of the vessels' filling may be considered as a kind of offspring of the authors (M.V.) had in the course of the excavation of the iron age graveyard of Piovego (Padua/Italy), by the Institute of Archaeology of the Padua University. During the excavation, Giovanni Leonardi, Armando de Guio, Claudio Balista had shown that a very detailed recording of the inte. nal microstratigraphy of the burried vessels could give a wide set of a new data on the ritual of deposition, as well as on the post-depositional behaviour of the graves. It is impossible, in this occasion, to account for the importance of the cooperatin with Giovanni, Claudio, Armando in my scientific work. Anyhow: Thanks. (M. Vidale)

Bibliography

HLOPINA (L.J.) 1974, Novyi Tip Rosudy Epoxi Bronzy. In: *Sovestskaja Arxeologija 4* (1974), pp. 212-213.

MACKAY (E.J.H.) 1938, Further Excavations at Mohenjo-Daro, Vols. I-II, New Delhi

MARSHALL (Sir J.) 1931, Mohenjo-Daro and the Indus Civilization, Vols. I-III, New Delhi

TOSI (M.) 1968, Excavations at Shahr-i Sokhta, a Chalcolithic Settlement in Iranian Sistan. Preliminary Report on the First Campaign Oct.-Dec. 1967, EW, XVIII, 1-2, pp. 9-66.

TOSI (M.) (ed.) 1983, Prehistoric Sistan I, *IsMEO Reports and Memoirs*, Vol. XIX, 1, Rome.

VATS (M.S.) 1940, Excavations at Harappa, Vol. I-II, New Delhi.

Shell Industries at Moenjodaro, Pakistan

Jonathan Mark Kenoyer
University of California, Berkeley

Introduction

For many years, archaeologists studying the Indus Civilization have concentrated on the major features of pottery, architecture and the enigmatic Indus script, giving only passing attention to the numerous varieties of „minor" artifacts. Among the most common of these „minor" artifacts are fragments of marine shell ornaments, utensils and manufacturing wasters. The deemphasis of shell artifacts is entirely unjustifiable in view of the fact that, after terra cotta and stone, shell is one of the most durable materials found in the archaeological context. Because of their durability, shell artifacts are among the few objects that have survived to help us reconstruct the ancient trade networks within the Indus valley, as well as between the Indus valley and adjacent regions. Some shell species have isolated or limited distributions along specific coastal regions and by determining the ancient source areas for these species, we can gain a new perspective on the trade networks and the exploitations of marine resources by protohistoric coastal populations.

The Moenjo Daro Shell Industry

Even though the site of Moenjo Daro is located far inland *(Fig. 1)*, a large number of shell artifacts were recovered during the early excavations from 1925 to 1938. These artifacts are spread out in numerous museums and reserve collections throughout both India and Pakistan. In 1980-81 I was able to make a detailed study of most of these collections by the kind permission and encouragement of the Department of Archaeology, Government of Pakistan, the Archaeological Survey of India and the different Museum Institutions. In 1983, I was fortunate to be invited by the IsMEO/RWTH Joint Moenjo Daro Project, to participate in the collection and analysis of shell artifacts in the surface survey of the site. This additional research was supported by a grant from the Smithsonian Institute, Foreign Currency Program.

By combining the data collected from the earlier excavations and the important new data recovered from the recent surface survey, it has been possible to gain a new understanding of the outstanding technological developments of the Harappan shell industry and its socio-economic role at a large urban center such as Moenjo Daro.

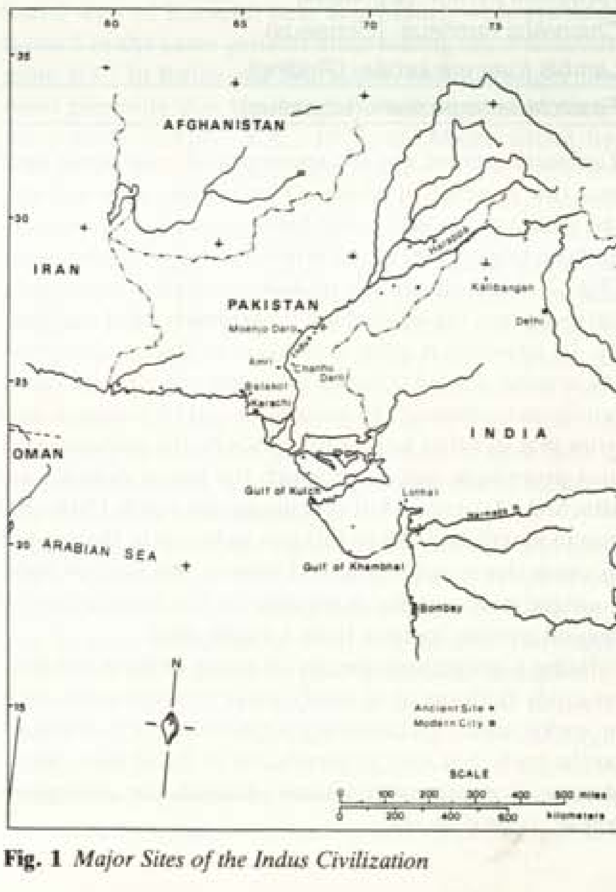


Fig. 1 *Major Sites of the Indus Civilization*

Species of Mollusca Used as Raw Materials

Although many different species of marine and fresh water mollusca have been recovered from Moenjo Daro, the shells of only a few of these were actually used as a raw material for the manufacture of ornaments and utensils such as bangles, inlays, ladles, figurines, etc. (Natural shells that have simply been perforated for use as ornaments are not included in this present discussion.) All of the species used as raw materials are still found in the Arabian Sea and come from different areas of what used to be the coastal regions of the Indus Civilization, extending from Sutkagen-dor on the Makran coast, to Lothal on the Gulf of Khambhat (Cambay). Each species is adapted to a specific habitat area in the coastal environment. A brief review of their basic physical characteristics, habitat and distribution is important for better interpreting their archaeological occurrences and understanding how the protohistoric coastal populations exploited their marine resources.

Major Gastropods Used in the Shell Industry at Moenjo Daro
Turbinella pyrum (Linnaeus)
Chicoreus ramosus (Linnaeus)
Lambis truncata sebae (Roding)
Fasciolaria trapezium (Linnaeus)

Turbinella pyrum was the species most commonly used as a raw material at Moenjo Daro. In its natural form, the shell is ovate with a well balanced spire and a smooth globose body whorl that has no external protruberances *(Fig. 2)*. Underneath the protective exterior covering or periostracum the white shell is extremely hard and sturdy. Its structure is quite massive, with thick walls spiraling around a solid columella, joined together by thick, reinforced sutures. This columella can be distinguished from that of other large gastropods by the presence of 3 or 4 prominent ridges, to which the major muscles are attached. Average adult specimens can reach 150 to 200 mm in length and 100 to 150 mm in breadth. Because of its ovate shape and well joined sutures, this shell provides a unique structure that is suitable for the manufacture of several circular bangles from a single shell.

Being a gregarious species, it tends to form colonies on sandy bottoms or in sandy areas between coral reefs or rocky areas. Occasionally specimens are washed up on the reefs, but they generally live in the shallow littoral zone, to depths of 20 meters *(Mahadevan, Nagappan Nayar, 1974: 118-119)*.

Turbinella pyrum has a fairly restricted distribution, occuring only in the protected bays of the Indian subcontinent. This limited distribution makes it possible to trace the movement of the shells from their source areas to distant inland markets. At present there are major concentrations of *Turbinella pyrum* at the southern tip of India, in the Gulf of Mannar, all around Sri Lanka and as far north on the eastern coast as the mouth of the Godavari River. These source areas, however, were not exploited during the Indus period. On the western coast of the sub-continent it is not so common, but in the Gulf of Kutch and along the coast of Sind and Baluchistan, west of Karachi, large populations are to be found. Harappan shell collectors probably used these source areas to supply inland manufacturing centers *(Fig. 5)*. The westernmost occurrence of this species is reported from Pasni, on the Makran coast *(Khan, Dastagir, 1971: 56-57)*, but it is not found in the Arabian/Persian Gulf itself (hereafter referred to as the Gulf).

Another commonly used species was *Chicoreus ramosus*, a large shell characterised by an inflated body whorl, covered with sets of 3 long curving varices or spines and numerous smaller tubercules *(Fig. 3,c)*. Adult specimens range in size from 70 mm to 250 mm in length and 60 mm to 200 mm in width, including the varices. Although generally larger than the *Turbinella pyrum*, it has much thinner body walls and a hollow, spiraling columella. The sutures are quite solidly joined making it possible to produce several circlets from each shell, providing all the exterior spines are first removed. However, the shell of this species is usually perforated by numerous holes from boring organisms, because it has only a very thin periostracum and lives primarily in rocky areas or near reefs where such organisms abound.

Even though this species has a wide distribution throughout the Indo-Pacific region, its actual distribution along the coasts of the subcontinent is somewhat limited. It is quite common in South Indian waters and also along the southern shore of the Gulf of Kutch, becoming less common further west along the Sindh and Makran coasts. One modern source is noted in the Gulf of Oman around Fahal Island near Muscat *(Bosch and Bosch, 1982: 89)*, but is either extinct or extremely rare in the Gulf. Smythe *(Smythe, 1982: 59) (Fig. 5)* suggests that this is only a recent development based on the fact that she has seen well preserved specimens purported to have come from inside the Gulf itself.

Lambis truncata sebae is the most massive shell used at Moenjo Daro, ranging in size from 200 mm to 300 mm in length and 130 mm to 200 mm in width, including the digitations *(Abbott, 1961: 156) (Fig. 3b)*. One of the characteristic features of this genus are 6 or 7 digitations extending from the outer lip. In *sebae* these are not very distinct due to the massive build up of porcellaneous, enamel layers on the outer lip and over part of the spire. The spire itself is well balanced and has a series of small tubercules along the shoulder ridge near the sutures. As in most gastropods, the columella is solid and spiraling, but it is not as massive as would be expected for a shell of this size. In fact, except for the heavy accumulations on the outer lip, the remainder of the shell is quite thin, and the sutures are relatively weak.

This species is also gregarious, and large numbers are found on sandy or coral rubble bottoms, especially on the seaward side of the reefs *(Abbott, 1961: 155)*. Occasionally, specimens can be found washed up on the reefs, and since they have a very thin periostracum most specimens are covered with calcareous algae and honeycombed by numerous burrows *(Abbott, 1961: 155)*.

There has been some confusion regarding the distribution of this subspecies, due to the occurrence of the flat-spired subspecies *truncata* in an intervening geographical region. *Sebae* is basically found throughout the Pacific region and then again along the western coasts of the Indian subcontinent from Kutch to the Makran. It is also reported from the Gulf, the Gulf of Oman and the Red Sea *(Fig. 5)*. *Truncata* on the other hand is found from South Indian waters across the Indian Ocean to Zanzibar and the east coast of Africa. *(Abbott, 1961: 156)*.

Fasciolaria trapezium is similar in form to the *Turbinella pyrum*, but slightly more elongate, reaching 200 mm in length and 150 mm in width *(Fig. 3a)*. A series of short nodes or tubercules is located on the shoulder of the spiraling whorls and the spire is well balanced. Although the columella is solid, spiraling and massive, it can be distinguished from that of the *Turbinella pyrum* by the presence of two or three low columellar ridges or folds. Traces of the thick periostracum are often fused in the center of the columella and in the spiraling sutures, resulting in a less homogeneous columella and weak sutures.

Occuring in habitats similar to the *Turbinella pyrum*, these two species are often found together on sandy bottoms *(Hornell, 1951: 27)*. In some regions however, *Fasciolaria trapezium* occurs around rocky areas or reefs, where it is exposed to the predations of burrowing organisms. Most specimens found at Moenjo Daro are badly damaged by their interlacing burrows.

Unlike the *Turbinella pyrum*, this species has a widespread distribution, and is common throughout the Indo-Pacific region. Along the coasts of the Indian subcontinent, it is found from South India to Kutch, with occasional specimens reported from the Sindh and Makran coasts. Like the *Chicoreus ramosus* it is found in the Gulf of Oman around Fahal Island and off the coast from Muscat *(Bosch and Bosch, 1982: 107)*, but it is quite rare or possibly extinct in the Gulf itself *(Smythe, 1982)*.

In studying the various coastal changes that have occurred over the last 5000 years in western India and Pakistan, we see that the most drastic changes have taken place in delta regions or rocky coasts, where *T. pyrum* do not normally live. Snead's study of the Makran coast indicates that there has been some tectonic uplift, about 2 meters along the Karachi coast and increasing westerly to as much as 30 meters near Ras Jiwani near the Iranian border *(Snead, 1967: 564-565)*. The absence of sub-fossil examples of *Turbinella pyrum* and the other large gastropods in the uplifted beaches may indicate that, as is the case today, there were no major concentrations of these species along the western Makran coast or in the Gulf. In the east, however, the coast has been more stable and there has been relatively little silting. In view of these factors, we can assume that there has been little change in the marine habitats of this region during the last 5000 years, and that the *Turbinella pyrum* beds found west of Karachi, near Ras Mauri, were probably located in the same general areas during the 3rd millennium B.C. In Kutch and Saurashtra, recent changes have been primarily due to silting and not because of tectonic activity *(Gupta, S.K., 1977, a)*. Major silting has completely changed the present ecology of the Little and Greater Rann of Kutch. On the basis of an average silt rate of 2 mm per annum, Gupta has calculated that as late as 2000 years ago, the Little Rann of Kutch was about 4 meters deep and was inundated throughout the year *(Gupta, S.K., 1977, b)*. This silt factor may have destroyed many shell beds further in the Gulf of Kutch, but it has not affected the shell beds on the southern shore and nearer the mouth of the Gulf. In view of these studies, it is probable that the distributions of shell beds as we see them today is very similar to the distribution during the 3rd millennium B.C.

Keeping in mind the variable distributions and habitats of these species, we can see that a wide range of marine eco-systems were being exploited by the Indus peoples in their collection of food and suitable raw materials. Bivalves and smaller gastropods were undoubtedly gathered from beaches, protected lagoons and estuaries simply by digging in the sand at low tide, but the larger gastropods could only be obtained from less accessible areas. Some gastropods were probably collected from reefs and rocky areas by wading and submerging at low tide; while others were obtained by making shallow dives, possibly from reed or wooden boats. The fishing seasons for the intertidal species could have extended throughout most of the year, but the use of boats and diving was probably limited by seasonal weather conditions, such as the monsoons. Present day weather conditions do not appear to have changed drastically since the 4th and 3rd millennium B.C. so the ancient shell fishing season probably followed the same pattern as the modern shell fisheries in Kutch and South India. These fisheries begin around April and continue through June, until the onset of the monsoon storms, after which they continue from October to the beginning of January.

The collection of shells is relatively simple once they have been located, but the sea is not a gentle playground and it contains numerous other creatures that must be respected and avoided. Sharks do not pose a grave problem to divers, since collection areas are in relatively shallow water and large sharks do not normally haunt these regions. However, several species of poisonous fish and snakes inhabit the coral reefs, along with moray eels, and when the wind blows them inshore, there are the extremely poisonous *Pysallia (Portugese Man-o-War)* and the *Chrysaora 'jelly-fish' (Hornell, 1914: 20).*

Very little research has been done at the coastal sites of the Indus Civilization, regarding subsistence patterns and social organizations *(see Meadow, 1979)*, but it is probable that the collection of shells was a part of the subsistence strategy of those coastal populations specializing in the exploitation of marine resources, and was not done by the groups who actually manufactured the shell objects. It is not improbable that at the coastal sites of Balakot, Allahadino, Nageshwar, or Lothal, for example, there may have been a close relationship between shell collectors and shell workers, while at larger inland centers they were undoubtedly quite removed from one another, both physically and socially.

The Moenjo Daro Shell Industry

Looking now at the shell working industry at Moenjo Daro, we are confronted with a vast array of shell objects made by various technological processes, from several different species. During my research over the past three years it has been possible to examine and record over 2800 shell artifacts collected during the early excavations and the more recent surface surveys. In order to facilitate the study of these numerous artifacts it was necessary to devise a recording system that could be transfered to a computer readable format for efficient data processing. By classifying all of these artifacts on the basis of morphological and possible functional variables, we can group them into eight basic categories:

1) Finished Ornaments,
2) Unfinished Ornaments and Manufacturing Waste,
3) Finished Utensils,
4) Unfinished Utensils and Manufacturing Waste,
5) Finished Inlay,
6) Unfinished Inlay and Manufacturing Waste,
7) Other Special Objects,
8) Unfinished Objects and Manufacturing Waste

Ornaments

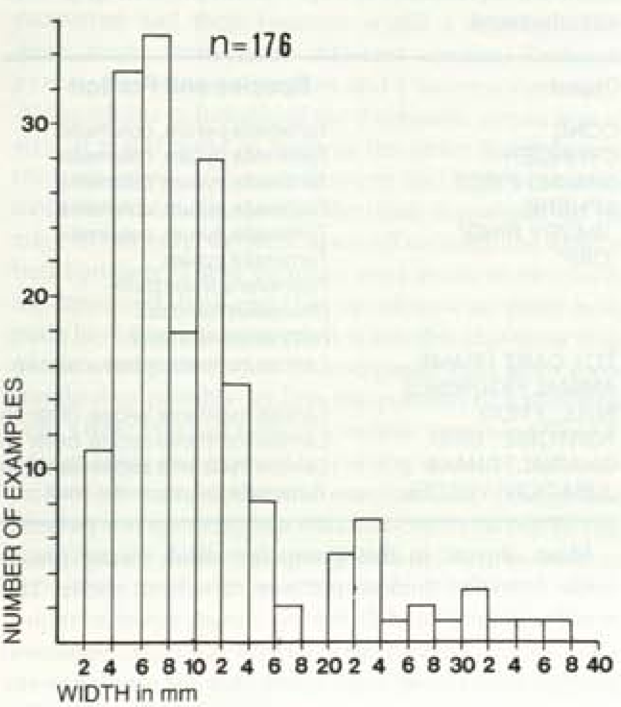
The most common shell ornament at Moenjo Daro is represented by shell bangle fragments. These bangles were produced almost exclusively from the *Turbinella pyrum*, using a variety of specialized and unspecialized tools. First, the shell was prepared for sawing by hollowing out the interior and breaking the thick columella *(Fig. 6 a-f)*. A stone or metal hammer was used to perforate the apex and then a metal pick (or hammer and punch) was used to break the internal septa. Once the shell had been hollowed out in this manner, it was sawn at a diagonal to avoid the aperture and remove the irregular anterior portion *(Fig. 6 g-i)*.The remaining hollow spire was then sawn into rough circlets of the desired width *(Fig. 6 j-k)*. These circlets were ground on the interior using a cylindrical piece of sandstone or some other type of abrasive tool, while the exterior was probably ground on a flat sandstone slab *(Fig. 6 m-n)*.

Most of the finished bangles have an incised design carved into the shell at the point where the suture joins the whorls together.*(Fig 6, o)*. The motif is generally in the form of a chevron, "V", which very neatly transforms the natural irregularity of the shell circlet into an attractive design. During the surface survey, one unique bangle fragment was discovered with a single Indus script character inscribed over the more common chevron motif *(Fig. 10-1)*. This is the only example of script occuring on a shell bangle, and could indicate a specific socio-ritual use of this specific bangle.

Usually the bangles are thin and have a basically triangular or peaked section *(Fig. 10-3.7)*, but others are quite wide, each bangle being made from a single shell *(Fig. 10-9, 10)*. The range of bangle widths in our sample (176 measurable bangle fragments) shows a definite bi-modal and perhaps even a tri-modal distribution *(Table 1)*. First there is a narrow group that could possibly be divided into

Tab. 1 *Shell Bangle Width Distribution*

two sub categories, those having widths of 6 to 8mm, and those from 10 to 12 mm wide. The second group is much more varied, ranging from 20 to 38 mm in width, but there is a slight concentration between 22 to 24 mm. Preliminary analysis of the entire sample of shell bangles recorded from the earlier excavations shows a similar distribution in bangle widths, but further studies may be able to isolate specific widths and bangle styles temporally and spatially.



Getting back to the manufacture of these ornaments, the incised design could have been made using a chert blade or a more specialized copper/bronze file, and a study of the striae suggests that both types of tools were used. Sawing, on the other hand, was not done with stone tools, as has been suggested in the past, but with a highly specialized form of bronze saw. A detailed study of sawing wasters from various Indus sites indicates that the saw had a long convex cutting edge, that was extremely thin; between 0.4 and 0.6 mm. Usually, this saw was only needed to cut through the thickness of the shell body wall, about 5 to 7 mm, but the maximum recorded depth of the cut is between 20 to 30 mm. The section of the saw edge is generally slightly rounded, and the cutting striae indicate that the saw was bi-directionally denticulate, cutting equally well with each thrust as it was moved back and forth. There is no evidence to suggest that any form of abrasive was used in the cutting process. Several convex saws have been recovered from the earlier excavations, but none of them fit the requirements indicated by the shell wasters. The only ethnographic example of a similar saw is the large crescent saw used by modern shell cutters in West Bengal and Bangladesh.

In addition to*Turbinella pyrum,* two other species, *Chicoreus ramosus* and occasionally *Pugilina buchephala* were used for manufacturing bangles *(Fig. 10-5).* It is usually difficult to determine the species of a shell from a small bangle fragment, but if the shell suture is present one can distinguish bangles made from *Turbinella pyrum* (thick, heavy), from those made from *Chicoreus ramosus.* Out of 183 bangle fragments found during the surface survey, only five were made from *Chicoreus ramosus.*

Other ornaments made from shell include various sizes of rings, beads, perforated discs, pendants etc. *(Fig. 11-5 to 18).* Although for a small fragment it is often impossible to determine which species of shell it was made from, some artifacts portray characteristic structural features of the original shell. On the basis of this type of evidence, it appears that rings were generally made from the spire portion of the *Turbinella pyrum*, and perforated cylinders from the columella; while the remaining beads, pendants, etc. could have been manufactured from any of the larger gastropods. These objects were produced by various processes of chipping, sawing, grinding and drilling. Many of the circular pieces *(Fig. 11-27)* were made using a tubular drill, which was probably made of copper/bronze. Smaller perforations were undoubtedly made by tiny chert drills using a simple bow drill. Experiments using replicas of these chert drills have shown that a piece of shell 3 mm thick, can be perforated in about one minute.

Utensils

One of the most distinctive utensils found at Moenjo Daro is the large shell ladle or spoon made from *Chicoreus ramosus (Fig 7; Fig. 13-1)*. It is interesting that no other shell was ever used to make this type of ladle, even though it required an unproportionate amount of labour to produce. Before the body of the shell could be cut, all of the exterior spires and varices had to be first sawn or chipped off *(Fig. 7 a-b)*. Then, a diagonal cut was made from the top of the main whorl extending around both sides of the shell and eventually reaching the narrow anterior end of the shell *(Fig. 7 c-d)*. A handle was formed by making two parallel, longitudinal cuts extending from the anterior tip towards the main body whorl *(Fig. 7 e)*. In this manner, a rough ladle was detached from the body of the shell, and by repeating the process on the remaining half of the shell, a second, but smaller ladle could also be produced *(Fig. 7 d,e)*. These rough forms were then ground smooth and polished, but due to the irregular nature of the exterior surface, traces of the natural shell are usually visible on the exterior of the finished ladle *(Fig. 7 f)*. Another apparent defect in the ladles are the numerous holes left by burrowing organisms. Some of these holes actually perforate the body of the shell and were presumably stopped up with some sort of plaster to make the ladle functional.

Inlay

Due to the small size of most inlay pieces, it is often impossible to determine the species of shell used to make a particular piece, but a study of the shell wasters indicates that all of the large gastropods were used in the production of inlay. Waste fragments of *Turbinella pyrum* left from bangle manufacture were recycled to make various flat geometric designs. *Chicoreus ramosus* fragments were also reused, but it is interesting that on the evidence from the types of manufacturing waste recovered throughout the site, *Fasciolaria trapezium* appears to have been used solely for the manufacture of inlay *(Fig. 9)*. Numerous examples of this shell have been found where only the thick body whorl was removed by chipping or sawing, leaving the columella and spire as waste. The large pieces of body whorl were sawn, chiseled, drilled and ground to produce various geometric shapes *(Fig. 11-19 to 35)*. Another species, *Lambis truncata sebae,* was used primarily for making exceptionally large, solid plaques *(Fig. 8; Fig 12-11)*. The outer lip was sawn into thin sheets or planks, that could then be cut into the desired designs. Saw marks on many of the inlay wasters, especially those cut from the *Lambis*, appear to have been sawn by a saw having a fairly flat cutting edge. This saw was also bi-directionally denticulated, but the saw cuts are slightly thicker, indicating that the saw edge was about 0.7 mm thick

Shell inlay was probably used in wooden furniture or paraphernalia, and occasionally was used for accentuating features or decorations on statuary. On most inlay pieces, the edges have been intentionally bevelled to facilitate setting, which was done using a form of gypsum plaster *(Marshall, 1931: Vol. I: 566)*. Some pieces also have traces of red, and occasionally black pigment around the edges or inside the incised designs. Unfortunately, no examples of inlaid wooden objects have been recovered from Moenjo Daro, but ceramic motifs can provide us with some idea of the exquisite geometric and floral designs made from the white shell, outlined in red and black.

Special Objects

This group includes all of those shell objects not covered by the above categories, and only a few of the major types are discussed below, because it is not in the scope of this paper to present a detailed discussion of all the different varieties. The craftsmen at Moenjo Daro were extremely skilled at working shell and they chose different species to produce a wide range of objects that were often made in terra cotta or other materials. Below is a list of the most common objects, and the species from which they were manufactured.

Object	Species and Portion
CONE	*Turbinella pyrum*, columella
CYLINDER	*Turbinella pyrum*, columella
GAMING PIECE	*Turbinella pyrum*, columella
SPHERE	*Turbinella pyrum*, columella
„WAVEY RING"	*Turbinella pyrum*, columella
„CAP"	*Turbinella pyrum*, *Fasciolaria trapezium* *Chicoreus ramosus* body whorl and spire
TOY CART FRAME	*Lambis truncata sebae*, outer lip
ANIMAL FIGURINES	
BULL, FROG	*Lambis truncanta sebae*, outer lip
TORTOISE, BIRD	*Lambis truncanta sebae*, outer lip
GHARIAL, SNAKE	*Lambis truncanta sebae*, outer lip
„LIBATION" VESSEL	*Turbinella pyrum*, entire shell

Most objects in this group are solid, heavy pieces made from the thickest portions of various shells. The massive columella of *Turbinella pyrum* was used to produce a wide range of these objects *(12-1, 2)*. Numerous pointed cones have been found that are similar to the more common terra cotta cones *(Marshall, 1931: 476)*, but unfortunately the examples in shell do not shed any more light on possible uses for this simple object. The columella was also used to make various sizes of solid and perforated cylinders. Many of the solid cylinders appear to be rough-outs for making smaller objects, such as spheres, „gaming pieces" or „wavey rings" *(Fig. 12-3 to 6,7 to 10)*. Some of the large perforated cylinders are smoothed from wear on the exterior as well as the interior of the hole, suggesting their use as an ornament. Other examples, however, are only smoothed on the exterior, but not inside the hole. These may have been used as components in segmented or composite rods as has also been suggested for the „wavey rings" by Mackay *(Marshall; 1931: 475)*. After considerable detailed examination of these artificats, I would agree with Mackay's interpretation, primarily on the basis of the lack of wear on the interior and the ends of the „wavey rings" and the presence of a high polish on the exterior. The only major problem is that we have found no evidence of a paste or mastic used to join the rings on a central rod, but this discussion must await further research and exploration.

Another intriguing object is the shell „cap". These objects were comprised of two or three convex pieces that theoretically joined together to form a low, flat-topped dome. The exteriors are incised with single or parallel grooves *(Fig. 12-16)* that were often filled with red coloring. So far, however, no matched sets have been recovered and their function is still a mystery. They were made from three different species, *Turbinella pyrum, Fasciolaria trapezium* and *Chicoreus ramosus*. Although the columella of the *Turbinella pyrum* is massive, it is not quite as large as the outer lip of *Lambis truncata sebae*, and most figurines and toys were made from this shell. Generally, the thick digitations on the edge of the outer lip were sawn off to make the head of bull figurines. These figurines were made in two parts, the head and the hump, but up till now no other body parts have been discovered. It is possible that these fragments were joined onto the composite rods as a carved standard or possibly set into the pommel of a tool/weapon. Other types of figurines include tortoises *(Fig. 12 - 14)*, gharials and birds. The carving on all of these objects is so exceptional that one can only assume that Mackay was speaking in a different context when he suggests that the shell workers of Moenjo Daro were not so „adept" as the Sumerians *(Marshall, 1931:568)*.

One other group of special objects deserves special mention, particularly because its significance has been overlooked in the earlier reports. These are called „shell receptacles" by Mackay and he mentions that *„In Sumer similarly smoothed shells were used as drinking cups or for libations or ablutions" (Marshall, 1931: 569)*. These objects are almost exclusively made from *Turbinella pyrum* (only one possible example is from *Chicoreus ramosus)* and are basically just a hollowed out shell. The apex was left intact, and the columella and internal septa were tediously chiseled out. This difficult process was often even further extended by the careful smoothing of the interior chipped edges, while the exteriors are always smoothed and incised with single or parallel grooves. These grooves were then filled with red coloring.

I have called these „Libation Vessels" because of their special manufacture and shape, which is suited to pouring some form of liquid. There are no evidences of burning at the edges, so we can rule out the possibility of their use as lamps. In South India similar, unincised, but hollowed out shells are used by traditional mothers, to milk-feed infants. More elaborate and carefully manufactured vessels are made in the shell manufacturing centers in Bengal for special ritual libations, but some of the simpler styles are identical to those found at Moenjo Daro. Without getting into the lengthy discussion of cultural continuity or dis-continuity, we can see that there are many new and interesting aspects of the shell industry that will be revealed through more detailed research, and we may find that many of the so called „utilitarian" or ornamental objects, such as bangles and inlay, had more important socio-religious functions in the Indus culture. Looking now at the distribution of shell artifacts within the site itself, we are confronted with some interesting new data regarding the role of this industry at Moenjo Daro.

Distribution of Shell Artifacts

Early excavations: Marshall & Mackay

Our present understanding of the shell industry at Moenjo Daro is based primarily on the data presented by Marshall and Mackay in the original excavation reports (1931 and 1938). Mackay's technological interests led him to study many of the craft activities represented at Moenjo Daro, but shell working was evidently not one of his main interests. In the first report, only ten different species of mollusca were identified *(Marshall, 1931: 664-665)*, whereas now, over 33 species have been recorded. The technological aspects of the shell industry were also dealt with quite briefly; a short reference was made regarding the possible similarity of the bangle manufacturing industry to the modern industry in Bengal, and a general discussion was provided on the possible different manufacturing techniques used to cut and shape inlay pieces *(1931: 563-570)*. Mackay notes that *„in the manufacture of shell inlay, however, the people of Moenjo Daro were not so adept as the Sumerians. In India we do not find the wonderful figurines carved in this material that we find in Sumer. Possibly the people of Mohenjo Daro used wood as their chief medium of expression" (1931: 568)*. He also points out that the major species used at the site was *Fasciolaria trapezium*. A reexamination of the shell artifacts indicates that although *Fasciolaria trapezium* was indeed important in the manufacture of inlay, it was by no means the major species used at the site, this position is held by *Turbinella pyrum*. Fortunately, the generalizations and interpretations made by the earlier excavators were based on excavated shell artifacts that were recorded by provenience and preserved for future study. It has been possible to relocate most of the shell objects recorded in the field registers, but the descriptions are often brief and occasionally incorrect, indicating that the recording was done without making a detailed examination of each object. This lack of interest can be understood in view of the large quantities of artifacts that were being processed, but cannot be ignored when assessing the reliability of the artifact descriptions in the registers.

Another problem in understanding the shell industry at the site, is the relative chronological position assigned to different architectural levels. Both Marshall and Mackay were aware of the stratigraphic complexity of the site, but they were not able to resolve the problem satisfactorily. Consequently, I have hesitated to use their designations of Late, Intermediate and Early when discussing the different shell working areas or proveniences. This problem of stratigraphy also affects the interpretation of the horizontal and vertical distribution of the artifacts. Generally speaking, the excavation reports do not go into detail describing the contexts in which shell artifacts were found. Without this information, it is difficult to understand the processes involved in the final deposition of the artifacts and any conclusions based on the published reports, must necessarily remain generalized and conjectural.

Nonetheless, certain areas of the site appear to have been used specifically for the manufacture of shell objects, and these can be recognised by the presence of raw materials, unfinished pieces, manufacturing waste, finished objects and occasionally even tools. *(Fig. 4)*

In „L" area, south of the stupa mound, a large quantity of unworked and partially worked *Fasciolaria trapezium* were discovered in the partitioned apartments south of the „Pillared Hall". Marshall suggests that shell workers came and occupied these quarters after the original function of the building had ceased, and assigns this occupation to the *„latter end of the Late Period" (1931: 165)*. He mentions that in some areas the „late" floor was still used by the artisans, while in other areas they had built up mud floorings. In one of the adjacent chambers *(Chamber 6)* a large sandstone grinding stone was found, which Marshall interpreted as being a possible leather-worker's whetstone. On the basis of its association with shell fragments and inlay manufacturing waste, it is more likely to have been used as a grinding stone or whetstone by the shell workers. One further point of interest that has come out in the restudy of the shell fragments from this area, is that there is a conspicuous lack of shell bangles and bangle manufacturing waste. From the entire „L" area excavations, only three shell bangle fragments are recorded in the registers, and there are very few examples of *Turbinella pyrum* wasters. Most shell fragments belong to *Fasciolaria trapezium*, with a few examples of *Lambis truncata sebae* and *Chicoreus ramosus*. Almost all of the shell wasters from this area are definitely related to inlay manufacture, or the manufacture of discs and beads.

Another possible workshop for inlay is in the „HR" area (Section B, Block 2, House IX, Room 85), where a mass of inlay and waste pieces were found, together with a copper chisel *(1931: 195)*. The room in which these artifacts were found, was supposedly built in the „Intermediate" period and then rebuilt again in the „Late" period. Not far from this building, another area was located that may have been used for processing „oyster" shells to make lime/gypsum plaster (Block 2, House X, Rms. 134, 135) *(1931: 197)*.

The presence of a wide range of waste fragments from different stages in bangle manufacture, indicates that bangle manufacturing was definitely being carried out somewhere in or near the site. One possible manufacturing area was located in „VS" area (Block 2, House XIII), where numerous broken shell fragments and 41 shell cores were found. After examining many of these cores or rather columellae, it was evident that they were all from *Turbinella pyrum*, and sawn from the shell in the process of bangle manufacture. This collection of columellae could indicate a primary context where the shells were actually sawn, or it could represent a storage area or workshop where they were being reprocessed to make cylinders, cones, beads, etc. If we had more details regarding the stratigraphy of this area it might have been possible to interpret this cache more specifically. In „HR" area (Sec. A, Blk. 2, east of House III) we encounter a similar situation, where a large pot was found containing 15 complete, but unfinished shell bangles. From ethnographic examples in the shell working community in Bengal, we know that merchants often provide workmen with unfinished bangles to be processed at home and then returned after they have been ground and carved. The cache of unfinished bangles could have been passing through a similar chain, when it was lost or abandoned.

These few examples are the only clues provided in the excavation reports regarding the role of shell working at Moenjo Daro. The only way to acquire new data was to prepare a map of the overall distribution of the different artifact types on the basis of my reanalysis of the shell artifacts collected by the early excavators. Presently the artifacts are being recorded for computer analysis, and specific programs are being developed to map the artifacts in the locations that are recorded in the original field registers. This study is being done in cooperation with the more comprehensive program being undertaken by Dr. Michael Jansen and his team on the relocation of all artifacts recorded in the registers. By relocation, we are referring to the three dimensional relationship of specific objects to the architectural features with which they are associated. The results of this study will be presented in more detail when the analysis has been completed.

One important objective of the surface survey was to sample unexcavated surfaces of the site to try and locate possible shell manufacturing areas. Another objective was to examine the previously excavated sections and dump areas in order to better understand the contexts from which shell artifacts were recovered and also to determine what types of artifacts were discarded in the dumps.

Over 700 shell artifacts were recovered from the exposed surface areas of the site, coming from three basically different contexts, 1) in association with excavated structures, 2) in dump areas, and 3) on unexcavated eroded surfaces.

Only a few artifacts were recovered from the previously excavated areas and these are comprised of fragments of finished ornaments, utensils, etc. The dumps however, yielded a large quantity of wasters as well as semi-finished objects. In the L Area dump *(Fig. 4)* there were 53 wasters of *Fasciolaria trapezium*, variously sawn or chipped and all resulting from inlay manufacture. Only one fragment of *Turbinella pyrum* waste was found in this same area, and this appears to have been a waster from inlay manufacture rather than from bangle manufacture. Only four finished bangle fragments were recovered from the dump, bringing the number of shell bangles from L Area to a total of seven. The evidence of inlay wasters from the dump areas would lend support to the interpretation that this was an inlay manufacturing area, but unfortunately it does not throw any more light on the problems of chronology or rare occurance of shell bangles. Similar concentrations of *Fasciolaria trapezium* fragments were found in the dumps associated with SD Area and the excavation of the so called „Granary". Other dumps from VS Area, HR Area and DK Area were also examined but they do not provide any conclusive evidence for specific types of manufacturing activities, because of the small sample size and the varieties of artifact types.

In the unexcavated areas within the main site we found only two important concentrations of manufacturing waste, one in a recently exposed room eroding out of the ridge to the north of L Area, and the other eroding from the northern face of the southern east-west ridge located to the east of HR Area *(Fig. 4)*. The concentration in L Area consists of inlay waste fragments (8) and unfinished inlay pieces (2). Due to time constraints, this area was not fully sampled, but will hopefully provide an interesting area for study in the following season. It appears that the shell fragments are part of a deposit enclosed by three walls, and as such may indicate a primary manufacturing area where inlay and small ornaments were being processed.

In HR East, the concentration consists of numerous manufacturing wasters from bangle, ladle and also inlay production. The fragments were found eroding from the side of the ridge and lying on the silty aeolian and fluvial deposits at the base of the slope. These fragments could possibly indicate the presence of an ancient dump area, from a nearby workshop, or the secondary deposition of such an area.

The most interesting discovery relating to shell manufacture was on a low mound, several hundred meters northeast of the Moneer Area. Although it has not yet been properly mapped, the eroding structures appear to be oriented in the cardinal directions and the associated pottery and artifacts are all of the mature Harappan period. This mound is isolated from the main site by a recent river flood channel and is cut in two by an old road leading to Dokri village. The eastern portion of this mound was covered with large quantities of tiny chipped fragments of *Turbinella pyrum*. This type of fragment is produced during the preliminary chipping stages of bangle manufacture, when the apex is perforated and the internal septa are broken. The hollowed out shell would then be sawn into rough circlets. Only a few fragments of these subsequent stages of manufacture were found during the sampling of this area, suggesting that this location may have been used for only the preliminary preparation of the shell for sawing.

A brief look at modern shell workshops in Bengal may help provide a possible interpretation for this distribution pattern. In Bengal, shell workshops acquire their raw shells from South Indian suppliers. Coastal fishermen collect the shells and tear off the large meaty parts of the mollusc, leaving the stomach and soft organs to rot inside the apex. These shells are sewn up in burlap sacks and shipped to Bengal by land or by sea, and even before they arrive there, the organic matter in the apex is putrified and reduced to an odiferous, black maggoty mess. The shell workers quarter of any village or town is famous for its stench and generally avoided by other villagers. Even in a large urban center like modern Calcutta, the shell workers live and work on the outskirts of town, along crowded streets characterised by numerous shell wasters and a distinctive odor.

The shell working area on the northeast mound, outside the main site of Moenjo Daro, definitely represents a location where the preliminary chipping of the shell took place, but it also may indicate the segregation of an odiferous task away from the habitation areas in the central parts of the city. In the following season we hope to be able to carry out detailed mapping of this area to learn more about the surface distribution of the waste fragments and their relationship to portions of architecture that are evident on the surface. This area will provide important comparative information for the concentration of wasters eroding from the room in L Area.

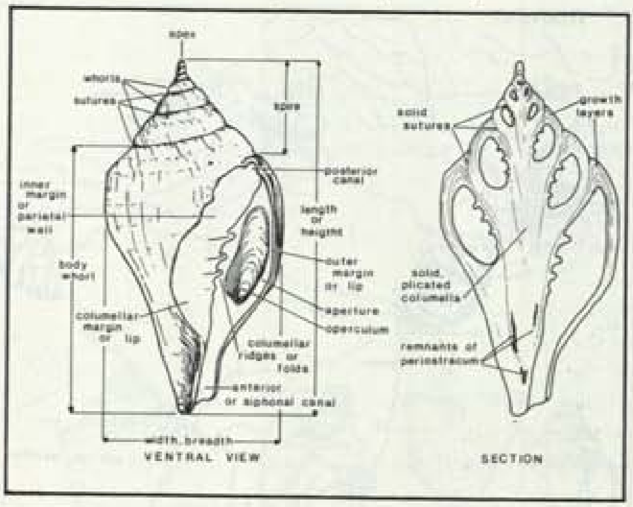
In addition to the location of these important manufacturing indicators, other shell artifacts were recovered that were used by bead drillers as backing for a bow drill *(Fig. 13-3)*. These pieces were made from broken fragments of ladles or sawn wasters that fit easily in the palm of the hand. By placing the concave side against the back of the drill, steady pressure could be applied during the drilling process. Numerous shallow depressions in the concave portion of these pieces indicate that the back of the drill shaft was probably tipped by a stone or copper/bronze point. It is possible that the shell pieces were being used by craftsmen who were drilling shell beads, but they may also have been used in drilling other types of beads or ornaments. Further surface analysis in the areas where these objects were found may help in our understanding of these other important craft activities at Moenjo Daro.

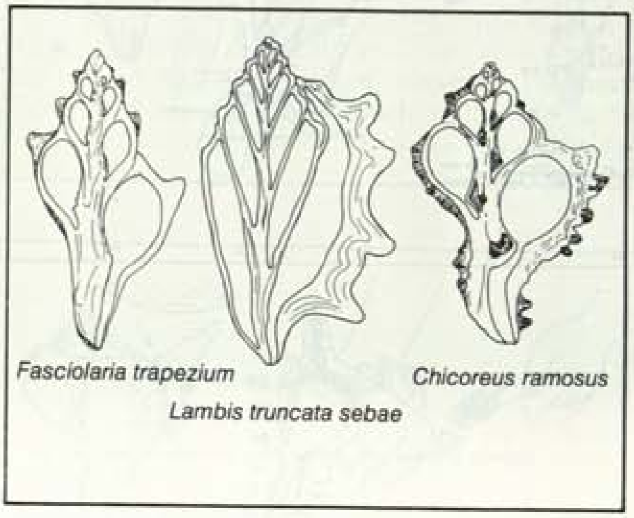
Summary and Conclusion

On the basis of these preliminary observations it is evident that Moenjo Daro definitely had workshops that specialized in the production of shell objects such as bangles, beads, inlay, utensils and other decorative objects. The excavated materials and the collections from the surface survey have provided us with a fairly comprehensive set of data representing all of the basic manufacturing stages of the various types of objects, and it is evident that large quantities of bangles, inlay and other special objects were being made at the site. Ladles too, were being made there but on the basis of quantitative analysis of finished to unfinished pieces *(Kenoyer, 1983)*, it is suggested that some finished ladles were being brought to the site from other manufacturing centers. The raw shells, however, were most certainly transported to the site, and three major source areas can be defined on the basis of modern distributions of shell species; the Karachi coast, which supplied *Turbinella pyrum* and *Pugilina buchephala*; the Gulf of Kutch, which supplied the previous two species as well as *Chicoreus ramosus*, and possibly *Lambis truncata sebae* and *Fasciolaria trapezium*; and the coast of Oman, where all of the above species, except for *Turbinella pyrum* are found. The recent discovery of a Harappan potsherd with graffiti in the Harappan script from the site at Ra's Al-Junayz in Oman *(Tosi, 1982)* may indicate that this area had close contacts with the Harappan sites across the Gulf, and raw shells may have been one of the important commodities in this trade/exchange. The raw shells were probably brought to Moenjo Daro along riverine trade routes and from there, it is likely that many shells were traded further into the interior. In terms of finished shell objects the quantity of shell wasters discovered from the site does not indicate a large scale industry manufacturing products for external trade purposes. The size of the work areas discovered so far at the site suggest that the industry was guaged for local markets either within the city itself or at the most for nearby communities that had close contacts with the urban center.

The manufacturing areas in certain rural areas of Bengal, that produce goods only for the local market are very similar to those seen at Moenjo Daro. On the other hand, manufacturing centers that produce semi-finished products and finished products for local and long distance trade are much larger, and have extremely high percentages of waste to finished goods. The recent discovery of a mature Harappan shell working site in Kathiawar illustrates this point. Nageshwar, is a small Harappan site on the southern shore of the Gulf of Kutch *(Bhan and Kenoyer, 1983)* where extremely large quantities of shell wasters from bangle and ladle manufacture have been found. It is possible that some of the ladles made at this site were traded to the major inland sites such as Moenjo Daro. Bangles too, appear to have been made in unusually large quantities. In one dump area about one square meter in area, there were literally hundreds of columellae from *Turbinella pyrum*, many more than have been found from the entire site of Moenjo Daro. We have not yet discovered any such concentrations of wasters at Moenjo Daro, but before arriving at any conclusions, we must consider that a lot of the shell waste at the site was being reprocessed into ornaments, or inlay, and many of the fragments may have been burned to produce lime. As mentioned above, Marshall does report one room in HR Area (Section B, Block 2, House X, Room 135) where he found a large concentration of „oyster" shells that may have been used for making gypsum plaster. However, even with these factors considered, shell manufacturing at the site does not appear to be in the form of a large scale industry, producing trade items that would comprise a major asset in the overall economy of the site. On the other hand, it was most certainly an important industry, and this is demonstrated by the distances from which raw shells were obtained and the presence of shell artifacts throughout the entire site. As we continue to study the different crafts and small industries at the site of Moenjo Daro we will be able to better interpret the role of various objects, such as shell, in the socio-economic and possibly the socio-religious spheres of this complex culture.

