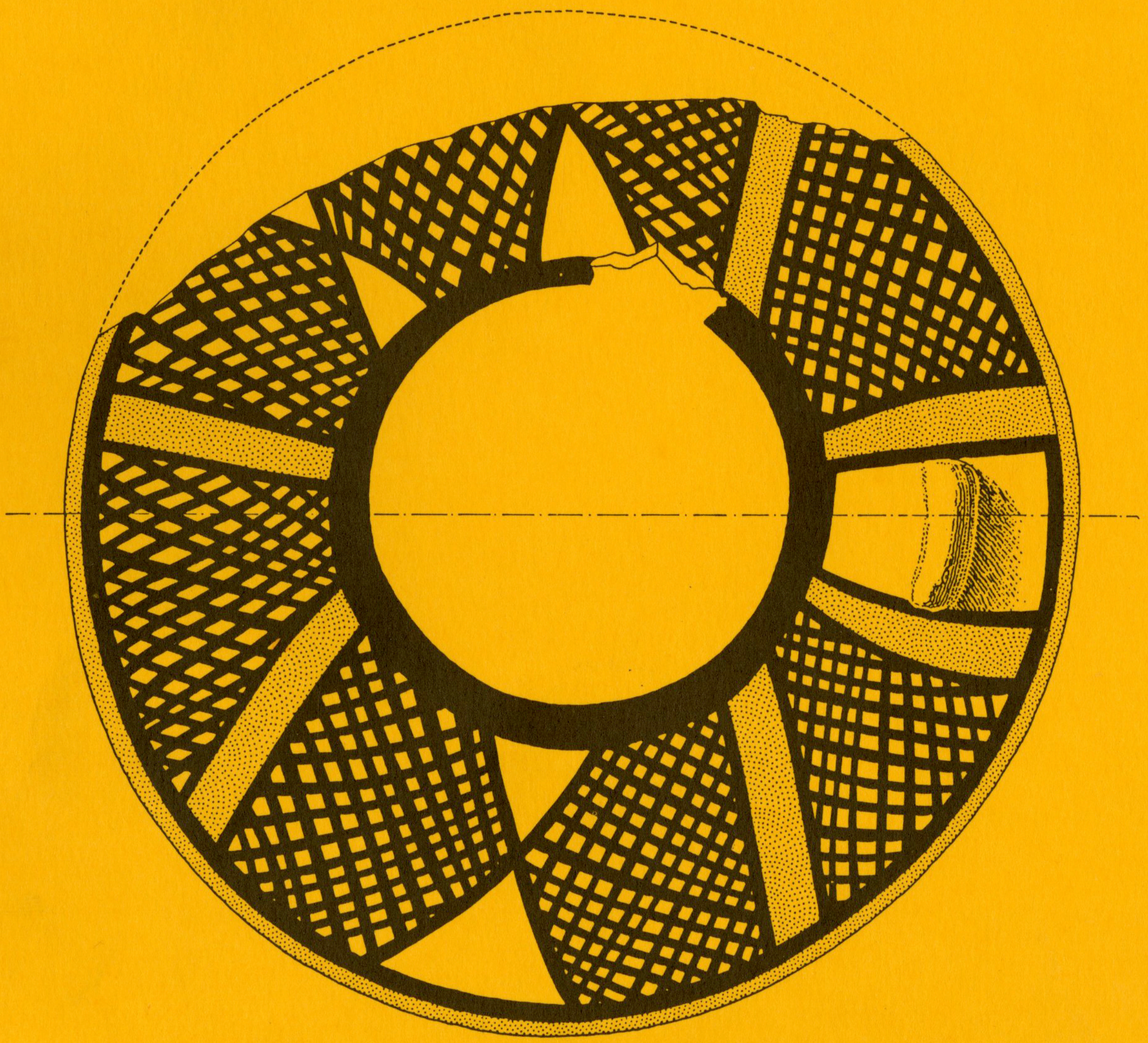
THE CHICAGO-COPENHAGEN EXPEDITION TO THE HAMRIN

UCH TEPE

II

Technical Reports

Edited by McGuire Gibson



CHICAGO AND COPENHAGEN

UCH TEPE
II

DIRECTORATE OF ANTIQUITIES AND HERITAGE, BAGHDAD

Hamrin Report 11

Ministry of Culture and Information
Republic of Iraq

THE CHICAGO-COPENHAGEN EXPEDITION TO THE HAMRIN

UCH TEPE
II

Technical Reports

by
Ingolf Thuesen, McGuire Gibson, Emil Makovicky, Kaj Heydorn,
Richard F. Scholl, Donald H. Campbell, Ruben J. Baer, Joachim Boessneck,
and Mogens Trolle Larsen

Edited by McGuire Gibson

Illustrations by
Dan Nielsen, John C. Sanders and Peggy Bruce Sanders

The University of Chicago
The Oriental Institute

University of Copenhagen
The Carsten Niebuhr Institute

1990

Uch Tepe II

The book is laserprinted in 10' Times and produced for
The University of Chicago, THE ORIENTAL INSTITUTE
University of Copenhagen, THE CARSTEN NIEBUHR INSTITUTE
by Akademisk Forlag

Printed by Rounborgs grafiske hus aps, Holstebro
Printed in Denmark 1990
ISBN 87-500-2909-6 (Denmark)
ISBN 0-918986-61-3 (USA)

The book is sold through Akademisk Forlag except in
North, Central and South America, where the book is
sold through the Oriental Institute, University of Chicago

Table of Contents

Foreword

McGuire Gibson and Mogens Trolle Larsen

In this volume, we present technical analyses on material derived from the excavation of Tell Razuk (Pl. I p. 126), one of the mounds at Uch Tepe in the Hamrin Salvage area. Chapter I, by Ingolf Thuesen, is a discussion of his approach to pottery analysis and some procedural, technological, and cultural implications derived from it. The mineralogical analysis of the Razuk pottery and other samples is reported by E. Makovicky and Thuesen in Chapter II. Thuesen and K. Heydorn follow this with the results of Instrumental Neutron Activation Analysis (Chapter III) carried out on pottery from Razuk and other sites, seeking to answer questions on the relationship of various production centers and findspots of Scarlet Ware and other kinds of Early Dynastic pottery. All analysed samples are listed in a cataloque, associated with plates (Appendix A).

On the basis of technical analyses by R. F. Scholl and D. H. Campbell (Chapter IV) done on a mudbrick from the Round Building, Ruben Baer presents an analysis of the vault of the Round Building at Razuk (Chapter V). He shows that the vault was under very little stress and could easily have carried more than the one story height that we have reconstructed.

Given the expertise shown in the design and construction of the Round Building, a second story would have presented no difficulty to the builders. On the evidence of stratigraphy, however, Gibson has argued (Gibson 1986) against the Round Building's having had more than one story, contrary to a proposal by J.-D. Forest (1982). The evidence of the strata as found and recorded (Gibson 1981: Pls. 11-12), made such a reconstruction improbable. Dietrich Sürenhagen (1986) has questioned the existence of the vaults, asking for more proof. Gibson will take up these matters in Chapter VI.

Joachim Boessneck's report on the fauna from Tell Razuk and the other Uch Tepe sites has already been published (1987). We include here for the first time his listing of *all* the bone lots from the four sites we excavated at Uch Tepe (Appendix B). For Tell Razuk we have added to that list information on find spots and Level, and a brief explanatory note. In his published report, Boessneck gave the total number of each species in one table (1987: Tab. 2), but did not give detailed locus information. In the more complete description of the selection of better preserved bones which he analyzed in detail, there is only a date (ED I, II, etc.) and the lot number, without information on findspot and the nature of that findspot. On the basis of the information provided by Boessneck in Appendix B, Gibson has attempted (Chapter VI) to draw some conclusions based on differences in distribution of the faunal remains. Responsibility for any errors in this discussion are his alone.

This volume has been made possible through the aid of Dr. Moayyad Said Damirchi, Director of Antiquities of Iraq, who allowed the expedition to export not just soil, bones, and seeds, but also to borrow flint and pottery samples for analysis. We especially appreciated the extension of permission for some of the pottery samples to remain in Copenhagen until the study was completed. Some irradiated ceramic samples could not leave Denmark, but all other pottery items and flints have been returned to Baghdad.

Grants for carrying out the instrumental neutron activation analysis were given by the Danish Research Council for the Humanities. The publication of this volume was made possible by subventions from Knud Højgaards Foundation together with the University of Copenhagen and the Oriental Institute of the University of Chicago.

We wish to acknowledge the assistance of Augusta McMahon in proof-reading and editing parts of the book, and especially for her suggestions on content and style of Gibson's chapters. As with the first volume of the Uch Tepe reports, Miss Rose Diamond furnished insightful, though oblique, comments.

This volume has been produced, in great part, through the efforts of Ingolf Thuesen. He coordinated the analyses of the pottery and took on the task of layout and computer-printing of the book. The continuing interest of Kaj Heydorn and Emil Makovicky in analyses of archaeological material is greatly appreciated.

John Sanders and Peggy Sanders provided archi-

tectural and other drawings. Dan Nielsen inked drawings and did layout for this volume. Lis Skærboe typed part of the manuscript, using WordPerfect. The book is offset-printed from galleys produced using Ventura Desktop Publishing software.

Bibliography

Boessneck, J.

1987 Tierknochenfunde vom Uch Tepe. *Acta Prehistorica et Archaeologia* 19: 131-163.

Forest, J.-D.

1982 Review: Uch Tepe I. *Paléorient* 8/2: 113-15.

Gibson, McG. (Ed.)

1981 *Uch Tepe I.* Chicago and Copenhagen.

1986 The Round Building at Razuk: Form and Function. In J.-L. Huot (Ed.),, *Préhistoire de la Mésopotamie.* Paris. Pp. 467-74.

Sürenhagen, D.

1986 Review: Uch Tepe I. *Zeitschrift für Assyriologie* 76: 314-18.

Chapter I
Introduction to the Scientific Analysis of Early Dynastic Pottery from Tell Razuk and the Diyala Region

Ingolf Thuesen

General Remarks

Archaeological exploration of the Hamrin Basin has revealed significant occupation during the earlier phases of the Early Dynastic period, traditionally referred to as ED I-II. Sites of this date are particularly easily identified because of a characteristic pottery: painted vases of the Scarlet Ware tradition. At Tell Razuk a settlement of late ED I and II date was found, and there we obtained a sequence of pottery from stratigraphically controlled contexts. Less than ten percent of the pottery corpus from Razuk was Scarlet Ware (Thuesen 1981: Table 26), but the examples exhibited most of the typical attributes of that tradition.

Scarlet Ware has been described and analyzed by Delougaz (1952) in his report on the pottery found in excavations of the Oriental Institute in the Lower Diyala Region[1]. The characteristics, besides fugitive scarlet red paint, are changes in certain shape attributes such as an increasing tendency towards a sharp shoulder-body carination in contrast to the preceding Jemdet Nasr tradition with plum red paint and vague carination. In the Razuk sequence, which represents the late Scarlet Ware tradition, it has been possible to observe the development of relatively standardized concepts of shape and modes of painted decoration[2]. Standardization is often associated with centralized production. Thus Scarlet Ware could indicate the existence of specialized workshops, with the implication of a developed exchange system in the region. Acquiring insight into the mechanism of distribution and exchange of Scarlet Ware could subsequently provide a better understanding of the socio-economic structures in the Diyala Region.

In order to trace exchange patterns, we performed mineralogical analyses by means of microscopic and chemical examinations of paste and pigments concurrently with trace element analyses by means of instrumental neutron activation analysis (INAA). The mineralogical analyses took place at the Institute for Mineralogy at the University of Copenhagen, the INAA at the Risø National Laboratory in Denmark. The results are reported in the following chapters.

Papers on intermediate results of the INAA have been presented at two meetings (Thuesen *et al.* 1982 and Thuesen 1987) and a synopsis of methods and results at another meeting (Thuesen 1988). The results which appeared in those papers are not different in general from the results given here, since they are based on the same raw data. However, the following presentation is more comprehensive. Some of the graphical presentations already published, showing results from the INAA, vary from the plots shown in this volume. Any divergences of this nature are due to the capability of the plotting program to turn the field of samples to present it from the most illuminating angle, depending on the number of samples included.

1. The geographical division of the Diyala Region into a Lower, Middle and Upper region follows the work of Mitchell and Naylor (Mitchell 1959, Mitchell and Naylor 1960).
2. Late Scarlet Ware similar to that from Tell Razuk was also observed in the Lower Diyala Region, illustrated by two vases, which unfortunately had no precise provenience (Delougaz 1952: 69 ff. and Pls. 60-62). Delougaz hesitated to accept this late stage since Scarlet Ware in ED II contexts was insignificant (ibid. p. 80).

This does not affect the relative position of the samples.

As discussed below, the mineralogical analyses primarily deal with the technological infra-structure of the pottery assemblage of Tell Razuk. The trace element analysis focuses on the inter-site relationships, aiming directly at reconstructing the exchange patterns of the region. Samples used for the mineralogical analyses and about 50% of the samples for the INAA are from Tell Razuk. They were selected during the field work in the Hamrin, September 1978 through March 1979 and September through December 1979.

At a meeting held at the house of the Japanese expedition to the Hamrin in the spring of 1979, with participants from several of the expeditions involved in the excavation of Early Dynastic Sites, Scarlet Ware pottery was compared and the sequence discussed. At that time the INAA project was suggested and immediately the British and the French expeditions agreed to contribute samples from their sites. Later we incorporated samples from the Japanese expedition as well as sherds of Scarlet Ware found in the Lower Diyala sites published by Delougaz (1952). The last group of sherds is from the Oriental Institute of The University of Chicago, whose director, Janet Johnson, we thank for permission to analyze and publish results. H.T. Wright kindly contributed a set of samples from early third millennium contexts in Farukhabad, Deh Luran, to be used as a reference group. This expansion of the project had an interest beyond methodology, as there are shared traits between the painted traditions of the two regions, e.g. in the composition and choice of motifs. Samples of natural clay from the Uch Tepe area were also analyzed; one of the provenances was the present-day source for pottery production exploited by the villagers and to that we added samples of recent pottery produced from that source. Since clay and silt usable for pottery are abundantly available in the region, an exhaustive collection would have entailed major effort and time. The sampling of natural clay was not determined by ambitions to locate the clay sources for the ancient pottery, but rather by the intention to observe how the manufacturing process might alter the composition of a selection of clay.

As an integrated part of an attempt to improve on our reconstruction of early Mesopotamian societies, the following section provides a general introduction to the Scarlet Ware tradition. Further, it suggests a paradigm which should clarify the position of the analyses inside a wider reconstructional frame, based on the data extracted from the pottery.

Classification of pottery

The description and classification of ceramics by their physical attributes involve observations of three major parameters, ware, shape, and decoration, which are determined by the potter's skill and creativity, plus feedback demands from users (Table 1). The relationship among the three parameters is more complicated than immediately expected. Figure 1 shows three different stages in the process of description and classification of pottery. The first and simplest stage describes each of the parameters separately. In the second, the parameters are accepted as complementary and partly dependent, e.g. cases in which a particular ware is necessary for certain shapes, or ware-shape combinations are associated with particular decorations. The third is in theory the comprehensive structural approach, assuming the product is the result of a completed process, characterized by three integrated parameters. A shape cannot exist without a ware, or a decoration without a shape, which implies a ware. The third paradigm opens possibilities for such phenomena as un-decorated pottery (hatched ring) and unfinished shapes, e.g. kiln wasters (cross-hatched ring).

The three stages may also be conceived as a projection of developmental phases in any pottery classification procedure, rather than alternative approaches. Traditional descriptions are located in the first two stages, which hopefully one day will lead to the third comprehensive stage. In an analytical sense, the third stage dissolves the rigid structural approach introduced in the initial stage. The analytical structure composed of three parameters gets reduced to its proper nature: a tool for our attempt first to describe, next to classify the pottery. The classification potential of the descriptive procedures is indicated below the paradigm on the figure, if the classification should be based on the sum of pottery attributes.

Parameter	Main variables	Level of determination
WARE	clay mixing/ tempering/ firing	technical
SHAPE	dimensions	functional
DECORATION	motif-element combinations	aesthetic/ symbolic

Table 1. Parameters and variables used in pottery description and classification

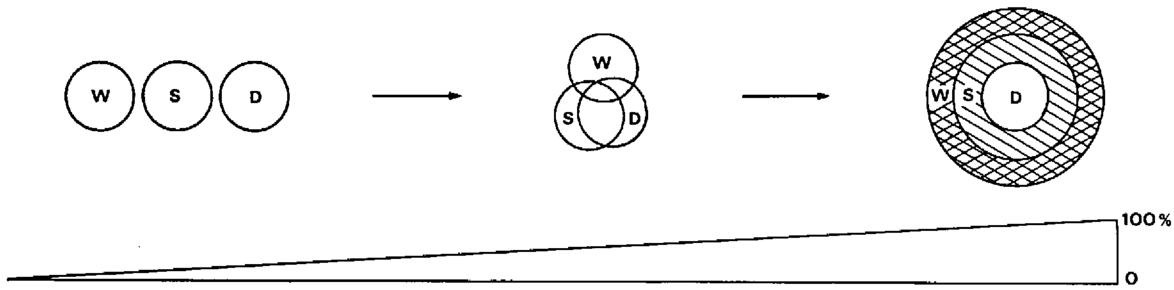


Figure 1: Schematic illustration of three phases in a procedure describing pottery involving three main parameters: W=Ware; S=Shape; D=Decoration; and their classificational potential.

In the terminal stage of pottery classification, we ought to find ourselves in the third stage. However, it is more realistic, at least for classificational procedures of Mesopotamian pottery which are still primarily based on shape typologies, to expect a pottery description to be terminated in or between the two preceding stages. Methodologically, this situation is the result of a combination of analytical ignorance and lack of relevant data, particularly for the ware parameter. It is our experience that trying to make a short-cut to reach the third stage directly, without going through the two preceding, causes too much complexity, and this therefore has not been the procedure used in this project. However, whatever strategy, it is imperative to realize where the stop has been made in the descriptive process and to let this determine the interpretational value of the data. Painted pottery compared to other artifacts can be extremely complex in attribute structure, and despite the impressive progress made in the application of scientific methods during the last decades, we still have not established a conclusive analytical procedure for sampling the crucial data combinations from sherds.

This is the analytical background for the scientific project reported below. Based on data determined by the reported technological analyses, especially involving the ware parameter, we have derived certain cultural interpretations. By doing so we hope to have brought the unfinished picture of the preceding report (Thuesen 1981) closer to completion.

Scarlet Ware Pottery

Scarlet Ware consists of a limited repertoire of shapes and a limited combination of stylistic attributes. If not for the painted decorations it would be impossible to distinguish Scarlet Ware jars from non-painted jars.

At Tell Razuk the jars are made of a buff, pink, or greenish ware, which can only be separated by this colour variation after a microscopic visual examination. The vessels are well-fired, mineral-tempered, and normally extremely hard to break or polish. This was observed several times when samples were prepared for the scientific analyses. Voids occur in the paste, created by the burning-out of very finely chopped organic tempering material. A range of colour inside the individual vessels is the rule: for instance, the surface might have a pink colour, while the core is light buff. Non-oxidized gray cores occur rarely.

Even though no complete profiles of Scarlet Ware jars were found at Tell Razuk, it appears that only a single jar shape was attested, shape 7 (Thuesen 1981: 118ff.). This is a medium tall jar with ring base, high body-shoulder carination with a raised ridge, vertical neck and everted bevelled rim (*ibid.* Pl.84). The range of standard diameters is from 12 to 14 centimeters. Apparently the volume of the jar did not differ significantly from similar non-decorated vessels.

The jars are decorated all over: the neck is covered by solid red paint, the shoulder and the body are divided into panels by horizontal and vertical red bands often bordered by black lines. On the shoulders the panels are commonly filled with geometric motifs, of which cross-hatching is dominant. The repertoire of individual motif-elements used as decoration is limited to about 20, but their combinations are numerous. Naturalistic or representational motifs include five elements, which are typically placed on the body (*ibid.* Pls.89-91).

The Scarlet Ware of Tell Razuk represents the

terminal phase of the tradition. To understand its position we should view it within the framework of a wider chronological sequence. The key ED site excavated in the Hamrin is Tell Gubba (Fujii 1981), with a sequence covering a time span from the Jemdet Nasr through a time equivalent to that covered by the earlier levels of Tell Razuk. Outside the Hamrin Basin the crucial sequence is that provided by the Lower Diyala Region, with inventories excavated at Khafajah, Tell Asmar and Tell Agrab (Delougaz 1952). Delougaz' publication of the pottery along with the excavation reports from the Diyala Region still remain the most comprehensive account of the Early Dynastic period in Mesopotamia and allow a synchronism of the Hamrin Basin with the Sumerian heartland. A concordance of the sites and levels referred to in this report is suggested in Table 2.

Through time Scarlet Ware passed through a number of recognizable developments. Details of the ware are difficult to observe due to the lack of standardized descriptions. However, it is possible to conclude from the published data that variations exist with respect to texture, application of slip, and colour of paste. The fabrics of the Gubba inventory, for instance, seems to become sandier through time[3]. Chaff or other organic tempering material was not observed at any of the sites. The colour range is wide, from a creamish green to a pinkish red; and for the earlier phases of the tradition, the application of a cream slip is apparently typical; it is less pronounced in the Razuk inventory (Thuesen 1981: Table 8).

Comparing the shapes of painted vessel from Jemdet Nasr through ED II we find a measure of continuity in change. Figure 2 shows the most common shapes from some of the better known sites. Also included is the initial stage of vase painting that leads to the Scarlet Ware tradition, namely that of Jemdet Nasr, best represented by examples from the site of Jemdet Nasr itself and Tell Uqair (Mackay 1931, Lloyd 1943). As may be seen from the excavations at Gubba and in the Diyala the size of the jars increases through time, until Gubba IV, with sizes measuring 50 centimeters in maximum diameter and height (Fujii 1981: Fig. 18). The repertoire of shapes decreases from ED I to II. As shown in Figure 2, by the time the later phases of the tradition have been reached, we are basically dealing with minor variations on a single standardized shape. Other observations on the development of Scarlet Ware shapes are: the four-lugged jar is found especially in the Jemdet Nasr and ED I periods and it can be traced further back into the Uruk period. A typical ED feature is the upright lug handle on the shoulder, which in the beginning of the tradition is oriented to the radius of the vessel, but later turns perpendicular.[4] In the Jemdet Nasr period, some polychrome painted jars have two carinations: one at the body-shoulder junction, one at the top of the shoulder. The lower carination moves up at the same time as the jars become taller and slimmer, while the upper carination disappears or turns into a ridge. This probably happens in ED I. Finally, and as a hallmark for the late Scarlet Ware and contemporary non-painted jars, a ridge is applied to the body-shoulder carination. This form is common at Tell Razuk and is perhaps the first stage in the development of multi-ridged shoulders in the subsequent ED III and Akkadian periods. The preferred rim shape is the everted bevelled rim; but other shapes are seen as well, especially in association with the four-lugged early jars and spouted vessels, the latter found abundantly at Tell Gubba (Fujii 1981: Fig.13). To complete this summary of the shape inventory of painted vessels, it should be mentioned that

Site Period	Nippur Inanna	Akkad	Khafajah	Asmar	Agrab	Gubba	Razuk
Ed II	VIII		Oval	Square			II-III
	IX		Temple	Temple			IV
ED I	X		Nintu	Archaic	Shara	IV	V-VI
	XI		Small T.	Shrine	Temple	V	
	XII		Houses		Houses	VI	
JN	XIII	Uqair	Sin T.	Early Shrine	Sounding	VII	
	XIV	J. Nasr		H 18/D 15			

Table 2. Correlation of sites with painted wares during Jemdet Nasr and the Early Dynastic periods.

3. However, the four sherds from Tell Gubba examined by INAA in this project do not differ significantly from the Razuk Scarlet Ware in terms of visually recognizable ware characteristics.

4. Compare the early handle type as found in Tell Gubba, level VI (Fujii 1981 Fig.14.3) with one of the Razuk example (e.g. Gibson 1981 Pl.94).

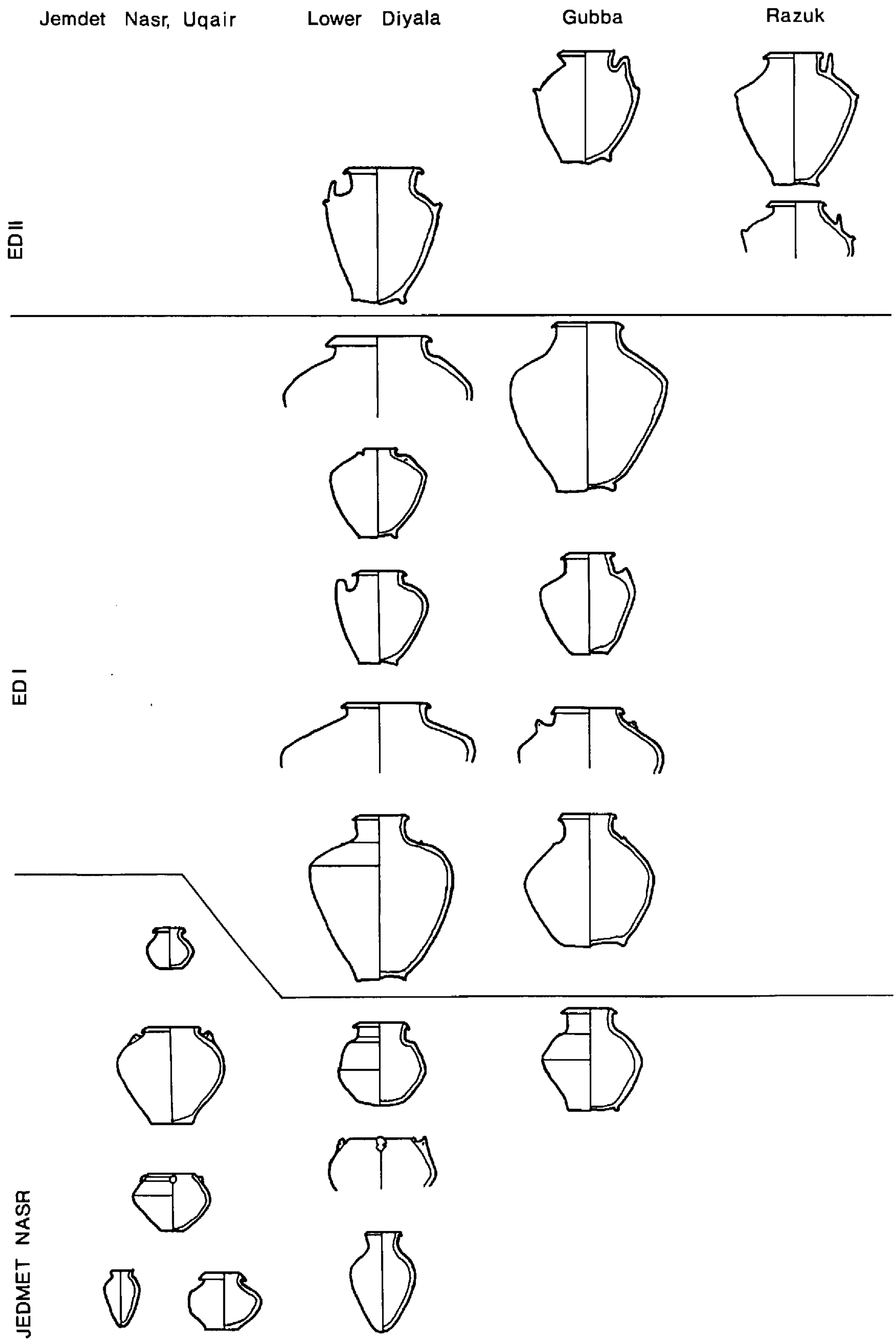


Figure 2. Shape repertoire of painted vessels during the Jemdet Nasr and Early Dynastic Periods.

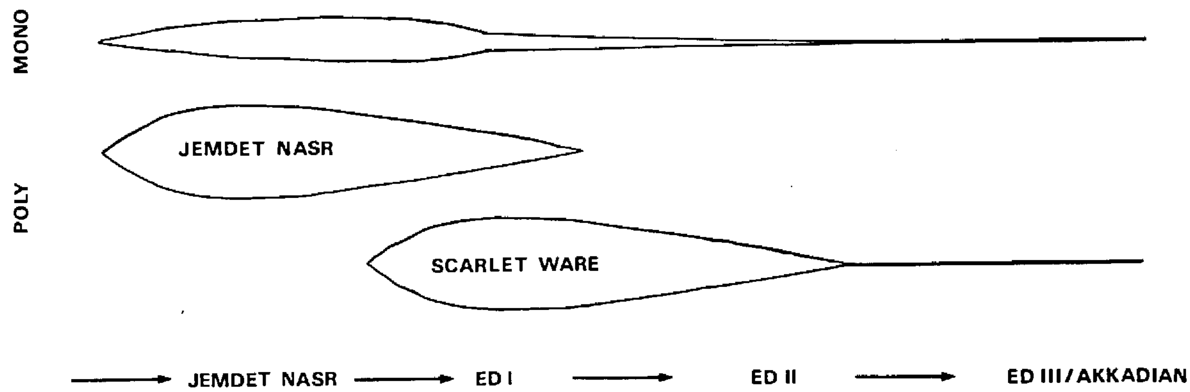


Figure 3: Sub-structure of the painted (mono- and polychrome) pottery during Jemdet Nasr and Early Dynastic

in ED I there were a number of zoomorphic vessels painted in Scarlet Ware (Delougaz 1952: Pl.7).

During the ED III/Early Akkadian, the Scarlet Ware tradition had an epiloque, which is represented in the burial inventories of the time in the Hamrin Basin. At both Tell Gubba and Tell Razuk such burials were excavated, cut into the ruins of the ED I-II round buildings. Two jars, one from each grave, are painted. The Gubba example is bichrome, red and black (Fujii 1981: Fig.21.2), the Razuk example is monochrome black (Gibson 1981: Pl.98.10). In both instances the shape of the jar is transitional ED III/ Akkadian. These, together with some examples from burials in the Zagros valleys (e.g. Haerinck 1987), seem to be the final appearance of Scarlet Ware.

Paint colour and choice of motifs show related temporally dependent variations. The paint develops from a plum red to a light red, orange, or pinkish colour - the so-called scarlet. The later paint is fugitive and simply applied to the jar, normally after firing. The extremes may best be illustrated by comparing vases from Jemdet Nasr with vases from Tell Razuk. The placement of motifs and their combination also changes through time. In the Jemdet Nasr period motifs are generally placed in symmetrical panels on the shoulder - often in a multiple of four. Thereafter, through the ED period, the solid painted areas between the panels narrow into bands, reflectional symmetry is given up, and the panelling spreads to the body, which originally was solid red. The inventories of Razuk and Gubba IV and some ED II examples from the Lower Diyala Region sites are all characteristic of late compositions. The change from a strict symmetric-geometric lay-out to a non-symmetric panelling is associated with an expansion of the motif repertoire, especially in naturalistic or representational motifs. Despite the clear continuation of the painted vessels from Jemdet Nasr through ED in technological and formal properties, there is a distinction between the rigid geometric-symmetric concept of the Jemdet Nasr painter and the more experimental and innovative concept of the late Scarlet Ware painter. In terms of other motif elements, the basic repertoire of geometric elements introduced with the Jemdet Nasr polychrome survived in the ED inventory. However, naturalistic motifs showing birds, fish and animals, or more rarely humans and gods, flourished only in the late part of the tradition, when the body of the jar was first utilized as a field for designs.

Some of the major chronologically dependent variations are summarized in Table 3. Despite these variations (most conspicuous for the ED I Scarlet Ware and the preceding Jemdet Nasr) a certain degree of continuity of the tradition may be observed, which allows us to talk about one extended tradition of mono- or polychrome painting of vessels, as illustrated in Figure 3.

There is also variation in the geographical distribution of painted vases through the observed time span (Figure 4). The Jemdet Nasr polychrome is found as far south as Ur in Lower Mesopotamia (Woolley 1955: Pl.26), while ED Scarlet Ware is common only in the Diyala Region[5]. There is sparse information from the areas immediately north and east of the Hamrin Basin. Beyond this, a totally different ceramic tradition is found in the Assyrian plains, e.g. the Ninivite V, which indicates a rather prominent frontier separating the regions, at least in terms of pottery production.

5. Exceptions are, for instance, a Scarlet Ware sherd from Abu Salabikh (J.Killick personal communication); and Scarlet Ware in the Inanna Temple at Nippur (Hansen 1965).

Period	Ware	Shape	Decoration
ED II	fine-medium	body-shoulder ridge standardized	naturalistic on body
ED I	sandy	fewer shapes increasing size	assymetric scarlet
JN	w/slip		symmetric on shoulder plum red

Table 3. Major variations of the main parameters of painted vessels during the Jemdet Nasr and ED periods

Exchange, Trade and Scarlet Ware

During the last decades, a number of scientific methods have been developed to establish exact descriptions of pottery (e.g. Olin and Franklin 1982, Bishop *et al.* 1984, Nelson 1985). Basically, they can be separated into two groups: visual identification of components using microscopes, or chemical identification of minerals and trace elements. The latter are often a combination of microscopic techniques and chemical identification, e.g. electron emission. Additionally, there are methods to determine firing conditions (differential thermal analysis), vessel construction (xeroradiography), and dating (thermoluminescence). These methods make it possible today to establish a much better framework for a reconstruction of the technological level of a given tradition.

A preliminary attempt to recognize exchange patterns involving ancient pottery production involves first of all a detailed examination of the visual attributes associated with the shape and decoration. If it can be demonstrated that these attributes are similar over a wide geographical area, one must then turn to an examination of the ware or fabric to complete the data base necessary to establish the evidence for exchange. In reality we are often dealing with a much more complex situation. Each of the analytical parameters may show variations which would not preclude the conclusion that there was trade in pottery. For instance, different shapes could be prepared in the same workshop, but distributed to geographically sep-

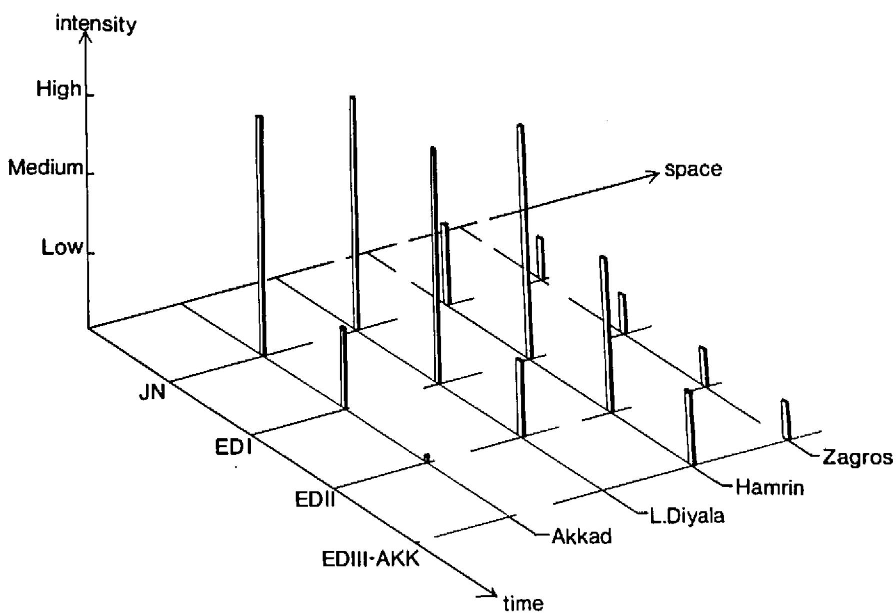


Figure 4: Estimated representation of painted pottery in Mesopotamia and the Zagros during Jemdet Nasr and Early Dynastic

arated social groups. Similarly, pottery from a workshop might be decorated in a number of ways, particularly in the case of post-firing applications, and then be distributed widely.

In the case of Scarlet Ware, the situation involves pottery inventories of rather similar appearance (shape, style) in the Diyala Region. The pottery is therefore a potential carrier of information concerning the internal exchange network of the region. However, any reconstructed exchange patterns may actually result from a much more integrated regional workshop structure, and the similarity among pottery inventories from various sites may not be caused by physical movements of finished products alone. Raw materials, techniques, and know-how may have been just as important components of the exchange system. An example could be a travelling potter, who would be responsible for variations of an indirect nature, e.g. by using local raw materials but his own techniques to form vessels on demand - according to local functional requirements - and perhaps in the end adding conventional decorations. Therefore, in order to obtain a better impression of the overall exchange situation, the major components of the exchange, each related to an important aspect of the pottery manufacturing process, may be outlined in a four-factor paradigm (Figure 5):

A: Raw materials (preparation of a fabric)
B: Technical know-how (potter's technical skill)
C: Functional demands (shape formation)
D: Aesthetic-symbolic concepts (application of decoration)

Any of these might appear as either local or non-local, theoretically creating sixteen different distributional situations. Non-local in this connection has a broad definition meaning not only physical importation of materials, but also imitational phenomena. Broadly speaking, the observed phenomena may be classified in three groups, genuine innovations, imitations, and imports. Concerning pottery, the imitation group is probably the most prominent in any inventory, resulting from the diffusion mechanisms of cultures. The following table (Table 4) shows each of the sixteen situations; a local trait is characterized by an "x" after one of the four letters introduced above, a foreign element by a "y".

The main condition for actual trade of centralized production perhaps associated with a travelling potter is the existence of a non-local technical aspect. Most of the hybrid situations are likely to be explained by the existence of a travelling potter, reflecting a slightly stronger degree of regional dependency than that involved in purely local production. An interpretation of the paradigm is suggested in Table 5, including degrees of inter-site relationship, which shows the range from total acceptance of non-local types and traditions through various stages of imitation to local genuine innovations. Implicit is the varying degree of inter-site relationship. The central field is a group of complex situations which cannot yet be defined more precisely. This model may be used on site inventories in a reverse chain reaction, to trace the origin of specific elements.

The paradigm demonstrates that physical move-

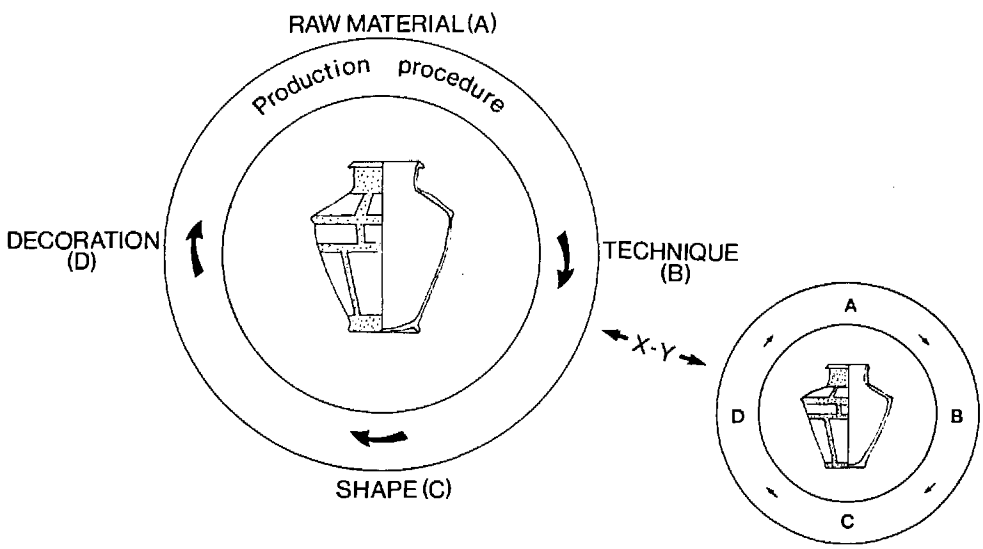


Figure 5: Four-factor diagram illustrating some of the major properties in respect to exchange-trade phenomena of pottery (x-local; y-foreign)

$(ABCD)_x$	100% local production, reflecting the highest level of site differentiation in a region and insignificant potential for inter-site relations.
$(ABC)_xD_y$	Local production with non-local decorations, imports or imitations, a travelling artist.
$(ABD)_xC_y$	Local production with imitations of non-local shapes.
$(ACD)_xB_y$	Local raw materials, functional and decorative concepts; but carried out by a potter using non-local techniques, e.g. a travelling potter.
$(BCD)_xA_y$	Import of raw materials for local production.
$(AB)_x(CD)_y$	Probably the most common instance of imitations in differentiated production: foreign shapes and decoration produced by local potters.
$(AC)_x(BD)_y$	Ware and shape local, technique and decoration not, perhaps carried out by a travelling potter.
$(AD)_x(BC)_y$	As above with the difference of local decoration but imported/imitated shapes.
$(BC)_x(AD)_y$	A local production with imported raw materials and imitations of non-local decorations.
$(BD)_x(AC)_y$	As above with imitated shapes but local decoration.
$(CD)_x(AB)_y$	A travelling potter producing vessels according to local demands using his own raw materials, or specialized orders placed in centralized workshops.
$A_x(BCD)_y$	Application of local raw materials for imitations, travelling potter?
$B_x(ACD)_y$	Imitations produced by local techniques using imported raw materials.
$C_x(ABD)_y$	Travelling potter or centralized workshops producing on demand.
$D_x(ABC)_y$	Imported pottery with local decoration added, only possible in the case of post-firing techniques of application.
$(ABCD)_y$	100% imported pottery, highest integration of pottery crafts, and a high potential for developed inter-site relationships.

Table 4: Sixteen theoretical exchange situations for pottery.

ments of goods should be indicated primarily by the presence of non-local raw materials or applied techniques. Both are directly represented in the first of the three descriptive parameters, the ware. In the case of Scarlet Ware, we have a homogeneous pottery type (with regard to shape and decoration) spread over a wide geographical region around the Diyala River. To gain insight into the nature of intra-regional relationships, we chose this group for systematical technical ware studies. The project involved two sets of analyses. The first deals specifically with the pottery inventory of Tell Razuk, and examines the basic nature of the ware and pigments used in decoration. The Razuk inventory was examined by a series of methods describing the clay paste, tempering materials, firing conditions, and composition of the paints and slips. The overall results indicate that the mineralogical composition of the ware did not differ significantly from other Mesopotamian samples analyzed by researchers in related projects. This was in some ways a disappointment, as it limited the potential for identifying different workshops in the region. However, inter-site relationships can be studied by other methods, e.g. by measuring the concentrations of trace elements; so instrumental neutron activation analysis was carried out parallel to the mineralogical analyses.

IMPORT(%)	100	75 (-50)	(75-)	50 (-25)	(50-) 25	0
	$(ABCD)_y$	$(ABC)_yD_x$	$(BCD)_yA_x$	$(ACD)_yB_x$	$(CD)_y(AB)_x$	$(ABCD)_x$
		$(ABD)_yC_x$	$(BC)_y(AD)_x$	$(AC)_y(BD)_x$	$C_y(ABD)_x$	
		$(AB)_y(CD)_x$	$(BD)_y(AC)_x$	$(AD)_y(BC)_x$	$D_y(ABC)_x$	
			$B_y(ACD)_x$	$A_y(BCD)_x$		
FACTOR		$(AB)_y$	A_xB_y	A_yB_x	$(AB)_x$	
CONCEPT	Accept	Request	(Hybrid)		Imitation	Innovation
PRODUCTION	Centralized		Travelling Potter (?)			Local
CULTURAL PATTERN	Integrated					Differentiated

Table 5: Suggested structure for degrees of non-local influence in a ceramic inventory

In this part of the project, the scope was more regional. Samples from several site inventories with Scarlet Ware were compared to the substantial corpus of samples analyzed from the Razuk inventory, thereby tracing some of the variations in the region caused by the choice of raw materials and the preparation and firing of the fabrics. The next chapter (II) deals with the mineralogical analyses of the Razuk pottery inventory as well as a sample of raw clay from the area of the site, providing us with data concerning the technological aspects of the craft at Tell Razuk. Chapter III reports the results of INAA of samples from the Diyala Region and elsewhere, which makes it possible to reconstruct inter-site relations during the Early Dynastic period in the Diyala Region.

Bibliography

Bishop, R.L., R.L. Rands, and G.R. Holley

1982 Ceramic Compositional Analysis in Archaeological Perspective. *Advances in Archaeological Method and Theory* 5: 275-330.

Delougaz, P.

1952 *Pottery from the Diyala Region*. Oriental Institute Publications 63.

Fujii, H. (Ed.)

1981 Preliminary report of excavations at Gubba and 1981 Songor. *Al-Rafidan* II.

Gibson, McG. (Ed.)

1981 *Uch Tepe I*. Chicago and Copenhagen.

Haerinck, E.

1987 The chronology of Luristan, Pusht-i-Kuh in the Early Bronze Age I (ca. 3000 to ca. 2600 B.C.). In *Préhistoire de la Mésopotamie*. J.-L. Huot, Ed. Paris. 55-73.

Hansen, D.P.

1965 The Relative Chronology of Mesopotamia. Part II. In *Chronologies in Old World Archaeology*. R.W.Ehrich, Ed. 201-215.

Lloyd, S.

1943 Tell Uqair. *Journal of Near Eastern Studies* 2: 131-55.

Mackay, E.

1931 *Report on Excavations at Jemdet Nasr*, Iraq. Field Museum of Natural History. Anthropology Memoirs, Vol. I, No.3. Chicago.

Mitchell, C.W.

1959 Investigations into the soils and agriculture of the Lower Diyala area of Eastern Iraq. *The Geographical Journal* 125: 390-97.

Mitchell, C.W. and P.E. Naylor

1960 Investigations into the soils and agriculture of the Middle Diyala Region of Eastern Iraq. *The Geographical Journal* 126: 468-75.

Nelson, B.A. (Ed.)

1985 *Decoding Prehistoric Ceramics*. Carbondale and Edwardsville.

Olin, J.S. and A.D. Franklin

1982 *Archaeological Ceramics*. Washington D.C. Smithsonian Institution Press.

Thuesen, I.

1981 The Early Dynastic Pottery from Tell Razuk. In *Uch Tepe I*. M.Gibson (Ed.), 1981. 99-144.

1987 Distributional Patterns Behind the Scarlet Ware Tradition. In *Préhistoire de la Mésopotamie*. J.-L. Huot (Ed.), Paris. 461-66.

1988 Technical Analysis of Scarlet Ware Pottery. *Paléorient* 13: 123-31.

Thuesen, I., K. Heydorn and R. Gwozdz

1982 Investigation of 5000-years-old pottery from Mesopotamia by Instrumental Neutron Activation Analysis. *PACT* 7: 375-81.

Woolley, C.L.

1955 Ur Excavations IV: *The Early Periods*. Philadelphia.

Chapter II
Paint and paste studies on selected pottery sherds from Tell Razuk, Iraq

Emil Makovicky and Ingolf Thuesen

I. Introduction

The ceramic inventory of Tell Razuk represents the late Early Dynastic I and Early Dynastic II period in early 3rd Millennium Mesopotamia[1]. Located in an ecologically and geologically transitional zone between the alluvial plains and the foothills of the Zagros range, the site is particularly important for examining the relationship between these two different areas, both crucial for the evolution of the early state in Mesopotamia. The Razuk inventory is closely related to the traditions of the lowlands, particularly the Scarlet Ware of the Lower Diyala Region.

In an attempt to examine intra-site and inter-site relationships that might contribute to a reconstruction of the economic and social structure of Early Dynastic society, the ceramic inventory of Tell Razuk has been a major focus of technical analyses following the completion of the Chicago-Copenhagen expedition. In this chapter we report on the mineralogical analyses of paste, paint and raw clay, which are site specific, i.e. Razuk. In a following chapter instrumental neutron activation analysis is reported. These analyses, since dealing with samples from several sites in the Hamrin, the Lower Diyala Region and elsewhere, may allow a reconstruction of inter-site relationships. The sherds used in the mineralogical analyses were also included (with two exceptions) in the neutron activation analysis. A catalogue of samples and illustrations can be found on pp. 119 below.