Upper
Fig. 2 *Parts of the Gastropod: Turbinella pyrum*
Middle
Fig. 3 *Internal Structure of other Large Gastropoda*





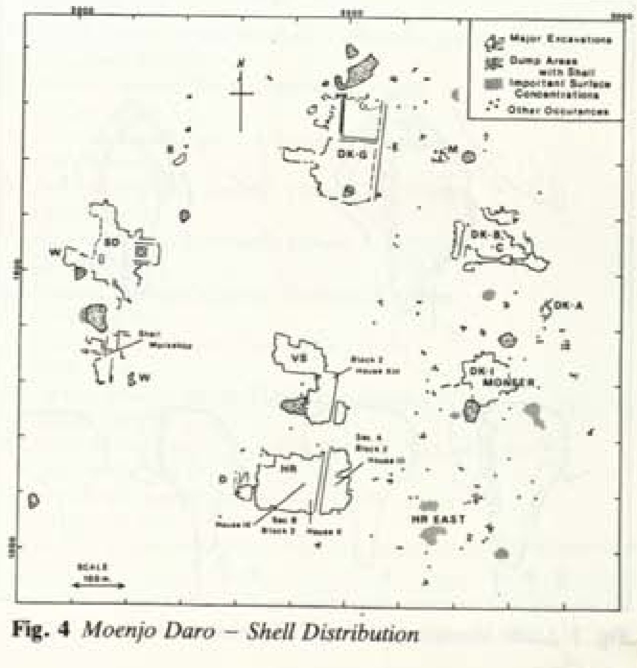


Fig. 4 *Moenjo Daro – Shell Distribution*

Fig. 5 *Distribution of Major Shell Fisheries*

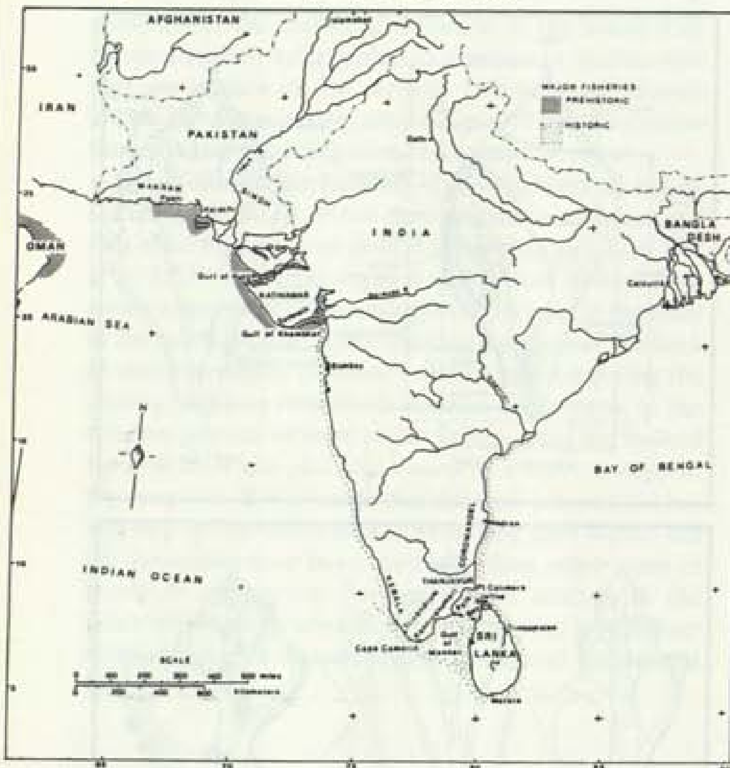
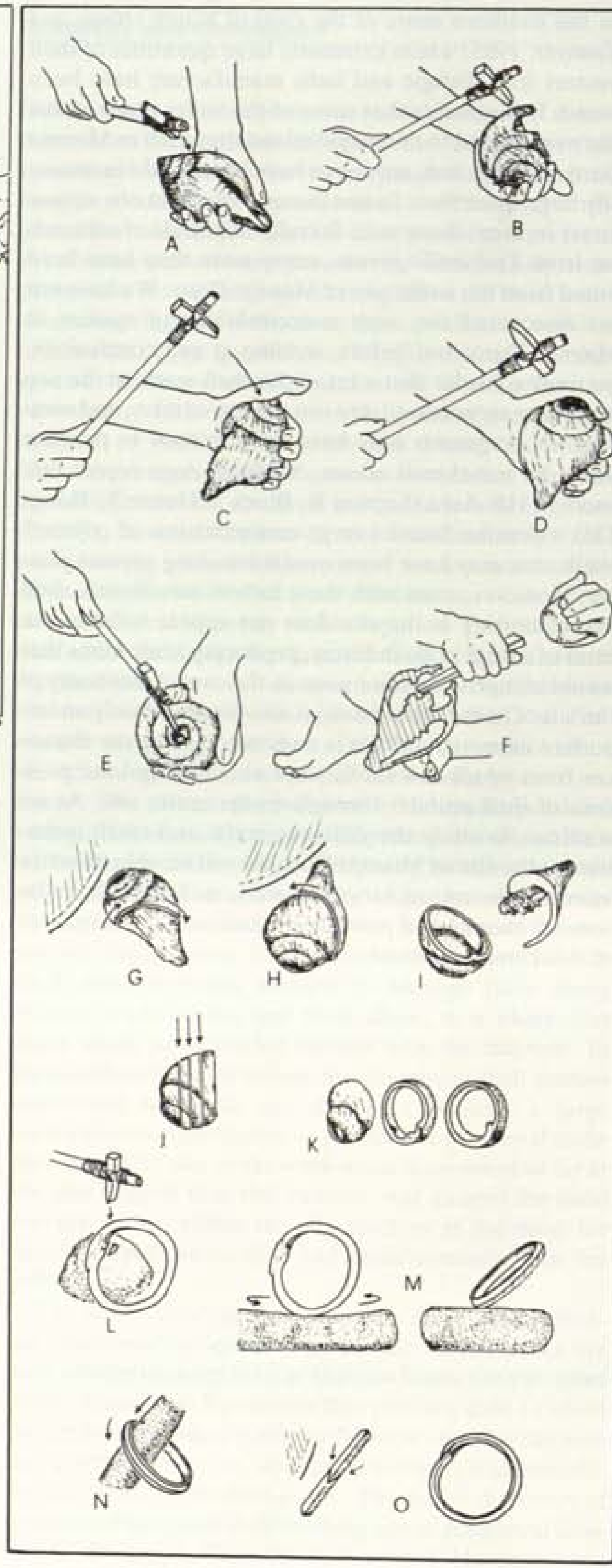


Fig. 6 *Bangle Manufacture with Turbinella pyrum*



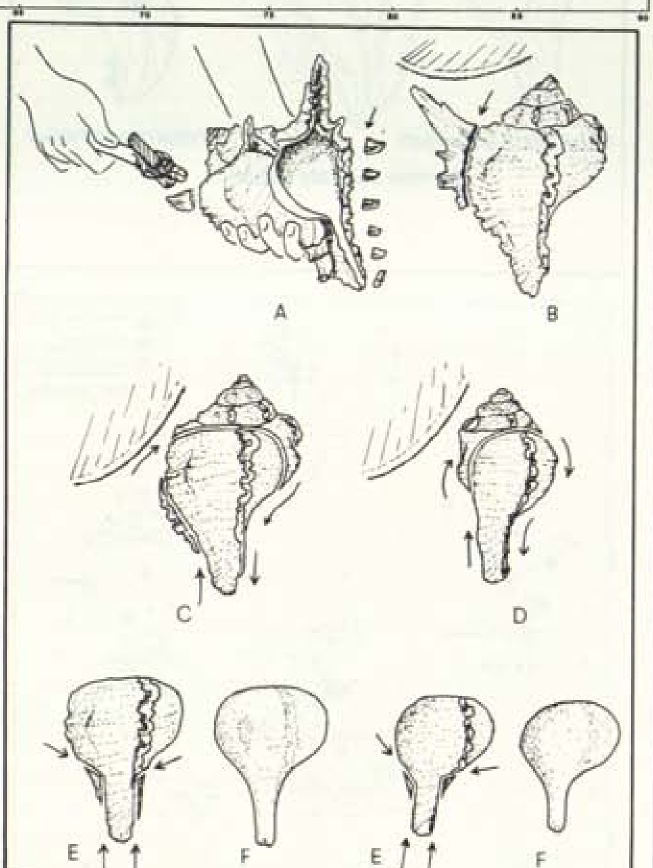


Fig. 7 *Ladle Manufacture with Chicoreus ramosus*

Fig. 8 *Inlay Manufacture with Lambis truncata sebae*

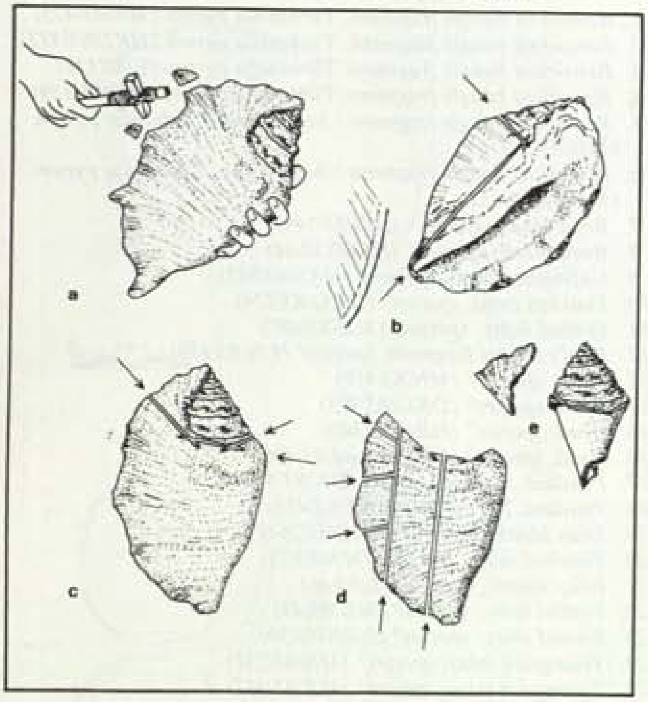
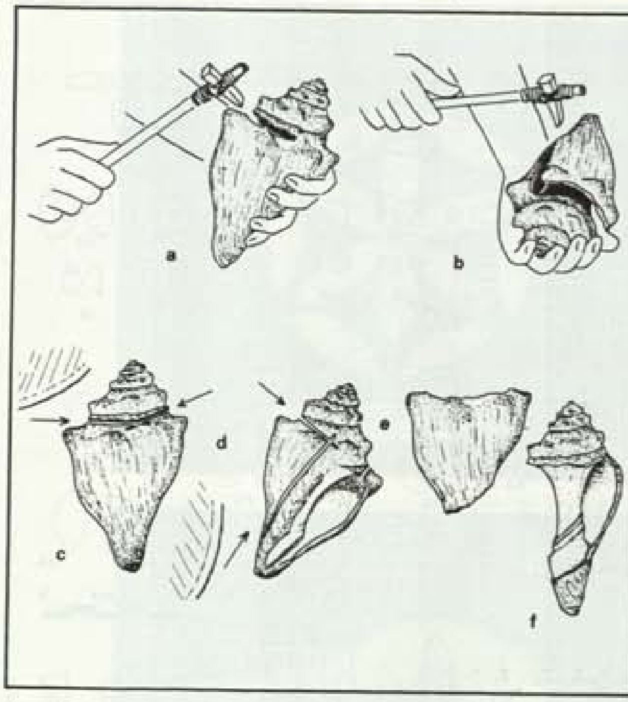
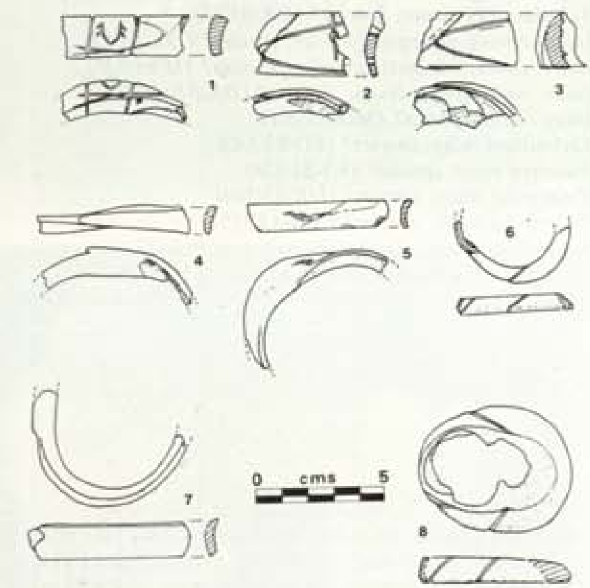


Fig. 9 *Inlay Manufacture with Fasciolaria trapezium*

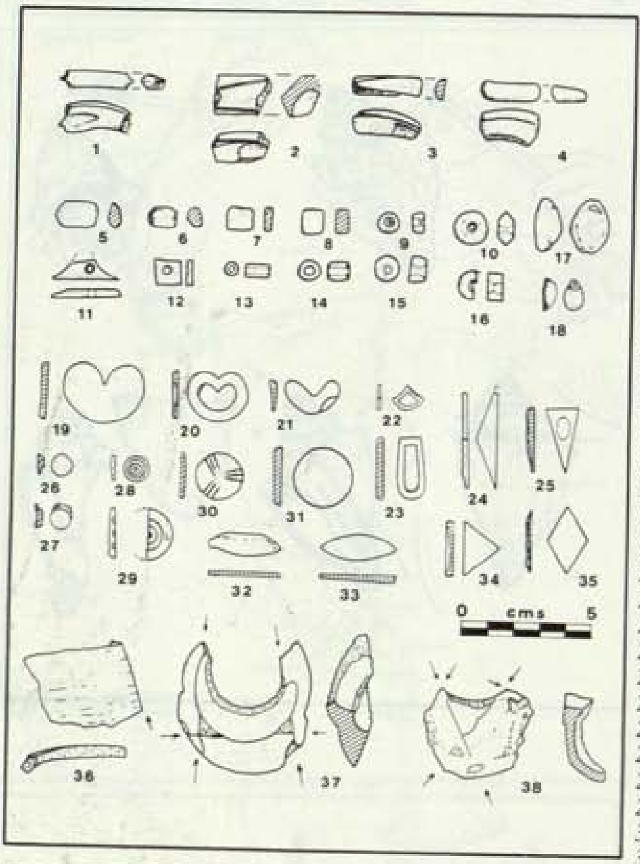




1. *Incised and engraved with script, Turbinella pyrum (MD/83/150)*
2. *Incised and repaired, Turbinella pyrum (HRE/83/554)*
3. *Incised, interior not finished, Turbinella pyrum (Channel/82/107)*
4. *Incised, heavily worn, Turbinella pyrum (MD/83/170)*
5. *Incised, heavily worn, Chicoreus ramosus (MN/83/416)*
6. *Incised, multiple slashes, Turbinella pyrum (MN/83/403)*
7. *Heavily worn, Turbinella pyrum (MD/83/148)*
8. *Incised, multiple slashes, Turbinella pyrum (DK/83/439)*
9. *Wide, heavily worn, Turbinella pyrum (E/83/104)*
10. *Wide, heavily worn, Turbinella pyrum (E/83/105)*
11. *Non-Harappan, ? Buddhist Period, Turbinella pyrum (MD/83/155)*
12. *Repaired, heavily worn, Turbinella pyrum (HRE/83/298)*

Fig. 10 *Moenjo Daro Bangle Fragments 1982-83*

Fig. 11 *Shell Artifacts – Moenjo Daro 1982-83*



1. *Reworked bangle fragment, Turbinella pyrum (MN/83/475)*
2. *Reworked bangle fragment, Turbinella pyrum (HRE/83/432)*
3. *Reworked bangle fragment, Turbinella pyrum (E/83/122)*
4. *Reworked bangle fragment, Turbinella pyrum (MD/83/159)*
5. *Reworked bangle fragment / bead blank, Turbinella pyrum (MD/83/539)*
6. *Reworked bangle fragment / bead blank, Turbinella pyrum (MD/83/540)*
7. *Bead blank, species? (MN/83/549)*
8. *Bead blank, species? (HRS/83/544)*
9. *Unfinished bead, species? (HRS/83/547)*
10. *Finished bead, species? (DKG/83/524)*
11. *Drilled Inlay, species? (MD/83/487)*
12. *Partly drilled fragment, species? (LN/83/418)*
13. *Bead, species? (MN/83/419)*
14. *Bead, species? (DKG/83/493)*
15. *Bead, species? (HRE/83/349)*
16. *Bead, species? (NE, Mound/83/490)*
17. *Pendant, Cypraea turdus (DK/83/525)*
18. *Pendant, Nerita, sp. (HRE/83/413)*
19. *Inlay blank, species? (HRE/83/264)*
20. *Finished inlay, species? (MN/83/71)*
21. *Inlay waster, species? (L/83/46)*
22. *Fretted inlay, species? (MN/83/49)*
23. *Fretted inlay, species? (HRN/83/50)*
24. *Triangular inlay, species? (MN/83/531)*
25. *Triangular inlay, species? (MN/83/417)*
26. *Unfinished ground disc, species? (MN/83/121)*
27. *Tubular drill waster, species? (DK/83/545)*
28. *Inlay, concentric incised circles, species? (DK/83/53)*
29. *Inlay, concentric incised circles, species? (M/83/535)*
30. *Inlay, with incised design, species? (DK/83/(220)*
31. *Inlay / disc, species? (MD/83/201)*
32. *Unfinished inlay, species? (SD/83/330)*
33. *Finished inlay, species? (VS/83/358)*
34. *Triangular inlay, species? (DK/83/304)*
35. *Triangular inlay, species? (MN/83/315)*
36. *Sawn body whorl, Turbinella pyrum (L/83/445)*
37. *Sawn apex fragment, Turbinella pyrum (MN/83/190)*
38. *Sawn and ground apex fragment, Turbinella pyrum (DK/83/523)*

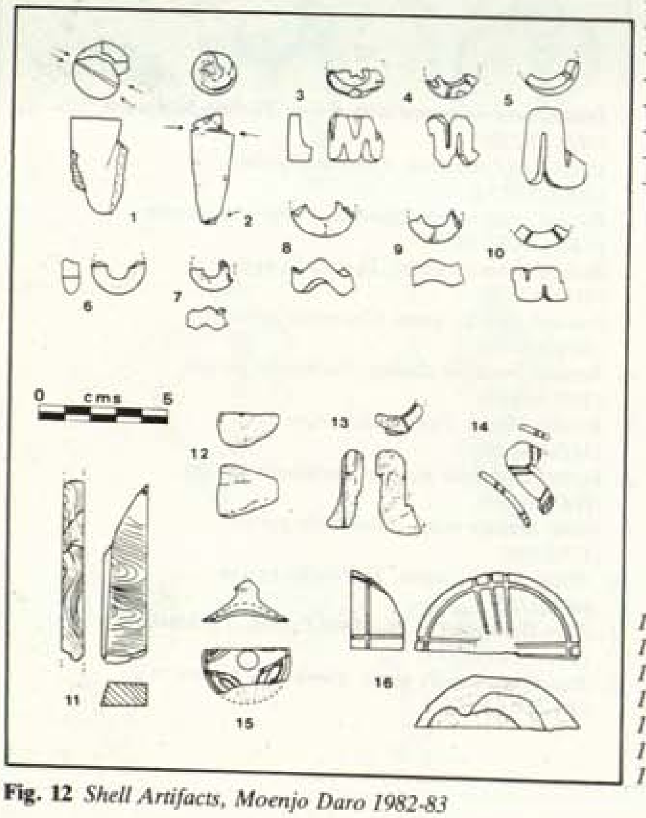
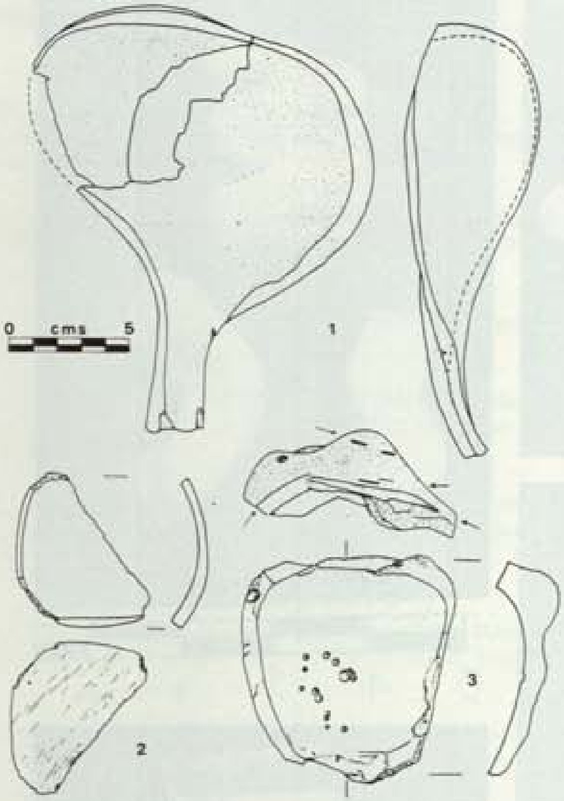


Fig. 12 *Shell Artifacts, Moenjo Daro 1982-83*

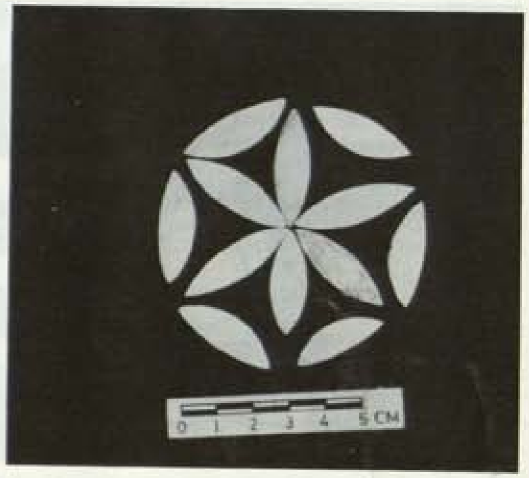
1. *Sawn columella, Turbinella pyrum (MD/83/196)*
2. *Sawn and ground columella, Turbinella pyrum (HR/83/412)*
3. *Unfinished „wavey ring", Turbinella pyrum (DK/83/415)*
4. *Unfinished „wavey ring", Turbinella pyrum (DK/83/546)*
5. *Finished „wavey ring", Turbinella pyrum (HRS/83/110)*
6. *Finished ring, Turbinella pyrum (MD/83/203)*
7. *Finished „wavey ring", Turbinella pyrum (MD/83/191)*
8. *Finished „wavey ring", Turbinella pyrum (MN/83/209)*
9. *Finished „wavey ring", Turbinella pyrum (DK/83/52)*
10. *Finished „wavey ring", Turbinella pyrum (HRE/83/252)*
11. *Sawn plank, Lambis truncata sebae (MD/83/198)*
12. *Sawn and ground columella, Turbinella pyrum (SD/83/542)*
13. *Unfinished object, Turbinella pyrum (DK/83/542)*
14. *Broken figurine, ? Tortoise, species? (HRS/83/526)*
15. *Carved lid, Lambis truncata sebae (MN/83/414)*
16. *„Cap", ½ type, Turbinella pyrum ((MN/83/72)*

Fig. 13 *Moenjo Daro Shell Artifacts 1982-83*

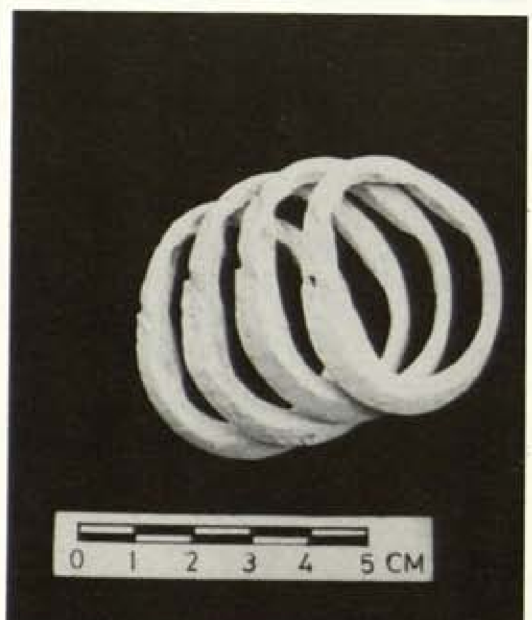
1. *Ladle, heavily worn, Chicoreus ramosus (E/83/99)*
2. *Inlay rough-out, sawn and chipped, Turbinella pyrum (E/83/97)*
3. *Drill back made from inlay waster, Lambis truncata sebae (DK/83/45)*



Upper
MD Reserve *Shell Inlay*
Middle
MD Reserve *Shell Container „Libation vessel" Turbinella pyrum*

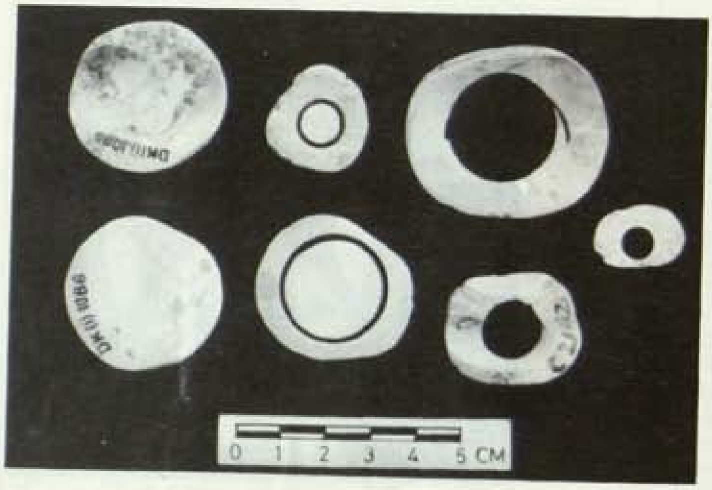


MD 1983 *Cone Manufacture from Columella of Turbinella pyrum*

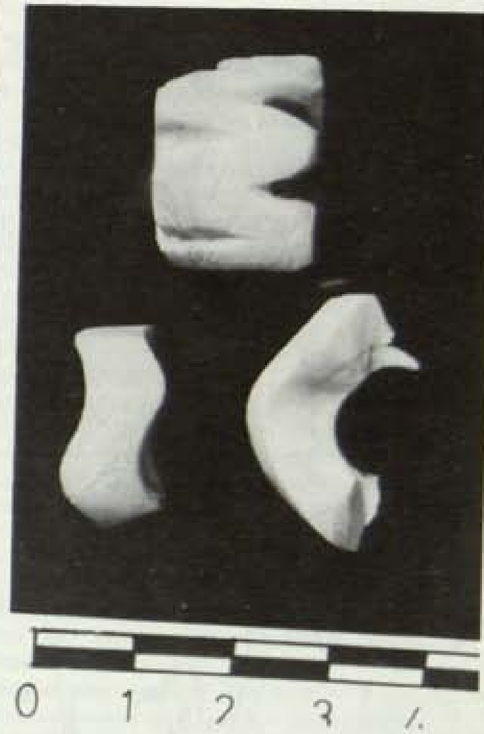


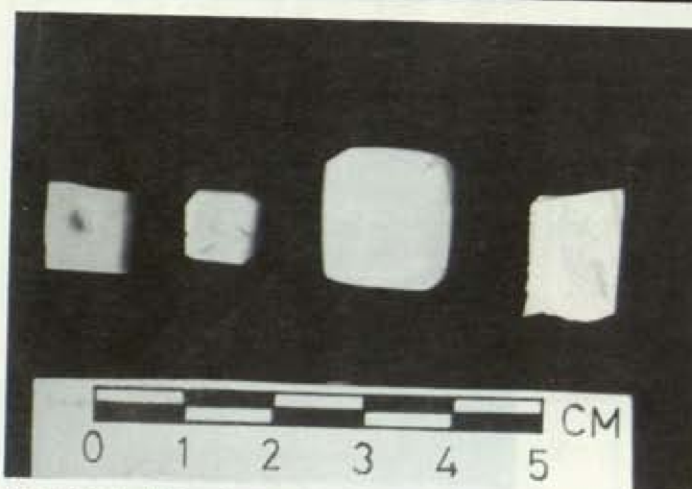
MD Reserve *Shell Bangles Turbinella pyrum*

MD Reserve *Tubular Drill Blanks – Discs and Wasters*

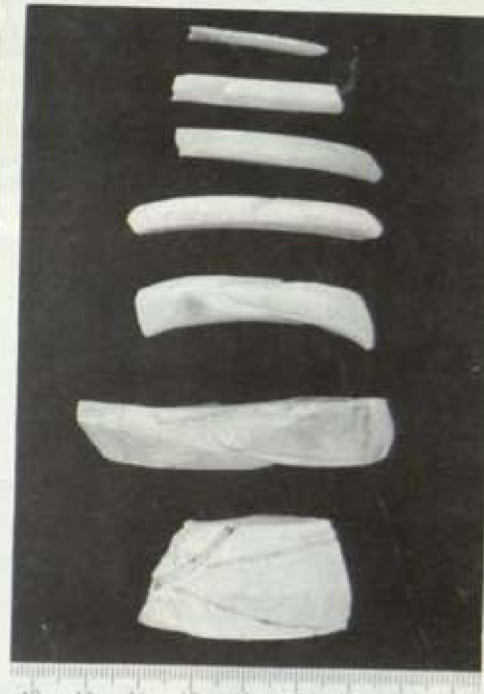


MD 1983 *Wavey Ring Manufacture*





MD 1983 *Bead Manufacture from Small Wasters*



MD 1983 *Turbinella pyrum*

Bibliography

ABBOTT (R.T.) (ed.) 1959-1976, Indo-Pacific Mollusca, Vol. 1,2,3, Philadelphia: Dept of Mollusks, Academy of Natural Sciences.

BHAN (K.), KENOYER (J.M.) 1983, Nageshwar, an Industrial Centre of the Chalcolithic Period, *Puratattua No. 12 (1980-81), pp. 115-120.*

BOSCH (D.), BOSCH (E.) 1982, Seashells of Oman, London-New York.

DALES (G.F.), KENOYER (J.M.) 1977, Shell Working at Ancient Balakot, Pakistan. In: *Expedition*, Vol. 19 (2), pp. 13-19.

GUPTA (S.K.) 1977a, Quaternary Sea-level Changes on the Saurashtra Coast. In: *D.P. AGRAWAL, B.M. PANDE (eds.), Ecology and Archaeology in Western India*, Concept Pub., New Delhi.

GUPTA (S.K.) 1977b, Holocene Silting in the Little Rann of Kuch. In: *D.P. AGRAWAL, B.M. PANDE (eds.), Ecology and Archaeology in Western India*, New Delhi.

HORNELL (J.) 1914, The Sacred Chank of India. A Monograph of the Indian Conch, (Turbinella pyrum) Bull. 7, Madras Fisheries Bureau, Madras.

HORNELL (J.) 1915, The Sacred Conch (Turbinella pyrum Linne) and its relation to Hindu Life and Religion, London.

HORNELL (J.) 1951, Indian Molluscs, The Bombay Natural History Society, Bombay.

KENOYER (J.M.) (in press), Shell Working at Mohenjo-Daro, Pakistan. paper presented at the 7th Annual Conference of the Association of South Asian Archaeologists in Western Europe, Brussels (1983).

KHAN (M.D.), DASTAGIR (S.G.) 1971, Records: Zoological Survey of Pakistan, Voll. II, No. 1, Karachi, pp. 17-130.

MACKAY (E.J.H.) 1938, Further Excavations at Mohenjo-Daro, Vol. I-II, Delhi.

MARSHALL (Sir J.) 1931, Mohenjo-Daro and the Indus Civilization. Vol. I-III, London.

MAHADEVAN (S.), NAGAPPANNAYAR (K.) 1974, Ecology of Pearl Oyster and chank Beds. In: *R.V. NAIR, K.S. RAO (eds.), The Commercial Molluscs of India*, ICAR Bull. of the Central Marine Fisheries Research Inst., No. 25, pp. 106-121, Cochin.

MEADOW (R.) 1979, Prehistoric Subsistence at Balakot: Initial Consideration of Faunal Remains. In: *M. TADDEI (ed.), South Asian Archaeology 1977, Naples, pp. 275-315.*

SMYTHE (K.) 1982, Seashells of the Arabin Gulf.

SNEAD (R.E.) 1967, Recent Morphological Changes Along the Coast of West Pakistan. In: *Annals of the Assoc. of American Geographers*, Vol. 57, No. 3, pp. 550-565.

SNEAD (R.E.) 1969, Physical Geography Reconnaisance: Pakistan Coastal zone, Univ. of New Mexico Press, Albuquerque

TOSI (M.) 1982, A possible Harappan Seaport in Eastern Arabia: Ra's Al-Junayz in the Sultanate of Oman. Paper presented at the 1st International Conference on Pakistan Archaeology, Peshawar.

A Selection of Inscribed Objects Recovered from Mohenjo-Daro

Ute Franke
Freie Universität Berlin

Appendix I by
Gerwulf Schneider
Wilhelm Büsch
Freie Universität Berlin

A Selection of Inscribed Objects recovered from Mohenjo-Daro

The objects published here for the first time were unearthed in Mohenjo-Daro in the 1982 and '83 seasons by members of the German Research Project Mohenjo-Daro in cooperation with the Joint Mission ISMEO/RWTH Aachen to Mohenjo-Daro. My thanks are due to the directors, Dr. M. Jansen and Dr. M. Tosi for their kind permission to publish the objects, and for their constant support during the preparation of this paper.

The research carried out by M. Vidale furnished the basic information without which it would not be possible to comment on the production technology of certain objects discussed here (cf. this vol.).

Discussion with these colleagues, especially with Dr. M. Jansen and T. Urban, stimulated many of the points raised in this contribution.

I am also grateful to Prof. H.J. Nissen, Dr. D. Potts and T. Goetzelt for checking the manuscript.

A special word of thanks to the Project members in Aachen, particularly to the coordinating editor Dr. I. Leinen, our photographer G. Helmes and graphics expert R. Bunse. Dr. M. Mulloy kindly checked the translation.

A. Holdsworth revised those parts of the text which were originally written in English.

Introduction

The various types of objects described here have one common denominator – they all bear inscribed characters. As long as the Harappan script defies decipherment however, we are denied direct access to the information these inscribed objects were intended to transmit. Thus we have no alternative but to attempt to reconstruct this information by direct means, using the inscribed objects and their archaeological context as the starting-point. In other words, rather than attempting an abstract study of the written characters in isolation, we have to concentrate initially on the broad material aspect – the actual objects bearing the inscribed Harappan characters in relation to their finding-places.

Both seals, seal impressions and/or other inscribed objects are not only themselves the end-products of a particular technology but also play – to a certain extent – a part in the production processes of other objects. If the function of the objects bearing characters within these continuing processes were known, then (according to our hypothesis) inferences could be drawn regarding the 'function' and significance of the script itself and hence also regarding the general organisation of the economy and society in the broadest sense.

As instruments designed for repeated routine use, the seals would appear to have had a special function in this organisation. As a sealing and seal impressions on various vessels testify, one of their fields of application was trade and manufacture. The areas of human activity indicated by other uses of seals, such as seal impressions on clay tablets etc., cannot yet be determined. This is also true of the written characters, whose inscription on objects of various types (vessels, bangles, small sticks of ivory etc.) could, but need not necessarily be directly related to the actual objects bearing them and their function.

Apart from considering the relationship between the written characters and the objects thus inscribed with a view towards reconstructing the possible function of the latter, attention will also be focussed on the script types and character combinations. This analysis involves studying the script as a whole within its archaeological context, i.e. going beyond the purely linguistic aspect to include the entire situational perspective.

Before the investigation proper can begin, the archaeological material must be documented in full according to products, means of production and context. This work is currently being carried out as part of the Surface Evaluation Programme (SEP) and the Architectural Documentation. The preliminary work of Halim/Vidale (cf. this vol.) on the context of the sealing discovered and the reconstruction of part of the manufacturing process of 'stoneware bangles' has already produced concrete observations in this field. These bangles have turned up in unexpectedly large numbers in comparison to the types of objects previously published, and therefore assume new importance as bearers of inscribed characters. Because of their sheer quantity, the 'stoneware bangles' provide ample opportunity for comparative studies and are the major theme of this paper.

Naturally, much detailed research still remains to be done before results can be expected confirming that this hypothesis (which will be treated more extensively elsewhere) is on the right track. Apart from this caveat however, the very discovery of a whole new category of material inscribed with characters is in itself an event which deserves to be made public.

The Objects

The 39 objects presented here comprise 3 seals, 1 sealing, 9 vessel fragments with seal impressions, 4 with inscribed characters, 20 bangles with inscribed characters and 2 small copper tablets. With the exception of the sealing[1], all these objects were surface finds. Largely as a result of a systematic surface analysis[2], concentrations of objects were found in certain areas (MN-S, HR-E, VS). So far, only objects found in the MN-S area have been analysed within their archaeological context.

1. Seals

Pl. 4, 5. Fig. I, 1.1 - 1.3

With their square shape and perforated 'boss' on the reverse the 3 seals correspond to Marshall's Type B *(Marshall, 1931: 370)*. Two of the seals (Nos. MN 83-611 and MN 83-611a) are made of grey steatite and show the 'unicorn'; they were recovered from the rubble heaps left over from earlier excavations in the Moneer site[3]. The third seal, made of light-blue frit, was unearthed by workmen engaged in clearing operations in the modern rubble fill of a room in the VS-A area. It bears the Greek cross, a motif which in contrast to the swastika is of very rare occurrence.[4]

2. The Sealing

Pl. 6, Fig. I, 2.1

Eight earthenware vessels came to light in the course of the SEP in the Moneer-East area in 1982 *(Halim/Vidale: this vol.)*. Two of these vessels, classified by Vidale as 'Coated Carinated Containers' or 'Jars', each displayed 2 clay discs with seal impressions still fixed in place. The evidence of one of the jars shows that the lid as well as the upper rim was covered by a clay disc applied before the vessel was fired. The sealing was broken when the jar was opened. The seal impressions preserved on Jar F are too fragmentary for the seal type to be determined. Jar E, on the other hand, bears one complete impression and half of another, both very probably left by the same seal – square in shape with 7 Harappan characters and depicting a unicorn facing a so-called 'stand' or 'brazier'. This find represents the first genuine sealing known from Mohenjo-Daro as all the loose clay impressions previously published merely bore traces on the reverse of having once been affixed to objects but none was actually found in situ[5]. The Jar E sealing is also significant because of the particular vessel type it is attached to, which may perhaps have been used in some manufacturing process *(Halim/Vidale: this vol. and pers. comm.)*. The sealing indicates that some sort of control was exercised on the jar, and this check together with the marking of the jar and its contents is therefore evidence of a particular function for which seals were employed.

3. Seal Impressions on Vessel Fragments

Pl. 7, Fig. II, 3.1 - 3.9

All 9 sherds bearing seal impressions that we found belong to the type of ware classified by Marshall *(1931: LXXX)* as *'Scored Ware'*, *'Pointed Goblet'* or *'Pottery Type B'*. Four of the sherds are rim fragments, 4 are wall fragments and 1 a base fragment. The seal impressions were all made with the same type of oblong seal showing characters only. All the previously published examples of sherds with seal impressions also belong to this class of vessel and were also marked with the same type of seal. The function of these pottery vessels, ranging in quality from coarse, hand-formed ware to fine, wheel-thrown pieces, has yet to be discovered. However, the concentrations of pottery wasters and nodules found to the E of VS-B and HR[6] indicate that these wares were made on the spot and/or reused within other firing processes. The inscriptions, which vary in length from 2 to 4 characters, are often barely legible as a result of the poor quality of the impressions, misfiring or other damage.

4. Copper Tablets

Fig.I, 4.1-4.2

The two tablets presented were both found near the VS-Area. Their state of preservation is relatively good, although one piece is broken, but both are covered by a thick layer of corrosion. Using our facilities this could only be partly removed and thus their decoration is still uncertain.

Both belong to the common, oblong type with scratches on both sides. No. 609 has on one side a single sign in the middle. The identity of the roughly scratched sloping animal figure on No. 610 is uncertain.

5. Graffiti

5.1 On Pot-Sherds Fig.III,5.1.1-5.1.4

Only four examples of graffiti were found, two of them (MN-E 82d, MN-E 82e) are more likely to be potter's marks rather than inscriptions. The longest inscription consists of three signs (Channel 82-32).

Each sign consists of overlapping strokes which, through this overlapping quality reveal the sequence in which they were applied. But as the signs themselves do not overlap the direction of the writing cannot be deduced from this specimen.[7]

The mark on the lid MN-E 82e does not resemble a sign, but it is significant in relation to it's supposed function. As fragments of this kind of lid, stoneware covered with a thick layer of chaff-tempered clay, have been found in the proximity of Coated Sub-Cylindrical Bowls, which were probably used in the production of the bangles, it is possible that the lid was used as a cover for them. On the evidence of the coarse clay layer it would appear that the stoneware bowl and lid were used together to form a closed container.

5.2 On Bangles
Pls.1-3, 8-12. Figs. IV,V,VI,5.2.1-5.2.20

19 out of the 20 inscribed bangle-fragments found are made of stoneware, the remaining one of shell. The stoneware is characterised by a very fine texture with hardly any signs of tempering visible to the naked eye.[8] In colour the pieces range from sand or beige to black, many of the fragments being mottled.

Out of 60 bangle-fragments found altogether only one specimen is red (629). Both colour and consistency indicate a high firing temperature for all pieces except the red one, which was probably fired at a lower temperature and in an oxidising atmosphere.

The surface, in some cases highly polished, often exhibits shallow, regular grooves. Additionally some pieces have a concentric, regular deeper groove in the inner surface (612, 613, 621, 627, 2966).

More often slight concentric ridges are visible on one edge of the inner surface, which mostly remained unpolished, and may be traces of some form of attachment (612, 615, 617, 618, 621, 623, 624, 625, 626, 2966).

The profiles of the bangles being oval, and no two exactly alike, Marshall suggested the use of a wheel in their manufacture, probably because of the shallow grooves *(1931: 530)*, and Mackay a mould *(1939: 536)*. But no traces of a join are visible on the complete specimen (621), nor on the fragment cut for the thin-section analysis. Nevertheless, a cast or mould would appear to be more probable because of the exterior appearance of the bangles.

Both Marshall and Mackay noted the occurence of these kind of bangles on the basis of their technically interesting aspects rather than on the inscriptions. Comparing an analysis made by L.D.S.Ullah *(Marshall 1931: 530, 686, 689)* with one of the brownish-green substance found inside the sealed and overfired jar, Vidale took into account the possibility that this substance was used in the manufacture of the bangles *(Vidale: pers. comm.)*.[9]

Further evidence on the manufacturing process was obtained from two waste bangle fragments which were found still joined to the interior of a coated stoneware-bowl. Vidale has suggested that a maximum of three specimens could be fired in one bowl *(Halim/Vidale 1983: 5)*. More bangle fragments were found in connection with these bowls (612, 616, 629), two of which have almost identical inscriptions (616, 629). Others were found in a kiln-area together with bowl-wasters (623, 624, 626, 2966). Bangles, bowls, lid and container thus provide us with evidence of a complicated, technically highly developed and labour-intensive production process of a distinctive group of artifacts, with which the script is interrelated, by the use of sealing in the initial stages, by inscribing the bangles before firing, and by marking the lids of the bowls before firing. The inscriptions on the bangles and their variations to those on the seals, due to the material and possibly their purpose, aroused only the superficial attention of Marshall and Mackay.[10] The inscriptions were incised with a pointed tool averaging 0.05 cm in width, and range in height from 0.2 cm to 0.5 cm. Thus they are in some cases minute and hard to recognise, which is probably the reason why they have been overlooked to some extent.[11] The number of signs varies from one to seven for each inscription.[12] Apart from No. 629, which has two inscriptions, all fragments have only one. The total number of signs used is 43[13], 25 of which are basic signs, the remaining 18 being variants of these.[14]

Allowing for minor discrepancies 22 of the signs could be identified with those documented by *Parpola (1980)* and *Mahadevan (1977)*, while for 17 signs iden.ification was difficult due to the greater degree of variation, and it was totally impossible for four.[15]

The problems of identification, and defining the limits of variation are due in part to subjectivity, but greater difficulties arise from the fact that the sign-lists are *„normalized"* according to the script on seals and the capabilities of a computer.[16] Through this method, variants, which occur more frequently in a cursive script than in a hieratic one, necessarily become adjusted and are lost for further research.

Therefore the collection of inscribed bangles is an important part of the overall corpus of inscribed objects, as it forms an alternative to the present limitations of the inscriptions preserved in stone. The more cursive character of the script in clay provides more insights into the development and variability of the Harappan script on the one hand, and on the other it is more suitable for a comparison with other scripts.[17] In this respect the question of whether the variants should be considered as *„new"* signs is of secondary importance. An analysis of sign-distribution in relation to different object-classes would be of interest, but requires more material. The same goes for the question of the function of the inscriptions on the bangles, which in general are too minute to be read from a distance. Through traces of wear, in the form of scratches, and because of the diameter [18] we may assume that they were personal ornaments, but it remains unsure as to whether they were common, a luxury, or had some sort of function. The shell-bangle fragment is the only inscribed specimen of its kind known so far *(Marshall 1931: 531)*. It is made of Turbinella pyrum L. or *„conch shell"*, a shell which was and still is the common raw-material for bangle production *(Kenoyer 1984)*. Evidence of local production at Mohenjo Daro is obtained from the distribution of wasters and refuse, particularly in L-Area *(Kenoyer 1983)*.

Catalogue of Objects

Abbreviations:

FS: Findspot. The numbers refer to the Co-ordinate Grid established by the German Research Project (GRP).

Mt:	*Material*	*M:*	*Measurements*
D:	*Description*	*C:*	*Comparanda*
Pl.:	*Plates*	*Fig.:*	*Figures*
w:	*width*	*h:*	*height*

The object numbers refer to Area, year and subsequent classification number. Objects collected before 1983 do not have subsequent numbers and are registered by year and a, b, c,... The textual reference to subsequent numbers is only for the sake of space.

Figures I,1,3,4, II,5, III,2 are prepared by R. Bunse (GRP), figures II,6-9 by T. Urban.

1. Seals

1.1 MN 83-611 Pl.4. Fig.I,1

FS: 2730/1240. Dump-area southwest of Moneer

Mt: light-grey, glazed steatite

M: 2,5 x 2,5 x 0,6 cm

D: square seal with perforated boss on the back, showing the *„unicorn"*-figure, *„stand"* and five script-signs. The seal is in a very good state of preservation with only some corner-fragments broken off. The animal's head is raised, the tubular mouth opened. To the left of the horn a part of the second ear is visible. Behind the cheeks, which appear to be very thick, a segmented band runs around the neck. On the forepart two plain bands, each consisting of two lines, indicate the so-called *„cover"*· The left-hand band is curved and ends at the breast of the animal, while the right one is straighter and stops behind the left foreleg. Running from between the forelegs to the tommy is a feature, which may be the dewlap. The *„manger"* is placed below the head, the lower part being formed by a semi-circle with simple horizontal lines, the upper part being an approximated square with concave right- and left-hand sides. It is segmented by one horizontal and 14 vertical lines. Proportional relations and workmanship of the seal are good.

1.2 MN 83-611a Fig. I,2

FS: 2890/1390. Dump-area northeast of Moneer

Mt: grey steatite

M: 3,3x3,3 (?)x0,4cm

D: square seal with perforated boss on the back. Due to it's fragmentary state of preservation not much can be said about this object. Still visible is the forepart of a unicorn with most probably the same decoration on the neck and breast as on No. 611. Above it's head two characters are partly preserved, possibly both the same sign.

1.3 VS-A 83a Pl.5. Fig.I,3

FS: 2480/1280. VS-A. Block 2, house XII, Room 45 north-east corner, ca. 10,0 cm below surface, in the deposits in the room.
Mt: light, blue paste
M: 1,5x1,5x0,4cm
D: square seal with perforated boss on the back. The very unusual motif consists of a cross with equally proportioned arms, in the middle of which a second cross is formed by two incised lines. The space between the arms and the outer frame is filled in three cases by drilled circles, while the remaining one has only a cut, probably from a tool.
C: Marshall 1931: Pl. CXIV, 520, 528b. Mackay 1939: 342, Pl. LXXXIII,1; LXXXVI, 156

2.Sealing

2.1 MN 82a Pl.6 Fig.I,4

FS: 2820/1210. Trench Moneer-East
Mt: clay
M: not available
D: the sealing depicts the unicorn with *„manger"* and pictographs. Although the impression is quite deep, except for the lower part, no decoration is visible on animal or *„manger"*. Horn and parts of inscriptions are destroyed, five complete and one half sign being readable, while the suspected last sign is too fragmentary to be identified.[19)]
C: Marshall 1931: Pl.CXVI, 30.
Mackay 1939: Pls. XC, 17, CII, 2,4,5,6,8,11; CIII, 10; XCI,11,22.

3. Seal Impressions on Vessel Fragments

C: Marshall 1931: 292, 380f., 393, 397; Pls. LXXVIII, 3:1; CXV, 558-560
Mackay 1939: 183f., Pls. LX, 15; LXVII, 5

3.1. VS-E 83-605 Fig. II,1

FS: 2530/1260. East of VS-B in an area with concentrations of pottery wasters, all belonging to the Scored Ware, classified as Type B *(Marshall, 1931: Pl. LXXX, 1-8)*.
Ware: Red-brownish clay with fine inorganic temper. On the outside a greenish-yellow glaze, forming drops and bubbles. Overfired.
Waster of Type B.
M: Ø 9,8 cm
thickness: 0,4 - 0,7 cm
D: A slanting seal-impression measuring 1,93 x 1,2 cm is placed between the rim and the slight groove on the shoulder. Due to the bad condition only one of the two signs is legible.

3.2 VS-W 83-606 Fig. II,2

FS: 2405/1260. Southwest of VS-A in unexcavated area.
Ware: Fine grey clay with inorganic temper. Fired at high temperature. Type B?
M: Ø 7,15 cm
thickness: 0,35 - 0,4 cm
D: A faint seal impression measuring 1,6 x 1,05 cm is placed 1 cm below the rim. Of the three signs the left one is very faint.

3.3 D-N 83-607 Fig. II,3

FS: 2250/1250. North of the excavations of Dales.
Ware: Grey clay with coarse inorganic temper and a yellowish slag in- and outside, forming drops, bubbles and holes.
Overfired rim-waster of Type B.
M: Ø 8,2 cm
thickness: 0,5 - 0,6 cm
D: The seal-impression, measuring 1,7 x 1,05 cm is placed below the rim. Due to the bad preservation, the signs, probably two, are illegible.

3.4 VS-E 83-608 Pl.7, Fig. II,4

FS: 2510/1260. Area east of VS-B with concentrations of Type B wasters. Near to VS-E 83-605.
Ware: Dark-grey clay with coarse inorganic temper. Fired at high temperature. Rim-fragment of Type B.
M: Ø 8,4 cm
thickness: 0,4 - 0,5 cm
D: The impression is placed below the rim and shows three signs.

3.5 Channel 82-1535 Fig. II,5[20)]

FS: Dump of Channel
Ware: Type B, bottom
M: thickness: 0,6 - 0,9 cm

D: The impression is placed above the bottom, and points downwards. One corner is broken off, leaving four signs. The measurement is ?? x 1,2 cm.

3.6 Channel 82-1536 Fig. II,6

FS: Dump of Channel
Ware: –
M: –
D: The faint impression, measuring 2,7 x 0,95 cm, depicts 9 signs, 8 of them being strokes, which probably form 2 units.

3.7 Channel 82-1537 Fig. II,7

FS: Dump of Channel
Ware: –
M: –
D: One part of the faint impression is broken off, the height being about 1,1 cm. Three of the seven preserved signs are long strokes, two are short ones.

3.8 Channel 82-1538 Fig. II,8

FS: 2820/1295. Dump of Channel east of Moneer
Ware: –
M: –
D: The sherd is a fragment of the shoulder, upon which the impression is placed. The limitations to the right and the left of the three signs are not clearly visible, the height is 1,1 cm.

3.9 MD 82b Fig. II,9

FS: –
Ware: brick-red, coarse tempered clay. Type B.
M: –
D: The only partially preserved impression is placed on the lower part of the body and contains only 5 small strokes, being arranged in two lines.

4. Copper Tablets

4.1 VS-N 83-609 Fig.I,5

FS: 2500/1450. North of VS-Area
Mt: copper
M: 2,9 x 1,6 x 0,15-0,25 cm
D: The badly corroded oblong tablet, which is broken info two pieces, is inscribed on both sides. On one side a single sign is placed in the middle, and due to the corrosion on the other side only a part of one sign is visible, on the right-hand side.

4.2 VS-E 83-610 Fig.I,6

FS: 2540/1260. East of VS-B in the area where wasters were also found. Near to Nos. 605 and 608.
Mt: copper
M: 3,45 x 1,6 x 0,22-0,42 cm
D: An inscription is scratched on one side, of which only the right-hand sign is clearly legible, while the one on the left is unsure due to the corrosion. A crude animal is to be seen on the back, also partly covered by corrosion, which makes an identification of the slanting figure merely hypothetical.

5. Graffiti

5.1 On Pot-Sherds[21]

C: Marshall 1931: 291 f., Pls.XC,5-7 (s.a. LXXXIII, 52)
Mackay 1939: 182-3, Pls. LVII,35,36,38,42; LXIII,3,6.[22]

5.1.1 DK-B 82c Fig.III,1

FS: DK-B
Ware: light-red, fine tempered clay
M: –
D: Bottom of a dish (?), dia approx. 11,0 cm, with one fragmentary sign on the outside

5.1.2 MN-E 82d Fig.III,2

FS: Moneer-Area
Ware: red,coarse clay
M: –
D: body-fragment with grooves and one sign, partly broken off.

5.1.3 MN-E 82e Fig.III,3

FS: 2950/1250. Dump of a channel, southeast of Moneer
Ware: The sherd consists of two layers of different material. The lower one, in thickness 0,5 to 0,65 cm, is of a very fine texture, the colour inside being grey, outside more brownish. It belongs to the „stoneware" group. The upper layer adherent to it on the top and sides, is formed by a coarse chaff-tempered clay. This type of ware is the sa-

me as used for the Coated sub-cylindrical Bowls *(Halim/Vidale, 1983: 4)*, for which this piece might have served as a lid.

M: Ø 12,0 cm; thickness 0,8-1,2 cm

D: On the remaining half of the lid an engraved mark is visible, which is not reminiscent of a script sign, but is more of a floral design, the application of which might be seen in the context of the production processes referred to above (see section on graffiti on bangles).

5.1.4 Channel 82-32 Fig.III,4

FS: Dump of channel.[23)]

Ware: reddish clay with fine inorganic temper. Wheel-made

M: outer Ø of ring: 12,8 cm; thickness: 1,3 cm

D: The sherd is a fragment of an even round plate or stand *(Marshall 1931: Pl. LXXXIII,52)* with a 2,2 cm high ring, behind which the rest is broken off. Towards the middle three large signs are engraved, measuring 3,3 to 4,2 cm in height and about 0,2 cm in width. The strokes, of which one sign is formed are overlapping and thus reveal their sequence of engraving. In the centre traces of cutting off the pot from the wheel are clearly visible.

5.2 On Bangles

a. „Stoneware"

C:[24)] Marshall 1931: 529, 530f, 686, 689, Tf.1. Pls.CLII,1,10-12.
Mackay 1939: 536f, Pls. CXXXVI, 93, 94; CXL, 65, CXLII, 7, 8, 19, 23, 25, 26

5.2.1 MN-E 83-612 Fig.IV,1

FS: 2950/1250. Moneer east, near to the channel.

Ware: [25)]inside – black to sand with small holes; outside - spotted black to sand, highly polished.

M: Ø 9,0 cm / 5,1 cm[26)] w:1,95 cm; h:1,0 cm

D: On the inscribed side the piece shows concentric ridges 1,0 cm broad, and up to 0,15 cm high; on the other side a 0,1 cm deep regular groove. The inscription consists of three signs, average height 0,35 cm.

5.2.2 E 83-613 Fig.IV,2

FS: 2750/1725. North of Trench E

Ware: inside – darkgrey; outside – shiny dark-brown, polished

M: Ø 8,0 cm / 5,0 cm; w:1,5 cm; h:1,3 cm

D: a very slight regular groove in the side with the 0,6 cm high sign

5.2.3 E 83-614 Pl.8 Fig.IV,3

FS: 2775/1730. North of Trench E

Ware: inside – light to dark grey; outside – shiny, dark-beige to black

M: Ø 8,5 cm / 5,2 cm; w:1,65 cm; h:1,3 cm

D: The height of the five, thin signs ranges from 0,2 cm to 0,3 cm. The upper part of this side shows a lot of small scratches.

5.2.4 DK-M 83-615 Fig.IV,4

FS: 2760/1720-5. Near DK-M, north of Trench E

Ware: inside – grey to sand mottled; outside – spotted from shiny dark-grey to dark-beige

M: Ø 8,0 cm / 5,5 cm; w:1,65 cm; h:1,2 cm

D: slight regular, concentric ridge on both sides. The height of the inscription, consisting of three strokes, is 0,3 cm.

5.2.5 MN-E 83-616 Pl.9 Fig.IV,5

FS: 2950/1250. Moneer-East near to channel

Ware: in- and outside matt sand with dark-grey spots

M: Ø 8,4 cm / 5,6 cm; w:1,45 cm; h:1,4 cm

D: This piece is of a more coarse consistency than the others and is unpolished. The two, 0,6 cm high signs are nearly exactly the same as those on MN-S 83-629

5.2.6 MN 83-617 Fig.IV,6

FS: 2750/1325. Moneer-East

Ware: inside – dark grey; outside – black, highly polished.

M: Ø 8,4 cm / 5,6 cm; w:1,45 cm; h:1,3 cm

D: The highly polished bangle has faint regular scratches and a slight, grey, unpolished ridge on the side where the three, shallow signs are applied. The height of the signs is 0,25 cm.

5.2.7 DK-G 83-618 Fig.IV,7

FS: 2500/1900. Dump area north of DK-G

Ware: inside – grey with small holes; outside – spotted dark to light-grey, polished.
M: Ø 8,4 cm / 5,4 cm; w:1,55 cm; h:1,25 cm
D: On both sides a concentric ring, unpolished and grey in colour. The sign is 0,25 cm in height.

5.2.8 HR-E 83-619 Fig.IV,8

FS: 2550/1125. Unexcavated area east of HR-A
Ware: inside – sand to grey spotted; outside – matt, light to dark-brown
M: Ø 8,4 cm / – ; w:1,4 cm; h:1,35 cm
D: The small fragment has an inscription consisting of 4 signs, 0,3 cm in height. Very faint regular grooves.

5.2.9 MD 83-620 Fig.V,1

FS: unknown
Ware: inside – dark grey; outside – shiny, spotted sand to black
M: Ø 9.0 cm / 6,0 cm; w:1,45 cm; h:1,4 cm
D: The inscription is partly broken off, leaving two intersecting and one single circle, 0,2 cm in height.

5.2.10 HR-E 83-621 Pl.10, Fig.V,2

FS: 2250/1150. Unexcavated area east of HR-A
Ware: inside – light grey; outside – dark grey with grey spots, polished
M: Ø 8,75 cm / 5,15 cm; w:1,8 cm h:1,3 cm
D: This bangle, the only complete specimen found, shows a 0,5 cm broad, light-grey unpolished ring along the inner surface and slight groove on the other side. The other parts have a slight lustrous copper shine. It contains a lot of scratches interpreted as traces of wear. The very faint sign measures 0,25 cm in height.

5.2.11 HR–E 83-622 Fig.V,3

FS: 2520/995. South-east of HR.
Ware: inside – matt dark-brown. Outside – dark-brown, highly polished. Very fine, homogenous texture.
M: Ø 8,1 cm / 4,9 cm; w:1,6 cm; h:1,35 cm
D: The inscription is broken on the left, three signs of 0,3 cm height are preserved.

5.2.12 MN-S 83-623 Fig.V,4

FS: 2840/1210. Southeast of Moneer
Ware: inside – spotted sand to grey, with small holes. Outside – spotted dark-beige to dark-grey, matt
M: Ø 8,35 cm / 5,05 cm; w:1,7 cm; h:1,2 cm
D: The piece shows a concentric ring of slight ridges on the inside. The three signs are 0,4 cm high.

5.2.13 MN-S 83-624 Fig.V,5

FS: 2840/1210. Southeast of Moneer
Ware: inside – sand to grey. Outside – light to dark-brown spotted, polished.
M: Ø 8,2 cm / 5,0 cm w:1,6 cm; h:1,3 cm
D: a concentric ring of slight irregular ridges and scratches. The inscription consists of two, 0,35 cm high signs.

5.2.14 MN-S 83-625 Fig. VI,1

FS: 2640/1250. Southwest of Moneer
Ware. inside – sand to grey spotted. Outside – dark-beige to dark-brown spotted.
M: Ø 8,3 cm / 5,1 cm w:1,5 cm; h:1,45 cm
D: Slight ridges are still adherent to the surface, one sign of 0,25 cm height is faintly scratched into the surface. Very slight regular grooves.

5.2.15 MN-S 83-626 Fig.VI,2

FS: 2840/1220. Southeast of Moneer
Ware: inside – light grey. Outside – light grey spotted.
M: Ø 8,4 cm / 5,0 cm; w:1,65 cm; h: 1,25 cm
D: Like No. 621 this piece has a concentric, 0,5 cm broad ridge around the inner circle and plenty of small scratches. The inscription has three, 0,3 cm high signs.

5.2.16 DK-A 83-627 Fig.VI,3

FS: 2810/1490. South of DK-C and northeast of DK-A
Ware: inside – light grey with small holes. Outside – lightgrey with dark grey spots.
M: Ø 8,7 cm / 5,1 cm; w:1,7 cm; h:1,25 cm
D: The side inscribed with one, 0,3 cm high sign has a 0,8-1,3 cm broad, 0,2 cm deep groove. On the back the groove is 0,4 cm broad, 0,05 cm deep.

5.2.17 W-S 83-628 Pl.11 Fig.VI,4

FS: 1925/1080. South of L-area

Ware: inside - brick-red. Outside - brick-red polished with black spots. The texture is homogenous, but different to that of the other pieces and it is more porous. Fired at lower temperature. Scratches.

M: Ø 9,2 cm / 5,5 cm; w:1,85 cm; h:1,7 cm

D: This speciman is unique, not only because of its ware and colour but additionally it is the only one bearing two inscriptions. One consists of two signs, measuring 0,51 cm in height, broken in the middle. On the back the second inscription, consisting of three, 0,2 cm high strokes.

5.2.18 MN-S 83-629 Fig.VI,5

FS: 2950/1250. Moneer East, near the channel

Ware: inside – sand to grey with small holes. Outside – matt sand to dark-grey.

M: Ø 8,7 cm / 5,9 cm w:1,45 cm; h:1,4 cm

D: The inscription, consisting of two 0,55 cm high signs, shows only slight variations from that on No. 616.

5.2.19 MN-S 83-2966 Fig.VI,6

FS: 2870-5/1245-50. Southeast of Moneer

Ware: inside – light to dark – grey, spotted. Outside – dark-grey with some black spots

M: Ø 8,4 cm / 5,1 cm w:1,6 cm; h:1,3 cm

D: Slight ridges on the side inscribed with two intersecting circles, 0,2 cm high, on the other a very shallow groove.

b. on a shell-bangle

5.2.20 MD 83-150 Pl.12, Fig.VI,7

FS: unknown

Mt. Turbinella pyrum L.

M: w:1,6 cm; h:0,5 cm

D: This fragment of a shell bangle is the only inscribed example known. The 0,85 cm high sign is bordered on each side by an incised line. The surface is polished, traces of a saw are visible on some parts.

Footnotes

1) The sealing was excavated in MN-Area (Halim/Vidale 1983)

2) A systematic surface analysis, with special reference to craft-indicators, was begun in 1982 in MN-Area and extended in 1983 to the entire city (Bondioli/Tosi/Vidale 1984, Kenoyer 1983b)

3) These heaps show a greater concentration of steatite-wasters. In DK-G-Area only indicators for the production of micro-beads were found, in L-Area only for bangles. (Personal information from J.M. Kenoyer).

4) For comparanda refer to the Catalogue

5) Marshall 1931: 379, Mackay 1939: XC, 17; CII, 2,4,5,6,8,11, CIII,10.

6) Both areas are unexcavated. Although nodules and wasters are also used as a filling for bathing-platforms, the circumstantial evidence points to small-scale production in these areas. (Bondioli/Tosi/Vidale 1984, this volume.)

7) For a discussion of this problem refer to Lal 1960, 1966, 1975; Fairservis 1977; Parpola 1973, 1979; Mahadevan 1977; Rao 1982.

8) Refer to the report from Schneider and Büsch, Appendix I.

9) Refer to Appendix I.

10) Marshall 1931: 531 – „rarely these bracelets are inscribed with one or two very minute pictographs, which may be the name of the owner." Mackay 1939: 536 describes them as occuring frequently in lower and upper levels, occasionally having carefully inscribed pictographs on one side, which probably have magical or religious significance. While Marshall made no further reference to the inscriptions, Mackay published 4 more reports.

11) Especially comparing the number of objects found by chance with the recorded ones. Besides Mohenjo Daro seven fragments, incl. two red specimens, have been reported from Harappa (Vats 1944: 448, 449. Pl. CXXXVIII,1,4,7,8), and six from Sutkagen Dor (Stein 1931: 64,Pl. VI,32-33).
A second clay disc with the impression of a seal, of which only a line of 9 pictographs is preserved, and traces of attachment to a vessel at the reverse was found in HR in 1984.
5 more inscribed stoneware bangles were found in 1984.

12) 1 sign on seven bangles (613, 615, 618, 621, 625, 627, 2966)
2 signs on five bangles (616, 620, 622, 624, 629)
3 signs on five bangles (612, 617, 623, 626, 628)
4 signs on one bangle (619)
5 signs on one bangle (614)

13) One sign (No. 8 according to the sign list App. III) occurs four times; four signs (4,6,9,33) three times; seven signs (1,2,13,16,17,18,29) twice and thirteen signs (3,5,7,10,12,15,24,25,27,30,31,34,35) once.

14) Basic signs: 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 12, 13, 15, 16, 17, 18, 24, 25, 27, 29, 30, 31, 33, 34, 35.

15) For the numbers see App. II.

16) The Concordance of Mahadevan contains many more variants than Parpola's.

17) A comparison with potter's marks (Potts 1981, Quivron 1980, Dollfuß et al. 1981, Hakemi 1976) shows similarities, with few exceptions, only to common signs such as circles and strokes.

18) Their size ranges from 8,0 cm to 9,2 cm for the outer and from 4,9 cm to 5,9 cm for the inner diameter, which are reasonable sizes still in use today.

19) The reading by Prof. A. Parpola (letter May, 28, 1982) takes the last three signs from the right as uncertain. He suggests comparing these to seal 5064 from Chanhudaro (Parpola) and the four signs to the left to inscription 1113 (Parpola) from Mohenjo Daro.

20) Nos. Channel 82-1535, 82-1538 + MD 82b were available to the author as drafts only. Coordinates of the Findspots are unknown for Nos. 1535-1537 and MD 82b.

21) Nos. DK-B 82c and MN 82d are available as photographs only.

22) See further Fairservis 1977, Lal 1960, '65, '75, Potts 1981, Quivron 1980.

23) No co-ordinates were available.

24) Referring to bangles of this type with and without inscriptions.

25) The ware of these kind of bangles is always of very fine texture with hardly any temper visible. For details see Appendix I. For this reason it is generally referred to in colour only.

26) Inner/outer diameter

27) Quivron, Potts, Dollfuß and Hakemi are referred to only for signs other than strokes and circles. V = Variant. Number and question mark indicates unsure identification due to greater variation.

Bibliography

BONDIOLI (L.), TOSI (M.), VIDALE (M.) 1984, Craft Activity Areas and Surface Survey at Moenjodaro. Complementary Procedures for the Revaluation of a Restricted Site. This Volume.

DOLLFUSS (G.), ENCRERE (P.) 1981, Marques sur Poteries dans la Susiane du Ve.mill.. In: *Paléorient 8/1, pp. 107-115.*

FAIRSERVIS (E.) 1977, Excavations at Allahdino, Vol. III, New York.

HAKEMI (A.) 1976, Ecriture Pictographie Découverte dans les Fouilles de Shahdad, Teheran.

HALIM (M.), VIDALE (M.) 1983, Ceramic Production in Closed Containers at Moenjodaro. Paper presented at the 7th International Conference of the Association of South Asian Archaeologists in Western Europe, Brussels.

HALIM (M.H.), VIDALE (M.), 1984, Kilns, Bangles and Coated Vessels: Ceramic Production in Closed Containers at Moenjodaro. This Volume.

KENOYER (J.M.) 1983, Shell Working at Moenjo-Daro. Paper presented at the 7th International Conference of the Association of South Asian Archaeologists in Western Europe, Brussels, forthcoming publication.

KENOYER (J.M.) 1984, The Sacred Conch Shell: From the Indus Civilisation to modern Bengal.

LAL (B.B.) 1966, The Direction of Writing in the Harappan Script. In: *Antiquity* XL, pp. 52-55.

LAL (B.B.) 1967-68, A Further Note on the Direction of Writing in the Harappan Script. In: Puratattva 1, pp. 15-16.

LAL (B.B.) 1975, The Indus Script: Some Observations based on Archaeology. In: *Journal of the Royal Asiatic Society*, pp. 173-177.

MAHADEVAN (L.) 1977, The Indus Script. Text, Concordance, Tables, New Delhi.

MACKAY (E.J.H.) 1938, Further Excavations at Mohenjo-Daro, Vols. I-II, New Delhi

MARSHALL (Sir J.) 1931, Mohenjo-Daro and the Indus Civilization, Vols. I-III, New Delhi.

PARPOLA (A.), PARPOLA (S.), KOSKENNIEMI (S.) 1973, Materials for the Study of the Indus Script, Helsinki

PARPOLA (A.), PARPOLA (S.), KOSKENNIEMI (S.) 1979, Corpus of Texts in the Indus Script. Dept. of Asian and African Studies, Research Report 1, Helsinki.

PARPOLA (A.), PARPOLA (S.), KOSKENNIEMI (S.) 1980, Documentation and Duplicates of the Texts in the Indus Script. In: *Research Report 2*, Helsinki.

PARPOLA (A.), PARPOLA (S.), KOSKENNIEMI (S.) 1982, A Concordance to the Texts in the Indus Script. In: *Research Report 3*, Helsinki.

POTTS (D.) 1981, The Potter's Marks of Tepe Yahya. In: *Paléorient 7/1*, pp. 107-121.

QUIVRON (G.) 1980, Les Marques incisées sur les poteries de Mehrgarh au Baluchistan. In: *Paléorient 6/1*, pp. 269-280.

RAO (S.R.) 1982, The Decipherment of the Indus Script, New Delhi.

STEIN (Sir A.) 1931, An Archaeological Tour in Gedrosia. In: *Memoirs of the Archaeological Survey of India*, No. 43, Calcutta.

VATS (M.S.) 1944, Excavations at Harappa, New Delhi.

Appendix I

Chemical and mineralogical investigation of a stoneware bangle fragment

Gerwulf Schneider and Wilhelm Büsch

One fragment of a pottery bracelet was placed at our disposal for investigation in the laboratory. It was about 3 cm long, dark-brown in colour on both the exterior and interior surfaces, and exhibited a very uniform, extremely fine texture. A cross-section cut exposed layers running parallel to the outer rim, which is of importance in any discussion of the manufacturing techniques. There is very little open porosity, water hardly even moistening a cut or broken surface. The water absorbing capacity is less than 2 %. This points to the same kind of stoneware which was previously examined by Sana Ullah *(Marshall 1931)*. The material is very hard (6 ½ on the Mohs Scale) and breaks leaving a glass-like fracture. Melting experiments using small fragments indicate a firing temperature, in a reducing atmosphere, between 950° and 1050° C. Above 1100°C the fragments became totally molten, in a reducing atmosphere.

The investigation of a fresh fracture under the scanning electron microscope showed an advanced stage of vitrification *(Pl. 1)*[1]. A scanning electron microscope image of a totally vitrified fragment of stoneware from Tell Chuera (N.E. Syria, 3rd millenium B.C.) is included for comparison *(Pl. 2)*. One composite group of this N.E. Syrian stoneware is made of calcareous clays and is of a similar composition to the bangle, although all these examples are of a much coarser texture.

The extremely fine and uniform texture and the partly vitrification were confirmed by a microscopic examination of a thin section (less than 10 μm thick) *(Pl. 3)*. The maximum grain size of nonplastic material (natural temper), which consists mostly of partly molten quartz and a few feldspar crystals, is less than 20 μm. Opaque phases in amounts less than 2 % are visible. X-ray diffraction data indicate only quartz, plagioclase and diopside, which is a normal phase composition of highly burnt calcareous clays. The dark colour must be due to the high iron content of the vitreous matrix.

1. The scanning electron microscope photographs were taken by Dr. H. Ghobarkar, Institute for Mineralogy.

The chemical composition of the bangle fragment as determined by X-ray fluorescence *(table 1)* is one of a fired calcareous illitic clay, the sort prefered in nearly all ancient pottery manufacture. The amount of flux (sodium, potassium, magnesium, lime and iron, which is a flux only in a reducing atmosphere) is very high. No other major or minor elements were detected by X-ray fluorescence. The trace elements are the same as in normal clays (chromium 130 ppm, rubidium 180 ppm, strontium 260 ppm, zirconium 150 ppm). The new analysis confirms to a large extent the findings of the chemical analysis carried out by Sana Ullah *(Marshall 1931)*. This agreement is also a clear indication of a uniform composition of these bangles. It would be worthwhile to carry out further analysis experiments to prove this theory. Comparison with the analysis of a supposed raw material found in a „coated carinated jar" *(Halim/Vidale 1983)* shows significant differences in the amounts of sodium and magnesium *(Table 1)*. One must also consider the fact that it would be impossible for clay minerals to remain intact in a closed, overfired container. So the conclusions drawn remain doubtful. Further investigations and a more wide-scale analysis of possible raw material and pottery at the site are necessary.

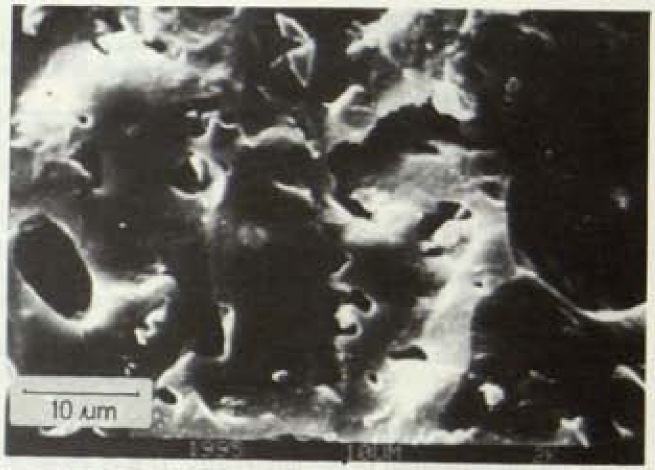
Conclusions

The stoneware bangles demonstrate a very high degree of ceramic technology. They are made from a special, cleaned and very finely prepared calcareous clay, containing large amounts of calcium carbonate and silica, whose size is limited to less than 20μm. There is a large amount of evidence to suggest that they were made in moulds. This was probably done by pouring a fine suspension of clay into a porous ceramic or gypsum mould, possibly in successive stages. This would account for the zoned cross-section and the ridges on the surface. The technique is similar to that used in bronze casting and uses the same kind of mould. After drying the object was polished so that no traces of a joint are visible. Firing was done at a rather high temperature in a reducing atmosphere, probably enclosed in a sealed pottery container *(Halim/Vidale 1983:5)*. Final conclusions on this sophisticated technique of bracelet manufacture can only be drawn with the help of reconstructions of the method using similar clay raw materials. Further research will be carried out in the hope of answering these questions.

Upper
Table 1 *Chemical analysis of the investigated bangle fragment by X-ray fluorescence compared with the analysis of a supposed raw material* (Halim & Vidale 1983, table 1), *calculated to the state after firing.*
Middle
Plate 1 *Scanning electron microscopic image of a fresh fracture of the bangle fragment. It shows the typical texture of a ceramic in a stage of advanced vitrification. The holes are micropores.*

		BANGLE	FIRED RAW MATERIAL
Silica	SiO_2	54.5	50.4
Titanium oxide	TiO_2	0.915	–
Aluminium oxide	Al_2O_3	18.3/0	21.0/0
Iron oxide	Fe_2O_3	8.37	11.9/0
Manganese oxide	MnO	0.125	0.36
Magnesium oxide	MgO	3.85	0.45
Calcium oxide	CaO	8.98	12.7/0
Sodium oxide	Na_2O	1.08	0.17
Potassium oxide	K_2O	3.46	3.00
Phosporus pentoxide	P_2O_5	0.155	–
		99.73	99.98

Upper
Plate 2 *Scanning electron microscopic image of a fracture of a stone ware fragment from Tell Chuera (NE-Syria, 3rd millenium B.C.) showing total vitrification. The micropores are rounded.*
Middle
Plate 3 *Fotomicrograph of a thin section of the bangle fragment under polarized light. In the center a small, partly molten quartz crystal. The microcrystalline matrix consists of newly formed minerals and unmolten rests of quartz. The round black areas are micropores (compare with plate 1).*



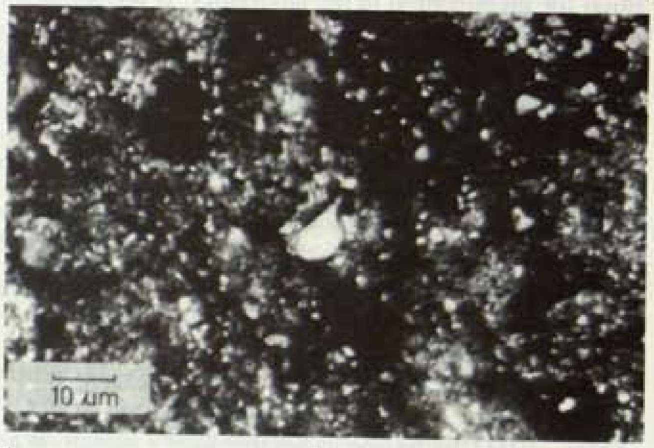
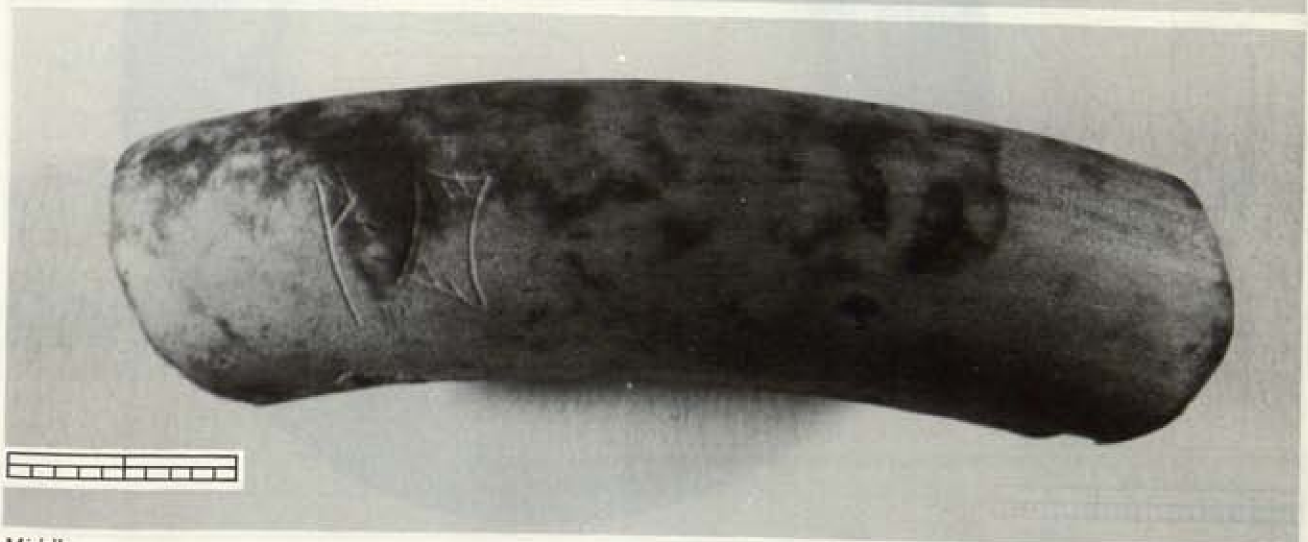


Plate 4. *1.1 Seal MN 83-611*

Plate 5. *1.3 Seal VS-A 83 a*

Plate 6. *2.1 Sealing MN 82a*

Plate 7. *3.4 Potsherd with Seal-impression VS-E 83-608*



Middle
Plate 8. *5.2.3 inscribed bangle E 83-614*

Lower
Plate 9. *5.2.5 inscribed bangle MN-E 83-616*

Plate 10. *5.2.10 inscribed bangle HR-E 83-621*

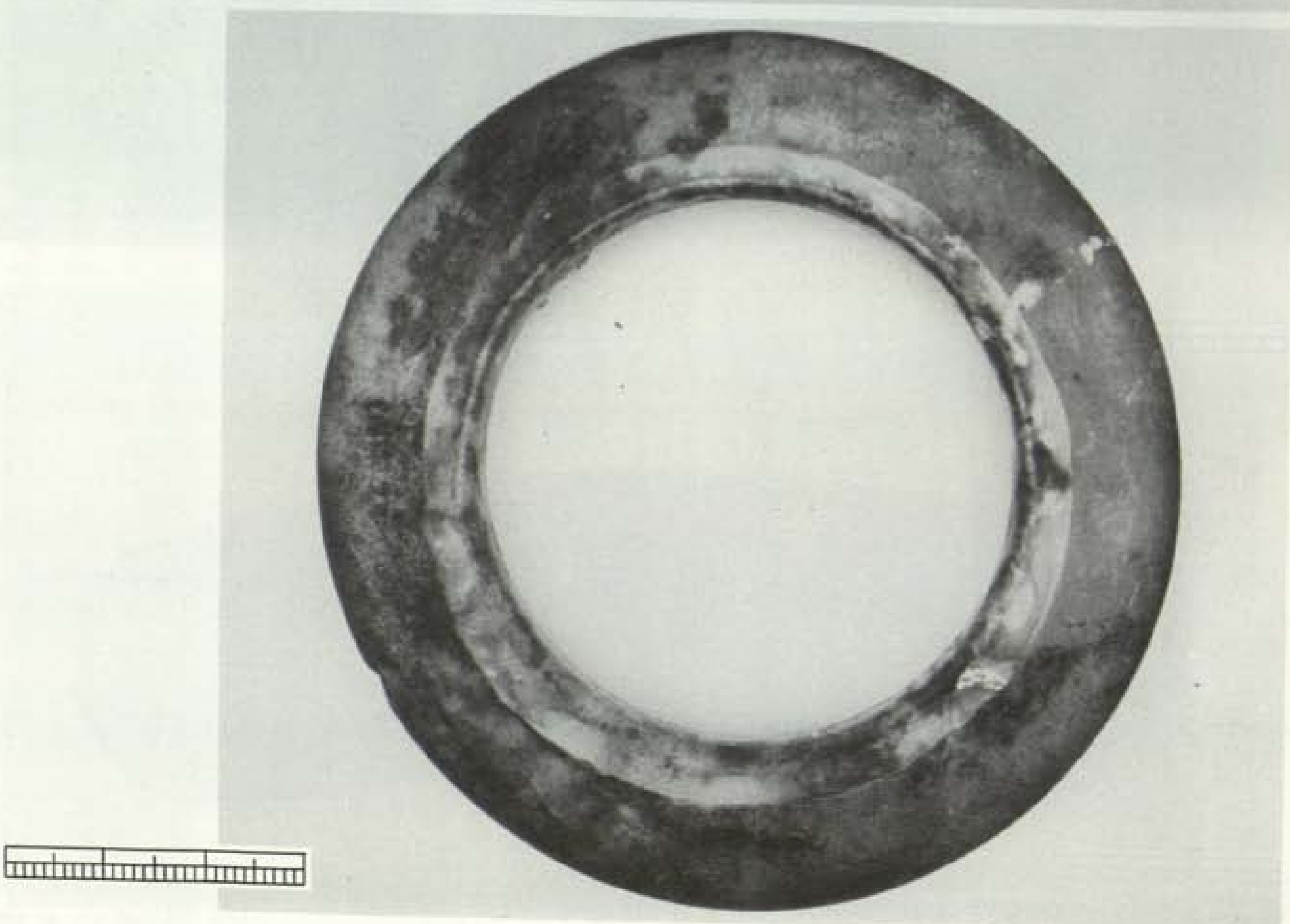


Plate 11. *5.2.17 inscribed bangle W-S 83-628*

Plate 12. *5.2.20 inscribed bangle (shell) MD 83-150*

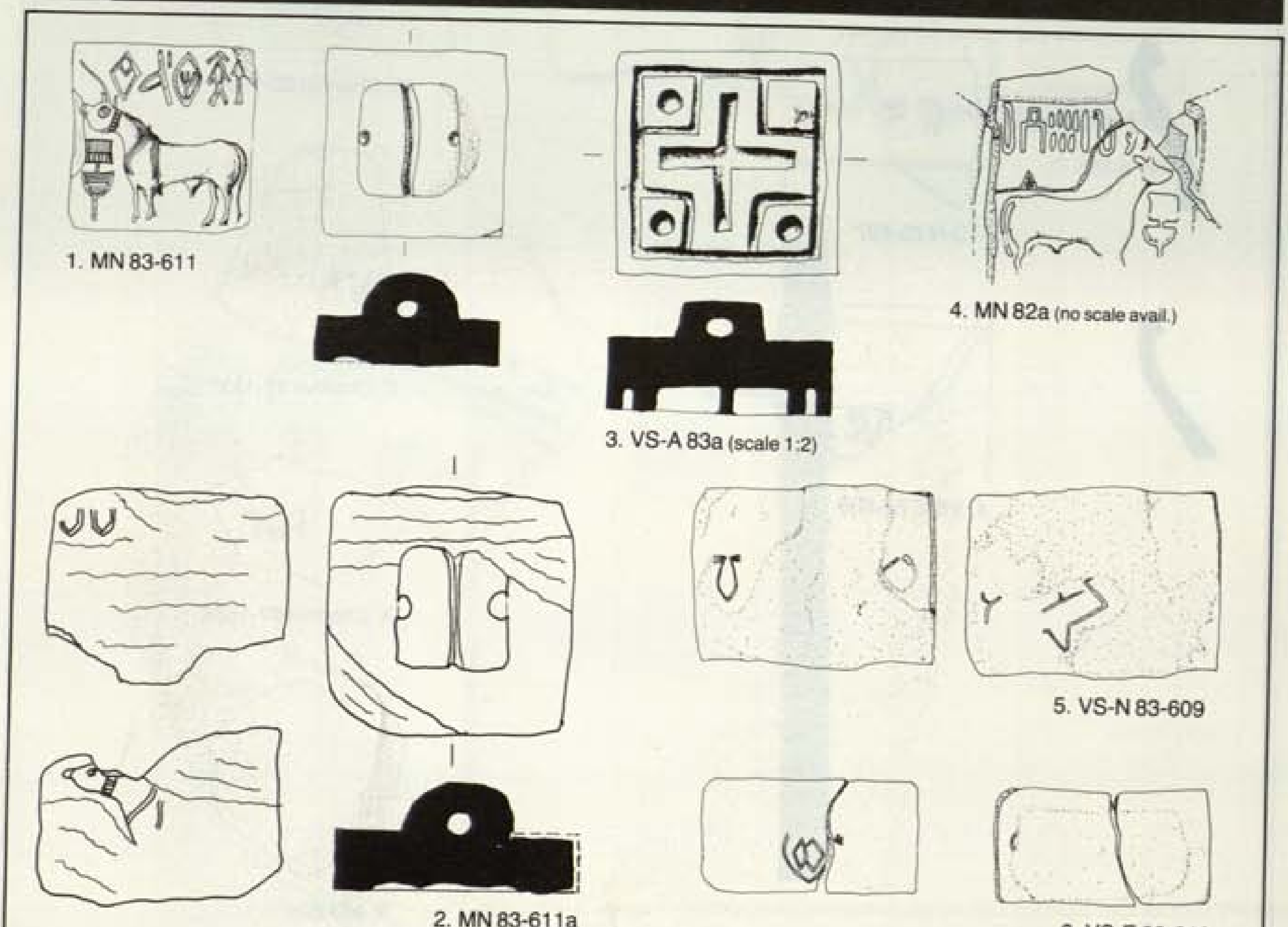


Fig. 1 *scale 1:1*

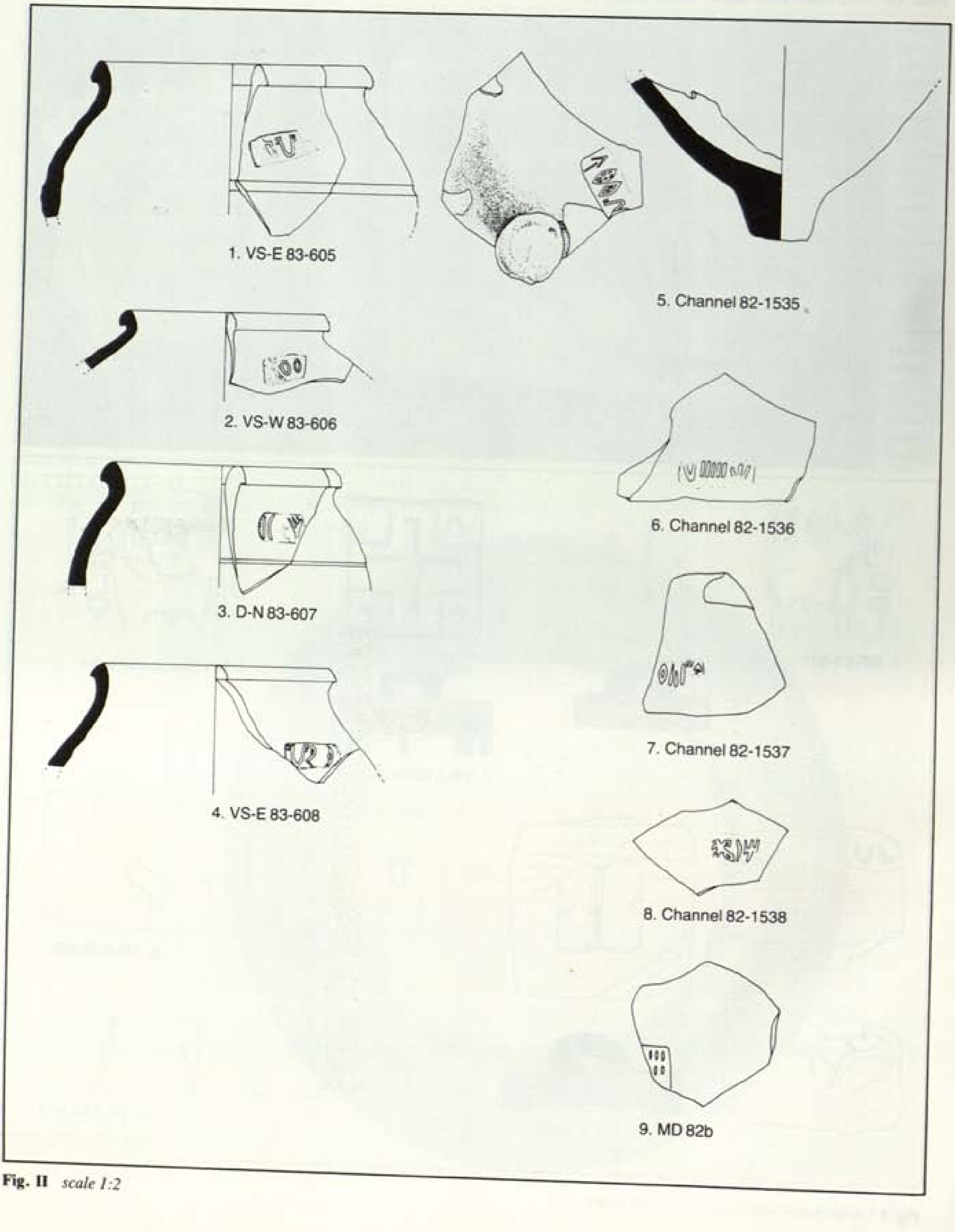


Fig. II *scale 1:2*

1. DK-B 82c (no scale avail.)

2. MN-E 82d (no scale avail.)

3. MN-E 82e

4. Channel 82-32

Fig. II1 *scale 1:2*

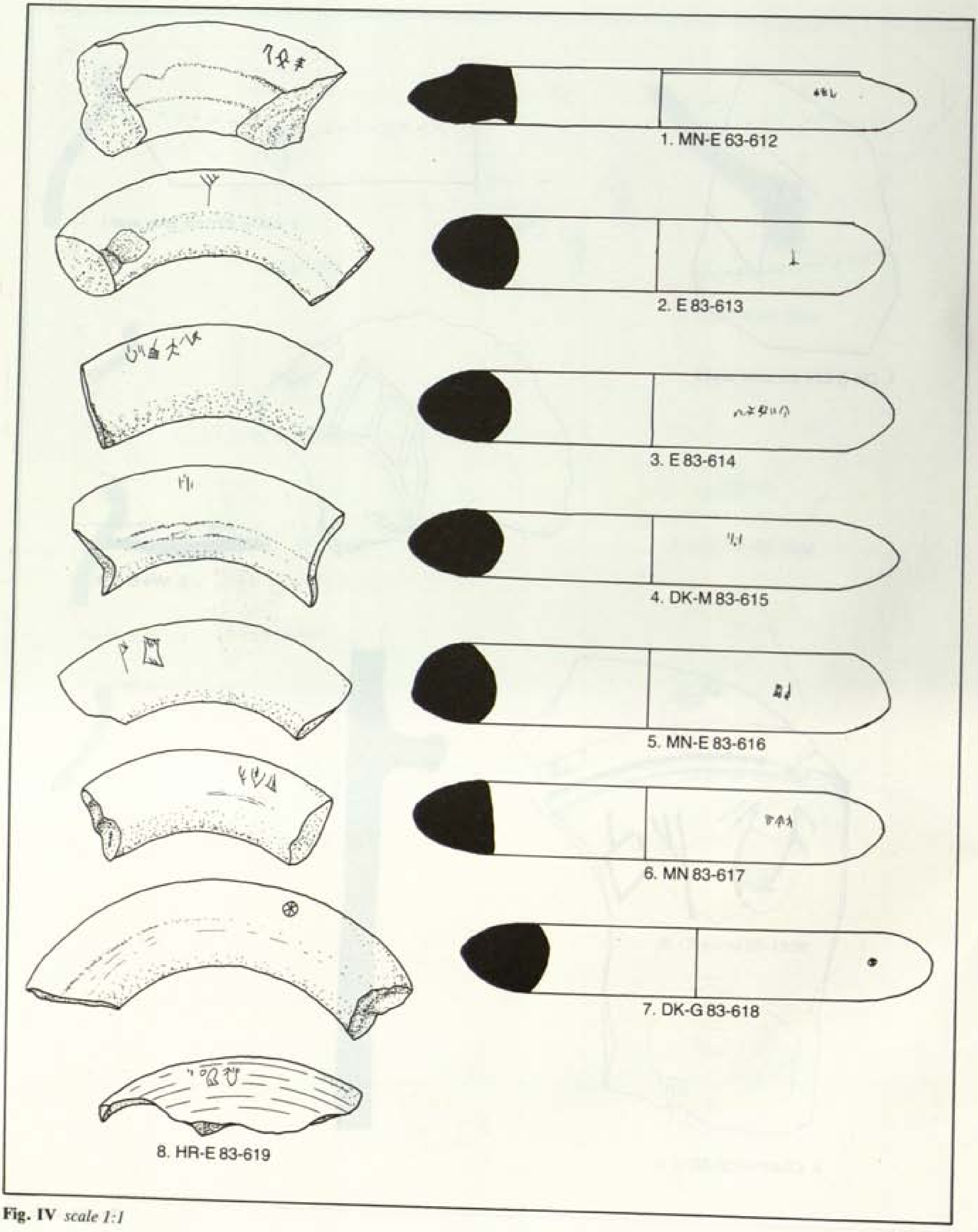


Fig. IV *scale 1:1*

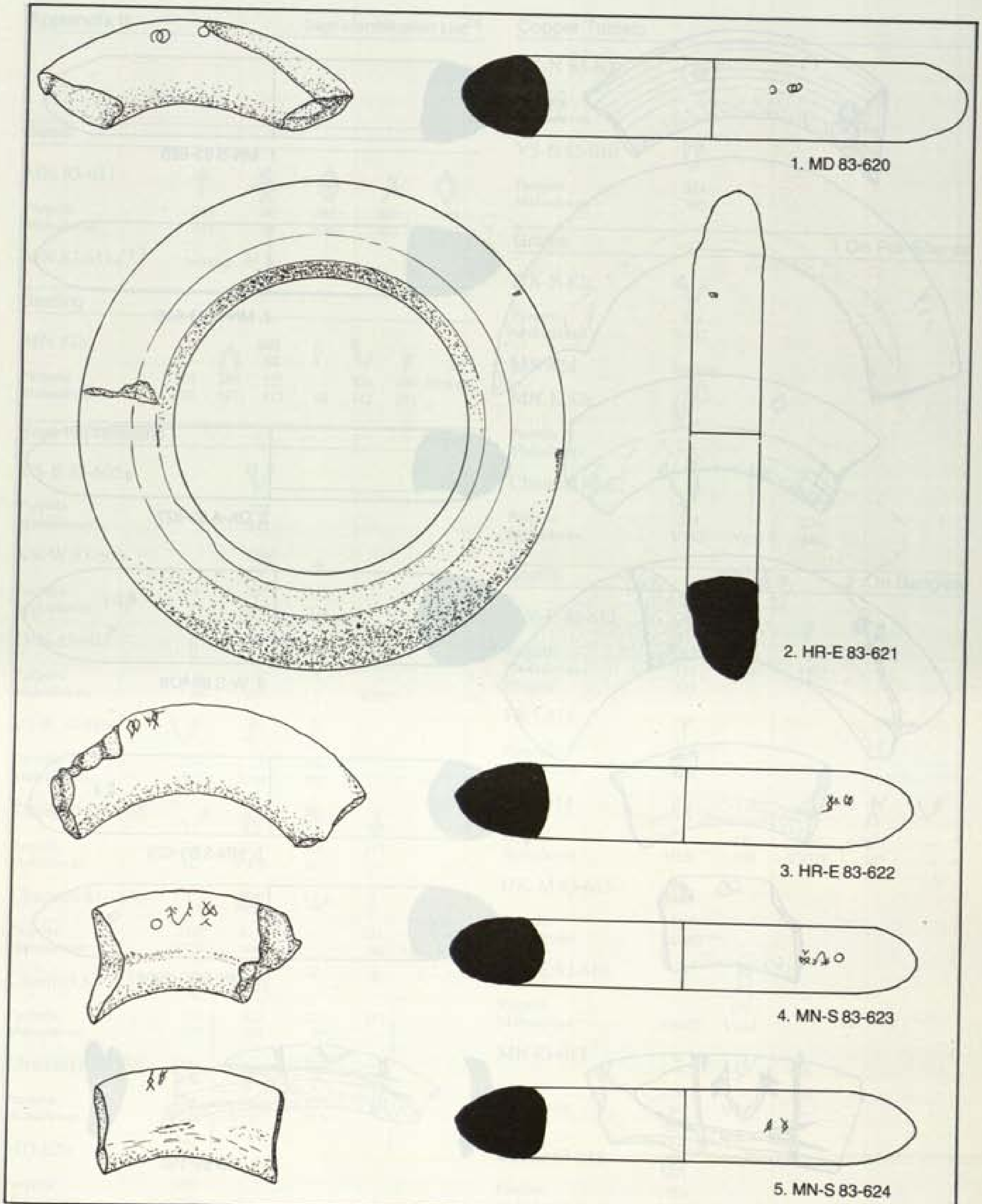


Fig. V *scale 1:1*

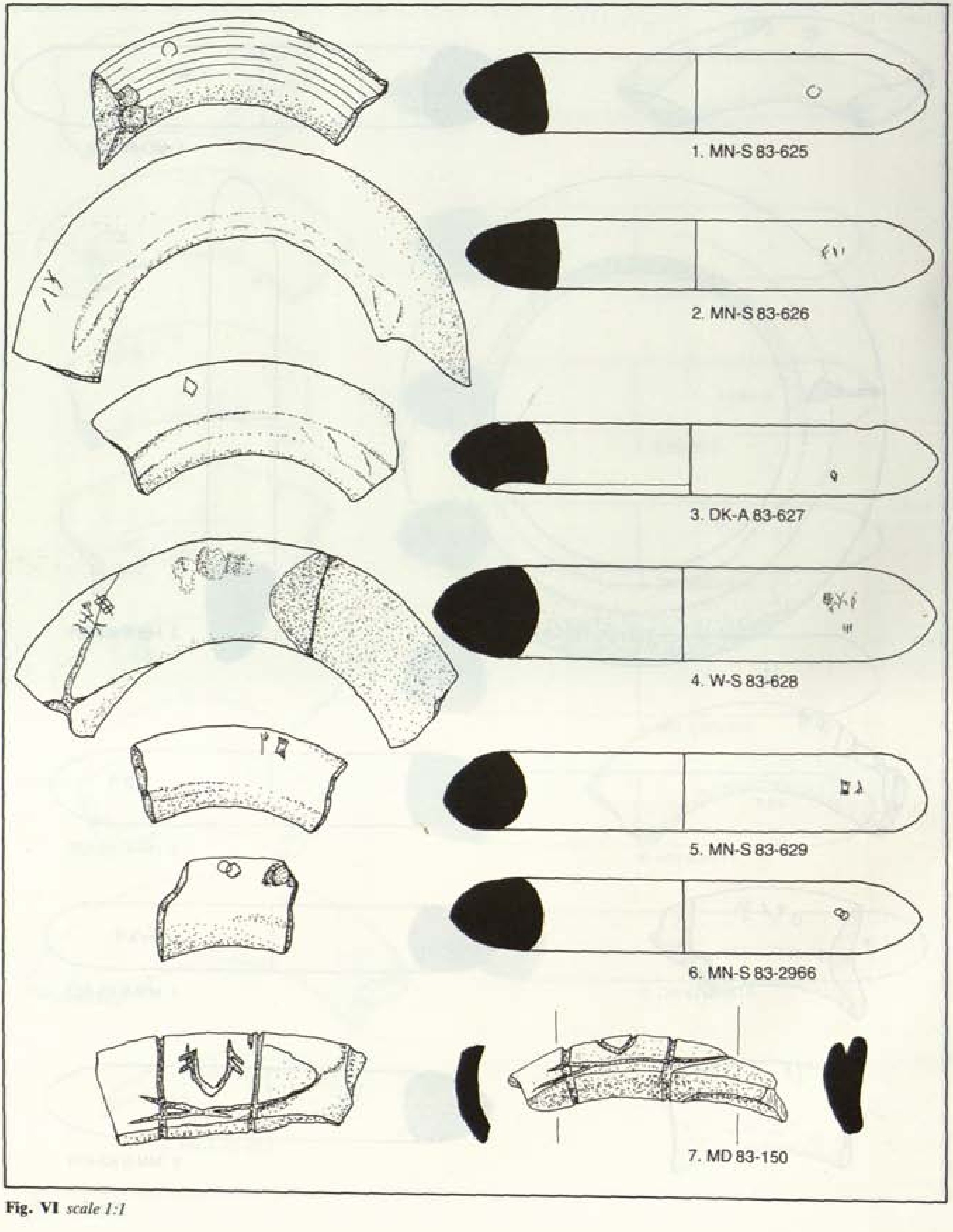


Fig. VI *scale 1:1*

Appendix II — Sign-Identification List[27]

Seals

MN 83-611

Parpola	217	60	365	202	385
Mahadevan	211	65	V387	402	267

MN 83-611a broken

Sealing

MN 82a

Parpola	310	289	127		326	160	broken
Mahadevan	328	197	112	86	342	293	

Seal-Impressions

VS-E 83-605

Parpola	?	324
Mahadevan	?	342

VS-W 83-606

Parpola	?	38?	355
Mahadevan	?	31?	374

D-N 83-607

Parpola	121	163	?	–
Mahadevan	86	299	?	V169

VS-E 83-608

Parpola	324	–	160
Mahadevan	342	V49	293

Channel 82-1535

Parpola	324	372?	378	217?
Mahadevan	342	V379	391	153?

Channel 83-1536

Parpola	310?	151	–	121
Mahadevan	V328	106	–	86

Channel 82-1537

Parpola	355	123	122	111
Mahadevan	373	102	99	–

Channel 82-1538

Parpola	254	–	92?
Mahadevan	V146	V287	171?

MD 82b

Parpola	125
Mahadevan	107

Copper Tablets

VS-N 83-609

Parpola	–
Mahadevan	–

VS-E 83-610

Parpola	324	?
Mahadevan	342	?

Graffiti — 1 On Pot-Sherds

DK-B 82c

Parpola	324
Mahadevan	V342

MN 82d broken

MN-E 82e

Parpola	
Mahadevan	

Channel 82-32

Parpola	324	–	276
Mahadevan	V342	V613 ?	249

Graffiti — 2 On Bangles

MN-E 83-612

Parpola	283	50	99?
Mahadevan	127	59	177?
Hakemi	175		

E 83-613

Parpola	86
Mahadevan	169

E 83-614

Parpola	–	122	280?	23?	–
Mahadevan	V336	100	V252?	18?	–

DK-M 83-615

Parpola	123?
Mahadevan	V86?

MN-E 83-616

Parpola	–	270
Mahadevan	V613?	V244

MN 83-617

Parpola	85?	–	208
Mahadevan	161	V336	–
Quivron	V32		

DK-G 83-618

Parpola	378
Mahadevan	V391

HR-E 83-619

Parpola	119	355	205?	–
Mahadevan	99	V374	V180?	V343?

MD 83-620

Parpola	349	355
Mahadevan	403	373

HR-E 83-621

Parpola	182
Mahadevan	V307

HR-E 83-622

Parpola	–	–
Mahadevan	V403?	–

MN-S 83-623

Parpola	355	–	11?
Mahadevan	V374	V343	17?

MN-S 83-624

Parpola	–	182
Mahadevan	–	V307

MN-S 83-625

Parpola	355
Mahadevan	373

MN-S 83-626

Parpola	121?	121	–
Mahadevan	V86	86	–

DK-A 83-627

Parpola	–
Mahadevan	V261
Potts	33e?

W-S 83-628

Parpola	160	26	275	/	147
Mahadevan	293	V19	V253	/	102
Potts			49?		

MN-S 83-629

Parpola	–	270
Mahadevan	V613?	V244

MN-S 83-2966

Parpola	349
Mahadevan	403

MD 83-150

Parpola	324
Mahadevan	342

Appendix III Signs and Variations

(B = bangle)

1. 605,608,82a 150 32 1535 619B 623B 609
2. 614B 617B 1536
3. 614B
4. 614B 628B 606B
5. 623B
6. 612B 611 622 B 624 B
7. 619B
8. 620B,625B 606 623B 611 619B
9. 620B,2966B 622B
10. 627B 1537
11. 1535
12. 618B 1535
13. 621B 624B
14. 611
15. 617B
16. 626B 626B,607,1536,82a 607
17. 614B 619B,1537
18. 628B,1537 615B
19. 1536
20. 82b
21. 82a
22. 1536
23. 1535
24. 1538 626B
25. 612B
26. 608
27. 628B,608,82a
28. 611
29. 616B 629B
30. 628B
31. 614B 32
32. 1538
33. 613B 607 616B,629B 32
34. 612B
35. 617B
36. 1538
37. 82a
38. 1537
39. 83a

Stone Sculptures from Mohenjo-Daro

Alexandra Ardeleanu-Jansen
Aachen

This present paper was conceptionalized during 1983 while the German Volkswagen Foundation generously sponsored my research. I am deeply thankful to the German Volkswagen Foundation and Professor Dr. H.J. Nissen, Seminar für vorderasiatische Altertumskunde, Free University of Berlin and Professor Dr. G. Urban, Department for History of Architecture and Architectural Preservation, Technical University of Aachen who supported my studies. My research would have been impossible without the unconditioned support of the German Research Project Mohenjo-Daro, Technical University of Aachen, especially of Professor Dr. G. Urban and Dr. M. Jansen.

In Pakistan, I have to thank Mr. M. Ishtiaq Khan, Director General of Archaeology and Museums, for his generous permission to work in the institutions of his Department. His acceptance was supported by the engagement and help of numerous members of the Department of Archaeology and Museums, notably Mr. Khurshid Hasan, Mr. M.A. Halim, Mr. H.A.S. Bokhari in Karachi and Mr. M. Siddiqui, Curator of the Archaeological Museum Mohenjo-Daro, Mr. Abdul Ghafoor, Mr. Avais, Mr. Babujee and many more helpers in Mohenjo-Daro.

Some aspects and considerations have been developed through interesting discussions with Cathérine and Dr. J.F. Jarrige, C.N.R.S., Paris, Professor Dr. G.F. Dales, University of California, Berkeley, Professor Dr. M. Tosi, IsMEO, Rome, Massimo Vidale, Rome, and Dr. M. Jansen, Technical University of Aachen.

Special thanks to those who have contributed to the technical aspects and to the sometimes troublesome work of data collection. I am indebted to M. Vidale who helped me to find the fragment of sculpture HR 5785, to Dr. Irmgard Leinen and Andrew Holdsworth for translating and correcting the text, to Georg Helmes for the photographic work and to Rolf Bunse for executing the drawings and the lay-out.

Introduction

This present paper is based on an idea given to me by G.F. Dales' essay „Stone Sculptures from the Protohistoric Helmand Civilization, Afghanistan".[1] Dales wrote in his article that the sculptures from the Iranian and Afghan areas of Sistan (Helmand Civilization) are to be considered on the basis of their iconographic and stylistic details as being somehow connected to the stone sculptures from Mohenjo-Daro. Of the four heads discussed by Dales three are belonging to the Helmand Civilization and one example is from Mohenjo-Daro. Two of the Helmand heads were already known from previous publications; the white limestone head from Mundigak, Period IV,3 *Casal, 1961: Pls. XLII-XLIV); and the small head similarly made of limestone from Tepe Chah-i Torogh 2 (Jarrige, C. & Tosi, M., 1981: 133, Fig. 5b).*

The origin of the third Helmand head, from the private collection of an Afghan tribal leader, is according to Dales the Afghan-Iranian border of Sistan *(Dales, forthcoming, Fig. 1, upper row).* Dales pointed out four iconographic and stylistic attributes of which he regarded the „one or another" as being similar to the Mohenjo-Daro sculptor's art:

„*1. the fillet descending in two flat bands at the back of the head, and having possibly an ornamentation in front*
2. the distinctive rendering of the ears
3. the taut, sharply incised horizontal mouth
4. the smaller than life size scale" (Dales, forthcoming)

In order to contribute to the discussion and to the wish of the above cited author, I collected all available data and illustrations relative to the Mohenjo-Daro sculptures which are presented in this paper. The informations are gathered from the „Fieldbooks"[2], the unpublished excavation inventories of Mohenjo-Daro, and the so-called „Sind Volumes"[3] which yielded most of the photographs of the sculptures.