Although dealing with sherds from Tell Razuk alone, the mineralogical analyses make it possible to look farther afield. Related analytical work has been done on other ceramic inventories in the Middle East. These analyses can, potentially, give information on the technological state of the tradition and eventually the origin of the samples. Although we were not able to make a systematic collection of clay sources in the Razuk area, we could furnish one sample of clay from the base level at Tell Razuk. Alteration of sherds due to contamination from the surrounding soil has been examined, particularly in connection with the paint analyses since paint can be very sensitive to such contamination.

The samples were selected to represent a cross section of the major groups identified by archaeological classification, with samples of the major wares (buff, pink, green and gray) and decorated sherds (Scarlet Ware) representing 55, 29, 6, 1 and 8% respectively of the ceramic inventory (Thuesen 1981). Eventually, we wished to know if they all represented one and the same technological tradition and if this could be considered local.

A scientific approach to study the material parameter of ancient pottery has followed the developments of methods in general physics. Mineralogical analysis of the main components of fabrics or wares, is turning increasingly into an explicit discipline involving a series of procedures. These methods, chemical or microscopic, primarily deal with the technological dimension of the ceramics studied, i.e. reconstructing the procedures of the potter from the moment clay has been dug up till the finished product is traded.

In this work, highest priority was given to a multi-dimensional analytical program on a relatively small sample instead of analyses involving only a few procedures on a large selection of material. It is our impression that the field of archaeometry already abounds with examples of analyses in which only one or two methods have been applied. It has been our intention to demonstrate that our strategy, besides

1. In Gibson 1981, we used the Diyala sequence as the basis for periodization. The Diyala system is undergoing major revision (D.Hansen, in *Chronologies in Old World Archaeology*, ed. by R.Ehrich, forthcoming) and our ED II material might be included in a very late ED I.

extracting crucial data for the pottery making process, allows a sounder evaluation of the representative methods applied.

Complexity of pottery craft represented by the high number of interacting and culturally dependent variables observable in the ware may appear overwhelming, particularly if several more or less complementary methods are used simultaneously to descibe the phenomena. But this should be a challenge rather than an obstacle for the researcher. The combination of approaches to characterize technological properties of ceramics carries a high potential for the discrimination of pottery traditions. In addition to a reconstruction of the production procedures, time- and-space dependent variations may be recognized, bringing forth new arguments in the study of dynamics of the societies responsible for the ceramics.

II. Paste Samples

Description

0140, Buff Ware. Sherd of jar, type 15aii[2]. Fragment of shoulder-body carination, wall thickness 8 mm. A ledge is applied to the carination and decorated with impressions simulating a rope. Light brownish paste (Munsell 10 YR 7/3).

0201, Pink Ware. Sherd of bowl, type 1a. Fragment of base, string-cut, wall thickness 8 mm. Pinkish paste (Munsell 5 YR 7/6).

0231, Pink Ware. Sherd of jar, shape type 8. Fragment of shoulder and rim, wall thickness 10 mm. Paste is pinkish at the surface (Munsell 5 YR 6/6), core light brownish.

0362, Green Ware. Sherd of jar, type 5a. Fragment of body, wall thickness 6 mm. Greenish yellow paste (Munsell 2.5 Y 8/4).

0419, Gray Ware. Sherd of jar, type 7 (?). Fragment of ring base, wall thickness 6 mm. Grayish brown paste (Munsell 10 YR 5/2).

0517, Scarlet Ware (Pl. IV.19). Sherd of jar, type 7. Fragment of body, outer surface decorated with a red painted band, wall thickness 8 mm. Buff coloured paste (Munsell 10 YR 7/4).

0518, Scarlet Ware (Pl. IV.11). Sherd of jar, type 7. Fragment of shoulder with red and black painted geometric decoration and a ledge applied to the body/shoulder carination, wall thickness 8 mm. Light brownish paste (Munsell 7.5 YR 8/4).

0580, Scarlet ware (Pl. II). Sherd of jar, type 7 ? Fragment of shoulder with trichrome painted geometric decoration, wall thickness 8 mm. Light brown paste (Munsell 5 YR 7/4).

0900, Modern Pottery (p. 68 Fig. 3). Sherd of a water jar, produced and used recently by the people of Uch Tepe village. Fragment of body, wall thickness 10-15 mm. Light greenish paste (Munsell 2.5 Y 8/2).

Bulk Chemical Analysis

The studied sherds were pulverized, homogenized and subjected to x-ray fluorescence analysis at the Geological Survey of Greenland, Copenhagen. Prior to these analyses, the contents of volatiles were read off the corresponding thermogravimetric analyses. The Fe^{3+}/Fe^{2+} ratio was obtained from wet chemical analyses. Analyses were performed by Ing. J.Kystol.

All sherds display the same compositional pattern: richest in SiO_2 and CaO, closely followed by Al_2O_3, with only moderate amounts of Fe (predominantly as Fe_2O_3) and MgO. Among alkalis, K_2O (with one exception, that of modern jar **0900**) predominates over Na_2O. Low Mn percentages are conspicuous. The most notable variations occur in the Fe^{2+}/Fe^{3+} ratio, where the sample **0362** (Green Ware) and especially **0419** (Gray Ware) differ from the rest by the higher percentage of Fe^{2+}.

The standard compositional triangle for ceramic evaluation, SiO_2 - Al_2O_3 - (Ca+Mg)O, was used (see Noll, 1976, 1978, 1982; and Maggetti 1986). The analytical result of all sherds, as well as that of the palygorskite-smectite clay described below, fall into the category of calcium-rich pastes, within the three-phase field: diopside (wollastonite) - anorthite - SiO_2. The only exception, **0900**, consists of a long-used water jar with all pores completely filled and the surface coated with calcium carbonate precipitated from the evaporated water. Therefore, its true paste composition does not differ from the rest of clays used. The palygorskite-smectite clay reveals high amounts of free calcite as well (Fig. 1).

The results are tightly clustered, with only a small spread along the line of constant weight percentage of Al_2O_3. Their position in the cluster does not appear to correlate with the predominance of chert or limestone in temper or with the total content of temper; i.e., the influence of the latter on total chemical

2. For shape typology see Thuesen 1981. For catalogue and plates see Appendix A p. 121.

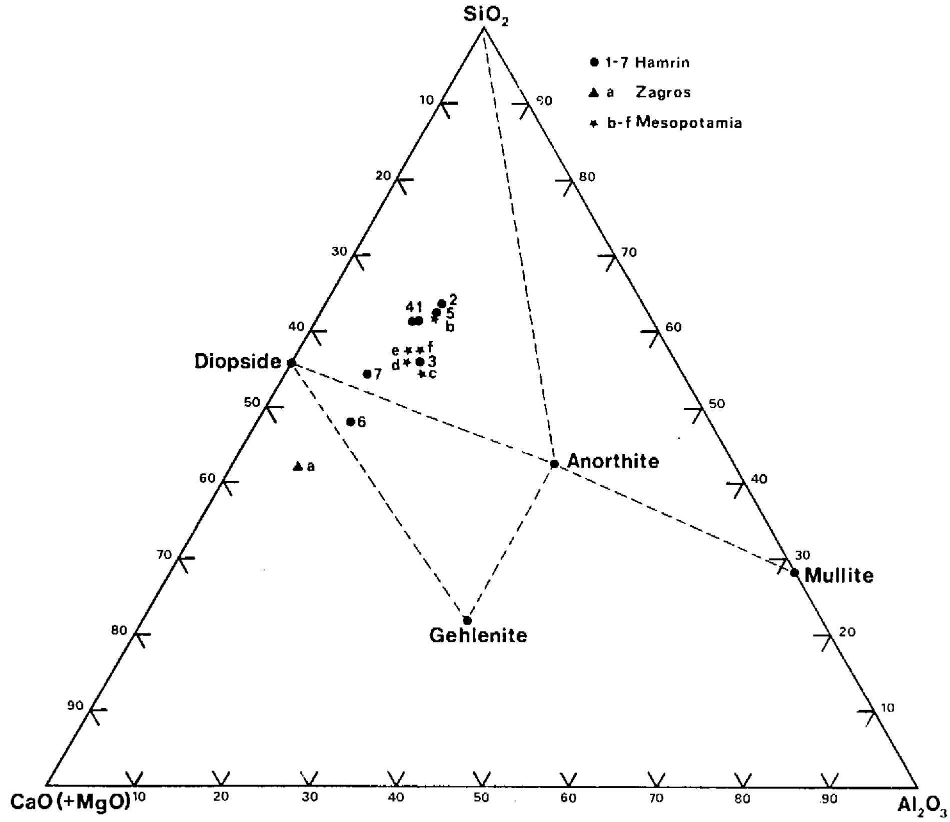


*Figure 1a: Composition of the studied samples in the compositional triangle SiO_2-Al_2O_3-CaO(+MgO). The circles indicate the position of the samples from Uch Tepe (1=***0140***; 2=***0201***; 3=***0362***; 4=***0419***; 5=***0517***; 6=***0900***; 7=**Clay**). The remaining data points represent analyses of material from Tepe Guran, in the Zagros (triangle, a), and from several Mesopotamian occurences (asteriscs, b=Tell Hassuna, c=Samarra, d=Tell Halaf, e=Uruk, f=clay from Seleucia on the Tigris) published by Noll (1976).*

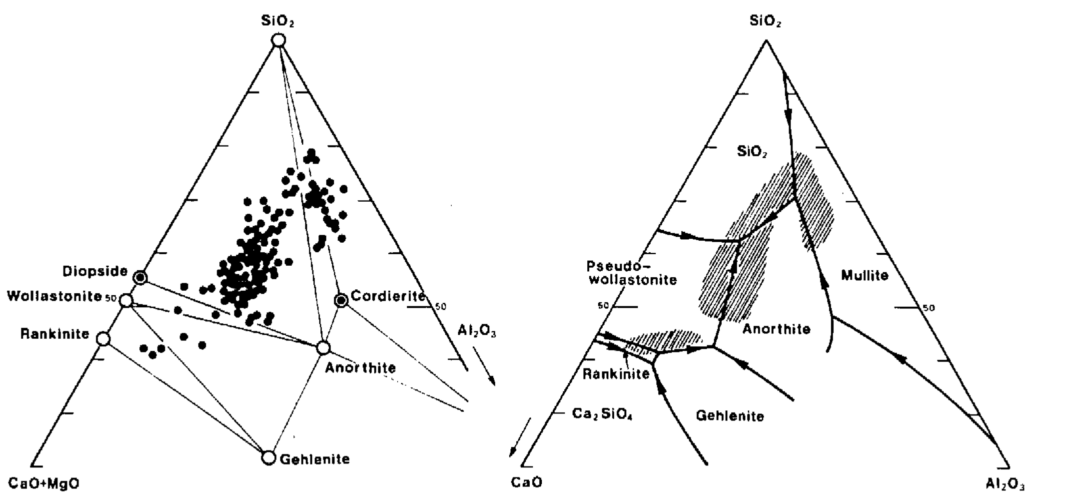


Figure 1b: Composition of 143 analyzed samples of ancient ceramics from various times and cultures plotted in the compositional triangle SiO_2 - Al_2O_3 - (CaO+MgO). Left-hand side: analytical data points in the reference framework of mineral phases; right-hand side: areas with clustering of analytical data points on the background of the liquidous surface of the system CaO - Al_2O_3 - SiO_2 with primary phase fields, boundary curves and eutectic points indicated. The lowermost cluster relates to ceramics very rich in limestone and dolomite temper. Analyses were kindly collected and plotted by Dr. J. Kornerup-Madsen.

	0140	0201	0362	0419	0517	0900	Clay[3]
SiO_2	47.18	47.93	44.62	46.33	50.72	39.00	38.57
TiO_2	.53	.56	.70	.48	.64	.53	.43
Al_2O_3	9.23	10.13	11.58	8.31	11.06	8.28	6.57
Fe_2O_3	3.90	4.29	4.12	2.08	4.73	4.01	2.50
FeO	.54	.56	1.34	1.88	.68	.16	.68
MnO	.09	.10	.07	.07	.10	.07	.07
MgO	3.67	4.53	4.20	3.06	3.91	3.32	3.20
CaO	17.17	12.99	19.51	17.61	15.52	30.50	22.41
Na_2O	1.00	1.12	1.68	.97	1.37	1.12	.63
K_2O	2.22	2.99	1.82	1.80	2.43	.94	1.19
Volatiles	12.133	12.54	8.02	15.63	7.50	10.25	20.07
P_2O_5	.27	.22	.36	.15	.31	.13	.46
Sum	97.91	98.04	97.97	98.43	99.03	98.38	96.82
Sr ppm	545	509	699	476	475	779	525

Table 1: Chemical analyses of selected sherd types and of the palygorskite clay.

composition is minor. Strikingly, all the Mesopotamian pottery sherds analysed by Noll (1976), except for Tepe Guran in Iran outside Mesopotamia proper, are tightly clustered in the same area of the compositional triangle, showing the great uniformity of raw materials used by Mesopotamian potters through time. The possible geological (stratigraphic) reasons for this phenomenon were suggested by Noll (1976), although climatic pedology should be considered as well. As a corollary, it is not possible to separate Mesopotamian pottery into groups based on the bulk chemical composition of the paste.

X-ray Powder diffraction

An X-ray powder diffraction study was carried out on the pulverized bulk samples. Guinier-Hagg cameras, CuK radiation and quartz internal standard were used. This approach was chosen in order to separate as many individual lines as possible in the very complex patterns[4].

In general,the presence of 2 to 3 silicate compounds in substantial amounts obscures the presence of any minor silicate components. Likewise, the technique does not distinguish between the components of the matrix and those constituting the temper of the sherd. Finally, it also includes mineral components deposited in the sample's pores and grooves after burial, if they are present in sufficient amounts.

0140, Buff Ware

Quartz is very prominent, followed by calcite. From the high temperature phases, gehlenite dominates, followed by diopside and perhaps plagioclase.

0201, Pink Ware

In this sherd, quartz and calcite are again of primary importance. The rest of the diffraction lines are best explained by plagioclase, the lines of which possibly mask smaller amounts of other components.

0362, Green Ware

In this sample, diopside, gehlenite and plagioclase, accompanied by calcite, explain practically all the lines of the x-ray diffraction pattern (Table 2). Dr. Gwozdz's powder diffractogram shows that the role of quartz has diminished in comparison with **0517**.

0419, Gray Ware

Quartz and calcite represent by far the most prominent components in this sample. The remaining, much weaker, lines represent plagioclase and, possibly, diopside. Gehlenite, if present, is only in traces. The pattern was checked against a number of possible low-temperature phases (e.g. clay minerals) inherited from the original material. None was found with certainty.

0517, Scarlet Ware

The x-ray pattern suggests that gehlenite, plagioclase and diopside represent the principal silicates in

3. See below p. 59 under *Raw Clay*.
4. A concurrent powder diffraction study of the Hamrin material done by Dr. R. Gwozdz (personal communication) using a powder diffractometer and a multichannel analyser gave ample warnings of the problems to be tackled.

d obs (Å) quartz lines subtracted	**I obs(rel.)**	**Interpretation** (relative line intensities for pure standard patterns are given in brackets)
5.58	2	gehlenite(6)
4.035	2	plagioclase(80)
3.700	2	plag(65),gehl(20),diopside (4)
3.421	3	plag (50)
3.223	3 broad	plag (100),diops (25)
3.184	3 broad	plag (90)
3.103	2	plag (?)
3.071	2	gehl(25)
3.028	3 broad	calcite (100)
2.988	4 broad	diopside (100)
2.946	2 double	diops(25),plag(70)
2.893	2 double	diopside (30)
2.853	5	gehlenite(100),plag
2.565	2 broad	diopside (20)
2.536	3 broad	diops(40),gehl(8),plag
2.511	3 broad	diops(30),plag,calc
2.402	1 double	diops(4),gehl(25)
2.298	1 double	diops(16),gehl(14)
2.222	1	diops(14)
2.207	1	diops(12),gehl(2)
2.088	1	calc
2.038	2	diops(14),gehl(16)
2.019	2	diops(10)
1.7570	3	diops(12),gehl(35)
1.6894	1	-
1.6605	1	diops (16)
1.6312	1	diops(25),gehl(2)

Table 2: Guinier powder diffractogram of the pulverized bulk material. Sample 0362 *- Green ware.*

the sample. They are accompanied by calcite and by substantial amounts of quartz (not detectable in our study, but revealed in powder diffractograms without the quartz internal standard). These principal minerals explain nearly all the lines of the pattern.

Mineralogical analysis of temper components

Polished thin sections were prepared from all the examined types of pottery. Microscopic examination of them was followed by microprobe analyses of individual mineral grains. JEOL Superprobe 733 in either energy-dispersive (Link system) or wavelength dispersive mode was used, with the original on-line correction programs. Silicate and oxide standards were employed.

With a broad spectrum of compositions and polishing properties it cannot be expected that the analyses are of top quality. However, they are accurate enough for positive identification and further classification of mineral components. Many components must have been dehydrated, dehydroxylated, and/or decarbonatized, as well as partly oxidized during sherd firing and were reconstituted to some degree after it, during use and burial. Thus, their optical properties are often obscured by intense brown stain, and the analytical deficits observed may not truly depict the original oxidation states and water (hydroxyl) contents. For all these reasons we refrain from publishing the extensive tables of analytical results for the components of temper and give only the atomic ratios found.

0140 (AL 914), Buff Ware

The thin section reveals a well-tempered sherd, with many contraction fissures and irregular pores parallel to its surface. The sherd has crystalline incrustations on the inner walls of the vessel consisting of gypsum and calcite.

The rock fragments in temper represent: (1) Irregular fragments of chert, fine-grained with mosaic or fibrous texture, with spherulites filling up spherical radiolaria tests; sometimes chert is associated with calcite. (2) Well-rounded grains of fine-grained limestone, occasionally with cross-cutting veins of calcite, groups of calcite crystals and a rare fossil. (3) Spillite with a grainy to fibrous hydrogoethite-stained matrix and feldspar lamellae. (4) Irregular, rather abundant fragments of a quartz-mica (muscovite) schist. (5) Brown, dark-stained pellets, sometimes with dessication textures; on microprobe analysis they indicate higher Si and Al contents (±Ca) and moderate Mg, K, and Fe concentrations. A microprobe analysis of limestone grain shows $Ca_{99}\ Mg_{.5}\ Fe_{.5}$; another one $Ca_{98.9}\ Mg_{1.1}$; another one indicates a high quartz impurity with possible small amounts of clay minerals. A twinned feldspar fragment apparently liberated from spillite consisted of $Ab_{98.5}\ An_{.8}\ Or_{.7}$, another saussuritized feldspar fragment indicates $Ab_{71.3}\ An_{26.8}\ Or_{1.9}$. Feldspar fragments are usually irregular, only slightly rounded on the corners. Chert is chemically very pure, in some cases with attached hydrogoethite. Grains of quartz occur. Rare, small, occasionally rounded grains with vivid interference colours appeared to be epidote with $Fe^{3+}_{62.5}\ Al_{37.5}$ and $Fe^{3+}_{80.9}\ Al_{19.1}$ in species-determining structural sites. Greatest description problems were encountered for the light to dark brown and orange-brown mineral grains with

usually obscured optical behavior. A brown cleavage flake appears to be chlorite ($(Fe,Mn)_{2.61}$ $Mg_{1.75}$ $Al_{1.62}$)($Si_{2.85}$ $Al_{1.15}$); a light ochre grain showed $Mg_{5.25}$ $Fe_{.24}$ ($Si_{3.91}$ $Al_{.09}$), perhaps a phyllosilicate; another brown grain with a fibrous appearance in transmitted light might be chlorite ($Fe_{2.08}$ $Mg_{2.11}$ $Al_{1.81}$) ($Si_{2.99}$ $Al_{1.01}$); a rounded cleavage flake is a titaniferous biotite ($K_{.73}$ $Ca_{.10}$ $Na_{.08}$)($Fe_{1.56}$ $Mg_{.96}$ $Ti_{.22}$ $Al_{.24}$ $Mn_{.02}$) ($Si_{2.78}$ $Al_{1.22}$) and, finally a small red-brown grain might be a fragment from the altered spillite matrix, recalculated here as a "trioctahedral K-Mg vermiculite" ($K_{.31}$ $Na_{.13}$ $Ca_{.07}$ $Mg_{.36}$)($Mg_{1.81}$ $Fe_{1.11}$ $Mn_{.03}$ $Ti_{.02}$) ($Si_{2.73}$ $Al_{1.27}$). An opaque grain with fine exsolution lamellae in reflected light had the composition of impure titanomagnetite with 6.53 wt % TiO_2.

0201 (AL 915), Pink Ware

The sherd is very rich in temper. At the same time, it has many irregular, sometimes interconnected cavities which might stem from burnt-out chaff. Sample colour is light brown.

Temper contains mostly angular fragments of chert, in lesser amounts than **0231**. Spherulitic structured chert was found as well. The principal component of the temper, however, is the rounded grains of fine-grained limestone, rarely intergrown with chert. Furthermore, abrasion-rounded single crystals of calcite and grains of limestone with calcite veinlets or crystals are fairly abundant.

Grains of quartz with undulose extinction are fairly abundant. Fragments of polysynthetically twinned, saussuritized feldspars and, occasionally, of feldspars with microcline-like "tartran pattern" twinning occur in the section. Fragments of other minerals are less common.

Typically the grains of both limestone and chert contain impurities of Mg, Al, Si, Fe, K, Na; whereas the carbonate pellets altered and shrunk on firing, have the composition $Ca_{99.2}$ $Mg_{.8}$.

Dark aggregates of this type indicate calcite, quartz and admixtures of the above spectrum of elements. The analysed feldspar grain consists of $Ab_{49.6}$ $Or_{1.8}$ $An_{48.7}$.

Among the coloured minerals, a very small brown fragment can best be identified as Mg-K vermiculite ($Mg_{.35}$ $K_{.22}$ $Na_{.06}$ $Ca_{.07}$) ($Mg_{2.00}$ $Fe_{.75}$ $Al_{.23}$ $Mn_{.02}$ $Ti_{.01}$) ($Al_{.98}$ $Si_{3.03}$); a red-brown pellet has a similar composition; whereas small crystal fragments appear to be diopsidic augite $Ca_{3.1}$ $(Mg,Fe)_{4.8}$ Si_8, with a minor amount of Na and Al present, and epidote $Fe^{3+}_{84.7}$ $Al_{13.7}$ $Mn_{1.7}$.

0231 (AL 916), Pink Ware

The sherd has a compact paste with small temper grains evenly distributed, reddish on the surface, light brown in the interior. Pores are nearly absent.

The most abundant component of the temper is angular, or only slightly rounded, grains of chert (mosaic-like, occasionally also spherulitic structures filling radiolarian tests), sometimes intergrown with light brown or green parts which represent limestone ($Ca_{98.8}$ $Mg_{1.1}$ measured on one grain). Less abundant are rounded to irregular grains of fine-grained limestone. Partly rounded pellets with deep brown to black colour occur, baked to a translucent red close to the surface of the sherd.

Among mineral grains, irregular twinned feldspar grains occur, a muscovite grain ($K_{.74}$ $Na_{.20}$) ($Al_{1.82}$ $Fe_{.07}$ $Mg_{.05}$ $Ti_{.03}$) ($Si_{3.09}$ $Al_{.91}$) was found, as well as rounded clinozoizite-epidote grains ($Al_{68.5}$ $Fe^{3+}_{30.1}$ $Mn_{1.5}$ and $Al_{69.0}$ $Fe^{3+}_{30.7}$ $Mn_{.3}$) and a grain of Ca-Mg amphibole (tremolite) with small contents of Na, Al and Fe, ($Ca_{1.89}$ $Na_{.11}$) ($Mg_{4.54}$ $Fe_{.22}$ $Ti_{.02}$ $Mn_{.02}$) ($Al_{.13}$ $Si_{7.74}$).

0362 (AL 917), Green Ware

Temper consists of a rather fine-grained sandy fraction. Pores are fairly rare, extended parallel to the sherd walls. The paste contains several pellets of irregular hydrogoethite-stained material (with dark irregular cores), shrunk on firing. It also contains pellets of greenish groundmass with a small temper content, sometimes dessicated and cracked on firing.

Fine grained calcite ($Ca_{94}Mg_6$ measured) and gypsum line or fill cavities probably created by the burning of limestone grains. A layer of groundmass was sometimes detached from the cavity wall on firing. Often these portions are deep brown and fine-grained.

While limestone as a rule did not survive firing, small irregular grains of fine-grained chert are as common as in the other sherds studied. Besides irregular detrital grains of quartz and partly twinned feldspars, small brown grains with indistinct optic characteristics occur. These brown grains appear to have the composition of a "dioctahedral Si-rich mica" (in two cases): ($K_{.80}$ $Na_{.23}$ $Ca_{.02}$)($Al_{1.58}$ $Mg_{.17}$ $Fe_{.12}$ $Ti_{.02}$) $Si_{4.07}$; of an unidentified silicate ($Ca_{1.92}$ $Na_{.08}$ $K_{.01}$) ($Al_{.95}$ $Fe_{.76}$ $Mg_{.57}$ $Ti_{.02}$ $Mn_{.01}$) ($Si_{3.69}$ $Al_{.31}$), or of a presumed phyllosilicate mixture ($Na_{.31}$ $K_{.21}$ $Ca_{.11}$) ($Fe_{1.10}$ $Mg_{.31}$ $Al_{.18}$ $Ti_{.01}$ $Mn_{.09}$) ($Si_{3.26}$ $Al_{.74}$) in other cases.

0419 (AL 918), Gray Ware.

The polished thin section reveals a well-tempered to richly-tempered paste, with several extended fissures parallel to the surface.

Chert is represented by irregular fragments. It is fine-grained with coarser crystallized portions, sometimes intergrown with calcite. Spherulite aggregates also occur, either in an unorganized fibrous rock or as loose radiolaria fillings. Grains of carbonates give an impression of having been destroyed on firing and reconstituted later. However, remnants of single crystals of calcite (e.g. $Ca_{98.5}Mg_{1.5}$) partly torn out of the section during polishing occur as well.

Fragments of spillite occur, with brownish and opaque minerals in a matrix intensely stained by hydrogoethite and with laths of plagioclases. Much rarer are fragments of layered rocks (biotite and quartz) as well as dark brown pellets. Among mineral fragments, only slightly rounded, angular, partly saussuritized feldspars occur ($Ab_{45.2}$ $An_{54.8}$, $Ab_{42.4}$ $An_{57.6}$, $Ab_{73.5}$ $Or_{1.5}$ $An_{25.0}$, $Ab_{58.6}$ $Or_{2.4}$ $An_{39.0}$) together with relatively rare grains of quartz and other minerals. Calcite microfossils occur loose in the matrix of the sherd, with single round chambers or with strings of such chambers.

Spillite feldspars represent $Ab_{85.3}$ $Or_{2.1}$ $An_{12.6}$ (edge of lamella); $Ab_{92.1}$ $Or_{4.6}$ $An_{3.3}$, $Ab_{98.2}$ $Or_{.3}$ $An_{15.8}$, $Ab_{98.1}$ $Or_{.5}$ $An_{1.4}$, and $Ab_{97.3}$ $Or_{.1}$ $Ca_{2.6}$. Measurements such as $Na_{71.0}$ $K_{20.6}$ $Ca_{8.4}$ and $Na_{43.2}$ $K_{44.2}$ $Ca_{12.7}$ show that parts of feldspars underwent zeolitization during the spillitization process. In the brown matrix, hornblende ($Ca_{1.84}$ $Na_{.13}$ $K_{.01}$) ($Mg_{4.17}$ $Fe_{.71}$ $Mn_{.02}$ $Ti_{.01}$) ($Si_{7.56}$ $Al_{.41}$) was found as well as diopsidic augite $Ca_{.88}$ $Na_{.05}$ $Mg_{.83}$ $Fe_{.20}$ $Ti_{.02}$ $Mn_{.08}$ $Al_{.10}$ $Si_{1.91}$ and altered groundmass which can be best identified as vermiculite $(K,Na,Ca)_{.06}$ $Mg_{.28}$ ($Mg_{2.00}$ $Fe_{1.12}$ $Ti_{.03}$)($Al_{1.61}$ $Si_{2.29}$), or close to this, mixed with Ca minerals; another as $K_{.12}$ $Na_{.10}$ $Ca_{.06}$ $Mg_{1.45}$ $Fe_{1.57}$ $Mn_{.01}$ $Al_{.02}$ ($Si_{2.25}$ $Al_{1.75}$).

Another type of spillite-like fragments consists of crystal laths with green interstitial minerals. The laths turned out to be clinozoizite-epidote with anomalous interference colours ($Al_{59.8}$ $Fe^{3+}_{39.3}$ $Mn_{1.0}$ and ~ Fe_{99} Mn_{1} in species-determining sites) whereas the green component is quartz stained with impurities (chlorite?).

Among fragments of independent minerals, colourless alteration products ($Na_{1.98}$ $Ca_{.22}$ $Al_{2.97}$ $Si_{9.16}$) associated with the feldspar ($Na_{91.6}$ $K_{1.1}$ $Ca_{7.3}$) (apparently related to spillite formation), biotite ($Na_{.08}$ $K_{.77}$ $Ca_{.25}$) ($Mg_{1.00}$ $Fe_{1.44}$ $Ti_{.24}$ $Mn_{.01}$ $Al_{.31}$) ($Si_{3.19}$ $Al_{.81}$), and almost pure andradite ($Ca_{4.02}$ $Na_{.06}$ $Mg_{.10}$ $Al_{.10}$ $Fe_{2.55}$ $Ti_{.04}$ Si_4O_{10}) were identified.

0517 (AL 923), Scarlet Ware.

This sherd is distinctly more tempered than the green ware. The temper (sand fraction) is coarser as well. Fragments of chert are abundant, with both the mosaic and radially fibrous texture. They contain spherical radiolaria with clear or limonite-coloured cavity fillings. Some chert fragments are coloured, especially by hydrogoethite. Most abundant are grains of fine-grained limestone, grayish-brownish in thin section, analogous to those observed in other sherd types. In some cases, "shrunk" fillings of perhaps originally carbonate grains, burnt away on firing and partly reconstituted afterwards, are observed. Furthermore, the temper contains grains of quartz with mosaic extinction, fragments of feldspars (the measured fragment indicates $Ab_{56.8}An_{41.1}Or_{2.1}$), fragments and pellets of various brown mineral grains and aggregates. A turbid fine-grained fragment of this category with aggregate polarization gave the composition recalculable as chlorite with the cation distribution: ($Fe_{1.99}Mg_{2.89}Al_{1.10}Mn_{.02}$) sum = 6 ($Si_{3.55}$ $Al_{.45}$) sum = 4. A brownish cleavage piece with oblique extinction, typical of several such fragments, represents a Ca-(Mg,Fe) amphibole with a minor amount of Na: ($Ca_{.78}$ $Na_{.11}$ $K_{.01}$ $Fe_{.10}$ $Mn_{.01}$) ($Mg_{.86}$ $Fe_{.62}$ $Al_{.04}$ $Ti_{.02}$) ($Si_{3.88}$ $Al_{.12}$). Finally, a rounded lamella corresponds perhaps to a phyllosilicate with the composition ($Mg_{5.92}$ $Fe_{.44}$) Si_4.

Scattered throughout the sherd are fragments of rock material with brown to blackish-brown matrix, with or without lamellar crystals of feldspar. This material appears to be spillite. For the twinned feldspar lamellae, the compositions $Ab_{93.9}$ $An_{4.9}$ $Or_{1.1}$ and $Ab_{96.3}$ $An_{2.3}$ $Or_{1.4}$ were obtained. The nature of the hydrogoethite-stained matrix cannot be ascertained: two analyses can be conveniently recalculated as "trioctahedral K-Mg vermiculite" (and not pure celadonite) and apparently they represent a mixture of phyllosilicates: ($K_{.36}$ $Na_{.13}$ $Ca_{.02}$ $Mg_{.32}$) ($Mg_{2.00}$ $Fe_{.90}$ $Al_{.10}$) ($Si_{2.37}$ $Al_{1.63}$) and ($K_{.26}$ $Na_{.08}$ $Ca_{.05}$ $Mg_{.31}$) ($Mg_{.94}$ $Fe_{2.03}$ $Mn_{.03}$) ($Si_{2.32}$ $Al_{1.70}$). Grains with high birefringence in the matrix represent TiO_2; opaque grains (pink in reflected light) are a slightly titaniferous magnetite (1.56 wt % TiO_2); and grains with high birefringence, enclosed in the feldspar lamellae represent sphene, $CaTiSiO_5$. The entire assemblage illustrates movement of elements in the spillitization process.

0900 (AL 919), Modern Ware

Paste is very porous; pores mostly originate from burnt-out chaff and have elongated, curved and triangular cross-sections. They also display clayey fill of cavities, which were present in the original plant fragments.

The pores are lined with rich druses of crystals with triangular cross-sections and high birefringence, growth zones, and very good cleavage. These uniaxial

crystals consists of calcite, which is to be expected, as the original jar served as a porous, water-storage cooling container.

Little tempering is evident, except for the abundant fine-grained fraction. This consists primarily of chert with fine- to medium-grained structure; a few larger fragments are present as well. Abundant minute quartz grains, rare feldspars, and hydrogoethite-coloured particles which sometimes stain the surrounding matrix, are also present. The latter may either represent an oxide grain ($Fe_{18.4}$ $Mg_{1.8}$ $Al_{1.2}$ $Ti_{.6}$, Mn absent), or Fe-Ca-Si (Al) rich mixtures, impure titano-magnetite (1.1 wt % TiO_2), or brown silicate grains, $Ca_{1.38}$ $(Na,K)_{.05}$ $Mg_{4.60}$ $Fe_{.44}$ $Mn_{.01}$ $Al_{.06}$ $Si_{3.94}$ and $Ca_{2.71}$ $(Na,K)_{.08}$ $Mg_{3.30}$ $Fe_{1.79}$ $Mn_{.05}$ $Ti_{.01}$ $Al_{1.94}$ $Si_{3.77}$. Another silicate grain, with vivid interference colours, indicates $Ca_{3.43}$ $Na_{.02}$ $Mg_{3.33}$ $Fe_{1.12}$ $Mn_{.04}$ $Ti_{.03}$ $Al_{.12}$ $Si_{7.92}$ with no analytical deficiency to indicate structural H_2O or OH, i.e., diopsidic augite.

Differential thermal analysis

Differential thermal analyses were performed on pulverized sherd material which was also used for bulk chemical analyses. Charges of 0.3-0.4 gram were used, rate of temperature rise was 10° C/minute. The DTA curve as well as the thermogravimetric curve, TG, and its derivative, DTG, were recorded with linear rising temperature.

Sample **0140**, Buff Ware (Fig. 2). The pinkish-orange powder released water in a complex drawn-out endothermic reaction (85-200° C), with principal water releases at 85° C and 185° C (2.4 wt %). Afterwards, a drawn-out weight loss (10.4 wt % till its end at 880° C) started which culminated with a small endothermic maximum at ca. 715° C and a pronounced one at 850° C. The subsequent small weight loss culminated at the endothermic aximum at 1190° C. No subsequent reaction above 1200° C was observed.

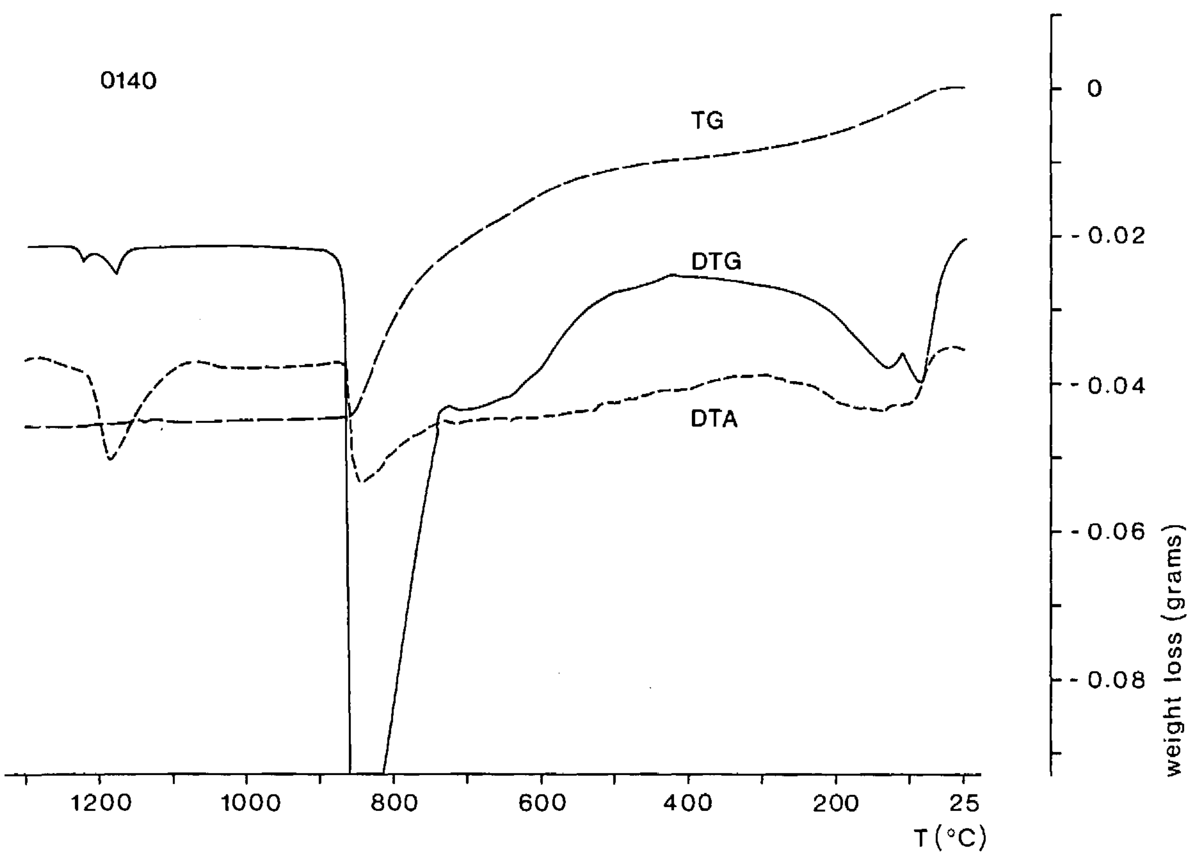


Figure 2: Differential thermal analysis of pulverized sherd material, from sample **0140**, *Buff Ware. DTA curve represents temperature difference between the sample and an inert standard (Al2O3) at given temperature; the TG curve indicates cumulative weight loss on heating and the DTG curve its first derivative. Linear temperature and weight-loss scales are employed. Endothermic reactions have DTA peaks oriented downwards, exothermic reaction upwards.*

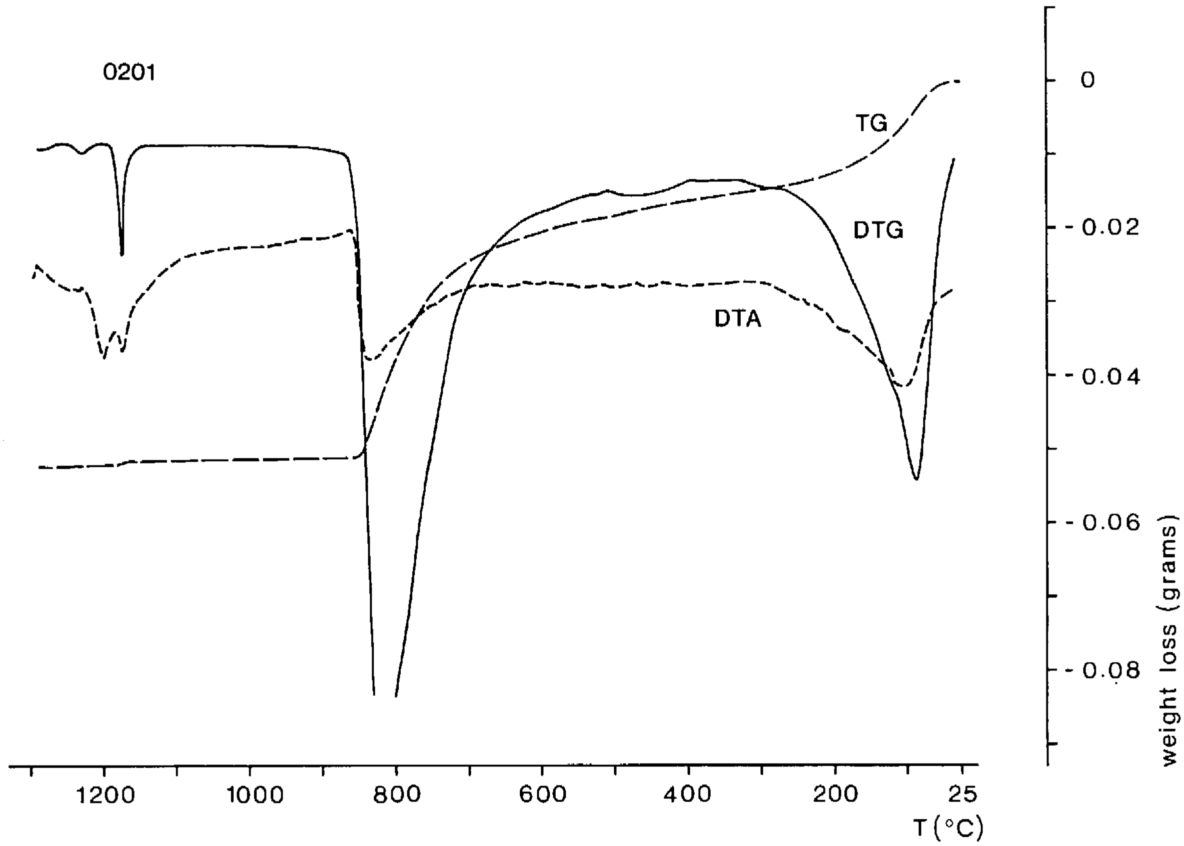


Figure 3: Differential thermal analysis of sample **0201**, *Pink Ware (see also Figure 2).*

Sample **0201**, Pink Ware (Fig. 3). The orange-pink powder released water in a single strong reaction (108° C) with small subsidiary reactions at 200 and 260° C. It represented a loss of 4.6 wt % by 410° C. The next pronounced reaction set in slowly, with a peak at 848° C. The weight loss at its end at 870° C was 10.0 wt %. After this, the weight loss was minimal, culminating in an endothermic reaction at 1190° C, followed by another at 1212° C.

Sample **0362**, Green Ware (Fig. 4). The buff powder released variously bound H_2O during the complex endothermic reaction (97, 130 and 195° C, end of reaction at 300° C). The loss slackened at 420° C, the total loss until this point being 3.4%. At 420° C the previous weight loss already overlapped with another one, culminating in an endothermic reaction at 768° C, with a shoulder at 720° C. 5.1 wt % was lost in this endothermic reaction which ended at 810° C. The most pronounced endothermic reaction occurred at 1155 and 1182° C, the first sub-peak being connected with a further loss (.5 wt %).

Sample **0419**, Gray Ware (Fig. 5). The brownish-gray material released H_2O in a broad maximum with a peak stretching from 85 to 180° C. Until the slackening in weight loss at 228° C, 2.1 wt % was lost. At this temperature, the remaining water loss overlapped with a weight loss from the burning organic material which reached its peak at 327° C. This process lasted until 560° C, with the total weight loss representing 4.3 wt %. Again, at this temperature a small slackening but not a stop in weight loss occurred, at which point the next weight loss process connected with an endothermic reaction peaking at 837° C (a shoulder at 720° C) assumed a principal role. Until the end of this process, at 855° C, 10.0 wt % was lost. Afterwards a slight continuous weight loss occurs, accentuated just below 1200° C in connection with an endothermic reaction.

Sample **0517**, Scarlet Ware (Fig. 6). The pinkish-buff material released water in a single endothermic reaction beginning at 110° C (a slight shoulder at 200° C). Until 295° C it lost 2.9 wt %. The principal weight loss of 5.2 % was connected with two very broad endothermic reactions, at 570 and 745° C, respectively. The last part of the heating curve displays an endothermic maximum at 1140° C, connected with a weight loss of 1.1 wt %, followed immediately by another maximum at 1190° C, this time without a weight loss.

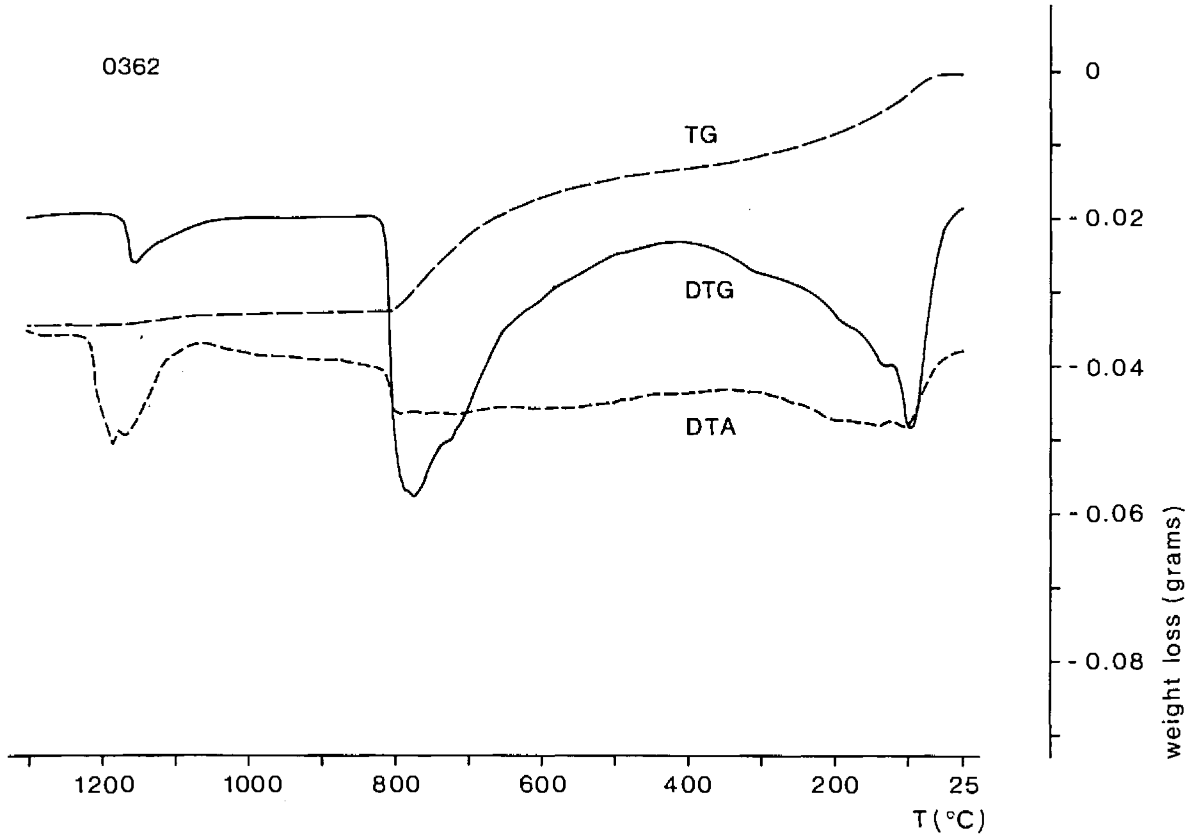


Figure 4: Differential thermal analysis of sample **0362**, *Green Ware (see also Figure 2).*

Sample **0900**, Recent Pottery (Fig. 7). The buff powder released variously bound H_2O in two stages at 110° C and 143° C on the DTA curve, with further minor loss at ~ 270° C. Until 405° C, when the weight loss slackened, 2.9 % of original weight was lost. Another pronounced weight loss occurred at 820° C, with a smaller one preceeding it at 715° C. It made up 8.0 wt % by the end of reaction at 850° C. A continuous weight loss occurred afterwards, until a sharp endothermic reaction at 1220° C took place.

Optical and Scanning Electron Microscopy of the Paste

For optical studies, polished thin sections of standard thickness were prepared from the principal sherd types. The same sections were used for the analysis of temper components.

Scanning electron microscope studies were performed on fresh, gold-coated fragments of the same material using the microscope available at the Institute of Historical Geology & Paleontology of the University of Copenhagen. Because of the well-known incompatibility of high-quality imaging with the adjustments required for energy-dispersive semiquantitative analyses, the majority of scanning work could not be directly accompanied by analytical data. Thus, interpretation of some photographs must remain tentative to some extent. S.E.M. studies give the best answer on the degree of sintering of the paste as well as on its relationships with the non-plastic components.

Buff Ware, **0140**

Well-tempered sherd with 10 to 25 % non-plastic components, depending on the cut-off value chosen to define the temper, which is very variable in grain size. Both the largest and smallest grain categories occur in high quantities. The former category is the coarsest of all the samples studied.

Several instances of shrunken clay pellets, or perhaps of burnt-out chaff imprints with clay cores, occur; it is impossible to classify them with certainty. The groundmass is brown, filled with small mineral grains. Its grainyness is closest to the sample **0517**. Clear cases of partly decomposed limestone grains appear in this thin section.

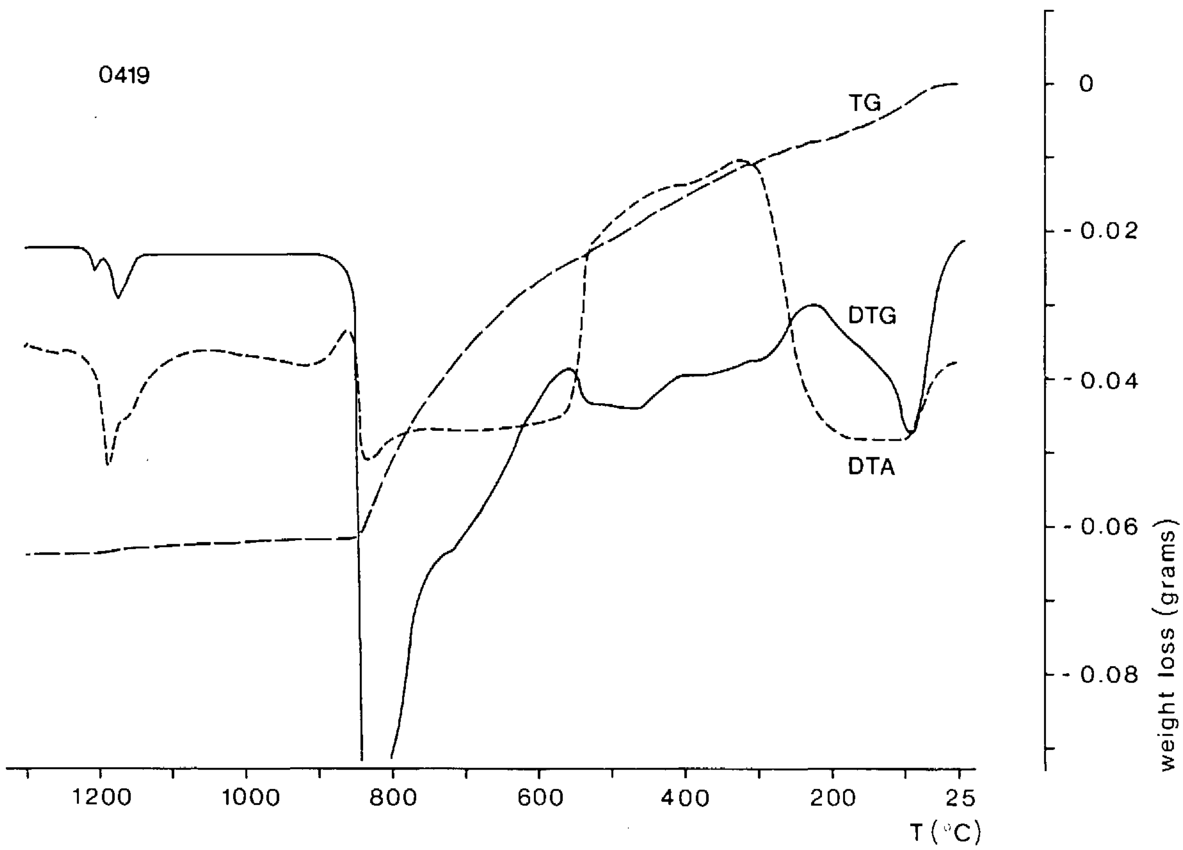


Figure 5: Differential thermal analysis of sample **0419**, *Gray Ware (see also Figure 2).*

The sherd contains abundant hair-like, wavy fissures of variable length, all parallel to the walls and mostly open. They were apparently formed during working of the richly tempered paste. A smaller number of rounded pores appear as well.

Pink Ware, **0201**

Optically, the light brown paste contains at least 20-25% non-plastic components of variable grain size, evenly distributed over the thickness of the sherd. Clay pellets are absent; smaller amounts of lobed or oval pores with very irregular clayey cores (probably imprints of burnt-out chaff which had clay pressed into their cavities) occur together with (usually healed) hair-thin cracks parallel to the surface.

S.E.M. shows that the degree of sintering is moderate and the original texture and fissures and irregular cavities of the clay material are still present (Fig. 8).

Pink Ware, **0231**

The light brown core has turned pink on both surfaces of the sherd. It is compact, "temper" (5-10%) is represented by mostly smaller grains evenly distributed in the matrix. Pores are rare; some contain clay remnants and might represent chaff imprints. Clay pellets are absent. No S.E.M. study of this sample was performed.

Green Ware, **0362**

Optically, the fine grained homogeneous paste of brownish green colour contains small amounts of elongated pores with rounded outlines. Rarely, narrow pores, more-or-less parallel to the walls of the vessel, occur. Tempering constitutes about 10% of the sherd mass; several clay pellets with little or no temper, and usually more iron-rich than the matrix (intense green to brown), shrank and detached themselves from the walls on firing; they occur all over the sherd. Some calcite/limestone grains appear to be partly decomposed and detached from the walls on firing, often with a shell of detached matrix lining their cavity. In S.E.M. photographs, the paste is dense, with only small pores (Fig.9a) and several larger, irregular cavities. Degree of sintering is medium to high as can be ascertained from the coating of fused material on branched relics in the cavities (Fig.9b). Even crystals growing into the cavity appear coated in this way (Fig.9c).

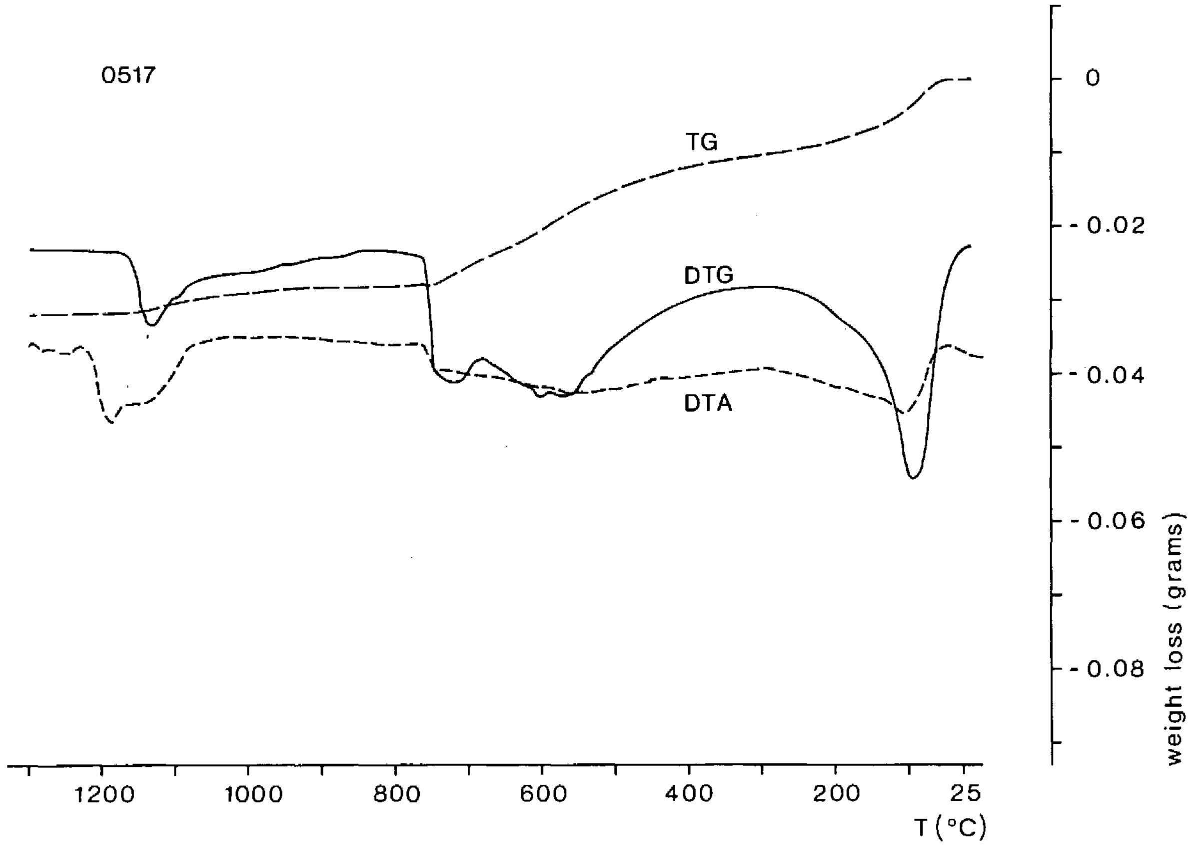


Figure 6: Differential thermal analysis of sample **0517**, *Scarlet Ware (see also Figure 2).*

Gray Ware, **0419**

S.E.M. photographs show that this sample is locally well sintered, with fused partitions of the cellular structure and coating of small crystals in the pores and cavities (Fig.10a). Other areas appear to preserve some original features of the clay paste, e.g., casts of plant (chaff) remnants (Fig.10b), and the flaky character of clay (Fig.10c) as well as the compact character of the paste.

Scarlet Ware, **0517**

Optically, the paste is brown, compact and fine-grained with only small percentage of elongated, rounded to lobed pores. The amount of temper (of very variable grain size) reaches ca. 20%. Pellets of older clay incorporated in the matrix are very rare. S.E.M. studies reveal sintered, temper-rich paste with the original texture of clay partly preserved (Fig.11a). Voids are lined with small crystals among which needles of gypsum appear (Fig.11b). Partly dissolved (?) calcite grains can occasionally be observed with a complex system of cavities and secondary phases present (Fig.11c).

Scarlet Ware, **0518**

This other sample of Scarlet Ware, used for paint studies, shows paste as least as sintered as in **0517** (compare **0517** and Fig.12b) with large, elongated pores present (Fig.12a). This cellular texture occurs especially under the outer (painted) and inner (slipped) surfaces of the vessel (Figs. 21b and c). The above pores are accompanied by a series of narrow wavy pores, parallel to the vessel walls and clearly connected with the rolling of mineral grains in the pot-making process (Figs.12a-b). Plant remnants (clay-filled stalks, chaff (?)) were incorporated into the clay mass as well, yielding crystal-coated cavities after firing (Figs. 12c-d). Temper grains, sometimes partly dissolved, are abundant (Fig.12e). Increased porosity under both surfaces of the sherd is very typical.

Scarlet Ware, **0580**

S.E.M. photographs show that the sherd has a cellular texture. It is filled with irregular pores of various sizes, both sinous and isometric ones. Matrix is sintered to a considerable degree, with the fused partitions (walls) covered by fine-grained crystallites (?)(Fig.13a). Locally, flaky character of the original material can still be observed (Fig.13b). Temper grains are well accommodated in the paste, they are both micaceous (Fig.13d) and fragmentary in character (Fig.13d). Partial decomposition of calcite and

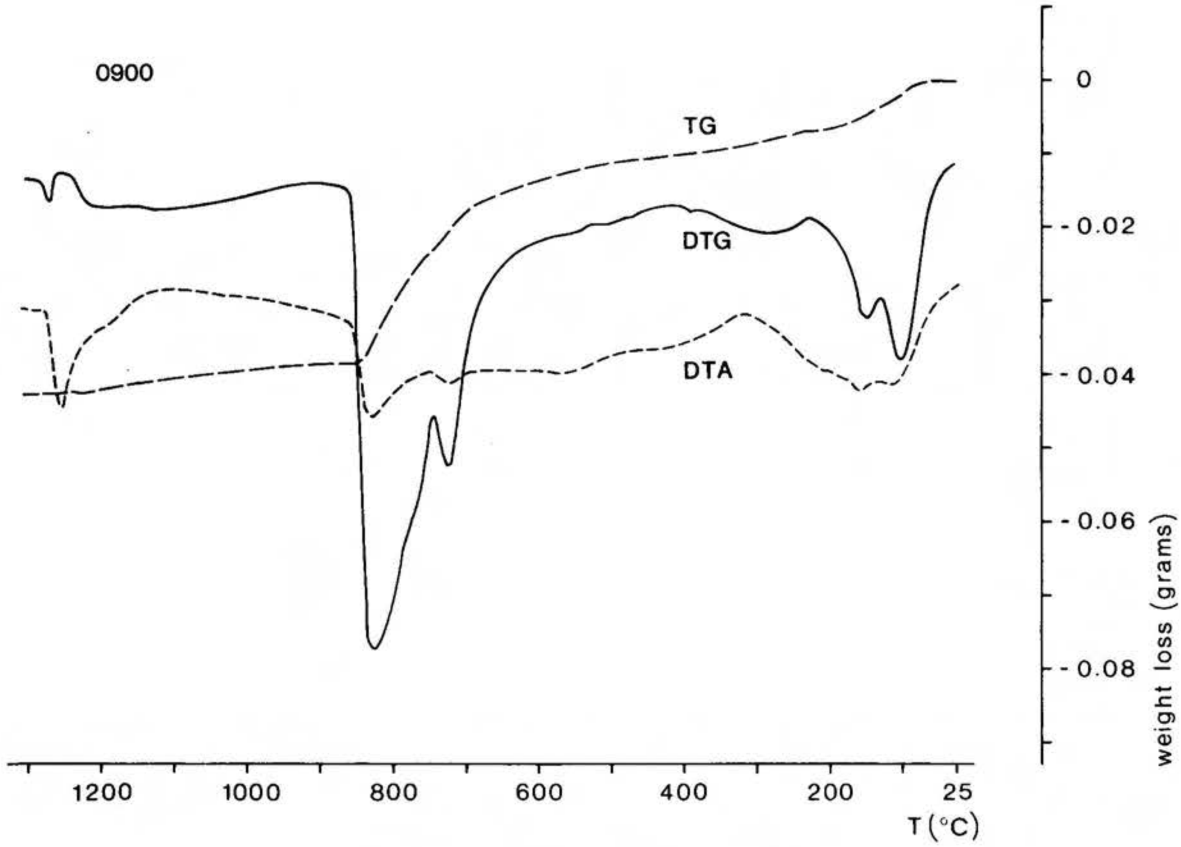


Figure 7: Differential thermal analysis of sample **0900**, *Modern Pottery (see also Figure 2).*

Figure 8: Texture of the matrix of the sample **0201** *at 4,250x magnification. Original textural features of the paste are still preserved. S.E.M. photograph, gold coating.*

filling of cavities by secondary calcium minerals can be observed (Figs.13d and e).

Modern Pottery, **0900**

The sherd is very porous; irregular to oval pores alternate with extended narrow and curved, curled-up, multiple-lobed, bent, or triangular pores. Some pores of the first category contain irregular clay fillings. The majority of pores clearly come from very abundant chaff incorporated into the paste in order to produce a very porous, permeable vessel after firing.

The matrix is gray-brown, optically dense to opaque and "flow-textures" produced around non-plastic particles are common. The amount of "temper" is low (5-10%) and it might represent original components of the natural clay material. Clay pellets have shrunk on firing occasionally; the spaces thus created, as well as almost all the pores, are filled with crystals or aggregates of secondary calcite formed by water evaporation. A thick, fine-grained evaporation crust covers the outer wall of the sherd.

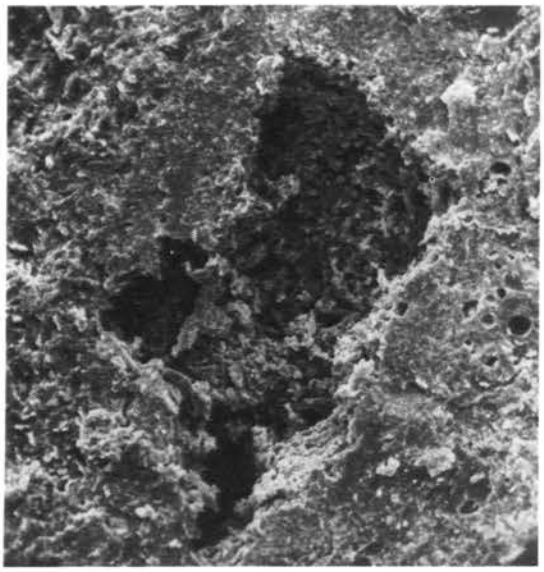


Figure 9a: Dense, sintered matrix of Green Ware sample **0362** *with a cavity lined with branched, well-fused outgrowths. S.E.M. photograph, gold coating, magn. 425x.*

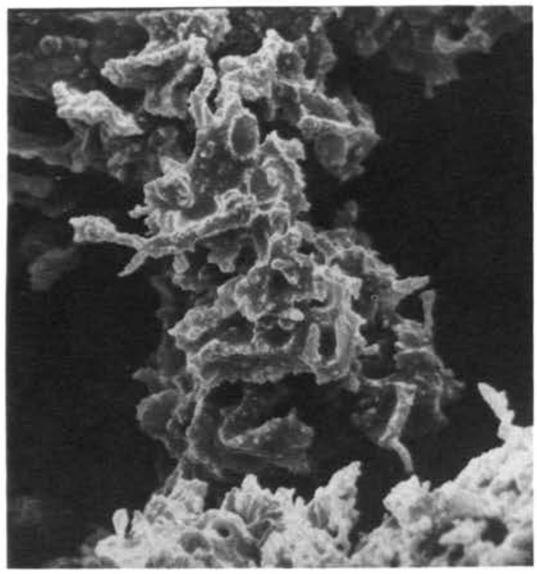


Figure 9b: Sintered branched aggregates in a cavity of the sample **0362** *covered with a fused surface layer. Magn. 1,360x.*

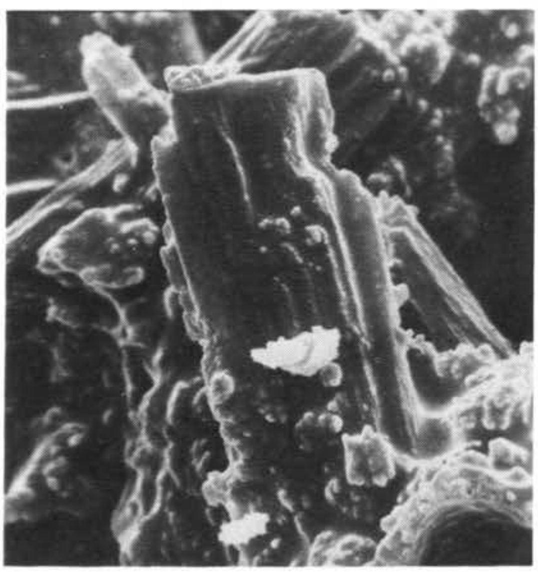


Figure 9c: Flat crystals in a matrix cavity of the sample **0362** *covered with a fused layer and small crystallites. Magn. 4,250x.*

Conclusions

Bulk chemical composition

The bulk chemical composition of all Tell Razuk earthen ware examined as well as those of other Mesopotamian occurences lie closely aligned parallel to the eutectic cocrystallization curve for anorthite and wollastonite (diopside) in the phase triangle CaO(+MgO) - Al_2O_3 - SiO_2 (Fig. 1a). Their compositions richest in Si (**0201**) are at the ternary eutectic point SiO_2 - wollastonite - anorthite (or the quaternary eutectic point SiO_2 - anorthite - wollastonite - diopside). We can expect that these compositions, besides having the right plasticity, represent also the compositions with the best sintering properties (aided by the small contents of alkalies, Table 1) and subsequent chemical/mechanical properties.

Thus, perhaps by a combination of favorable natural compositions and conscious experimentation, the Mesopotamian potters arrived at the optimal pottery composition already soon after 6000 BC (Noll 1976) and preserved this achievement through the subsequent millennia. Unfortunately, from Noll's (1976) data it is not possible to extract complete information on the paste and temper compositions,

Figure 10a: Well sintered, rather compact paste of the Gray Ware sample **0419** *with crystallites in pores. S.E.M. photograph, gold coating, magn. 4,250x.*

Figure 10b: Chaff impressions in the dense, sintered paste of the sample **0419**. *Magn. 1,700x.*

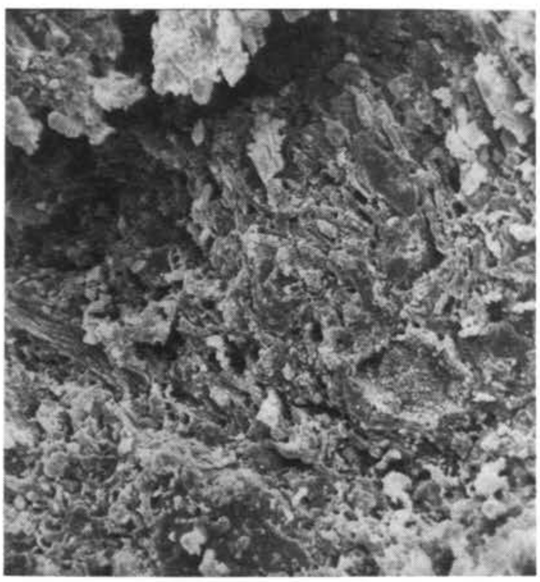


Figure 10c: Sintered paste of the sample **0419** *still preserving the original small cavities and flaky character of the clay paste. Magn. 1,700x.*

and their volume ratio, for the highly calcareous Tepe Guran sample that predates this development.

If we continue to examine the most ancient pottery occurrences of the Old World, according to Noll (1978) a sample from a predynastic Nagade II stratum from Egypt (about 3200 BC) already belongs to a well sintered Ca-rich earthen-ware. However, it is followed by a long history of Ca-poor unsintered or weakly sintered ceramics, until the times of 18-19th dynasty when Ca-rich wares reappear among Egyptian decorative ceramics (Noll 1978). All of these again fall into the region of technologically most favourable compositions. With Noll's research concentrated upon the decorated, "representation" wares, we can hypothetize overall dichotomy in the ceramic production throughout Egyptian history: the well-sintered Ca-rich and the unsintered or weakly sintered Ca-poor wares were probably produced contemporaneously, respectively from Ca-rich clays and from Nile mud (Noll 1978). Probably some of Egyptian culture centres were so positioned that they had no choice but to use the less favorable clay from the Nile.

In the third ancient cultural area, Crete (Noll 1982), the Neolithic potters used either Ca-poor or highly calcareous material; both remain unsintered, fired at low temperatures. The Ca-rich character of the latter category appears to be due to very abundant limestone and dolomite temper. Early Minoan wares (about 2600 BC) concentrate between the ternary eutectic SiO_2 - anorthite - mullite and the ternary eutectic SiO_2 - anorthite - wollastonite (diopside). However, according to Noll (1982) from Early Minoan III through Middle Minoan (i.e. from before 2000 BC. onwards) and especially in Late Minoan, the picture stabilizes into the same area of ternary field wollastonite (diopside) - anorthite - SiO_2 as do the Mesopotamian samples.

The comparisons were not extended to younger cultures (e.g. Greece, Rome, Carthage or central and

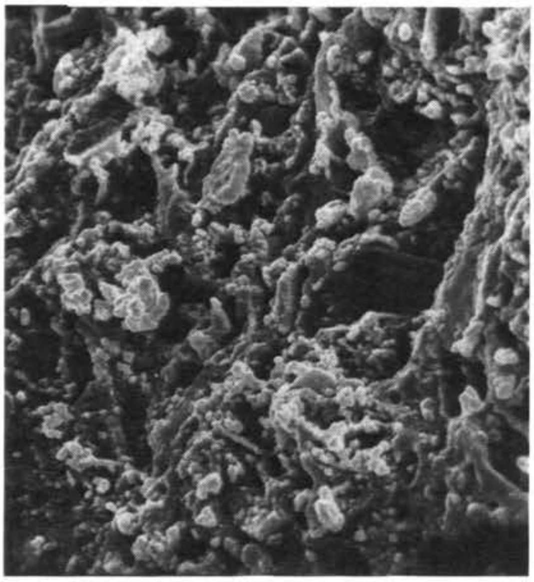


Figure 11a: Sintered matrix of Scarlet Ware sample **0517** *with original texture of clay partly preserved. S.E.M. photograph, gold coated, magn. 4,250x.*

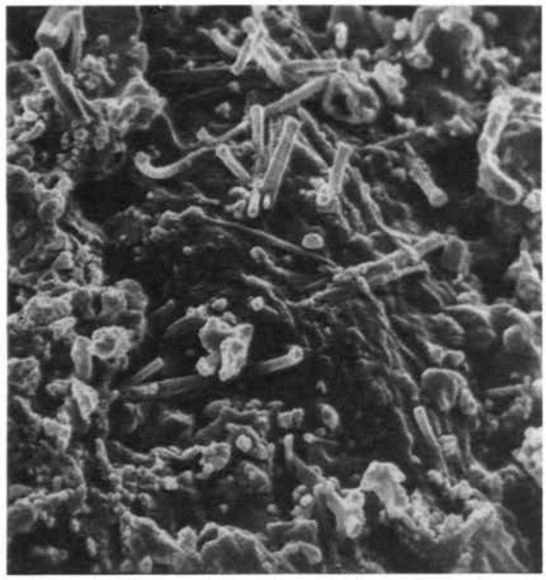


Figure 11b: Gypsum (?) crystals as well as fine-crystalline and fused surfaces of sintered partitions in sample **0517**, *magn. 4,250x.*

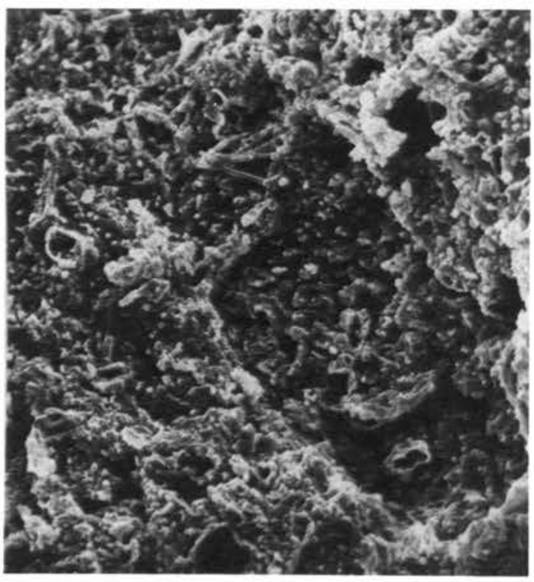


Figure 11c: Partly decomposed calcite (?) grain in the sintered matrix of sample **0517**. *Complicated system of channels and secondary coatings, as well as nearby needle-like crystals are conspicuous.*

northern Europe) because of the paucity of complete chemical analyses in literature and/or great variability of areas involved.

Thus, we conclude that the Neolithic ceramic revolution was followed by an active evolution process. The experimentation led to production of calcareous earthen ware of definite, most favourable composition whenever it was possible (Fig. 1b). The timing of this achievement seems to differ substantially in different cultural regions. Whenever the natural materials of the right composition were not available, mixing of different raw clays was undertaken (Noll 1982, Maggetti 1986).

In the case where nature prevented the use of calcareous compositions, the materials used have compositions corresponding roughly to the triple eutectic anorthite - SiO_2 - mullite (Fig. 1b), which occurs at temperatures significantly higher than the eutectic point SiO_2 - wollastonite (diopside) - anorthite. Consequently, the products are much less sintered and are of a quality inferior to the calcareous earthern ware. However, it must be a frequent case that local compositions in these wares actually lie on the other side of the Alkemade line anorthite - SiO_2 or they belong in the quaternary eutectic anorthite - cordierite - SiO_2 - mullite, and as a consequence, end up in a deeper eutectic point instead, with some sintering as a consequence.

Even in these cases, cultures as far apart as Egypt (Noll 1978) and the Aztecs (Maggetti 1986) arrived at about the same $CaO(+MgO)$ - SiO_2 - Al_2O_3 ratios (Si-richer than pure montmorillonite), with the lowest melting temperatures possible, although they started from very different raw materials (Nile mud versus montmorillonite clays after weathered volcanic tuffs).

Although it might have been facilitated by nature, the compositional perfecting of ceramic raw

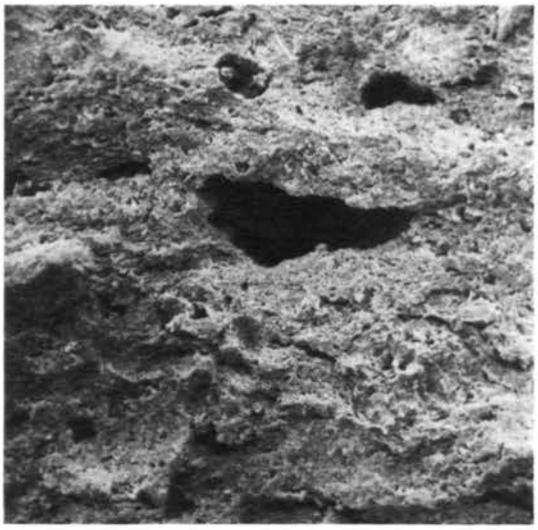


Figure 12 a

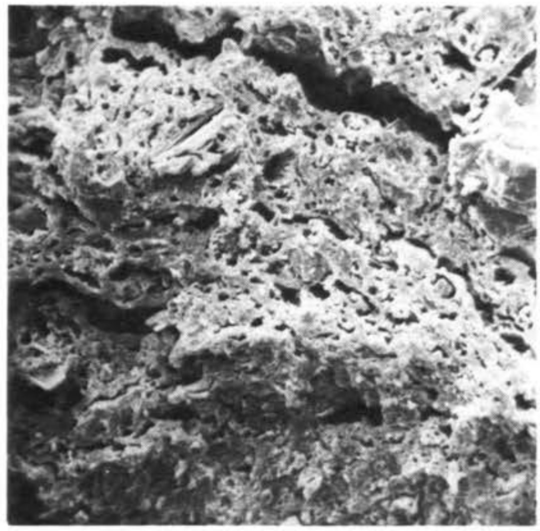


Figure 12 b

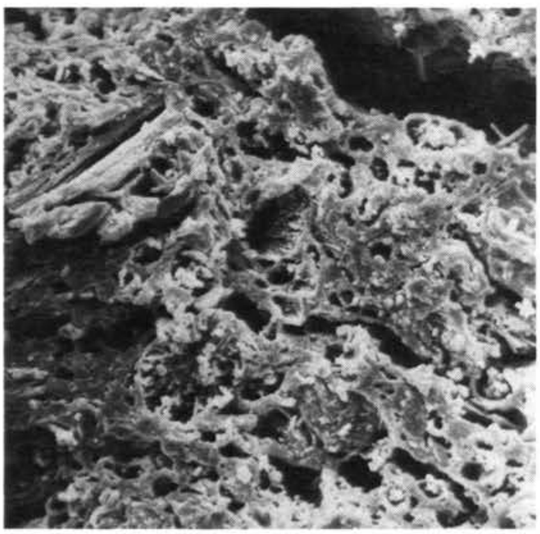


Figure 12 c

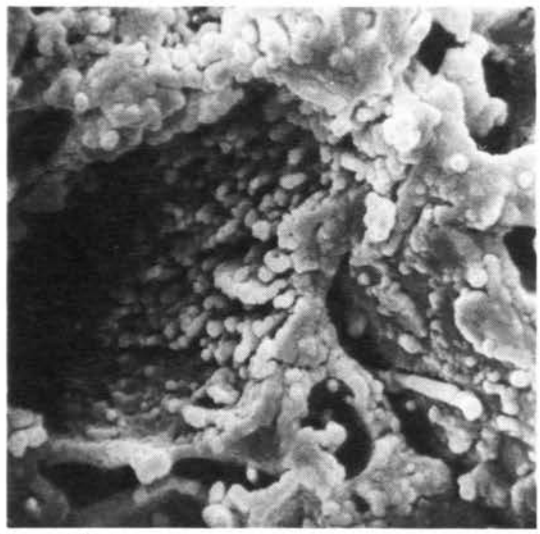


Figure 12 d

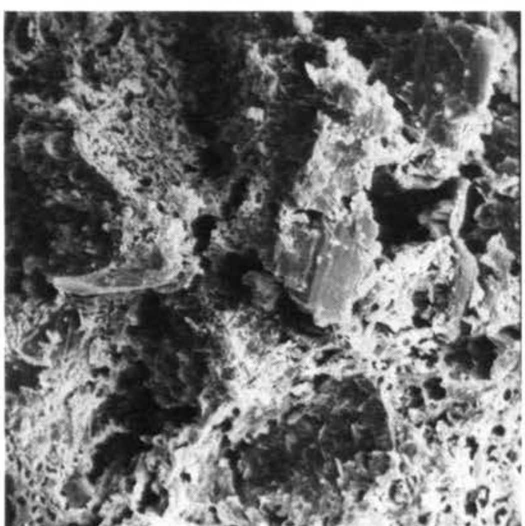


Figure 12 e

Figure 12: (a) Well sintered ceramic paste of sample **0518** *with cavities, temper grains and planar pores after rolling of grains during paste working. S.E.M. photograph, gold plated, magn. 160x.*
(b): Detail of the previous photograph, magn. 800x.
(c): Imprints of plant remnants, detail of central parts of the previous photograph, magn. 1,600x.
(d): Crystalline coating of one of the cavities in the well-sintered matrix after burnt-out plant material. Magn. 8,000x.
(e): Temper grains (partly dissolved in the left parts of the photograph) in sherd **0518**. *Magn. 800x.*

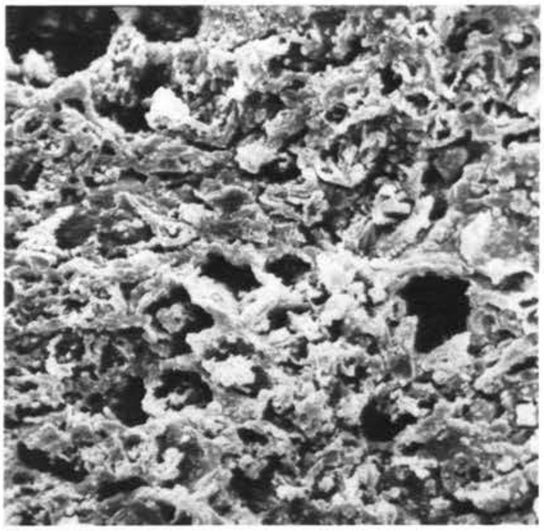


Figure 13 a

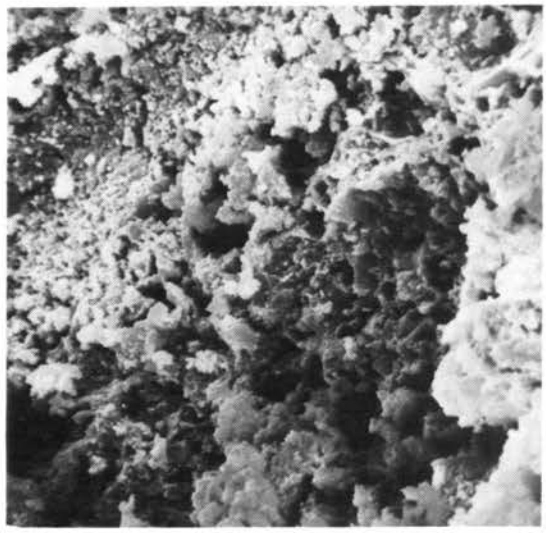


Figure13 b

Figure 13 c

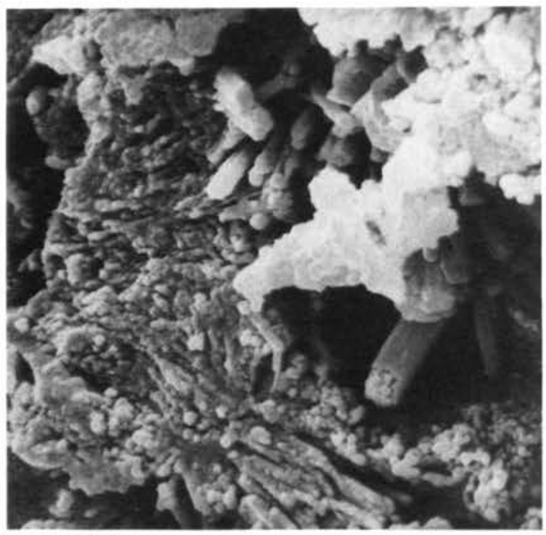


Figure 13 d

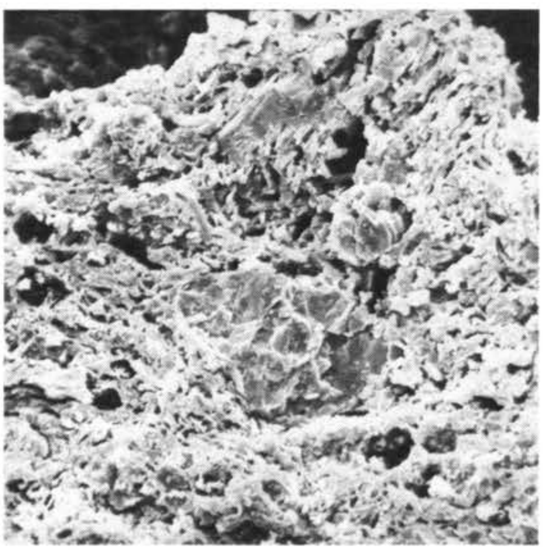


Figure 13 e

Figure 13 (a): Sintered cellular matrix of sherd **0580** *with occasional small crystallites on fused partition walls. S.E.M. photograph, gold coated, magn. 1,600x.*
(b): Flaky matrix of sherd **0580**. *Magn. 1,600x.*
(c): Micaceous temper grain in the sintered matrix of sherd **0580**. *Magn. 1,600x.*
(d): Temper grains in a well sintered matrix of sherd **0580**. *The upper grain appears partly decomposed (calcite) and the cavity filled by secondary minerals. Magn. 800x.*
(e): Secondary calcium minerals in a cavity of the matrix in sherd **0580**. *Magn. 6,000x.*

materials in the course of early human history represents perhaps the first human success in the field of chemical technology. Further, detailed research within a much broader range of cultures and regions is very desirable.

Composition of temper

Like all the major rivers in the foothills of the Zagros Mountains of NE-Iraq, the Diyala River crosses the major tectonostratigraphic units in the area. Its upper reaches are situated in the Thrust Zone, in the intensely folded Imbricated Zone, as well as in the folded Jurassic and Cretaceous of the shelf area, followed downstream by folded Paleogene and Miocene, as well as by Pliocene and Quaternary filling of intramontane basins and valleys (Buday 1980).

Limestones with or without fossils are dispersed throughout the stratigraphic columns of the tectonic units in the area (Buday 1980). Thus, in spite of their high concentration, the limestone and calcite grains in the "temper" cannot be considered indicative of the place of origin without detailed studies. Multiple sources of limestone and calcite represent a distinct probability.

The other typical rock types of the temper, cherts (radiolarites) and basic effusives (spillites) can be tentatively referred to three distinct formations:

a) the Qulqula radiolarian formation in the Imbricated Zone of NE-Iraq, which in its typical development contains cherts of various colours, intercalated by cherty radiolarian limestone and dark red shales. In the upper part of this formation diabase volcanics are supposed to occur (Bolton 1958). The formation is probably Middle Cretaceous (Albian-Aptian) and supposedly continues into Iran as Coloured Melange (Stocklin 1968) with diabases and other volcanics.

b) the insufficiently described Khwakurk series of acid and basic lavas, agglomerates, cherts, jaspers, purple slates and some limestone, which correlates stratigraphically with the Qulqula formation, but unlike the Qulqula portion of eugeosynclinal sediments, lies to the west of the Zagros Main Thrust. Its distribution in Iraq has been mapped insufficiently (Buday 1980), but it apparently corresponds to the Radiolarite Group (thick post-Cenomanian radiolarian cherts and submarine volcanism) of the High Zagros Range in Iran immediately to the south-east of the Diyala River valley (Huber & Eftekhar-nezhad 1978). Due to its position and presumed extent, this is the most likely contributor of siliceous material to the "temper" of the studied ceramics.

As for the submarine volcanic rocks, they appear nearly all over the Cretaceous zones of the Zagros Thrust Zone, and their study has not been profound enough to pinpoint spillites at any locality/ unit. Therefore, spillites are not quoted by Buday (1980). Thus, the spillite fragments and the probably related relatively abundant epidote grains cannot be referred to any definite formation in the area.

c) the last chert-volcanic formation in the area is the Walash formation in the Paleogene of the Zagros Mountains. It contains basic (often pillow-) lavas (no spillites mentioned), pyroclastics, and the entire spectrum of other sediments (flysch, limestones, occasionally radiolarites). The outcrops and the lithology of this formation in the tributary area of the Diyala River are not known (Buday 1980) so that its role cannot be ascertained.

The rare metamorphic rocks present in the temper of the sherds must have come from the uppermost reaches of the Diyala tributaries, on the Iran-Iraq border (Huber & Eftekhar-nezhad 1978). It should be stressed, however, that the Tertiary conglomerates contain redeposited cherts and other rocks, i.e., the transportation of many of the above-mentioned rock fragments into the sediments used for pottery might have been indirect and transcending the present lithological boundaries and watersheds. The detrital intermediate plagioclase, titaniferous biotite, magnesium-rich augite, tremolite and andradite suggest igneous and (contact) metamorphic origin, respectively. Rare Mg-rich phyllosilicates might be in connection with ophiolite occurences in the area, e.g., in connection with formations sub a) and b).

In conclusion, three distinct stratigraphic formations may have contributed the radiolarian chert, whereas several formations might have been the source respectively of limestone and volcanic material in the temper. Intermediate deposition of any of these in Tertary sediments cannot be excluded.

All of the contributing formations strike perpendicularly to the major river valleys in the area so that, to the first approximation, a number of adjacent river valleys ought to have very similar composition of temper material. Only detailed geological studies of individual drainage basins could lead to finer local divisions of pottery based on its temper composition. The temper composition confirms the origin of the Tell Razuk pottery from the foothills of the Zagros Mountains, quite probably from the locality itself.

Firing conditions

The estimates for the firing conditions (especially temperatures and oxygen fugacity) can be obtained (1) from the mineralogy of the paste, (2) its texture and colour shade, (3) its organic carbon (graphite) contents and (4) the preservation of temperature-sensitive components of the temper. In all instances it must be kept in mind that the time of the firing process is of the order of tens of hours and the sintering of the paste often seals tight the local environments, preventing free escape of volatiles, so that neither the equilibrium diagrams (especially those involving volatile components either at 1 atm or at their own dissociation pressure) nor the results of the fast kinematic methods (on the time scale of tens of minutes), e.g. the differential thermal analysis, can be directly applied to our observations. Moreover, no true homogenization is achieved in the paste prior to or during the firing which would overcome the inhomogeneities of the clay mixture itself and the variegated local environments created on the contacts of clay with various reactive, yet mostly unspent, temper components. Therefore, comparison with direct firing experiments that simulate "natural" firing conditons (Letsch 1981, Magetti 1986, Peters and Jenni 1973) is essential.

The upper limits for firing temperatures are set by the ternary, resp. quaternary eutectic points SiO_2 - wollastonite - anorthite - (diopside), at 1170 C and 1130° C, respectively (Levin *et al.* 1964) or the neighbouring cotectic lines wollastonite - or diopside - anorthite (max. 1200-1300° C). These temperatures were never reached, as was confirmed by DTA analyses, in all of which sharp endothermic effects connected with melting at 1140-1200° C occur.

X-ray powder analyses indicate that plagioclase, diopside and gehlenite represent in nearly all examined classes the principal component of the matrix. They are accompanied by quartz and calcite, the role of which in the matrix is obscured by the great abundance in temper. According to Peters and Jenni (1973), those three new phases should all appear in Ca-rich clays at and above 850° C. Letsch (1981) and Magetti (1986) present heating diagrams (Figs. 14 and 15, respectively), the former for a clay mixture somewhat richer in calcium than our material, the latter for a Ca-rich clay mixture without the composition indicated. Their data for high-temperature phases differ substantially in several instances, making any comparison difficult. Also, both the onset and the fading out of individual phases are very gradual and appear to depend on many factors.

Judging from overall chemical composition, gehlenite should not appear in our material. However, with the abundance of limestone grains in temper, plenty of local environments are created which lie within the gehlenite-containing phase assemblages and gehlenite is abundant in the sherds studied. It is well documented even in Green Ware, the greenish colour of which should - according to Matson (1971) indicate firing at or above 1100° C. In spite of long burial, degradation of gehlenite was not substantial in our case.

As can be seen from Figs. 14 and 15, the "negative" mineralogical criteria for firing temperatures, i.e. disappearance of certain primary phases, are equally difficult to apply. Traces of common clay minerals should disappear between 840 and 950° C, depending on firing conditions. Grim and Bradley (1979) have shown that clay minerals heated below

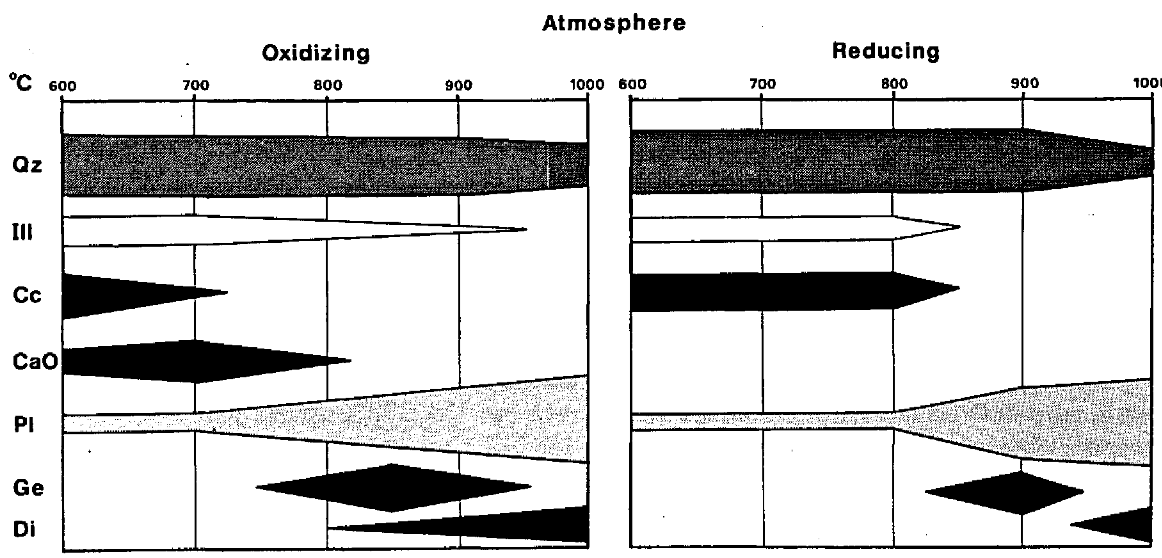


Figure 14: Phase changes in controlled firing experiments on a Ca-rich clay mixture by Letsch (1981).