Fig. 1 *Limestone head DK-B 1057 height: 14,5 cm (front view) Mohenjo-Daro, Site Museum (Sind Vol.XXVI, 1935-40,582)*

Upper
Fig. 2 *DK-B 1057 (side view) (Sind Vol.XXVI, 1935-40,584)*
Middle
Fig. 3 *DK-B 1057 (back view) (Sind Vol.XXVI, 1935-40,583)*

Stone Sculptures from Mohenjo-Daro

The 14.5 cm high brown limestone head from the Mohenjo-Daro Museum *(Figs. 1-3)* which Dales described and related to the heads of the Helmand Civilization was entered in the Fieldbook under number DK-B 1057, found on 9.4.1938 in southern DK-B Area, Block 5, Room 20, 0.96 meter below the surface of the excavation and therefore classified as being of the „Late" period in the inventory book. This smaller excavation was carried out between 9.4. - 14.4.1938 after the extensive excavations by E.J.H. Mackay (DK-G, SD Southern Buildings Section) had taken place but unfortunately the results were never published.[4] Up to the present day we have no groundplans or photographs of these exposed architectural remains, and it seems that until such time as the original plans are found, a horizontal and vertical identification of the place of discovery of the sculpture (as well as approximately 100 other artifacts) remains impossible.

DK-B 1057 has already been examined by G.F. Dales with special regard to the characteristics in common with the heads from the Iran-Afghan borderland of Sistan but apart from them, a few more distinctive features will be added here; independently of their traits in common:

- thickset trapezoidal facial shape.
- small, horizontally aligned eyes, with a large interocular distance. The interiors of the eyes are slightly hollowed, and probably contained paste inlays.
- broad cheek-bones and a short receding forehead.
- the short, straight nose is badly damaged.
- the corners of the wide mouth with its thick bottom lip, are slightly downward pointing.
- the chin is short but prominent.
- the abstract shape of the ears has indeed faint resemblance to the ears of the Helmand heads and shows a differentiation from Helix, Skapha, Anthelix, Concha, Tragus and Lobulus. An almost circular hole can be found in the middle of the brezel-shaped form.
- the long, wavy hair is combed straight back from the forehead and is knotted in the neck into a divided bun, being held by a headband and two pins.
- the frontal aspect *(Fig. 1)* shows a thickening of the throat below the chin, which can be interpreted as Adam's apple.

Upper
Fig. 4 *Limestone head HR 910*
height: 18 cm (front view)
New Delhi, National Museum
(Sind Vol. VII, 1925-26,322)

Lower
Fig. 5 *HR 910 (side view)*
(Sind Vol. VII, 1925-26,323)

In order to complete the data, the following associated finds according to the excavation inventory should be cited(all found in Room 20 / 3.3 ft. below the surface):

DK-B 1057	– statuary (female head), ht. 5.3"
DK-B 1058	– unfinished shell bangle, dia: 2.5"
DK-B 1059	– terracotta spindle-whorl, dia: 1.4"
DK-B 1060	– terracotta bull, burnt to black, h. 5.2"

The head HR 910 *(Figs. 4 & 5)* was found in the southern HR-A area, House I, Room 14, 2 meters below the surface. A reconstruction of the excavatory surface showed that the depth of the find corresponds to the settlement level of Courtyard 10, which adjoins Room 14 on the western side. According to the excavation inventory, the following objects were found on the same settlement level in both rooms, corresponding to the level upon which HR 910 was found:

ROOM 14 (square 38w/25):

HR 910	6.7 ft.b.s.	– fragment of a sculpture
HR 911	6.7 ft.b.s.	– faience object like a chessman
HR 959	7.0 ft.b.s.	– 4 fragments of an ivory object
HR 960	7.0 ft.b.s.	– 1 ivory object, complete
HR 961	7.0 ft.b.s.	– 1 T.C. pot, ht: 4 1/2"
HR 963	7.0 ft.b.s.	– 2 fragments of a T.C. vase, ht: 6"
HR 979	7.0 ft.b.s.	– 2 fragments of a horn
HR 980	7.0 ft.b.s.	– 3 fragments of a painted lid of a T.C. jar

COURTYARD 10 (pegs I-J exterior south):

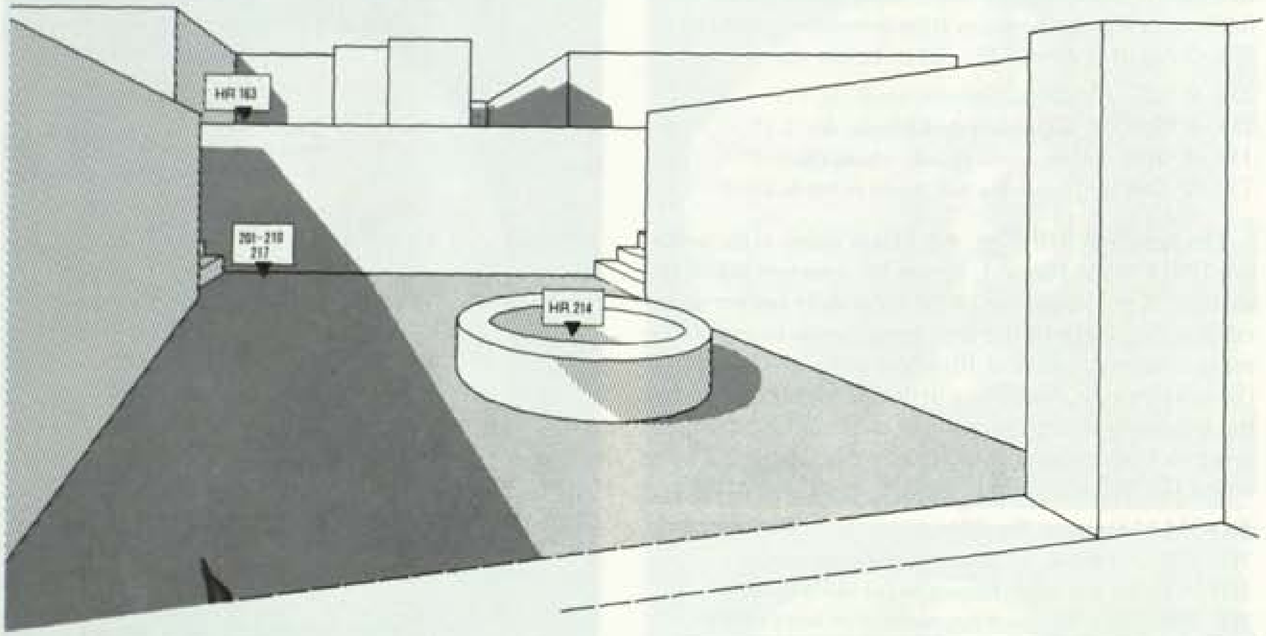
HR 201	8 ft.b.s.	– 1 marble stone-weight, ht: 6 1/2"
HR 202	8 ft.b.s.	– 1 blue faience object, a chessman? (found in courtyard below steps)
HR 203	8 ft.b.s.	– 14 faience beads of various sizes (found in courtyard below steps)
HR 204	8 ft.b.s.	– 3 cornelian beads (found in courtyard below steps)
HR 205	8 ft.b.s.	– 1 black stone conical object (found in courtyard below steps)
HR 206	8 ft.b.s.	– 2 fragments of copper (found in courtyard below steps)
HR 207	8 ft.b.s.	– 1 T.C. toy plate
HR 208	8 ft.b.s.	– 1 T.C. lid
HR 209	8 ft.b.s.	– 1 amythist crystal
HR 210	8 ft.b.s.	– 2 bone objects
HR 214	8 ft.b.s.	– 1 conch shell (found inside well in courtyard)
HR 217	8 ft.b.s.	– 1 bead

ft.b.s.=feet below surface

Hargreaves mentioned in the first excavation report on Mohenjo-Daro that „*numerous small objects of faience and alabaster were recovered at the base of the north wall*" in courtyard 10 *(Marshall, 1931:177)*, but the discovery of the gastropod shell in the circular brick structure, described as well in the inventory book, obviously not appeared noteworthy to him; although he pointed out, that this architectural feature could not have been a well.

Upper
Fig. 6a *Reconstructional view into Courtyard 10, House I in HR-A*
(drawing: R. Bunse)

Lower
Fig. 6b *Ceramic lid? HR 980. Karachi: National Museum (Sind Vol.VII, 1925-26,330)*



The striking lay-out of courtyard 10 with its axially symmetric staircases, the masonry ring, and the two symmetrically arranged rooms joining in the south, have already been remarked by others.[5)] Wheeler suggested for the area of House I the interpretation of having been used as temple or shrine because two stone statues have been found in it. Furthermore he emphasized the axial access through a double entrance towards the court and the staircases. The masonry ring, Wheeler saw as „*apparently designed for the protection of a tree or other object – possibly even of the statue whereof the head was found only a few feet away.*" *(Wheeler, 1968) (Fig. 6a)* The recovery of a sánkh (Turbinella pyrum) shell from the round brick structure accentuates the possibly religious function of the architecture when we consider the potential mythical meaning of shells and shell objects in Mohenjo-Daro (cf. *Kenoyer, this volume)*, and when we include the painted ceramic lid (?) HR 980 *(Fig. 6b)* from Room 14 in our considerations. The painted motif on the lid appears to be rather significant as will be discussed later.

In order to revert to the object HR 910, following characteristic features can be observed:

- oval-shaped face
- hollow, almond-shaped eye-sockets, which were almost certainly fitted with inlays. The outer corners of the eyes are turned down.
- broad cheekbones and a receding forehead
- a straight nose, whose tip has been restored

- the narrow top lip contrasts with the thick bottom lip. The corners of the mouth are turned slightly upwards.
- the short chin shows traces of a beard, the moustache seems to be clean shaven.
- the long, wavy hair is combed straight back and knotted in three strands into a bun, held in place in the neck by a headband.
- the shape of the ears has been reduced to a simple oval; the auditory canal being indicated by a chiseled round hole.

The image is ca. 18 cm in height and made out of white limestone covered with a yellowish coating.

According to the publication the limestone head L 898 *(Figs. 7-9)* was found in Room 77 in L Area at a depth of 0,53 meter below the first pavement. Mackay,

Fig. 7 *Limestone head L 898 height: 19,5 cm (front view) (Sind Vol.VII, 1926-27,442)*

Fig. 8 *L 898 (side view) (Sind Vol.VII, 1926-27,444)*

Fig. 9 *L 898 (back view) (Sind Vol.VII, 1926-27,443)*

remarking on the circumstances under which the head was recovered, noted that it was lying on the drain in chamber 77, 0,70 meter below the datum level[6]; thus it could belong to the same period as the drain, which was classified as „Late" by the excavators. The only associated objects mentioned in the report are; a ceramic plate (L 932) and a ceramic cone (L 933). Apart from these, the Fieldbook lists as a contemporary find:

L 917 1 ft.b.s. of wall – irregular limestone, probably part of a statue.[7]

The yellowish limestone image L 898 is 19,5 cm high and shows the following characteristic features:

- an oval-shaped face.
- hollow, almond-shaped eye-sockets, whose drilled holes suggest some sort of inlay work (cf. *Marshall, 1931: 358*). The corners of the eyes slant downwards.
- broad cheekbones and a receding forehead.
- straight nose with carved nostrils.
- simple, oval-shaped ears in which the auditory canal is indicated by a drilled round hole.
- the narrow upper lip contrasts with the fleshy bottom lip.
- the chin is short and receding.
- the undulating hair is combed back from the forehead and knotted in three strands in the back of the neck, thus being held in place by a fillet running across the forehead.[8]
- the thickening of the throat which is visible below the chin, represents most probably the Adam's apple.[9]

The sculpture L 127 *(Figs. 10-12)* is a 15 cm high grey limestone head, which was found on 11.12.1926 in Room 100 of L Area „just below" the first pavement.

Fig. 10 *Limestone head L 127 height: 15 cm (front view) (Sind Vol.XII, 1926-27,432)*

Fig. 12 *L 127 (back view) (Sind Vol.XII,1926-27,434)*

Fig. 11 *L 127 (side view) (Sind Vol.XII, 1926-27,435)*

According to the excavation report, two pavements were exposed in Room 100, both of them considerably damaged. The older pavement lay 0.91 meter below the datum level[10], the younger one 1.31 meter above the latter. The image was found at a height of 0.33 meter below the bench mark and Marshall noted:

„The position of the head was therefore, between the two pavements found in this room, but as the upper pavement like the one below it had been almost entirely removed, it is possible that the head may once have lain on the upper pavement and that it was thrown aside when the pavement was removed for its brick." (Marshall, 1931: 155)

This description of the find situation makes it highly presumable that the context of the exposed remains including the associated artifacts was already disturbed when excavated. Notwithstanding the opportunity should be taken here to publish the finds which were made in this Room according to the Fieldbook of L-Area:

L 33	p.l.	– 1 model bird in pottery
L 34	n.l.	– model head of a man in pottery
L 35	n.l.	– well made pottery jar cover with perforated hole string
L 45	n.l.	– 2 small bivalves shells
L 46	n.l.	– Gastropod shell (Turbinella species)
L 47	n.l.	– 4 beads, shell and faience
L 48	n.l.	– fragment of bead
L 49	n.l.	– pottery object of unknown use
L 52	p.l.	– cornelian globular bead bored from both ends
L 55	p.l.	– disc-shaped shell bead
L 56	p.l.	– shell
L 62	p.l.	– paving brick polished by use
L 69	2 ft.b.s.,	small pottery ball
L 75	p.l.	– cylindrical rubber pestle, grey stone, 3,5" long
L 77	1 ft.b.s.,	core of shell
L 89	p.l.	– baked clay flat round bead, somewhat roughly made
L 96	p.l.	– small pottery ball
L127	n.l.	– head of statue, limestone, broken at neck and lower portion missing, badly weathered; apparently female head with long curly hair hanging down

p.l.=pavement level; n.l.=no levellement

The face of the sculpture L 127 is so badly damaged that the nose and mouth are hardly recognizable. The following characteristic features can, however, be distinguished:

- a square face.
- hollow, almond-shaped eyes, in the right one of which the original inlay of white stone is still preserved. The eyes are more closed and longer than those of heads HR 910, and L 898, and run horizontally, i.e. the corners of the eyes are not turned downwards.
- the cheekbones are broad, the forehead short, but not receding as in the previous examples.
- the nose is completely destroyed.
- the mouth is so badly damaged that its form cannot be distinguished.
- the chin is short and beardless.
- the ears are of an abstract and ornamental shape, whereby Helix, Skapha, Anthelix and Cavum are recognizable in the ornamentally reduced form. Again a hole has been bored in the middle to represent the auditory canal.[11]
- the wavy hair is combed back from the forehead, leaving the ears free, and falls loosely in the back of the neck.
- from the front, 2 pairs of circular holes of differing sizes are distinguishable on both sides of the head, below the ears. That they served for the adjustment of some ornament was already proposed by Mackay.[12]

As the image L 127 is in so far differing from the other stone sculptures as the hair style and its beardlessness are concerned, it might be probable to assume the representation of a female individual, as has already been mentioned in the first provisional description in the Fieldbook of L-Area. This would then be a rare case, as all the other stone sculptures from Mohenjo-Daro are of male sex.

The well-known bust of the so-called „Priestking" *(Figs. 13-15)* is numbered DK 1909 in the Fieldbook of the Dikshit excavation. It is made from light-coloured steatite and is 17.8 cm high. The object was found on 10.1.1927 in the south of DK-B Area, Block 2, Room 1, 1.37 meter below the surface and was classified as being of the „Late Period" by the excavators. The theory that Room 1 was used as a bath or Hammam has been discussed in detail by Mackay in the first excavation report on Mohenjo-Daro *(Marshall, 1931: 236-7)*. According to Mackay the bust was found below the floor level in one of the three „hypocausts". It is most likely that this findspot points towards a secondary position of the sculpture and therefore we may not draw farleading conclusions out of the artifact assemblage unearthed from square 22/0 22 in which Room 1 was located. The following associated object numbers and their description are according to the Fieldbook DK excavation (all found in square 20/0 22):

DK 1909	4.6 ft.b.s.	a stone bust of a bearded nobleman
DK 1910	4.6 ft.b.s.	stone weight
DK 1921	6 ft.b.s.	red stone
DK 1922	5 ft.b.s.	black polished stone

Fig. 13 *Steatite bust DK 1909*
height: 17,8 cm
Karachi, National Museum
(Sind Vol.X, 1925-26,6956)

Fig. 14 *DK 1909 (side view)*
(Sind Vol.X, 1925-26,6959)

Fig. 15 *DK 1909 (back view)*
(Sind Vol.X, 1925-26,6957)

DK 1923	4	ft.b.s.	marble stone piece
DK 1924	5	ft.b.s.	broken shell bangle
DK 1925	5	ft.b.s.	broken conch shell
DK 1926	5	ft.b.s.	pieces of some green stone
DK 2074	5	ft.b.s.	a sandstone pyramid
DK 2075	4	ft.b.s.	a terracotta bangle
DK 2076	4	ft.b.s.	a terracotta lid, broken
DK 2077	4	ft.b.s.	green glazed stone piece
DK 2078	5	ft.b.s.	three shell pieces
DK 2186	3	ft.b.s.	a black stone with scratches
DK 2219	2	ft.b.s.	two shell segment pieces
DK 2220	6	ft.b.s.	a seal
DK 2240	4	ft.b.s.	green polished stone pieces
DK 2241	4	ft.b.s.	a terracotta lid, broken
DK 2270	5	ft.b.s.	copper rods & a square piece
DK 2271	4	ft.b.s.	an alabaster round stone
DK 2272	4	ft.b.s.	a red sand stone
DK 2319	6	ft.b.s.	shell bangle pieces & 1 round piece of shell
DK 2320	6	ft.b.s.	paste beads
DK 2359	6	ft.b.s.	copper pieces
DK 2421	7	ft.b.s.	1 terracotta pot
DK 2422	7	ft.b.s.	2 terracotta lids
DK 2423	7	ft.b.s.	1 terracotta jug

The faience monkey DK 2091 which was attributed to Room 1 in the excavation report *(Marshall 1931: 254)* is listed in the Fieldbook as coming from the dump.

The trefoil pattern[13] on the garment of the bust has already proved a talking point for others[14], and thus at this point nothing more will be said about it and we will concentrate first of all on the peculiarities of the sculptures' outer appearance:

- the shape of the face is rather square.
- the half-closed eyes have long eyelids, with inner and outer corners horizontally opposed. When the image was found, one shell inlay was still fixed to the left-hand eye.[15]
- the face shows broad cheekbones and a short receding forehead.
- although the tip of the straight nose has been broken off, the chiseled holes of the nostrils are still distinguishable.
- the mouth shows full lips with turned-down corners.
- the chin is prominent and bearded, the moustache is clean-shaven.
- in the a-naturalistic ornamental shape of the ears, abstract reproductions of Helix, Skapha, Anthelix and Concha are recognizable.[16] Deep, round holes indicate the auditory canal.
- the straight hair has a centre parting and is combed back behind the ears. The headband which is encircling the head, has above the lengthened root of the nose a circular ornament, which could like the trefoil design of the garment and the round device on the wristband have been filled with a coloured paste. At the back of the head the headband falls in two strands down the back.
- the smoothed, sloping surface on the back of the head suggests an additional attachment , made separately, which would have been fixed onto the head.
- in the 3/4 portrait view *(Fig. 13)* a wedge-shaped groove is visible below the ear, which exists also on the other side. These recesses gave rise to the speculation that there had also formerly been some kind of ornament, possibly a necklace, which decorated this sculpture as well (cf. *L 127*).[17],[18]

Fig. 16 *Alabaster sculpture HR 163/193/226 height: 42 cm (front view) (Sind Vol.XI, 1926-27,312)*

Fig. 17 *HR 163/193/226 (side view) (Sind Vol.X, 1925-26,2367)*

Fig. 18 *HR 163/193/226 (back view) (Sind Vol.XIV, 1927-28,420)*

Apart from the five stone heads, we know about seven more or less complete[19] full-length stone statues from the Mohenjo-Daro excavations, of which only five have been published up to the present day. As three of the seven sculptures (or sculpture fragments) still have their heads attached to their bodies and as in all probability the stone heads originally also belonged to bodies, all heads show irregular broken edges pointing to a forceful demolition, we may draw conclusions from the full-length images to the head fragments and viz versa.

In order to recall the already published statues into the mind of the reader, we begin with figure HR 163/193/226 which has been discussed in detail by Marshall in his first report on Mohenjo-Daro. *(Marshall, 1931: 178, 359)*

The statue *(Figs. 16-18)* is a ca. 42 cm high grey alabaster image, which was found in three fragments and was then reconstructed. The different find-spots were dispersed throughout the southern part of HR-A Area: the body, HR 163, was found on the wall crest of the western staircase in Courtyard 10 of House I *(Fig. 6a)*. A few days later, a part of the head was found about 13.70 meter north of the first discovery, in „South Lane". The rest of the head, HR 226, lay approximately 2.50 meter further to the north-east in Courtyard 34 of House V. All the pieces of the figure lay on the surface of the site, and thus one cannot be sure of their provenience, and their destruction probably took place in more recent times.[20] In spite of this Wheeler refered to a possible relationship between the discovery of this figure and that of the already mentioned head HR 910, and the striking architectural features of House I. The characteristic features of the figure are as follows:

- a squatting position, with right leg bent higher than the left one. It appears that the posterior is resting on the foot of the lower leg i.e. the leg with the knee touching the ground.
- both hands are laid across the knees.
- the folds of a garment between the legs suggest some sort of loincloth, tied around the hips; as can be seen from the rear view *(Fig. 18)*, it was probably fastened with a cord.[21]
- the statue has an oval-shaped face.
- the eye-sockets have lost their inlays. The outer corners of the eyes are drawn sharply downwards.
- the cheekbones are high and broad, the forehead short and receding, the nose straight.
- the area around the mouth is too badly damaged for any close description. The chin appears too long; this impression is due to the long, full beard.
- the ears are represented by a simple ring-shaped oval, in whose centre there is again a circular hole.[22]
- the hair cannot be studied in detail because of the figures' bad state of preservation. It is, however, likely that the sculpture had short hair which left the ears free.
- the only decorative feature is a headband, falling down the back of the figure in two strands.

Object L 950 *(Figs. 19-21)* is a 29cm high figure made of grey alabaster, whose head has been broken off and was not found. The sculpture was discovered in the north-eastern corner of L Area, on the brick floor in Room 75, 0.76 meter below the datum level[23] and was classified as „Late" by the excavators. Marshall mentioned

Fig. 19 *Alabaster sculpture L 950 height: 29cm (front view) Karachi, National Museum (Sind Vol.XI, 1926-27,309/XII, 1926-1927,445)*

Fig. 20 *L 950 (side view) (Sind Vol.XII, 1926-27,447)*

Fig. 21 *L 950 (back view) (Sind Vol.XII, 1926-27,446)*

no further discoveries associated with the sculpture in his excavation report and also the Fieldbook of L-site gives no information about connected finds. There is, however, a possible temporal and functional relation between figure L 950 and head L 898, which was found in close proximity (Room 77, 0.70 meter below the bench mark). Furthermore, four so-called „ring-stones" were found at a depth of 0.68 meter below datum[24], approximately 9 meters to the north of the find-spot of sculpture L 950, and these can probably be dated in the same period as the fragments of the images. As Marshall pointed out in his report, it is presumable that due to the extraordinary finds in the area of Block 3, there should have formerly existed a number of special architectural structures, which at a later date, around the end of the settlemental period of Mohenjo-Daro, were disturbed and destroyed and used for purposes other than their original ones.[25]

The object L 950 displays the following characteristics:

- it is in a half-crouching/half-sitting position, whereby the left knee is bent higher than the right one. The left hand holds the left knee, the right hand rests flat on the lower thigh.
- the toga-like garment covers the sculptures' left shoulder and arm, leaving the right shoulder and arm bare (cf. *footnote 21)*.
- a differentiated modelling of the chest and abdomen is recognizable in the frontal view *(Fig. 19)*. Furthermore the irregular break at the upper chest suggests the rest of a long beard, comparable to the beard of sculpture HR 163/193/226.
- the rear view *(Fig. 21)* shows a square, roughly hewn portion of stone, upon which the chisel marks can still be plainly seen. While all other parts of the image are in an endpolished state, it is probable that this part was only roughly prepared because it was intended that a separately manufactured additional piece (from another material, or similarly alabaster) should cover it.[26]
- to the right of this roughly hewn patch hangs a pigtail-like shape, marked with horizontal grooves. This could be interpreted as a pigtail, as Mackay has already suggested.[27] It is quite possible that this was a typical hairstyle worn in Mohenjo-Daro (by certain individuals) or that the personifications of certain imaginary beings were thought to wear this special kind of hairdo. E.g. pigtail-like shapes are also visible on the heads of figures on seal DK 6847 *(Fig. 22)*.[28] A similarly shaped addition of head-dress or hair-dress can be suggested for the back of head of sculpture SD 2781 *(Fig. 25)*, even though this shape is chiseled in a negative form, i.e. carved out of the stone, possibly to ease the fitting of the additional piece.

Fig. 22 *Steatite seal DK 6846, size: 4,06x3,94x0,84cm. Karachi, National Museum (Sind Vol.XVIII, 1928-29,621)*

Fig. 23 *Limestone torso SD 2781 height: ca. 22 cm (front view) (Sind Vol.XIV, 1926-27,202)*

Fig. 24 *SD 2781 (side view) (Sind Vol.XIV, 1926-27,203)*

Fig. 25 *SD 2781 (back view) (Sind Vol.XIV, 1926-27,204)*

The figure SD 2781 *(Figs. 23-25)* was found on 9.11.1927 in SD Area, Block 1, south-western corner of Courtyard 61, 0.73 meter below the excavation surface. The excavators deemed it to be of „Late Period". The inventory of the SD excavation lists in addition to those mentioned by Mackay[29] the following artifacts, which might be related to the circumstances of the discovery of the sculpture:

SD 2781	F.*7.75;	B.**10.22 ft.	–	statue
SD 2782	F. 7.54;	B. 10.22 ft.	–	macehead
SD 2783	F. 7.75;	B. 10.22 ft.	–	faience beads
SD 2784	F. 7.75;	B. 10.22 ft.	–	carnelian unfinished beads
SD 2785	F. 7.5;	B. 10.22 ft.	–	part of shell lid
SD 2786	F. 7.5;	B. 10.22 ft.	–	part of shell lid
SD 2787	F. 7.5;	B. 10.22 ft.	–	mace heads
SD 2788	F. 7.5;	B. 10.22 ft.	–	terracotta vessel
SD 2789	F. 7.5;	B. 10.22 ft.	–	ornamental alabaster piece
SD 2821	F. 7.5;	B. 10.22 ft.	–	terracotta vessel
SD 2822	F. 7.5;	B. 10.22 ft.	–	faience bead
SD 2826	F. 7.7;	B. 10.22 ft.	–	copper rods
SD 2827	F. 7.7;	B. 10.22 ft.	–	shell inlay
SD 2832	F. 7.6;	B. 10.22 ft.	–	stone weight
SD 2833	F. 7.6;	B. 10.22 ft.	–	copper ring
SD 2834	F. 7.6;	B. 10.22 ft.	–	shell bead
SD 2835	F. 7.6;	B. 10.22 ft.	–	stone bead
SD 2836	F. 7.6;	B. 10.22 ft.	–	macehead

* Foreward reading;
** Backward reading (of level instrument)

The figure is made of a light limestone and is ca. 22 cm high. It is in a fragmentary condition; the head, neck and shoulders as well as the feet are missing. Nevertheless, the squatting position of the figure can be recognized: the right leg is bent higher than the left. The left hand rests flat on the left knee; the right hand is clenched into a fist on the right knee.[30] Because of the large amount of damage the figure's garments cannot be distinguished in detail. It can, however, be assumed on the evidence of folds of a drape between the thighs, that it was wearing a dhoti-type loincloth which did not cover the upper-part of the body as a circular depression visible in the middle of the abdomen obviously represents the navel. As already mentioned, the rear view *(Fig. 25)* shows a shape carved in the stone whose contours are similar to those on the back of L 950. Mackay and Wheeler have already commented on a series of small circular holes, which are to be found in five concentric rows on the shins of both legs.[31] They interpreted these respectively as tattoos, or rows of several anklets.

The figure DK 4647 *(Figs. 26-28)* is also in a fragmentary state. It was found at a depth of 2.80 meter[32] in Room 6, Block 5, in DK-G Area, which according to Mackay dates it in the „Late III Phase". It is carved out of a cream-coloured limestone and is about 21 cm high. Mackay deemed it as being unfinished *(Mackay, 1938: 257)*. Associated finds are neither mentioned in the excavation report nor in the Fieldbook of DK-G excavation. Again this sculpture shows the characteristic squatting position, with the right leg bent higher than the left. Although both hands are damaged, it can be assumed from the position of the arms, that they must have lain on the knees. The folds of a dhoti can also be distinguished between the legs in the frontal view *(Fig. 26)*, as well as a chiselled navel. The rather plump back of the head, which runs directly into the torso with no neck, shows signs of regular fluting, which does not however encircle the head. Mackay remarked that he could detect traces of a headband in this feature *(Mackay, 1938: 257)*.

Fig. 26 *Limestone sculpture DK 4647 height: ca. 21 cm (front view) (Sind Vol.XIV, 1926-27,343)*

Fig. 27 *DK 4647 (side view) (Sind Vol.XIV, 1926-27,345)*

Fig. 28 *DK 4647 (back view) (Sind Vol.XIV, 1926-27,344)*

One object which has remained unpublished up to the present day is a figure from the museum in Mohenjo-Daro *(Figs. 29-32)*. It is 33 cm high and made out of white limestone. The image carries the Fieldbooknumber DK-I 419 and was found on 27.2.1934 in Room 31 of DK-I Area. The excavators classified it as being of „Late" date. The DK-I Area, in the eastern settlement area of Mohenjo-Daro, was excavated in the years 1932-33 and 1935-36 by the archaeologists Q.M. Moneer and K.N. Puri, but the results were never published due to lack of money.[33] In the meantime, through the redocumentation of Mohenjo-Daro by the German Research Project Mohenjo-Daro the architecture of DK-I site has been once more assessed, and it has been renamed the „Moneer" Area. A relocalisation of the artifacts brought to light by the excavation however, has not been possible while the original excavation plans, showing the old room numbers, have not been found. In spite of that, we will take the opportunity to list all artifacts from almost the same level excavated in Room 31 according to the excavation inventory:

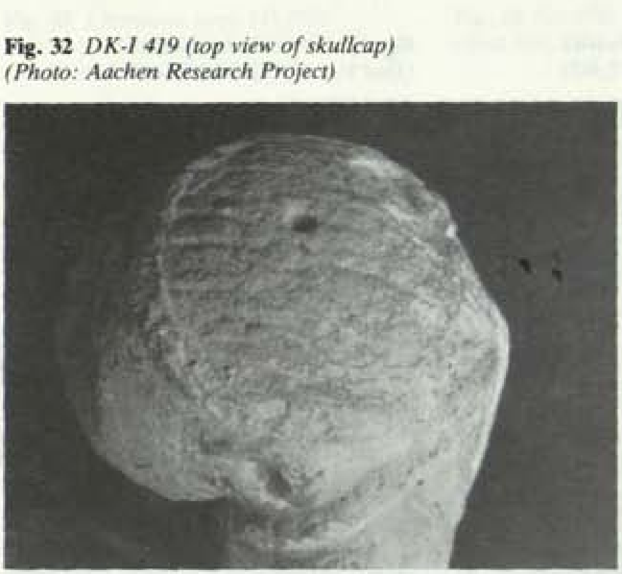
DK-I 419	27.2.34	F.13.2; B.6.65 ft. near door in wall	–	male stone statue seated on haunches
DK-I 429	1.3.34	F.12.6; B.6.75 ft.	–	shell inlay
DK-I 430	1.3.34	F.12.6; B.6.75 ft.	–	ivory stick
DK-I 434	1.3.34	F.12.6; B.6.75 ft.	–	limestone linga

Fig. 31 *DK-I 419 (back view) (Photo: Aachen Research Project)*

Fig. 29 *Limestone sculpture DK-I 419 height: 33 cm (front view) Mohenjo-Daro, Site Museum (Photo: Aachen Research Project)*

Fig. 30 *DK-I 419 (side view) (Photo: Aachen Research Project)*

Fig. 32 *DK-I 419 (top view of skullcap)*
(Photo: Aachen Research Project)



The sculpture again depicts a squatting figure with both hands resting on the knees. The knee and parts of the thigh and shin of the right leg are damaged. The folds of a garment between the legs leads us again to the conclusion that it is wearing a dhoti-cloth. The upper part of the body is naked (shown again by the presence of the navel), and as in the previous examples suggests a man's anatomy. The head of the statue is top-heavy in comparison with the body; a feature which could be observed on all the other Mohenjo-Daro images inasmuch as (for the head fragments) at least the shoulders were preserved. The characteristic details of the face are:

- a proportionally square face.
- hollow, almond-shaped eyes, containing in the right eye-socket the original (?) inlay of shell. In comparison to the other Mohenjo-Daro sculptures the eyes are noticeably small and the outer corners of the eyes are not slanting downwards as this was the case in the faces of HR 910, L 898, HR 163/193/226.
- the eyebrows are accentuated.
- the cheekbones, as with all Mohenjo-Daro sculptures, are broad.
- the nose is badly damaged; in this condition it appears short and flat.
- in relation to the rest of the face the mouth is rather small. The lips are pursed together, as though in the action of whistling.
- the straight hair is combed away from the forehead. Again a hairband leads around the head, the ends of which fall in two strands down the neck.
- a new interesting feature are the two plait-like forms which are descending from the back of the head and lie on both shoulders. That they represent pig-tails is indicated by the parallel incisions which are still vaguely traceable on them.
- the ears are conventionally shaped and have a round chiselled hole in the centre.
- the chin is broad and wears a beard, the moustache seems to be clean-shaven.
- on the top of the head there is a round hole carved into the skull-cap *(Fig. 32)*. It is 0.77 cm in diameter and 0.6 cm deep and could have been intended for the attachment of some kind of head-ornament.[34)]

Another, yet unpublished stone sculpture from Mohenjo-Daro is a fragment of a squatting figure *(Figs. 33-35)*. The object was discovered during the last campaign of the German Research Project Mohenjo-Daro (1984) in Mohenjo-Daro, but unfortunately no legible Fieldbooknumber was traceable on it. But as the excavation inventory of HR site gives the following details,

HR 5785 27.1.27 Room 301 5 ft.b.s. – a broken leg of a figure in squatted posture, fragment of a limestone statuette,

it is most likely that the image fragment figured in *Figs. 33-35* is identical with HR 5785 as its outward appearance proved to be suitable to the description. The sculpture has a present height of 17 cm and is made out of light yellow limestone. The image is dressed in a toga-like garment which covers the upper left arm and chest. As the right part of the statue is missing, it cannot be decided whether the cloth cased right arm and shoulder as well, but the probability is high that the costume was identical to those of figures L 950 and DK 1909. An interesting feature is the geometrical pattern on the garment: the whole cloth is covered with shallow, round holes varying in diameter and depth from 0.3 to 0.5 cm and from 0.27 to 0.34 cm. Presumably these deepenings were originally filled with a coloured paste as this has been suggested for the indentations in the trefoil-design on the garment of DK 1909. The typical posture of the Mohenjo-Daro sculptures can again be recognized; one knee is touching the floor while the posterior sits on the heel of the foot. The other leg (in this case missing) is bent higher, in a way that the shank stands upright and parallel to the body. The hands of the outstretched arms rest on the knees. This basic attitude could be observed on all full-length Mohenjo-Daro sculptures in a qualified sense as far as the interchangeability of the position of legs and arms is concerned. The Fieldbook of HR Area lists the following artifacts as coming from Room 301, which is according to the later established nomenclature of Housenumbers Block 5, House XL, Room 94 in HR-B Area:

HR 5786 27.1.27 Room 301 5 ft.b.s. – a polished limestone cone, an alabaster piece, a painted potsherd, a figure of a female bust with neck ornament.

Fig. 33 *Limestone fragment HR 5785*
height: 17 cm (front view)
Mohenjo-Daro, Reserve Collection
(Photo: A. Ardeleanu-Jansen)

Fig. 34 *HR 5785 (side view)*
(Photo: A. Ardeleanu-Jansen)

Fig. 35 *HR 5785 (back view)*
(Photo: A. Ardeleanu-Jansen)

In comparing the stone sculptures from Mohenjo-Daro, formal similarities can be observed, the details of which must be viewed in regard to their iconographic parallels in other cultures as well as in relation to their possible contextual meaning.

The similarities in outward appearance may be summarized as follows; one can distinguish four types of head-dress or hairstyle of which three have parallels in neighbouring civilizations, leading to the assumption that there could have existed binding cultural connections. The sculptures HR 163/193/226, DK 1909 and DK-I 419 show a hairstyle, whose decorative feature is a headband split into two ends at the back of the head, and falling down the neck and back. This type of head-dress has already been pointed out by G.F. Dales, because it appeared on two of the Helmand heads discussed in his paper (Mundigak IV,3 and the head from the private collection). A variation of this fashion could be observed on figure DK-I 419; the two plaits of hair, which descend from the back of the head and fall down the shoulders have resemblance to the hair-style of a male torso from Tepe Yahya IV B,1 which displays two ropes of hair coming down on either side of the chest *(Kohl, 1979: Figs. 20-21)*. The dressing of the hair-plaits is executed in a similar way by chiselling horizontal parallel grooves into the stone. A further hairstyle could be seen on the heads DK 1057, HR 910 and L 898: the long, wavy hair (of the male figures) is combed back from the forehead and tied in a knot at the back of the head, which is then held in place by a narrow headband *(Figs. 3,5,9)*. M. Tosi and E. During-Caspers mentioned the parallel appearence of this hairstyle in examples from the Helmand Civilization and Mesopotamia in the Early Dynastic Period. The chignon-type knot, which holds the figures' long hair in the neck, gave them grounds to propose temporal and cultural connections.[35] *(Tosi, 1983: 371 & During-Caspers, 1984: 367)* The fourth type of hair- or head-dress was exemplified by sculptures L 950 and SD 2781 *(Figs. 21 & 25)*: a single pig-tail-like rope of hair was visible on the back of the sculptures. Just like the divided bun, this hair-style could be recognized on representations of human individuals on seals (cf. *footnote 28)* and thus proved to be a common fashion within the range of the Harappan Civilization. Parallels of this hair- or head-dress in neighbouring cultures are not present to the author but the three other examples of joint fashion may suffice to underline the observation already made by M. Tosi:
„... that in the second half of the 3rd. Millenium the cultural integration of southwest Asia, stimulated but surely not caused by increase of mutual trade, was by now an established fact, perhaps exceeding our own suppositions drawn from present state of research, and probably unrealized by the inhabitants themselves of Mesopotamia and the Indus." (Tosi, 1983: 317)

Another noticeable feature which should not be overlooked on the Mohenjo-Daro stone sculptures, is the manner in which the ears are represented. On all examples these organs have been reduced to an abstract, almost ornamental, shape. The ear is without doubt one of the most complicated external features of the human body, and an anatomically correct reproduction of such requires a great deal of sculptural artistry; but already Marshall was convinced that no true to life delineation was intended:
„It is strange, though, that the sculptor should have been content with such conventional, saucer-like ears, when he obviously had the power to do much better. It looks as if there must have been some particular reason for this peculiar distortion, which is found in the other heads also, though what the reason was is hard to guess.[1]

Footnote 1: The hole in the centre of the ear is evidently intended for some attachment which may have concealed the shapelessness of the ear but does not excuse it." (Marshall, 1931: 44)

Fig. 36 *Shell inlay pieces,different sites of Mohenjo-Daro. (Sind Vol.XI, 1926-27,402)*

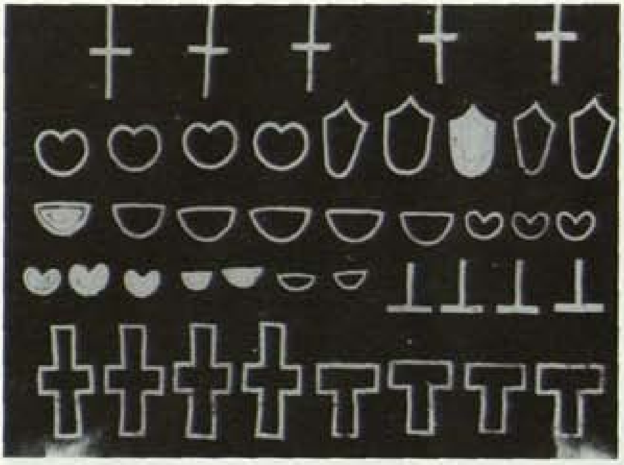
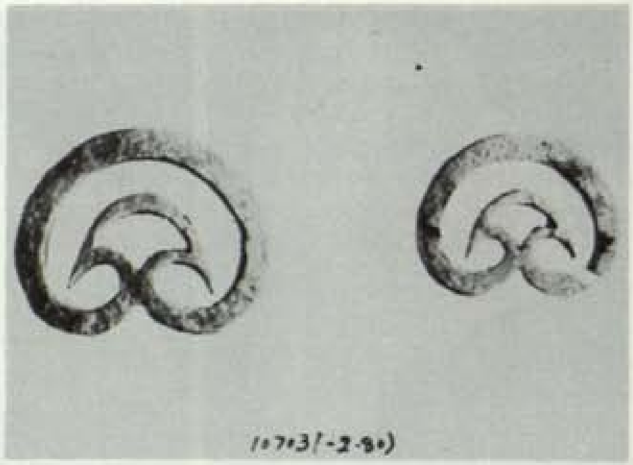


Fig. 37 *Shell inlay pieces DK 10703. (Sind Vol.XIII, 1930-32,579)*



The shape of the ears on the Mohenjo-Daro sculpture heads ranges from a simple oval form, with slightly depressed interior and chiselled hole in the centre (HR 163/193/226; HR 910; L 898; DK-I 419), to a differentiated formation of the basic oval figure with heartshaped sweeps (L 127; DK 1909). As has already been noted in footnote 16, Mackay compared the shape of the ears on bust DK 1909 to two double shells, and mentioned similar configurations, recognized as special shell-inlay-work. Wheeler believed that he could distinguish the cross-section of a shell in the shape of the ear of the „Priest-king".[36] A few years later, Mackay formulated his ideas about the similarity between the form of the ear and shell inlay ornaments in a more interpretative way:

„The frequently found shape seen in Pl. CXLI, 11-13, is, I think, intended to represent an ear. Its strong similarity to the ears of the fine steatite portrait-head illustrated in the first book on the site[2] is significant. Even the more elaborate pieces of this type, such as those illustrated in Pl. CVI, 4,5, still strongly suggest the ear with an ear-hole added. The steatite pectoral or amulet (Pl. CXL, 59) discussed in chapter XIV, p.546, on the Personal Ornaments may have had some religious significance. The wearer was perhaps regarded as the ear of the god, whose animal emblem it may be that is cut in shell on the amulet. Whether this ear motif, which it should be mentioned, does not appear on the pottery,[37] was in general use on ceremonial articles is not yet known. In fact, it is not impossible that votive plaques were thus ornamented in the manner of the ear tablets of the Eighteenth Dynasty from Memphis in Egypt, where the ear occurs singly, doubly or in numbers, and was sometimes accompanied by the figure of the god Ptah, the patron deity of the city.[3] Sir Flinders Petrie regards the ears of these tablets as representing the ears of the god to receive and preserve the prayers breathed into them.

Footnote 2: Mohenjo-Daro and the Indus Civilization, Pl. XCVIII, 3,4.

Footnote 3: Petrie and Walker, Memphis I,pp. 7,8; Pls. IX-XIII. These tablets are of stone or faience and are not inlaid." (Mackay, 1938: 585)

We cannot determine here if Mackay's interpretation of the meaning of the ear motif is correct. There is, however, convincing evidence, most possibly in his favour, that special consideration must be appointed to the auditory organs of the sculptures. The hollow at the ear-hole and the abstract ornamental design suggest a context more important than that of the simple sense of hearing. Even if the hole in the middle was used to secure an appliqué, this ornamentation would underline the special meaning of the ear. The „ear-motif" appears not only on the ears of the sculptures but also on a variety of other artifacts from Mohenjo-Daro and Harappa. Perhaps the most well-known and numerous of these objects are the already mentioned shell ornaments, which were used as inlays on objects which are still unknown to us *(Figs. 36-37)*.[38]

E. During-Caspers proposed another interpretation of the „ear-motif" in a paper in 1970-71. This was in relation to texts from the Early Larsa Period, which tell of precious gifts having been offered to the goddess Ningal in Ur. Amongst them were said to be *„kidney-shaped beads of cornelian" (During-Caspers, 1970-71: 114)*. But as there remains no archaeological evidence of these *„kidney-shaped beads of cornelian", „... it may be surmised that, in the light of the discovery of kidney-shaped inlays at Tell Asmar as well as in the Indus Valley cities, the Larsa records refer to pieces of inlay which had been transported from the Indus Valley to Dilmun (= Bahrain) via the Persian Gulf route." (During-Caspers, 1970-71: ibid.)*

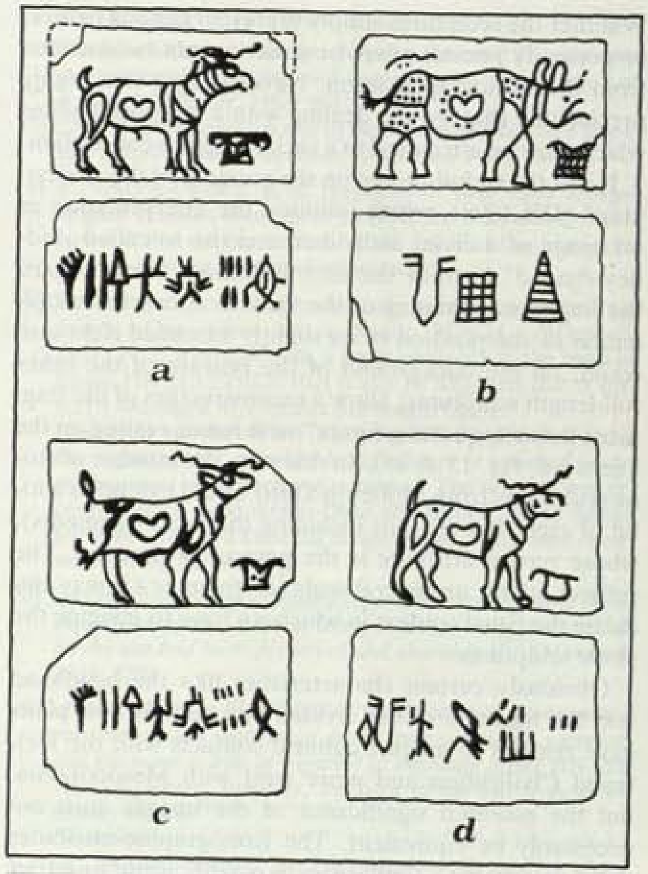
E. During-Caspers places special emphasis on the word kidney in interpreting the contents of the motif. Her interpretation refers to Mallowan, who ascribed kidney-shaped seals and amulets from Tell Brak to prophetic purposes, in much the same way as Babylonian astrologers used the liver and kidneys of sheep.

Upper

Fig. 38 *a) copper tablet HR 4337 (Marshall, 1931/Pl.CXVIII,3)*
b) copper tablet VS 3500 (Marshall, 1931/Pl.CXVII,7)
c) copper tablet DK 4672 (Mackay, 1938/Pl.XCIII,11)
d) copper tablet DK 5996 (Mackay, 1938/Pl.CIII,3)
(drawings: R. Bunse)

Lower

Fig. 39 *White, steatite circular seal E 1886, size: 4,98 cm ø (Sind Vol.V, 1924-25,6627)*



Without wishing to commit ourselves on the appropriateness of E. During-Caspers' ideas, we must mention here the four copper tablets, each depicting an animal upon whose torso appears the „kidney-shaped motif" *(Fig. 38)*. This occurance is even more striking when one considers that on three of the tablets (HR 4337, DK 4672, DK 5996) the same animal appears, and that on two of them (HR 4337 & DK 4672) there is even the same inscription on the back. Parpola identified this animal as *„ram with curling horns and short tail"*, and lists four more similar tablets carrying the same animal and identical inscription. All four are unpublished and come from Mohenjo-Daro *(Parpola, 1973: 103; Nos. 384, 385, 387, 388)*. We are thus dealing with six copper tablets which bear identical animal *(„ram with curling horns and short tail")* designs and inscriptions. The whole corpus of Indus seals contains no more than sixteen seals, copper tablets or sealings showing a *„ram with curling horns and short tail"*. This, and the fact that the named examples are on a rather rare material (according to Mitchiner, 233 copper tablets have been recorded, which contrasts with the total of 2958 seals and tablets of other materials), would seem to lead to the conclusion that these tablets had a special meaning.[39]

Just as important appears the round seal E 1886 *(Fig. 39) (Marshall, 1931: Pl. CXIII, 383)*. Its circular exterior form is rare for Harappan seals. Just as extraordinary is the illustration of six animal necks with heads arranged around a central motif.[40] E. During-Caspers named this composition a *„whorl-motif"* and also noted the *„kidney-shaped"* centre around which the animal necks are arranged. *(During-Caspers, 1970-71: 107)*

A further, third level of significance was suggested by Wheeler and Goloubew; they believed that they could distinguish a cross-section of a shell in the shape of the sculptures' ears (cf. *footnotes 16 & 36)*. In his paper on „Mohenjo-Daro Shell Industries" J.M. Kenoyer draws attention to the fact that shell in Mohenjo-Daro, and the Harappan Culture as a whole, could possibly have had a socio-religious significance, as is the case in modern day India. Clearly the present state of the research allows no final decision to be made on the symbolic significance in the Harappan culture of the ear-shape of the sculptures and on other artifacts as well. It can, however, be assumed that this ornament had a similarly important significance such as the pipal-leaf design, the trefoil pattern and the swastika.[41] In conclusion , it may be stressed that *„an increase in the significance of a figure is obtained by ornamentation, when the ornament itself has a significance."*[42]

Similarities, which appear to have iconographic significance, can also be observed when comparing the attitude of the statues in full-length: all these figures are male and all are in the same posture. This squatting position, can, independent of traditional and cultural conventions, I think, be regarded as a submissive gesture which is to be understood as a way of expressing servitude to a highranking power.[43] Furthermore, the static form of the squatting position represents an attitude of inactivity, giving the impression of a reflective, contemplative state of mind. The block-like, closed shape of the images reinforces the effect of retraction and durability, which is stressed even more by the actual material, the stone.[44]

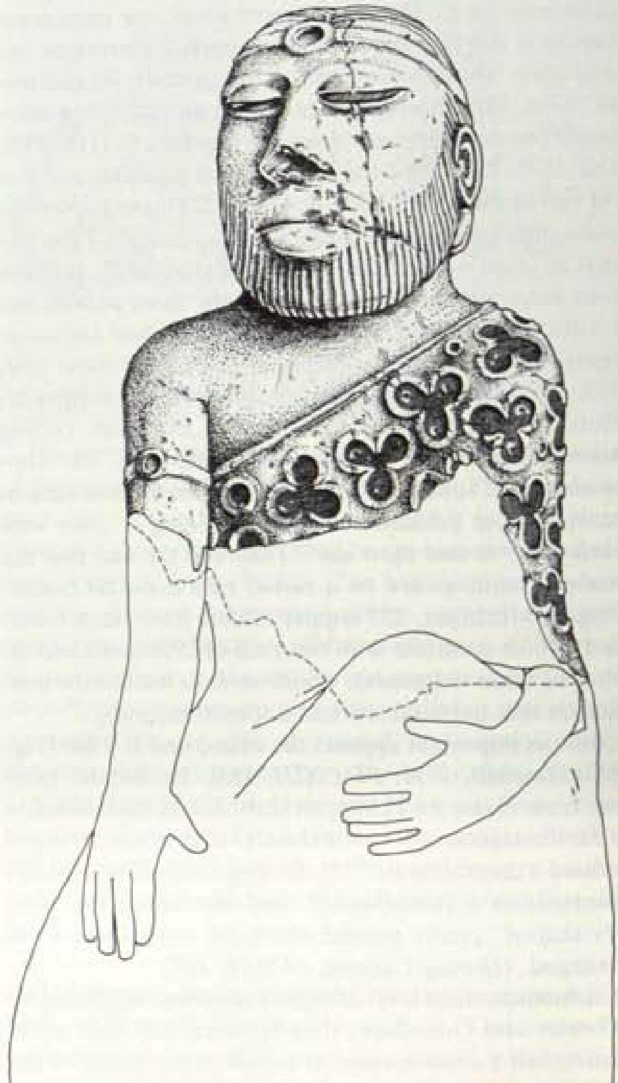
Whether the sculptures simply represent praying figures, or personify priests, rulers or gods, cannot be deduced from the iconographic form. Nevertheless, it is highly presumable that we are dealing with a sculptural genus which must be attributed to a socio-religious conception.