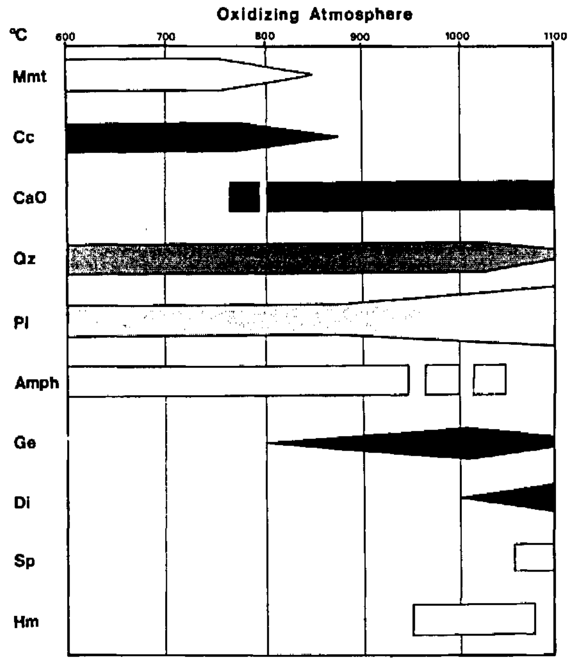


Figure 15: Phase changes in the firing experiment on a Ca-rich clay mixture from Mexico by Maggetti (1986).

800° C can become gradually reconstituted, i.e., a complete recovery of crystal water and lost hydroxyl groups can take place. These phenomena were used by Enriquez *et al.* (1979) in their study of Lower Amazonian pottery fired below 700-800C, where regenerated smectites and illite-chlorite were found.

The appearance af amorphous "glassy" phases in bricks or sherds after thermally destroyed clay minerals has been stressed by Jensen (1978) (from below 600° C onwards for Ca-rich clays) and by Capel *et al.* (1985) (700-800° C). Its decomposition into smectites on cooking (and in the simulated hydrothermal treatment), but only minimally on burial since the Bronze Age in the soils of Central Spain, has been documented by the latter authors.

As will be discussed in the section on potential raw materials, the burial soil contains smectite and palygorskite as principal components. Paint scrapings from washed sherds often contain admixtures of palygorskite revealed by x-ray powder diffraction. Therefore there is a strong possibility of clay mineral particles being transported into sherd cavities and deposited there; even chemical precipitates cannot be excluded (Singer 1984). Thus the question of sherd weathering vs. acting as a passive receptacle is very difficult to resolve.

The amounts of clay components are too small to show in the complex x-ray powder diffractograms of sherd material. Before any attempt is made to assess their appearance in the DTA analyses, two other components with overbearing influence on DTA results ought to be discussed.

Calcite - both as limestone and as vein calcite - is a common constituent of temper in our material. Only in a part of the samples studied were there clear signs of thermal decomposition of this calcite on firing. First of all, it is Green Ware in which fine-grained secondary calcite and gypsum line up cavities after limestone grains that have burnt out. Partial decomposition (and reconstitution?) of calcite is observed in Gray Ware (**0419**), Scarlet Ware (**0580** and **0517**) as well as Buff Ware (**0140**). Disappearance of calcite in ceramic material is again estimated differently by different authors and it is sensitive to CO_2 fugacity (i.e. to the degree of sealing of calcite grains by matrix and to the oxidation/reduction regime of firing) and reactivity (primarily to the size of the $CaCO_3$ particles). Dissociation of calcite at atmospheric pressure takes place at 894.4° C (Southern and Royster 1936) whereas in CO_2 atmosphere it will be retarded to 970° C (Rowland and Lewis 1951). On the other hand, increase in dissociation temperature with pressure is quite steep (Harker and Tuttle 1955). Because of all these factors, dissociation temperatures from 850° C to 1010° C have been recorded in DTA analyses.

Because of these factors, in our case (partial) preservation of temper calcite overlaps with formation of gehlenite and even diopside in (perhaps somewhat different portions of) the same sherd.

Secondary calcite might represent reconstitution of CaO, or be deposited by pore water during the use and/or burial of the vessel.

Gypsum is ubiquitous on sherd surfaces and in the paint layers as well as it was observed by S.E.M. as crystals lining sherd cavities. Its principal DTA fingerprint, two endothermic minima below 100° C and at 150° C, interfere strongly with those of smectite and palygorskite. Again, it was deposited from pore water during use or especially during burial of original sherd material. In addition, small $CaSO_4$ and $CaCO_3$ contents of the original clay, unless reacted away on firing, could be reconstituted in the sherd cavities.

The size and position of the carbonate dissociation peak of calcite varies widely in the sherds examined, decreasing appreciably for the low $CaCO_3$ contents, rarely even below 800° C (**0416** and **0517**). In the majority of cases (unobserved only for **0201**) it is accompanied by a small endothermic reaction positioned rather constantly around 700° C and/or a drawn out reaction at and above 600° C. These could reflect

the presence of smectite (and palygorskite) in the sherd material. In the region of 50-150° C, a combined water loss from clay minerals and gypsum would take place. The weight loss of sherds on heating to 300-400° C typically represents 3 wt %, to be compared with the weight loss of dry palygorskite-smectite clay (4.5 wt %, further loss occured during drying of the sample prior to the DTA analysis) as well as with up to 17 wt % for natural montmorillonite and 20 wt % for gypsum.

The presence of ample unreacted calcite grains and, presumably of some rehydrated clay minerals in the sherds on the one hand, of the well-developed high-temperature phases in differing proportions on the other hand, suggests firing temperatures from about 850° C to above 1000° C (for the highest temperatures attained when producing Green Ware).

The Fe_2O_3/FeO ratio is high for all cases except for Green Ware in which diopside, $Ca(Mg,Fe)Si_2O_6$ requires presence of Fe^{2+} and for Gray Ware (**0419**) which, as suggested by its high organic (or dispersed graphite) contents (up to 4 wt %) was fired in reducing conditions at least at the end of the firing process. All the rest underwent oxidizing firing at least in the final, for the color and chemistry decisive stages.

Textural S.E.M. studies of the paste indicate for all examined sherds a moderately to well-sintered paste, often with a well developed cellular texture and fused partitions. Highest degree of fusion occured in Green Ware in which also partial isotropisation of matrix can be observed in the thin section and all other temperature indicators show high firing temperatures. Again, combining the results of Noll (1976) and Tite and Mantias (1975), the textural studies indicate firing temperatures between 850° C and 1050° C, for the best sintered cases even up to the region of 1150° C.

These data are comparable to other Mesopotamian pottery traditions. Tite and Mantias (1975) indicate 850-1050 (-1150)° C for Samarra ware, 850-1050 for Halaf ware, and (850-) 1050 - over 1150° C for Ubaid ware with the uncertainty of at least 50° C caused by possible variation in oxidation/reduction conditions. Values at and over 1150° C ought to be questioned because of the possible collapse of ceramic material so close to melting temperatures. Occurrence of less-sintered portions, with the original flaky texture in our sherds alongside the well-sintered ones points towards compositional inhomogeneity of the paste.

The last estimates of firing temperature can be attempted from temper components other than already mentioned calcite/limestone grains.

Although quartz is unstable over 870° C, its transformation to tridymite is so sluggish that it does not take place during the firing. Should it be otherwise, most of chert-rich Tell Razuk pottery would shatter during high firing temperatures due to the large volume expansion connected with this transformation.

According to Maggetti (1986), magmatic amphiboles do not survive dry heating much over 900° C, whereas DTA analyses of tremolite indicate its breakdown between 900 and 1150° C, strongly dependent on the OH/F ratio in the mineral.

Epidote, fairly abundant in our samples, reveals similarly high thermal stability, in many cases retaining some of its hydroxyl groups even at temperatures slightly over 1000° C (Smethurst 1935). Effective sealing if these temper minerals in the paste will only raise the temperature of their stability.

In conclusion, from the results of our studies we can assume that the sherd material examined was fired in the temperature range from 850° C to over 1100° C, the majority of the studied cases belonging to the lower half of this range. Oxidation firing was maintained at least in the decisive stages for all sherds except Gray Ware. Based on research of Shepard (1954), such temperatures should indicate more sophisticated techniques of firing, i.e. kilns of some sort.

III. Paint Samples

Description of samples studied

Scarlet Ware **0580** (Pl. II)

A sherd fragment with a buff slip (or surface layer). Overpaint was executed in two, or perhaps three, tones: deep red ("plum red"), pink? and black. Matt red, clearly different from the "red" tones in the following material, was applied in broad bands between ornamental elements; matt black was combined with the original buff slip into ornamental panels and triangles. Finally, what appears as the original pink colour was combined with black borders and core in a triangular motif in the center of the sherd.

Scarlet Ware, **0518** (Pl. IV.11)

The buff slip had two tones applied: matt black as border lines of brick red fields or as hatching and cross-hatching executed directly on the slip. The monotonous brick red areas might have been lightly burnished and are often covered by hard gray deposits from the burial environment.

Scarlet Ware, **0513** (Pl. IV.16)

The slightly convex surface of the sherd has a brick- or orange-red band bordered by black stripes painted over it. The remaining parts were left unpainted.

Scarlet Ware, **0540** (Pl. IV.17)

A fragment of pottery with a ridge and the adjacent area painted in vivid brown.

Scarlet Ware, **0583**

Sherd fragment with brick-red painted bands bordered by black stripes and remnants of motifs painted in black between the bands.

Emission Spectrographic Analyses

Paint from three samples, **0580**, **0540**, and **0583**, was scraped off with the minimum contamination possible (stemming both from the underlying slip and from the overlying burial deposits) and submitted for spectrographic analysis. Two samples of adjacent slip were analysed as well, in order to establish possible differences in the trace element pattern and contamination of paint by slip.

The analyses were performed in the spectrographic laboratory of the Institute of Petrology, University of Copenhagen, by H.J.Bollingberg. Quantitative spectrography was performed using DC arc, with pure SiO_2, $SrCO_3$ as an internal standard and spectral pure carbon powder as a buffer. Uncertainty on pigments is ±25 rel. %, on slips ±10 rel. %.

Slip **0580** (charge weight 1.35 mg)

8% Ca, 1.4% Mg, 1.8% Fe, 60 ppm Ni, 100 ppm Zr, 20 ppm Cu, 1200 ppm Mn, 2 ppm Cr, 4% Al, 2840 ppm Ti, trace V and B.

Pigment **0580** (.52 mg; poor analysis, exploded on burning)

16% Ca, 1.8% Mg, 3.3% Fe, 160 ppm Ni, 230 ppm Zr, 100 ppm Cu, 2500 ppm Mn, 2 ppm Cr, 3.5% Al, 3900 ppm Ti, trace V and B.

Slip **0540** (.93 mg)

14% Ca, 1.2% Mg, 1.6% Fe, 100 ppm Ni, 120 ppm Zr, 24 ppm Cu, 1200 ppm Mn, 50 ppm Cr, 3.8% Al, 2700 ppm Ti, trace V, B and Pb.

Pigment **0540** (.50 mg)

12% Ca, 9800 ppm Mg, 3.6% Fe, 120 ppm Ni, 144 ppm Zr, 46 ppm Cu, 1960 ppm Mn, 2 ppm Cr, 2.4% Al, 2360 ppm Ti, trace V and B.

Pigment **0583** (.54 mg)

14% Ca, 2% Mg, 3.2% Fe, 166 ppm Ni, 200 ppm Zr, 66 ppm Cu, 2000 ppm Mn, 2 ppm Cr, 4.0% Al, 3900 ppm Ti, trace V, B and Pb.

Not detected (<10-50 ppm): Co, Sn, Ba, Sb, Bi, Ag. Minor Zn (<200 ppm) is present in all samples.

X-ray powder diffraction

In the x-ray diffraction analysis of pigments (and slips), both a 118 mm powder diffraction camera with a Gandolfi attachment and the Guinier-Hagg cameras were used. CuK radiation was employed and, in the latter case, quartz powder was added as internal standard. Considerable effort was invested in this work, due to the ambiguity of many results.

Sample 0580: The buff slip from the areas left unpainted contains quartz, calcite and gypsum as the principal phases detected. Some lines of plagioclase might be present, but no diopside, gehlenite, kaolinite or illite were detected. Traces of clay minerals from the burial environment might be present (faint d values 10.8 Å and 4.55 Å were traced on the powder diffraction photograph).

The red pigment gave a clear Gandolfi pattern of a mixture of quartz, hematite and calcite. The hematite lines dominate the picture. Due to higher resolution and much more extensive scraping required to collect enough material for a Guinier pattern, the gamut of minerals found is richer in this case. The principal phases are gypsum, hematite and calcite (original quartz is obscured by the internal standard). Traces of diopside and plagioclase (from the slip) might be present as well.

The black pigment gave only the lines of gypsum, calcite and quartz. No lines of graphite, magnetite or of the entire spectrum of manganese oxides/hydroxides were found.

The pink paint was examined by the Guinier method parallel to the red paint. The patterns were largely identical in their contents of gypsum. The pink paint contains more calcite and less hematite than the adjacent red paint. None of the two contains lines of hydrogoethite, the principal natural hydroxide of iron.

Sample 0518: Fine scraping from the inner, slipped surface represents a mixture of calcite, gypsum and quartz, in that order of importance. The grayish white coatings on the black-painted and buff outer surfaces of the vessel yield the same result. None of the high-temperature minerals found in the paste of this type of ware appeared in the pattern.

The red-brown pigment from this fragment yielded a Gandolfi pattern of calcite, quartz and gypsum. At 2.67 Å the main line of hematite appears as very weak (unfortunately overlapping with a reflection of gypsum), accompanied by possible traces at

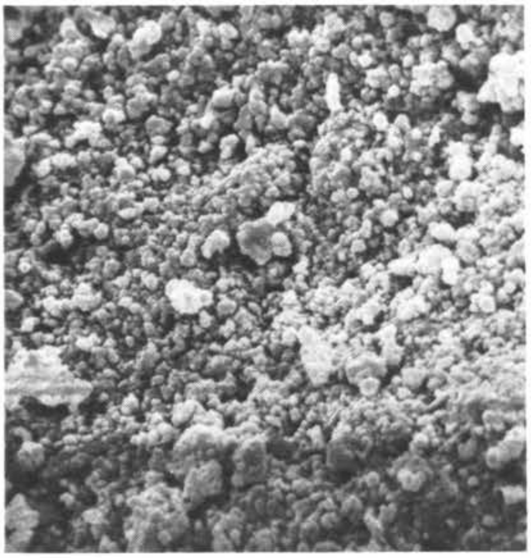


Figure 16a: Red paint on the surface of Scarlet Ware sample, **0580**. *Few flaky (secondary?) particles can be observed on the grainy surface. S.E.M. photograph, gold coated, magn. 4,000x.*

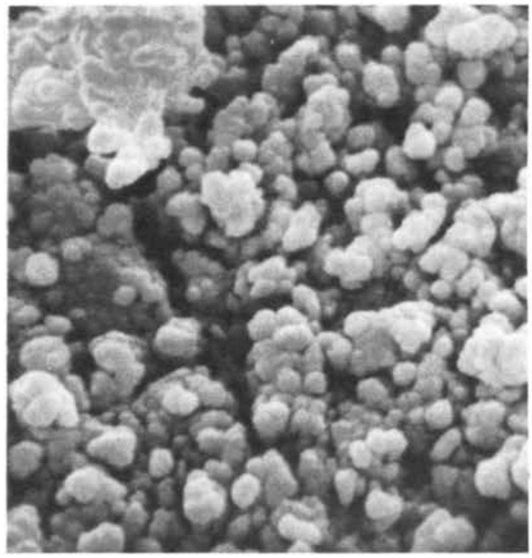


Figure 16b: Detail of red paint surface, Scarlet ware sample **0580**. *Magn. 16,000x.*

Figure 16c: Red paint layer on the surface of the sintered sherd, Scarlet Ware sample **0580**. *Cavities in, and the irregular thickness of the paint layer are prominent. Magn. 4,320x.*

Figure 16d: Secondary gypsum-containing deposits on the surface of red paint layer. Sample, **0580**, *magn. 1,600x.*

2.45 Å and 3.43 Å. An entire range of other iron minerals can be excluded, the only indecisive case being ferrihydrite. The Guinier pattern again reveals calcite as the principal phase, with gypsum and palygorskite, perhaps the measure of contamination by the soil during the burial. Hematite is definitely present, but its principal line (2.70 Å) is still a weak line. It is accompanied by four other recognizable lines, the two higher of them being 3.69 Å and 2.52 Å. No hydrogoethite or ferrihydrite are detectable.

Sample 0513: The Gandolfi pattern of black pigment from this sample reveals the exclusive presence of calcite, gypsum, and smaller amounts of quartz. Neither graphite nor manganese oxides nor

Figure 16e: Red paint layer with embedded micaceous and fragmentary particles. Sample, **0580**, *magn. 1,680x.*

Figure 16f: Loosely structured red paint layer on sintered ceramics with the flaky primary structure locally preserved. This is the only photograph which displays under the paint layer a flaky (pretreatment?) layer, potentially different from the sherd mass (otherwise their contact is direct). Sample, **0580**, *magn. 1,760x.*

other possible black pigments could be detected. When heated in air at 600° C for two hours, the black pigment burned away without leaving a trace on the sherd.

The brick red pigment again reveals the presence of calcite, gypsum, and small amounts of quartz. Except for the line at 2.69 Å (overlap of gypsum with hematite), no potential lines of hematite were positively identified. The same holds for all other Fe oxides or hydroxides. The only possible exception is ferrihydrite, for which very weak broad lines at d 2.50 Å, (?) 1.96 and 1.51 Å were found. After oxidizing heating at 600C, the pigment turned more into pastel pink, although the colour change appears still to lie within the spectrum of shades observable on the sherd. The paint from the annealed fragment shows calcite, anhydrite, minor quartz, and traces of all principal hematite lines, which were not observed before annealing. A Guinier pattern of original paint shows gypsum and calcite as substantial components (quartz is obscured by the internal standard used) as well as a possible admixture of palygorskite. No lines can be identified as hematite. Ferrihydrite peaks or goethite lines were not found.

Sample 0540: In the Guinier pattern of the unpainted slip, calcite and gypsum are accompanied by high-temperature phases; principally it is gehlenite, with smaller amounts of plagioclase and diopside present as well. Hematite lines are missing. In the brown pigment of this sample, gypsum and calcite represent the principal phases, accompanied by hematite in substantial quantities and possible minor plagioclase and gehlenite. Goethite is missing; possible ferrihydrite is covered by other phases.

Scanning electron microscopy and energy-dispersive analysis

S.E.M. and the parallel energy-dispersive analyses of paint layers turned out to be a decisive tool for their interpretation, equal in importance to powder diffraction analysis. They helped to resolve some of the ambiguities of the latter because of their ability for spatial resolution of fine-grained material. On the other hand, S.E.M. has limitations, especially the inability to analyse tiny individual grains of paint without contamination by the surrounding material as well as its inability to discern the compositional variability of individual grains without a number of element-distribution maps or a tedious search on a pre-set wavelength. These problems were joined by the complications stemming from the loose, discontinuous character of paint layers, through which signals from underlying ceramics or from secondary coatings contributed to the spectrum obtained.

Morphological studies of good quality were performed on gold-coated samples with microscope arrangement precluding simultaneous chemical analyses. Another set of observations were made with the chemical analyses in mind, on carbon-coated samples and with diminished picture quality. In these measurements the separation of signals from the paint layer from those of the underlying ceramics was the major problem. Finally, this problem was overcome by a novel "layer reversal" approach, very suitable for loosely attached paints or coatings. A layer of paint was covered with double-sided adhesive tape and slowly peeled off the sherd, securely attached to the tape. This was then positioned on top of a several-layers-thick pile of tape on the specimen disc of the microscope. Thus, internal portions of the paint layer were exposed to the electron beam whereas no electrons could reach the aluminium disc through the adhesive tape pile. The tape itself displayed a continuous x-ray background with only weak characteristic lines of S and Cl present.

Lot 0580, Scarlet Ware

The three kinds of paint present on this sample, red, black and pink, were subject to detailed S.E.M. studies both from the morphological and compositional viewpoints.

The red paint represents morphologically an unsintered agglomerate of fine isometric particles, flocculated into small groups that are of variable size and rather loosely bound together (Figs. 16 a-b). The thickness of the paint layer varies somewhat, and it can contain irregular cavities (Fig.16c). It was applied directly onto the surface of the sherd, without an intervening layer. Locally, a lot of flaky particles cover the surface of the paint, apparently the deposition products of the burial (Fig.16d). Particles other than isometric (e.g. micaceous) seldom play prominent roles (Fig.16e). The sherd itself is either well fused or still preserves flaky portions and traces of textures produced by paste working (Fig.16f).

Chemically, the sintered ceramic which underlies the red paint layer displays in energy dispersive spectra high contents of Si, Ca, Fe, Al, K as well as small peaks of Mg, Ti, Cl, and S. Mn is nearly absent. Na was outside detector range. Measurements on the red paint in situ show all these elements in variable proportions. Si is always abundant, K loosely correlates with Al, Ca and Fe are very pronounced. S is sometimes present in high concentrations and there is a loose positive correlation with Ca. However, sections of paint layer with high Ca contents and S nearly absent, almost identical with the spectrum of the pure sherd material, have been recorded. They apparently represent discontinuities in the paint layer and indicate the difficulties of *in situ* work. Flat coatings of gypsum over the red paint layer, produced on burial, could be observed by the *in situ* method.

The samples of the red paint layer obtained by the "layer reversal" method consist of loose aggregates of grains, due to partial disintegration on sample collection. Element-distribution maps in principal analytical wavelengths indicate that the bulk of grains are usually iron-rich whereas distinct grains or grain clusters are purely Si-rich or Ca-rich (the latter include calcium carbonate occurrences). The K-Al-Si enriched phases, often of recognizable micaceous morphology, do not show very prominently on K-distribution maps. Constant contents of S and Cl occur; contamination from the underlying adhesive tape is a possibility (Fig. 17).

Burial coatings taken from the surface of red paint show primarily flaky grains. Their distribution maps are variegated. Only rarely distinctly Fe-rich grains can be found, in most instances Fe and K correlate in them with Si. A number of small Ca-rich grains occur, distributed rather evenly among the other phases. S contents are more prominent. Overall analyses indicate Si, Ca and Fe as the most important elements, and Al, K, Mg, S, Cl and Ti among minor elements. Neither here nor in the red pigment does Mn play any role. A Mg-Fe-K (Ca?) alumino-silicate represents the largest grain in the photograph.

The pink pigment has been analysed both in situ and by the "layer reversal" method.

In the "layer reversal" case the disintegrated pigment has a rather more flaky appearance than does the red pigment. The overall analyses of this pigment indicate much lower Fe contents than those of the red paint. Furthermore, high Si and Ca peaks occur as well as relatively low contents of Al, K, Mg (Ti), as was also the case for the red pigment. In the element distibution maps, iron is again rather evenly dispersed throughout the material, whereas locally Si-rich, or Ca-rich, S-rich or rarely also K-Si rich grains can be traced out (Figs. 18-19). Some portions of this paint can be quite rich in Fe, without accompaniment of other elements.

Black paint again represents a loose aggregate in which flat areas of loose-to-coalesced particles alternate with loosely positioned, more-or-less isolated, larger and flat particles or their aggregates (Fig.20a). In fine detail, as well as in cross-sections, loose flocculation of fine particles is apparent (Figs.20 b-c). No fusion or cementing agent were observed; the overall impression is that of a dessicated surface after its application. No charcoal or other textures were ob-

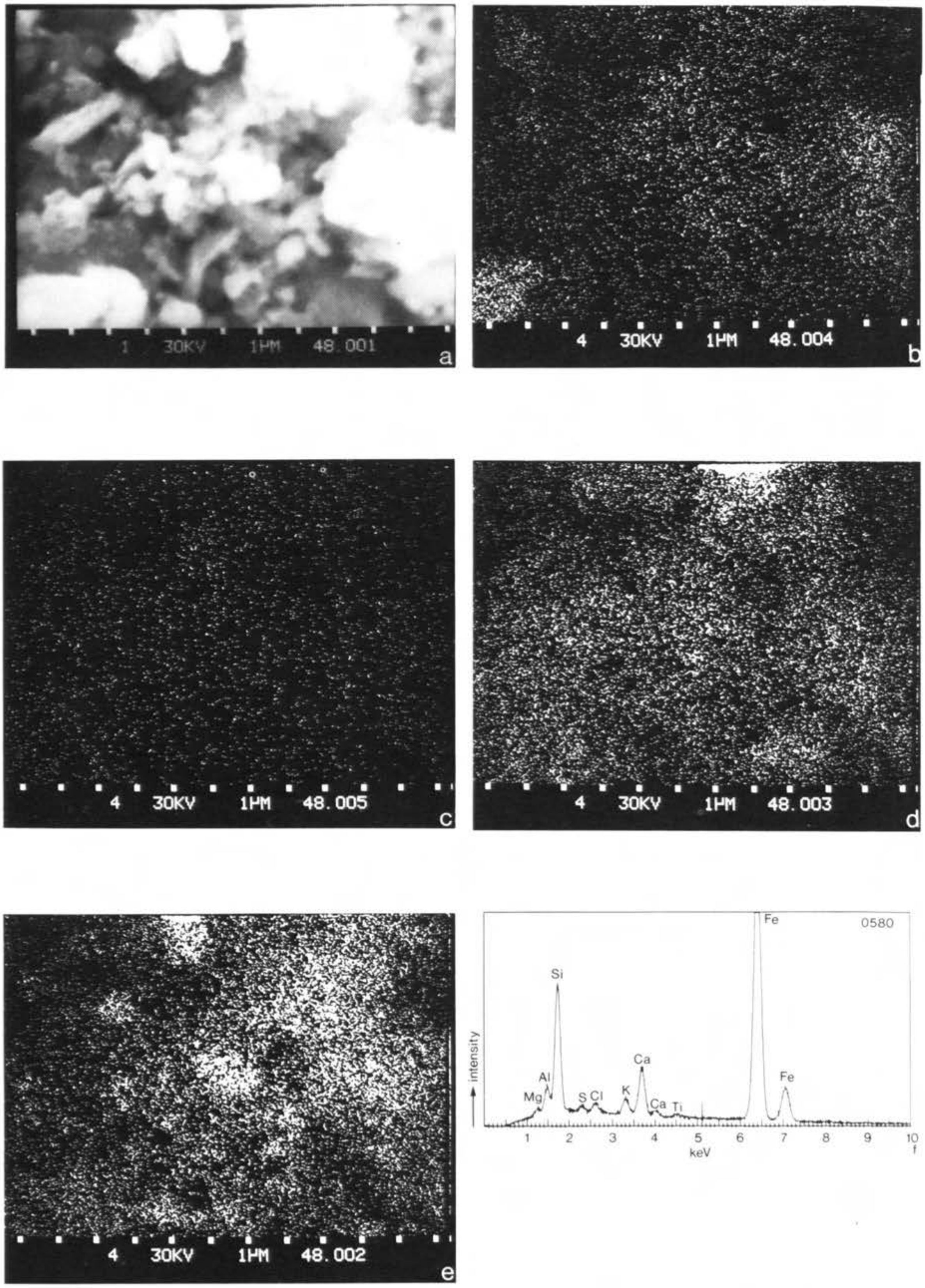


Figure 17: Texture (a), distribution maps of principal elements (b: CaK ; c: KK ; d: SiK ; e: FeK) and the overall energy-dispersive spectrum of a disintegrated "reversed" red paint layer (f). S.E.M., carbon coating.

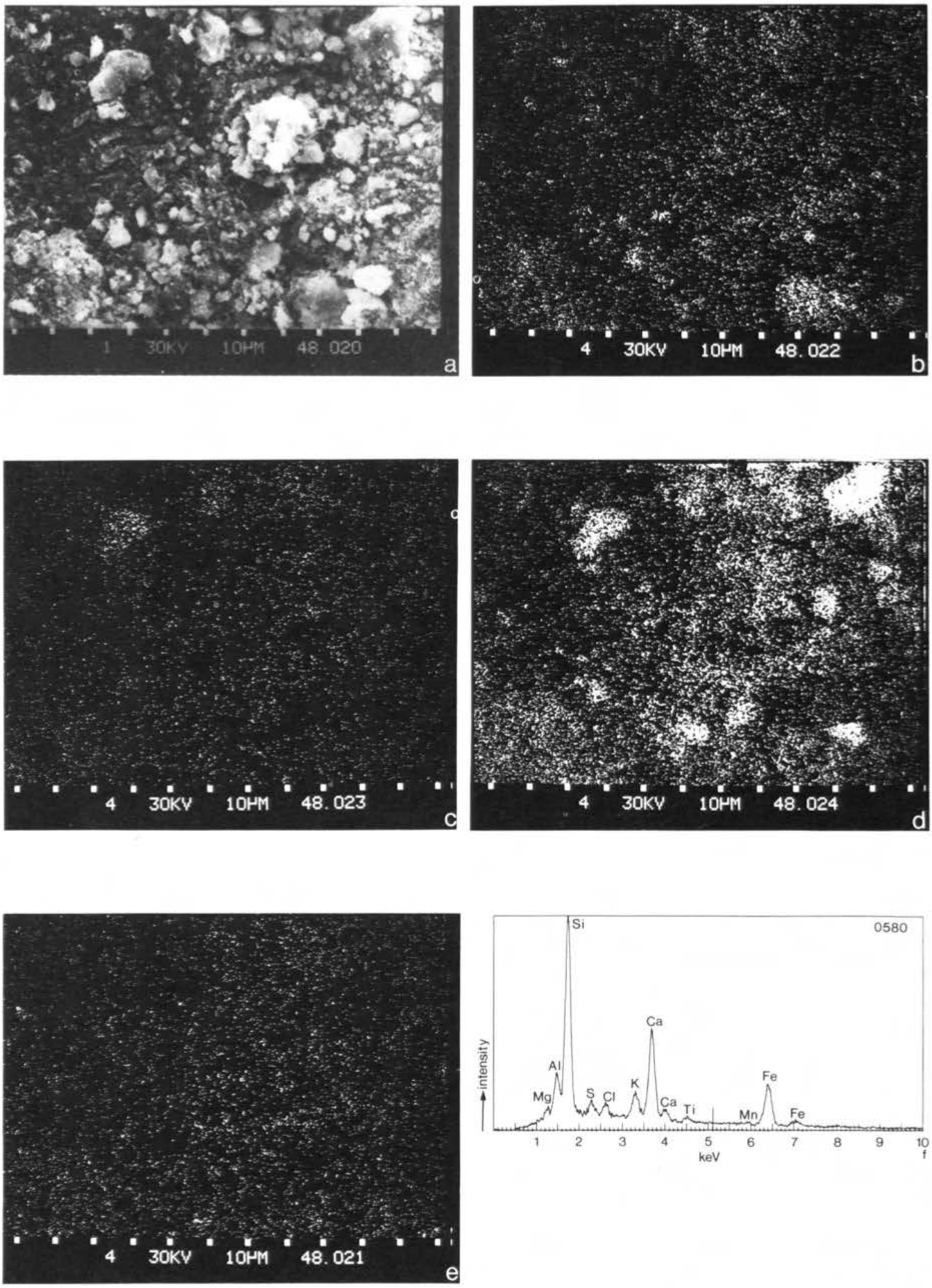
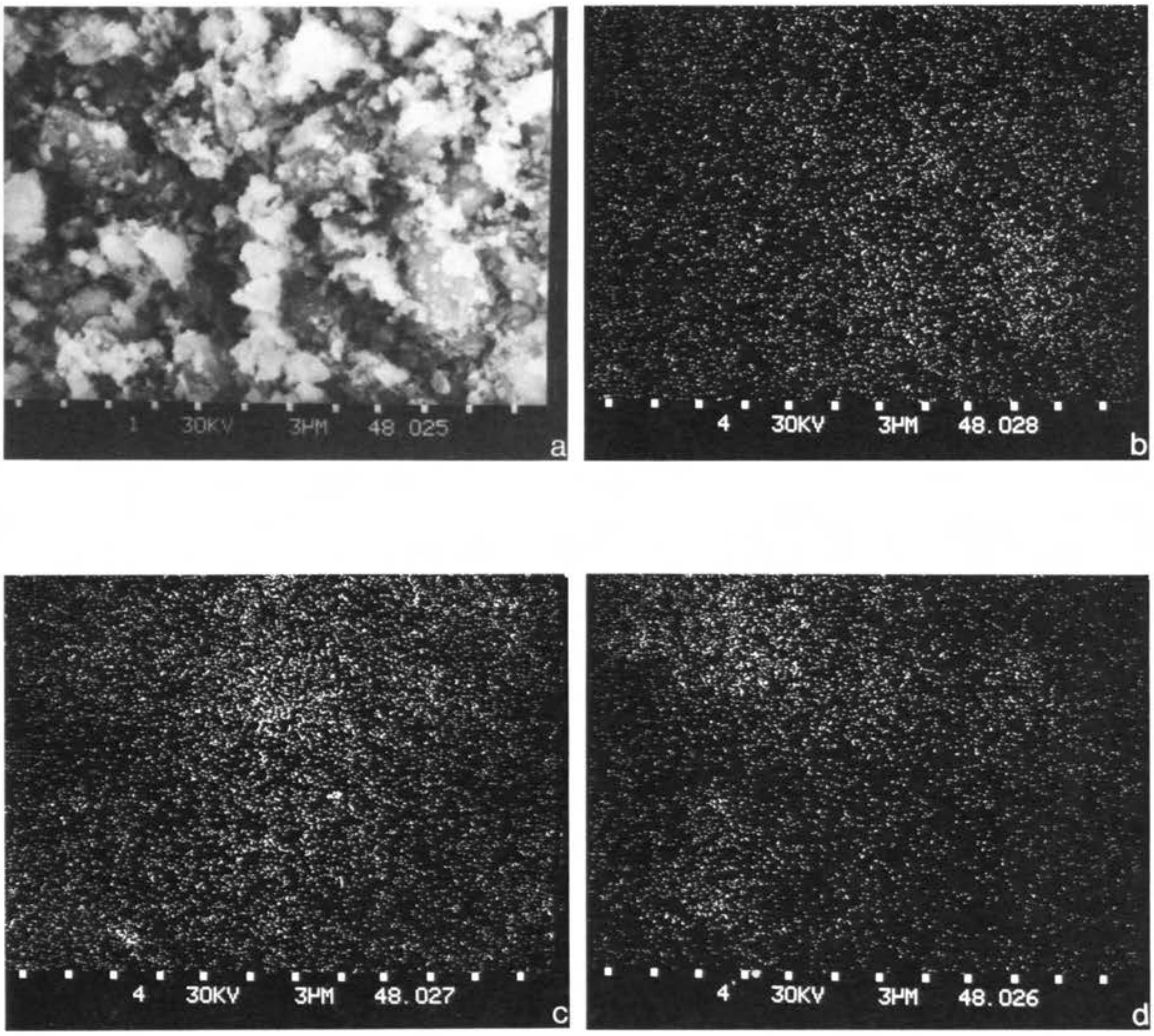


Figure 18: Texture (a), distribution maps of principal elements (b: Ca; c: K; d: Si; e: Fe) and the overall spectrum of a partly disintegrated, "reversed" pink paint layer from the Scarlet Ware sample, **0580** *(f). S.E.M. photograph, carbon coating.*



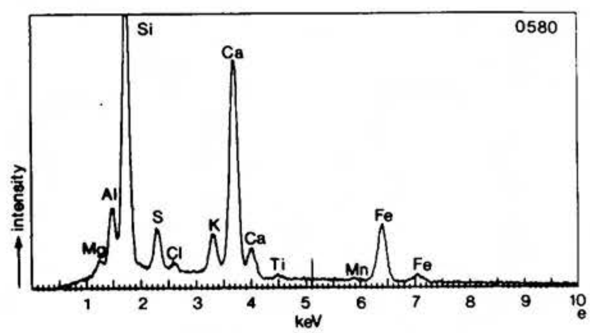


Figure 19: Another area of the same pink paint layer.Texture (a), distribution maps of principal elements (b: K; c: Fe; d: S) and overall spectrum (e).

served. The textural differences against the red paint are best visible at medium magnifications (Figs. 16c and 20d).

Penetration of paint into some cavities of the underlying sherd can occasionally be observed (Fig.20d). Admixture of foreign particles, except for secondary coatings, appears minimal. Thickness of this paint layer is smaller than for the red paint (Fig.20d).

0518, Scarlet Ware

The brick-red and black pigments as well as the unpainted slip were examined by S.E.M.

The slip surface is smooth and composed of a fine-grained mixture of isometric and needle-like crystallites (Fig. 21a), the identity of which could not be ascertained. In fractures, orientation effects created during vessel production (parallel flakeness, Fig. 21b) can be observed but no signs of chemically/mineralogically distinct slip can be found with certainty.

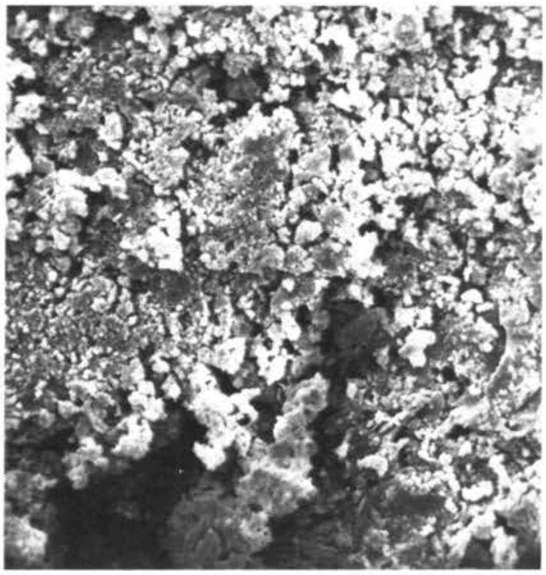


Figure 20a: Surface of black paint layer, Scarlet Ware sample, **0580**. *Fine-grained areas alternate with coarser aggregates, secondary coating appears in the lower part of the photograph. S.E.M. photograph, gold coated, magn. 1,600x.*

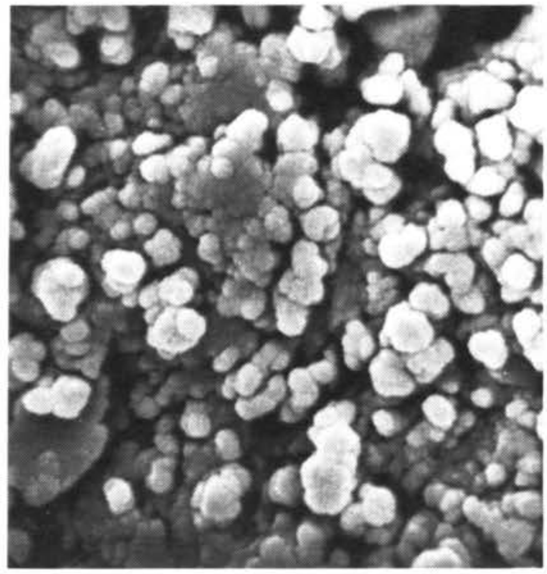


Figure 20b: Detail of the fine-grained area of paint layer from the previous photograph. Flocculated soot particles. Magn. 16,000x.

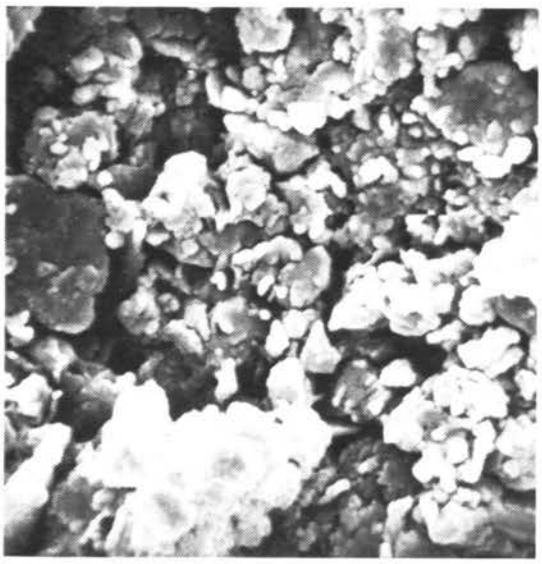


Figure 20c: An entirely different aspect of black layer at high magnification (8,000x).

Figure 20d: Black paint layer on sherd of Scarlet Ware sample, **0580** *with partly preserved flaky structure. Paint has intruded into sherd cavity. Magn. 4,240x.*

Red pigment represents a thin, sometimes discontinuous, layer of relatively loosely aggregated isometric particles on the surface of the porous ceramic material (Fig. 21c). Both the edge-on and vertical, higher-magnification S.E.M. photographs resemble in the majority of cases those from the red pigment in sample **0580**, except for more pronounced differences in grain size and more intimate coalescence of individual particles into "framboidal" hillocks on the surface of the paint layer (Fig. 21d). In some cases, this coalescence is considerable. The origin of deeper grooves separating hillocks or flocculated groups of grains (Fig. 21e), as well as the reason for the presence of elongated flocculae, are not

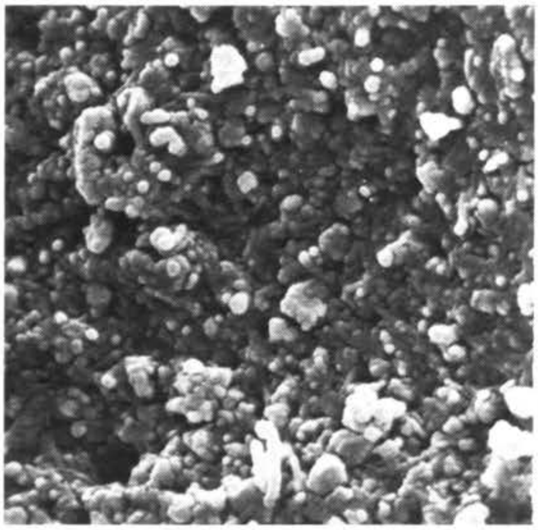


Figure 21 a

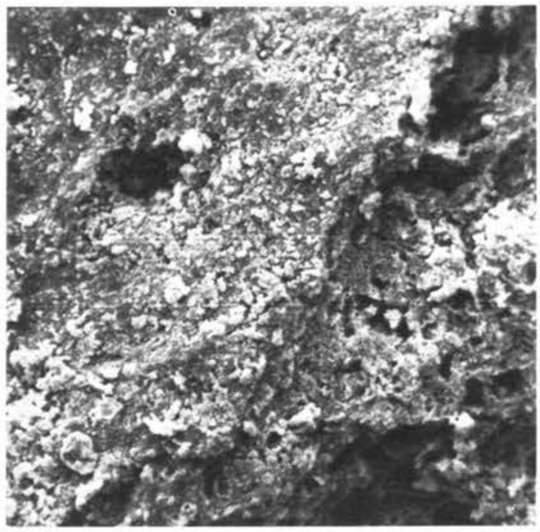


Figure 21 b

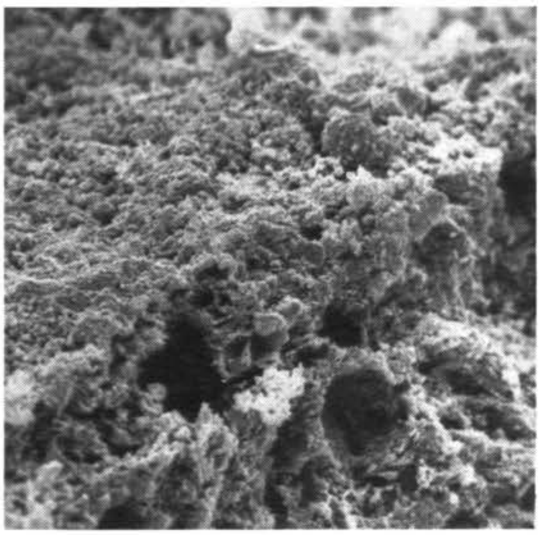


Figure 21 c

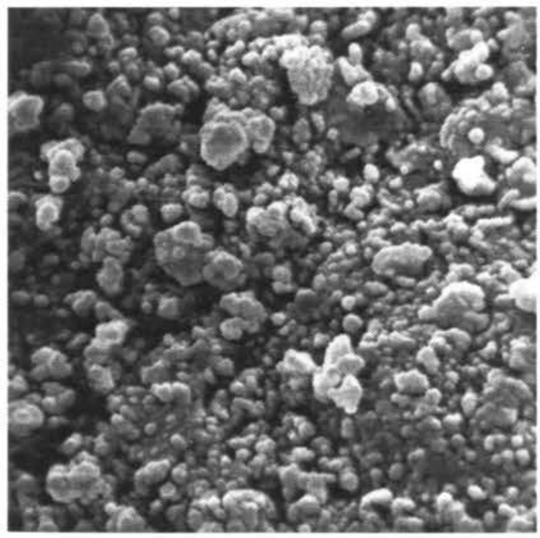


Figure 21 d

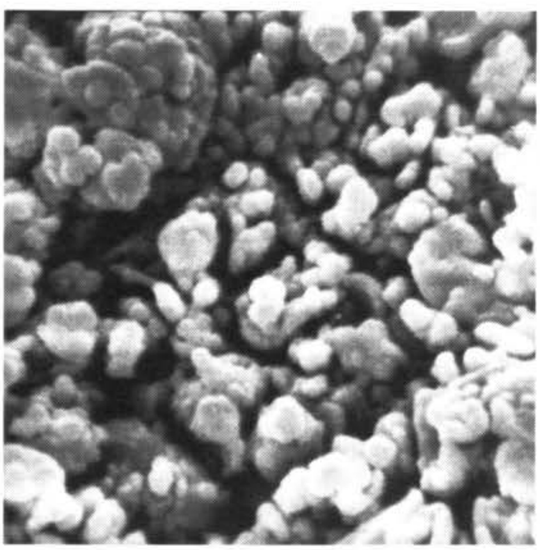
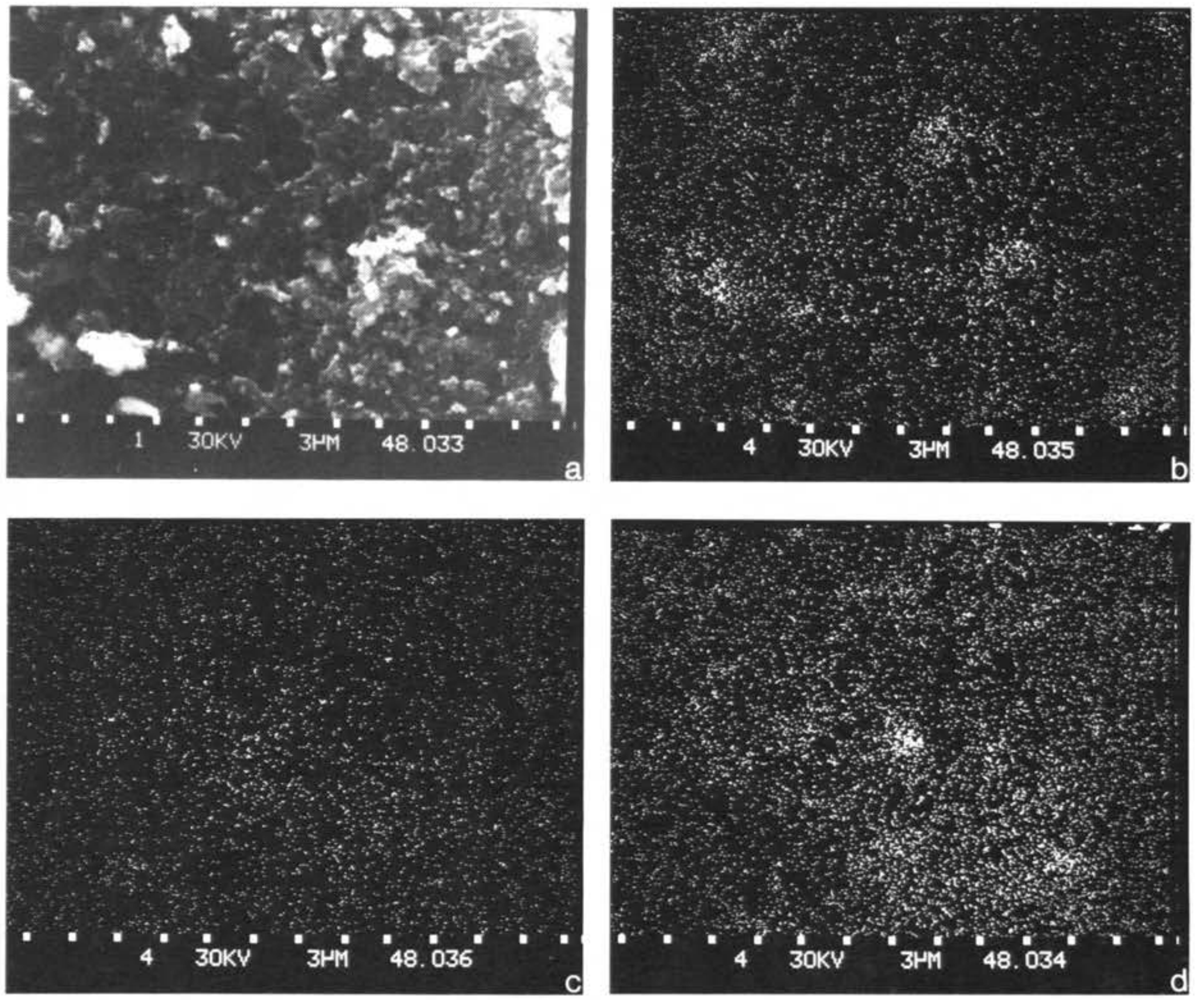


Figure 21 e

Figure 21a: Porous surface of unpainted slip on the sherd **0518**. *S.E.M. photograph, gold coated, magn. 8,000x.*
(b): Fracture of unpainted portion of the sherd **0518** *showing texture of the slip surface (magn. 800x).*
(c): Red pigment as a thin layer on a very porous (cellular) sintered sherd **0518**. *The painted surface is in the upper part of the photopraph, the edge of fracture runs diagonally. Magn. 1,760x.*
(d): Texture of red pigment from the Scarlet Ware sample, **0518**. *Increased coalescence of particles and a slightly hillocky character are observed. Weak surface contaminations by flaky rosettes. magn. 8,000x.*
(e): The system of regular grooves in the surface of red paint. Origin discussed in the text. Magn. 16,000x.



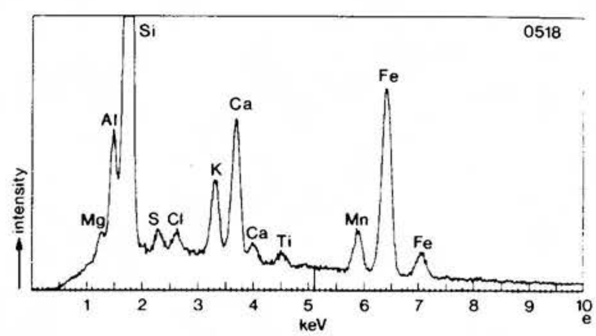


Figure 22: "Reversed" sample of red paint (a) with corresponding element distribution maps (b: Ca; c: K; d: Fe) and an overall energy dispersive analysis (e). S.E.M. photograph, carbon coated.

clear; perhaps the former originated on coagulation and drying of the paint layer whereas the latter come from the original material or were formed during preparation of the paint.

In the "layer reversal" samples, the Fe backgrounds are only seldom strong, homogeneous and featureless. Fe distribution is often limited to several Fe-rich grains and the medium strong background. Again, Ca is primarily limited to grains, K has an irregular distribution as well (Figs. 22). Fe-rich grains and the overall (area) analyses of pigment show constant contents of Mn, which very occasionally occurs in amounts comparable to the Fe contents (Fig. 23-24). Only a single Fe-rich grain was found which did not contain manganese. Mn cannot be detected in the mass of the sherd. All overall analyses as well as the local (paint) analyses (albeit not pure because of scattering) also show substantial contents of Si (also pure Si-rich grains), Ca, variable amounts of Al,K, ubiquitous Ti, some Mg as well as variable amounts of S and Cl. In the coating material, gypsum crystals, quartz

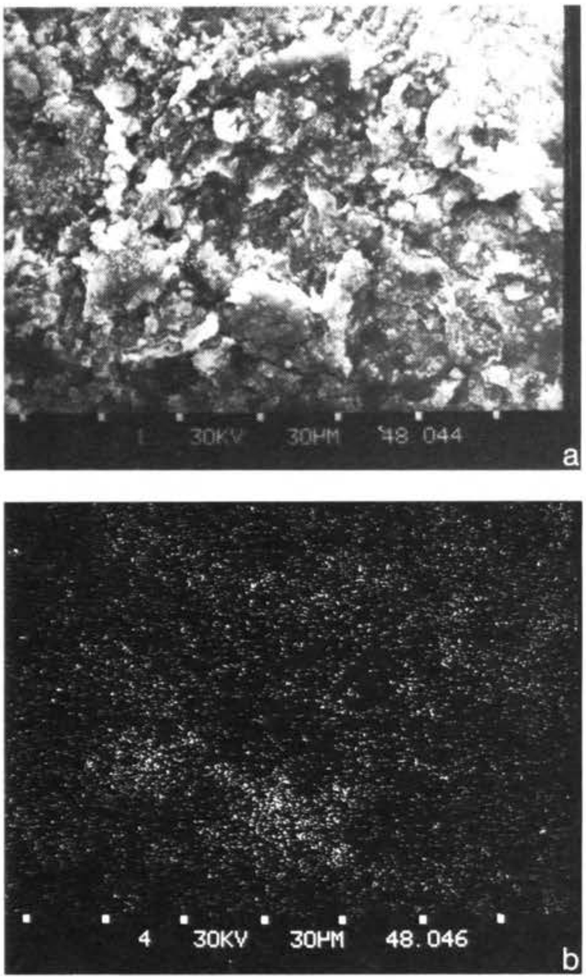


Figure 23: Disintegrated red paint in the "reversed" sample (a) and its corresponding Fe distribution map (b), sample **0518**. S.E.M. photograph, carbon coating.

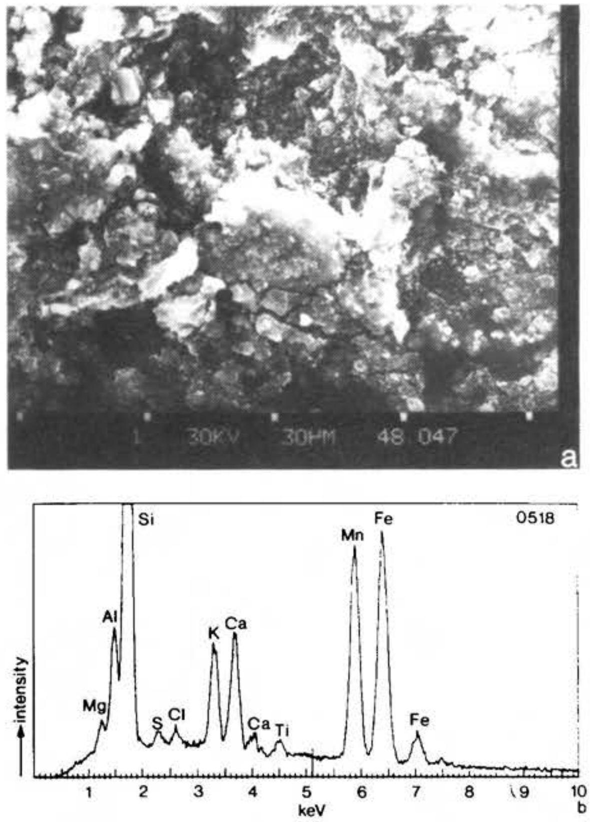


Figure 24: A Fe-rich grain in the red pigment from the previous photograph (a) and its energy dispersive spectrum (b).

grains, as well as flaky Mg silicates appear (Figs. 25-26).

Black pigment again represents alternation of flocculated, albeit porous areas with regions of coarser loose particles that separate them. The paint forms a thin, rather loose layer on the sherd (Fig. 27).

0540, Scarlet Ware

The brown-red (brick-red) pigment has been examined both *in situ* and by the "layer reversal" technique.

The "layer reversal" technique shows that the Fe "background" of the pigment is more saturated than in the other brick-red samples but it again contains distinct particles of very variable size with very high Fe-contents. In this case, their morphology is more complex; they appear to represent irregular agglomerations composed of small, irregularly shaped grains packed loosely to tightly together (Figs.28-30). Besides them, the pigment contains grains of quartz, K-Al (also Na,Mg) silicates, grains or crystals of gypsum (Fig.31) as well as (presumably flaky) (K)-Fe silicates. Mn is practically absent from the pigment mass.

The *in situ* measurements confirm the previous observations, i.e., the Fe-rich grains in Si-Fe rich matrix, occasionally saturated with gypsum (Figs. 32 and 33). Besides variable Ca and S contents, a distinctly Si-Al-K rich character with some Mg, Na, Cl and traces of Ti emerges, the entire mass having medium high overall Fe contents. The grainy character of the paint surface as well as the gypsum burial coating of the latter can be seen in Figs.32 and 33.

0513, Scarlet Ware

The brick-red pigment from this sherd was analysed by the "layer reversal" technique.

The ample secondary coating present on this sample has in general a flaky character and contains Si-rich, Si-Al rich, and gypsum particles (Fig. 34). Fe

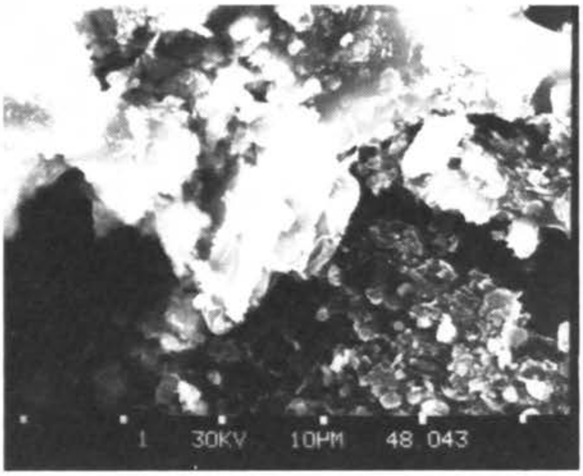


Figure 25: Flaky Mg-silicates in the burial coating of red paint in sample **0518**. *Carbon coating.*

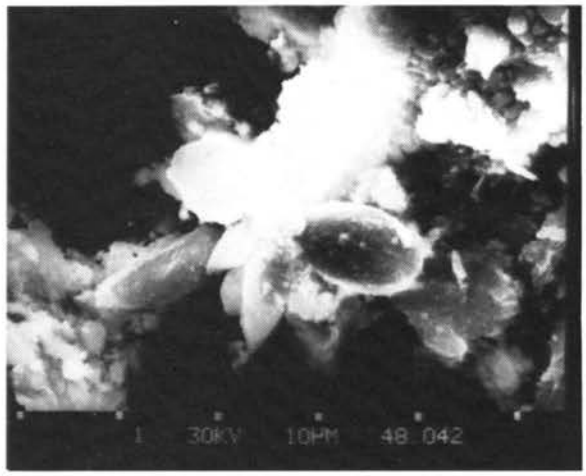


Figure 26: Gypsum crystals and a rounded quartz grain in the burial coating of red paint in sample **0518**.

Figure 27a: Texture of black paint from Scarlet Ware sample, **0518**. *Magn. 8,500x.*

Figure 27b: Black pigment layer on a sherd **0518**. *Magn. 1,700x.*

contents of the coating are low, no Fe-rich particles can be found, and small amounts of Mn are present. On the other hand, the ceramic material is studded with gypsum particles, it is rich in Si and contains K-Al (Mg) silicates dispersed throughout the matrix. Again, Fe contents are low with traces of Mn present.

The pigment itself appears to be composed essentially of non-ferrous phases (quartz, gypsum, calcite, and K-Al silicates were found by point analyses) in which grains with high Fe contents are thinly dispersed. They presumably (radiation contamination by surrounding areas!) do not contain substantial amounts of other elements, except for Si in some instances. Mn is practically absent. In all recognized cases the morphology of these grains is simple, irregular to flaky but not granular (Figs. 35-36).

Conclusion

Only two (or three) kinds of paint were used by the Tell Razuk potters: black and red, with pink present on the Scarlet Ware sample from the lot **0580**.

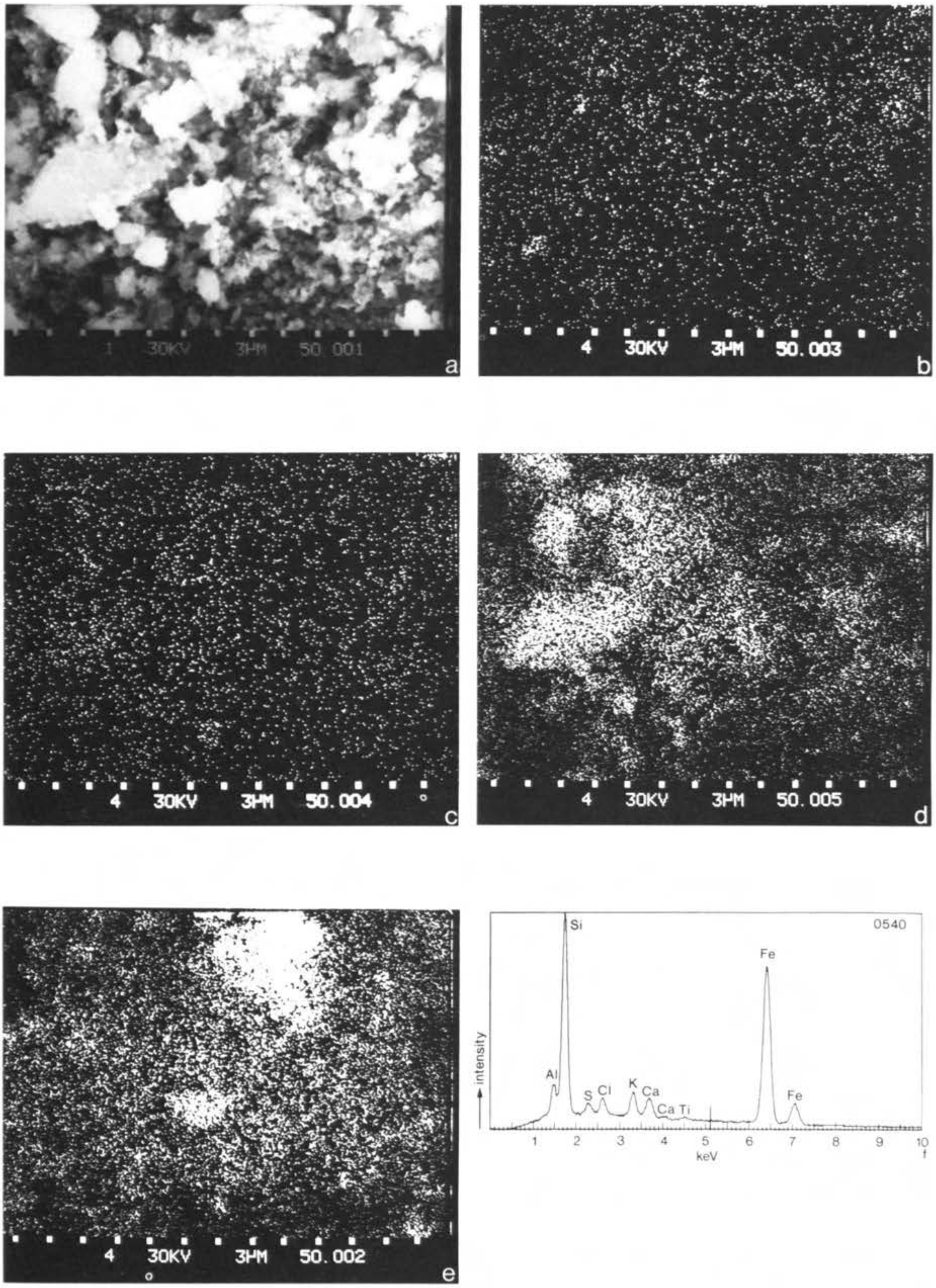
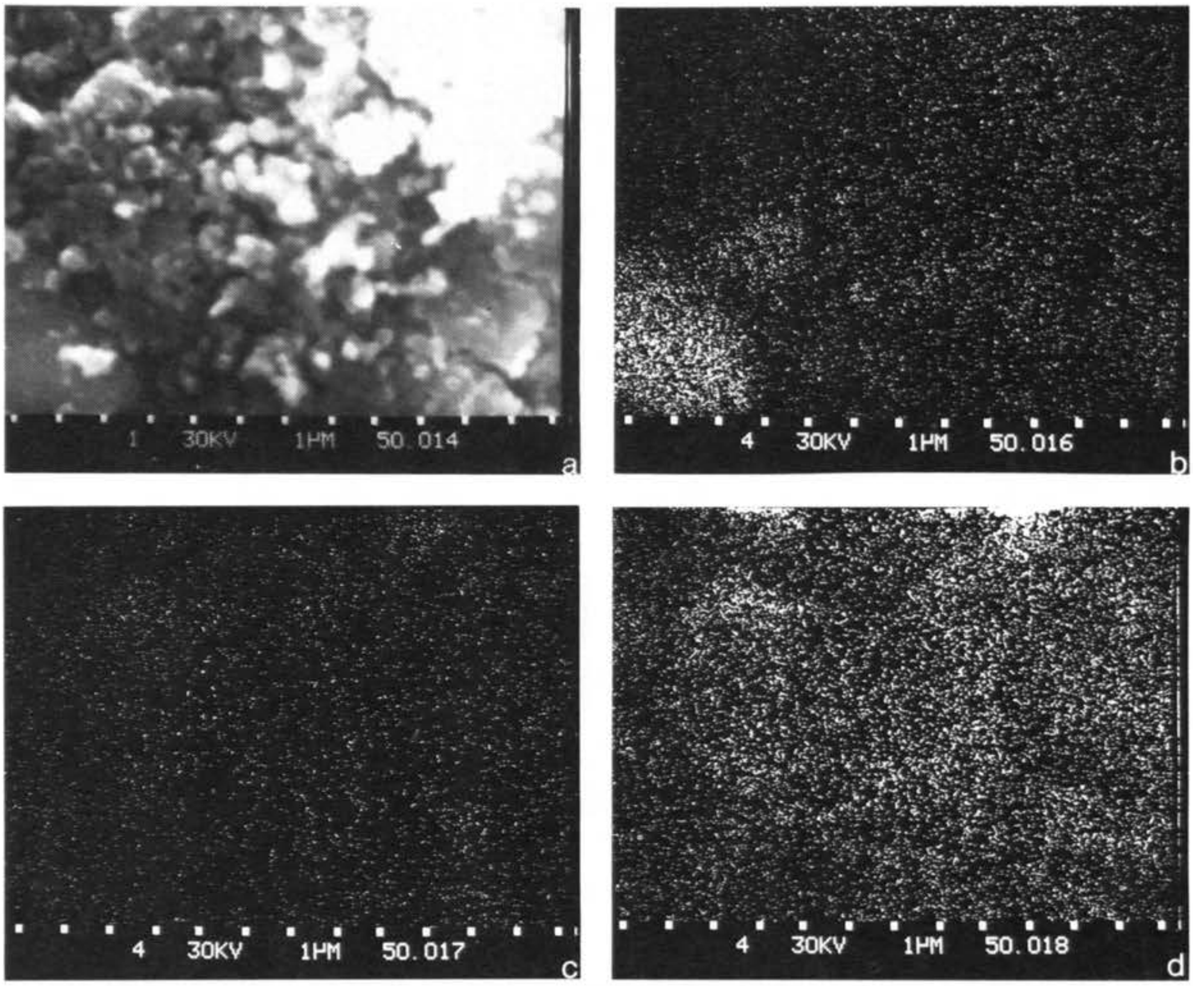


Figure 28: Texture and composition of the brick-red pigment layer of the sample **0540** *by means of "layer reversal" technique. S.E.M. photograph (a), element distribution maps for Ca (b), K (c), Si (d) and Fe (e) and the overall energy dispersive spectrum of the depicted area. Scale in m is shown in the photograph.*

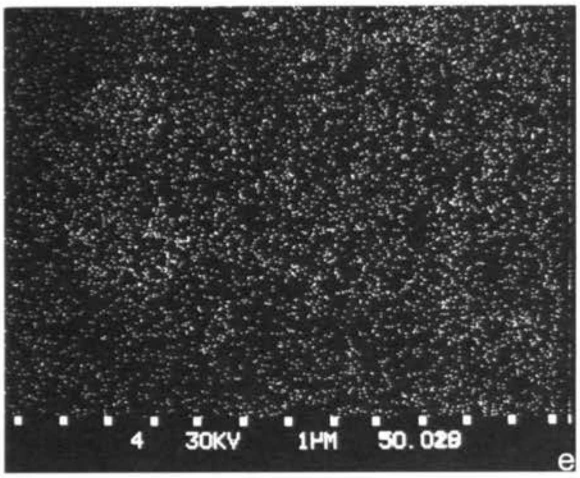


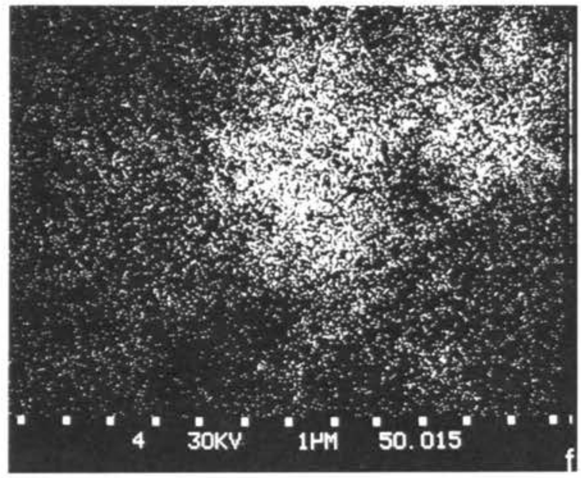
Our study of black paint indicates that it is unique in the Near Eastern context as it was described by Noll *et al.* (1975). All the samples examined represent amorphous carbon. The morphological investigation by S.E.M. suggests soot rather than ground carbonized organic material. Absence of appropriate diffraction lines excludes ground graphite as well. The universally oxidic firing of the sherds which display black ornamentation and the easy burn-out of this pigment on moderate annealing in air suggest unambiguously cold, post-firing application. The surface structure is consistent with wet application of a soot suspension.

The use of soot as paint is relatively rare in ceramic history. If we exclude the conscious use of black produced by reduction firing (e.g. the Neolithic and Early Minoan ceramic ware of Crete (Noll 1982), Neolithic ware of Greece (Letsch 1981), Etruscan Bucchero Nero ware (Winter 1956), or present-day Pueblo potters in New Mexico, the use of carbon black means cold application (overpainting) of finished pottery. Closest examples described in literature come from the El Tarif pottery (Thebes, 11th Dynasty), i.e. soot cold-applied onto white, ground calcite "priming" (Noll 1978). Soot was the common black pigment for frescoes in ancient Egypt (ibid.). No examples of cold-applied soot on ceramics were quoted from Mesopotamia itself, this being the region of iron-based paints (Noll 1976, Steinberg & Kamilli 1984).

The red and brownish-red paints studied all differ from each other to a varying degree. Only the Scarlet Ware, **0580**, outstanding among the sherd material because of its rich, matt plum red paint layer, displays predominance of Fe-rich particles (i.e. hematite) in the paint material. The pink paint **0580** has lower Fe contents than the red pigment but iron still appears rather homogeneously distributed in the paint mass. All other samples studied show individual or clustered Fe-rich pigment particles in a background of medium to insignificant iron contents.

X-ray diffraction reveals that in all cases, except for the orange red pigment from sample **0513**, hematite is the colouring agent in the paint layers. No





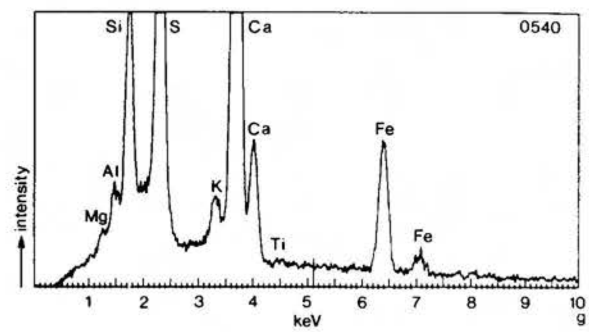


Figure 29: Another area of the same sample; S.E.M. photograph (a), element distribution map for Ca(b), K (c), Si (d), Al (e), and Fe (f) and spectrum of the large Fe-rich particle located in the Fe-distribution map (g).

other colour-contributing iron compounds have been found in powder diffractograms. The pigment particles appear more or less pure in energy dispersive analyses, sometimes with Si and other impurities. Their texture resembles that of the hematite-rich layer in **0580**, i.e., that of iron ochre (cf. Noll 1978). Still, caution has to be exercised when interpreting S.E.M. photographs, as shown by the similarity of layer texture of the Fe-poorer sample **0518** to that of **0580**, and by the abundant presence of non-pigment particles in the latter, as ascertained by energy-dispersive analysis. Finally, the pigment particles in **0513** differ from the other samples by their simple morphology.

Based on morphology, we can assume that in all cases where hematite was proved to be the pigment, iron ochres mixed to different degree with other components were used. However, the same ochre was not used in all instances: the composite particles in **0518** are all enriched in Mn, which is practically absent elsewhere. Manganese probably does not enter the crystal structure of hematite in the particles of pigment in appreciable amounts, because the colour of hematite has not been visibly altered to brown. A small percentage of Mn_2O_3 in hematite ought to be sufficient to cause such a colour change (Noll 1978).

The most problematic to explain is the brick- to orange-red pigment of lot **0513**, in the paint layer of which no hematite diffraction lines were found. Its sparse pigment particles have simple irregular outlines and practically no Mn. Without the appearence of hematite on annealing, one could hypothetize that the amount of pigment in the paint was not sufficiently high to show in x-ray diffraction. With its appearance, however, other explanations are to be advanced: either no hematite was originally present in the paint; or its proportion in the iron pigment was low, the rest being other, badly diffracting phases; or its diffraction was enhanced by recrystallization on annealing. No lines of alternative pigments were recognized except for the questionable ferrihydrite. This phase ought to be very unstable (Murray 1979) and its survival over millennia would be remarkable. Naturally, the principal question is whether such relatively small concentrations of a poorly diffracting phase can be detected in the complex powder pattern. The source of ferrihydrite would be local; it usually formed from iron-containing mineral water springs by the action of iron bacteria (Murray 1979). The colour of the pigment would agree well with ferrihydrite or, perhaps, with a mixture of hematite and goethite.

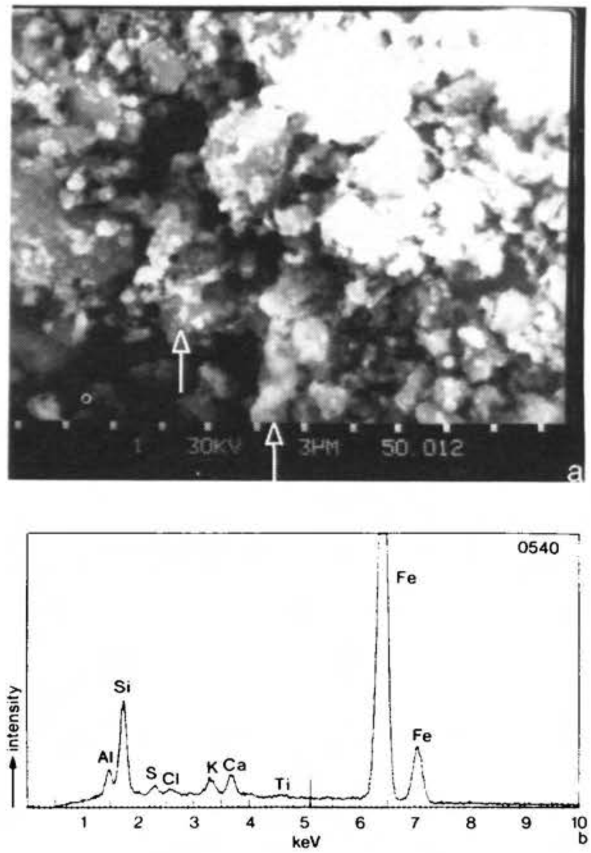


Figure 30: Morphology (a) and spectrum (b) of Fe rich particles (indicated by arrows) in the paint layer of the sample **0540**.

Provenience of several iron pigments has been studied by means of spectroscopic analyses of red-brown paint, parallel to those of unpainted "slip" surface. Although amounts sufficient for such analysis could not be obtained from all paint samples studied, the three analysed samples do not suggest trace element patterns attributable to some specific modes of formation, e.g., by weathering of polymetallic deposits or by weathering of crusts of ultrabasic massifs. The patterns observed allow perhaps for all associations with the common element patterns and a small concentrating role (absorption complex) of iron hydroxides, i.e. intense rock weathering, sedimentary iron ores or weathering of iron-containing carbonates. In the finely ground material it is impossible to see whether a pure hematite ochre has been used or its hematite contents and colour have been increased by further oxidation annealing in a fire before application.

The most difficult problem is the identification of non-pigmentary material used in the paint as binders, colour-diluting agents, or other admixtures. The paint layers are porous and loose, so that they would not bear even a routine archaeological cleaning. During the burial, chemical and mechanical deposits should not only cover but also penetrate them in their entire thickness. Therefore, for each component of the paint, several origins may be considered; they can represent (1) the original, intentionally added components, (2) products of impregnation by groundwater during burial, (3) parts of the underlying ceramic mass or slip or parts of a "priming" layer under the paint, or (4) portions of secondary coatings from the burial period. The final category, perhaps not applicable to this painted pottery would be (5) heavy secondary impregnations and coatings of mineral products deposited from evaporating water that has penetrated the vessel walls during its use (as it is the case for the recent material, **0900**, descibed above).

Material scraped from unpainted inner or outer surfaces of the painted sherds, even when they are macroscopically clean, or from the light gray secondary coatings, always contains quartz, calcite and gypsum as principal components in powder patterns, rarely accompanied by smaller amounts of high-temperature ceramic phases or some clay minerals. The same major phases are the principal components, detectable by x-rays, of the carbon black as well as of the red and red-brown pigments used. In this situation, one is forced to use indirect, textural criteria, e.g. the grain size, possible crystal shape, and the homogeneity of distribution, for deciding about the possible origin of any components.

In the red pigment of the sample **0580**, the amount of K-aluminosilicates is low and no distinct crystalline aggregates of Ca-rich components can be detected (whereas they are present in some of the paste

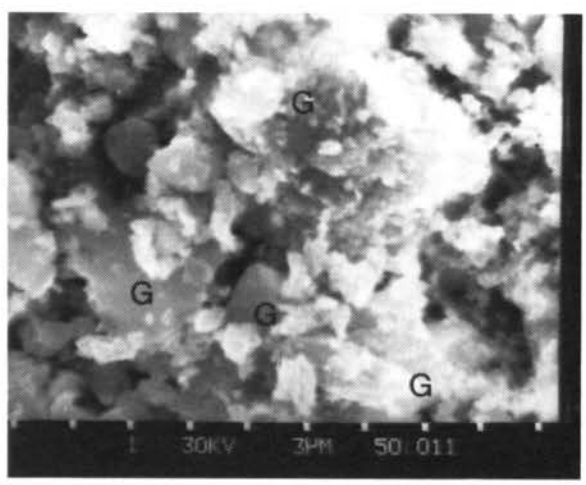


Figure 31: Grains of gypsum (G) in the paint layer disintegrated by the "layer reversal" technique.

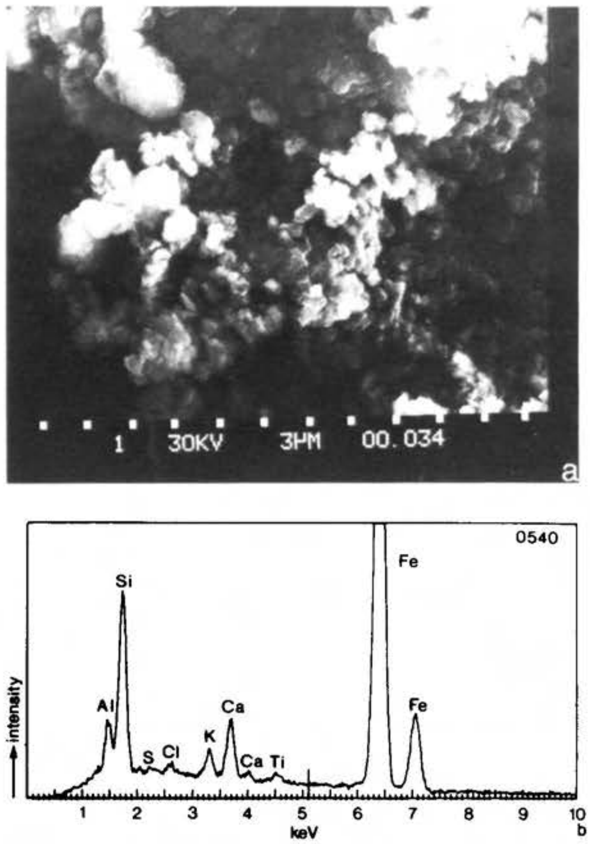


Figure 32: The Si-Fe rich red paint layer of the sherd **0540** *photographed in situ (a) and the energy dispersive spectrum of a Fe-rich particle in it (b). S.E.M. photograph, carbon coating.*

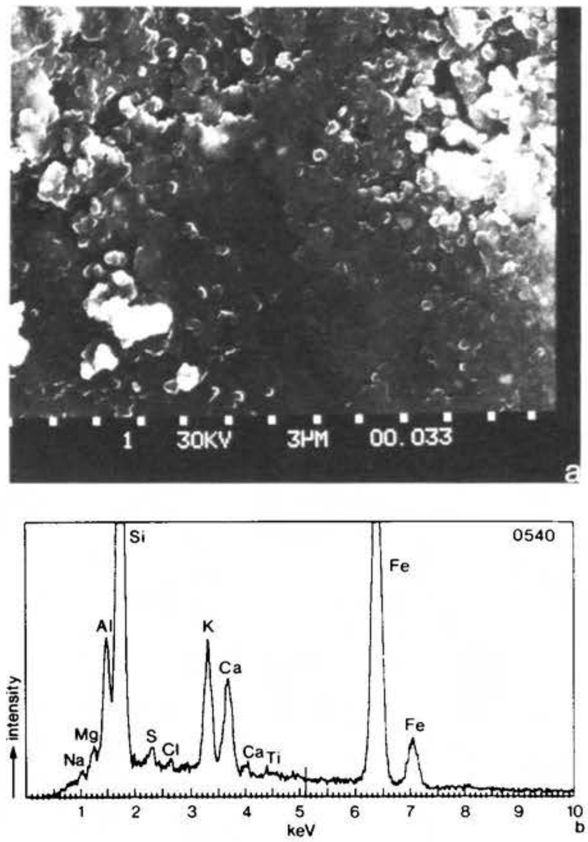


Figure 33: The same layer in situ, coated by gypsum (a), and the relevant overall spectrum (b).

samples described previously). From the red to the pink paint, the K-Al concentration increases much less than do the Ca and Si concentrations; S is variable and Fe content always drops significantly. The x-ray pattern confirms that the colour change is caused by increased contents of calcite in the paint.

Therefore, in the red and pink paints from the scarlet ware sample **0580**, the original binder might be a fine grained mixture of calcite and gypsum (plus quartz) with or without further organic binder used. The clay component, as indicated by the S.E.M. distribution maps for potassium, would play only a minor role. Calcite would be the principal dilutant of colour in the pink paint. The use of gypsum and calcite as binders as well as pigments in the analogous environment of Ancient Egypt has been discussed in detail by Noll (1978). The paint from **0518** contains relatively higher amounts of potassium and aluminium. This, together with the more coalesced surface texture, and the texture of the disintegrated sample in the "layer reversal" method, suggests that (besides the three above components determined by x-ray diffraction) a higher percentage of clay minerals occurs in the paint. Gypsum crystals, quartz grains, and flaky Mg silicates all belong to the secondary, burial coating.

The other samples, **0540** and **0513**, share the same characteristics: calcite, gypsum, and quartz as the principal components in the x-ray patterns, and appearance of the corresponding micrograins in the S.E.M. analyses, but together with K-Al silicates and similar material. Therefore, all these examples appear to represent the more standard approach to ceramic paint, fine dispersion of ochre with the fine clay fraction, with intentional or unintentional addition of finely pulverized calcite or/and gypsum.

In the same general area, the brown or red paints from Choga Mami and Tepe Gawra (Halaf ceramics) described by Steinberg & Kamilli (1984) appear to be compositionally closest to the present red-paint layers. Full comparison is difficult because of different research methods used.

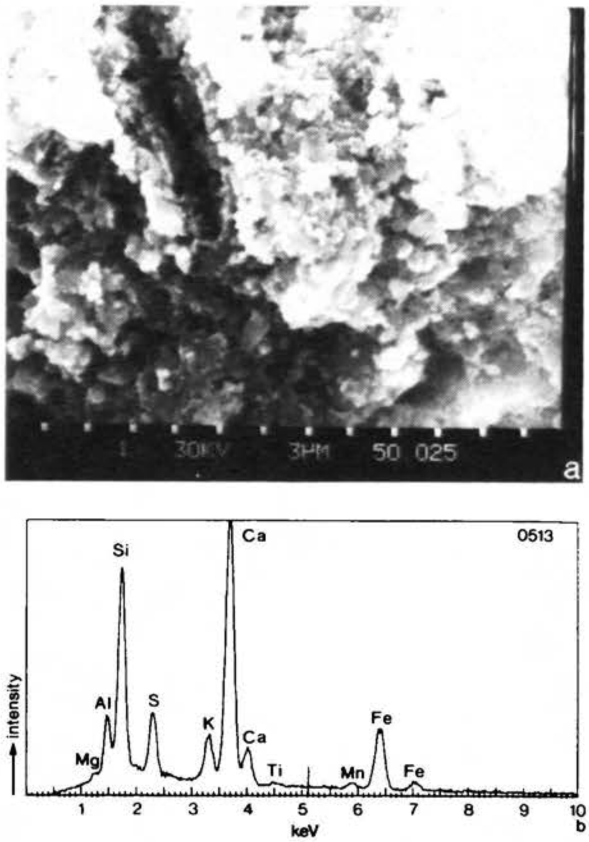


Figure 34: Flaky morphology (a) and overall energy-dispersive spectrum (b) of secondary coating on brick-red pigment from sample **0513** *obtained by the "layer reversal" technique. S.E.M. photograph, carbon coating; scale μm in the photograph.*

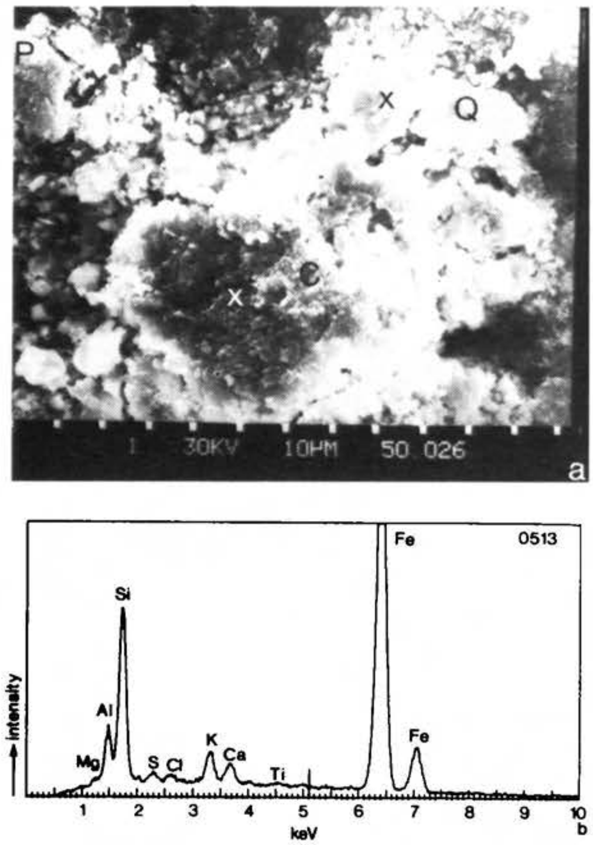


Figure 35: S.E.M. photograph (a) of iron-rich particles (denoted by "x") in the disintegrated brick-red paint layer from the sample **0513** *by the "layer reversal" technique. Adjacent particles are calcite (C), quartz (Q) and K-Al silicates and gypsum (area P). Spectrum describes the iron rich particle with Si present (b).*

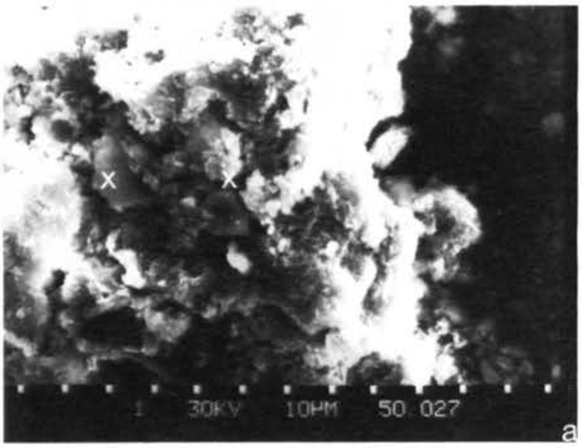
The final question to address is the pre- or post-firing application of the red paint layers. None of these revealed substantial amounts of high temperature silicates in the powder pattern. Thanks to their low contents of alkalis (as derived from mineralogical investigations) no substantial sintering or melting could be expected. It is difficult to evaluate to what extent the fine-grained anhydrite produced on firing of such a layer would survive in groundwater during the burial. Under these circumstances we are led to believe that the red paint layers of Tell Razuk underwent firing at relatively low temperatures (as did those at Choga Mami and Tepe Gawra, Steinberg & Kamilli 1984) or some - the Ca-rich ones especially - could have been cold-applied, as was proven for the very similar paints from Gizeh (1.-4. dynasty) in Egypt by Noll (1978).

IV. Raw materials

Provenience

No clay deposits that served as a source for the ancient potters were found. Unfortunately, the samples from the clay deposit that serves the modern potters (the water storage jars, fragment **0900**) were not available for this analysis, as the material had been used for the preceding instrumental neutron activation analysis.

The excavated building at Tell Razuk was built on a layer of clay from which a sample was taken and used for the present study.



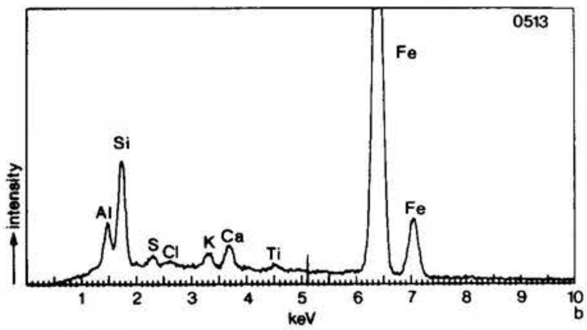


Figure 36: Iron-rich particles (x) in the same paint layer surrounded by grains of calcite, quartz, gypsum and silicates. Spectrum (b) refers to the iron-rich particles in the photograph (a).

Bulk chemical analysis

The chemical analysis (Table 1[5]) indicates high SiO_2 and CaO contents in the bulk material, which has 20.07 wt % of volatile substances. However, the SiO_2 content is lower than in all bulk ceramic samples except for **0900**, which has been only weakly tempered.

X-ray powder diffraction analysis

X-ray powder diffraction analysis of the bulk sample was performed by means of Guinier photographs, similar to the other samples studied. It revealed that calcite, apparently quartz and palygorskite represent the principal minerals of this "old" clay. In order to check these conclusions, a thick air-dried smear of clay saturated with aethylenglycol was x-rayed by the Guinier camera. All palygorskite lines remained unchanged whereas the broad (001) and (002) reflections of saturated smectite could be discerned at 14.08 Å and 7.01 Å (Table 3).

Because of its general interest, the sample was submitted to Dr. H.Lindgren (Danish Geological Survey) for detailed clay mineralogical investigation. His powder diffractometer data for the bulk sample showed calcite, quartz, feldspars, and gypsum, with additional reflections at 4.48 Å, 7 Å, 10 Å and 14 Å, all ascribed to clay minerals.

After separation into size fractions, the sample was found to contain 17% of the clay fraction 2.0-0.2 µm and 37% of the clay fraction below .2 µm.

d(obs)	I(obs)	Interpretation
14.08	1	smectite
10.27	3	palygorskite
8.30	1	
7.01	1	smectite
6.31	1	pal.
5.35	1	pal.
5.11	1	
4.237	5	pal.
4.114	1(double)	pal.
4.015	2	
3.835	4	calcite
3.740	2	smectite
3.634	1	pal.
3.430	1	pal.
3.362	1	pal.
3.236	2	pal.
3.207	1	
3.179	2	pal.
3.024	10	calcite
2.924	1	
2.870	1	
2.838	2	
2.781	1	
2.588	2 broad	pal.
2.557	2 double	pal.
2.491	5	calcite
2.092	5	calcite
2.074	1	pal.
2.047	5	pal.
1.989	1	
1.926	3	calcite
1.911	7	calcite
1.874	8	calcite

Table 3: X-ray powder diffraction data on palygorskite-smectite clay wetted by aethylenglycol. Guinier-Hagg camera, CuK radiation, quartz internal standard (subtracted here).

5. See above p. 22.

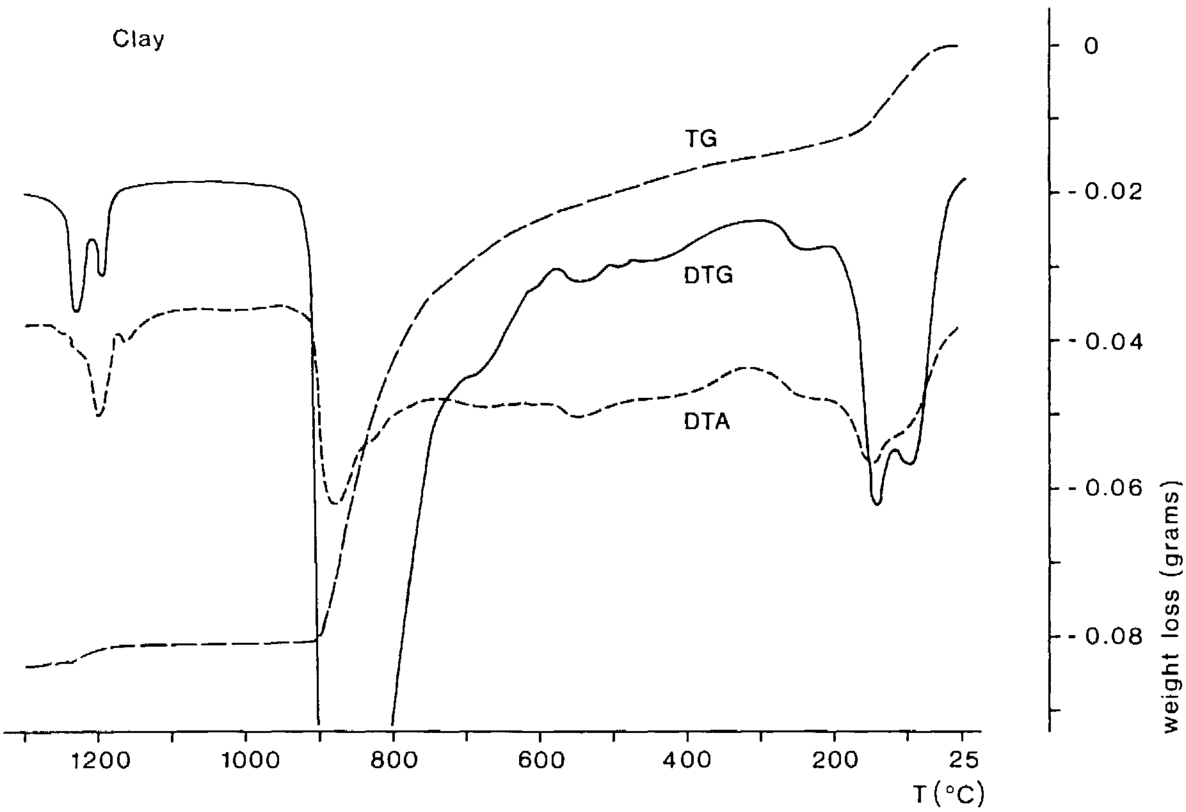


Figure 37: Differential thermal analysis of untreated, pulverized and predried palygorskite-smectite clay. For details see Figure 2, p. 00.