It was the trefoil-design on the garment of the „Priest-king" (DK 1909), which initiated the interpretation as an image of a divine individual and the so-called „kidney-shaped" form of the ears underlines in our regard the important meaning of the bust. – A careful examination of the position of its slightly extended right arm could, on the background of the posture of the other full-length sculptures, allow a reconstruction of the fragment into a „squatting figure" with hands resting on the knees (cf. *Fig. 13 & 40)*. In this way, the number of stone sculptures from Mohenjo-Daro would extend to a total of eight figures (not including the head fragments), whose typical attribute is the pose of prostration. The subject matter on several seals (cf. *footnote 43*) may elucidate the ritual context in which we have to imagine the stone sculptures.

Obviously certain characteristics like the headband and the hairstyle of the divided bun and the two plaits gave reasons to assume cultural contacts with the Helmand Civilization and more west with Mesopotamia, but the essential significance of the images must not necessarily be equivalent. The iconographic attributes show despite their similarities to neighbouring countries much individualism in their composition so that this is one more argument for the distinct character of the Harappan Civilization.

It is further noteworthy that all sculptures found in Mohenjo-Daro are from upper levels, classified as „Late" by Marshall and Mackay. This could mean that in the later phases of occupation there existed a cult exemplified by sculptural artistry which formerly was unknown, and could have been influenced by contacts with other cultural enteties. On the other hand, it is as likely that the sculptures existed in earlier settlemental periods of Mohenjo-Daro and played just as an important role. – Perhaps the sculptures were so precious (sacred?) that they were honored from one generation to another and were erected in each new phase of construction. This supposition could be underlined by the findsituation of the seals which depict scenes in which squatting figures occur: with two exceptions (DK 7033 & DK 6847), they all came from the upper levels of the site. On the other hand, the forceful demolition of the images – none of them has been found in complete condition – and their mainly disturbed findcontexts makes it probable that the cultural conception which they represent was given up in the late phase of occupation. The abandonment of the

Fig. 40 *Attempted reconstruction of steatite bust DK 1909 (drawing: R. Bunse)*



original function of such an outstanding architectural feature like the Great Bath (see: *Ardeleanu, Franke & Jansen, 1983)* in the late times, underlines the observation that fundamental changes took place during the last decades of the Harappan occupation in Mohenjo-Daro.

However, whatever the situation may have been, the most interesting fact remains that Mohenjo-Daro is the only place in the sphere of the Harappan Culture, where stone sculptures of this size and form have been found. This phenomenon is again an argument for the reconsideration of the peculiar status that Mohenjo-Daro holds within the Harappan Culture.

Footnotes

1) „Stone Sculptures from the Protohistoric Helmand Civilization, Afghanistan"; George F. Dales, University of California, Berkeley.Manuscript from July 1983. To appear in: Professor Giuseppe Tucci Felicitation Volume. G. Gnoli (ed.), Rome, IsMEO, forthcoming

2) Fieldbooks of the Mohenjo-Daro Excavations 1924-38, courtesy of the Archaeological Survey of Pakistan. Our special thanks to the Director General of Archaeology and Museums, Mr. M. Ishtiaq Khan , for his friendly support and permission to study the original copies of the fieldbooks.

3) „*Sind Volumes*" of the Phototheque of the Archaeological Surveyof India 1902-1940. We wish to thank the Archaeological Survey of India, New Delhi, and the Archaeological Survey of Pakistan, Karachi, for their permission to study and use the photographic material.

4) The DK-B fieldbook was completed on 26.05.1938 and signed by A. Rahman.

5) Marshall, 1931: 165, 177; Wheeler, 1968: 53; Jansen, no date: South Asian Archaeology 1983, Brussels, forthcoming

6) „*This datum level, which stands 181 feet above mean sealevel, is one of the points used by Mr. Francis in marking his general survey of the whole Mohenjo-Daro site.*" *(Marshall, 1931: 175)*

7) This object is unpublished, and also the photographic records of the „Sind Volumes" contain no illustration which could provide more information on the appearance of this fragment.

8) The hairstyle is identical to that of HR 910; the 3 strands of the knot are set in the same way, upper right to lower left. The illustration in Marshall, *1931: Pl. XCIX, 9* is mirror-inverted.

9) Mackay made the following observation: „*A curious projection just below the chin may be a rough attempt of a beard.[3]*" Footnote 3: „*Or Adams' apple.*" *(Marshall, 1931: 358)*

10) 55.17 m above mean sea-level *(Marshall, 1931: 152)*

11) Mackay remarked: „*These holes, which are found in all these heads, seem intended for the attachment of some ornament in the middle of the ear and perhaps explain why the ears themselves are left without structural definition.*" *(Marshall, 1931: 358, footnote 1)*

12) „*That there was once a necklace is suggested by the presence of two holes on each side of the neck, just in front of the hair.*" *(Mackay in Marshall, 1931: 358)*

13) Mackay made reference to the indentations in the trefoil-shaped and circular ornaments which were possibly filled with a red paste. *(Marshall, 1931: 356)*

14) Marshall, 1931: 356-7, footnote 2; Wheeler, 1968: 86-7, 100, 110; During-Caspers, 1970-71: 114; et al.

15) Marshall, 1931: 357

16) Mackay remarked upon this: „..., *and the curiously shaped ears resemble double shells, with a deep hole in the middle[2]*" Footnote 2: „*Note the resemblance of these ears to the pieces of shell inlay in Pl. CLV, 38-44, and especially to Nos. 45-7.*" *(Marshall, 1931: 357)*
Wheeler writing about the shape of the ears: „..., *the ears conventionally rendered and suggesting the cross-section of a shell.*" *(Wheeler, 1968: 86)*

17) „*A hole bored on each side of the neck may have been intended to hold a metal necklace.*" *(Wheeler, 1968: 86)*

18) E. During-Caspers is of the opinion that these wedge-shaped recesses were there to hold the head-dress, which covered the sloping surface at the back of the head. (E. During-Caspers, personal information)

19) Two of these seven statues are only indicated by mere fragments. One piece of a hand, SD 624, *(Marshall, 1931: Pl. C,8)* shows such a great similarity to the hand of figure HR 163/193/226 that it can be assumed that it formerly belonged to a similar full-length figure.
Under the number HR 5785 in the HR Fieldbook there is the registration: „*a broken leg of a figure in squatted posture, fragment of a limestone statuette.*" The original was recently traced in Mohenjo-Daro and turned out to be the left lower part of a kneeling image. Head, right-hand chest, arm and leg are missing.

20) „*As the three pieces so widely separated were all found in the superficial debris, it seems likely that they were scattered after the site had been destroyed and abandoned.*" *(Marshall, 1931: 178)*

21) „*Figure No. 1 in Pl. C [L 950] would seem to be wearing a very thin shawl that hangs down over a kilt-like garment, and the same is true of Figure 4 in the same plate [HR 163/193/226] where, however, the cord of the kilt is more distinctly shown.[1), 2)]*"
Footnotes
1) „In some respects this kilt resembles the modern dhoti. Whether anything else was worn beneath this lower garment we have no knowledge."
2) „... The upper garment resembles those of other countries. In Babylonia a garment was frequently worn from the waist (kaunakès), and sometimes, in addition to it, a shawl under the right and over the left shoulder. Archaic female figures always had the upper part of the body covered. In Egypt a garment was worn over a vest in very early times, though the plain kilt hanging from the waist was also popularly worn by rich and poor alike." (Mackay in Marshall, 1931: 363)

22) „..., *and the chevron treatment of the hair of the beard and the rudimentary form of the ear clearly link it [HR 163/193/226] with the head found in Room 14 [HR 910].*" *(Hargreaves in Marshall, 1931: 178)*

23) 181 feet above mean sea-level *(Marshall, 1931: 152)*

24) 181 feet above mean sea-level *(Marshall 1931: 152)*

25) „*Block 3 has been sadly denuded and but little remains of its original buildings. It is nevertheless, interesting because of the unusual objects that were found in it.*" *(Marshall, 1931: 173)*
„*Most of the exposed walls of Block 3 unquestionably belong to the latter end of the Late Period; but that there are earlier walls below is proved by the remains found in chamber 77, which has been excavated rather deeply.*" *(Marshall, 1931: 175)*

26) *„A squarish projection at the back of the head is evidently intended to represent a knot of hair. It is, however, unfinished and shows the chisel marks of the preliminary dressing." (Mackay in Marshall, 1931: 359)*

27) *„There is somewhat more finish about what may be a rope of hair hanging down the back." (Marshall, 1931: ibid.)*
„The head is missing; the back of the hair is unfinished, and is flanked by a rope-like pendant which may be hair or head-dress." (Wheeler, 1968: 88)

28) All seven figures which appear in processional form in the bottom row of the seal, have either a pigtail or head-dress, which on some of them is decorated with horizontal lines. The two figures which appear above these also display a pigtail or head-dress, but which is slightly thicker than those of the lower figures. Parallel lines are also distinguishable on them, which suggest some form of plaiting or pattern.

29) *„An unfinished limestone statue (SD 2781, Pl. LXXI, 30-32) found in the S.W. corner of the fenestrated court (61) at the level 2,4 ft. was very probably in the process of being carved when the building had to be abandoned owing to the flood which took place at the end of the Late III Phase. Other objects found in the same court at slightly higher levels are less ecclesiastical in character, and comprize of a fine limestone mace-head (SD 2782; Pl. LXXI, 22), 3,2 inches in diameter; a faience ball (SD 2705, Pl. LXXI, 9), and a gamesman (SD 3010; Pl. LIII, 59) of the same material." (Mackay, 1938: 10)*

30) Not visible in Figs. 23 & 24, but mentioned by Mackay, is a ca. 3 cm deep and ca. 8 mm wide opening in the fist, which according to Mackay could have been to secure either a sceptre or something similar. *(Mackay, 1938: 257)*

31) Mackay, 1938: 257; Wheeler, 1968: 88

32) In relation to the datum level at 178.7 feet above mean sea-level.

33) Two short reports refering to this excavation were published in the „Annual Reports of the Archaeological Survey of India"; ARASI, 1930-34: 51, 72; and ARASI, 1936-37: 41ff.

34) For comparison see again seal DK 6847 *(Fig. 22)* on which a figure is depicted in a similar squatting posture in front of another figure floating in a pepaltree-like motif. The figure in the adoring gesture wears an ornamentation on the head, the ends of which have pipal-leaf-like forms. – All the other human representations on this seal have headornaments too; they vary in appearance from a trident-like form to a single feather-like shape.
Other examples of this peculiar type of head-ornament depicted on seals are published in Mackay, 1938: Pl. LXXXII, 1-2 = SD 3089 Pl. LXXXVII, 222 = DK 12050; 235 = DK 3883

35) In summary, some of the examples cited by Tosi should be mentioned here: the bronze statuette from Shahr-i Sokhta, Pl. CIII 4-7; the statue of King Lamgi-Mari, Pl. CVII, 17; the Stele of Ea-ana-tuma from Telloh, Pl. CVIII, 20-21; the bronze head of „Sargon of Akkad"? from Niniveh, Pl. CX, 25; the statue of the „Goddess of the Waters" from Mari, Pl. CX, 26 et al. The references are to Tosi, 1983.

36) Wheeler, 1968: 86. Compare Höltker, 1944: 18, refering to Goloubew, who equated the representations of the human ear in Mohenjo-Daro with a cross-section of the shell of a marine mollusc (mussel or snail).

37) However, the motif can be found on Harappan ceramic, even if only on few examples: Marshall, 1931: Pl. LXXXVII, 3 = HR 980; Pl. LXXXVII, 4 & Pl. XC, 24 = DK-D 287; Vats, 1940: Pl. LXVII, 19 & 32. The scarcity of the design on normal pottery could point towards its exceptionel significance so that it was more appropriate to representations in valuable material.

38) Other objects on which the „ear-motif" occurs include: wavy faience rings, exhibiting the pattern in white on a red background *(Marshall, 1931: Pl. CLVII, 10* = HR 1797; *Pl. CLVII, 12* = HR 1960); a metal object, probably worn as an amulet *(Mackay, 1938: Pl. CXXIV, 27* = DK 4036); steatite amulets *(Mackay, 1938: Pl. CXL, 59* = DK 8036; *Marshall, 1931: Pl. CLVIII, 12* = HR 5463); a gold brooch from Harappa *(Vats, 1940: Pl. CXXXVII, 8)*; two faience bangles in ear-shape from Harappa *(Vats, 1940: Pl. CXXXVIII, 2 & 3)*; a ceramic bangle painted with the „ear-motif" *(Vats, 1940: Pl. CXXXVIII, 7)*; two Harappan seals with unusual ornamental external appearance *(Vats, 1940: Pl. XCI, 381, 415)*; ceramic fragments showing painted „ear-motifs" *(Marshall, 1931: Pl. LXXXVII, 3 & 4; Vats, 1940: Pl. LXVII, 19 & 32)*; some copper tablets from Mohenjo-Daro depicting an animal, with the „ear-motif" on the rump *(Marshall, 1931: Pl. CXVIII, 3* = HR 4337; *Pl. CXVII, 7* = VS 3500; *Mackay, 1938: Pl. XCIII, 11* = DK 4672; *Pl. CIII, 3* = DK 5996); and finally the strange, round seal, depicting four, from a total of six, different animals clustered around the central „ear-motif" *(Marshall, 1931: Pl. CXII, 383* = E 1886).

39) *„The very fact that certain tablets were manufactured in the material copper – as opposed to steatite, terracotta or similar – would tend to indicate that such tablets bear a particular significance which is likely to differ somewhat – either in content, or in importance, or in both – from that of the steatite or similar seals." (Mitchiner, 1978: 28)*

40) The seal is damaged, and because of the fracture two of the animal heads cannot be identified.

41) Attempts have been made to relate the trefoil-motif from the Harappa Culture to its cooccurance in Mesopotamia and Egypt. *(Marshall, 1931: 356f.; Wheeler, 1968:87)* In like the manner one could refer to steatite vessels from Bactria *(Sarianidi, 1979: Fig. 5,16)* which display an outer form of a kidney and are engraved with pipal-leaves on their sides. Similar „kidney-shaped" vessels have been found at Mehrgarh VIII, Cemetary *(Santoni, 1984:52)*, and another link could be the appearance of the „kidney-shaped" motif reported from Altyn Tepe, where in a Namazga V context, a small bull's head was found with a „kidney-shaped" inlay piece fitted into the forehead of the animal *(Kohl, 1980: Fig. 14)*.

42) Professor Dr. H. Holländer in a lecture at the University of Aachen, Winter Term 1983/84.

43) It is interesting at this point to consider some examples of seals depicting human figures in a similar squatting position to that of the stone sculptures. Seal DK 6847 *(Fig. 22)*,

which has already been mentioned in relation to the hair-styles and head-ornaments, shows in its upper row a squatting figure, which assumes an adoring posture in front of an individual surrounded by vegetal motifs.
Similar figures can be found on seals B 426 and VS 210 *(Marshall, 1931: Pl. CXVIII, 7 & 11)*; on seals D 392 and DK 2869 *(Marshall, 1931: Pl. CXI, 353 & 355)* and in Mackay, *1938: Pl. XC, 13, 20, 23,* = DK 11583, DK 11429, DK 10237; *Pl. XCVI, 522* = DK 7033 and *Pl. LXXXII, 1-2* = SD 3089 from Mohenjo-Daro.
From Kalibangan there is reported a seal depicting a tiger and a human figure squatting in a tree from Period II (see *Thapar, 1979: Pl. XXVIII)* and similar devices are published in Vats, *1940: Pl. XCI, 248; Pl. XCIII, 308.*

44) Limestone, alabaster and steatite are comparatively more precious and hard-wearing than the more common terracotta. *„Stone of any kind was a rarity³⁾; for none occurs in the alluvium of the Indus plain, and whatever stone might be required for building or other purposes had to be imported from more or less distant places.*
Footnote 3): As a proof of its rarity, Mr. Mackay remarks on the finding of a broken stone vessel which had been laboriously rivetted in antiquity." (Marshall, 1931: 51)

Bibliography

ARDELEANU, FRANKE, JANSEN 1983, An Approach Towards The Replacement of Artifacts Into The Architectural Context Of The Great Bath In Mohenjo-Daro. In: *Forschungsprojekt DFG Mohenjo-Daro. Dokumentation in der Archäologie. Techniken, Methoden, Analysen. URBAN, JANSEN (eds.)* Aachen

CASAL (J.M.) 1961, Fouilles de Mundigak. Vols. I+II, Paris.

DALES (G.G.) s.d., Stone Sculptures from the Protohistoric Helmand Civilization, Afghanistan. To appear in: *G. GNOLI (ed.), Professor Tucci Felicitation Volume*, IsMEO, Rome.

DURING-CASPERS (E.C.L.) 1970-71, Some Motifs as Evidence for Maritime Contact Between Sumer and the Indus Valley. In: *Persica 5*, s'Gravenhage, pp., 107-18.

DURING-CASPERS (E.) 1984, Sumerian Trading Communities Residing in Harappan Society. In: *Frontiers of the Indus Civilization.* Sir Mortimer Wheeler Commemoration Volume. *LAL/GUPTA (eds.)*, New Delhi. pp: 363-370

GOLOUBEW (V.) 1938, Essais sur l'art de l'Indus. In: *Bulletin de l'Ecole Francaise d'Extrème-Orient.*

HÖLTKER (G.) 1944, Das herz- oder nierenförmige Ornament auf einer Vase von Mohenjo-daro. In: *Ethnos*, Vol. 9, No. 1, Stockholm, pp. 1-34

JARRIGE (C.), TOSI (M.) 1981, The Natural Resources of Mundigak. Some observations on the location of the site in relation to its economical space. In: *H. HÄRTEL (ed.), South Asian Archaeology 1979*, Berlin, pp. 115-142.

JANSEN (M.), s.d., Lecture held on the 7th International Conference of the Association of South Asian Archaeologists in Western Europe. Brussels 1983. To appera in : *South Asian Archaeology 1983*

KENOYER (J.M.) 1984, Moenjo Daro Shell Industries. Aachen (this volume)

KOHL, PHILIP (L.) 1979, The 'World-Economy' of West Asia in the Third Millennium BC. In: *South Asian Archaeology 1977*, Vol. 1: 55-85. Naples *M. TADDEI (ed.)*

LEEMANS (W.F.) 1960, Foreign Trade in the Old Babylonian Period. Brill, Leiden.

MACKAY (E.J.H.) 1938, Further Excavations at Mohenjo-Daro. Vols. I&II, New Delhi.

MALLOWAN (M.E.L.) 1947, Excavations at Brak and Chagar Bazar. In: *Iraq*, Vol. IX, London.

MARSHALL (Sir J.) 1931, Mohenjo-Daro and the Indus Civilization. Vols. I-III, New Delhi/Varanasi.

MITCHINER (J.E.) 1978, Studies in the Indus Valley Inscriptions. New Delhi.

PARPOLA (A. & S.), KOSKENNIEMI (S:) 1973, Materials for the Study of the Indus Script I. A Concordance to the Indus Inscriptions. Helsinki.

SANTONI (M.) 1984, Sibri and the South Cemetery of Mehrgarh: third millenium connections between the northern Kachi Plain (Pakistan) and Central Asia. In: *South Asia Archaeology 1981. B. ALLCHIN (ed.)*, Cambridge: pp. 52-60.

SARIANIDI, VICTOR (I.) 1979, New Finds in Bactria and Indo-Iranian Connections. In: *South Asian Archaeology 1977*, Vol. 2: 643-659 Naples *M. TADDEI (ed.)*

THAPAR (B.K.) 1979, Kalibangan: A Harappan Metropolis beyond the Indus Valley. In: *Ancient Cities of the Indus. POSSEHL, G. (ed.)* Delhi: 196-202

TOSI (M.) 1983, A Bronze Female Figurine from Shahr-i Sokhta. Chronological Problems and Stylistical Connections. In: *M. TOSI (ed.), Prehistoric Sistan 1*, IsMEO, Rome, pp. 303-317.

VATS (M.S.) 1940, *Excavations at Harappa. Vols. I & II, New Delhi.*

WHEELER (Sir M.) 1968, The Indus Civilization. Third Edition, Cambridge University Press, Cambridge.

The Calendar Stones from Moenjo-daro

Erkka Maula
Hauho, Finnland

Summary

This paper presents a novel interpretation of great stone objects excavated in Moenjo-daro and Harappa, and commonly called „great ring-stones or *yoni* stones", „great wavy ring-stones", „*linga* stones", „cones", and „baetylic stones". The work is based on newest documentation.

In some specimens of „great ring-stones" of Moenjo-daro, which can be described as flattened spheres, there are two smaller holes on either side of the central hole, and a number of even smaller spots drilled on the smoothed surface. In three cases the pattern of these small spots is sufficiently well preserved to admit an exact measurement of their azimuths from a point determined by an isosceles triangle with its height equal to its base, the latter connecting the two holes on either side of the central hole. These „great ring-stones" (HR 5924 = MM 1407, HR 5929 = MM 1406 now in Moenjo-daro, and HR 2810(e)? now in Bombay) are shown to be *azimuth calendars* for the latitude of Moenjo-daro by computing the dates corresponding to the azimuths of the small spots in 2500 and 2000 B.C., which establishes their synchronization. These stones, accordingly, are called the Calendar Stones of Moenjo-daro. Three other potential Calendar Stones exist, of which two have recently been located by the author.

One was unbroken and synchronized with the previous three, according to measurements from an ordinary photograph.

In the discussion, the function of the „great wavy ring-stones" from Harappa, and of the combination of the „*yoni* and *linga* stones", is considered. It is suggested that both types of „great ring-stones" serve not only as the earliest known calendaric instruments in history, but also as observational instruments in naked-eye astronomy, suitable for studying sunsets and sunrises, heliacal risings and settings of other heavenly bodies, and planetary phenomena. Together with „*linga* stones", they can be associated with vestiges of the Indus Valley cosmology. As an example, an Indus seal (No. DK 2430) is astronomically interpreted.

The Great Stones

The Calendar Stones of Moenjo-daro, our main objects of interest, are first recorded in H. Hargreaves' (unpublished) „Field Register 1925-1927, HR Area" on February 12, 1927 under the field numbers 5923-42 (p. 229, bottom). The relevant description reads (handwritten): *„17 colossal stone rings, 2 stone caps and 1 square capital, a copper object ϒ shaped"*. The discoveries were made in Room 49, House 5, Block 2, Section B, HR Area, close to the north wall of the room. The entry poses several problems, beginning with the field numbers. First, R.B.D.R. Sahni *(Sahni, 1930: 68)* mentions *„some 18 round stone rings"*, not seventeen, with field Nos.HR 5923-5933 and 5936-5942, which make 18. Nos. HR 5935 and 5939, however, are called on the same page *„two round stone caps"*. And under No. HR 5934 are listed *„two or three square stone capitals ... with spiral volutes"*. What is then the field number of the mysterious „copper object γ shaped"? E.J.H. Mackay, in turn, lists HR 5939 as a stone ring *„too much damaged to be measured" (Mackay, 1976: 596)*. Unfortunately, the recent MM Museum nos. cannot be fully correlated with HR nos.; in Mackay's list all diameters and heights are inaccurate, as if measured without sliding callipers. This mystery is deepened by two more finds made in the same room, viz. *„the bust of a beautiful miniature monkey (HR 6104, height 7/8 in.) of white faience, originally coloured yellow"*, and *„the skull of a young female" (Marshall, 1973, Vol. I:191)*: this skull, again, has lost its field no.

Annual Report of the Archaeological Survey of India 1926-1927 adds the information that the stone rings of Room 49 (HR 5923-33, 5936-42) *„differ from those found in previous seasons in that some of them have a narrow hole neatly sunk on either side of the large hole in the centre, while others have grooves for metal clamps in the top and the bottom, while others again are further decorated with lines of tiny cupmarks" (Sahni, 1930: 68)*. The rest does not concern us. E.J.H. Mackay *(Mackay, 1976: 596)* gives a list of 27 (*„possibly originally twenty-eight")* stone rings, their field numbers and rough descriptions. He also mentions (p. 597) *„the fact that these ring-stones were gathered together"* and *„that they had suffered badly before collection is quite evident since not all of them were perfect"*. In Mackay's vocabulary the small pits or cupmarks are *„spots"*; I shall call them *azimuth holes*. The somewhat bigger holes on either side of the large hole in the centre he calls *„dowel-holes"*; I shall call them *gnomon holes*. In Mackay's list there are still six stone rings with *gnomon* and *azimuth* holes (HR 5924, 5937, 5930, 5929, 5926, 2810(e)), five with *azimuth holes* only (HR 5931, 5927, 2810(a), 2810(d), 5936), five with *gnomon holes* only (HR 5925, 5928, 2810(b), 5938, 5940), while in all other cases „the question-marks indicate that certain details were obscured by more or less damage to the stone". These *gnomon holes* are „set at equal distances from the edge of the central hole". In three cases there are both *gnomon holes* and grooves for clamps (HR 5925, 5928, 5940), but no *azimuth holes*. It is impossible to tell whether everything possible was done to record the details; at any event Mackay, who considered that the ring-stones constituted two pillars around a tapering pole, was interested in them only from the architectural point of view, as also the schematic Pl. CXLIV, 2 shows (stone ring HR 5930). For the sake of easy reference, however, I call them *yoni stones* with Sir John Marshall *(Marshall, 1973, Vol. I, Ch.V.: 61-63)* as their association with the *linga stones* seems warranted at least on the level of cult objects. Not to be confused with the flattened *yoni* stones are the *„wavy ring-stones"* encountered in Harappa, of which Sir John Marshall writes as follows:

„The most typical of them have their upper and lower surfaces undulating (Pls. XIII, 9 and 10, and XIV, 6 and 8); in others, the lower surface is flat, and the top takes a quatrefoil form (Pl. XIII, 11 and 12)" (ibid., p. 61).

As for the *linga stones*, Sir John Marshall distinguished them from *baetyls*, and considered the smaller specimens of conic stones to be possibly gamesmen (p. 63, cf. Pl. XIV and p. 191. n). Of the *linga stones* he writes as follows:

„We have already seen that the presence of phallism at Moenjo-daro is proved by the discovery of realistic lingas, as to the character of which there is no question."

Finally, it must be mentioned that both baetylic and *linga* and *yoni* stones of various sizes have turned up, albeit the great *yoni* stones alone bear the *gnomon* and *azimuth holes* (or anything like these). One particular set of small *yoni* stones is described by Sir John Marshall, who had excavated them in Taxila and dates them to the Mauryan period:

„In these ring-stones, which are quite small and used perhaps as ex-voto offerings, nude figures of a goddess of fertility are significantly engraved – with consummate skill and care – inside the central hole, thus indicating in a manner that can hardly be mistaken the connection between them and the female principle" (pp. 62-3).

He adds the note that the Buddhists also copied such rings, though eliminating the nude goddess.

*

The *present study* is based on the documentation of the extant stones carried out by the Research Project „Mohenjo-Daro", and on the photographs of all stones uncovered. Nine of them are kept in the Moenjo-daro Museum, three in the Prince of Wales Museum in Bombay, and one in the Madras Museum. A fragment of a possible ring-stone (from Harappa?) in the British Museum, in the collection of D.H. Gordon, is reported by Dr. Bob Knox of the British Museum. The rest of the *yoni* stones have not been located so far. At Harappa Museum there are two *„great wavy ring-stones"* displayed on the courtyard. Of the documented *yoni* stones, only three still have both *gnomon* and *azimuth holes.* They are MM 1407 (HR 5924) with nine *azimuth holes*, and MM 1406 (HR 5929) with five *azimuth holes*, both in the Moenjo-daro Museum, and HR 2810(e) with three *azimuth holes* in the Prince of Wales Museum Bombay, but this stone was badly broken recently and is now held together by a rope. As the reconstruction of the calendar must be based on these stones alone, I call them *Calendar Stones*. Three other potential *„Calendar Stones"* exist. Recently the author has discovered two of them, viz. HR 5937 which is broken since Mackay's *Further Excavations* (1937-1938) and does not display any azimuth holes, and HR 5930 with eight azimuth holes, already photographed for the azimuth measurements.

Full documentation is not available for HR 5930 and HR 5937. The whereabouts of the remaining potential *Calendar stone*, HR 5926, is not yet known. The documentation team of the Aachen Technical University, led by Dr. Michael Jansen, has also confirmed the existence of *engraved circles* in two *Calendar Stones* (MM 1406, 1407) with ø = 27.3 cm and ø = 25.6 cm, respectively, and in one ring-stone (HR 5942) in Bombay which seems semifabricated and bears no holes except the central one. Furthermore, on the rough surface of MM 1403, which has no holes either, the weathered forms of *fishermen* can still be seen. This fact may be associated with the astronomical interpretation of the *„great ring-stones"* based on one interpretation of the Indus script (see below), and is perhaps significant in the light of the observation that all *„great ring-stones"* at Moenjo-daro Museum resemble each other in being more or less accurately formed with the same proportion of diameter to height, $A:H \approx 0.6$ (ranging from 0.56 to 0.62); the Golden Mean is 0.61. In addition to this, the outer form of these stones approaches a sphere with both calottes cut off and the edges rounded. (Mackay noted that they could have been turned on the lathe). Finally, one whole (MM 1411) and one broken (MM 1412), finely worked *„great anti-torus stone"* must be mentioned, even though their function is unknown.

The Calendar Stone Hypothesis

To us the term „*calendar*" means a sequence of the days of the year, arbitrarily sub-divided into months and weeks. Time, abstracted from the underlying celestial phenomena, becomes a reservoir of events. In more primitive types of calendar, such as the „*lunar*" and „*solar*" calendars, observations of the moon and sun directly indicate the beginning and the end of the „*month*", the „*year*", and traditional working periods, as well as festival days. As for the *lunar calendar,* no instrument is needed, and different phases of the moon were recorded on bone perhaps some 30.000 years ago. One scholar, W. A. Fairservis Jr., has recently claimed that similar „*lunar*" calendars, on ivory, occur also in the Indus Culture. The situation is entirely different with respect to „*solar*" *calendars.* The „*lunar*" month (c. 29 1/2 days) does not divide the „*solar*" year without remainder, and the sun does not go through any phases. Its positions *in the sky* must be determined instrumentally, by means of a *gnomon.* Alternatively, the points of sunrise and sunset on different days of the „*solar*" year can be registered *against the horizon,* where prominent landmarks, e. g. mountains and hill-tops, are available. In Moenjo-daro , however the horizon is not broken by any natural landmarks rising from the alluvial plain. Thus a *calendric instrument* is necessary to determine the beginning and end of the „*solar*" year and its seasons, i.e. the winter and summer solstices, and the vernal and autumnal equinoxes. Within this framework, then, other important days, such as the beginning and end of the monsoon, and seasoned work such as repairing the irrigation system, ploughing and harvest, can be determined by the same technique. Indeed, a seasonal or „*solar*" calendar must be presupposed in that strictly organized society of farmers, fishermen, artisans, traders, and priests. After a visit to Moenjo-daro in December, 1979 I formulated the hypothesis regarding the Calendar Stones that the two holes on either side of the central hole (the *gnomon holes)* once contained *gnomons* for determining the local meridian or North-South axis, the small spots (the *azimuth holes)* indicated the points of sunrise and sunset on some particularly important days of the year, and that the engraved circle represented the horizon, while the flat, smoothed surface correspcnded to the alluvial landscape (see *Historia Mathematica 8 : 75).*
The relevant parameters of this hypothesis are interrelated as follows.

$$\cos\ \xi = \tan\varphi\ \tan\epsilon$$
$$\tan\ \delta = \tan\ \xi\ \sin\varphi$$

where $\varphi = 27^015'$ (latitude of Moenjo-daro), $\epsilon =$ $23^058'$ or $23^053'$ (the obliquity of the ecliptic in 2500 and 2000 B.C.), and ξ an auxiliary parameter (half the night-arc). Hence the points of sunrise, measured along the horizon from East at summer and winter solstices, are determined by the complement of δ ; and $\overline{\delta} =$ $27^010'$ in 2500 B.C. and $27^005'$ in 2000 BC. To make sure that the fixed dates hold from year to year, one must fix the point from which the sunrises and sunsets are observed. Nothing, however, that $\tan\varphi \approx \tan\overline{\delta} \approx 1:2$ both 2500 and 2000 B.C., it can readily be fixed for the whole mature period of the Indus Culture. In an isosceles triangle with its height equal to its base, which connects the two *gnomon holes* of a Calendar Stone, the apex is the viewing point. The second part of my hypothesis is that $\tan\overline{\delta} = 1:2$ (thus $\overline{\delta} = 26°34'$) and $\tan\varphi = 1:2$ in the Indus Culture (without any knowledge of trigonometry, of course). In other words, I claim that the locality of Moenjodaro was chosen because the ratio 1 : 2 characterized its *'cosmic parameters'*. As the apparent diameter of the Sun $\approx 0.^05$, the ensuing observational error is negligible. In the azimuths, roughly $0.^03 =$ 1 day.

There is, however, even *circumstantial evidence* for the hypothetical use of $1:2 = \tan\overline{\delta} = \tan\varphi$, i.e. for the claim that in 2500 and 2000 B.C. the angular height of the Polar Star (α Draconis or Thuban) and the sun's maximum deviation from East measured along the horizon at the summer and winter solstices, were characterized in Moenjo-daro by the ratio 1 : 2. Many architectural units in Moenjo-daro are built to the same ratio *(M. Jansen 1979 a, 1979 b).* As a rule, the proportions of the building bricks are 1 : 2 : 4 *(E.J.H. Mackay 1935:26).* In addition, the metrology of the Indus Culture was based on the binary system; series of weights display the ratios 1 : 2 : 4 : 8 : 16 : 32 : 64 etc. *(E.J.H. Mackay, 1943, Ch. XV).* Having noted this recurrent ratio of 1 : 2 to be characteristic of the Indus Civilization, I suggested to Dr. Jansen that he should look out for an additional copper or bronze device perhaps excavated together with the „*great ring-stones*". That is how he discovered the unpublished „*Field Register 1927, HR area*" of Hargreaves. I think that the „*copper object* ϒ *shaped*" mentioned there is this device *(Fig. 1),* which is attached to the two *gnomons* and determines the exact point of observation in such a way that $\tan\overline{\delta} = 1:2$. Unfortunately, it has not yet been relocated. Perhaps each stone has its own „ ϒ *shaped object*"; the distances between the *gnomon holes* of the documented Calendar Stones suggest at least three such observation point standards (which disproves Mackay's idea that the holes were „*dowel holes*").

Fig. 1 *The „Calendar Stones" of Moenjo-daro in use. Drawing by Eeva-Maija Tuomi, Od.Lic., from Dr. Erkka Maula's document film „The Lost River Where the Stars Swim" (60', colour), Finnish TV-2.*

Azimuth Measurements and Computations

The azimuths of the small holes or *azimuth holes* of all three Calendar Stones were measured according to my hypothesis from photographs by means of astronomical calculation. The measurements were carried out in the winter of 1982/1983 at Oulu University Observatory, Finland, under the supervision of Prof. K.A. Hämeen-Anttila. The photographic-microscopic technique turned out to produce far more accurate results than measurements from the *„graphical reconstructions"* of the documentation team. Finally, the dates corresponding to these azimuths, interpreted as azimuths of sunrises and sunsets in Moenjo-daro in 2500 and 2000 B. C., were computed, the former at Oulu Observatory, the latter at Helsinki Observatory by Dr. Heikki Oja. The following table summarizes the results for *sunrises and approximate dates* in 2500 B. C. in Moenjo-daro (other results omitted here). *(Table 1)*

MM 1406	*MM 1407*	*HR 2810 (e)?*	*DATE OF SUNRISE*
1 -109°.43 ± 0°.00			8.5. / 3.8.
2 -107°.39 ± 0°.01			2.5. / 9.8.
	1 -106°.36 ± 0°.01		29.4. / 12.8.
3 -105°.82 ± 0°.02			28.4. / 13.8.
4 -103°.98 ± 0°.00	2 -103°.73 ± 0°.02		23.4. / 19.8.
5 -101°.33 ± 0°.00	3 -101°.10 ± 0°.01		16.4. / 25.8.
	4 - 98°.23 ± 0°.02		9.4. / 1.9.
		1 -96°.57 ± 0°.01	5.4. / 5.9.
	5 - 95°.66 ± 0°.01		3.4. / 7.9.
	6 - 93°.94 ± 0°.04	2 -93°.97 ± 0°.01	31.3. / 11.9.
		3 -91°.94 ± 0°.01	26.3. / 15.9.
	7 - 91°.15 ± 0°.02		24.3. / 17.9.
	8 - 88°.45 ± 0°.04		18.3. / 23.9.
	9 - 86°.19 ± 0°.05		13.3. / 28.9.

Fig. 2 *Indus Seal No. DK 2430.* Drawing by Eeva-Maija Tuomi, Od.Lic. All details, e.g. the sacrificed head, based on special studies on the original seal by other scholars.*

It appears that MM 1407 is a *Master Calendar*, while MM 1406 is synchronical with it on at least two dates, and HR 2810 (e)? on at least one date, both in the spring and in the autumn season. The azimuths of the *gnomons* imply according to my hypothesis, the winter and summer solstices (and the direction of East, indicated by a groove in some *„great ring stones"*, the vernal and autumnal equinoxes). No sub-division into *„weeks"* is discernible. It seems likely, therefore, that each Calendar Stone was intended for one single typical working-process considered particularly important in Moenjo-daro, even though days of festivities may also be included. Synchronization is necessary, because seasoned tasks overlap.

First measurements from ordinary photographs suggest that also HR 5930 is synchronised with the three previous Calendar Stones.

Test of Validity

Due to the two-part structure of the Calendar Stone hypothesis, it can be disproved in two ways. First, if a potential Calendar Stone should be discovered which is *not* synchronized with MM 1407, and secondly, if a *„copper object* ϒ *shaped"* should be discovered which does *not* display the characteristic ratio of 1 : 2. It may be noted that the extent Calendar Stones do not yield dates during the monsoon period, when the observation of the sunrise and sunset is uncertain, while the dates obtained fit in significantly with the annual agricultural cycle (see *Jansen 1979 a: 51 - 54*).

According to our sources, the correct number should be DK 6846 (ed.).

The dates corresponding to the azimuths of sunrises in 2500 B.C. are given to the nearest day. In 2000 B.C. the corresponding dates are about three days earlier in the spring and three days later in the autumn. This degree of accuracy is justified because in the excavated series of Master Weights the difference between the measured and computed values in some cases is in the region of a thousandth of a gram (see *Mackay 1943 : 244*).

An Example of Astronomical Application

Contrary to what is usually thought *(S.M. Ashfaque, 1977, vol. 21, No. 2 : 177)*, the „*year*" in the Indus Culture probably began at the winter solstice, when the sun rose in the ESE, in the direction indicated by the southern *gnomon*. The keeping of the stone calendar presupposed constant observation of the sunrises in other days of the year, whenever cloud conditions permitted it. Thus the Calendar Stone also served as an instrument for the observation of heliacal risings and settings of planets and constellations. Such observations, indeed, are presupposed in the astronomical interpretations of the Indus script and the Indus seals.

Only one example is considered here, the seal No. DK 2430 *(Fig. 2)*. The astronomical interpretation that I suggest reads as follows. (I) Just *before sunrise*, the sun being represented by the ram or bull with a human face, in the beginning of a new year *at winter solstices*, a priest is kneeling close to the sacrificed head which is placed on a raised shelf or an altar. (II) In front of the priest there is a deity inside the pipal tree, which implies the time of the *new moon*, when the moon is invisible; the crescent horns probably symbolize a link between the priest and the divinity. (III) Above the ram or bull is a fish-pictogram with a vertical stroke, signifyfing the *planet Jupiter;* its position refers to its *heliacal rising*, for the sun is bearing it up, as it were. (The house-like figure at the side probably refers to ritual purity ascertained before the sacrifice.)

So far, this interpretation is compatible, even though not identical, with Ashfaque's interpretation, which in turn is closely associated with the astronomical interpretation of the Indus script attempted by Prof. Asko Parpola *(Ashfaque 1977 : 167 ff.)*. In the final step, however, my interpretation differs completely from it. (IV) I interpret the seven divinities in a row at the bottom of the seal as representing the *visibility of all seven planets* in that particular night; it is not astronomically informative to refer to the seven stars of Ursa Major or Ursa Minor, which are always visible, nor to the Plejades, whose heliacal rising occurs after the vernal equinox. I use the term „*planet*" of the Sun and Moon, too. The question reads: have the four Conditions (I - IV) ever been *satisfied simultaneously* in Moenjo-daro during the Indus Culture? Prof. K.A. Hämeen-Anttila has tested my interpretation, and his computations show that this was indeed once the case, at the winter solstice of 2108 B.C.

WS-2108	MORNING I		MORNING II	
PLANET	$\lambda - \lambda_\odot$	h	$\lambda - \lambda_\odot$	h
Moon	$-12°$	$+9°$	$0°$	$-2°$
Mercury	$-26°$		$-26°$	
Venus	$-32°$		$-32°$	
Mars	$-173°$	$+8°$	$-175°$	$+7°$
Jupiter	$-18°$	$+16°$	$-18°$	$+16°$
Saturn	$-65°$		$-67°$	

Here Morning I is the last morning before WS, and Morning II the first after it; the exact moment of WS is between them. $\lambda - \lambda_\odot$ is the angular distance from sun anti- clockwise along the ecliptic, and h the height above ($h > 0$) or below ($h < 0$) horizon at sunrise. In the Morning I there is a magnificent spectacle in the sky just before sunrise. Five bright heavenly bodies are marching along the ecliptic in a row (arc only 53°), and the sixth, Mars (the aggressive Rudra of the later Hindu pantheon) is also visible on the western horizon. In the Morning II the moon is already below the horizon at sunrise. And then the sun of the new year rises – such a unique scene inspired the artist of the seal DK 2430.

Discussion

All technical discussions, an expansion of the argument, and most of the details are given in a forthcoming book (*Errka Maula & Michael Jansen: The Calendar Stones of Moenjo Daro, 1984/85)*. Some general comments must suffice here.

The Calendar Stones represent a primitive calendaric instrument in a locality where there are no natural markers of sunset or sunrise on the horizon. In Harappa, however, the Khirtar Range is visible on the western horizon and hence the „*great wavy ring-stones*" may have served as Calendar Stones there, at least for sunsets. In addition to being calendaric instruments in naked-eye astronomy based on the geocentric world-view, the *„great ring-stones"* probably represented also the Earth, or Mother Earth. Hence the *yoni* stone interpretation may also be accepted. The *linga* stones, then, represent the masculine element at the level of cult objects. Taken together, they may be associated also with a pivotal feature of oldest Indian cosmology, which probably derives from the Indus Culture, viz. the myth of the Churning of the Milky Ocean, the *yoni* stone representing the churn and the *linga* stone the dasher. Their perfected forms also support this interpretation. Finally, the *linga* stones may have had geographical connotations in the myth of Mt. Meru (or Sumeru, or Sineru, or Mandara) representing, perhaps, the Himalayas. The *„copper object ϒ shaped"*, then, is a typical *„key"* to the myth, which closes its gates to the unordained, perhaps the *„anti-torus Stones"* represent the reverse side of the world view.

Accurate observations of celestial phenomena are presupposed in astronomical interpretations of the Indus Script and seals. Without the context of astronomical instruments they remain uncertain. This context is provided by the Calendar Stones.

Bibliography

ASHFAQUE (S.M.) 1977, Astronomy in the Indus Valley Civilization. In: *Centaurus*, Vol. 21, No. 2, pp. 149-193.

FIELDBOOKS 1924-1938 of the Mohenjo-Daro Excavations. Archaeological Survey of Pakistan. Unpublished.

JANSEN (M.) 1979a, Architectural Problems of the Harappa Culture. In: *South Asian Archaeology 1977*, Naples, pp. 405-431.

JANSEN (M.) 1979b, Architektur in der Harappakultur. Eine kritische Betrachtung zum umbauten Raum in Industal im 3.-2. Jahrtausend, Bonn.

MACKAY (E.J.H.) 1935, The Indus Civilisation, London.

MACKAY (E.J.H.) 1943, Chanhu-daro Excavations 1935-36, New Haven 1943.

MACKAY (E.J.H.) 1976, Further Excavations at Moenjodaro, New Delhi (Reprint of the 1st ed. 1938).

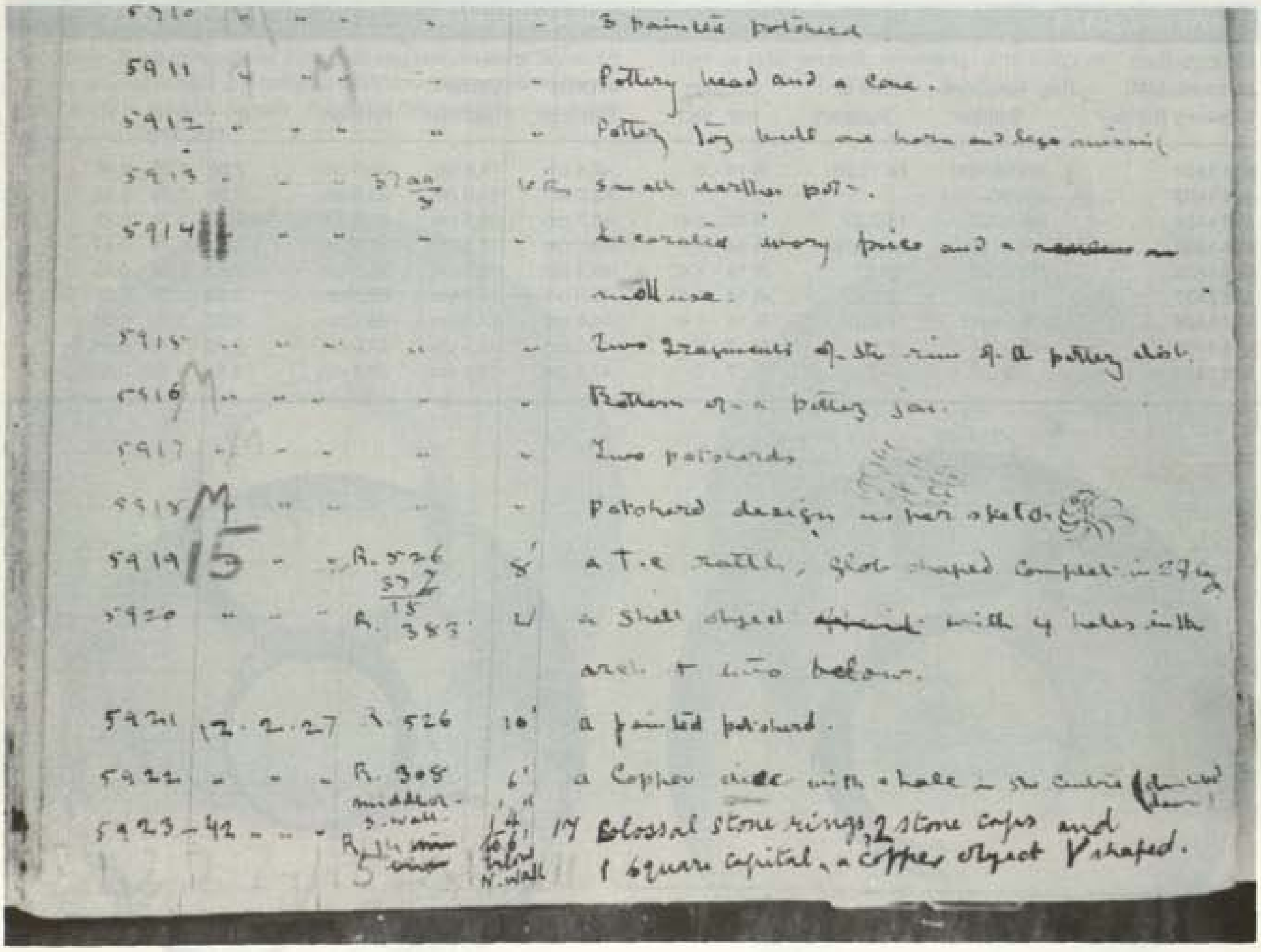
MARSHALL (Sir J.) 1973, Mohenjo-Daro and the Indus Civilization. Vol. I-III, New Delhi. (Reprint of the Ist ed. 1931)

SAHNI (R.B.D.R.) 1930, Mohenjo-Daro. In: *Annual Report of the Archaeological Survey of India 1926-1927*, Calcutta, pp. 60-88.

Upper
Plate 1 *Ringstones in the Foyer of the Mohenjo-Daro Museum*
Middle
Plate 4 *Ringstone HR 2810 e, Prince of Wales Museum Bombay*

Plate 2 *Ring-stone MM 1407 = HR 5924, Mohenjo-Daro Museum*

Plate 5 *Extract of page 226 of Hargeaves' Fieldregister 1925 - 1927*



5910	-	-	-	3 painted potsherd
5911	M	-	-	Pottery head and a cone.
5912	-	-	-	Pottery toy bull one horn and legs missing
5913	-	37		Small earthen pot.
5914	-	-	-	decorated ivory piece and a [illegible] molluse.
5915	-	-	-	Two fragments of the rim of a pottery dish.
5916	M	-	-	Bottom of a pottery jar.
5917	-	-	-	Two potsherds
5918	M	-	-	Potsherd design as per sketch
5919	5	R. 526 / 37	8'	a T.C. rattle, globe shaped compact in 37 [illegible]
5920	-	15 / R. 383		a shell object ~~[illegible]~~ with 4 holes in the arch & two below.
5921	12.2.27	R. 526	10'	a painted potsherd.
5922	-	R. 308	6'	a Copper disc with a hole in the centre (damaged)
5923–42	-	middle of S. wall R. [illegible] 5	14' below N. wall	17 colossal stone rings, 2 stone cups and 1 square capital, a copper object V shaped.