After treatment, which consisted of preliminary chemical cleaning, Mg-saturation plus subsequent glycerol saturation, as well as the parallel K-saturation and subsequent annealing at 460° C, the oriented samples of the coarser fraction revealed:

chlorite 7%	mica(illite) 13%
vermiculite 1%	palygorskite (10Å) 8%
smectite 60%	kaolinite 19%

The percentages given represent relative x-ray peak areas.

The x-ray diffraction analysis of similarly treated and oriented samples of clay fraction finer than .2 µm gives two principal peaks situated at 10.2 Å and 5.3 Å. The unoriented diffractogram of this fraction featured only lines of palygorskite: 10.7 Å (relative intensity 22), 6.1 (2), 5.4 (12), and 4.48 (5). As confirmed by the DTA analysis of this fraction descibed below, the .2 µm fraction represents almost pure palygorskite.

Differential thermal analysis

DTA analysis of the bulk sample (charge size 1/3 g, linear temperature increase 10° C/min, Fig. 37) represents essentially an overlap of the DTA curves of palygorskite and calcite (Neumann 1977). The double peak caused by dehydration at ~100° C and 143° C (palygorskite, smectite and gypsum?) is followed by a minor peak at 250° C. The small peaks at 545° C and 690° C are also connected with small weight losses. The former corresponds to palygorskite, the latter to the admixed smectite. The next stage is completely covered by the large endotherm of calcite (top at 883° C) onto which a smaller endotherm of palygorskite could be overprinted at 838° C. A minor loss of weight is connected with the endothermic reaction at 1200° C and another at 1237° C.

For the pure polygorskite fraction (finer than .2 µm) H.Lindgren obtained two endotherms at 165° C and 255° C, connected with a loss of H_2O. They are followed by a weak endotherm at 650° C and a sharp exotherm at 675° C. The latter reaction lies much below the expected reactions at 880° C indicated in literature (Martin-Vivaldi and Fenoll Hach-Alli 1970).

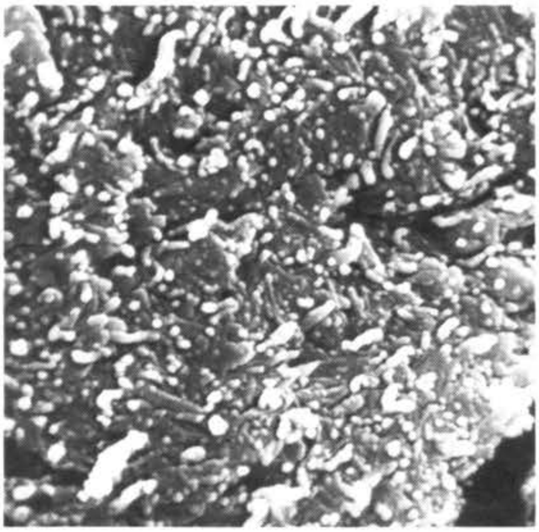


Figure 38: The fibrous-flaky texture of the fresh fracture surface of the original palygorskite-smectite clay. S.E.M. photograph, sample gold coated, magn. 8,500x.

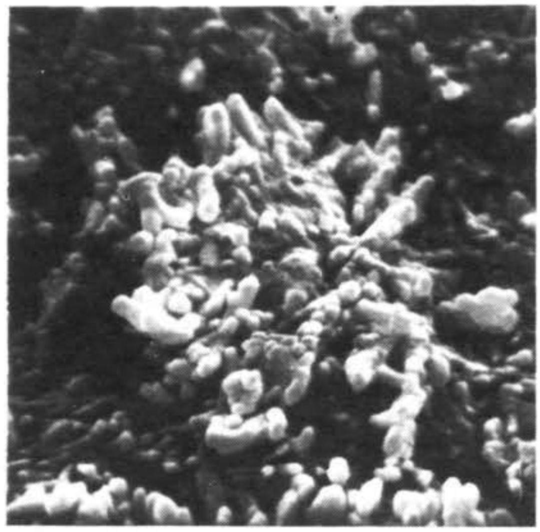


Figure 40: An entangled palygorskite-smectite (?) aggregate on a fresh fracture surface of clay. Magn. 17,000x.

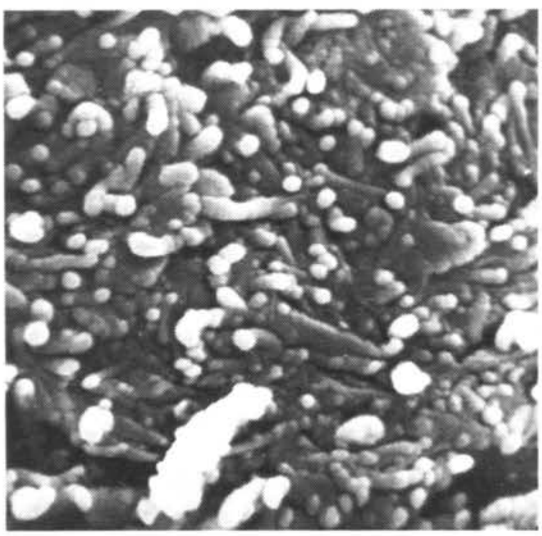


Figure 39: A detail of the entangled fibrous texture from the previous photograph. Magn. 17,000x.

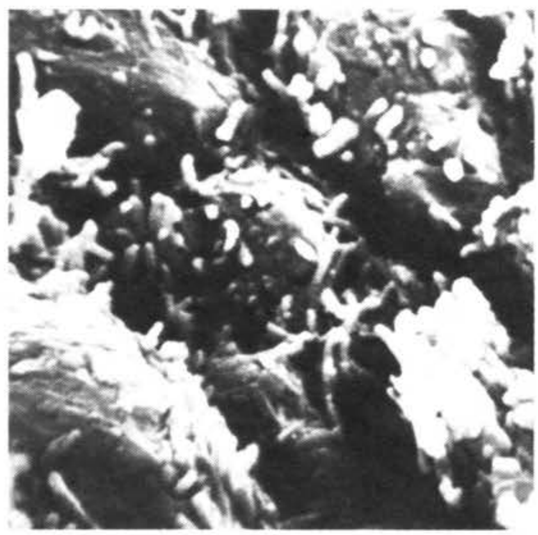


Figure 41: A less frequent situation on a fresh fracture surface of the examined clay: palygorskite (+smectite?) coatings of mineral grains. Magn. 17,000x.

Scanning electron microscopy

Scanning electron micrographs of a fresh, gold-coated fracture surface of the bulk sample display a fibrous texture typical for intermeshed palygorskite. Palygorskite bundles appear to be unusually thick (Figs. 38-41).

Conclusions

Unfortunately, little has been recorded about the clay layer from which the analysed sample was taken. In general, for arid environments of the Middle East and elsewhere, Singer (1984) distinguishes three modes of formation: (a) soils affected in the present or in the past by rising ground water; (b) soil formations with a sharp textural transition (paleosols), and (c) crusts, caliche and calcretes.

The studied occurence apparently corresponds to type (a) genesis on flood plains or low terraces. As shown by Eswaran & Barzanji (1974), it is not unique in Iraqi context. In agreement with general observations in the broad area, the soil is calcareous. DTA and x-ray powder diffraction show that calcite is the principal (or only) carbonate component in our ware. Ca and Mg are the principal soluble cations, sodium contents are low. Coexistence of palygorskite in the soil with smectite suggests that the conditions were close to, or oscillating about, the Mg and H_4SiO_4 concentrations as well as about the pH values close to the phase boundary between smectite and palygorskite. The peculiar features visible in S.E.M. photographs can be tentatively explained as coating of palygorskite fibres (bundles) by smectite, a case not yet reported in the literature. Total mineralogical composition of the soil clay agrees in principle with wadi soils from Saudi Arabia and South Yemen (Mackenzie *et al.*, 1984).

Our rudimentary material does not give us the opportunity to choose sides in the question of neoformation vs. inheritance (deposition) of palygorskite as well as in the possibilities of smectite-palygorskite transformation or direct chemical precipitation of palygorskite from Mg, Si - bearing solutions (Singer 1984). We ought to stress, however, that Elprince *et al.* (1979) and other authors conclude that the pore solutions in arid soils of the Middle East meet the conditions for stability of palygorskite established by Singer & Norrish (1974).

Matson (1971) states that the pottery clay from Seleucia on the Tigris, chemically rather similar to our clay (although Si- and Fe-richer), contains illite. In agreement with Singer (1984), it should be stressed that the major x-ray diffraction reflection (10.2Å) used for the cursory identification of palygorskite is masked by that of illite, i.e., Matson's data might be incomplete. As far as we can tell, the present study is the first instance in which a palygorskite-rich clay is considered as a paleoceramic raw material.

Acknowledgements

The authors profited from the assistance of senior lecturers E. Leonardsen, J. Rønsbo and H. J. Hansen as well as of the laboratory personnel at the Institutes of Mineralogy and of Historical Geology, University of Copenhagen. The kind assistance of Dr. S. Karup-Møller, Institute of Mineral Industry, Danish Technical University, Dr. H. Lindgren, The Geological Survey of Denmark, and Ing. J. Kystol, The Geological Survey of Greenland has been appreciated.

Dr. R. Gwozdz has been instrumental in arranging this cooperation and has kindly shared some of his results with us. Several of the analytical instruments used were financed by the National Research Council of Denmark (Natural Sciences).

Bibliography

Bolton, C.M.G.
1958 Geological Map, Kurdistan Series. *Site Inv.Co.Reports* 276-78, Baghdad.

Buday, T.
1980 *The Regional Geology of Iraq.* Vol. 1. *Stratigraphy and Paleogeography.* State Org. for Minerals, Baghdad, 445 ff.

Capel, J., F. Huertas and J. Linares
1985 High temperature reactions and use of Bronzean pottery from La Mancha, Central Spain. *Miner.Petrogr.Acta* 29: 116-128.

Elprince, A.M., A.S. Mashhady and M.M. Abu-Husayn
1979 The occurrence of pedogenic palygorskite (attapulgite) in Saudi Arabia. *Soil Sci.* 128: 211-18.

Enriquez, C.R., J. Danon and M.da C.M.C. Beltraõ
1979 Differential Thermal Analysis of some Amazonian Archaeological Pottery. *Archaeometry* 21: 183-186.

Eswaran, H. and A.F. Barzanji
1974 Evidence for the neoformation of attapulgite in some soils of Iraq. *10th Congress Int. Soc. Soil Sci., Moscow* 7: 154-60.

Gibson, McGuire (Ed.)
1981 *Uch Tepe I.* Chicago and Copenhagen.

Grim, R.E. and W. Bradley
1948 Rehydration and dehydration of the clay minerals. *Amer. Mineralogist* 33: 50-59.

Harker, R.I. and O.F. Tuttle
1955 Studies in the system CaO - MgO - CO_2. Part I: The thermal dissociation of calcite, dolomite and magnesite. *Amer. J. Sci.* 253: 209 ff.

Huber, H. and J. Efterkhar-nezhad
1978 *Geological map of Iran. Sheet No. 1. North-West Iran.* Nat. Iran. Oil Co., Teheran.

Jensen, E.
1978 The typical Danish brick. A phase analytical study by x-rays. *Kgl.Vet. og Landbohøjsk. Årsskrift* 1978: 53-63.

Letsch, J.
1981 *Material und Herstellung der neolitischen und chalcolitischen Keramik Mittelgriechenlands.* Thesis, Univ. Köln.

Levin, E.M., C.R. Robbins and H.F. McMurdie
1964 *Phase Diagrams for Ceramists.* Amer. Ceram. Soc. Columbus, Ohio.

Mackenzie, R.C., M.J. Wilson and A.S. Mashhady
1984 Origin of palygorskite in some soils of the Arabian Peninsula. In: Palygorskite - Sepiolite. Occurrences, Genesis and Uses. Singer, A & Galan, E. (Eds.) *Developments in Sedimentology* 37: 177-86, Elsevier, Amsterdam - Oxford - New York - Toronto.

Magetti, M.
1986 Majolika aus Mexico - ein archaometrisches Fallbeispiel. *Fortschritte der Mineralogie* 64: 87-103.

Martin-Vivaldi, J.L. and P. Fenoll Hach-Ali
1970 Chapter 20. In *Differential Thermal Analysis.* R.C.Mackenzie (Ed.) Vol.1. Academic Press, London.

Matson, F.R.
1971 A study of temperatures used in firing ancient Mesopotamian pottery. In: *Science and Archaeology.* Brill, R.M. Ed. M.I.T.Press, Cambridge Mas. 65-79.

Murray, J.W.
1979 Iron oxides. In: Burns, R.G. Ed. *Marine Minerals. Reviews in Mineralogy* 6: 47-92. Mineralog. Soc. America, Washington D.C.

Neumann, B.S.
1977 Thermal Techniques. In: *Physical Methods in Determinative Mineralogy.* Zussman, J. (Ed.) Academic Press, London - New York - San Francisco.

Noll, W.
1976 Mineralogie und Technik der frühen Keramiken Grossmesopotamiens. *Neues Jahrbuch f. Mineralogie, Abhandlungen* 127: 261-288.

1978 Mineralogie und Technik der bemalten Keramik Altägyptens. *N. Jahrb. Miner. Abh.* 133: 227-290.

1982 Mineralogie und Technik der Keramik Altkretas. *N. Jb. Miner. Abh.* 143: 150-199.

Noll, W., R. Holm and L. Born
1975 Bemalung antiker Keramik. *Angew. Chemie* 87: 639-651.

Peters, T.J. and J.D. Jenni
1973 Mineralogische Untersuchungen über das Brennverhalten von Ziegeltonen. *Beitr. Geol. Schweiz. Geotechn. Ser.* 50.

Rowland, R.A. and D.R. Lewis
1951 Furnace atmosphere control in differential thermal analysis. *Amer. Mineralogist* 36: 80 ff.

Shepard, A.O.
1954 *Ceramics for the Archaeologists.* Carnegie Inst. of Washington. Pub. 609. Washington D.C.

Singer, A.
1984 Pedogenic palygorskite in the arid environment. In: Palygorskite - Sepiolite. Occurrences, Genesis and Uses. Singer, A. & Galan, E. (Eds.) *Developments in Sedimentology* 37: 169-75. Elsevier, Amsterdam - Oxford - New York - Toronto.

Singer, A. and K. Norrish
1974 Pedogenic palygorskite occurences in Australia. *Am. Mineral.* 59: 508-17.

Smethurst, A.F.
1935 Anomalies in the analytical determination of water in epidote. *Mineral.Mag.* 24: 173 ff.

Southard, J.C. and P.H. Royster
1936 The thermal dissociation of calcium carbonate. *J.Phys.Chem.* 40: 435 ff.

Steinberg, A. and D.C. Kamilli
1984 Paint and paste studies of selected Halaf sherds from Mesopotamia. In: *Pots and Potters.* P.M.Rice (Ed.) University of California Los Angeles. 187-208.

Stocklin, J.
1968 Structural history and tectonics of Iran. *Bull. Amer. Assoc. Petr. Geol.* 52, No. 7.

Thuesen, I.
1981 The Early Dynastic Pottery of Tell Razuk. In *Uch Tepe I.* M.Gibson (Ed.) Copenhagen.

Tite, M.S. and X. Mantias
1975 Examination of ancient pottery using the scanning electron microscope. *Nature* 257: 122-123.

Winter, A.
1956 "Bucchero Nero", die Technik ihrer Herstellung. *Keram. Zeitschr.* 8: 614 ff.

Chapter III

Instrumental Neutron Activation Analysis of ED I-II Pottery from the Diyala Region and Farukhabad

Ingolf Thuesen and Kaj Heydorn

Introduction

Instrumental neutron activation analysis (INAA) is one of the most sophisticated methods for studying provenience of pottery. The method requires reactor facilities and is disciplinarily distant from traditional archaeological work[1]. INAA identifies trace elements in pottery fabric in a quantity of a few parts per million, trace elements which are characteristic of a certain pottery. In terms of the analytical parameters for pottery described above (p. 9 ff.), it characterizes a ware and implicitly the technical procedures of the workshop. It is important to realize that in many cases we are not able to distinguish the variations in trace element concentrations caused by choice of different clay sources or applied techniques, including tempering and firing, from the changes in composition caused by interactions between the sherd and the debris in which it has been deposited. However, as argued earlier (Thuesen 1987), in the case of Scarlet Ware we do feel confident that the variations of the trace elements due to contamination are minimal; and therefore we are allowed to talk about typical compositional patterns of the fabrics or wares as reflecting variations among workshop traditions. Identical or similar compositions in terms of trace elements do not necessarily mean identical sources or workshops, but only a high affinity between the compared samples in terms of manufacturing procedures.

Research Strategy

The value of an extensive INAA program was obvious, given the high potential for the existence of an exchange network or trade system in the Diyala Region. Such a network should be able to be proved responsible for the distribution of Scarlet Ware, particularly if viewed from the Razuk inventory. A primary goal was to identify inter-site relationships during the ED, and to try to explain the observed constellation inside a broader culture-historical environment.

The preceding speculations about ceramic analyses (chapter I) showed that a starting point should be to identify a supposed local or genuine tradition at a site. In the case of Tell Razuk, the assumption was that the major part of the pottery, i.e. the unpainted wares, was a local product, although in most instances imitating ceramics from contemporary sites - at least in terms of shape. Although there were no pottery kilns found at Razuk, some ovens had a structure that would have allowed firing pottery, e.g. the kiln excavated in locus 487 (Gibson 1981: 56). In short, the technical ability to build a pottery kiln was present. Moreover, in the Town Wall area there occurred a few sherds which were warped by heat, kiln wasters. The abundance of natural clay or silt, suitable for pottery production in the area, would have provided the raw materials for potters. We therefore expected the non-painted standard wares to be of local origin. They constitute more than 90% of the ceramic inventory in all levels.

The standard wares consist of four medium ware sub-groups distinguished by variations of colour: buff, pink, green, and gray respectively. Of those, only the gray ware was clearly distinct in terms of association with a shape type; it was used only for smaller jars of shape 7 (Thuesen 1981: 104). Further, it is often pattern-burnished and is relatively rare, never making up more than a few percent of the pottery assemblage of any given level (*ibid.* Table 4). A fifth group is a coarse ware used for large storage jars, very distinct

1. For a presentation of the method and its history see e.g. Perlman and Asaro 1969 or Harbottle 1976.

Figure 1: The pit just south of Uch Tepe from where clay was dug for pottery manufacturing

from the medium wares. It always has a dark gray core and is heavily chaff tempered.

The INAA project was arranged as a series of analyses starting with a set of samples from Tell Razuk, representing the above-mentioned ware groups, plus samples of local clay and pit-fired pottery recently produced from that clay by the women of Uch Tepe village (Fig. 1-3). This section of the project should provide information concerning the infrastructure of the Razuk inventory, for instance by comparing assumed Razuk local wares (un-painted pottery) to the Razuk Scarlet Ware. Considering the similarities between the ware groups of Razuk according to visual criteria, there was no reason to exclude local origin of the Scarlet Ware, other than the painted decoration. However, the standard ware shapes are also paralleled in known contemporary inventories from the Lower Diyala region, which could indicate a much more complicated situation than primarily local production with imports of decorated vessels.

Hereafter, a second set of analyses was performed, which aimed at placing the Razuk pottery inside a wide geographical horizon. Samples of Scarlet Ware from neighboring sites in the Hamrin Basin and samples from the Lower Diyala region were added, which should either confirm any local aspect of the Razuk pottery, or indicate connections between the sites of the region. This stage was facilitated by the extensive excavation activities in the Hamrin, which had produced an extraordinary amount of data for the relevant periods. Further, we had access to the material from the "classical" Scarlet Ware sites in the Lower Diyala Region, published by Delougaz (1952), and today stored in the museum of The Oriental Institute at Chicago. As a test group, samples of polychrome painted pottery from Farukhabad in the Deh Luran plain were included. To these samples was also added a new set of natural clay samples from Tell Razuk, this time from a layer of clay and silt reached beneath the foundation at the entrance to the Round Building. All samples are included in the catalogue (Appendix A).

Ideally, as many samples as possible should be analyzed to improve the characterization and statistical recognition of groups. However, the resources and cost associated with INAA normally set a limit to the number. This means that we had two types of sampling. First there was the total excavated sample generated by the depositional history and excavation strategy. The second sample consisted of a selection

Figure 2: Opening of the firing pit after the pottery had been fired for three days.

from the excavated corpus of pottery for the scientific analyses. In this project it was decided to let each group be represented by at least ten samples, with a group consisting of one ware from Tell Razuk, or Scarlet Ware from one other site. The criteria for choosing the ten samples was representation of as many as possible of the variations observed in a particular group, e.g. in the case of standard wares a range of shape types, and in the case of Scarlet Ware a range of different decorations, and for both, variation of the position of the sample on the vessel (rim, shoulder, body, base, etc.). Further, three samples were removed from a single large sherd in order to examine the internal compositional structure of a vessel. Initially, it was intended to include only ED I-II material, that is, proper Scarlet Ware and not the preceding Jemdet Nasr polychrome pottery. However, as the distinction between the two periods and their associated polychrome pottery is far from clear, this procedure could not be followed throughout the project, and a few Jemdet Nasr sherds were included as well. The presence of a range of variation inside the individual groups should make it possible to discriminate such groups that had not been recognized by applied ware definitions.

Samples were first removed from the sherds after they were brought to the laboratories at Risø. In the field the sherds to be analyzed were selected by members of the respective expeditions according to the outlined criteria.

Procedure of INAA

Sampling

Samples were removed from the individual sherds in areas without important characteristics, such as decoration or shape attributes, in order to avoid destruction of diagnostic elements. The sampling was carried out by first polishing the surface with a cylindrical diamond drill down to a depth where contamination on the surface from the burial deposit would be insignificant. A piece of the remaining core was then chipped off into an agate mortar, ground to a granular consistency, and weighed to make sure that enough material was available for analysis. 400 mg was set as a minimum (Hansen *et al.* 1978). Following this, the sample was poured into a porcelain crucible and fired in an electric furnace for one hour at 1000° C to remove volatile matter from the sample and to standardize firing conditions. After cooling the sample in the

Figure 3: The vessel produced by the women of Uch Tepe. It is primarily intended for water storage.

oven, approximately 300 mg was transferred to a weighed half-dram low-density polyethylene container. After a second weighing, the irradiation container was closed and heat-sealed by thermal radiation.

Irradiation

Irradiation took place in a special facility installed in the Danish heavy-water reactor, DR 3, operating at 10 MW at Risø National Laboratory. This facility permits the simultaneous irradiation of up to five floors, each comprising three irradiation cans; and the entire assembly was rotated 6 rph around its vertical axis, so that all three irradiation cans at each level receive exactly the same total neutron fluence. All the samples were irradiated for five hours at the lowest floor, which has a thermal neutron flux density of 4.5×10^{17} $m^{-2} s^{-1}$ and a fast neutron flux density of approximately 10^{15} $m^{-2} s^{-1}$ (Figure 4).

With a thermal-to-epithermal ratio of approximately 200 this irradiation facility provides excellent conditions for the use of a single comparator (Damsgaard and Heydorn 1978) with an accuracy of better than 2% for all elements determined in this study.

The irradiation cans are made of aluminum and have approximately 28 cm^3 volume, easily holding six half-dram polyvials, each heat-sealed separately in polyethylene bags. Five polyvials are used for samples and one for approximately 100 mg iron(III)oxide used as the single comparator. Accurate k-factors (Girardi *et al.* 1965) relative to iron were experimentally determined by irradiating samples of pure elements or oxides with known stoichiometry (Gwozdz 1985).

Measurement

Counting took place for 1-2 hours with a 55 cm^3 Princeton Gamma-Tech coaxial, wrap-around, Ge(Li) detector with a resolution of 1.71 keV at 1332 keV and a relative efficiency of 10.8%. The detector was installed in a Risø horizontal lead coffin (Heydorn 1980) and coupled to an Intertechnique Histomat N multichannel analyzer using 4096 channels at 0.7 keV/channel. A counting position was selected so that the total count-rate did not exceed 10^6 counts/s. Automatic processing of counting data took place by using a peak detection and evaluation program developed by Philippot (1970), and the processed data were transferred to a Univac 1108 mainframe computer for the final calculations.

After approximately one month decay all samples were counted again close to the detector for 3-4 hours, and the results were combined with those obtained from the first counting period. In this way no information was obtained on elements having short-lived indicators, such as aluminum, magnesium and manganese, but these elements seem to contribute very little to the distinction between various types of clay and pottery.

Results

Results for analyzed samples are shown in Tables 1-9 in % or mg/kg for 24 elements (p. 81). In cases where no reliable determination of an element could be made, upper levels could be estimated from counting data, but this information is not utilized in the classification of samples (Heydorn and Thuesen 1989 Table 2).

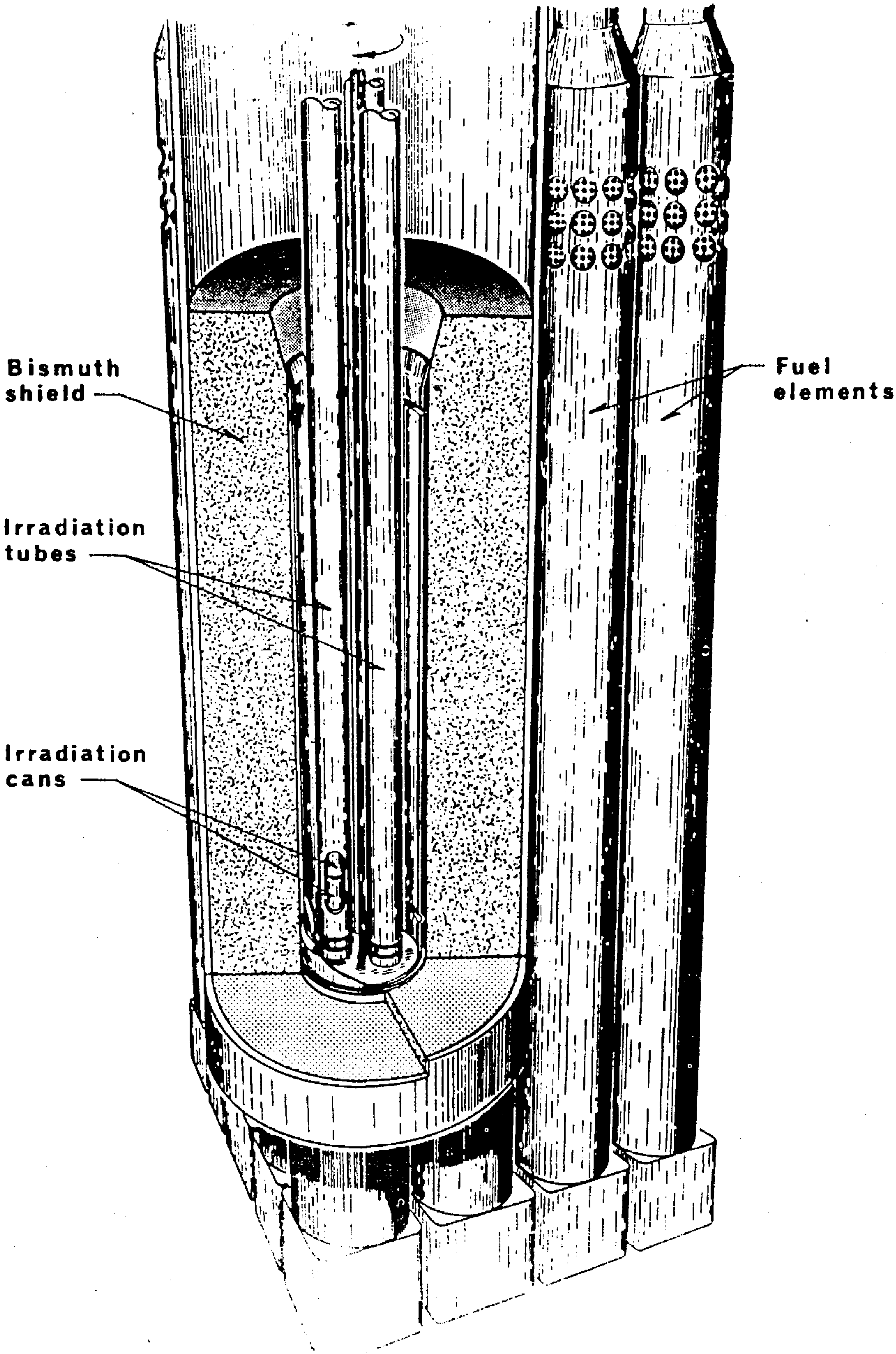


Figure 4: The Risø DR 3 irradiation facility.

Data processing

The purpose of the statistical analysis is to compare the archaeological classification with a classification based on the trace element data as determined by INAA. The clay composition with respect to major elements must stay within rather narrow limits in order to yield an acceptable final product (see also Chapter 2 p. 32). However, the concentrations of many trace elements may vary by orders of magnitude without any significant influence on the quality. These elements may therefore reveal the location of the production site independent of the physical appearance of the pottery. The specificity of classification based on trace element data improves with the number of trace elements determined, and INAA is the superior method for the analysis of clay materials in this respect.

Unsupervised pattern-recognition methods based on the detection of clusters in multi-dimensional observation space, or the determination of multidimensional discrimination surfaces, are useful techniques for finding structures in the results from a large number of samples for which relatively few variables have been determined. However, when the number of variables approaches the number of samples the risk of finding a false structure becomes excessive; the risk can be reduced by eliminating variables until the number of samples is three to four times the number of variables. Such elimination is not only a waste of analytical information, but also the criteria used for elimination are very critical and may lead to unsubstantiated discrimination.

Instead of discrimination methods, we have chosen to apply a method based on similarity classification, where assumed classes are subjected to a class-modelling technique which takes advantage of the large number of variables available for each sample. The prototype method named SIMCA (Wold and Sjöström 1977) that was used in our original classification studies (Thuesen *et al.* 1982) is also used for the more complete investigation reported here, although other methods with similar characteristics have now been developed (Derde and Massart 1986).

Each class is modelled by fitting a principal component model to the data, and a multi-dimensional box is created which surrounds the data. Classification of samples is now based on whether a particular sample falls inside this box or not, and the idea is that all samples are tested for all classes.

The number of principal components is chosen by means of the cross-validation technique (Wold 1978), and in most cases two principal components were found to be sufficient to characterize the data. Results are therefore conveniently shown by two-dimensional plots using the principal components as the axes.

Groupings according to two principal components

The first plot (Figure 5) shows all samples in one class projected from the multi-dimensional space on the plane represented by the two principal components, based on the concentration of 24 elements. The archaeologically defined groups or classes, separated according to sites and wares, are dispersed on the plot in what on a first impression may be seen as a highly integrated cluster. Only the samples of natural clay and modern pottery from Uch Tepe and the Farukhabad samples appear as two distinct groups. Both are located outside the large central group, which includes all ED samples from the Diyala Region. However, the Gray Ware from Razuk also tends to separate from the main cluster samples; but as demonstrated below it is associated with the so-called local Razuk group.

Natural Clay and Recent Pottery

A close look at this group reveals some internal division (Figure 6). Despite the small number of samples, the samples from beneath the Round Building in Tell Razuk, **0011-13**, can be distinguished from the samples from the vicinity of Uch Tepe village, **0053-65**. The latter is again distinct from the samples of recent pottery, **0900-02**, produced from that source. The two clay sources are geologically closely related: they are alluvial deposits within a distance of approximately one kilometre from each other. While the samples from the village were taken from a shallow pit (Figure 1) ca. 50 centimeters under the present surface, the samples from Tell Razuk were taken from a layer of culturally sterile clay and silt, located under the foundation of the round building, about 4.5 meters below the original surface of the tell. That clay had been soaked by ground water and water filtered through the debris of the site during almost 5000 years.

At this point, we are not able to exclude the influence of the soaking on the elemental composition; but can conclude that the INAA is sensitive to variations in the composition of clay within a geographically limited region.

Similarly, a change also seems to occur in the composition of the natural clay after it has been turned

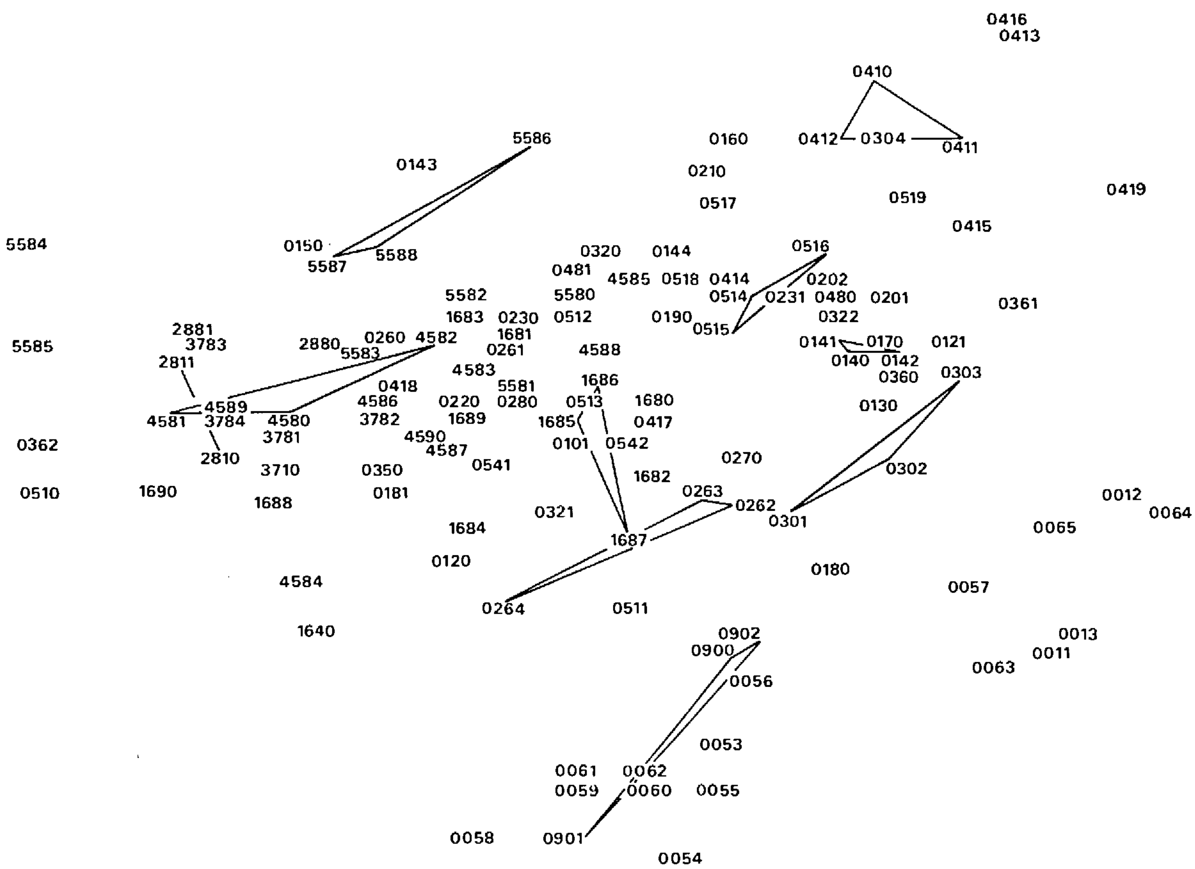


Figure 5: The distribution of all analyzed samples according to two principal components.

into pottery. A number of cultural circumstances might explain this variation, e.g. the tempering of the clay with salt and dung or the firing conditions. These are important aspects to examine in future trace element projects. Also, the results confirm the idea mentioned earlier, that the composition of ceramics cannot be directly compared with the composition of their known or assumed sources of raw materials. It emphasizes the importance of using the results of INAA as an expression of a combination of properties acquired from the raw materials utilized and the applied manufacturing techniques.

Farukhabad

All samples represent polychrome painted pottery of either ED II or III date[2]. Although the entire group clusters distinctly from the Diyala Scarlet Ware, it is far from being internally homogeneous. The samples from excavation B, layer 20, **5584-85**, a level overlying a large building complex, are most distinct when compared to all other samples (Figure 7). Samples from layer 6 in excavation A are separated from the excavation B samples and are relatively closer to the Diyala Scarlet Ware samples. In terms of motifs, shape, or other ware attributes, we are not able to see the same division, perhaps due to the small sample size[3]. It may be of some interest to note that the sample number **5583** is the least typical of the group in a compositional sense and approaches the Scarlet Ware. However, this does not affect the essentially independent compositional character of the Farukhabad group.

2. These dates are based on a re-dating of the layers and are later than the dates published earlier (Wright 1981 and Wright personal communication).
3. In the ongoing INAA project a larger number of samples from Farukhabad is being analyzed together with Scarlet ware related ceramics from cemeteries in the adjacent Zagros area (Heydorn and Thuesen 1989).

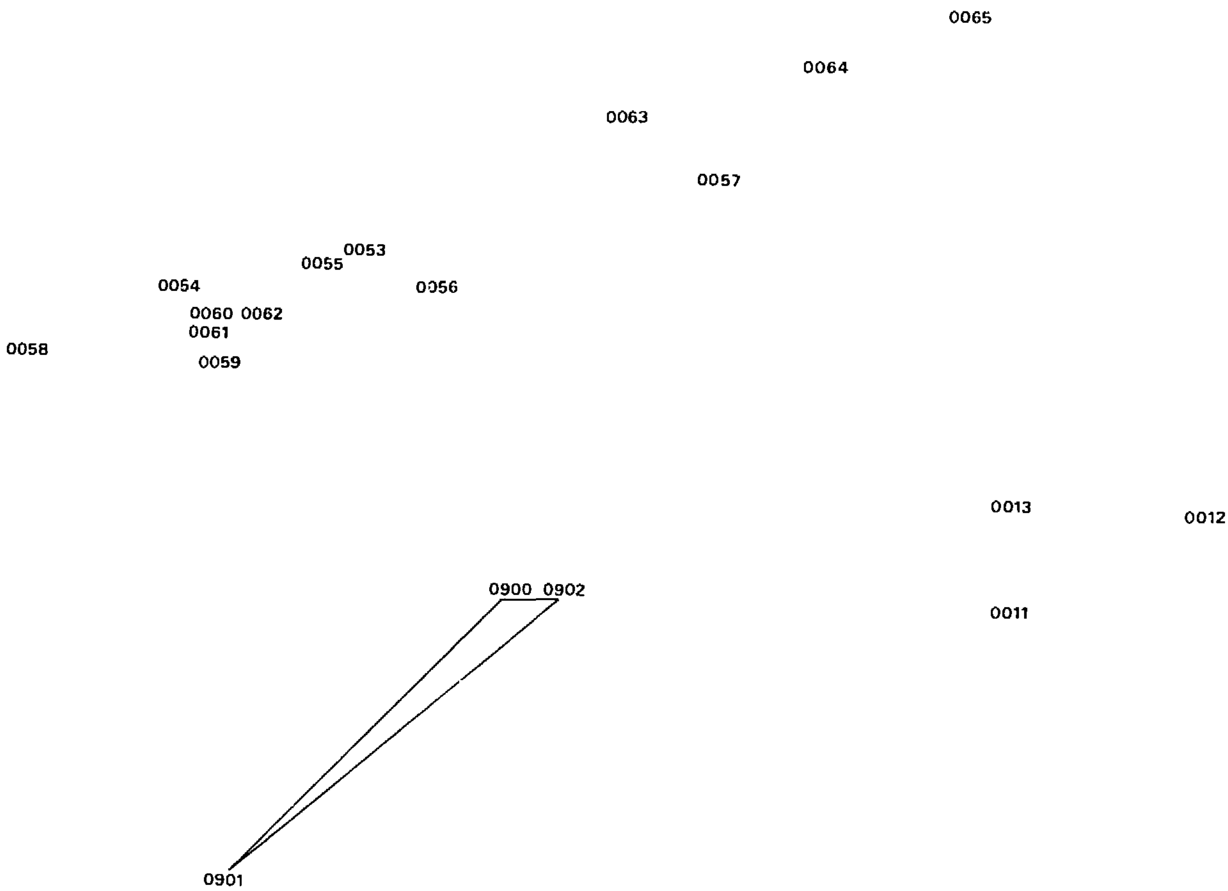


Figure 6: The distribution of samples of natural clay and modern pottery produced from that clay.

Early Dynastic Pottery from the Diyala Region including the Hamrin

The major cluster comprises all the Early Dynastic pottery samples from the Diyala Region. These have been analyzed in a separate plot shown in Figure 8. According to provenance there is no obvious internal structure in their distribution, but a closer look does reveal some groupings. Most conspicuously, the group of gray ware samples from Tell Razuk, **0410-81**, is located at the periphery of the cluster and only mingles with other Razuk samples. It may therefore be interpreted as a compositionally distinct group having a high affinity with the general Razuk inventory; and so far we do not know much about it from other sites (Thuesen 1981: 139). The shape, size, and pattern-burnished finish of gray ware vases may imitate metal vessels, which argues for a provincial, resource-poor situation in the Hamrin Basin. Further conclusions must await evidence from contemporary sites. The distribution of the Gray Ware group (Figure 9) shows that the three samples taken from one sherd, **0410-12**, are closely related. Two other samples also appear to be very similar in elemental composition, numbers **0413** and **0416**. They were excavated from debris above the same floor of a room, locus 49, and probably belong to the same vase. Most samples shows affinity with the local Razuk group defined below, but not with any of the other suggested groups, except perhaps for the sample **0481**, which has some similarity to the Intermediate group (Figure 8).

All other samples

Both Scarlet Ware and Standard wares, are distributed in a way that does not allow an immediate discrimination of classes. This could mean that in this case the INAA is unable to separate the actual groups according to the elemental composition, a situation which is unlikely, as the method has already demonstrated a potential for distinguishing clay sources in the area. A cultural explanation for the situation is more plausible: the ED pottery traditions of the Diyala region, except perhaps for the Gray Ware, are closely related; but very minor variations in elemental composition may still be diagnostic. These variations would appear

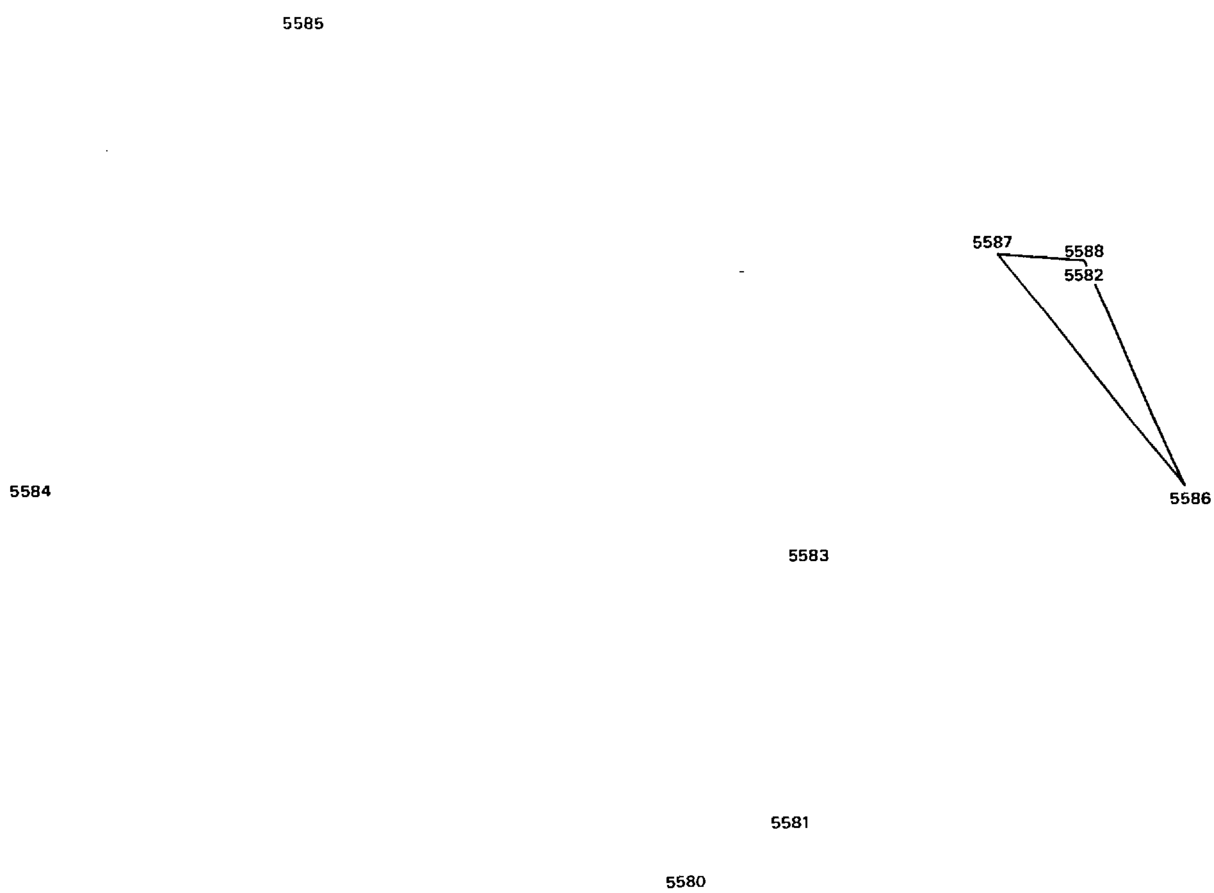


Figure 7: The distribution of the samples of polychrome pottery from Farukhabad.

as tendencies towards polarization of the cluster of samples, particularly if at the same time there is a reasonable cultural explanation for this observation. If we examine the plot with this in mind it becomes possible to locate some discrete classes or groups. In the conclusion these are accepted as evidence for the suggested reconstruction of regional inter-site relationships.

In general one of the most prominent distinctions is the distance between an early group consisting of the cemetery pottery from Kheit Qasim, **3710-84**, and Tell Gubba, **2810-81**, and the majority of the later Razuk samples, **0510-83** (Figure 10). However, some of the Madhhur samples and samples from the Lower Diyala region are located between these two extremes and within the borders. In an earlier paper it was demonstrated that the Standard wares and Scarlet Ware from Tell Razuk did not separate (Thuesen *et al.* 1981), and that cluster can be located on the plot (on the right side), thus providing the basis for distinguishing a local Razuk tradition.

From the graphic presentation of the results, we therefore suggest three main classes or groups besides the clay samples, Farukhabad samples, and the gray ware: a local Razuk group containing both Scarlet and Standard wares, an Intermediate group consisting primarily of Scarlet Ware from the Lower Diyala Region, Tell Madhhur and some samples from Razuk, and an Early group including the Kheit Qasim and Tell Gubba samples plus a few samples from the Lower Diyala region and Tell Madhhur. The last is called "Early" because the samples in general belong to a horizon that is earlier than the Razuk inventory (Jemdet Nasr-ED I *versus* ED I-II). The exact relationship of several samples is ambiguous due to the density of plot. In general, the Lower Diyala samples are spread out into all three groups, the Madhhur samples are associated primarily with the Razuk and the Intermediate groups, the Gubba and Kheit Qasim samples belong to the early group, and the Razuk samples form their own group. This indicates the central position of Scarlet Ware from the Lower Diyala Region among the analyzed inventories of the Hamrin sites.

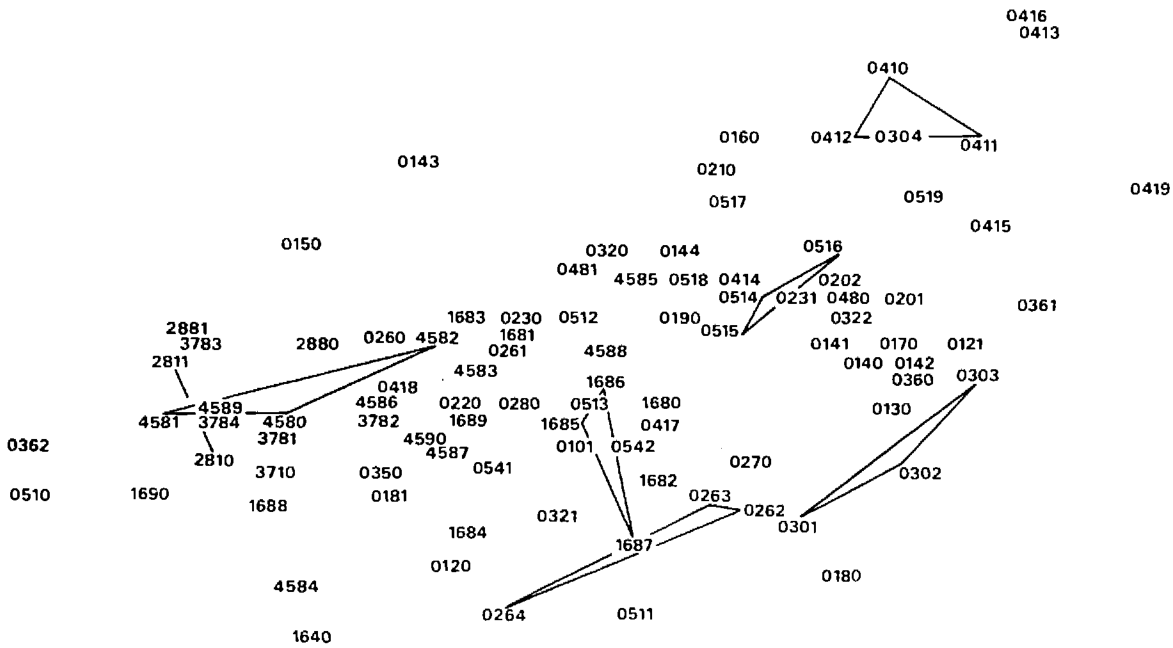


Figure 8: Distribuiton of all samples of ED pottery from the Diyala Region including the Hamrin.

Evaluation of group membership according to F-value

The plots represented so far are two-dimensional projections of the distribution of the samples in a multidimensional space. This projection may have caused some discrepancies in the actual mathematically calculated position. To test for group identity we include Figure 11, which illustrates the affinity between the individual sample and the defined groups calculated by SIMCA as an F-value. For each sample the F-value is illustrated according to four different classifications[4]. A solid line in a group means a F-value less than 1,5 in all four classifications, with the sample identification number centered in the group where the sample was placed during the analysis. A dotted line indicates a F-value less than 1,5 in two of four classifications. Contrary to the plots the Early group shows some affinity with the Razuk group, but no relationship to the Intermediate group. However, none of the Razuk group have affinity with the early group. This means that the group identity for the Razuk group is much better than for the Early group. The gray ware is again tied into the Razuk group; the Farukhabad and natural clay samples maintain their isolated position.

With this background let us look at the individual groups; they are numbered 1 though 6, including some sub-groups according to the results presented in Figure 11. The groups are identified as boxes of samples with a similar membership association to the six defined main groups.

Group 1 (Natural Clay)

Samples **0011-13**, **0900-02** and **0953-65**. The group includes the samples of recent pottery from Uch Tepe.

Group 2 (Gray Ware)

Sample **0413**, **0414**, and **0416-18** are all Gray Ware samples, and except for **0413** and **0416** all show affinities with group 3. The group includes a buff ware sample, **0144**, a shoulder sherd with a ridge, and sample of green ware, **0304**, a bowl of shape 1. All samples are from Tell Razuk.

Group 2/3

This is a border group consisting of three samples, all from Tell Razuk: a pink ware jar, **0220**, a gray ware jar, **0410-12**, and a Scarlet Ware jar, **0517**. This group

4. The classification was repeated four times, each time letting a member with dubious association be represented in either of two bordering groups.

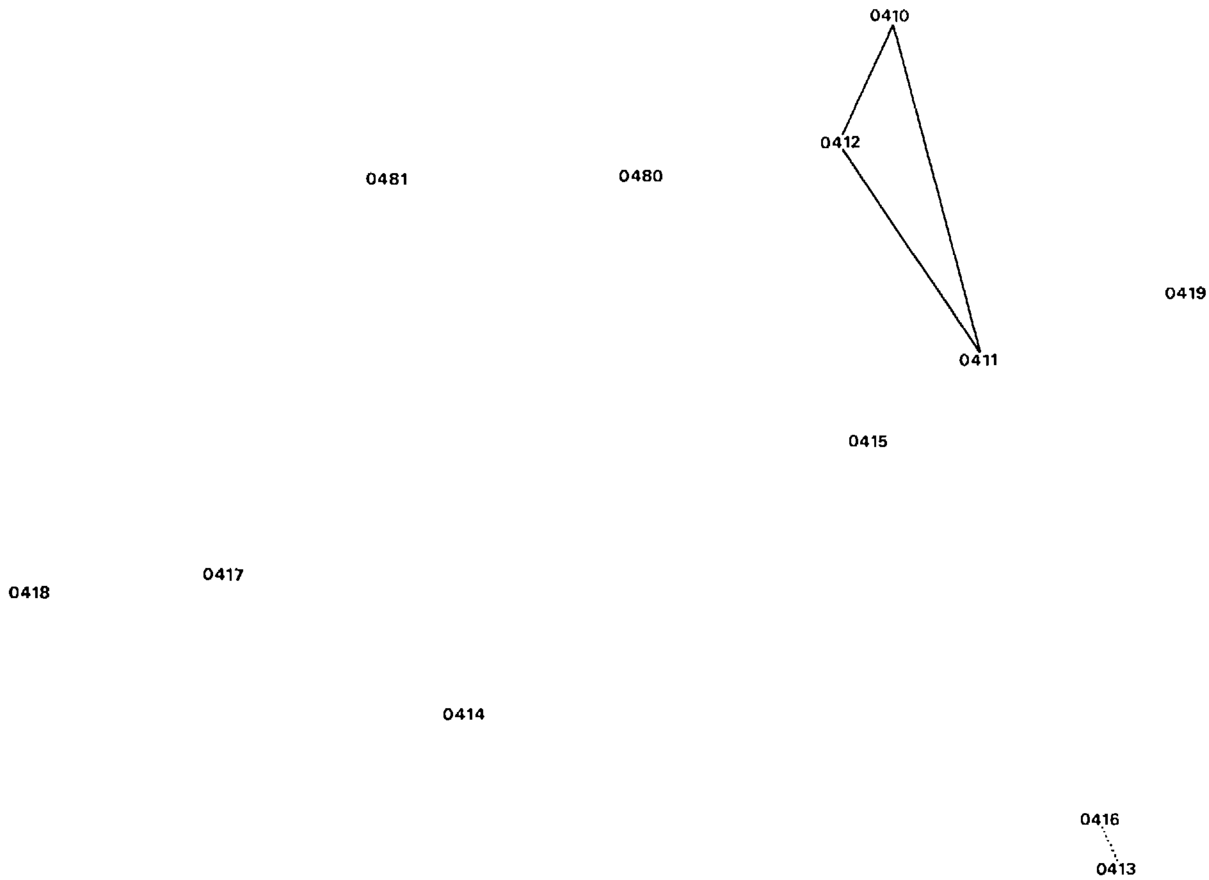


Figure 9: The distribution of all gray ware samples from Tell Razuk according to two principal components.

demonstrates the close relationship between groups 2 and 3, the gray wares and the other local Razuk wares.

Group 3 (Razuk local)

This is the largest group. It may be divided into four sub-groups according to the relationship with any other groups.

3a: This sub-group is made up of samples which centre in group 3, but show affinity to group 2, Gray Ware. It contains two pink ware bowls of shape 1, **0201** and **0202**, a pink ware jar, **0231**, three gray ware jars, **0415, 0419** and **0480**, two Scarlet Ware jars, **0518** and **0519**, and finally a sample of Scarlet Ware from Tell Madhhur, **1682**. The latter belongs to a jar with a ring base, painted with a horizontal band, on top of which is a pinnate motif. The paint has faded to a brownish colour. Both Scarlet Ware samples from Razuk are painted in the traditional Razuk style, red bands and cross-hatching in black.

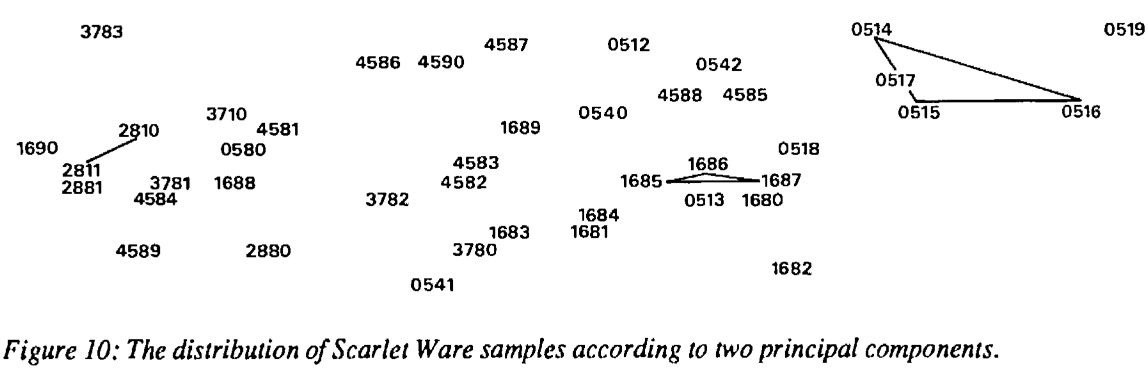


Figure 10: The distribution of Scarlet Ware samples according to two principal components.

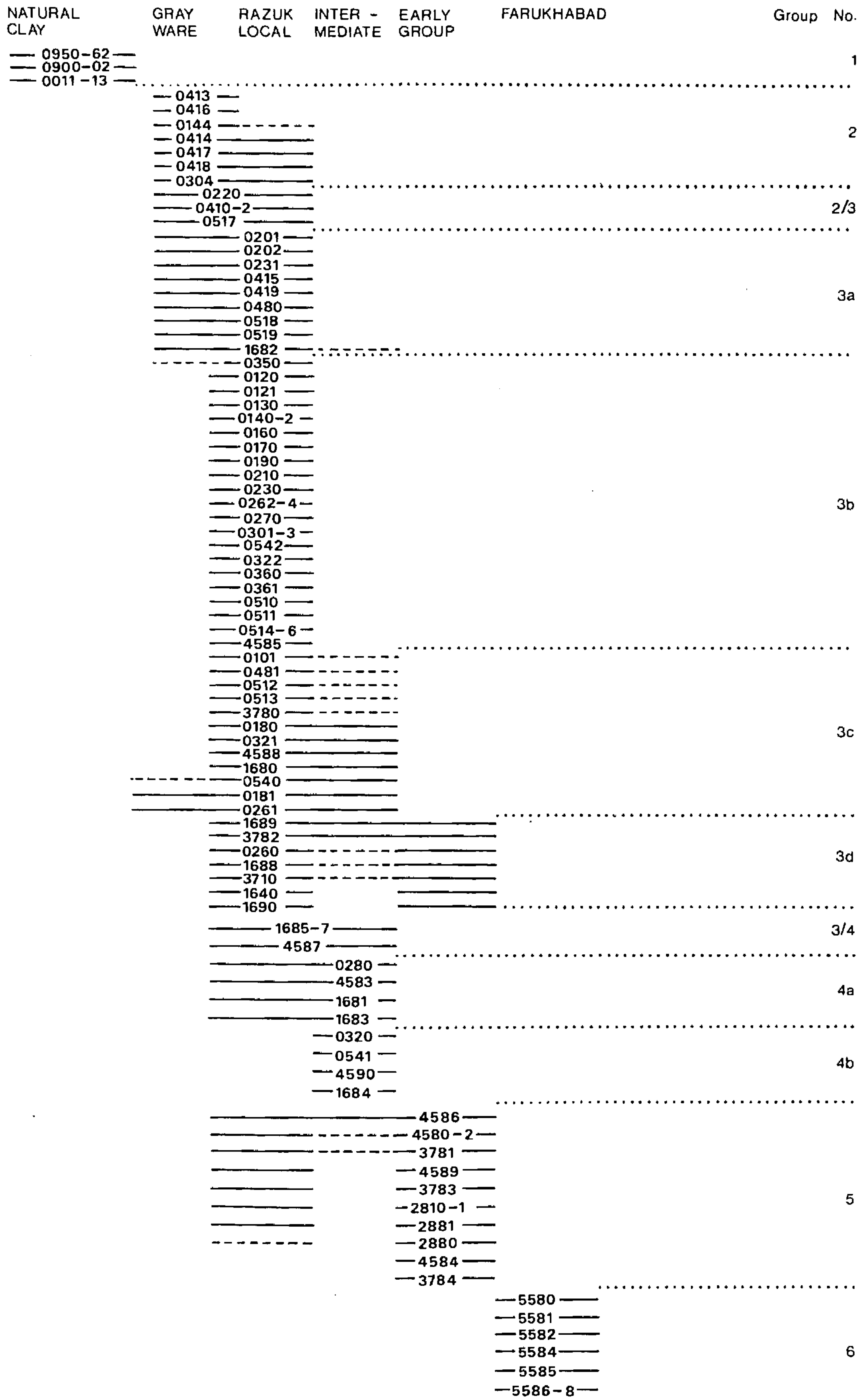


Figure 11: Sample groupings and relationship according to F-value (F < 1.5).

3b: This is the local Razuk group *par excellence*. It is the largest group recognized. With one exception all samples belongs to the Razuk inventory. The exception is a sample from Tell Asmar, excavated in room 8 of the Square Temple (ED II). Delougaz thought it was derived from ED I layers (Delougaz 1952: 80). The design of this sherd shows an arrangement of hatched arches in a square, a motif not observed in the Razuk repertoire. However, the elemental composition of the ware permits a late date for the sample, contemporary with the Razuk inventory, made in a closely related tradition but decorated differently. The Razuk samples include a variety of buff jars among which is a unique miniature vase, **0190**, and a fenestrated stand, **0170**. The pink and green wares are represented by different shapes, including a sample from a characteristic rope handle, **0270**. Razuk Scarlet Ware is represented by four samples, **0510**, **0511**, **0514-16** and **0542**. Two are fragments of jar necks, one of a shoulder/body carination with a ridge, and one of a body sherd with a naturalistic motif.

3c: This sub-group shows affinities with the following group 4, the Intermediate group. Of twelve samples, only three do not come from Razuk, namely one from Kheit Qasim, **3780**, a sample from Madhhur, **1680**, a body sherd with a naturalistic bird motif, and finally a sample from Tell Agrab, **4588**, with remains of a pinnate motif and a red band. The Razuk samples include a buff ware bowl, **0101**, two coarse ware samples, **0180** and **0181**, a gray ware sample, **0481** (which has a less pronounced affinity to group 4), a single pink ware jar sample, **0261** (which also shows relations to group 2), and finally the Scarlet Ware samples **0512**, **0513** and **0540**. All the Scarlet Ware samples are typical of the Razuk inventory: scarlet painted bands, cross-hatching of black lines, and naturalistic presentation of animals. This sub-group should be discussed together with group 3/4 and 4a.

3d: A group consisting of seven samples all centered on group 3, but having affinity with group 5, the early group. There is only one sample from Razuk, a pink ware jar, **0260**; all the remaining samples come from either Kheit Qasim or Madhhur. The Qasim samples are **3710** and **3782**, respectively a rim fragment (= Razuk shape 7) with traces of reddish paint, and a body sherd also with some traces of red paint. The Madhhur samples are **1689** (also with some affinity to group 4), a body sherd with a bird motif; **1688**, a shoulder sherd with a red band and arched border, atypical for Razuk; **1640**, a shoulder sherd with a ridge, decorated with a red band and cross-hatched panels similar to Razuk Scarlet Ware; and **1690**, a shoulder sherd with a triangular lug handle and plum red paint. This sample indicates an earlier phase at Tell Madhhur than that found at Razuk.

Group 3/4

This is another example of a vague group, comprising two samples which cannot be placed either in Razuk or in the Intermediate group. The samples are from Madhhur and Tell Asmar respectively. The former, **1685-7**, is a body sherd painted in a Razuk-related tradition with naturalistic motifs, the latter, **4587**, is a shoulder sherd with motifs foreign to Razuk: arches and a diamond-pinnate motif.

Group 4 (Intermediate)

This group is called the Intermediate due to its central position on the plot, but also because it seems to associate with several of the analyzed Diyala inventories. It divides into two sub-groups.

4a: The four samples in this sub-group all have affinity with group 3, and may therefore be examined together with sub-group 3c. While group 3c had members primarily from Razuk, 4a has only a single Razuk sample, an atypical miniature jar, **0280**. Other samples are from Khafajah: **4583**, a body sherd with a naturalistic motif, and from Madhhur: **1681**, a bird representation, and **1683**, a body sherd with a red band.

4b: This is the core of the Intermediate group, consisting of four samples. Two are from Razuk, a green ware jar, **0320**, and a Scarlet Ware jar, **0541**, with a shoulder ridge painted with a red band. One sample is from Madhhur, **1684**, also a shoulder fragment with red bands and geometric motifs in black. The final sample is from Tell Agrab, **4590**, with a naturalistic motif similar to those seen in the Razuk inventory.

Group 5 (the Early Group)

This group could have been subdivided as above, but the resulting sub-groups would consist only of two samples each. Therefore they are combined; the affinities are in most cases with group 3 (Razuk local) and more rarely with group 4 (Intermediate). However, the latter association does not appear significant. Of the ten samples none are from Razuk. All three samples from Gubba are included, among them a rim fragment with a black line, never seen in the Razuk inventory, **2810-11**. The other samples belong to a shoulder, perhaps with solid red paint below the carination, **2880**, and to a ring base, **2881**. All the Gubba samples have the plum red colour. The lower Diyala

region is represented by samples from Khafajah: **4580-2**, a body sherd with naturalistic motifs similar to the Razuk inventory; and Tell Asmar: **4586**, a sherd with a leaf-like motif found in an early Protoliterate context; **4589**, without provenance but with characteristic Scarlet Ware design; and finally **4584**, also from a Protoliterate context and apparently with an early type of design. In general, the Lower Diyala samples seem to confirm the early date of this group as indicated by the Kheit Qasim and Gubba samples. The three samples from Kheit Qasim, **3781**, **3783** and **3784**, all have plum red paint, similar to the Gubba samples. None of these samples are diagnostic in other aspects.

Group 6 (Farukhabad)

This is the second isolated group, consisting of all sherds from Farukhabad except one, **5583**. This last does not fit any of the groups at this F-level, but would fit group 3 at the 1,5 F2,0 level.

Not classified

There are three samples which cannot be associated with any of the groups. All are from Razuk: two buff ware samples of standard shape types, **0143** and **0150**, and a sample of a green ware jar, **0362**.

After comparing these results with the original classification based on geographical criteria and ware attributes, we should now add some modifications. The analysis shows that a discrimination of Standard wares from Scarlet Ware in the Razuk inventory is impossible. In terms of ware classification based on colour variations, there is no positive evidence for separating the buff, pink and green wares, a situation also confirmed by the mineralogical analyses (Chapter II). The Gray Ware can be separated, but it maintains close affinities with Razuk wares in general, and not with any other site inventories. The same occurs for most other samples from Razuk; they form a separate group with only a few infiltrations into the so-called Intermediate group.

The Intermediate group is the most difficult to characterize, as it contains samples from Razuk, Madhhur, and the Lower Diyala Region sites, each rather equally represented (groups 3c, 3/4, 4a and 4b). This could mean that the fraction of the Razuk inventory which cannot be identified as local is related to either the Madhhur or to the Lower Diyala Region's sites. For the Madhhur samples and the Lower Diyala samples it is impossible to recognize typical clustering; both are represented in groups 3, 4 and 5.

Gubba and Qasim belong primarily to group 5. Samples from neither Razuk nor Madhhur are found in group 5, although there are instances of affinities between samples from these two sites to the group.

Only two of the groups recognized according to the elemental composition are geographically defined, the Razuk group and the Farukhabad group. Two Razuk sub-groups are ware-defined, the Gray Ware and the group of natural clay and recent pottery. One group, 5, is chronologically defined as earlier than the others, including many samples of ED I Scarlet Ware and perhaps even a few Jemdet Nasr samples. Finally, there is a group, which cannot yet be explained in cultural terms, the Intermediate group.

Trace elements, Scarlet Ware and the Early Dynastic Period

Reconstruction of past movements of commodities or ideas requires evidence for contemporary settlements within reachable distance of each other. A tight control of the temporal factor is therefore necessary in order to examine the degree of external influence in a site inventory. However, one must realize that identical or strongly related artifacts at two sites do not necessarily have a common origin, although this often turns out to be the most plausible explanation. The alternative explanation is the presence of two independent parallel developments. And a critical element of the mechanism of any exchange does not involve movement of materials, but rather the spread of ideas or techniques, often labelled as cultural diffusion.

In a previous section (Chapter I), a paradigm was suggested which includes the range of external influence types. Regarding the results of the INAA of Scarlet Ware, we here return to this paradigm in order to explain the identified groups and to relate them to the overall culture-historical environment. Whatever methods are applied to tackle the mass of data, we are aware that the interpretational platform has been constructed with some ideas of the historical situation of Early Dynastic Mesopotamia in mind. This for instance includes the acceptance of a close relationship between the Lower and Middle Diyala Region, not just in terms of pottery.

The paradigm suggested above (p. 17 Tables 4-5), which simplifies the complexity of a ceramic tradition, includes sixteen possible types of exchange pattern. Scarlet Ware shows a high affinity among sites in the Diyala Region in terms of shape and decoration. That implies (according to Table 4), a

(CD)y situation i.e., at least that the ideas of function (shape) and appearance (decoration) were imitated. The elemental composition measured by INAA reflects a combination of raw materials and techniques and thus the tradition of the workshop or potter. More specifically, INAA provides insight into the combined A and B exchange factors. The present stage of research does not allow us to separate A and B further, as we do not yet know the degree of influence of the manufacturing procedures on the elemental composition.

If analysis indicates that A and B are non-local, we have an (ABCD)y situation, the actual import of pottery; if they are local, it is an (AB)x(CD)y situation, local manufacturing of vases imitating functional (shape) and visual (decoration) concepts from other inventories. The INAA has shown that for the Razuk Scarlet Ware in most cases the latter situation occurs. Razuk is a site which performs its own craft production, using imported ideas, or alternatively production is done by a travelling potter.

Turning to the other site inventories analyzed, we find other situations. Despite the fact that information on the shape and decoration is not as complete as in the case of Razuk, a (CD)y situation seems to exist at each. However, not all sites should have non-local C and D factors, as the concept of Scarlet Ware has to be local in at least one instance. We suggest that this place was the Lower Diyala Region. In that area we find the most substantial evidence of a differentiated settlement pattern developing out of the preceding Jemdet Nasr period and with ties to the Mesopotamian heartland. Most of the Hamrin sites were founded during ED I and their (AB) characteristics are as follows:

Tell Madhhur: The elemental composition does not indicate a definable group as in the case of Razuk. The samples are distributed over several classes but may perhaps favor a position in group 4, the so-called Intermediate group. It is therefore possible to argue that the Madhhur Scarlet Ware is non-local, the (ABCD)y situation; the pottery was brought in from several other places but primarily from the Lower Diyala Region.

Kheit Qasim and Tell Gubba: The origin of this early group is unclear, it might be originally produced at either or both of the sites or belong to a general early horizon, which originated in the Lower Diyala region. Similar elemental composition of pottery from these two sites and the Lower Diyala Region may not necessarily mean common origin but at least strongly related workshops or production procedures.

The result of the INAA do not present any obstacle to the previous assumption that the Hamrin Basin acted as a strategic buffer zone for the population on the alluvial southwest of the Jebel Hamrin (Gibson 1981: 160). In the defense of the Hamrin Basin by means of a string of fortresses, Tell Razuk has a long history founded in the late ED I and continuing into ED II. By the ED II the inter-regional ties had loosened to a degree, so that the pottery was locally produced and the fortifications acquired a more domestic character. The latter may be observed if the groundplan of the Razuk building is compared to the groundplan of the Gubba building (Thuesen 1988 Fig. 9).

With respect to Scarlet Ware, the indications are that this pottery was decreasing in frequency in the Lower Diyala Region. The number of Scarlet Ware sherds in ED II contexts is claimed to be insignificant (Delougaz 1952: 80). Perhaps the Razuk population maintained the use of Scarlet Ware as a symbol for their origin and position, during a period of decline in the Hamrin settlements. There is no clear evidence for substantial settlement in the Hamrin Basin during ED III.

As well as adding information to our picture of ED inter-site relationships in the Diyala Region, the INAA has also generated a number of conclusions.

First, in terms of pottery description and classifications, there is still far to go in the Mesopotamian sequence. It is necessary to move outside the sphere of rim-shape typologies; standardized description procedures for the pottery fabric are also needed. Second, concerning the cultural history of the period studied, the suggested reconstruction generates topics for further research, e.g. the nature of the relationship between a colony (the Hamrin?) and its homeland, the conflicts in the region, and the ecology and subsistence patterns of the Hamrin Basin. One problem which needs further explanation is the situation in the ED III, when settlement in the Hamrin disminished, while the cities to the southwest flourished. In the ED II and III a number of monumental building activities took place at Khafajah and Tell Asmar. If these cities were responsible for the fortified settlements in the Hamrin, they did not give them up due to insufficient economic resources. What happened to the threat or conflict which caused the construction of the Hamrin fortifications. The explanation must be sought in the counterpart of the Hamrin settlements to the northeast.

One may also speculate about the message of the motifs painted on the Scarlet Ware jars, if they are indeed symbolic. It is remarkable that motifs from the sphere of political and religious power are absent or insignificant in the Razuk inventory. Only two frag-

ments show human beings, perhaps in association with weapons (Uch Tepe I Pls. 88-91). A more common motif class consists of natural representations, especially scenes from marshes and fields. It is tempting to contrast this rather peaceful scenery with the apparent adversative political situation in the area.

Acknowledgement

The INAA project including data analysis, was sponsored by the Danish Research Foundation for the Humanities and the Natural Sciences. The foundation's generosity made it possible to analyze a relatively large number of samples. We are very grateful to Vagn Mejdahl at the Nordic Thermoluminiscence Laboratory for offering us his facilities for sampling and firing. We also thank M. Roaf, N. Postgate, J.D. Forest, H. Fujii, and H.T. Wright for supplying us with samples from their sites.

The project was first suggested by M. Trolle Larsen and C. Nylander while we were in the field for the first season in 1978. It was their ideas and vision that we intended to follow through the project.

Bibliography

Damsgaard, E. and K. Heydorn
1978 *Sources of Variability for the Single Comparator Method in a Heavy Water Reactor.* Risø-M-2141.

Delougaz, P.
1952 *Pottery from the Diyala Region.* Oriental Institute Publications 63. Chicago.

Derde, M. P. and D. L. Massart
1986 A Disjoint Modeling Technique for Pattern-Recognition Based on Normal-Distribution. *Analytica Chimica Acta* 184: 33-51.

Gibson, McG. (Ed.)
1981 *Uch Tepe I.* Chicago and Copenhagen.

Girardi, F, G. Guzzi, and J. Pauly
1965 Reactor Neutron Activation Analysis by Single Comparator Methods. *Analytical Chemistry* 37: 1085-92.

Gwozdz, R
1985 *Instrumentelle Multielementanalyse.* B.Sansoni, (Ed.) VCH Verlag, Weinheim. Pp. 141-43.

Hansen, B. A., M. Aa. Sørensen, K. Heydorn, V. Mejdahl, and K. Conradsen, K.
1978 Provenance study of Medieval decorated floor-tiles carried out by means of neutron activation analysis. *Arkaeo-Physica* 10: 119-40.

Harbottle, G.
1976 Activation Analysis in Archaeology. *Radiochemistry* 3: 33 ff.

Heydorn, K.
1980 *Aspects of Precision and Accuracy in Neutron Activation Analysis.* Risø-R-419.

Heydorn, K. and I. Thuesen
1989 Classification of Ancient Mesopotamian Ceramics and Clay using SIMCA for Supervised Pattern Recognition. *Chemometrics and Intelligent Laboratory Systems* 7:181-88.

Perlman, I. and F. Asaro
1969 Pottery Analysis by Neutron Activation. *Archaeometry* 11: 21 ff.

Philippot, J.Cl.
1970 Automatic Processing of Diode Spectrometry Results. *IEEE Transactions on nuclear science.* NS-17, 3: 446-8.

Thuesen, I.
1981 The Early Dynastic Pottery from Tell Razuk. In *Uch Tepe I.* M.Gibson, (Ed.) 1981. 99-144.
1987 Distributional Patterns Behind the Scarlet Ware Tradition. In *Préhistoire de la Mésopotamie.* J.-L. Huot, Ed. Paris. 463-66.
1988 Technical Analysis of Scarlet Ware Pottery. *Paléorient* 13: 123-31.

Thuesen, I., K. Heydorn, and R. Gwozdz
1982 Investigation of 500-year-old pottery from Mesopotamia by instrumental neutron activation analysis. *PACT* 7: 375-81.

Wold, S.
1978 Cross-validatory Estimation of Number of Components in Factor and Principal Components Models. *Technometrics* 20: 397-405.

Wold, S. and M. Sjöström
1977 SIMCA, a method for analysing chemical data in terms of similarity and analogy. In *Chemometrics,* Theory and Practice. Kowalski, B.R. (Ed.), American Chemical Society publication series 52: 243-82.

Wright, H. T.
1981 *An Early Town on the Deh Luran Plain.* Memoirs of the Museum of Anthropology. University of Michigan. 13.

Tables 1-9: Concentrations of 24 elements (INAA)

Table 1: Tell Razuk, Ancient Clay

No	Na	Ca	Sc	Cr	Fe	Co	Zn	As	Rb	Sr	Sb	Cs	Ba	La	Ce	Nd	Sm	Eu	Tb	Yb	Lu	Hf	Ta	Th
	%	%	mg/kg	mg/kg	%	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg
0011	.688	21.7	11.0	426.0	3.14	16.8	86.2	2.2	40.2	780.0	.283	2.4	382.0	18.6	43.0		3.85	.857	.589	1.62	.259	4.11	.563	4.98
0012	.68	23.8	10.4	360.0	2.99	15.3	97.4	3.14	46.5	785.0	.37	2.13	308.0	19.4	43.6	17.6	3.97	.777	.351	1.7	.257	3.52	.521	4.75
0013	.684	23.5	10.8	425.0	3.13	15.7	99.7	3.49	48.3	686.0	.463	2.27	458.0	19.7	46.3	16.3	4.02	.81	.522	1.74	.254	3.49	.514	4.99

Table 2: Uch Tepe Village, Natural Clay

No	Na	Ca	Sc	Cr	Fe	Co	Zn	As	Rb	Sr	Sb	Cs	Ba	La	Ce	Nd	Sm	Eu	Tb	Yb	Lu	Hf	Ta	Th
	%	%	mg/kg	mg/kg	%	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg
0053	.452	26.3	13.5	362.0	3.8	20.1	131.0	9.2	55.3	398.0	.691	3.05	438.0	21.1	48.8	14.3	4.32	.935	.648	2.01	.3	3.96	.571	5.96
0054	.452	26.5	13.8	383.0	3.84	20.7	117.0	9.73	53.8	394.0	.653	3.11	475.0	21.0	47.0	11.4	4.69	.964	.898	2.03	.308	4.2	.631	5.96
0055	.468	25.1	13.3	343.0	3.69	19.6	142.0	10.3	56.9	406.0	.705	3.04	571.0	21.7	46.2	16.7	4.61	.955	.587	1.71	.282	4.1	.656	5.97
0056	.46	24.9	13.1	340.0	3.66	19.6	105.0	9.04	56.0	411.0	.603	3.02	449.0	22.2	47.4	13.0	4.67	.921	.573	1.75	.287	3.78	.569	5.95
0057	.432	22.8	11.8	317.0	3.35	18.0	102.0	8.75	49.9	315.0	.503	2.93	427.0	20.3	42.3	14.1	4.55	.851	.549	1.79	.265	3.57	.588	5.41
0058	.47	28.2	14.5	398.0	4.11	21.9	142.0	9.71	65.4	390.0	.629	3.17	469.0	21.5	50.7	18.3	5.17	1.03	.627	2.02	.315	4.2	.64	6.99
0059	.462	26.5	13.8	383.0	3.86	20.5	131.0	9.15	54.3	402.0	.613	3.08	489.0	22.4	49.8	18.3	4.93	.948	.593	1.93	.3	3.96	.7	6.54
0060	.445	27.1	14.1	382.0	4.0	21.2	159.0	8.14	60.8	427.0	.655	2.96	481.0	20.5	49.0	12.1	3.83	1.03	.643	1.83	.311	3.97	.758	6.47
0061	.442	26.6	14.1	373.0	3.97	20.9	130.0	8.99	57.9	429.0	.654	3.17	440.0	21.2	49.0	18.6	4.53	1.0	.626	1.73	.313	3.98	.682	6.3
0062	.434	27.5	14.0	388.0	3.94	20.8	129.0	9.24	59.0	410.0	.569	2.99	460.0	21.4	51.5	22.1	3.98	1.0	.519	2.04	.306	3.99	.724	6.43
0063	.439	25.2	12.3	346.0	3.52	18.4		8.97	27.5	121.0	.612	2.49	525.0	20.3	42.8	18.3	4.24	.903		1.73	.285	3.67	.405	5.66
0064	.434	24.1	11.4	325.0	3.16	16.8	107.0	9.03	43.9	243.0	.588	2.32	367.0	19.6	38.6	24.1	4.15	.79	.501	1.69	.273	3.38	.285	4.94
0065	.40	22.1	12.1	331.0	3.41	18.0	26.8	8.34	46.4	251.0	.532	2.55	303.0	18.7	43.4		3.5	.873	.584	1.6	.258	3.53	.523	5.56

Table 3a: Tell Razuk, Early Dynastic Pottery, Buff Ware

No	Na %	Ca %	Sc mg/kg	Cr mg/kg	Fe %	Co mg/kg	Zn mg/kg	As mg/kg	Rb mg/kg	Sr mg/kg	Sb mg/kg	Cs mg/kg	Ba mg/kg	La mg/kg	Ce mg/kg	Nd mg/kg	Sm mg/kg	Eu mg/kg	Tb mg/kg	Yb mg/kg	Lu mg/kg	Hf mg/kg	Ta mg/kg	Th mg/kg
0101	.606	13.1	15.9	320.0	4.41	21.9	103.0	3.1	70.1	349.0	.411	3.58	326.0	21.6	50.9	20.7	4.41	.965	.497	1.65	.279	3.64	.565	6.2
0120	.761	13.8	15.5	287.0	4.29	21.7	71.0	3.92	60.5	779.0	1.77	2.48	173.0	21.2	51.0	20.4	4.28	1.04	.6	1.9	.3	3.77	.567	6.87
0121	.597	15.8	13.4	256.0	3.73	18.4	151.0	5.93	54.1	445.0	.381	2.72	282.0	18.3	46.4	15.4	3.48	.855	.506	1.42	.238	3.37	.629	6.04
0130	.586	17.1	13.7	293.0	3.83	18.6	96.5	4.94	40.8	403.0	.547	2.66	231.0	20.1	47.8	19.9	4.07	.943	.555	1.65	.242	3.43	.39	6.21
0140	.766	15.9	13.5	317.0	3.71	18.4	106.0	2.42	54.4	554.0	.227	2.42	202.0	20.2	45.4	20.5	4.15	.982	.515	1.88	.258	3.39	.518	5.8
0141	.784	17.6	13.2	294.0	3.64	17.5	158.0	5.28	67.7	606.0	.388	2.33	245.0	20.4	43.8	20.1	4.15	.937	.407	1.83	.282	3.28		5.41
0142	.78	15.4	12.7	294.0	3.63	17.4		5.64	49.9	503.0	.344	2.49	227.0	20.0	42.4	26.5	4.92	.898	.492	1.81	.299	3.12	.591	5.71
0143	1.14	13.5	18.8	144.0	4.12	21.2		5.84	87.2	420.0	.219	2.58	227.0	21.8	44.9	29.2	5.11	.958	.564	1.89	.336	3.67	.589	6.51
0144	.919	12.1	15.1	302.0	4.11	22.2	142.0		55.4	224.0	.174	2.95	186.0	21.4	46.4	25.9	4.57	1.0	.639	1.94	.291	3.44	.23	6.45
0150	.844	10.6	18.6	257.0	4.9	21.8	75.0		60.6	284.0	.271	3.48	211.0	23.6	51.0		4.97	1.04		1.91	.322	3.48	.506	7.24
0160	1.16	11.0	16.1	268.0	4.34	20.1	69.0		64.4		.331	2.76		19.7	42.7	17.9	4.31	.881	.441	1.59	.29	3.32	.431	6.07
0170	1.11	14.8	13.2	323.0	3.72	18.7	152.0	4.22	56.2	427.0	.351	1.64	227.0	18.6	45.9	16.1	3.57	.892	.651	1.85	.273	3.48	.573	5.85
0180	.931	18.3	12.4	378.0	3.58	16.7	147.0	11.9	41.6	537.0	.535	2.08	298.0	22.2	45.3	18.2	4.33	.934	.61	1.89	.291	3.54	.595	5.35
0181	1.23	16.1	14.6	321.0	4.1	21.8	162.0	6.39	49.7	528.0	.517	1.65	307.0	23.9	49.7	16.9	5.07	1.02	.688	2.04	.32	3.59	.584	6.58
0190	1.63	10.3	14.7	293.0	4.02	20.8		6.21	63.6	534.0	.628	2.72	305.0	19.8	44.9		4.26	.927	.536	1.83	.27	3.69	.538	6.4

Table 3b: Tell Razuk, Early Dynastic Pottery, Pink Ware

No	Na %	Ca %	Sc mg/kg	Cr mg/kg	Fe %	Co mg/kg	Zn mg/kg	As mg/kg	Rb mg/kg	Sr mg/kg	Sb mg/kg	Cs mg/kg	Ba mg/kg	La mg/kg	Ce mg/kg	Nd mg/kg	Sm mg/kg	Eu mg/kg	Tb mg/kg	Yb mg/kg	Lu mg/kg	Hf mg/kg	Ta mg/kg	Th mg/kg
0201	.889	11.7	13.5	271.0	3.85	18.9	162.0	8.4	52.3	462.0	.485	1.97	239.0	19.4	47.5	19.6	4.02	.868	.468	1.64	.25	3.22	.549	5.62
0202	1.03	13.7	13.3	298.0	3.71	18.9	136.0	6.23	54.7	377.0	.425	2.22	115.0	20.2	45.6	20.6	4.26	.911	.436	2.0	.278	3.46	.49	5.9
0210	.91	8.93	15.7	236.0	4.36	21.3	174.0	3.96	55.5	196.0	.489	2.95	170.0	19.6	48.7		3.82	.937	.51	1.83	.258	3.35	.56	6.13
0220	1.07	13.5	15.1	331.0	4.22	20.4	177.0		56.1	348.0	.32	3.0	112.0	22.0	51.1		4.95	.998	.661	2.01	.3	4.13	.683	6.39
0230	1.03	13.9	14.6	291.0	4.08	19.9	184.0	.031	60.9	536.0	.203	2.98	110.0	22.1	49.4	16.9	4.73	.985	.788	1.99	.298	3.73	.687	6.27
0231	.691	18.1	13.8	222.0	3.9	18.4	162.0	4.83	54.9	494.0	.257	2.52	170.0	21.6	46.9	16.0	4.5	.914		1.68	.285	3.32	.544	5.69
0260	1.03	13.3	15.8	270.0	4.37	20.9	256.0	2.74	63.3	723.0	.233	3.27	158.0	23.0	52.2	20.8	4.93	.98	.594	2.07	.331	3.76	.714	6.55
0261	.732	12.5	14.8	283.0	4.09	20.5	147.0		62.9	267.0	.419	3.31	243.0	23.1	47.9	20.4	4.88	.991	.735	1.97	.318	3.3	.592	6.15
0262	.647	17.7	13.8	283.0	3.76	20.4	208.0	7.09	32.8	679.0	.539	2.33	246.0	21.8	47.2	21.9	4.55	.883	.574	1.89	.304	3.71	.527	5.8
0263	.642	17.6	13.8	285.0	3.73	19.6		5.25	46.8	678.0	.424	2.1	233.0	21.3	47.9	21.8	4.52	.996		1.88	.281	3.72		5.95
0264	.723	19.5	14.7	305.0	4.1	18.2	225.0	5.36	51.1	679.0	.422	2.32	280.0	23.1	49.3	22.9	4.73	1.0	.582	2.09	.31	4.3	.852	6.19
0270	.773	17.0	14.8	299.0	4.03	19.5	125.0	4.94	46.4	588.0	.658	2.66	260.0	21.1	43.8	24.8	4.02	.968	.492	1.82	.299	3.69	.507	5.95
0280	1.71	12.7	15.1	319.0	4.03	19.8			38.5	508.0	.537	1.39	299.0	22.2	51.3	11.1	4.61	.992	.508	1.97	.336	3.73	.588	6.44

Table 3c: Tell Razuk, Early Dynastic Pottery, Green Ware

No	Na %	Ca %	Sc mg/kg	Cr mg/kg	Fe %	Co mg/kg	Zn mg/kg	As mg/kg	Rb mg/kg	Sr mg/kg	Sb mg/kg	Cs mg/kg	Ba mg/kg	La mg/kg	Ce mg/kg	Nd mg/kg	Sm mg/kg	Eu mg/kg	Tb mg/kg	Yb mg/kg	Lu mg/kg	Hf mg/kg	Ta mg/kg	Th mg/kg
0301	.941	15.8	14.0	400.0	3.89	18.2	80.0	4.12	35.2	219.0	.53	2.78	289.0	21.6	46.7	18.4	4.4	.92	.692	1.97	.301	3.98	.236	5.51
0302	.9	16.1	13.2	422.0	3.62	17.7			36.1	518.0	.377	3.06	216.0	20.7	40.9		4.2	.895	.544	1.82	.285	3.45	.644	5.52
0303	.854	16.4	12.5	369.0	3.47	16.9		4.52	30.9	364.0	.464	2.12	238.0	21.4	41.8	21.9	4.39	.881		1.84	.295	2.83	.466	5.33
0304	1.03	12.0	14.1	245.0	3.75	18.9	76.1		45.3	219.0		2.62	82.9	21.2	38.7		4.33	.851		1.79	.255	3.13	.679	5.37
0320	1.59	13.2	15.5	292.0	4.2	18.6	108.0		59.2	646.0	.212	3.14	245.0	22.3	43.8		4.78	.973	.419	2.08	.322	3.59	.439	6.23
0321	.833	16.4	14.5	321.0	4.09	18.1	151.0	8.22	65.5	788.0	.528	3.3	252.0	23.5	51.9	20.7	4.7	.99	.555	2.03	.309	3.77	.525	6.16
0322	1.24	16.3	14.2	243.0	3.93	18.8	106.0	10.8	20.6	536.0	.169	2.52	244.0	21.4	47.9	21.3	4.29	.918	.546	1.76	.279	3.27	.359	5.63
0350	1.04	14.4	15.6	325.0	4.43	19.7	102.0	7.13	48.2	285.0	.42	3.17	231.0	24.4	54.4	22.1	4.97	1.09	.622	2.09	.281	3.86	.753	6.62
0360	.832	15.9	13.3	290.0	3.77	17.6	176.0	12.0	56.9	419.0		2.57	235.0	19.9	47.1		4.08	.913	.432	1.64	.25	3.32	.557	5.62
0361	.835	15.7	12.9	283.0	3.64	16.0	122.0	4.79	14.1	578.0	.394	2.44	253.0	20.0	43.8	17.9	3.98	.878	.564	1.69	.268	2.85	.483	5.57
0362	1.51	16.0	15.7	225.0	4.44	22.0	115.0	1.98	28.1	527.0	.206	3.87	258.0	27.5	57.2	18.1	6.2	1.11	.856	2.44	.318	3.97	.887	7.97

Table 3d: Tell Razuk, Early Dynastic Pottery, Gray Ware

No	Na %	Ca %	Sc mg/kg	Cr mg/kg	Fe %	Co mg/kg	Zn mg/kg	As mg/kg	Rb mg/kg	Sr mg/kg	Sb mg/kg	Cs mg/kg	Ba mg/kg	La mg/kg	Ce mg/kg	Nd mg/kg	Sm mg/kg	Eu mg/kg	Tb mg/kg	Yb mg/kg	Lu mg/kg	Hf mg/kg	Ta mg/kg	Th mg/kg
0410	1.13	13.1	13.4	184.0	3.71	18.0	156.0	3.43	40.5	255.0		2.37		20.2	42.3		4.59	.853	.515	1.97	.282	2.86	.685	5.14
0411	1.08	14.3	13.4	197.0	3.7	17.4	154.0	7.18	45.3	355.0	.319	2.4	287.0	19.5	43.4	21.6	4.81	.735	.622	1.81	.276	2.74	.45	5.3
0412	.904	12.4	14.9	220.0	3.69	18.1	166.0	2.16	49.1	326.0	.183	2.42	226.0	20.6	43.4	20.9	4.96	.834	.509	1.79	.303	2.79	.563	5.52
0413	.617	9.9	14.4	171.0	3.85	17.8	130.0	5.79	66.4	126.0	.416	3.75	259.0	19.3	40.0	24.2	3.81	.727	.648	1.83	.256	2.67	.353	5.64
0414	1.01	12.8	15.0	284.0	4.08	18.8	136.0	4.46	54.7	382.0	.415	2.94	193.0	21.8	46.2	22.9	4.39	.909	.691	1.79	.286	3.63	.27	5.86
0415	1.17	14.3	13.6	269.0	3.62	16.2	161.0	6.36	34.4	270.0	.445	1.78	260.0	20.4	44.4	19.0	4.07	.856	.529	1.69	.257	2.97	.394	5.54
0416	.589	9.26	15.2	188.0	4.08	18.5	124.0	2.73	46.2		.237	3.93	216.0	18.2	38.2	16.6	3.35	.821	.617	1.51	.249	2.74	.399	6.07
0417	1.06	17.3	14.8	307.0	4.1	17.7	109.0	5.89	48.1	273.0	.406	1.53	220.0	22.7	51.0	20.2	4.68	.956	.836	2.03	.286	3.75	.468	6.16
0418	1.26	14.5	15.4	289.0	4.4	21.7		3.41	60.1	194.0	.568	2.27	216.0	23.2	51.3	19.9	4.79	1.02	.794	2.02	.316	3.85	.482	6.65
0419	.875	16.6	13.3	244.0	3.66	18.6	113.0	7.05	47.0	436.0	.375	1.94	222.0	16.9	41.3		4.06	.774		1.84	.232	2.6	.504	4.9
0480	.871	14.4	13.6	316.0	3.82	17.3	155.0	4.55	55.3	487.0	.302	2.59	131.0	20.0	47.2	18.9	4.18	.9	.559	1.72	.275	3.31	.614	5.87
0481	1.1	11.6	14.9	285.0	4.16	21.1	131.0	4.73	68.7	266.0	.351	2.28	152.0	21.2	50.6		4.46	.971	.583	1.89	.256	3.52	.747	6.48