Plate 3 *Ringstone MM 1406 = HR 5929, Mohenjo-Daro Museum*

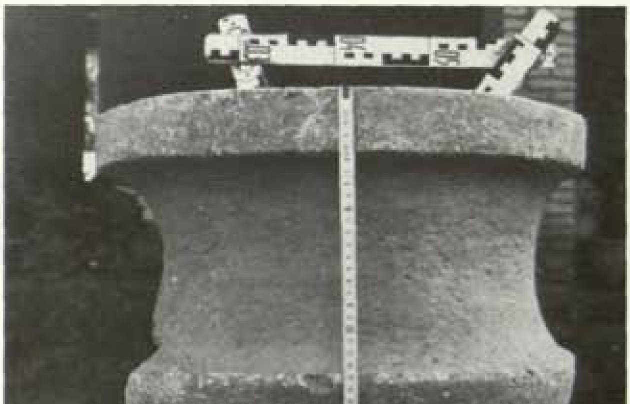
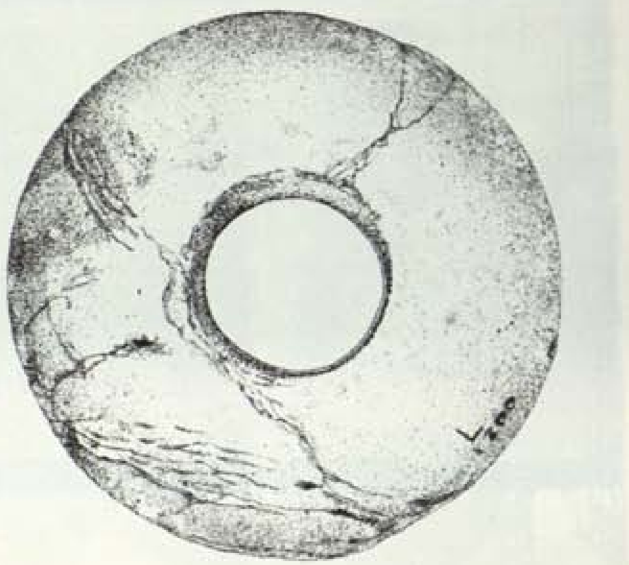
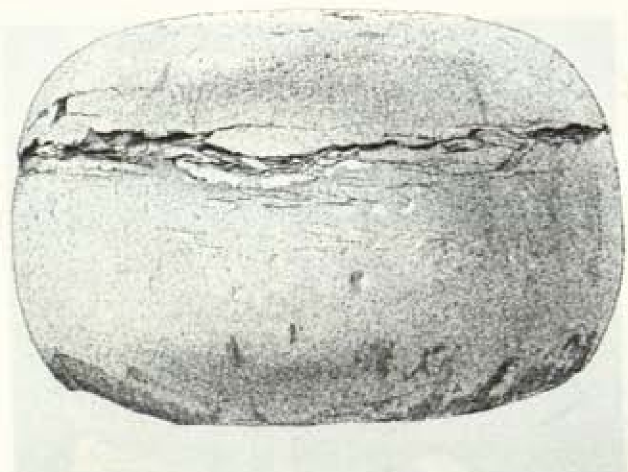


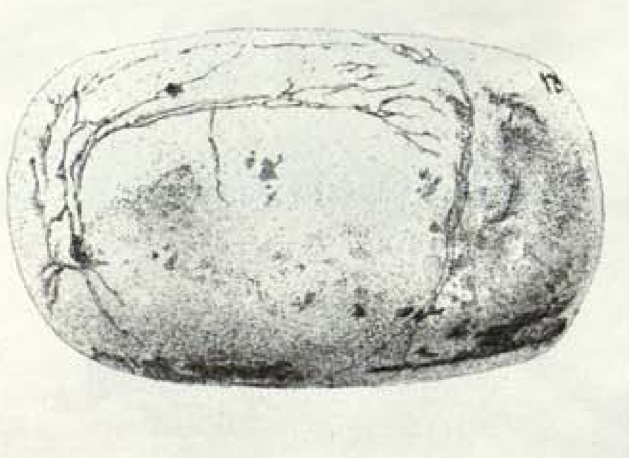
Plate 6 *Object MM 1411, Mohenjo-Daro Museum*

CALENDAR STONES FROM MOHENJO-DARO

GENERAL DATA				MEASUREMENTS			PROPORTIONS		
Mohenjo-Daro Museum (MM) Inventory Number	Orig. Fieldbook-Number	Date of Discovery	Location Hor. Vert.	A/Outer Diameter	I/Inner Diameter	H/Heigh	A:I	A:H	I:H
MM 1402	HR 2810d?	24.11.26	R 14 6'	49,5 cm	19,8 cm	30,0 cm	2,50	1,65	0,66
MM 1403	L 1200			42,0 cm	14,6 cm	23,5 cm	2,88	1,79	0,62
MM 1404	HR 5923	18.2.37	R 14 1'4"	48,7 cm	20,6 cm	28,5 cm	2,36	1,71	0,72
MM 1405	HR 2810c?	24.11.26	R 14 6'	43,6 cm	12,4 cm	24,5 cm	3,52	1,78	0,51
MM 1406	HR 5929	2.2.27	R 14 1'4"	45,1 cm	16,8 cm	28,3 cm	2,68	1,59	0,59
MM 1407	HR 5924	12.2.27	R 14 1'4"	45,0 cm	14,7 cm	26,5 cm	3,06	1,70	0,55
MM 1408	HR 5931?	12.2.27	R 14 1'4"	44,6 cm	17,0 cm	26,2 cm	2,62	1,70	0,65
MM 1409	HR 6084	18.2.27	R 12 5'	47,5 cm	17,3 cm	27,0 cm	2,75	1,76	0,64
MM 1410	?	?	?	47,4 cm	13,5 cm	27,5 cm	3,51	1,72	0,49





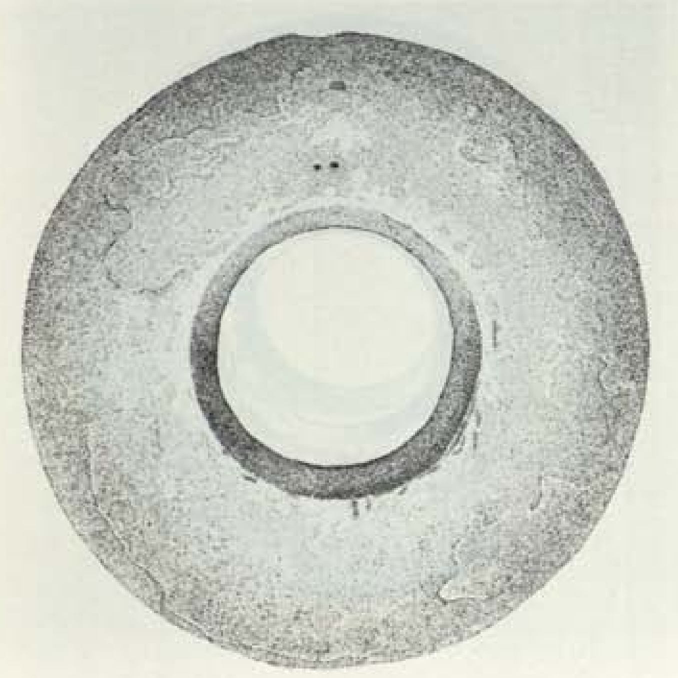


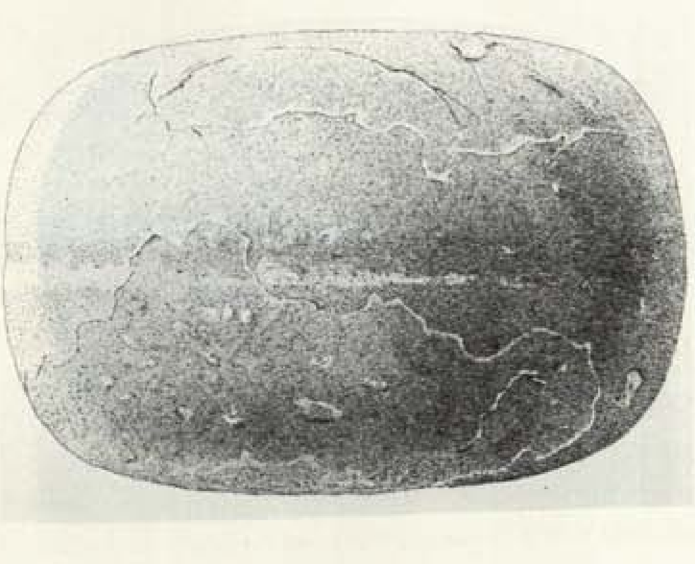
MM 1402 *Topside: smooth, polished. 2 spots in distance of 1.4 cm. Bottom: destroyed.*

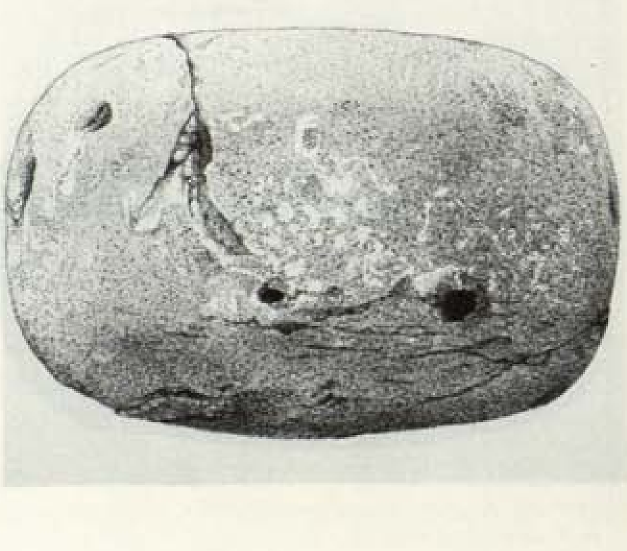
MM 1403 *Rough surface, weathered out fissures on surface.*

MM 1404 *Topside: smooth. 2 spots ø 5 mm, 12 mm distance. A beltlike slight depression is to be seen along the outer surface of the ringstone. It measures about 3 cm wide and one cm deep. Scratches on the general surface are collinear with the rotation axis but are in right angle to it at the chamfer. Probably these scratches are marks of softening the surface.*

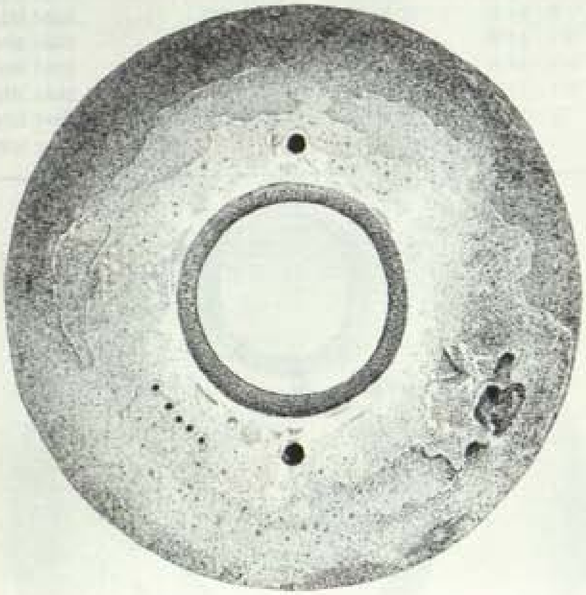
MM 1405 *Topside: slightly destroyed, two dowel-holes ø 14 mm at a distance of 18.6 cm, no spots to be seen. Bottom side: smooth, no marks, drill-holes etc.*

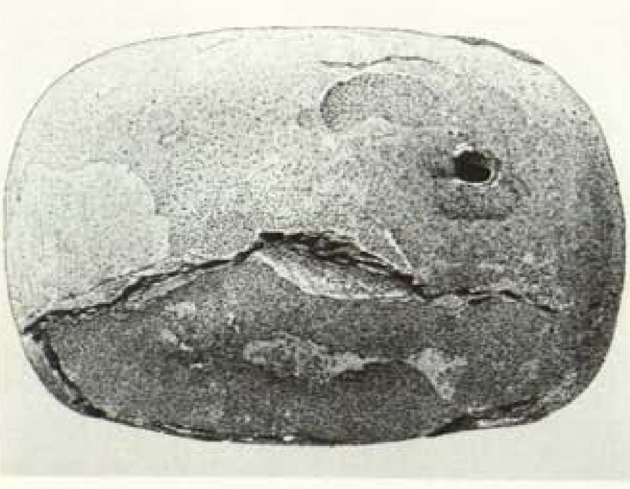




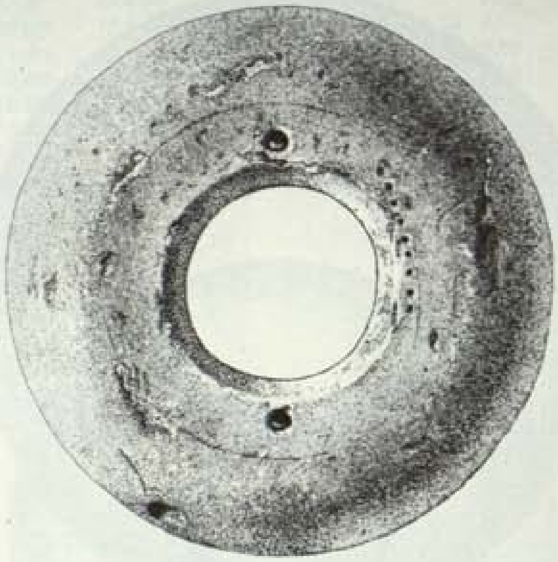


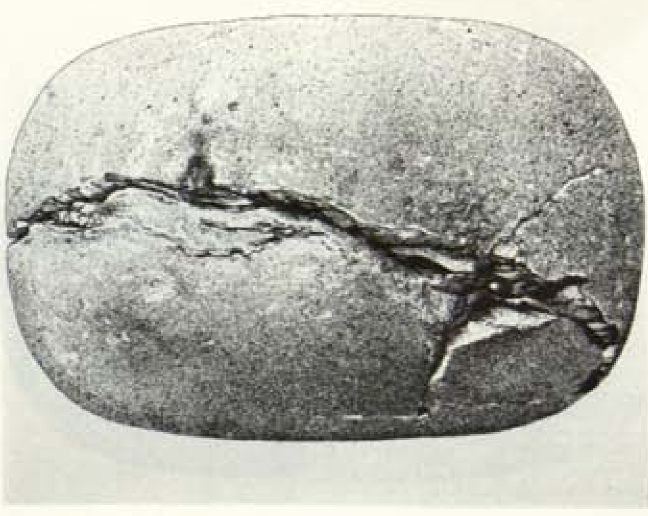
MM 1406 *Smooth polished surface*
Topside: 2 dowel-holes ø 16 mm, 22 mm deep, distance 22 cm, 5 little spots ø 5 mm, engraved circle ø 27.3 mm
Bottom side: 2 dowel-holes ø 4 mm, distance 22.5 cm



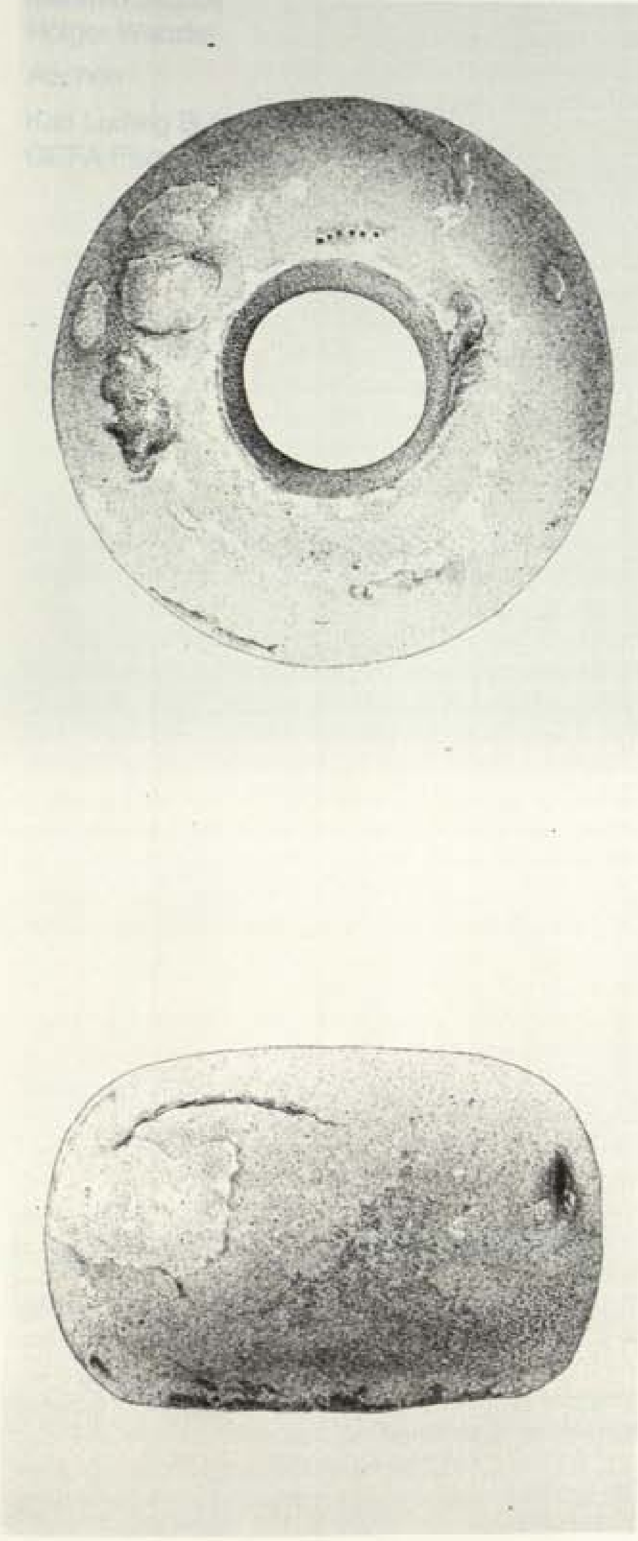


MM 1407 *Topside: 2 dowel-holes ø 16 mm, 25 mm deep, distance 20 cm, 9 little spots ø 5 mm, engraved circle ø 25.6 cm, radial scratches*
Bottom side: engraved circle ø 25.8 cm.

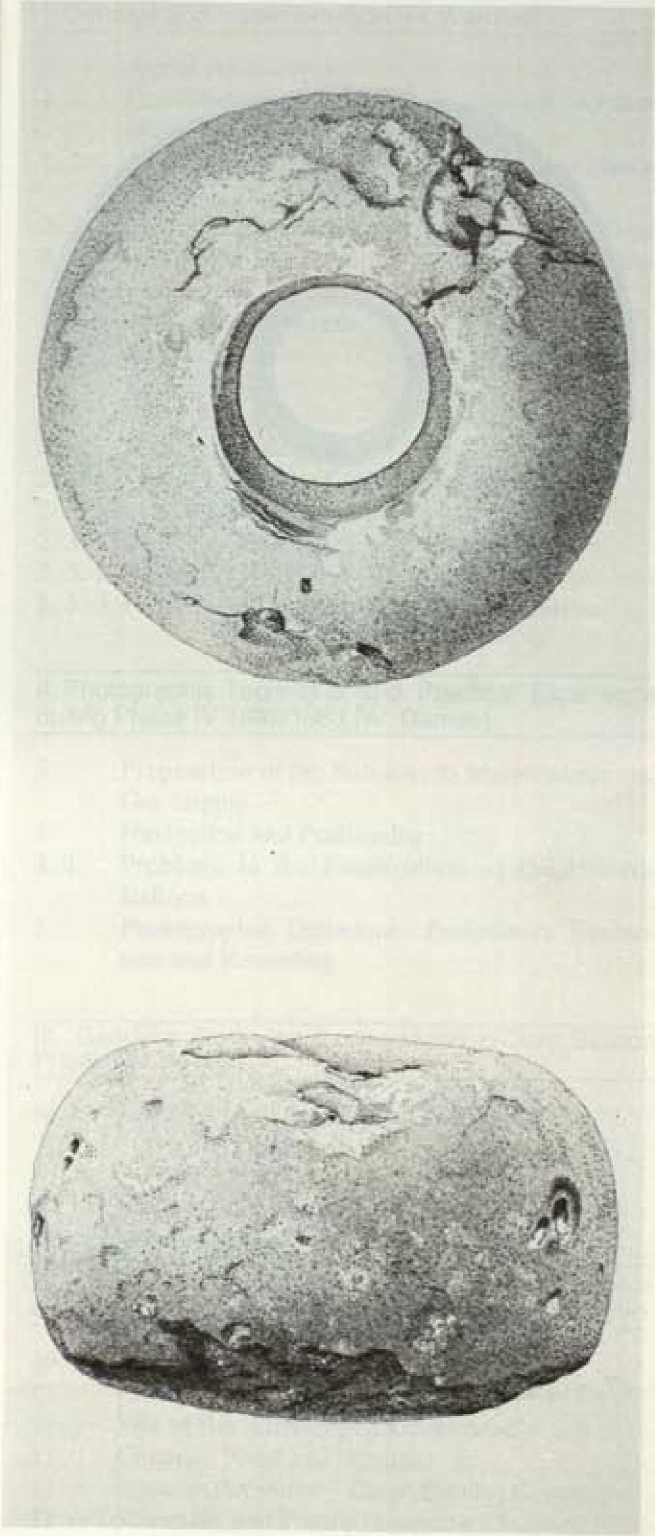




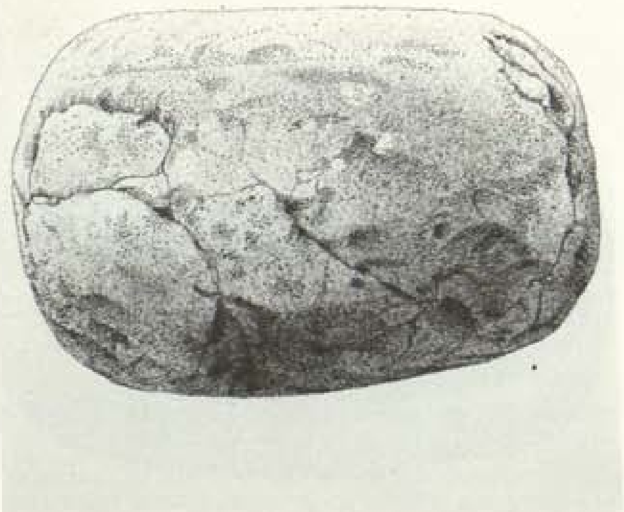
MM 1408 *Smooth polished surface partly destroyed*
Topside: 6 spots ø 3-5 mm distance each 8-10 mm.



MM 1409 *Heavily destroyed*



MM 1410 *Strong indications of weathering, surface destroyed, no further evidence.*



Close-Range Aerial Photogrammetry in Archaeology

The Use of a Hot-Air Balloon for the Stereogrammetric Documentation of Ancient Ruins.

Wolfgang Dames
Manfred Jacobs
Holger Wanzke

Aachen

Karl Ludwig Busemeyer
GEFA-Flug – Aachen

Contents

Concept and Implementation

1. Aerial Archaeology

1.1. The Contribution of Aerial Photography to Archaeology

The development of lighter and handier cameras in the late 19th century led to the first attempts being made to photograph archaeological excavations from manned balloons or model kites *(Dewel, 1972)*.

It was not until the invention of the aeroplane, however, and its being equipped with a camera for military reconnaissance that the systematic documentation of objects best visible from the air became possible. Thus in 1916 German pilots were able to make a photographic record of the state of ancient urban sites in Palestine and Syria on behalf of the German-Turkish Office for Architectural Preservation. Similar developments were also taking place on the English and French fronts.

Working in Wessex in the 1920's, the Englishman O.G.S. Crawford opened up a completely new field of application for the new technology – the prospection of archaeological remains buried under the surface. Experience taught him that every architectural fragment hidden just under the earth's surface causes a disturbance in the fabric of the soil which is only visible from the air.

According to the nature of the soil disturbance the archaeological sites thus discovered have been classed into the following:

SHADOW SITES betray their existence by casting characteristic shadows on the surrounding countryside when the sun is very low in the sky.
CROP SITES show up as areas of stunted corn growth due to the structural remains underneath, or of denser growth above filled-in ditches rich in organic waste.
SOIL MARKS are simply discolorations in the soil caused by subterranean remains.

Under suitable photographic conditions – position of the sun, season, climate – these soil disturbances can reveal an astonishingly clear picture of buried monuments *(Dewel, 1972)*.

In the 1950's and '60's this prospection method was utilized to great effect by the Rheinische Landesmuseum in Bonn under the direction of I. Scollar. In Northrhine-Westphalia alone, several thousand prehistoric and ancient historic settlement sites were discovered, particularly of the Roman period. Before a geometric evaluation of the photographs can be carried out, the distortion caused by the extremely oblique photographic angle has to be rectified by means of a digital photographic processing method. The rectified pictures are then entered accordingly on the German Base Map to the scale of 1:5,000 *(Robinson, 1982; Scollar, 1965)*.

So far, however, air photography has not succeeded in replacing the land surveying of archaeological excavations by photogrammetric evaluation. Apart from the cost and organisation involved, this is mainly due to the impossibility of taking large-scale pictures (mb ≥ 1:1000) from an aeroplane, restricted as this method is by minimum flight altitudes and speeds.

1. 2 Development and Progress of Low Air Photography in Archaeology

For the reasons mentioned above, the requirements made of a photogrammetric system suitable for surveying archaeological sites from the air must be met by other camera vehicles than the aeroplane. Numerous experiments have been carried out with a variety of vehicles, including

- model helicopters and planes,
- gas and hot-air balloons,
- kites *(Badekas et al., 1980; Georgopoulos, 1982; Heckes, 1982; 1983; Keune, 1983; Przybilla et al. 1982; Przybilla, 1979; Wester-Ebinghaus, 1980 a; 1980 b)*.

Generally, 35-mm or medium format cameras are used; the most recent development in the field, Wester-Ebinghaus' partially calibrated version of the Rolleiflex SLX, is becoming popular *(Wanzke, 1983)*.

Judging the various camera transport systems by their suitability for making stereo strip flights over pre-determined grid squares their most significant qualities may be summarised as follows:

SMALL PLANE: poor navigability, especially as regards flight altitude; very highly prone to mechanical break-downs; runway essential.
MODEL HELICOPTER: mechanically unfit for long-term operation; very difficult to fly – operational errors lead to crash landings; very highly prone to mechanical break-downs.
TETHERED BALLOON: dependent on weather and particularly on wind conditions; navigation not easy; safe; uncomplicated flying system; large payload capacity; flight altitude easily regulated; simple to operate and to repair.
BALLOON GAS: Hydrogen – stong lift, necessitating a very dense skin; highly explosive. Helium – safe, but very expensive; difficult to obtain. Hot air – large balloon; heating gas universally available; loss of volume through wind pressure.
KITE: low capital outlay, no running costs; very poor navigability, wind necessary, flight altitude difficult to regulate.

Because their operation is so uncomplicated and demands little prior preparation it its mainly tethered balloons that have been used for archaeological surveying to date. Some of the balloon types are here described.

Whittlesey (1970) studied several archaeological sites in Turkey, Greece and Italy from the air between 1967 – 70. He used a hydrogen balloon 17 m^3 in size and photographed with a Linhof 6 x 9, a Hasselblad 400 EL and a Graflex XL, concentrating mainly on the prospection of settlement remains along river courses from altitudes between 50 – 600 m. He also experimented with a kite of the Jalbert Parafoil type.

Badekas et al. (1980) report of their experience with various hydrogen balloons in flights over ancient sites in Greece, where they carried out photographic work only – an analysis was not part of their programme.

A hydrogen balloon system for use in air photographic surveying was developed at the Technical University of Vienna in 1977/78 by Lubowski and Waldhäusl. The most striking feature of their system is the very complicated mechanism for focussing the camera lens; it would appear extremely time-consuming and impractical to operate.

Heckes (1982; 1983) reports of the first time a hot-air balloon was used for photogrammetric photography. The camera he uses is a partially calibrated Rolleiflex SLX, the entire system is very robust and uncomplicated and proved its effectiveness in lengthy work sessions in Oman and Syria.

On the basis of experience to date it may be fairly claimed that the hot-air balloon is the most universally versatile camera vehicle available for archaeological surveying from the air.

2. Close-range Air Photography in Mohenjo-Daro

Our several years' experience of field conditions in Pakistan proved the value of large-scale aerial photographs for a complete and comprehensive documentation of the site. In 1981, work began on the development of a photogrammetric flight and photographic system using a hot-air balloon.

In *Keune, 1983* it is argued that it is only worthwhile using a balloon where small areas are to be covered, as getting a balloon off the ground is so time-consuming. This is particularly the case when the same results can be achieved using other camera vehicles, such as a small plane or helicopter. However, due to the technical, economic and political conditions currently prevailing in Pakistan no such alternative to the balloon is available. Attempts to take pictures from a model helicopter had to be abandoned because of its mechanical unreliability over longer working periods *(Wester-Ebinghaus 1980 a)*. For these reasons economic considerations such as those discussed in *Przybilla, 1982* do not apply in our case.

The balloon system was designed and constructed by the GEFA-Flug GmbH of Aachen under the direction of K.L. Busemeyer. The author was responsible for devising the photogrammetric concept, determining the demands this makes of the flight system and seeing it through its trial runs in Mohenjo-Daro. During this trial period a team of archaeologists and mine surveyors was made familiar with the research operation and its aims.

2.1. Aims and Expectations of the System Implemented

Of the catalogue of operations envisaged by the Mohenjo-Daro Research Project *(Jansen, 1983)* was planned to use a hot-air balloon for the following projects:

- To assemble a documentation of the excavated area with the help of strip blocks of aerial stereograms which would provide a record of the present state of Mohenjo-Daro suitable for use as a basis for further research.
- To draft ground plans and isometric sections to the scale of 1 : 200 by photogrammetric means of particular areas of the excavation where high walls make surveying from the ground very difficult *(Scollar, 1983)*.
- To consolidate the findings of the surface analysis carried out in the '82/'83 field season by detailed air photos taken from various altitudes so that rectified air plans of the areas in question could be assembled.

- To provide the material necessary for a visual interpretation of the surface by taking stereo colour photos with a fixed base.

The following table lists the conditions imposed by the aims for which the system is planned and the construction principles chosen for their fulfillment:

CONDITIONS	CONSTRUCTION PRINCIPLES
I. FUNCTIONAL CAPACITY	
WIND STABILITY Must be operable even in moderate winds.	Elongated balloon (Zeppelin shape); inner pressure stabilised by scoop.
EASE OF OPERATION All parts of the system must be easily accessible, the camera must be simple to instal and remove; the entire system must be easy to transport.	Open construction; easy to dismantle; basket also serves as container in transport; camera equipped with quick-locking mechanism.
REMOTE CONTROL All balloon and camera functions must be operable by remote radio control.	Installation of a 5-channel FM remote control system and the use of a motor-operated camera.
NAVIGABILITY The devices for outer orientation must be kept within certain practical limits.	Cardanic suspension of camera; camera mounted on a motor-powered, revolving vertical axis; altitutde marking line; plumb line.
II. SAFETY	
RELIABILITY Robust, reliable construction, as spare parts are unobtainable in Pakistan.	Only absolutely necessary components and as few electronic parts as possible in the construction; second set of important parts to be taken as spares.
CAMERA PROTECTION Camera must be suspended in such a way that it cannot be damaged in a careless, hard landing.	Camera mounted in a willow basket, this being an adequately tough and elastic material.
FIRE SAFETY No danger of fire even in an emergency landing.	Both main and ignition flames can be regulated by remote control.
III. ECONOMIC CONSIDERATION	
10 kg payload	Dimensions and capacity of balloon and burner must be carefully correlated.
Operation duration of 30 minutes.	Corresponding gas-carrying capacity.
Low overall weight, as air freight is expensive.	Skin made of balloon silk; stainless steel gas container; use of aluminium.
Adjustable heat output for climbing or hovering.	2 or 4 independently adjustable main burners, depending on purpose.

Fig. 1 *Hot-air ship GFL 145 after take off.*

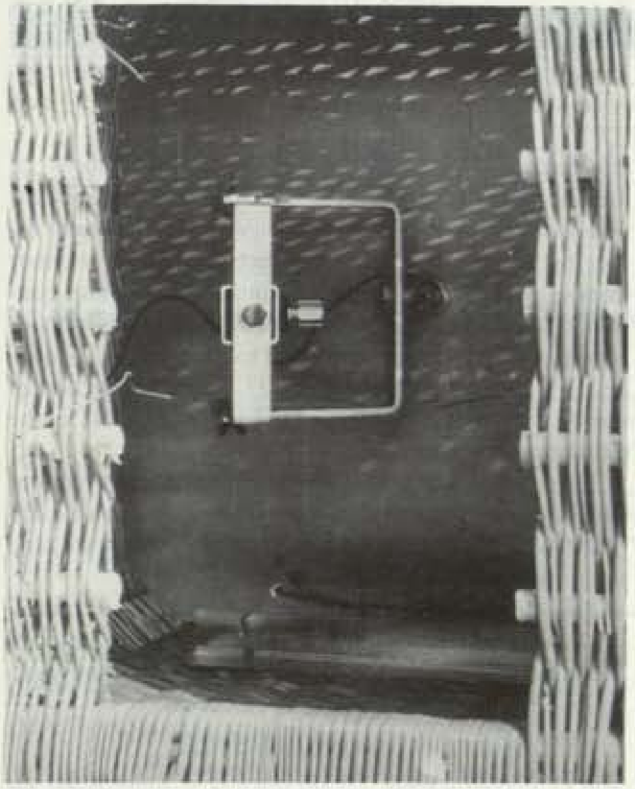
2.2. System Components

2.2.1 Balloon Skin

Experience with spherical hot-air balloons has shown that even a light wind will cause distortion of the balloon shape and this leads eventually to the balloon losing height through volume loss *(Busemeyer 1982)*. Thus only a Zeppelin-shaped balloon could provide the wind stability required. *(Fig. 1)* A side rudder at the stern makes the airship head into the wind, thus ensuring that the smallest surface area bears the brunt of the weather. In addition, a scoop is used to stabilise the inner pressure. This is a skirt attached to the burner opening of the balloon which traps the wind blowing in from the bow thus keeping up the inner pressure level.

For further technical details of the GFL 145 cf. *Busemeyer (1983)*.

Fig. 2 *View of balloon basket from below showing camera in position.*



2.2.2. Basket

The willow basket *(Fig. 2)* is suspended from the balloon on 4 steel ropes. Willow was chosen not only because of its lightness but also for its high elasticity and toughness. In the floor of the basket is the opening for the camera suspension. *(Fig. 3)*

2.2.3. Burner

The air inside the balloon is heated up by a burning mixture of liquid propane and butane. The liquid gas is supplied with the fuel necessary for evaporation by a length of tubing leading from the head of the burner *(Fig. 4)*. A constantly burning pilot flame is used for igniting the air/gas mixture. The gas is contained in a stainless steel cylinder with a volume of approx. 101; given an outside temperature of $+ 20^0$ C the internal cylinder pressure when filled with pure propane is 8.5 bar.

2.2.4 Camera Installation

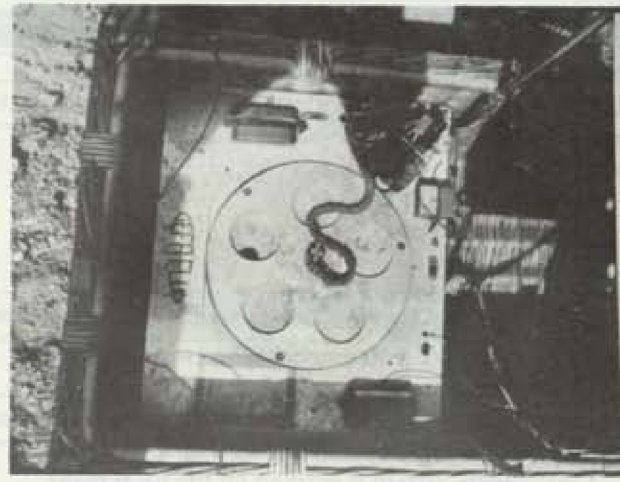
In order to ensure the most horizontal image plane possible while the photo is being taken the camera was suspended cardanically. By means of a turntable the cardan can be revolved about its vertical axis. The position of the camera can be seen from the ground through an indicator affixed to the base of the basket. *(Fig. 5)*.

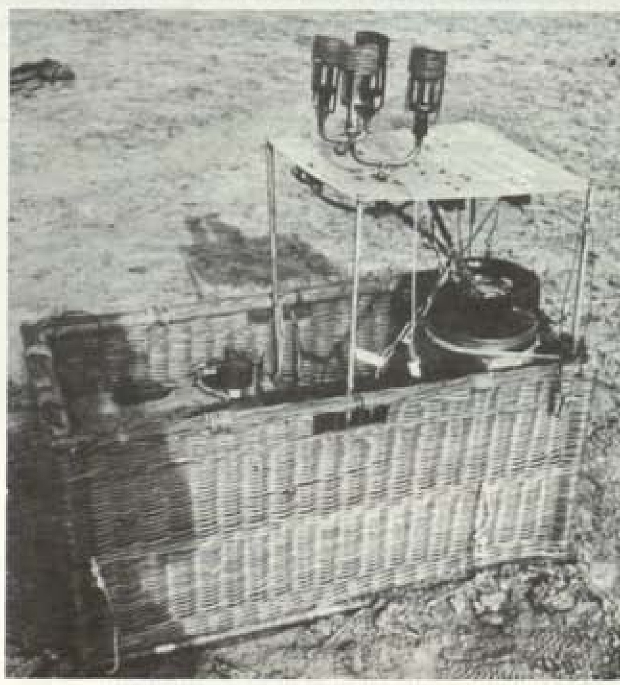
Upper

Fig. 3 *Remote control unit with rotating plate to determine camera direction.*

Middle

Fig. 4 *Balloon basket with gas bottles and burner.*





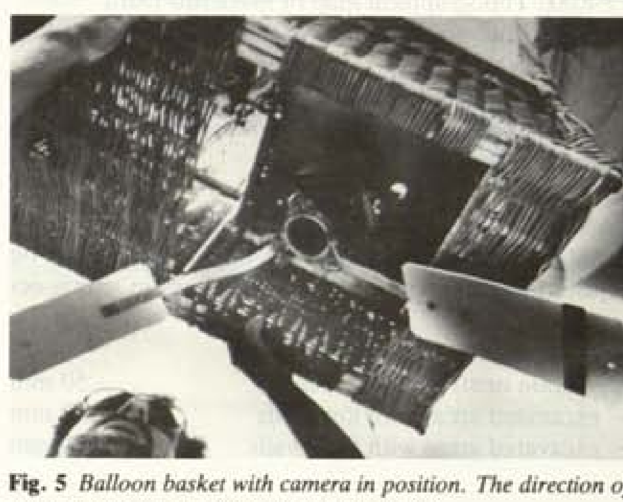


Fig. 5 *Balloon basket with camera in position. The direction of the camera is visible by means of the pointer.*

2.2.5 Photogrammetric Camera

The camera used is a refined, partially calibrated version of the medium format Rolleiflex SLX developed by Wester-Ebinghaus *(Wanzke, 1983)*. The advantages of this camera are:

- motor operated,
- automatic exposure,
- use of roll film,
- can be calibrated by a réseau,
- interchangeable lens.

The lenses used are a 50 mm distagon (wide-angle) and a 120 m S-Planar (tele).

The incorporation of a réseau transforms the Rolleiflex SLX into a partially calibrated camera:

- A coordinate system is marked on the focal plane.
- Affine and non-linear film distortion can be recorded.

2.3. Photogrammetric Concept

The planning of the photogrammetric operation depends on the following factors:

- the desired end product,
- the camera used,
- the evaluation facilities.

END PRODUCT. The set of plans and maps drafted of Mohenjo-Daro as part of the documentation of the historical architecture of the site is drawn to four scales differing from each other to the factor 4 – 5.

1 : 50 Plans of architectural details

1 : 200 Groundplans and isometric drawings of the excavated areas

1 : 1,000 Topographical map of Mohenjo-Daro

1 : 5,000 Topographical map of the environs and overall view of the site.

It was intended to cover the area drafted to the scale of 1 : 200 with line and air photo maps from the photos taken from the balloon.

CAMERA. The Rolleiflex SLX is equipped with two lenses, 50 mm and 120 mm. Thus the focal angle can be adjusted to the various categories of terrain which occur:

– open, slightly hilly ground, scant vegetation or structural remains	50 mm
– excavated areas with low walls	50 mm
– excavated areas with high walls	120 mm
– terrain covered with dense vegetation	120 mm
– areas with surface archaelogical remains, overall views	50 mm and 120 mm resp.
– oblique stereo photographs	50 mm

EVALUATION FACILITIES. The development of numerical processing has opened up completely new possibilities for applying close-range photogrammetry as, for instance, the camera geometry need be neither known nor unvarying, the amount of information contained within the lens field can be reduced and the photography instruction hardly need to be modified *(Wanzke, 1983; Wester-Ebinghaus, 1981)*. Nevertheless, a degree of exactness of ± 4 - 8 μm can be attained in the photographic image.

These advantages can only be secured if the system is backed up by a comprehensive range of electronic data-processing equipment, both software and hardware, and the personnel trained to operate it.

This circumstance is contrary to the declared aim of the Research Project, which is to make the air photos of Mohenjo-Daro available in the form of a basic universal archive for the benefit of future research.

Taking the technical and human possibilities of the Research Project Mohenjo-Daro into account, the photogrammetric operation must be so conceived that the desired end result can be produced from the air photos without any additional processing.

2.3.1 Planning of Photo Flight Sequence

The photo flight path parameters relate to

- the terrain detail concerned,
- the flight level,
- and the camera invariables

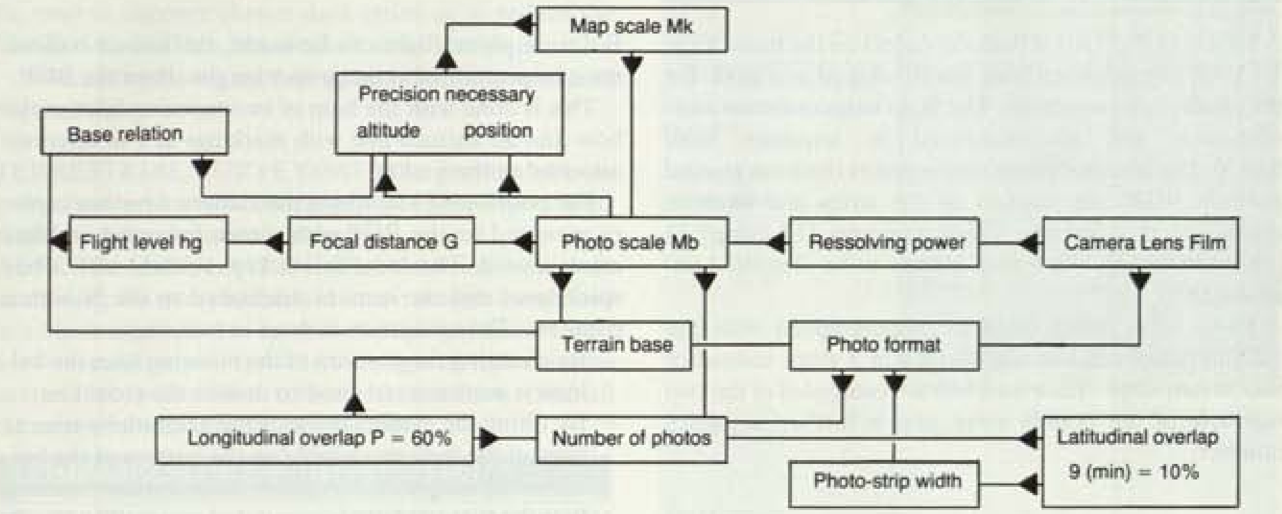
with which a photogram must be taken in order to produce a stereo model or, as the case may be, a block of aerial photograms. The most important parameter is the photograph scale. A large scale means high expenditure (= a lot of pictures per surface unit), but also that small details are recorded. In this connection it should be noted that the economics of such an aerial survey (number of photos : surface unit) are to be reckoned to the power of 2 from the photo scale chosen.

178 photos measuring 6 x 6 cm to the scale 1 : 1, 250 cover an area of 1 km^2 without any overlap. If the photo scale is increased to 1 : 1,000, 278 photos are required to cover the same area, i.e. 56 % more.

The most decisive factor in the choice of photo scale is the scale of the map to be drafted *(cf. Pl. 1)*.

Pl. 1 *Photo-flight parameters*

PHOTO-FLIGHT PARAMETERS



The Gruber Formula $m_B = K \cdot \sqrt{m_k}$ is used to calculate the photo scale necessary for drafting a map to a certain given scale. For the map scales ranging from 1 : 5,000 – 1 : 40,000 usually used in air photogrammetry the K-value of 200 has proved most practical. A map scale of 1 : 200 gives a photo scale of 1 : 2,800, which means that the clarity of detail expected when magnified 14 times cannot be produced by the resolution power of the photographic emulsion.

For large map scales, therefore, the choice of photo scale depends on the evaluation facilities available. The translation ratio from photo to map scale is limited to ~ 1 : 6 both for mechanically-operated analogue stereo plotters and for distortion rectifiers.

This results in a maximum photo scale of m_B = 1 : 1,200, the scale worked with when making photo flights with a wide-angle lens.

When using the 120 mm telephoto lens, however, the photo scale has nevertheless to be enlarged to 1 : 830 for the following reasons:

- A scale of m_B = 1 : 1,200 would mean a flight altitude of 144 m, where it is no longer possible to navigate safely.
- The larger scale means that the 2 flight strips which would be photographed with a 50 mm lens are covered exactly in 3 strips with the 120 mm lens to the scale of 1 : 830.

In this way both lenses (depending on the type of terrain involved, cf. 2.3) could be used to cover the whole Mohenjo-Daro site in a fixed sequence of flight strips (balloon grid) without unneccessary double takes or gaps arising.

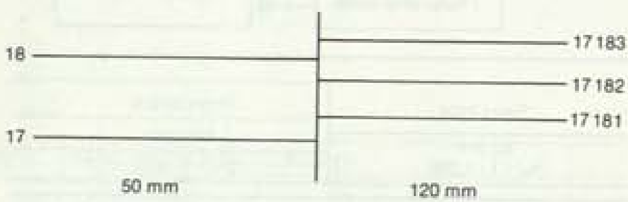
Two strips	Three strips
50 mm m_B = 1 : 1,200	120 mm m_B = 1 : 830

50 mm DISTAGON		120 mm S-PLANAR
51.17 mm	Calibrated focal length	121.47 mm
75°	Diagonal focal angle	36°
61.5 m	Flight level above MSL (= 55 m)	101.2 m
1:1170	Photo scale	1.823
– – –	Evaluable film format (55 x 55 mm)	– – –
60 %	Longitudinal overlap	60 %
10 %	Latitudinal overlap	13 %
26.40 m	Terrain base	18.33 m
59.40 m	Photo strip width	39.85 m
125.40 m	Width of a double strip / treble strip	125.50 m
4356 m²	Extent of area covered	2100 m²
1568 m²	Extent of new area covered in stereo overlapped area	730 m²
0.43 ~ 1/2.5	Base proportion	0.18 ~ 1/5

2.3.2 Navigation of Photo Flight Sequence Theoretical Background

A system of flight strips (balloon raster) on the basis of the 1 : 1,000 topographical map was developed as a guide for the photo flight navigation. The flight strips orientate east-westwards and are numbered in sequence from S to N. The relevant photo centrepoints (balloon ground position BGP) are marked on the strips and likewise numbered in sequence. These numbers (17 [strip] 23 [Photo number]) allow each picture to be identified unmistakably.

Those areas which must be photographed with the 120 mm telephoto lens are covered in 3 strips instead of two 50 mm strips. Their numbers are composed of the two numbers of the double strips plus a further sequence number.



After the balloon grid has been fixed the individual photo centrepoints (BGP) are marked on the terrain to be covered. On the basis of the Geodatic Network DFG 80 the coordinates are staked out and the BGP marked with wooden pegs.

A precision degree of ± 0.5 m is adequate for the staking of the coordinates; the subsequent calculation of the BGP should be accurate to within ± 3 - 4 cm for the position and ± 1 cm for the altitude. *(Fig. 6)*.

Navigation Practice

Before a photo flight can be made, the hot-air balloon must be positioned at the proper height above the BGP.

This is done with the help of two mooring lines at the bow and an altitude line with markings at 1 m intervals attached to the basket.

For positioning and tilting the camera a further camera mounted on the BGP with screen focussing and line cross is used. The focal axis is kept vertical with a box spirit level and the camera orientated to the N with a compass. The navigation is done in two stages:

- By changing the position of the mooring lines the balloon is manoeuvred close to or into the cross line.
- By tilting the camera towards the azimuth by remote control the indicator visible on the bottom of the basket is turned parallel to the cross line, thus ensuring that the survey photo is orientated correctly in the direction of the flight strip.

This process takes place dynamically through the movement of the balloon; 3 - 4 photographs are taken per positon.

2.3.3 Fixing of Coordinates and Documentation

The aerial stereograms taken from the balloon can only be evaluated geometrically if there are at least two easily identifiable coordinates indicating position and altitude on each stereo model, as well as an additional altitude control point.

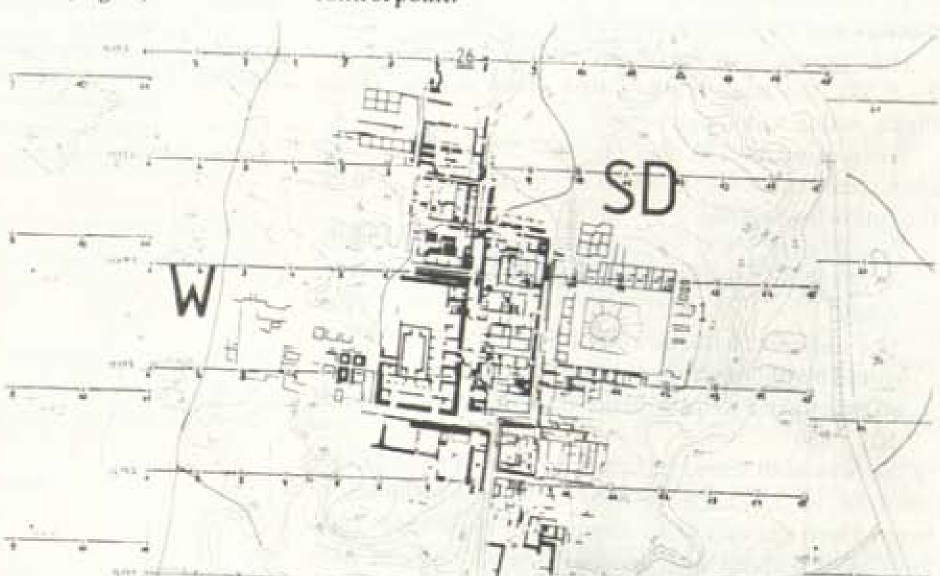


Fig. 6 *Balloon scan area in excavation areas SD and W. The known coordinates of the centre of exposure are transferred onto the frame. Balloon grid 120 mm.*

Should more coordinate points have been surveyed than necessary, the superfluous information can perhaps be used to uncover chance data errors or to reduce the likelihood of hidden miscalculations in the system.

Two methods are used to determine the position of the coordinate points:

TERRESTRIAL SURVEYING. The position of control points is calculated on the ground either trigonometrically or from the earth's poles.

AEROTRIANGULATION. This method involves combining the many individual stereo models comprised in a block of air photos by mathematical calculation. Just a few coordinate points round the edges as well as in the centre of the photo block suffice as a basis from which all the other coordinates can be calculated.

COMPARISON OF THE TWO SYSTEMS

TERRESTRIAL	*AEROTRIANGULATION*
ADVANTAGES	
Coordinate points are available for use immediately after being determined.	Little fieldwork involved Homogenous coordinate system
DISADVANTAGES	
Large-scale fieldwork necessary Inhomogeneous data complex	Aerotriangulation by numerical means necessitates special programming

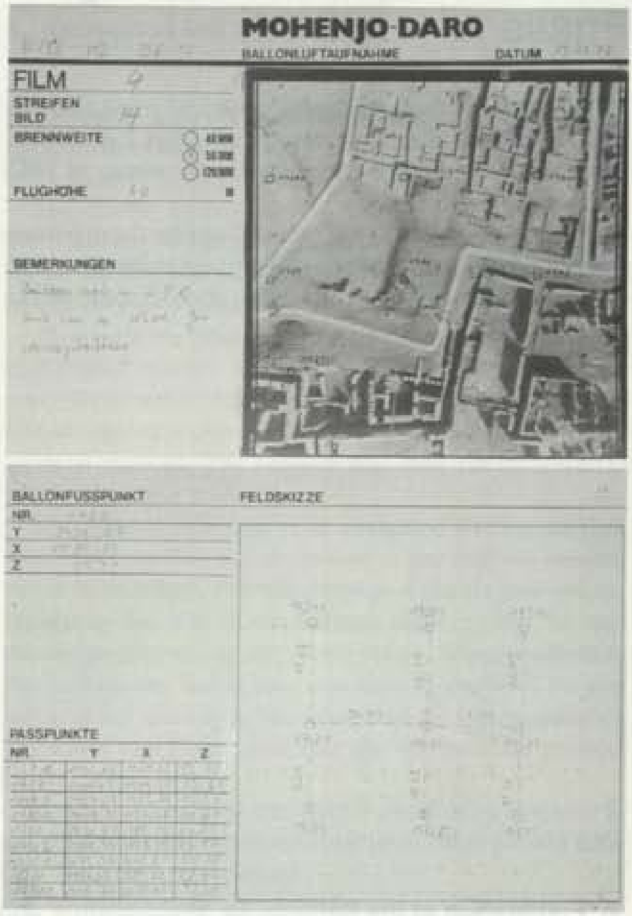
The terrestrial method of determining coordinate points was chosen for our photogrammetric concept for the following reasons:

- Although the Mohenjo-Daro Research Project has analogue plotters at its disposal, it has no aerotriangulation facilities.
- As a result of the BGP balloon grid plenty of surveyed and duly marked points were present in the excavated areas, so that the coordinate points could be calculated on the ground fairly straigthforwardly.

Where no suitably prominent, photogenic corners of buildings could be used as coordinates, boards 30 x 30 cm in size showing concentric circles were set up.

From the 3 - 4 pictures taken above each BGP one was selected as the final survey photo for evaluation on the plotter.

In order to have all the information necessary for evaluation available simultaneously, the data are entered on an index card along with an enlargement of the relevant survey photo.



Photographic Technique and Practical Experience during Phase IV (1982/83)

Working on an idea developed in 1981/82 using a hot-air balloon in aerophotogrammetry (c.f. Part I of this report), the practical test took place in the winte, of 1982/1983 at Mohenjo-Daro.

This second part of the report will describe the experiences gained through the use of the hot-air balloon, and also explain the technique used in the photographic work.

3. Preparation of the Balloon, its Maintenance and Gas Supply

One of the fundamental requirements of a hot-air balloon which is being used in photogrammetric work at an excavation, is its constant availability on site and also its speedy mobilization. The influencing factors are thus:

- easily transportable to where it is needed
- ready supply of fuel (gas)
- regular maintenance of remote control units, their electricity supplies and the camera
- availability of a five-man team
- favourable weather conditions (litte wind)

The amount of work on site then depends on what the balloon is used for. Possible uses are for

- stereophotogrammetric aerial surveys from a medium altitude (70 - 100 m)
- aerial-photography documentation of architectural remains or surface surveys from a low altitude (20 - 50 m)

In the case of stereophotogrammetric aerial surveys the previously plotted balloon foot-points (BFP) and pass-points have to be marked with specially prepared paper squares *(Fig. 7)* before the ascent of the balloon. This takes between a quarter of an hour and one hour depending on the size and topography of the area to be surveyed. These preparatory measures are unnecessary when the balloon is to be used for simple aerial-photography documentation.

The balloon is prepared on a suitably levelled piece of ground directly next to the area in which it is to be used *(Fig. 8a/8c)*. The burner and remote control unit are checked beforehand to see if they are functioning normally. Detailed checks are carried out on:

- transmitter power-source
- rotational function, right/left
- pilot light valve, on/off
- burner valves I and II, on/off
- micro-switch for camera shutter release

The burners are then tested. These heat up the air in the balloon itself producing the necessary lift.

The camera is secured in the universal-joint suspended in the basket of the balloon as soon as the balloon begins to float. The shutter release is tested by remote control, thus winding the film on to its starting position. Film sensitivity, shutter speed and automatic aperture are checked and set before commencing. The complete preparation presents no problems with light winds, and takes approx. 15 min. with an experienced team. Personnel required are two experts and three assistents.

Maintenance of the balloon is relatively uncomplicated because few delicate mechanical and electrical components are used in its construction. The following maintenance work was carried out on the balloon after each flight;

- visual check of the balloon skin for damages, and any necessary repairs
- check on the guide-lines
- control on the burner equipment and valves, clearance of main jets if necessary
- recharging of the transmitter, receiver and motor accumulators
- gas bottles filled from larger supply bottles

The Indus Gas Company of Karachi, Pakistan provided the Project with 40 kg bottles of a liquid gas mixture of propane and butane which was used as fuel for the balloon.

Each of the 8 kg liquid gas bottles used in the balloon itself were filled from these larger bottles.

Because of the limited amount of heat produced by the Pakistani gas and the high air temperature the balloon was equipped with two burners. In addition the gas bottles had to be warmed in a bath of hot water before each flight to increase the gas pressure. By these means an average flight duration of 40 min. per bottle was attained.

Fig. 7 *30 cm² sheets of paper nailed onto marked pegs served as pass points on open ground.*

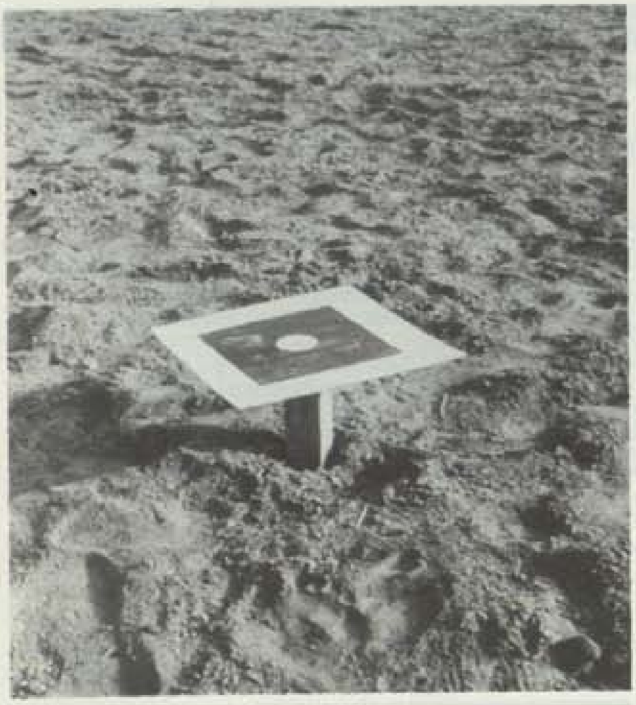


Fig. 8 a *Hot-air ship GFL 145 before assembly.*
Fig. 8 c *Assembly Phase II: the envelope is almost completely inflated.*

4. Navigation and Positioning

In order to achieve economical aerophotogrammetric pictures the camera carrier has to be positioned as exactly as possible above the centre of exposure.

The centres of exposure, or balloon foot points (BFP) were marked on the ground with wooden blocks according to the photo-flight planning, and then their position and height were measured.

Alongside the photographically accordinated BFP s, a half-frame camera with built-in line-cross viewfinder was also erected *(Fig. 9)*. Using a spirit level the direction of exposure axis of this Zenit camera was positioned in dead vertical. The camera was then set on a north/south axis using a compass.

The balloon now had to be navigated into the camera viewfinder so that the alignment of the balloon camera could be checked. For this purpose a plastic arm was attached to the lens of the balloon camera *(Fig. 5)*, and this lay parallel to one side of the photo. When positioning the balloon one had to take care that the centre of the plastic arm lay directly in the middle of the Zenit camera's line-cross viewfinder, and that the arm itself lay parallel to one of the lines.

Because the balloon was guided solely using two bow lines its positioning in architectural areas often proved difficult. Necessary personell are:

- two assistants on the bow lines
- one assistant on the plumb line
- one expert operating the Zenit camera and remote-control unit
- one expert standing on higher ground directing the assistents on the bow lines

The balloon was towed into position against the wind by the two assistents. Altitude was constantly checked on the graduated plumb line. Strong winds hampered navigation, on the one hand by rotating the balloon around it's base line; and also by causing an indentation of the nose-end, leading to a loss of volume, and thus loss of altitude.

Positioning was especially difficult in DK-G South Area due to the up to 6 m high protruding walls found there. The assistants on the bow lines could only move along narrow alleys.

Three flight corridors with a side overlap of 13 % were calculated in the photo flight planning. The difficult topographic conditions however, called for a change in the photo flight planning resulting in the use of four flight corridors with a side overlap of 25%. Because of this change most of the DK-G-South Area could be overflown in one day.

Table 1 *Problems encountered with the balloon during the test phase in Mohenjo-Daro.*

DISTURBANCE	CAUSE	REMEDY
Transmitter operating voltage too low, receiver accumulator too weak	Power-cut overnight, recharging impossible	Accumulators recharged out of activity approx. 1 day
Transmitter operating voltage too weak during Flight phase	4 hour Flight time exceeded	Doubling of the transmitter accumulators capacity
Liquid gas and black sludge emitted from burner jets during burner tests	During refilling of gas bottles, the primary tanks were completely emptied. Thus, sludge deposits transferred from primary tanks into gas bottles	Balloon preparation stopped; complete emptying of gas bottles; burner unit dismantled and all parts thoroughly cleaned (valves, hoses, jets, bottles). Balloon out of activity approx. 1 day
Camera shutter-release defect	Cable broken where it passes through rotating platform	Cable renewed Out of activity approx. 1/2 day
Film not properly wound on. Multiple exposure	Back of camera defect (counter)	Back of camera renewed
Film break	unknown: suspected faulty roll of film	New roll of film inserted
Lack of fuel	Delivery problems on the part of the Indus Gas Company	Balloon out of activity approx. 4 days

Fig. 9 *A north-south orientated, vertically positioned half-frame camera is used in the balloons navigation.*

4.1 Problems in the Employment of the Hot-Air Balloon

The balloon proved to be relatively uncomplicated in its operation. The few problems which we encountered could be remedied in situ, and in only a few cases did they lead to the balloon being out of action for any long period of time.

The main difficulties experienced during the trial phase in Mohenjo-Daro are listed in the following table *(Tab. 1)*.

5. Photographic Technique, Preliminary Evaluation and Recording

The majority of the aerial photographs in Mohenjo-Daro were taken with a modified 6 x 6 cm^2 calibre Rolleiflex SLX camera. The aerophotogrammetric work was carried out in exactly the same way as normal photogrammetry i.e. the exposure axis was dead vertical.

To achieve this the camera was hung on a universal joint in the basket of the balloon. *(Fig. 2)*. By means of a circular plate the camera could then be rotated about its exposure axis. *(Fig. 3)*.

These features of construction allow for the sufficiently exact positioning of the camera above the respective centres of exposure necessary in aerophotogrammetric work. However, the orientation sail on the camera lens which was intended for that purpose appeared to influence the vertical positioning of the exposure axis in a negative way. *(Fig. 5)*.

Fig. 10 *Well preserved corners of walls were used as pass points in architectural areas.*

The centres of exposure were calculated in the photo flight planning so that the areas to be overflown could be completely screened off with stereo models (the overlap between two neighbouring exposures). A longitudinal overlap of only 60 % and a side overlap of 13 % meant an allowance of ± 1,5 m in the east/west and north/south axes during positioning. This is assuming, however, that the edges of the photos are parallel to each other. If one or more photos in a single flight corridor are out of line, then this could lead to deficiencies in the analysis.

The quality of the aerial photos depends not only on the film material, but also on the position of the sun, the topography of the area to be overflown, and not least the developing of the photos. The film was chosen according to the purpose for which the photos were to be used later. *Table 2* shows the types of film used in the Rolleiflex SLX for aerial photos in Mohenjo-Daro.

Photographic contrasts are an essential aspect of aerophotogrammetry. The feet of walls in architectural areas must be visible for any reasonble analysis to be made. In cases with tall buildings, narrow spaces, or in strong sunlight the bottom parts of walls often fall in the area of darkest shadow. The Agfapan 100 film proves to be too strong in its gradation for this purpose. Better results were obtained with the Ilford FP 4 film, exposed and developed at 19 DIN exposure index to compensate for too strong photographic contrasts. Exposure at 19 DIN could only be carried out after 9 a.m., because between 7 a.m. and 9 a.m. shutter speed was too fast. In order to avoid blurredness the shutter speed was set at 1/500 sec. or maximum 1/250 sec..

The choice of film (120 or 220) depended to a certain extent on the flight time achieved using the gas bottles (usually 40 mins.). On economical grounds it was decided to change the film at the same time as the gas bottles were changed. In this way it is more economical to replace a partially exposed film than to bring the balloon down again after a further 6 or 8 exposures. As a rule, 3 or 4 pictures were taken over each point.

Fig. 11 *An outstanding brick construction can also be used as a pass point in architectural areas.*

Table 2 *Films used in Rolleiflex SLX camera for aerial photography in Mohenjo-Daro. (b/w = black and white, col = colour)*

PURPOSE	FILM (ROLL-FILM)				EXPOSURE INDEX / DIN/ASA	NO.
Aerophotogrammetry	b/w	120	AGFAPAN 100	neg.	21/100	12
	b/w	220	ILFORD FP4	neg.	22/125	24
Survey photos	b/w	120	AGFAPAN 100	neg.	21/100	12
	b/w	220	ILFORD FP4	neg.	22/125	24
	col	120	KODAK EKTACHROME	slide	18/64	12
Detailed photos of top surface for surface analysis	col	120	KODAK EKTACHROME	slide	18/64	12
Architectural documentation	col	120	KODAK EKTACHROME	slide	18/64	12

All the film shot with the aerial camera were developed in the Project's own colour laboratory using a semi-automatic Jobo CPA 2 developer, and thus an on the spot preliminary analysis could be made.

Contact prints were made from the negatives; the best range-finder image for each point selected and consequently a 12 x 12 cm^2 enlargement made.

With the aid of a stereoscope the stereo models could be continuously checked to see that the overflown area had been completely covered and that enough marked pass points were distinguishable to permit an analysis of each of the stereo models. Outstanding architectural features such as corners of walls *(Fig. 10)* or peculiar brick constructions *(Fig. 11)* were adopted as pass points in the preliminary analysis, especially in architectural areas, and their position and height were then recorded on site. This method aided the photography of open ground because it meant that pass points did not have to be marked and recorded beforehand.

Table 3 *Results of aerial-photography work carried out by the hot-air ship GFL 145 during Phase IV (1982/1983) in Mohenjo-Daro, Pakistan. (b/w = black and white, c = colour).*

EXCAVATION AREA	PURPOSE	DIRECTION OF EXPOSURE AXIS		ALTITUDE (m)	FILM MATERIAL				FLIGHT TIME
		VERTICAL	OBLIQUE		ROLLFILM 35 mm				DAYS
					bw 120	bw 220	c 120	c 135	
DK-A/B/C	Survey	*		60-70			6		
	Detailed	*	*	40				2	4
D	Survey	*		100	1		0.5		1
HR	Survey	*		120	1		0.5		1
EAST	Surface analysis	*		70		2	4		2
L	Survey	*		101					
FORTIFICATION		*		36			}1		}1
	Stereophotogramm.	*		100		5			3
MN	Survey	*		100					
EAST	Detailed	*		35		}5			}2
	Surface analysis	*		100					
	Surface analysis	*		40		}2	1		}2
	Detail	*	*	40				2	1
DK-G NORTH/SOUTH	Survey	*		105			1		1
NORTH	Stereophotogramm.	*		65					
SOUTH	Stereophotogramm.	*		100		}7			}3
NORTH	Detailed	*		40			4		3
	Detailed		*	40				2	1
SD	Survey	*		100		1			1
	Detailed	*		diff.		1	1		2
	Stereophotogramm.	*		106		12			8
VS	Survey	*		100		1			1
	Survey	*		70					
	Detailed	*		30-40			}6		}3
	Stereophotogramm.	*		65		7			3
	Detailed	*	*	diff.				2	1
MN HR EAST	Balloon Test	*		diff.		4			2
DK-G	Photogrammetry Test	*		diff.		8			4
				TOTAL	2	56	25	8	50

The range-finder images were recorded on specially prepared filing cards, upon which all the information necessary for an extensive analysis was stored. This consists of;

- a 12 x 12 cm^2 print from the negative
- passpoints marked and numbered on the print itself
- film and exposure number
- focal length of the camera lens
- altitude
- coordinates of all visible pass points and balloon foot points

In cases where outstanding architectural features were taken as pass points, these were also photographed separately and a contact print for each pass point attached to the filing card. *(Fig. 12).* It remains to be seen whether the negative should also be attached to the filing cards, which would then contain every single piece of information necessary for a thorough analysis.

An attempt was made to produce a series of low-level oblique photos complementing the vertical aerial photos. Satisfactory results were obtained through the use of a novel construction. Two 35 mm Olympus OM 2 cameras fitted with automatic winders were fixed to a bamboo pole, approx. 1,5 m long, in such a way that the direction of exposure axis of both cameras was parallel. This contraption was then hung on the universal joint in the ballon basket and shutter release was effected by remote control *(Fig. 13).* From an average altitude of 20 m a base-height ratio of 1 : 13 was achieved, while for aerophotogrammetric work the base-height ratio lay at 1 : 25.

The following film was used for stereoscopic work:
Colour slide Kodak Ektachrome 64 36 exposures 18 DIN/64ASA

It remains to be seen if the negatives of the aerial range-finder images are suitable for economical evaluation. Research in the summer of 1983 at the Institue for Mine Surveying, Subsidence and Geophysics in Aachen has shown, for example, that a relationship exists between the development, film material used and film distortion in roll films and cut films used in amateur measuring cameras.

Because the Rolleiflex SLX used in Mohenjo-Daro was equipped with a réseau a selection of negatives can be taken as examples and measured on a measuring

Fig. 12 *Recording surveying photos on a filing card containing all necessary information.*

microscope e.g. PK 1, and can thus be checked for film distortion.

To sum up, one can say that, counting both test flights and proper photographic work, the balloon was in daily use in Mohenjo-Daro, not least because of its versatility. The favourable climatic conditions in Mohenjo-Daro between December 1982 and the beginning of March 1983 allowed for the easy handling of the balloon, with only minor technical problems. It was virtually impossible to launch the balloon in March because of strong winds.

The foregoing table *(Tab. 3)* shows the amount of aerial photos shot, the period of activity of the balloon as well as an idea of the film material used during Phase IV in Mohenjo-Daro.

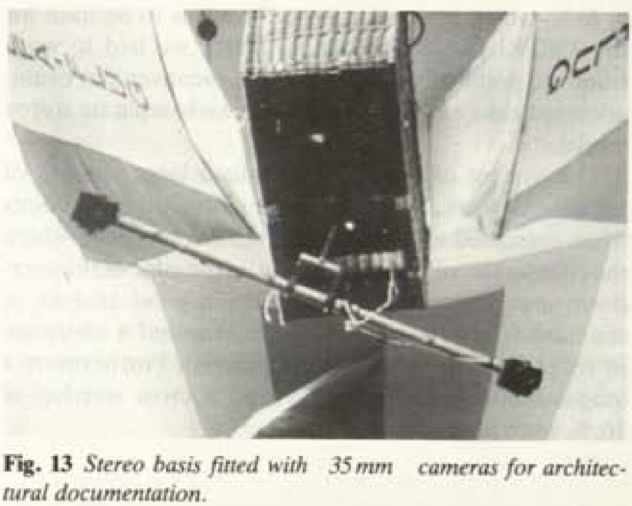


Fig. 13 *Stereo basis fitted with 35 mm cameras for architectural documentation.*

Geodetic Surveying for the Mohenjo-Daro Balloon Project

6. Laying Out of the Balloon Foot Points

The balloon project in Phase IV of the *German Research Project Mohenjo-Daro* was assigned to screen off all architectural areas through stereoscopic pictures, so that plans and isometric block diagrams could be made from these. Pass points, with known positional and height coordinates, are necessary in the evaluation of stereo models. The number of pass points for each stereo model depends on the following factors:

- type of lens used
- amount of longitudinal and cross overlap
- choice of evaluation procedure

Because there was still a certain amount of uncertainty as to which evaluation procedure was to be used for the 1982/83 phase in Mohenjo-Daro, we had to work from the point of view of the most inconvenient evaluation system i.e. the evaluation of each separate stereo model.

This system of evaluation entails a large amount of geodetical work in the determination of pass points when compared with the aerotriangulation system, where the coordinates of pass points only on the edge of the overflown area have to be known. For a good analysis of the models our evaluation system required a minimum of six pass point for each stereo model. Furthermore a longitudinal overlap of 60 % and a cross overlap of 10 % were necessary.

The choice of camera lens is determined by the topography and the types of architectural structures found in the area to be overflown. The following lenses were used in each of the different areas:

VS-Area 50 mm;
DK-G North 50 mm;
DK-G South 120 mm;
SD-Area 120 mm;
L-Area 120 mm;

Taking into account the 3 factors already mentioned in photoflight-planning the following data was established in laying out the pass points:

	VS	DK-G NORTH	DK-G SOUTH	SD/L
No. of flight corridors	4	2	4	15
Stereo basis	26,40 m	26,40 m	18,33 m	18,33 m
Distance between flight corridors	59,40 m	59,40 m	29,75 m	39,80 m
No. of pass points	74	26	124	252

The balloon foot points were laid out unsing a Kern DKR-V tachymeter according to the known coordinates of points on the trigonometric grid, DFG 80. Further pass points were plotted between the single flight corridors using a field rod and tape measure. To avoid difficult laying out work in areas of architectural remains, pass points for these areas were plotted from stereo models themselves. It must be noted that using this method one must be completely sure as to the position of each point, so that when it came to determining the coordinates of the point no mistakes were made. Laying out should be exact to the nearest decimeter.

7. Surveying the Pass Points

Because of the large number of pass points a rational procedure of determining their coordinates had to be found, but which maintained the necessary exactitude of ± 5 cm. The height of the points was determined through levelling. The trigonometric intersection principle was used to determine position. In this procedure solely goniometrical measurements are taken from two known grid points in relation to the new point. Other procedures such as traverse measuring were not suitable because the time needed for distance measurement in the areas in question would have been too great.

Only isolated pass points were surveyed by radiation, because of their good visibility. As a control against bad mistakes and as an enhancement to the degree of accuracy, all the points were additionally surveyed from a third grid point. These redundant observations can be included in the evaluation if needs be.

The evaluation of the results of surveying was carried out on a programmable HP 41 c calculator with connected printer.

In the evaluation the geometrical configuration of the intersections i.e. the angle of intersection of both collinating rays was also checked. The effect of this angle is expressed in the following formula, derived from the law of the propagation of errors, which calculates the degree of accuracy in the determination of a point.

$$M_p = \pm \sqrt{\frac{a^2+b^2}{\sin^2 \gamma}} \times \frac{M_r}{\rho}$$

M_p = standard error of position
a/b = lateral lengths
γ = angle of intersection
M_r = standard error of measured alignment
ρ = $200/\pi$

This formula was part of the programme used in the calculator. We could decide from the value of the standard error of position whether the angle of intersection should be checked using other geodetical procedures.

In addition an adjustment was made for some points according to the principle of intervening observations. The degree of accuracy in such cases led to a standard error of position ± 3 cm. It must be pointed out, however, that the goniometrical measurements were only carried out in one set and that only one redundant observation was available.

The use of field rods for marking new points had a negative effect on the accuracy of trigonometric point determination. At times the architectural remains made necessary the use of field rods up to 6 m in length. Taking this into consideration when dealing with accuracy, the standard error of position for some pass points was sometimes as high as ± 10 cm.

8. Personell and Time Needed

The amount of personell and time needed for the geodetical work involved in the balloon project is illustrated by the example of the DK-G Area, which had a total of 150 pass points which had to be surveyed.

TASK	PERSONELL	TIME
Laying out of pass points	1 expert 1 Pakistani Assistant	4 days
Surveying (position)	3 experts 2 Pakistani Assistants	2 days
Surveying (height)	1 expert 1 Pakistani Assistant	1 day
Coordinate calculation and control	2 experts	1 day

Similar figures were obtained in the other areas. The question remains whether the time needed for geodetical preparation for low-altitude photogrammetry using a hot-air ship is still economically viable in the whole concept.

9. Summary

This is the first time a hot-air ship, working with the close-range aerophotogrammetric system described in this paper, has been used to obtain the complete stereoscopic cover of an area divided into blocks.

During the four months of service in Pakistan the system proved its overall suitability; its availability was guaranteed through its simple construction which did away with complicated technology.

This system fills the gaps which have been left, in aerophotogrammetry, by certain features of other camera carriers. Thus, it should not be seen as an alternative to the former airborne systems, but rather as a further development thereof.

Possibilities and Limitations of Unmanned Balloons and Airships in Archaeological Work

The range of applications and usability of unmanned, remote-controlled balloons and airships as camera carriers has been put to the test in various archaeological research projects. The advantages of the aerodynamically shaped airship have also been proved; for use in the third world a hot-air system is also more fitting, because there is little guarantee that inert gases such as hydrogen or helium are obtainable. Apart from this the hot-air system has proved itself to be robust in its construction and simple in its operation and maintenance. Enough has been said in other articles about the state of technology. The aim of this article is to explain the range of applications and limitations in the use of an unmanned, remote-controlled, *aerostatic* airbone system (balloon or airship):

- size of the area to be documented
- climate, wind and weather
- limitations of construction in relation to profitability

10. Differences in the System

Normal balloons always have a right to a place alongside the aerodynamically shaped airships, even though their suitability for the production of pictures which can be used for measuring purposes is limited because of their much greater tendency to sway in high winds. The advantage of the „normal" balloon shape over the airship is its simple manufacture. When only survey photos of an excavation area are desired, and these pictures are not to be analysed for measuring purposes, then such balloons show definite advantages. Because the shape of the balloon has a much smaller surface area than that of an equivalent – in relation to its volume – airship, then the amount of material and hours required for its construction are greatly reduced, a ratio of approx. 2 : 3. A normal balloon envelope (hot-air) with an empty payload of 10 kg and a volume of about 100 m^3 would cost about 3000 German Marks. Approx. the same amount must be paid for the burner, remote-control unit and camera mounting. For an airship with the same payload one would pay about 15,000 Marks.

Through experience with these types of balloons and airships we estimate 300 hours to be the approximate service life of the balloon envelope; 400 hours have been achieved by manned balloons, but under easier conditions. A new envelope is required in all cases after this amount of time; the rest of the equipment should at least receive a general overhaul (remote-control unit, burner, camera mounting etc.).

This list gives a simplified estimate of the depreciation of a balloon or airship. A further 10 Marks for each operational hour must be included for fuel. We were able to produce 6 – 8 pictures suitable for measuring purposes in each hour in Pakistan; simple survey photos which required no positioning or alignment of the camera took only half the time.

11. Limitations

Through experience with different systems, certain different limitations can be noted.

11.1 Size of the Area to be Documented

An „aerostatic" airborne system is suitable for relatively small areas because it can record even the smallest of details. Thus there is no competition from conventional surface aircraft, because the latter can only offer cheap „documentation costs per hectare" for larger areas, and cannot pick out exact details *(cf. Wanzke, 1983; Heckes, 1983)*.

It is often the case that such a balloon or airship system is the only possibility for aerial photograph documentation, so that a higher interpretation expenditure per hectare, because of the large amount of pictures, seems justifiable *(cf. Wanzke, Part I)*.

Any solution to reduce the amount of pictures to be analysed through the use of large format cameras, must be viewed critically by the balloon/airship constructor, and more will be said about this problem later.

11.2 Climate, Wind and Weather

When the decision has been made to use a balloon or airship for aerial photography in the documentation of an excavation site, then the climatic conditions of the area must be comprehensively studied, while the success of the operation depends upon favourable conditions, especially wind speed.

The airship used by us in Pakistan proved to be operational for measuring work in winds of 8 - 10 knots. For survey photos (requiring less exact positioning) the airship could be used in wind speeds of up to 10 - 12 knots.

The appropriate information about temperature, air-pressure and wind speed, in daily, monthly and yearly form, can be obtained from airports or meteorological stations in the respective country.

When the field work is to be carried out over a period of weeks or months, then one can usually count on enough possibilities for the airship's operation. However, if the work is to be carried out „to order" then this can be disrupted by unfavourable climatic conditions.

11.3 Greater Payloads – Large Format Cameras

It is, in principle, conceivable to produce balloons or airships with greater payloads for the transport of cameras with a larger format than the previously used Rolleiflex 6 x 6.

The wish to reduce photo and analysis time is understandable, but from the point of view of the constructor, the following factors are against this:
A simple increase in the volume does not lead to a very great increase in the construction and fuel costs of such a system, in any case proportionally lower than the volumal increase and the greater payload. However, an enlargement does inevitably lead to an increase in operational personell. While our airship in Pakistan could be safely controlled by 3 - 4 people, an increase in volume and empty payload, with the thus increased air-resistance of the whole machine, leads to a steady increase in the amount of personell required.

Each member of the ground team can hold no more than 30 kg traction for any length of time, especially when the adhesion and stability are lowered in areas of rubble and debris. One solution could be improvements in the balloon or airship construction, with the aim of improving the positional exactness and reducing the amount of time needed for photographic work. Possible improvements have already been considered *(Busemeyer, 1983)*, such as the automatic alignment of the camera by gyroscope or electronic compass. The construction of movable steering elevators on the airship would most probably reduce the amount of time required per aerial photograph, but on the other hand it would increase the construction and production costs, and almost certainly lead to complications in the system as a whole. A consequence thereof is that the machinery would require more maintenance, and in some cases repairs could not be carried out on site with the equipment available, which never caused any problems with our simpler system in Pakistan. The constructor has the problem with each improvement in detail that this should not lead to more complications, and the problem that the airship can only be manned by a highly qualified team after the improvements.

12. Summary and Future Prospects

There are two different approaches to aerial photography work:
– a simple, relatively small system with a payload of only a few kilograms and corresponding low construction and operation costs, which can be easily operated and maintained by trained assistants and one „qualified" pilot. This system would be equipped solely with a miniature or 35 mm camera for survey photos only, and in exceptional cases photos for measuring purposes. The operation should be able to be carried out fully by a Research Project Team.
– a comparatively complicated system with automatic positioning and corresponding greater expenses, to be used solely for measuring photos, which can later be analysed. The operational costs would certainly be in the region of several hundred Marks per day, as a result of the high production costs and allowing for the fact that at least one qualified person, with the theoretical and practical knowledge of a hot-air balloon pilot, would be needed to control the machine (and would have to be paid for this). Only exceptional archaeological research projects would include such qualified personell.

It is hard to put payload limitations described here into concrete figures, the limits of such being clearly rather vague. Given the present state of balloon and airship technology, I would estimate the payload limit to be 30 kg, greater payloads and the associated costs would very probably exceed the budget of a „standard research project", these costs being close to those of a conventional manned aerial photography system. In an attempt to better define the limitations, we are at the moment working on a larger model of the type used by us in Pakistan, with a planned volume of 250 m^3 (previously 145 m^3) and payload of 30 kg, to be used with either several camera systems, or one, large-format camera.

Bibliography

BADEKAS, PEPPERS, STAMBAULOU 1980, Low Altitude Photography. In: *ISP-Kongreß Hamburg 1980, Kommision V. International Archives of Photogrammetry Bd. 13, Teil B 5.*

BUSEMEYER (K.L.) 1982, RC-Luftschiffe und Ballone, Villingen

BUSEMEYER (K.L.) 1983, Einige Gedanken zum Einsatz von ferngelenkten Ballonen und Luftschiffen zur Luftbilderstellung. In: *URBAN (G.)/JANSEN (M.) (ed.), Forschungsprojekt DFG Mohenjo-Daro. Dokumentation in der Archäologie. Techniken, Methoden, Analysen.* Veröffentlichungen des Geodätischen Instituts Nr. 34, Aachen, pp. 149-152.

DEWEL (L.) 1972, Flug in Gestern. Geschichte der Luftarchäologie.

GEORGOPOULOS (A.)1982, Balloon and Kite Photography. A hisotrical Review. In: *ISPRS, Commission V, Symposium York 1982, International Archives of Photogrammetry,* 24 V/2

HECKES (J.) 1982, Der Heißluftfesselballon des Deutschen Bergbau-Museums. In:*ISPRS Commission V, Symposium York 1982, International Archives of Photogrammetry,* 24 V/2.

HECKES (J.) 1983, Der Heißluftfesselballon für Luftaufnahmen im Nahbereich und Ergebnisse mit dem Rollei SLX Teilmeßkammersystem. In: *URBAN (J.)/JANSEN (M.) (ed.), Dokumentation in der Archäologie,* Aachen, pp. 143-148.

JANSEN (M.) 1983, Drei Jahre Forschung in Mohenjo-Daro. In: *URBAN (G.)/JANSEN (M.)(eds.), Dokumentation in der Archäologie*, Aachen, pp. 21-36.

KEUNE (W.) 1983, Korrektur systematischer Bildfehler bei Nahbereichsaufnahmen. Vortrag im Seminar „Nahbereichsphotogrammetrie" vom 6.10.1983, Technische Akademie Wuppertal.

PRZYBILLA (H.S.), BECKSCHÄFER (M.) 1982, Wirtschaftlichkeitsfragen in der Nahbereichsluftbildmessung. In: *ISRPS Copmmission V, Symposium York 1982, Internationales Archives of Photogrammetry*, 24 V/2.

PRZYBILLA (H.S.) WESTER-EBINGHAUS (W.) 1979, Bildflug mit ferngelenktem Kleinflugzeug. In: *Bildmessung und Luftbildwesen*, 47 (5), pp 137 ff.

ROBINSON (G.) 1982, A Helium Ballon System for Low Altitude Non-Metric Vertical Photography. In: *ISPRS, Commission V, Symposium York 1982. Internationales Archives of Photogrammetry, 24 V/2.*

SCOLLAR (I.) 1965, Archäologie aus der Luft. Düsseldorf.

SCOLLAR (I.) 1983, Digitale Bildverarbeitung archäologischer Luftbildaufnahmen. In: *URBAN (G.)/JANSEN (M.)(eds.), Dokumentation in der Archäologie*, Aachen, pp. 137-142.

WANZKE (H.) 1983, Geodätische Konzepte in der Archäologie am Beispiel von Mohenjo-Daro. In: *URBAN (G.)/JANSEN (M.)(eds.), Dokumentation in der Archäologie,* Aachen, pp. 71-80.

WESTER-EBINGHAUS (W.) 1981, Zur Verfahrensentwicklung in der Nahbereichsphotogrammetrie, Universität Bonn, Dissertation.

WESTER-EBINGHAUS (W.) 1980a, Numerische Verfahren für die Architekturphotogrammetrie. In: *ISP-Kongreß Hamburg 1980. International Archives of Photogrammetry*, 13, B 5. Kommission V.

WESTER-EBINGHAUS (W.) 1980b, Fernlenkbildflug mit Modellhubschrauber. In: *ISP-Kongreß Hmburg 1980, International Archives of Photogrammetry*, 13, B 5.

WHITTLESEY (J.L.) 1970, Tethered balloon for archaeological photos. In: *Photogrammetric Engineering 36* (2), pp. 181 ff.

Geophysical Investigations at Moenjo Daro

Mauro Cucarzi
Roma

Introduction

The geophysical survey presented here was conceived as a part of a series of investigations involving topographic studies, photos taken from a hot-air balloon and archaeological analysis of the surface evidence. The basic project was designed first to ascertain the horizontal and vertical boundaries of the site and then to identify areas which may have been used for particular purposes.

However, considering the vast, complex nature of Moenjo Daro and bearing in mind that no previous geophysical survey had been performed, it was deemed advisable for the time being to limit the survey to an appropriately selected part of the area in order to evaluate the response obtained with the various methods proposed. The survey was therefore carried out in the southern depression of HR (*Fig. 1*) because at the time all this area was under archaeological, topographic and photogrammetric investigation.

The second reason was that from surface observations this appeared to be a zone of transition between areas having diverse characteristics. Subsequently, the work was moved to the south of D area which is the logical continuation of the depression present in HR south.

The geophysical surveying involved:

1. GEOMAGNETIC MEASUREMENTS
   A. Taking soil samples and measuring their magnetic susceptibility.
   B. Measuring the earth's magnetic field intensity.
2. GEOELECTRICAL SOUNDINGS
   Apparent resistivity measurements.
3. STRATIGRAPHIC SAMPLING

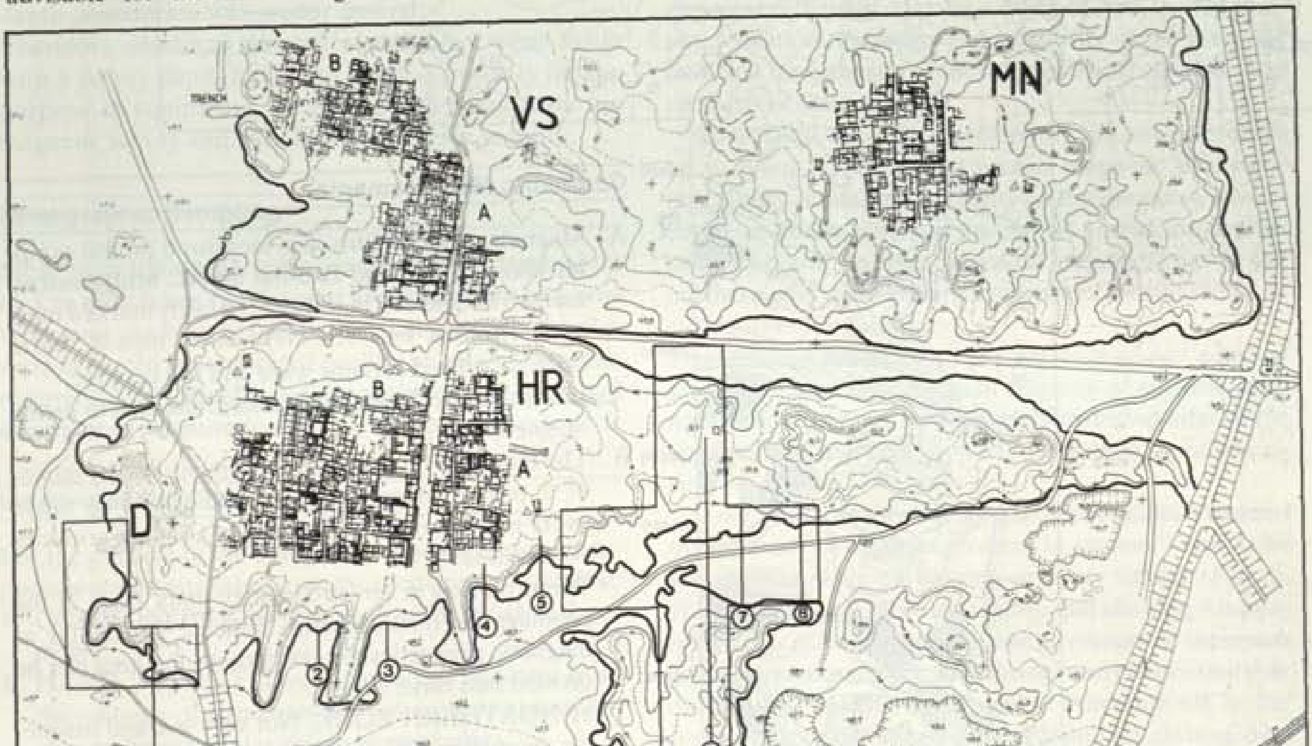
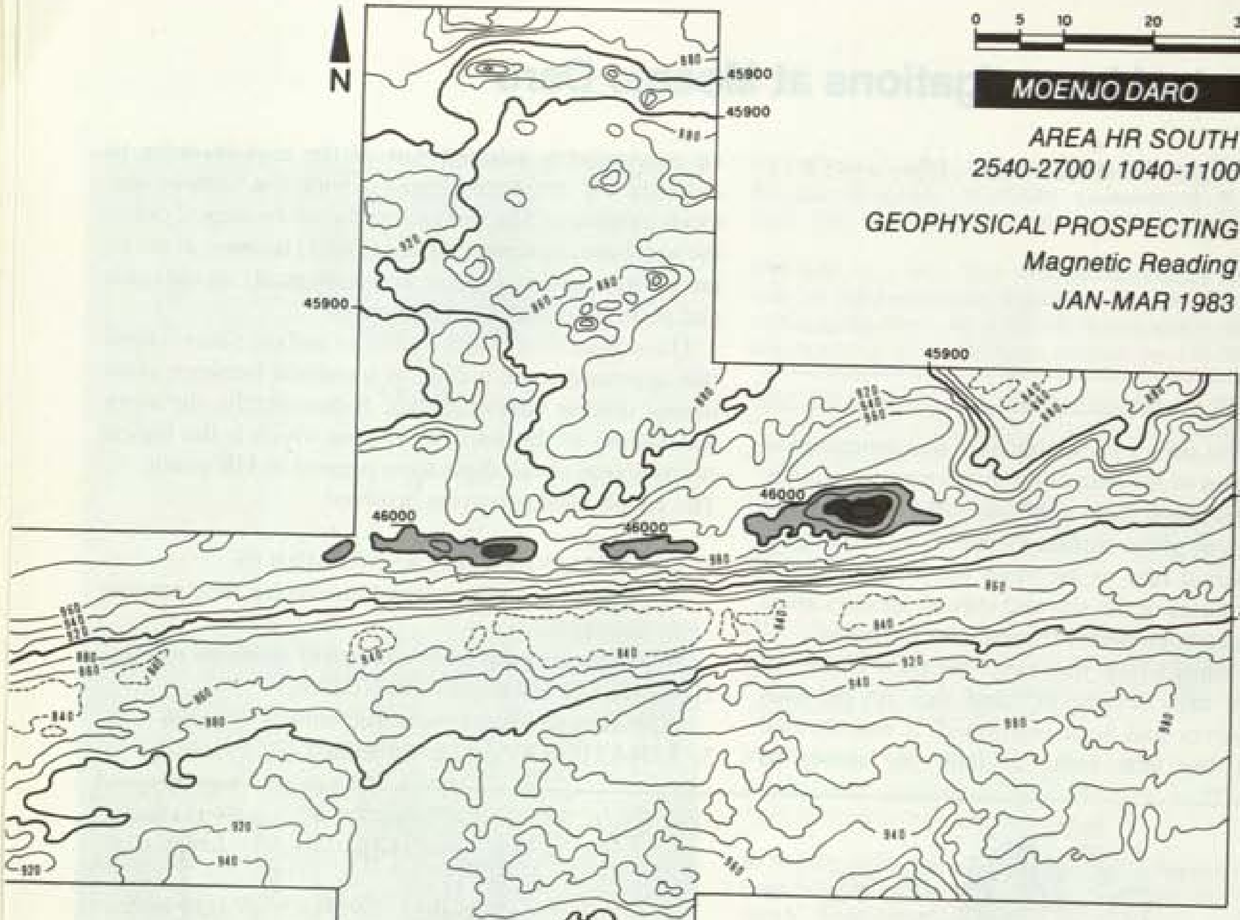


Fig. 1 *Map of southern part of Moenjo-Daro where thick line indicates the elevation of 49 m above MSL.*



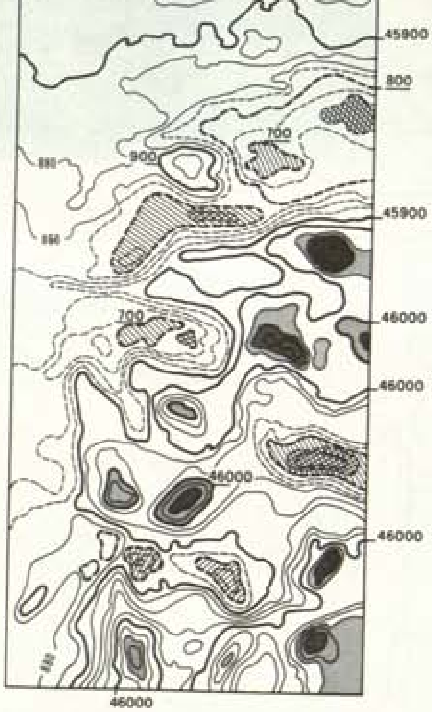


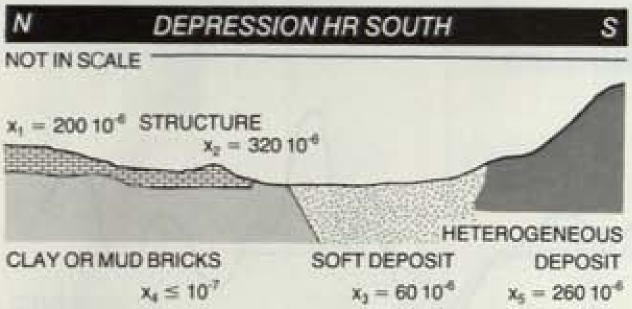
Fig. 2 *Area HR south; iso-anomalies map with readings of total earth magnetic field contoured every 20 gammas.*

Geometric Measurements

A. Magnetic susceptibility was measured on soil samples taken in HR and D using an AC bridge instrument. This showed that there is a fairly marked magnetic contrast between clay, other topsoil, burnt brick, overfired ceramic ware and red ceramic.
It was thus ascertained that conditions exist to justify magnetic surveying.

B. The magnetic field intensity was measured by means of a proton magnetometer, readings being taken every metre around the corners of a square grid with 20 m sides.
When plotted as an iso-anomaly map, (*Fig. 2*) the geomagnetic measurements indicate that as far as magnetic properties are concerned, the area can be divided into three zones:
a. NORTHERN ZONE. Not very marked magnetic anomalies with intensities between 10 and 30 gammas and width varying between 2 and 16 m.
b. CENTRAL ZONE. Very evident magnetic anomaly with intensity of about 150 gammas and width of 8 m oriented E-W along a profile some 140 m long.
c. SOUTHERN ZONE. Complex of magnetic anomalies of variable intensities up to 400 gammas and width between 3 and 8 m.

Fig. 3 *Magnetic model of a cross section N/S across HR south depression. The magnetic susceptiblity values are drawn to measurement taken from soil samples.*



Geoelectrical Soundings

Geoelectrical surveys were performed initially to see whether it was possible to distinguish different pedologic layers on the site. A DC resistivity rig which had given satisfactory results in other cases (*Cucarzi 1983, Linnington 1974, Iciek et al. 1974*) was used for this purpose. Unfortunately, the soil conditions encountered here induced such high current leakage on the surface that the depth penetration was greatly limited.
Therefore electrical resistivity soundings were made with a survey depth limited to only 2-3 m solely for the purpose of comparing the results with those from the magnetic survey and with the stratigraphic samples.

Stratigraphic Sampling

More than 100 stratigraphic samples with a depth of up to 3 m were taken by means of an 18 mm diameter portable unit made available by Dr. Jansen. The samples were collected from selected profiles at points where the magnetic field intensity and the apparent resistivity had clearly been measured.

Interpretation of Data

For the purpose of this study, the following classes of deposits were extrapolated from the stratigraphic samples:

1. COMMON BRICK: originating in structured remains
2. HARD DEPOSIT: layer of material resulting from the collapse of structures and subsequent atmospheric weathering (water action in particular)
3. SOFT DEPOSIT: layer of material produced mainly by the action of salt and atmospheric weathering (wind action in particular)
4. CLAY WITH CERAMIC FRAGMENTS: the matrix of the layer is clay with frequent ceramic fragments, etc.
5. CLAY OR MUD–BRICK
6. SAND OR SANDY CLAY

The magnetic susceptibility of all these types of sediments and of various types of ceramic, overfired ceramic, vitrified nodules and overfired bricks was measured, the values being as follows (all in emu/cm^3):

Common brick	60×10^{-6}
Hard deposit	120×10^{-6}
Soft deposit	60×10^{-6}
Well-fired deposit ware	213×10^{-6}
Vitrified nodules	260×10^{-6}
Red ceramic	316×10^{-6}
Clay, Mud brick, Sand	10^{-7}

The data from the stratigraphic sampling and the resistivity survey were compared with the magnetic anomalies, by analyses according to the wave parameters: amplitude, width, slope *(Dodrin 1960, Grant 1965)*. The results of these analyses led to the postulation of a magnetic model illustrated in *Fig. 3*.

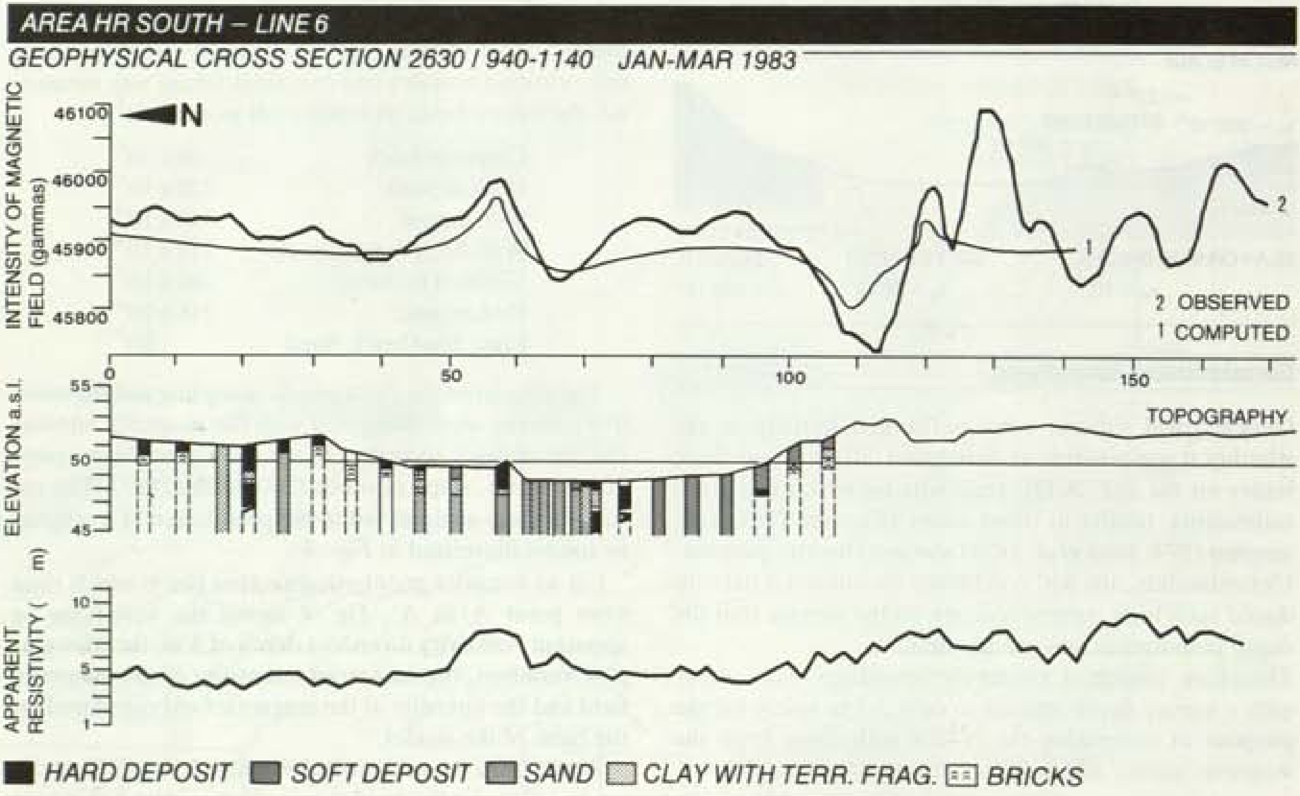
Let us consider geophysical section No. 6 which runs from point A to A'. *Fig. 4* shows the variations in apparent resistivity down to a depth of 2 m, the topographic variation, the measured intensitity of the magnetic field and the intensity of the magnetic field calculated on the basis of the model.

Apart from the not particularly significant differences up to point A, the model reveals magnetic behaviour that is very similar to the reality on the boundary between the northern zone and the central part of the depression. This can be interpreted as meaning, that in the northern part there are brick structures distributed fairly evenly over the terrain.
The anomaly is caused by the presence of two adjacent layers with high differences in intensity of magnetisation (common bricks, red ceramic and vitrified nodules on the northern side and clay or mud-bricks on the southern side).

If we now compare the magnetic anomalies expected of the model with those present in section 7 and 8, we see that the wave parameters are very similar *(Figs. 5, 6)*. It is thus reasonable to suppose that the long Anomaly No. 1 is caused by the horizontal contact of these two layers of common brick originating in structures and clay or mud-bricks. The amplitude of Anomaly 6B in the central part of the area is greater than that envisaged by the model, but since the other two wave parameters (width and slope) are similar, it can be presented to be caused by the soft deposit which, according to the model is present at a depth of about 3 m. Consequently the anomalies in the southern part of the study area are not in accord with the model proposed.

This supposes a deposit of heterogeneous material in this area with a magnetic susceptibility of 300 emu/cm^3

Fig. 4 *Cross section No. 6:*
1. Diagram of magnetic model proposed
2. Diagram of magnetic readings observed
3. Diagram of resistivity measurements
4. Stratigraphic logs



at the most, but from the data collected it was seen that there are in fact anomalies of up to 400 gamma (too high for a layer producing only 300 units of magnetic susceptibility). Evidently the situation is more complex.

The iso-anomaly map in *Fig. 8* exhibits, from the magnetic aspect, a series of positive and negative anomalies quite close to each other, indicating dipolar behaviour. One reason is certainly the topographic effect (where this exists) (*Gupta 1971*), while in the other places investigated the behaviour seems more in keeping with that provoked by the presence of kilns (*Bouisset et al. 1979*).

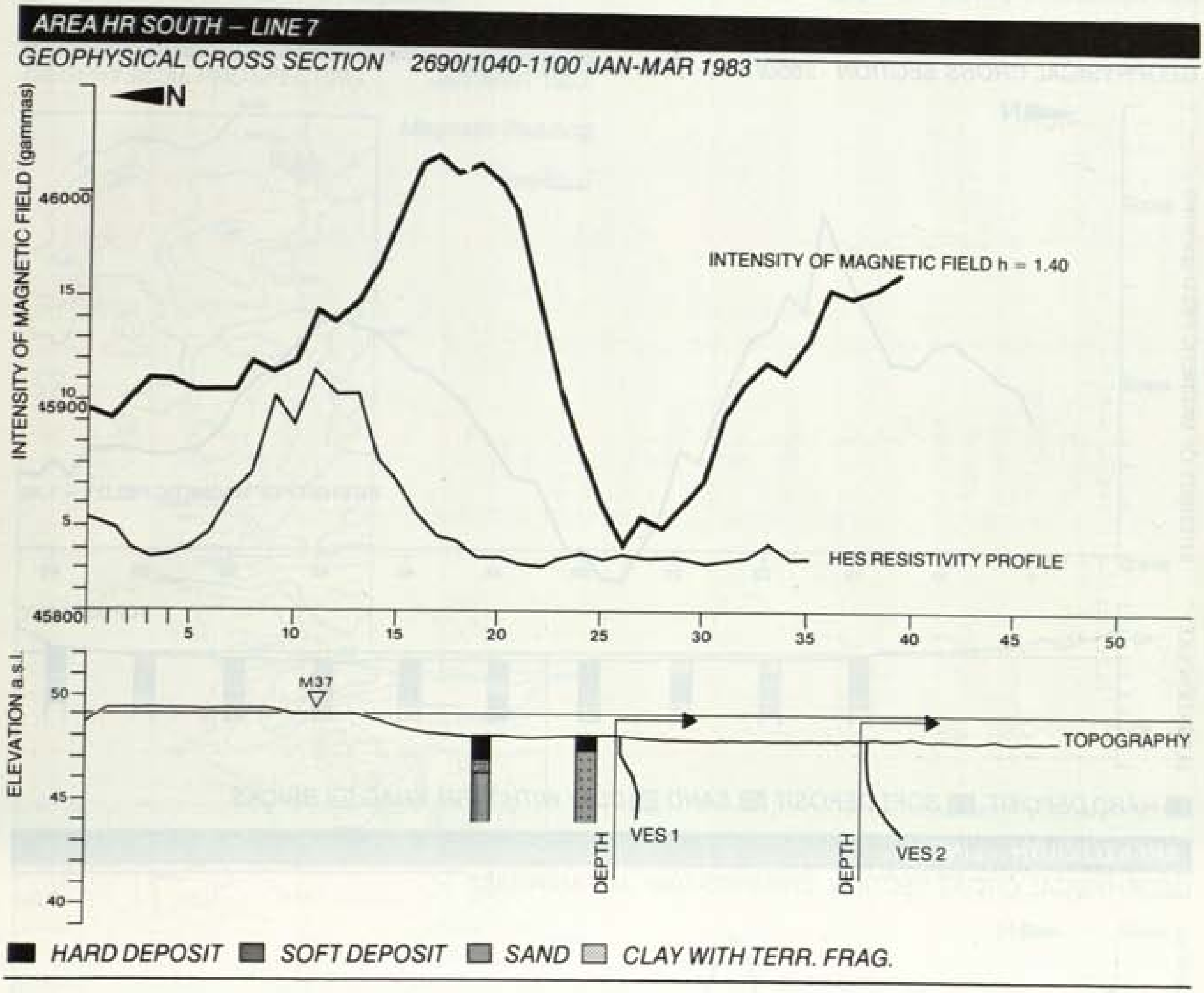
Moving now to the southern area and discovering the presence of structures (*Fig. 7*) which anyway can be seen on the surface, Geophysical Cross-Section No. 1 (*Fig. 8*) again presents the same situation as in HR south. In fact, the profile which was run here in the same manner as those in HR shows an anomaly with wave characteristics similar to those present in HR and, moreover, comparable with those of the magnetic model proposed. The stratigraphic sampling, in any case, confirms this idea, demonstrating the presence of a clear-cut line of separation between common brick belonging to structures and clay or mud-bricks. It is to be noted that the lines of separation L_1 in HR and L_2 in D south seem to be on the same straight line (apart from some small differences likely to be due to the measurements showing a varying degree of drift towards 74°).

Between Zone D and Zone HR, four more geophysical profiles were run at right-angles to line of separation L_1, using the same method as for HR and D. *Fig. 9* shows the presence of type A anomalies in every profile, (*Fig. 10*) the wave characteristics being comparable with those in D south and HR south.
If this situation is plotted on the plan it is seen that these anomalies also lie on line L (*Fig. 11*), (*Photo 1*).
It has been demonstrated that there is a well-defined interface between the points of coordinates 2285/1000 and those of coordinates 2700/1087, with a common brick structure phase to the north and a clay or mud-bruck phase to the south; the latter was followed for about 5 m to the south and about 3 m deep.

Conclusions

The first geophysical surveying campaign has served primarily to indicate the most suitable methods to be used to resolve the geophysical problems present in Moenjo Daro.

Fig. 5 *Cross section No. 7:*
1. Magnetic anomaly across HR south depression
2. Geoelectric anomaly across HR south depression, with 3 VES compared with stratigraphic sequence.



It transpires that geomagnetic measurements can produce satisfactory results within a reasonable length of time and so far they have provided information on a total area of 25.000 m^2.

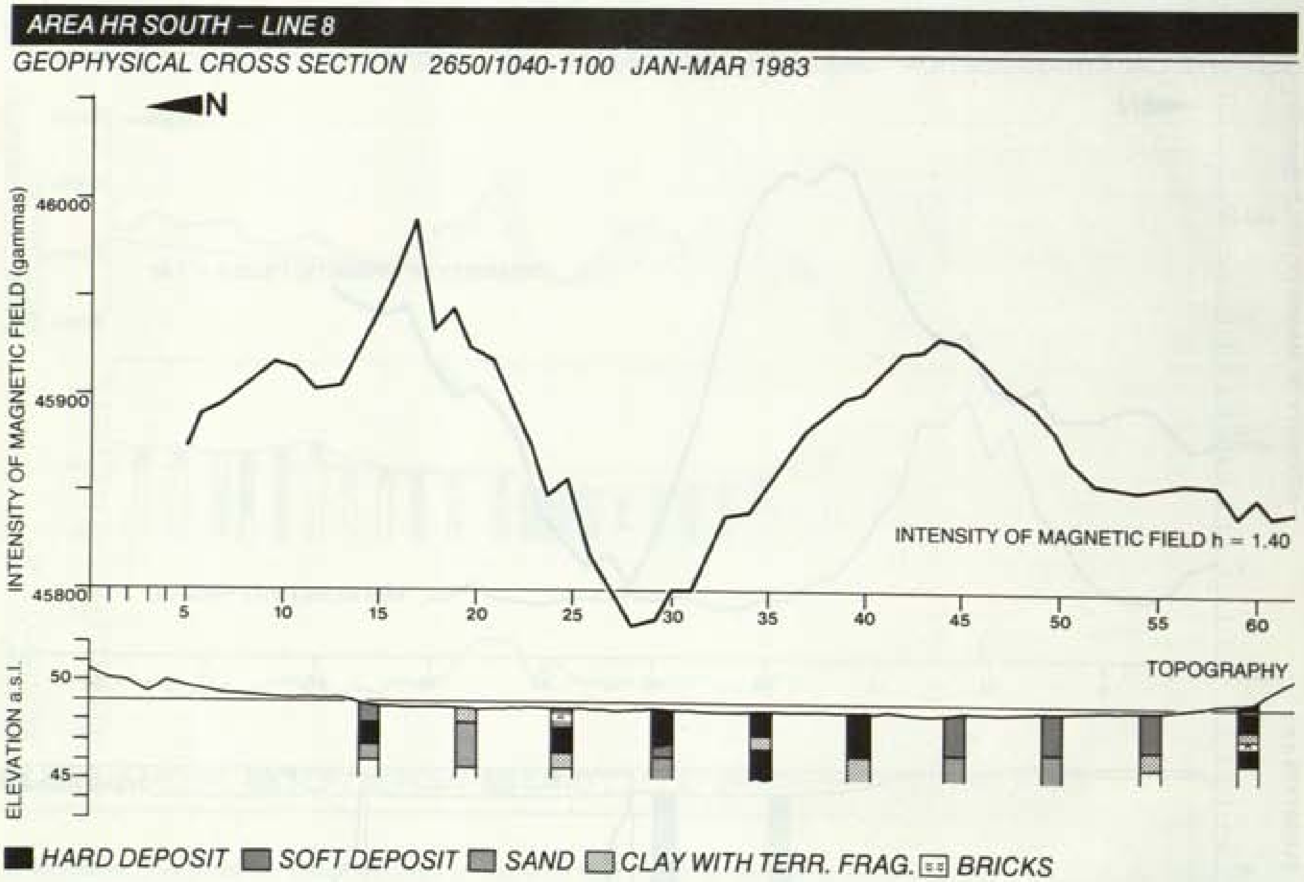
Geomagnetic surveying has, in fact, revealed the presence of a very specific zone where there is a clear-cut, rapid transition from a common brick structure phase to a clay or mud-brick phase. This transition is marked by a straight line some 400 m long, veering towards 74°. The regular features of this line would appear to indicate that it is a man-made feature. In particular, it could represent part of a clay or mud-brick platform marking part of the southern limit of a constructional phase of Moenjo Daro.

The southern side of the depression, where there are ridges 3 to 5 m high, has magnetic characteristics that would appear to exclude the presence of structures at least for the first 4-5 m below ground level.

It is impossible to say at the moment whether the magnetic anomalies are caused by deposits of kiln remains or by a series of superimposed kilns. The topographic effect, which is quite complex, is still being studied with the aid of magnetic models and calculations; the results should soon provide more information on the origin of the anomalies.

To conclude, it must be marked that on one point, namely the depth and thickness of the strata, the investigations performed during this campaign have not provided satisfactory data. It is felt, however, that the reason for this lack of success has been identified and it is possible that in a future campaign better results will be obtained by using other measurement techniques and instruments.

Fig. 6 *Cross section No. 8: Magnetic anomalies across HR south depression compared with stratigraphic logs.*



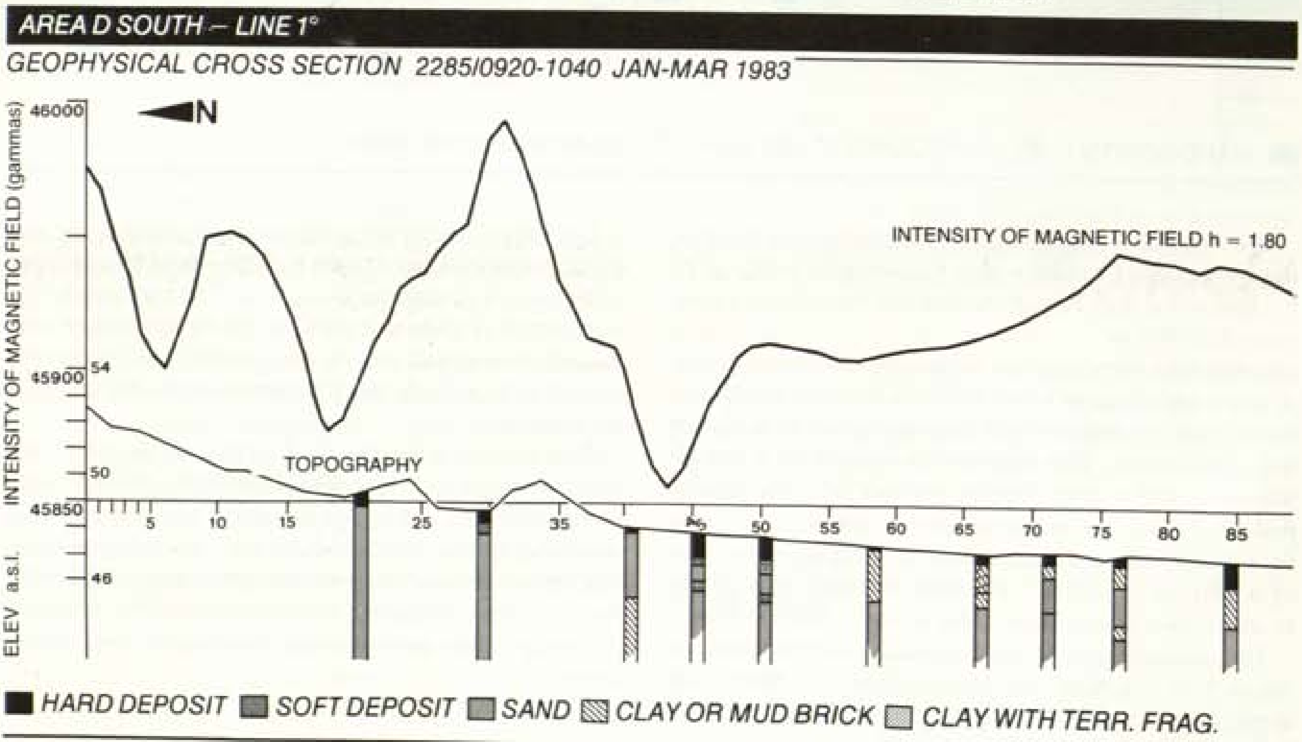
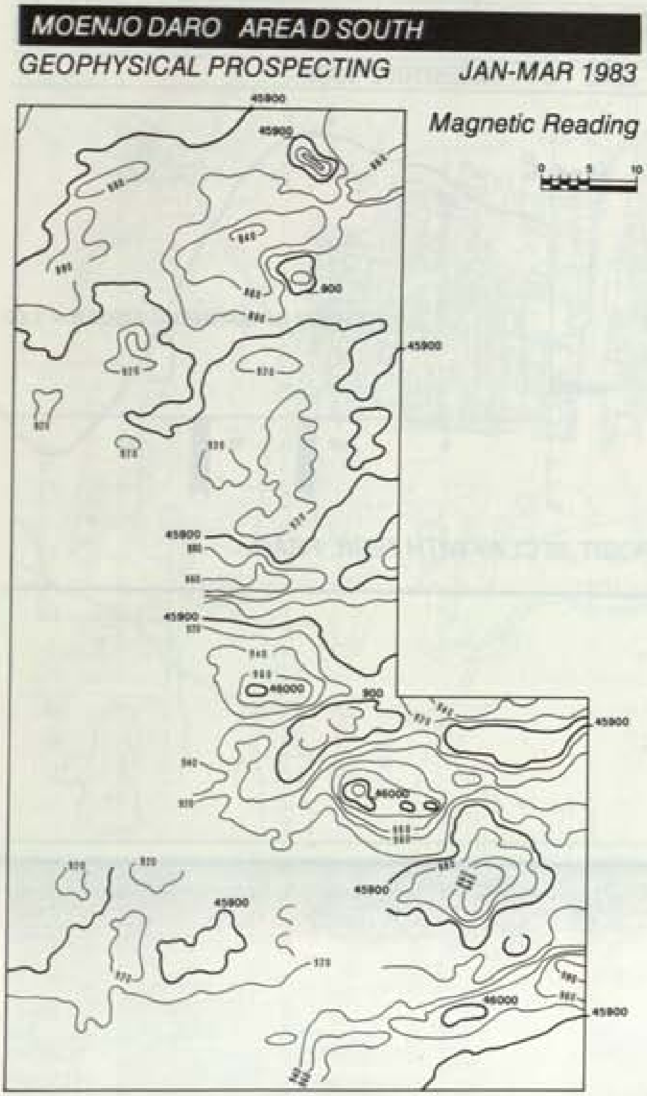


Fig. 8 *Cross section No. 1: across D south compared with topography and stratigraphic logs.*

Fig. 7 *Area D south; Isoanomalies map with readings of earth total magnetic field contoured every 20 gammas.*



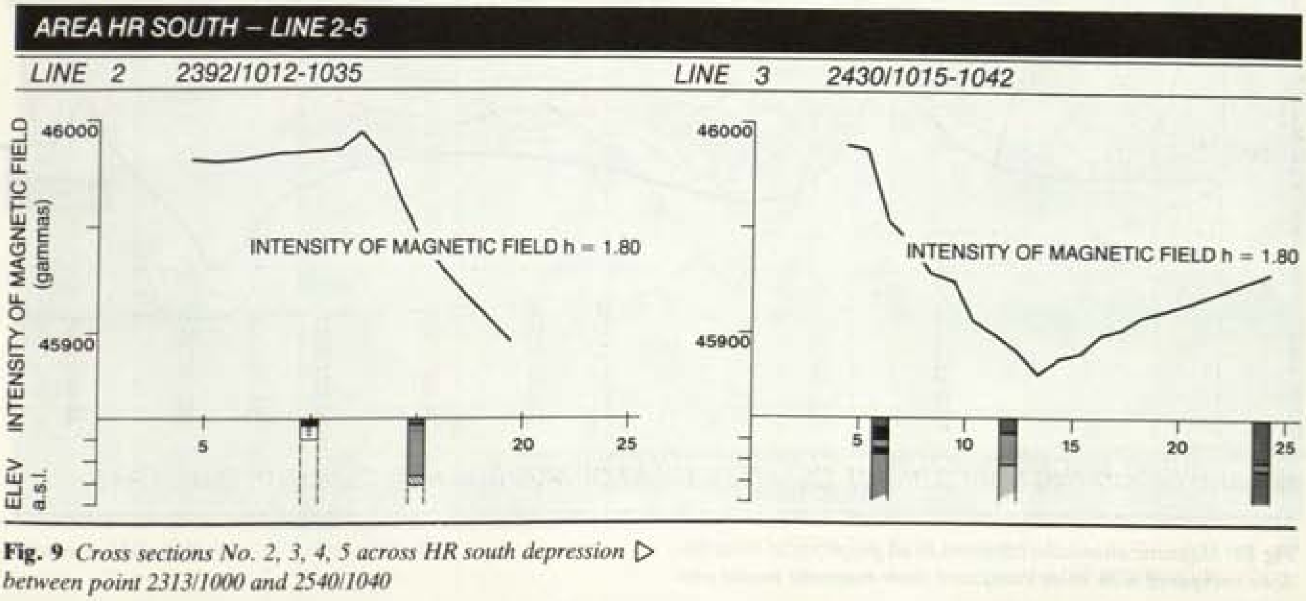
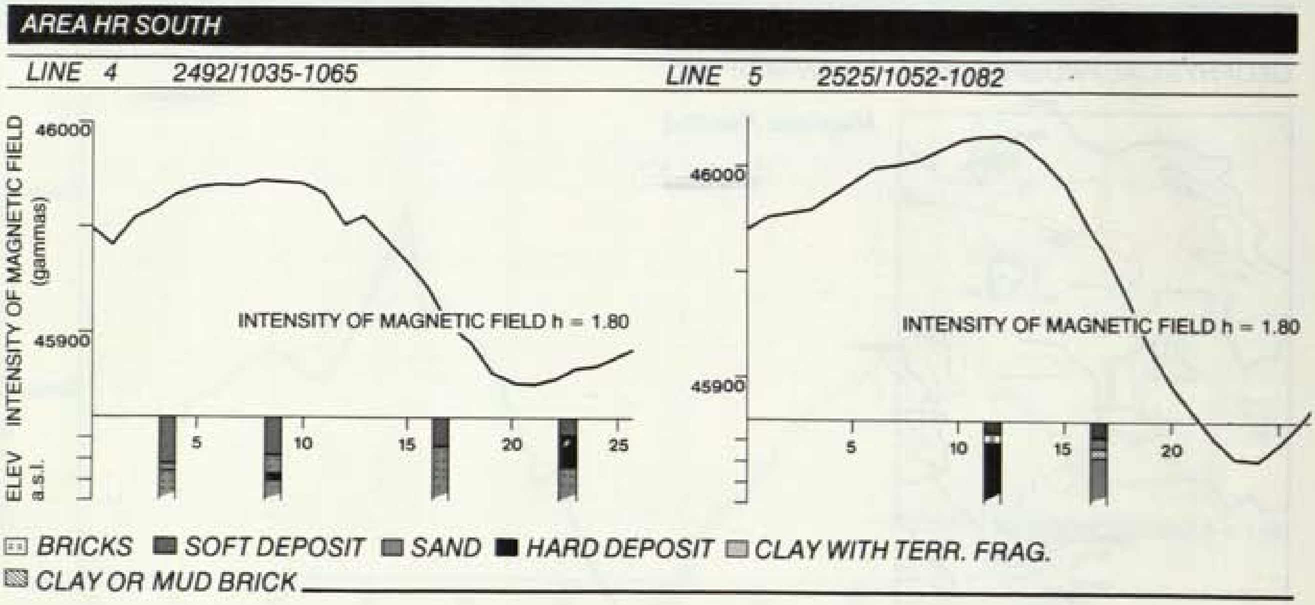


Fig. 9 *Cross sections No. 2, 3, 4, 5 across HR south depression ▷ between point 2313/1000 and 2540/1040*

Fig. 9 *Cross sections No. 2, 3, 4, 5 across HR south depression between point 2313/1000 and 2540/1040*



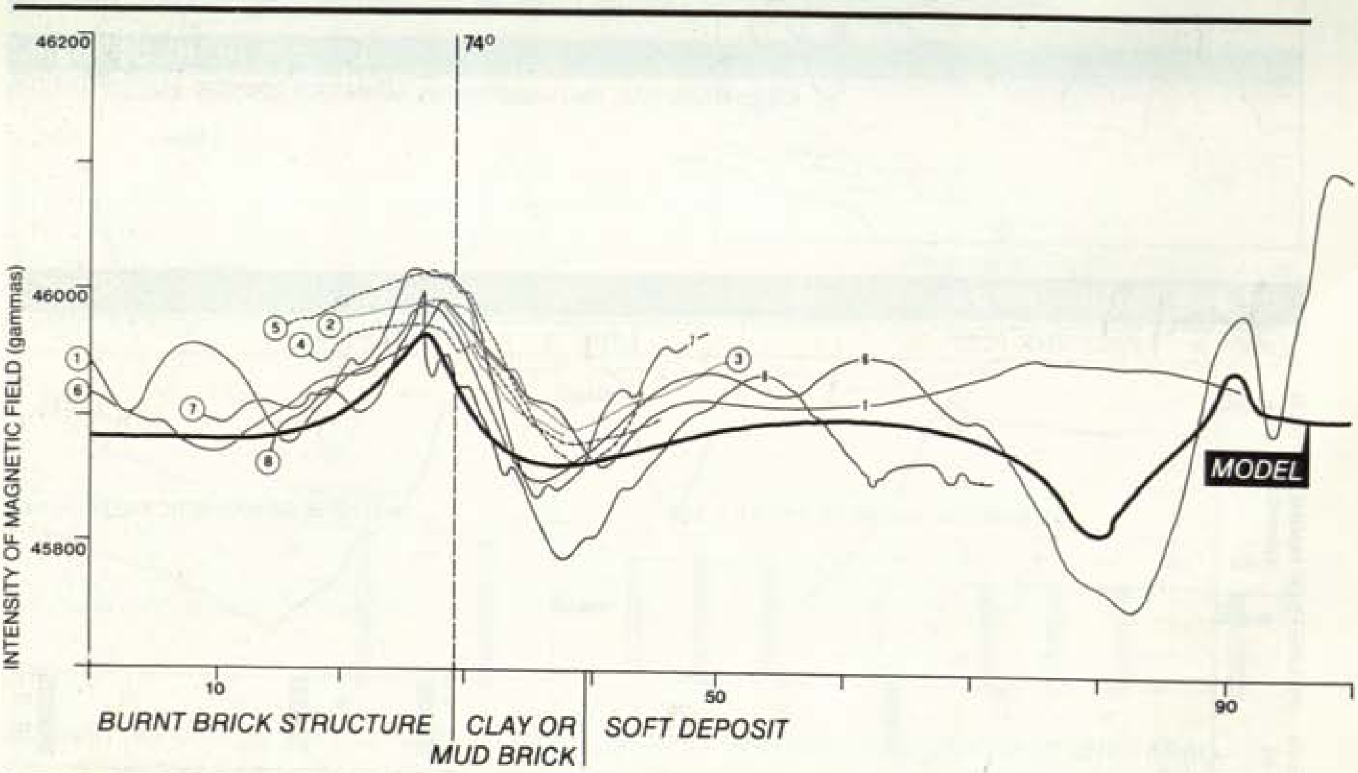


Fig 10 *Magnetic anomalies observed in all geophysical cross sections compared with those computed from magnetic model proposed.*

Fig. 11 *Line L is the limit between the burnt brick phase to the north and clay or mud-brick to the south. If the interpretation is correct, L represents part of a clay (or mud-brick) platform connected with a constructional phase of Moenjo Daro.*

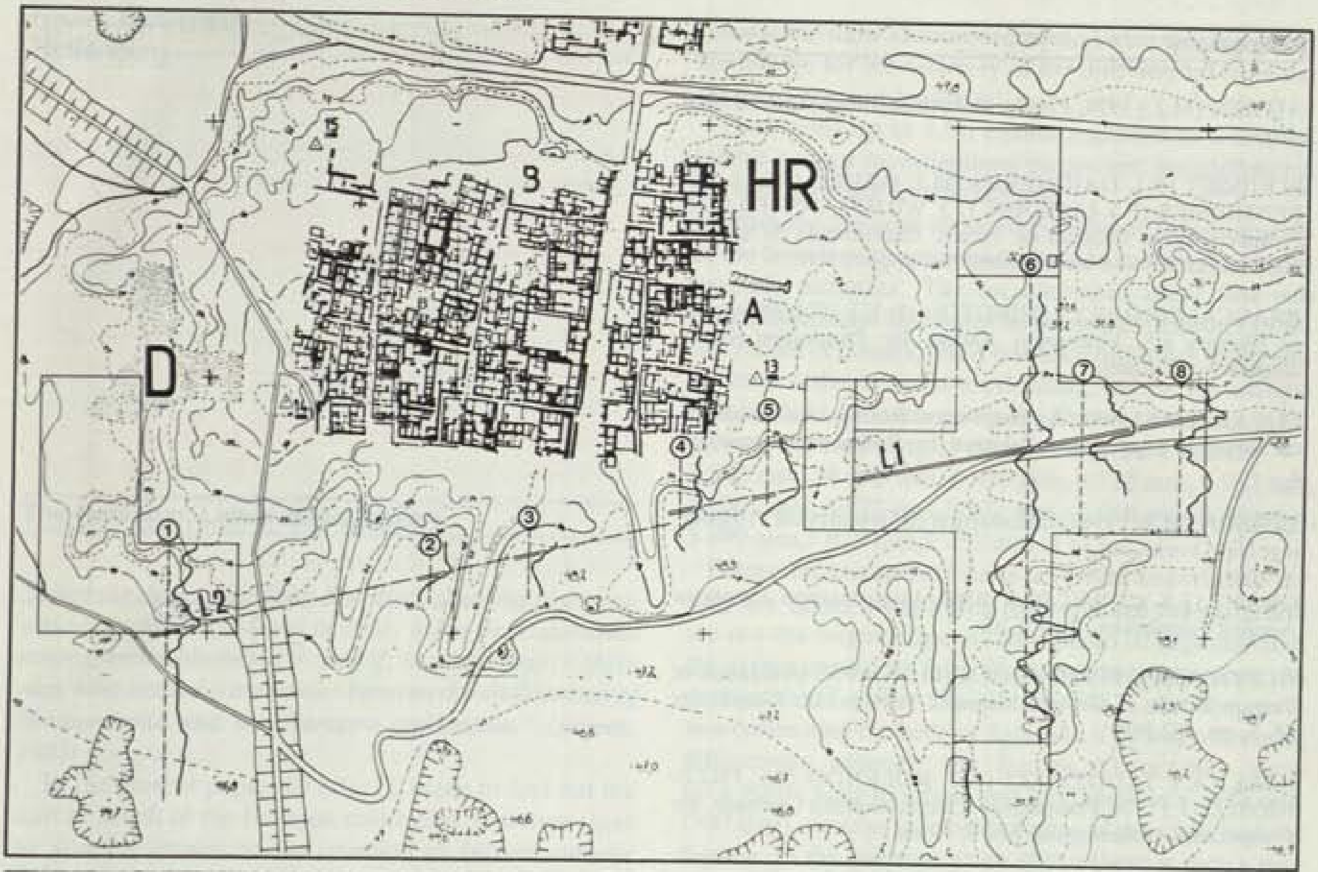


Photo 1 *MD; MN Area, VS Area, HR Area*

Bibliography

AITKEN (M.J.) 1974, Physics and Archaeology, Oxford (2nd ed.).

BOUISSET (P.), DAIGNERES (M.), GRUEL (F.), LAUBENHEIMER (F.), LEBLANC (J.), WIDEMANN (F.) 1979, Prospections sur l'Atelier de Potiers Galloromain de Salleles d'Aude. In: *Revue d'archéométrie No. 3*, pp. 23-41.

BRANCALEONI (F.), LININGTON (R.E.) 1974, Prospezione Elettrica a.S. Vincenzino, Cecina. In: *Prospezioni Archeologiche No. 9*, Roma.

CUCARZI (M.) 1983, Archaeological Results of a Geophysical Survey in Swat Valley, Pakistan. In: *Rivista di Archaeologia.*

DODRIN (M.B.) 1960, Introduction to Geophysical Prospecting, New York (2nd ed.).

GRANT (F.S.), WEST (G.F.)1965, Interpretation Theory in Applied Geophysics, New York.

GUPTA (V.K.), FITZPATRICK (M.M.) 1971, Evaluation of Terrain Effects in Ground Magnetic Surveys. In: *Geophysics 36*, 3, pp. 582-589.

ICIEK (A.), JAODZINSKI (A.), KOLENDO (J.), PRZENIOSLO (J.) 1974, Prospections Géophysiques à Carthage. In: *Prospezioni Archeologiche No. 9*, Roma.

LININGTON (R.E.) 1974, see BRANCALEONI (ed.)

URBAN (G.), JANSEN (M.) (eds.) 1983, Forschungsprojekt DFG Mohenjo-Daro. Dokumentation in der Archäologie, Techniken, Methoden, Analysen, Aachen.

The Harappan Linear Measurement Unit

R.C.A. Rottländer
Rottenburg

The Harappan Linear Measurement

„Since the days of Sir John Marshall, since the first excavations in Mohenjo-Daro in 1921, it has been discussed among archaeologists if – and if, in which way – there may have existed connections between the civilizations of Mesopotamia and the Harappa civilization." (Jansen, 1982)

In the present paper the effort is made to find out the unit of length of the Harappa civilization, and from there to give an answer to the question of further cultural contacts.

The following features are at our disposal in order to ascertain the unit of length in question:

1) The fragment of a scale carved into a piece of musselshell. It is probably only an ornament carved into the shell according to scale. Depending on its purpose, the exactness of scale must be estimated differently *(Graf, 1976; 461; Skinner, 1967; 12; Rottländer, 1979)*.
2) The fragment of a copper rule. (If it is really made of bronze, and of what sort of bronze, is not known because a chemical analysis has so far not been carried out) (*ibid.*).
3) The average of the dimensions of the millions of mud bricks of Mohenjo-Daro (*Jansen, 1982: 54*).
4) The measurements taken by M. Jansen and kindly supplied to us (*Jansen, s.d.*).
5) Five single measurements taken by Sir M. Wheeler, cited according to W. Graf (*1976: 461*).

The evaluation of these data is carried out in the way explained earlier *(Rottländer, 1982; 1983)*, using four figure numbers for each measurement wherever possible. Deviations of more than 0,2 % are not accepted for compatible units of measurement. Twice this amount is acceptable for the recovery of the unit derived from the measurements of buildings.

Deviations up to 4 %, earlier regarded as tolerable, inhibit serious investigations on ancient measurements for they give rise to arbitrariness.

From the material supplied by Jansen, measurements of the layouts of houses were selected to obtain the longest possible distances. The measurement listed first was found altogether five times as the inside diameter of inner rooms of houses, but it was used only once in the statistics in order to avoid overloading, in case the antique builder used an inaccurate rule. Transformed into millimeters, the following 13 measurements are found:
3 802 mm, 14 402 mm, 6 476 mm, 8 732 mm, 7 962 mm, 11 061 mm, 6 822 mm, 5 672 mm, 5 068 mm, 3 452 mm, 3 699 mm, 7 027 mm, 8 452 mm.

These measurements have a certain uncertainty for they are taken using a slide caliper from the plans and are not the original figures. But it is to be expected that the errors caused by this will cancel themselves out. As demonstrated earlier (*Rottländer, 1982*), the first question concerning the body of figures is, if by way of forming differences between the figures, there may show up a figure near to a foot unit (300 mm) or a cubit unit (500 mm), or near to another figure of the same body of figures. In the instance given above there is such a pair of figures:

a) The width of a house is 6 821,2 mm, rounded off to 6 822 mm *(Jansen, s.d.: plan 10, B VI_I including the outer walls)*.
b) The inner diameter of an inner room, 6 476 mm *(Jansen, s.d.: Pl. 2, not regarding the dividing walls of rooms 5 and 6)*.

The difference is 345,9 mm. This is a foot-unit, more exactly, a foot-unit of those feet made up of 18 digits. As explained elsewhere *(Rottländer, 1979: 33, 34)*, these feet belong to the double-feet measurements. (These normally have 36 digits, and in literature are frequently confused with cubit measurements which are approx. 600–700 mm.) Thus, as a preliminary result, we find a unit of 691,8 mm. In the same house *(Jansen, s.d.: plan 10, B VI_I, width of a room including outer walls)* there appears the distance 3 452 mm. Apparently this is ten times the measurement 345,9 mm just found. For reasons of comparison, the longer distance is divided by ten: 345,2. Since both of these figures are of equal importance, the average must be calculated:

$$(345{,}9\ \text{mm} + 345{,}2\ \text{mm}) \div 2 = 345{,}55\ \text{mm}$$

This would be the second approximation of the value of the foot-unit. The double-foot by this must then be 691,1 mm.

Using a table of ancient measurements of length, it immediately becomes clear that the palm of the unit of measurement of Nippur, the oldest unit known, equals 69,11 mm. Thus the double-foot unit just found turns out to be 10 times the palm of the oldest unit of length *(Rottländer, 1979: 7,92)*. The initially formed difference of the two measurements (345,9 mm) is obviously five times this palm, and for mathematical reasons at the same time 2/3 of the cubit of Nippur: 518,3 x 0,6666 = 345,53 mm. This naturally means that this distance is 20 digits of the cubit of Nippur, which has 30 digits. The measurement of a room with a width of 3 452 mm is 50 palmae, or 200 digiti of the cubit of Nippur.

At this stage of the investigation, the Harappan unit of length seems to be the Nippur–unit, but the sub-division of the Nippur cubit into three parts is not known in other regions, and up to this point the connection with the scale on the piece of mussel-shell has not been investigated.

According to Skinner *(1967:12)* the mussel-shell exhibits a group of five units collected together to form a unit of a higher order, and shows nine sub-units in total. The unit is 6,71 ± 0,13 mm; the five units together 33,5 mm. Apparently a sub-division of a higher unit into ten equal parts is meant. According to Graf *(1976:461)*, citing Wheeler, the length of the sub-unit is 0,6705 ± 0,0076 cm. This, for the higher unit of five units, would result in 3,3525 cm, but Graf recalculates the inaccurate value of Wheeler as 3,3528 cm.

The statement of the tolerance already shows that the sub-divisions carved into the shell are not too accurate. The more important information, is most probably the indication of a sub-division into ten equal parts. However, ten times the basic unit will be 67,05 mm. Another ten times this unit is 670,5 mm, which indeed is near the double-foot unit, but the difference between them is too large for them to be the same unit. Normally in cases of differences between the units derived from buildings and units derived from a rule, the latter must be favoured. The rule may happen to be inaccurate, but normally the error of measurement obtained from buildings is higher.

But in the present case it is not sure whether the piece of mussel-shell is a piece of a rule. Because it is relatively short, there is a high chance that it was part of an ornament or finger-board of a stringed instrument. The value of the error given by Skinner is one sigma, and that covers only about 68 % of the cases. Only 2 sigma comprise 96 % of the possible deviations, which may be regarded as a safe base. The addition of a 2 sigma error gives:
6,71 + 2 x (0,13) = 6,97 mm
The sub-unit of 69,11 mm from above is well within the range of 10 times the value found by this calculation.

At this stage of the investigation the decadic sub-division of the Harappa measure seems to be confirmed, as well as the suspicion that the cubit of Nippur itself was not used.

According to Jansen *(1982: 54)* the average dimensions of the bricks of the buildings in Mohenjo-Daro are 7 x 14 x 28 cm. These figures are derived from a lot of single bricks. They show a twofold doubling starting from the smallest dimension. Compared with the other figures already found one obtains:

a) from the room figures 6,91 x 13,82 x 27,64 cm
b) from the mussel-shell figures 6,71 x 13,42 x 26,84 cm.

The difference between 28 cm and 27,64 cm is not too bad in view of the fact that 28 cm is an average value. The difference between 28 cm and 26,84 cm however, is too large as not to be remarkable. So the scale carved into the mussel-shell plays the weaker part. On the other hand, the bricks give no clue as to whether the units of Nippur were used or not, for 28 cm are approximately the foot-unit of Nippur (16 digits, exactly 276,43 mm).

The last item at our disposal, is the – alas – very short piece of a bronze measuring rule. But the situation here is somewhat confused. Skinner *(1967: 12)* reports its length to be 1 1/2 inches (c. 3,8 cm) and belonging to a cubit of 20,62 inches. Converted this becomes 523,7 mm, thus only slightly different to the Egyptian Royal Cubit of 523,6 mm.
In contrast, Wheeler reports it to have carvings 0,367 inches apart, corresponding to one half digit. This calculation results in a cubit of 20,7 inches. Obviously a cubit of 28, not 30 digits is meant, but 0,367 x 2 x 28 is 20,55 inches. So Wheeler made his calculation too freely. Graf *(1976: 451)* correctly states the half digit to be 0,93218 cm. Two times twenty-eight times this amount is 52,20208 cm, whereas according to Wheeler it becomes 52,578 cm.

While, according to Wheeler starting from the half digit, the value is 0,3 % below the true amount of the Royal cubit, starting from his cubit-length, it is 0,42 % too high. Deviations of this magnitude are too high for metrological investigation, and Skinner's figure seems more reliable. Thus it turns out that there must have been a cultural contact with the West, because it is not important how far the Egyptian Royal Cubit was distributed in the Indus Valley civilization, but simply the fact that it was present. But the problem of the use of the unit of Nippur is not solved. In order to find out more about this, the initially alluded measurements from the plans of the houses must be investigated with respect to possible units of measurement.

1. The Nippur cubit 518,3 mm
2. The Nippur foot 276,4 mm

3. The Egyptian Royal Cubit 523,6 mm
4. The supposed Indus Valley measure 345,5 mm
5. The palma of the Nippur measure, the most probable junction to the Indus Valley measure 69,11 mm

The calculations will not be given here in detail, but the several steps to be carried out will be explained

STEP 1: The 13 single measurements taken from the plans of the rooms are divided by each of the 5 units listed above.

Thus five columns are formed, in which the figures show certain deviations from integer numbers, their halves, thirds (Nippur measurement), quarters or fifths (Indus Valley measurement).

STEP 2: These figures are rounded off to the next marks of the (hypothetical) measuring rule; e.g. 55,02 to 55,00.

STEP 3: The initially measured figure is divided by the corresponding figure obtained by rounding off, thus giving a number near the supposed unit of length, but with a small deviation from it.

STEP 4: The average (real value), standard deviation (s) and coefficient of variance (CV) are calculated. This is shown in the small table.

	best val.	real val.	s	CV
CUBIT OF NIPPUR	518.29 mm	518.02 mm	±1.83	0.35
FOOT OF NIPPUR	276.43	276.60	0.58	0.21
EGYPTIAN ROYAL CUBIT	523.60	524.56	3.70	0.71
INDUS FOOT	345.55	345.55	0.42	0.12
PALMA	69.11	69.11	0.05	0.07

From this it is clearly seen that the Egyptian Royal Cubit is ruled out. The deviation already occurs in the third digit, and standard deviation and coefficient of variance are twice those of the next candidate, the cubit of Nippur. The best results are obtained for the Indus foot and the palma of the Nippur foot. The palma fits better than the Indus foot because of its finer sub-division, going down to the digit (1/4 palma = 1 digit).

The decision is not in favour of the Nippur unit, neither foot nor cubit, while the deviation is somewhat lower for the foot, for it is 4/5 of the unit of the Indus foot.

Unequivocally the distance-carvings on the mussel-shell are short. The piece itself is most probably too short for its adequate estimation. On the other hand, the decadic sub-division is confirmed, for the foot of Nippur shows a deviation slightly higher than the Indus foot.

With respect to the chronology, it has been proved that in Egypt the Egyptian Royal Cubit appears at about 2 400 BC, early enough to find its way to the Harappa civilization. Naturally the cubit of Nippur is much older. It can be traced back to the late 4th millenium in Tepe Yahyah, a settlement of the old Elam civilization.

The five measurements given by Wheeler and mentioned by Graf *(1976: 461)* have not yet been examined. This is so because Wheeler is obviously very liberal in respect to exactness. But if the considerations made so far are sound, it must be possible to find out what is meant by these data.

First there is a pair from the granary at Harappa:

length: 51 ft. 9 in. equals 15 7734 m
width: 17 ft. 3 in. equals 5 2578 m.

Wheeler puts this at 30 x 10 cubits of the local measure, obtaining 525,78 mm for one cubit.

(The author of the present paper is in doubt as to whether these figures are not a little bit refined; obviously in one direction, the inner diameter, in the other direction the distance including the walls is taken, but in spite of this, the length is exactly three times the width.) Wheeler tries to rely on the piece of the copper measure rule mentioned above; but its unreliability in the hands of Wheeler has already been shown.

Taking it for more probable that it was a fragment of the Egyptian Royal Cubit, one obtains:

length: 15,7734 m ÷ 0,5236 m = 30,125
width: 5,2578 m ÷ 0,5236 m = 10,042

The piece of the bronze measure apparently does not fit. The situation changes if one tries with a palma of the Indus foot, erroneously a little bit too high:

length: 15,7734 m ÷ 0,06918 m = 228,01
width: 5,2578 m ÷ 0,06918 m = 76

Now, nearly integer numbers are obtained. The deviation between 0,06918 and 0,06911 is only 0,10 %, and thus acceptable. Both distances, 228 and 76, can be divided by four without rest: 57 and 19. So the foot of Nippur was employed in this building. A trial with the Indus foot has no success.

Wheeler gives the diameters of the circular working floors of Harappa as plain 11 English feet. They should correspond to 10 local feet. 11 English feet correspond to 3352,8 mm, so the local foot should be 335,28 mm, its digit 20,955 mm. The digit of the cubit of 525,78 mm, in this length calculated by Wheeler from the granary, is 18,773 mm. The contradiction is obvious; Wheelers interpretation fails. But starting again from a slightly higher palm, one obtains:

3352,8mm ÷ 69,13 mm = 48,5

The result is quite plausible. Moreover, with respect to Wheeler, one should pose the question if, in antiquity, plain 48 palms, or 12 ft of Nippur were intended or not. Calculated backwards the difference would only be 35 mm, or 1,06 %.

There remain the measurements of the Great Bath. The data are given by Graf *(1976:461)*: length 11 978,64 mm, width 10 314,94 mm. The difference of these two values is 1 663,70 mm. One can start from the latter figure to find out the figure employed. Division by the palm, 69,11 mm, gives 24,07, very nea· to 24. Again, apparently, a slightly too long a rule was used. On the basis of a palm of 69,23 mm, slightly too long, there result 173,03, 149, and 24,03 palms respectively. Again, division by four is possible without rest:
43,26 (43,25) x 37,25 and 6,01 (6,00), a Nippur foot sub-divided into quarters.
Again the question arises if the „superfluous" quarters of a foot may be due to the thickness of one layer of bricks, and the liberty taken by Wheeler.

The present author does not know if the measurements given by Wheeler may probably relate to buildings older than those of the plans provided by Jansen. But this question may be easily clarified by the archaeologists. As a result of this investigation of the units of measurement, it turns out that, initially in the Harappa civilization, the unit of the Nippur foot was known and employed. At a later date there developed independently from the palm of this system, a decadic system with a foot of five palms, and a cubit, more correctly the double-foot, of 10 palms.

Since there was only a small amount of data at our disposal, it cannot be said in how far the Egyptian Royal cubit, even though it was known, was employed for buildings; it could not at least be detected in our set of data. But it is not impossible that it was used only for merchants purposes. But without any doubt, cultural relations to the West are indicated by these units of measurements.

It is now no longer surprising that the foot of Nippur, under the denomination „water foot", is traceable in the China of the first millenium BC, and that furthermore the Egyptian Royal Cubit was employed there on ceramics as early as in the Chou Dynasty.

In this context, it is desirable that the ceramics of the Harappa civilization should at some time be metrologically examined, in case they were made according to standards *(Fairservis, 1983)*. Wheeler reports seals of the Harappa civilization as having been found in Mesopotamia, in layers dated at the time of Sargon of Akkad *(Wheeler, 1962: 230)*. By this. cultural connections between the Indus and the West have been proved to have existed in both directions.But these are not the only existing proofs. I like to refer to the ocular motifs occuring not only in Mesopotamia, but in the Mediterranean region too. They occur as well in the Indus civilization: firstly there is an ocular motif *(Sankalia, 1974: 334, fig. 84, No. 83)* of the same sort as found in Mesopotamia *(Rottländer, 1979: 107, No. 60)* and in Palestine *(Rottländer, 1979: 105, No. 48)*. Others are found described by Sankalia *(1974:394, Fig. 110; 450, Fig. 157; 452, Fig. 160)* as well as by Rottländer *(1979: 104-106)*. In particular, typologically very close is the congruence of an eye painting on a vessel from Navdatoli *(Sankalia, 1974: 457, Fig. 165, D 98)* and of Los Millares, Spain *(Rottländer 1979: 99, No. 26)*.

Because of its complexity, a simple coincidence must be ruled out, and it is more likely that a common basic idea was present. These ocular motifs are very frequent in the mid third millenium, particularly in the West, and are found as far afield as England and Scandinavia. They belong to the same era as the Harappan civilization.

Bibliography

FAIRSERVIS(A.W. jr.) 1983, Die Schrift der Indus-Kultur. In: *Spektrum der Wissenschaft (1983)*, No. 5, pp. 88-97.

GRAF (W.) 1976, Maß und Zahl in der Induskultur im Lichte der vergleichenden Musikwissenschaft. In: *PITTIONI (R.) (ed.), Archaeologia Austriaca*, Beiheft 14, pp. 461 ff.

JANSEN (M.) 1982, Der „Hügel der Toten" beginnt zu reden. In: *Bild der Wissenschaft (1982)*, No. 3, pp. 46-54.

JANSEN (M.) s.d., Preliminary results of two years' documentation in Mohenjo-Daro (Unpubl man.)

ROTTLÄNDER (R.) 1979, Antike Längenmaße, Braunschweig, Vieweg Verl.

ROTTLÄNDER (R.) 1982 , Ein metrischer Zusammenhang zwischen einem Maß der XII. Dynastie Ägyptens und Maßen vom nordwestlichen Südamerika. In: *Zeitschrift für Ethnologie (1982)*, 107, pp. 227-232.

ROTTLÄNDER (R.) 1983, Ein Beitrg zur Kenntnis des Zusammenhangs vormetrischer Längenmaße der Alten und der Neuen Welt. In: *Archäologische Informationen (1983)*, 5, pp. 145-172.

SANKALIA (H.D.) 1974, The prehistory and protohistory of India and Pakistan, Poona

SKINNER (F.G.) 1967, Weights and measures, London

WHEELER (Sir M.) 1962, Indiens Vorzeit. In: *STUART (P.) (ed.), Die Welt, aus der wir kommen*, Köln.

TABLE OF PRE-METRIC UNITS OF LENGTH

Denomination	double cubit	cubit$_{30}$	cubit$_{28}$	cubit$_{24}$	double foot	foot$_{18}$	foot$_{16}$	palm	digit	area
Gr. Ptolm. cubit		533,10				319,68	284,32	71,08	17,77	Egypt
			533,31				304,64	76,16	19,04	
Gr. Ptolm. foot				533,10		342,72	355,40	88,84	22,21	
Gr. Royal cubit			528,91	453,36	680,0	340,00	302,20	75,56	18,89	Egypt, China, Japan
'New' cubit			527,03	451,74		338,81	301,16	75,29	18,82	Egypt
'New' cubit		527,03				316,22	281,08	70,27	17,56	Egypt, Greece, China
Common gr. foot				474,33			316,22	79,06	19,76	Great-Greece, Vienna
Royal cubit			523,60	448,80	673,1	336,55	299,2	74,80	18,70	Egypt, China
Compromise cubit			520,95			334,68	297,68	74,42	18,60	? Syria, Anatol., Greece
Nippur cubit		518,30					276,43	69,10	17,28	Mesopot., Susa, Europe, Asia
'Remen'			518,30	444,24			296,17	74,04	18,51	Egypt, Levante, Asia
Pes Romanus				444,26		333,19	296,17	74,04	18,51	Rom. Empire
Gudea measure	992,5	496,08					264,58	66,14	16,54	Mesopot., Persia, Japan
Megalith. Yard	829,3									Asia, Europe
Osk.-umbr. foot							276,43	69,10	17,28	Italy, China (water-foot)
Att.-olymp. foot			544,21	466,47			310,98	77,74	19,44	Great-Greece
'Eginet.' foot				471,90			314,16	78,65	19,66	Greece, Peru, China, Rhineland
Double foot XII.D.					673,2	336,60			18,70	Egypt
Miles. foot			555,24	475,98		356,96	317,32	79,32	19,83	Europe (2/1 millenium B.C.)
Indus-foot							345,55	69,10	6,91	Indus-culture
Earth-foot							230,36	57,59	14,40	China
Water-foot							276,43	69,10	17,28	China
Schaku							302,2	75,56	18,89	Japan
Tiahuanaco							271,92	67,96	16,99	Peru
Vitasti					543,0	305,44	271,50	67,88	16,96	Persia
Little Ptolm. foot							308,51	77,13	19,28	Egypt, Great-Greece
Measure of Abydos					638,5	319,25			17,74	Egypt, XIX. Dynasty
Bronze age measure							284,43	71,11	17,78	Middle Europe
Pfahlbau cubit				444,00			296,00		18,50	Neolithic Europe
Tschi (off.)							318,00		19,88	China
Pythic foot					498,0		249,00	–	–	–
Sam.-ion. foot				521,55			347,70		21,73	Greece

Publications
German Research Project Mohenjo-Daro

1983
DOKUMENTATION IN DER ARCHÄOLOGIE.
TECHNIKEN, METHODEN, ANALYSEN 21,-- DM
with contributions from A. Ardeleanu-Jansen, K.L. Busemeyer, K. Fischer, U. Franke, R. Gussone, J. Heckes, E. Hektor, M. Jansen, U. Ludwig, L. Mauelshagen, R. Mughal, H.J. Nissen, J. Pieper, I. Scollar, V. Thewalt, G. Urban, T. Urban, M. Vidale, H. Wanzke.
169 pages, several maps, photos.

August 1984
FORTHCOMING
(Joint Publication with IsMEO, Rome)

INTERIM REPORTS VOL. I 50,-- DM
with contributions from A. Ardeleanu-Jansen, K.L. Busemeyer, M. Cucarzi, W. Dames/M. Jakobs, H. Wanzke, U. Franke, M. Halim/M. Vidale, M. Jansen, M. Kenoyer, E. Maula, R.C.A. Rottländer, M. Tosi/M. Vidale, G. Urban/M. Jansen.
205 pages, 156 photographs, 77 drawings, 32 tables.

December 1984
DATA COLLECTION
- Computer of the HR field registers, with an introductory note, ca. 120 pages, maps
- Computer Prints of the DK A, B, C Area, ca 120 pages, maps
- Computer Prints of the VS Area, ca. 120 pages, maps
- Computer Prints of the DKB Area, ca. 220 pages, maps
- Computer Prints of the SD Area, ca. 130 pages, maps
- Computer Prints of the L Area, ca. 110 pages, maps
- Computer Prints of the MN (DKI) Area, ca. 100 pages, maps
- Diary of M.S. Vats 1924-1925 (facsimile), with an introductory note, ca. 80 pages, 20 photographs
- Survey Data of Mohenjo-Daro, ca. 80 pages, plans, photographs

1985
EXCAVATION ATLAS MOHENJO-DARO
ca. 30 maps 1:200, incl. the original maps of Wheeler's excavation 1950

1986
THE REDOCUMENTATION OF THE EXCAVATED REMAINS AT MOHENJO-DARO
Monography ed. by Müller-Karpe / Urban

Orders should be sent to:
FORSCHUNGSPROJEKT MOHENJO-DARO
RWTH AACHEN
Schinkelstr. 1
D – 5100 Aachen

Mohenjo-Daro ↔ Archaeology ↔ Report