Table 3e: Tell Razuk, Early Dynastic Pottery, Scarlet Ware

No	Na %	Ca %	Sc mg/kg	Cr mg/kg	Fe %	Co mg/kg	Zn mg/kg	As mg/kg	Rb mg/kg	Sr mg/kg	Sb mg/kg	Cs mg/kg	Ba mg/kg	La mg/kg	Ce mg/kg	Nd mg/kg	Sm mg/kg	Eu mg/kg	Tb mg/kg	Yb mg/kg	Lu mg/kg	Hf mg/kg	Ta mg/kg	Th mg/kg
0510	.902	10.9	17.2	308.0	4.82	24.0	153.0	6.48	80.2	293.0	.548	3.98	234.0	25.1	59.3	24.6	5.33	1.18	.609	2.12	.353	4.2	.621	7.42
0511		9.36	17.2	326.0	4.71	23.0	156.0		51.2			3.25			53.4			1.1	.358	2.34	.212	4.12	.449	7.17
0512	.819	9.26	14.9	287.0	4.1	17.9	176.0	7.23	62.7	403.0	.789	2.86	120.0	23.1	47.5		4.52	1.03		1.82	.298	3.52	.683	6.4
0513	.649	14.3	15.6	310.0	4.2	18.8	109.0	7.91	63.1	592.0	.388	2.34	162.0	22.3	45.6		4.13	1.11		1.84	.283	3.64	.556	6.44
0514	.874	14.8	13.8	243.0	3.76	18.0	141.0		49.2	768.0		2.39	164.0	22.7	43.3		4.32	.93	.513	2.0	.284	3.41	.714	6.18
0515	.777	13.5	14.1	239.0	3.71	17.8	152.0	6.74	57.1	805.0	.434	2.75	178.0	21.7	44.1		4.06	.979	.739	1.87	.283	3.45		6.09
0516	.767	13.4	13.1	224.0	3.6	17.1	136.0	6.75	57.3	627.0		2.68	148.0	20.5	45.1		4.38	.88	.859	2.1	.267	3.07	.622	5.6
0517	.965	11.1	14.1	256.0	3.91	18.7		2.82	50.9	247.0	.264	2.61	108.0	20.9	45.6		4.42	.952	.626	1.74	.273	3.44	.577	5.92
0518	.746	10.5	14.2	300.0	3.97	18.8	98.6	2.97	59.8	269.0	.209	2.74	164.0	21.1	49.5	21.0	4.46	.922	.683	1.72	.295	3.62	.589	6.05
0519	1.05	15.5	13.2	220.0	3.68	17.8	117.0	4.87	46.2	545.0	.303	1.88	146.0	19.5	43.8		4.29	.867	.458	1.8	.285	3.15	.533	5.39
0540	.62	13.4	14.8	263.0	4.15	18.8	137.0	3.96	58.7	373.0	.328	3.24	158.0	22.5	50.6	21.2	4.76	1.0	.701	1.97	.32	3.48	.642	6.48
0541	.813	8.65	15.8	311.0	4.41	22.7	158.0	4.71	68.7	314.0	.343	3.1	541.0	21.6	52.8		4.76	.982	.492	1.84	.274	3.69	.683	7.03
0542	1.08	16.2	14.8	338.0	3.95	20.1			12.4	269.0		2.68	241.0	22.4	46.4		4.84	1.01		1.98	.317	3.51		6.24

Table 4: Uch Tepe Village, Modern pottery

No	Na %	Ca %	Sc mg/kg	Cr mg/kg	Fe %	Co mg/kg	Zn mg/kg	As mg/kg	Rb mg/kg	Sr mg/kg	Sb mg/kg	Cs mg/kg	Ba mg/kg	La mg/kg	Ce mg/kg	Nd mg/kg	Sm mg/kg	Eu mg/kg	Tb mg/kg	Yb mg/kg	Lu mg/kg	Hf mg/kg	Ta mg/kg	Th mg/kg
0900	.879	28.3	13.0	317.0	3.65	19.4	131.0	4.94	39.0	651.0	.39	.821	361.0	21.4	46.5	16.5	4.89	.964	.593	1.89	.294	3.93	.637	5.79
0901	1.36	28.0	13.9	357.0	3.8	20.6	117.0	4.2	17.1	635.0	.575	.373	756.0	22.3	49.9	14.9	5.55	1.0	.614	1.98	.313	4.01	.686	6.14
0902	.833	26.6	13.5	342.0	3.78	20.1	121.0	4.55	38.7	675.0	.389	.96	415.0	21.2	48.5	22.3	4.28	.934	.573	1.87	.288	3.86	.617	6.02

Table 5: Tell Madhhur, Early Dynastic Pottery (Scarlet Ware)

No	Na %	Ca %	Sc mg/kg	Cr mg/kg	Fe %	Co mg/kg	Zn mg/kg	As mg/kg	Rb mg/kg	Sr mg/kg	Sb mg/kg	Cs mg/kg	Ba mg/kg	La mg/kg	Ce mg/kg	Nd mg/kg	Sm mg/kg	Eu mg/kg	Tb mg/kg	Yb mg/kg	Lu mg/kg	Hf mg/kg	Ta mg/kg	Th mg/kg
1640	.76	18.3	15.7	312.0	4.43	22.7	143.0	6.57	68.8	634.0	.713	2.64	350.0	23.2	52.8	12.8	5.26	1.1	.671	2.05	.324	3.8	.72	6.64
1680	.691	15.8	15.1	324.0	4.21	20.4	133.0	7.73	61.5	550.0	.599	2.68	130.0	21.4	50.1		4.35	.881	.597	1.86	.291	3.35	.659	6.01
1681	.447	14.4	15.6	238.0	4.31	21.9	149.0	6.69	63.8	370.0	.517	2.96	254.0	22.1	51.3		4.78	.923	.741	2.05	.313	3.15	.654	6.34
1682	.732	14.1	14.0	389.0	4.03	20.5	136.0	4.88	54.2	470.0	.475	2.68	236.0	21.2	51.7		4.51	.923	.742	1.79	.294	3.41	.607	5.84
1683	.545	14.4	15.7	242.0	4.44	22.6	140.0	7.45	68.7	430.0	.454	2.59	140.0	23.1	54.0		4.78	.965	.675	1.92	.307	3.17	.615	6.35
1684	.664	18.1	8.28	294.0	4.23	22.0	143.0	7.27	61.7	686.0	.386	2.94	57.0	22.9	58.5	7.48	4.95	1.01	.765	2.55	.315	3.69	.701	6.59
1685	.702	15.5	14.4	292.0	4.0	20.3	136.0	6.47	67.6	332.0	.507	3.15	263.0	23.1	49.9	15.0	4.53	1.01	.642	1.98	.303	3.23	.711	6.14
1686	.665	13.7	14.1	289.0	3.93	20.2	113.0	5.95	68.8	423.0	.467	3.06	185.0	21.8	48.7	8.92	4.54	.963	.633	1.96	.301	3.36	.751	6.28
1687	.717	16.1	7.26	312.0	4.07	20.6	143.0	7.89	62.2	401.0	.521	2.8	295.0	23.9	55.2	12.0	4.87	.932	.667	2.19	.309	3.27	.65	6.18
1688	.883	13.5	16.1	356.0	4.52	21.0	219.0	3.87	71.4	558.0	.534	3.04	266.0	25.2	54.3	17.7	5.21	.997	.713	2.13	.338	3.71	.684	6.78
1689	.852	13.3	14.9	275.0	4.25	19.4	131.0	7.54	66.2	641.0	.586	2.26	268.0	24.1	51.3	7.48	4.9	.989	.668	2.08	.301	3.42	.677	6.4
1690	.808	14.4	16.5	227.0	4.58	22.2	153.0	8.66	81.8	423.0	.614	3.89	269.0	23.9	55.8	14.2	5.05	1.11	.726	2.11	.35	4.14	.712	7.29

Table 6: Tell Gubba, Early Dynastic Pottery (Scarlet Ware)

No	Na %	Ca %	Sc mg/kg	Cr mg/kg	Fe %	Co mg/kg	Zn mg/kg	As mg/kg	Rb mg/kg	Sr mg/kg	Sb mg/kg	Cs mg/kg	Ba mg/kg	La mg/kg	Ce mg/kg	Nd mg/kg	Sm mg/kg	Eu mg/kg	Tb mg/kg	Yb mg/kg	Lu mg/kg	Hf mg/kg	Ta mg/kg	Th mg/kg
2810	1.23	13.4	16.9	291.0	4.71	22.9	140.0	5.5	49.4	347.0	.55	3.63	282.0	24.5	54.5	23.4	5.41	1.03	.765	2.17	.315	3.95	.655	7.08
2811	.963	12.5	17.5	224.0	4.8	22.5	143.0	6.55	82.2	349.0	.432	2.09	269.0	24.0	53.3	23.0	4.8	1.03	.801	2.14	.334	3.75	.822	7.14
2880	.855	11.4	16.0	230.0	4.33	25.0	175.0	5.16	78.7	341.0	.446	3.7	243.0	23.0	53.4	18.0	4.19	1.07	.722	1.91	.334	3.61	.669	7.1
2881	.92	9.98	17.6	238.0	4.8	23.3	147.0	4.52	83.2	365.0	.547	4.24	229.0	23.5	55.0	21.5	4.63	1.08	.673	1.89	.32	3.69	.713	7.35

Table 7: Kheit Qasim, Early Dynastic Pottery (Scarlet Ware)

No	Na %	Ca %	Sc mg/kg	Cr mg/kg	Fe %	Co mg/kg	Zn mg/kg	As mg/kg	Rb mg/kg	Sr mg/kg	Sb mg/kg	Cs mg/kg	Ba mg/kg	La mg/kg	Ce mg/kg	Nd mg/kg	Sm mg/kg	Eu mg/kg	Tb mg/kg	Yb mg/kg	Lu mg/kg	Hf mg/kg	Ta mg/kg	Th mg/kg
3710	.857	9.89	15.5	302.0	4.25	22.3		3.0	66.7	663.0	.484	3.39	243.0	23.1	51.9	26.1	5.12	1.07	.626	2.05	.349	4.09	.655	7.23
3780	.771	10.8	14.8	284.0	4.09	22.3	139.0	5.45	59.4	562.0	.42	2.66	305.0	22.8	53.3	19.1	4.06	1.03	.7	1.84	.292	3.87	.848	6.87
3781	.917	13.6	17.0	293.0	4.74	23.5		5.79	68.0	557.0	.474	3.05	295.0	23.1	49.9	25.1	4.92	1.02	.57	1.95	.351	3.8	.685	7.35
3782	.792	8.94	15.7	309.0	4.4	21.7	43.0	4.61	64.3	702.0	.438	3.12	237.0	22.8	50.7	26.1	4.82	.975	.739	2.06	.321	3.86	.622	7.05
3783	1.24	14.3	16.5	230.0	4.5	21.9			72.3	671.0	.396	3.23	198.0	23.0	50.9	18.6	5.15	1.07	.633	2.18	.354	3.84	.701	7.99
3784	.7	15.4	16.2	218.0	4.69	23.1	158.0	2.81	78.4	977.0	.406	3.41	237.0	22.9	51.2	17.1	4.82	1.07	.694	2.2	.338	3.88	.764	7.6

Table 8a: Khafajah, Early Dynastic Pottery (Scarlet Ware)

No	Na %	Ca %	Sc mg/kg	Cr mg/kg	Fe %	Co mg/kg	Zn mg/kg	As mg/kg	Rb mg/kg	Sr mg/kg	Sb mg/kg	Cs mg/kg	Ba mg/kg	La mg/kg	Ce mg/kg	Nd mg/kg	Sm mg/kg	Eu mg/kg	Tb mg/kg	Yb mg/kg	Lu mg/kg	Hf mg/kg	Ta mg/kg	Th mg/kg
4580	1.15	15.9	16.5	301.0	4.61	22.1	155.0	8.22	76.8	465.0	.686	3.09	165.0	22.3	54.0	15.5	5.21	1.07	.655	2.16	.32	3.57	.734	6.68
4581	1.25	15.7	17.4	314.0	4.74	22.6	140.0	10.6	82.0	582.0	.447	3.5	239.0	22.5	54.0	17.8	5.33	1.06	.652	2.06	.331	3.66	.78	6.95
4582	1.21	15.2	16.0	278.0	4.47	22.5	135.0	7.42	78.1	512.0	.548	3.03	199.0	22.0	49.0	17.2	4.75	.979	.756	1.76	.311	3.48	.523	6.5
4583	1.22	9.17	16.1	327.0	4.45	20.7	172.0	4.3	78.6	779.0	.551	3.54	298.0	21.8	49.5	17.6	4.11	.974	.55	2.03	.302	3.7	.671	6.64

Table 8b: Tell Asmar, Early Dynastic Pottery (Scarlet Ware)

No	Na %	Ca %	Sc mg/kg	Cr mg/kg	Fe %	Co mg/kg	Zn mg/kg	As mg/kg	Rb mg/kg	Sr mg/kg	Sb mg/kg	Cs mg/kg	Ba mg/kg	La mg/kg	Ce mg/kg	Nd mg/kg	Sm mg/kg	Eu mg/kg	Tb mg/kg	Yb mg/kg	Lu mg/kg	Hf mg/kg	Ta mg/kg	Th mg/kg
4584	1.04	14.4	16.3	383.0	4.63	38.8	213.0	7.62	68.8	435.0	.451	3.0	287.0	22.2	48.7	17.1	4.77	.98	.589	2.13	.311	3.96	.72	6.72
4585	.942	14.9	14.8	232.0	4.12	19.6	59.1	6.85	71.7	508.0	.588	3.03	186.0	20.4	43.7	10.8	4.36	.978	.738	1.95	.319	3.33	.465	6.49
4586	1.31	13.7	15.7	366.0	4.15	20.5	132.0	8.45	68.6	545.0	.496	2.34	102.0	23.8	50.3	22.9	5.16	1.02	.559	1.79	.35	3.74	.53	6.82
4587	1.1	15.3	16.3	358.0	4.41	18.9		8.09	31.8	408.0	.618	2.32	92.9	22.3	48.0	13.6	4.96	.973	.741	2.0	.331	3.97	.628	6.81
4588	.936	16.1	14.9	259.0	3.96	20.0		5.74	61.9	856.0	.391	2.04	174.0	21.7	45.6	14.2	4.62	.964	.544	2.02	.327	3.51	.579	6.3
4589	1.06	10.4	15.7	270.0	4.58	28.1		7.56	76.0	467.0	.696	3.4	219.0	22.9	52.2	18.8	5.03	1.07	.583	2.15	.33	3.72	.675	7.28

Table 8c: Tell Agrab, Early Dynastic Pottery (Scarlet Ware)

No	Na %	Ca %	Sc mg/kg	Cr mg/kg	Fe %	Co mg/kg	Zn mg/kg	As mg/kg	Rb mg/kg	Sr mg/kg	Sb mg/kg	Cs mg/kg	Ba mg/kg	La mg/kg	Ce mg/kg	Nd mg/kg	Sm mg/kg	Eu mg/kg	Tb mg/kg	Yb mg/kg	Lu mg/kg	Hf mg/kg	Ta mg/kg	Th mg/kg
4590	1.63	15.3	16.1	388.0	4.27	20.8	118.0	4.99	52.6	682.0	.471	1.78	201.0	22.7	47.6	27.9	5.04	1.02	.633	2.15	.35	3.8	.486	6.54

Table 9: Farukhabad, Polychrome Ware

No	Na %	Ca %	Sc mg/kg	Cr mg/kg	Fe %	Co mg/kg	Zn mg/kg	As mg/kg	Rb mg/kg	Sr mg/kg	Sb mg/kg	Cs mg/kg	Ba mg/kg	La mg/kg	Ce mg/kg	Nd mg/kg	Sm mg/kg	Eu mg/kg	Tb mg/kg	Yb mg/kg	Lu mg/kg	Hf mg/kg	Ta mg/kg	Th mg/kg
5580	1.62	15.7	14.6	250.0	4.06	17.3		5.06	39.8	563.0	.721	.643	160.0	23.5	49.9	31.4	4.97	.959	.633	2.21	.325	3.78	.628	7.62
5581	1.52	16.3	13.6	230.0	3.82	15.6	86.9	6.56	45.1	355.0	.579	2.02		23.6	49.7	28.3	5.02	.953	.65	1.77	.321	3.79	.684	7.46
5582	.964	10.8	14.9	277.0	4.29	17.4		8.4	81.4	274.0	.603	4.16	244.0	22.9	48.7	22.0	4.85	.909	.613	2.13	.32	3.48	.737	7.53
5583	1.21	17.0	14.5	198.0	4.08	16.6	99.1	7.95	70.5	596.0	.683	1.7	66.7	23.5	51.0	17.5	4.69	.952	.576	1.93	.338	4.12	.656	7.82
5584	1.55	12.7	16.7	190.0	4.6	18.5	94.1	1.05	37.7	464.0	.448	4.45		27.1	54.2	20.5	5.77	1.07	.556	2.14	.341	3.86	.825	8.9
5585	1.5	13.9	16.2	213.0	4.49	18.5	135.0	4.79	90.5	566.0	.386	7.39	230.0	25.8	54.9	22.7	5.46	1.11	.593	2.38	.353	4.04	.815	8.46
5586	1.37	10.1	14.8	195.0	4.2	16.5	168.0	6.52	75.2	180.0	.806	3.6	53.9	21.9	45.7	15.4	4.57	.882	.577	1.75	.311	3.36	.648	7.78
5587	1.28	11.3	15.1	210.0	4.29	16.4		8.27	86.1	262.0	.794	3.38	142.0	24.2	50.8	24.4	4.91	.965	.579	1.63	.316	3.47	.693	7.85
5588	1.32	11.3	15.0	199.0	4.25	17.1	194.0	7.03	87.7	299.0	.8	3.61	194.0	23.1	49.0	14.5	4.78	.948	.609	1.67	.313	3.33	.679	8.03

Chapter IV

Analysis of a Plano-convex Mudbrick from the Round Building at Razuk

Richard F. Scholl and Donald H. Campbell[1]

Introduction

A mudbrick was received from Prof. McGuire Gibson of the Oriental Institute of the University of Chicago on July 29, 1980. Professor Gibson reported that the sample was part of a standing corbelled vault in an approximately 5000-year-old structure which was excavated in Iraq. The brick is representative of similar mudbricks in the building. The archaeologists consider the mudbrick in the structure to be significantly more durable than similar bricks generally used in Iraq through antiquity, perhaps enabling advanced structural use of mudbrick and early evolution toward the keystone arch. Compressive strength tests were requested with petrographic examination and x-ray diffraction analysis of the brick to determine the cause(s) of the strength and durability of the material.

Findings and Conclusions

The compressive strength of the brick material is 320 psi (pounds per square inch), averaged from results for six test specimens. The brick contains an abundance of gypsum (most of which may be secondary), quartz, calcite, limestone, and other constituents. An unidentified mineral cement, possibly a clay, may be responsible, in large parts, for the strength development of the brick.

Sample description

The mudbrick has the shape of a low, broad rectangular loaf of bread with a rounded top (Figures 1 and 2). The average dimensions of the brick are 12 x 18 x 7 inches. The surfaces of the brick are densely marked with the imprint of straw and matted grass blades emerging from the interior of the brick. A porous layer of mortar material, approximately 0,3 inch thick, occurs on parts of the bottom of the brick (Figure 3). The mortar appears to be similar to the brick material in composition. All of the fine-grained materials in the brick and mortar are similarly light to medium brown.

The form of the brick indicates features common to hand-made, sun-dried mudbrick. The rounded corners and irregularity of the rounded top suggest hand shaping. The flatness, uniform length, and rectangular plan of the lateral surfaces suggest use of a forming frame. The bottom of the brick is uniform, indicating use of the forming frame on a flat surface.

The impression from the impact of a pointed tool occurs in the top surface near the irregular break which separates the brick into two pieces (Figure 2).

The large piece of the brick was sawed into slices approximately two inches thick, which display parallel, vertical cross-sections of the brick material (Figure 3). Sawed surfaces of the slices were cleared of dust with a jet of compressed air, revealing certain internal features of the brick. Lumps of dense material with diameters up to 1.3 inches occur in a matrix of apparently similar composition.

1. Construction Technology Laboratories, a division of the Portland Cement Association, Skokie, Illinois. In this report, standard American terminology (feet, inches) is used. See report by R. Baer for conversion into metric units (Chapter V).

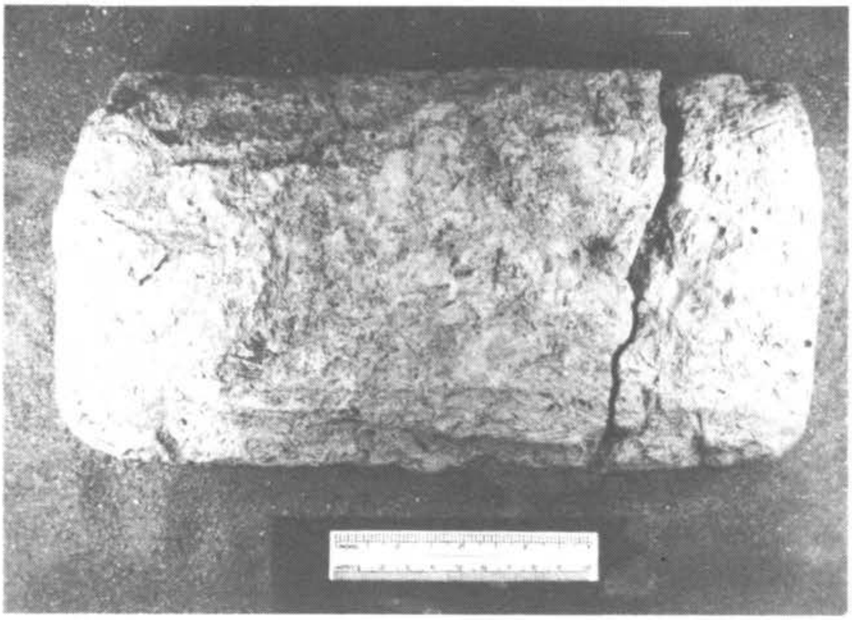


Figure 1. Top view of the mud brick.

Figure 2. Side view of the mud brick.

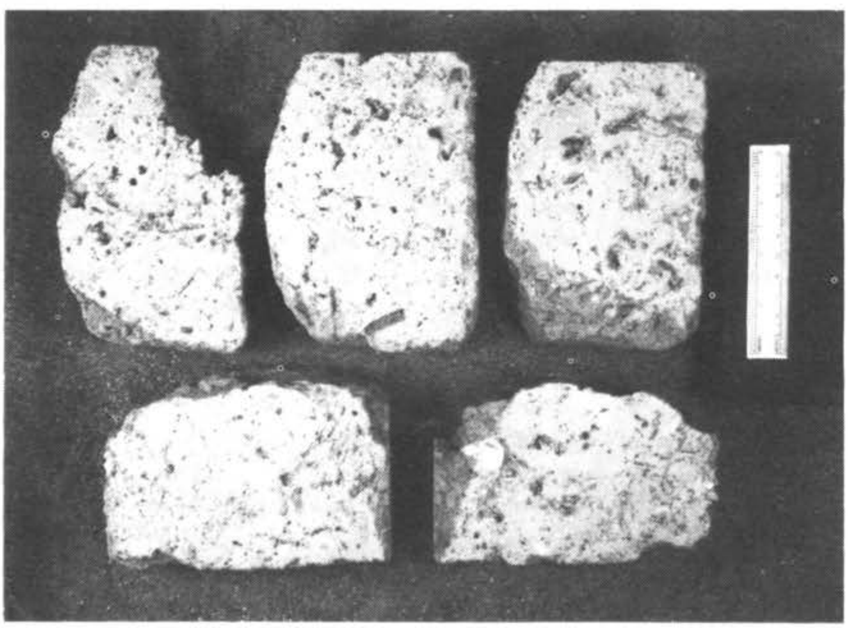


Figure 3. Parallel, vertical cross-sections of the large piece of the mud brick. The thin mortar layer can be seen at the right side (bottom) of the center section, top row. The upper ends of sections in the top row and facing ends of sections in the bottom row are sawed surfaces.

The matrix contains numerous voids. Elongated voids having small circular to flattened cross-sections are abundant and rather uniformly distributed in the matrix. The walls of some of these voids show the ribbed form of grass stems and leaf blades. Straw remnants were observed in a few voids. The few large tubular voids which occur include probable insect and worm burrows and perhaps root cavities. Large, irregular voids occur which are probably due to matted and twisted masses of grass binder in the brick.

Pebbles with diameters up to 0.5 inch occur sparsely distributed in the lumps and matrix of the brick and in the mortar. Most of the large pebbles are weathered cherts.

Mineralogy

Four thin sections, each approximately 25-30 microns thick, were made from an epoxy-impregnated slice taken from one end of the brick. The thin sections (one of which was polished) were examined with a polarized-light (petrographic) microscope in order to study the microstructure and mineralogy of the brick. An additional pair of thin sections was made in which the mortar is observed in its original contact with the brick.

Analysis of the thin sections reveals an abundance of whole, lozenge-shaped, gypsum crystals, generally with well-developed crystal faces, occurring with lengths up to 500 microns. The gypsum crystals are found principally in stringers and patches, and in some areas of the brick, small crystals are very delicately joined in fragile clusters. Gypsum may comprise as much as 35-40 percent of the brick. The gypsum crystals commonly contain carbonate inclusions and entrap relatively large portions of calcite particles like those found adjacent to the crystals. Other entrapped particles are quartz and mica which occur in trace amounts.

Examination with the scanning electron microscope reveals an abundance of intricately intergrown gypsum crystals of less-than-micron dimensions occurring as deposits on other larger crystals and on the walls of voids. The crystals of gypsum may have grown within the brick, entrapping other brick constituents in the developing crystals, or may have been part of the brick raw materials (sand and soft calcitic mud in which gypsum had grown secondarily). It is not impossible that both modes of gypsum origin will apply to the brick.

If the gypsum formed after brick manufacture, then the crystals are probably related to percolation of sulfate-bearing ground water. Subparallel orientation of the crystals in some parts of the thin sections may reflect secondary gypsum deposition along zones of presumably relatively high permeability developed during the shaping and molding of the brick. The particulate constituents also appear to show curving patterns perhaps reflecting a preferred orientation formed during molding.

Other constituents of the brick, as seen in thin sections, are grains of quartz, limestone, calcite, chert, plagioclase feldspar, chalcedony, metasiltstone, basalt, soil particles, and ferromagnesian silicate minerals. With the exception of some of the quartz and limestone grains, the particular constituents are angular. Microfossils such as *Globergerina* and possibly *Rotalidae* occur singly as particles in the brick and as constituents within the limestone fragments. The limestone chunks are predominately medium to microcrystalline calcite, with crystal sizes averaging 1 to 5 microns. Most of the dust particles in the matrix also have diameters of approximately 1 to 5 microns. Thus there is considerable similarity in matrix calcite dust and the calcite comprising limestone chunks.

An anisotropic crystalline cement also serves to bind the particles of the brick and appears to be the principal material that gives the brick its relatively high strength. The cement could not be positively identified microscopically but occurs as a pore-filling substance between particulate materials and may be a clay mineral. The cement is not colored by a stain selective for sulfate ion, therefore, the cement is not gypsum. Additional work is needed on this aspect of the mineralogy, perhaps with an electron microprobe.

Mortar constituents are virtually the same as those of the brick, but particle sizes are larger in the mortar.

A small specimen taken from near the end of the brick was crushed to particles with diameters less than 45 microns and subjected to X-ray diffraction in order to determine the crystalline phases present in the brick. In rough order of decreasing abundance, the phases identified on the diffractogram are:

Gypsum	$CaSO_4 \cdot 2H_20$
Quartz	SIO_2
Calcite	$CaCO_3$
Palygorskite	$(Mg,Al)_2Si_40(0H) \cdot 4H_20$
Plagioclase	$(Na,Ca)Al(Al,Si)Si_20_8$
Chloritee	Complex silicate
Cristobalite	SIO_2
Aragonite	$CaCO_3$
Sylvite	KCl

Compressive strength

Six blocks of the brick material were sawed from sections of the large piece (Figure 3). The block faces were worked with sandpaper to obtain specimens having cube proportions and regular bearing surfaces for compression tests. The bearing faces of each test specimen were capped with a sulfur compound.

Compressive strengths were determined with three groups of specimens, relating compression axes of the specimen correspondingly to the principal dimensions of the brick. The general test methods employed are given in ASTM C39-72, Compressive Strength of Cylindrical Concrete Specimens. Data are given on the attached Compressive Strength Tests report.

The average compressive strength of the six specimens is 320 psi. Three cubes tested with the major compression axis parallel to the vertical axis of the brick (height or thickness dimension) yielded at 370 psi, 370 psi, and 330 psi, averaging 360 psi. Two cubes tested with the major compression axis parallel to the direction of the brick width gave strengths of 200 psi and 280 psi. The remaining specimen, shortened along the major compression axis due to breakage in capping, had a compressive strength of 380 psi in the direction of the brick length.

Comprehensive Strength Test

Tested by: J. Patrick
Checked by: R.F. Scholl
Date: September 4, 1980
Client: Oriental Institute, University of Chicago

Structure: Mud brick from excavated corbel vault
Location: Hamrin Basin, N. Iraq

Specimen No.	Edge, Original (in.)	Cross-Sectional area (in.^{2})	Height, Capped (in.)	Date tested	Maximum Loads (lbs.)	Compressive Strength (psi)	Comments**
1	2.0	4.0	2.2	9-4-80	820	200	W
2	2.0	4.0	2.2	9-4-80	1,500	370	H
3	2.0	4.0	2.2	9-4-80	1,136	280	W
4	2.0	4.0	2.2	9-4-80	1,478	370	H
5	1.9*	3.6	1.8	9-4-80	1,366	380	L
6	2.2	4.8	2.4	9-4-80	1,608	330	H

* Shortened to a height of 1.6 inches due to breakage during capping.
** Brick dimension parallel to compression axis of test specimen: L, Length; W, width; H, height.

Chapter V

The Round Building at Razuk: a Structural Analysis

Ruben J. Baer[1]

Introduction

The Round Building at Tell Razuk is a structure approximately 28.7 m in diameter (Figs. 1-2). It consists of an outside wall, approximately 2.6 m thick, and a concentric interior wall 1.8 m thick. Between the two walls are five rooms, four of which are covered by a roof arch 5 meters wide. The fifth room, the West Room, is enclosed by a separate arch that measures 3 meters. Between the fifth room and the exterior wall there is a stairway with its own roof arch; it is separated from the room by a 1.2 meter thick wall. At the center of the building there is an open court that is approximately 10.7 meters in diameter. The five rooms are separated from each other by cross-walls that are approximately on the radial lines of the circle. The height of the rooms, at the crown of the arches, is approximately 2.3 meters.

Details of construction

The building was constructed using rectangular, unbaked mudbricks, each of which is approximately 30 to 36 cm long, 18 to 20 cm wide and 7 to 8 cm high. The bricks were made by hand using forms for the sides. The top surfaces have a convex surface; the bottom surface of the bricks is flat. There is some evidence of grass and straw chaff in the bricks. The unit weight of the bricks was determined to be 1200 kg/m^3. These bricks were generally placed horizontally with a running bond. The spaces between the individual bricks were filled with mortar made from the same material as the bricks. At the arches, the bricks were corbelled out over the openings. Each succeeding course projected approximately 10 cm beyond the previous course. The direction of the brick coursing is generally in a radial direction for the arches, while the coursing for the walls is tangential. The interior surfaces of the arches were covered with a mud-plaster (or mortar) finish.

The major components of the material from which the bricks and mortar are made are: gypsum, quarts, calcite and limestone. Other trace materials were found when the samples were examined with a polarized-light microscope. A brick was also tested for ultimate compressive strength. The average value was determined to be 320 lbs. per sq. in. (2206 kPa)[2].

An interesting aspect of this structure is the method which might have been used in the construction of the building. Today, the geographical area in which this structure was built is devoid of any timber. Even if timber were available at the time that the building was constructed, it is highly unlikely that scaffolding or shoring was used. However, the area does have extensive amounts of sand available. Therefore, it seems probable that the arches were constructed by filling the areas below the intrados with sand and laying up the bricks on the sand bed. After

1. Ruben J. Baer Associates, Skokie, Illinois. Editor's note: in this and the preceding chapter, the laboratory results are given in standard American measures, e.g. feet, inches, used in engineering and architectural practice. At the end of this chapter, Baer gives a conversion table.
2. See Chapter IV for laboratory analyses.

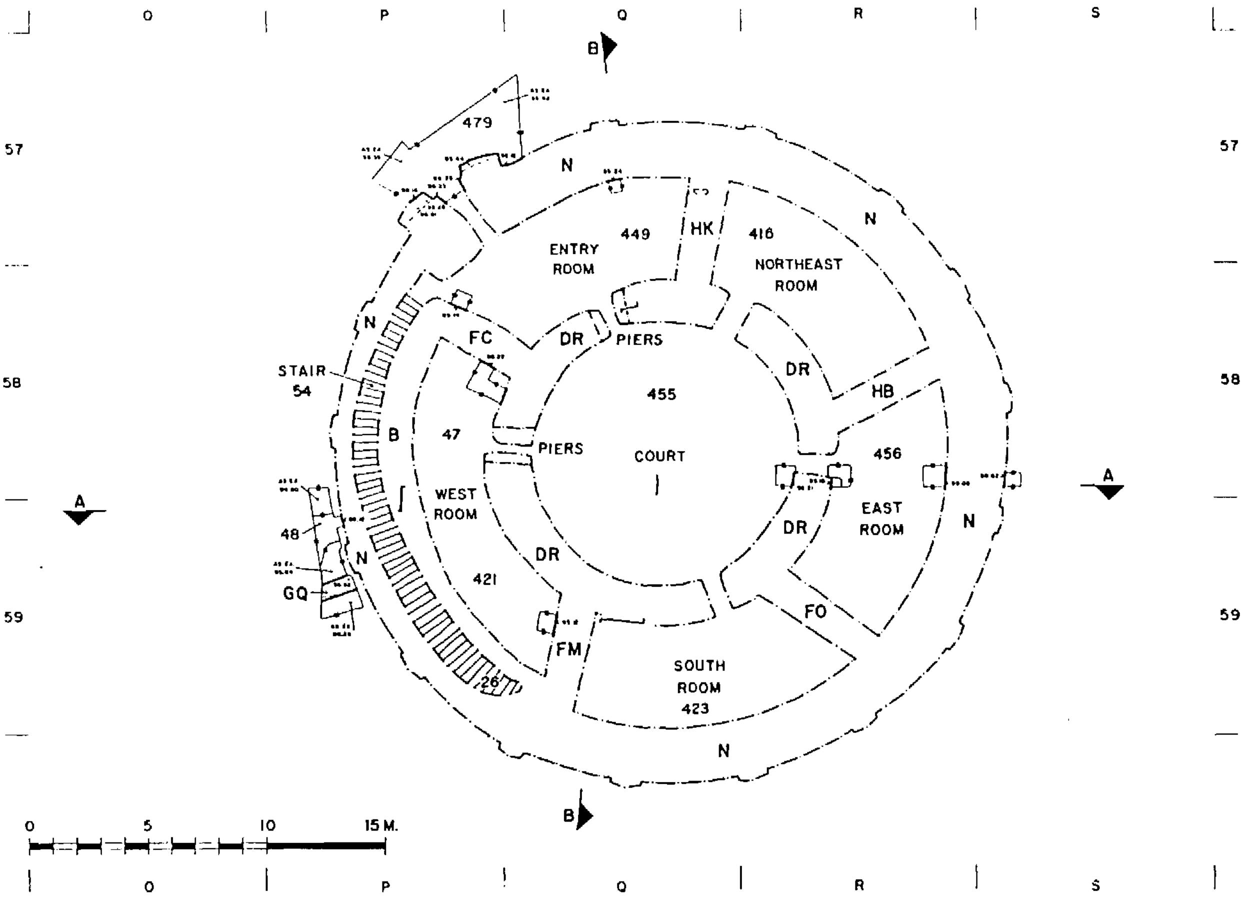
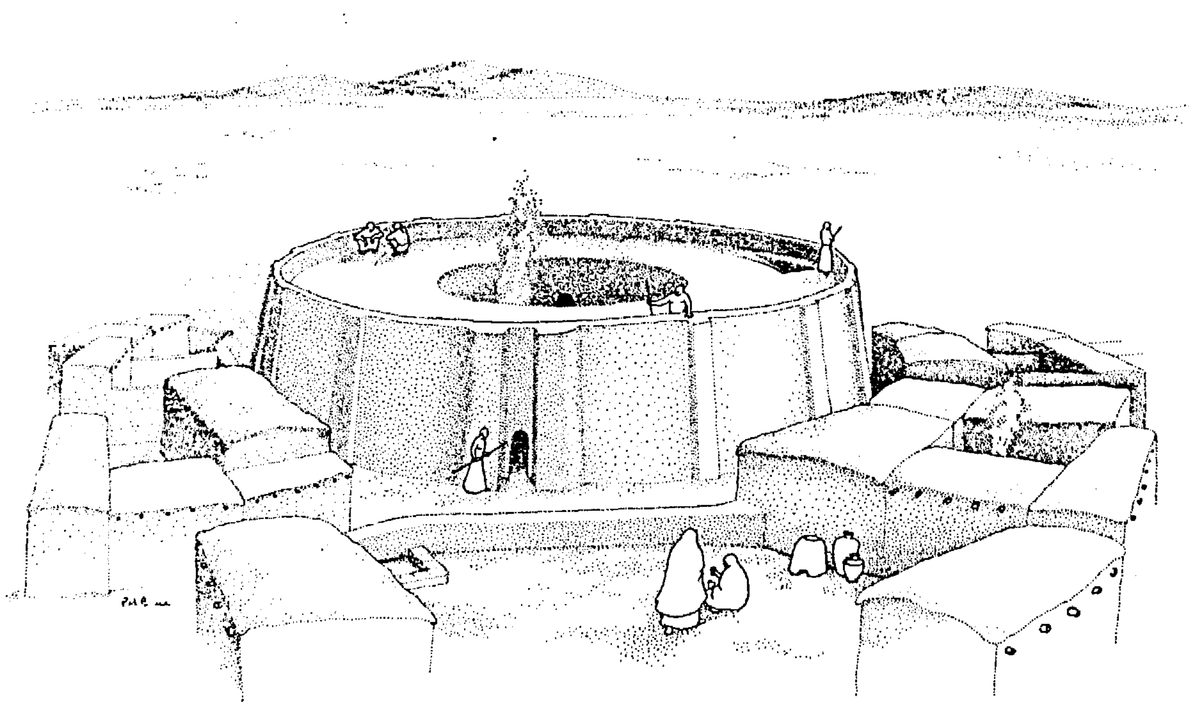


Figure 1. Plan, Razuk, Level VI B, lowest floor.



Figur 2. Artist's Reconstruction of Round Building at Razuk. Peggy Bruce Sanders.

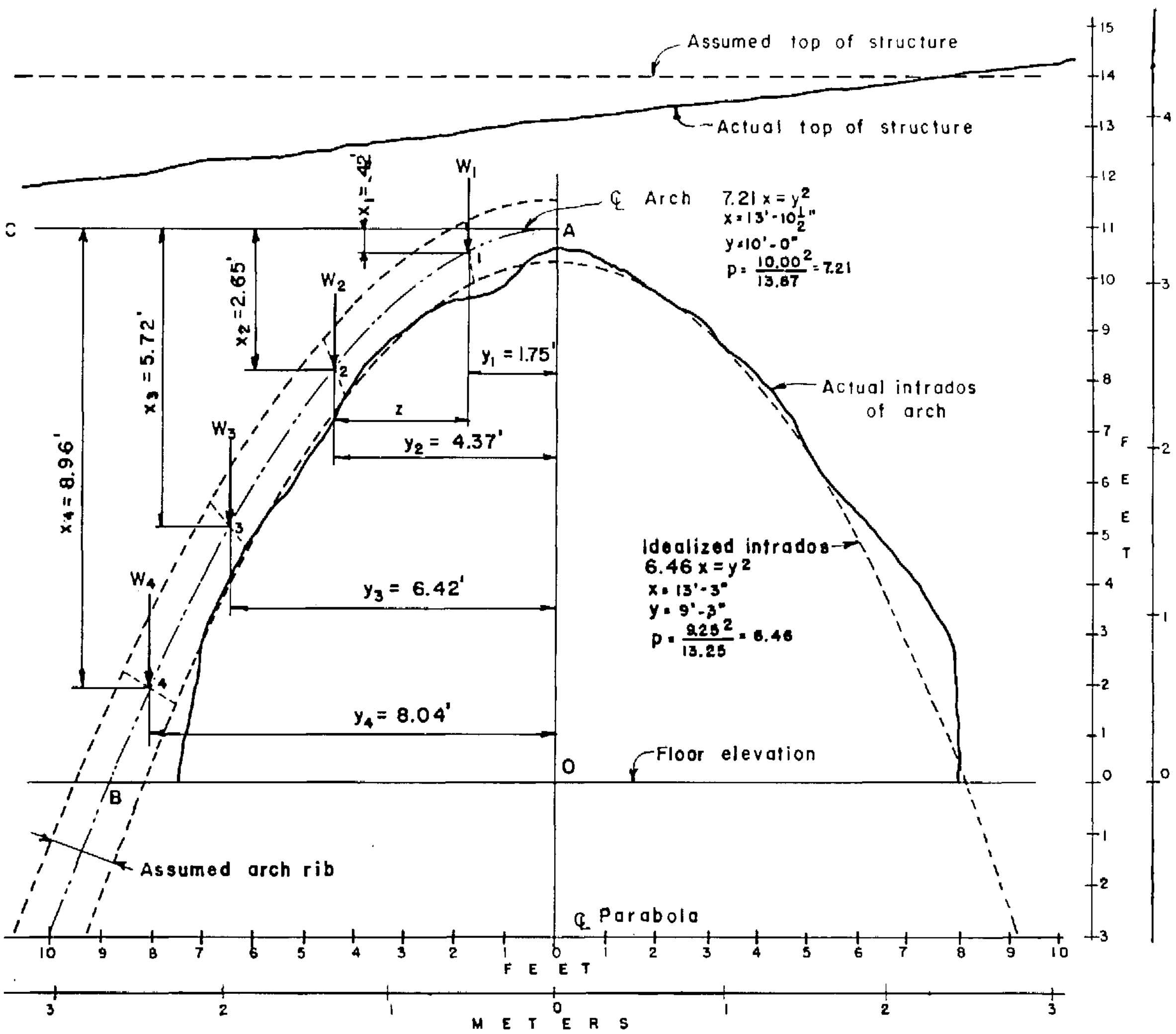


Figure 3. Section through corbelled vault, Round Building, Locus 421. Adapted from drawing of John Sanders.

the mortar hardened, more sand was added and the next section of masonry was laid; this process was repeated until the arches were completed. After the mortar in the entire construction had hardened (set), the sand was removed from the inside of the rooms, and the intrados of the arch was finished with plaster (or mortar). This method of shaping a sand bed and then building on top of it is occasionally employed even today in the United States for special structures.

Analysis of the Arch

The analysis of the arch is based on the assumption that the individual bricks, together with the mortar in the voids, form a homogenous material. This assumption was proven by a rather unscientific, but yet conclusive, method.

While being stored, the box containing the sample pieces of brick was accidentally submerged in water (flooded basement). The pieces disintegrated into a homogenous, mud-like mass; however, the shape of each piece of brick was still discernible. After the water evaporated and the mass dried, the pieces of brick formed a cohesive mass. It was not possible to break the pieces apart, especially along their former boundary lines. In its natural state the bricks and the mortar of the structure would have had a tendency to bond into a homogeneous mass following any rain that wetted the structure. That was probably also why it was difficult to delineate the brick courses in the field.

As can be seen from Fig. 3, the existing line of the intrados of the arch is not a true curve. It was therefore decided to idealize the intrados by a parabolic curve that approximates the intrados. The equation of that idealized curve is $6.46\,x = y^2$. The arch rib was divided into four equal segments as shown, with the centerline of the rib, Line A-B, having the equation of $7.21\,x = y^2$. It was further assumed that the original top surface of the structure was at Elevation +14.00

feet (4.26 m), rather than the sloping surface that was actually found in the field. The assumption of a constant surface would have the tendency to maximize the stresses in the arch rib.

Because of the actual shape of the arch and the assumption made for its analysis, the Elastic Method of Analysis is the best method to obtain reasonable results. An analysis by the Finite Element Method may give more accurate results, but such additional accuracy is probably not warranted for this structure.

The calculations for the arch rib are shown in the following tables. For subscripts see Fig. 3.

Conclusions

The resultant tensile and compressive stresses shown on Table 5 reveal that tensile stresses occur at the crown and skewback (abutment). However, two factors should be noted:

• 1) the magnitude of the tensile stresses is only six percent of the average ultimate compressive stress of the bricks, and,

2) an increase of the rib thickness from the assumed would reduce these tensile stresses.

The compressive stresses vary between 6% and 25% of the average ultimate compressive stress — certainly well below those that one could safely assign to this material. It is, therefore, not surprising that this structure has withstood the test of time.

S = length of the arch $\overline{AB}$ on the centerline ($7.21x = y^2$)

$$= \frac{b^2}{4a} [\sqrt{(c1+c)} + \ln_e (\sqrt{c} - \sqrt{1+c})]$$

where $a = \overline{OB} = 8.85$ ft.

$b = \overline{OA_2} = 10.87$ ft.

$$c = \frac{4a^2}{b^2} = 2.65$$

$$= \frac{10.87^2}{4 \times 8.85} [\sqrt{2.65 \times 3.65} + \ln_e (\sqrt{2.65} + \sqrt{3.65})]$$

S = 14.60 ft.

S/4 = 3.65 ft.

Loads on arch:

W_1	= 117/9 x 75 lbs./cu.ft.	= 975 lbs.
W_2	= 152/9 x 75 lbs./cu.ft.	= 1267 lbs.
W_3	= 162/9 x 75 lbs./cu.ft.	= 1350 lbs.
w_4	= 220/9 x 75 lbs./cu.ft.	= 1833 lbs.
TOTAL		**5425 lbs.**

Table 1

Point	y,ft.	x,ft.	x^2,ft^2	y^2,ft^2
1	1.75	.42	.18	3.06
2	4.37	2.65	7.02	19.10
3	6.42	5.72	32.72	41.22
4	8.04	8.96	80.28	64.64
Σ		17.75	120.20	128.02

$$n\Sigma x^2 - (\Sigma x)^2 = 4 \times 120.20 - (17.75)^2$$
$$= 480.80 - 315.06$$
$$= 165.74 \text{ ft.}^2$$

Table 2

	z, ft.			zx, ft.^{2}			zy, ft.^{2}		
Point	W_1	W_2	W_3	W_1	W_2	W_3	W_1	W_2	W_3
1	0			0			0		
2	2.62	0		6.94	0		11.45	0	
3	4.67	2.05	0	26.71	11.73	0	29.98	13.16	0
4	6.29	3.67	1.62	56.36	32.88	14.51	50.57	29.51	13.02
Σz	13.58	5.72	1.62						
$\Sigma x \Sigma z$	241.04	101.53	28.76						
Σzx				90.01	44.61	14.51			
Σzy							92.00	42.67	13.02

H_o = horizontal force at crown

$$= \frac{W}{2} \times \frac{n\Sigma zx - \Sigma x\Sigma z}{[n\Sigma x^2 - (\Sigma x)^2]}$$

$$= \frac{W}{2 \times 165.74} (n\Sigma zx - \Sigma x\Sigma z)$$

$$H_1 = \frac{W_1}{331.48}(4 \times 90.01 - 241.04) = \frac{975}{331.48} \times 119.00 = 350 \text{ lbs.}$$

$$H_2 = \frac{W_2}{331.48}(4 \times 44.61 - 101.53) = \frac{1267}{331.48} \times 76.91 = 294 \text{ lbs.}$$

$$H_3 = \frac{W_3}{331.48}(4 \times 14.51 - 28.76) = \frac{1350}{331.48} \times 29.28 = 119 \text{ lbs.}$$

H_o = **763 lbs.**

M_o = moment at crown

$$= \frac{\frac{W}{2} \times \Sigma z - H \times \Sigma x}{4}$$

$$M_1 = \frac{\frac{975 \times 13.58}{2} - 350 \times 17.75}{4} = \frac{6620 - 6212}{4} = 102 \text{ ft.lbs.}$$

$$M_2 = \frac{\frac{1267 \times 5.72}{2} - 294 \times 17.75}{4} = \frac{3624 - 5218}{4} = -398 \text{ ft.lbs.}$$

$$M_3 = \frac{\frac{1350 \times 1.62}{2} - 119 \times 17.75}{4} = \frac{1094 - 2112}{4} = -254 \text{ ft.lbs.}$$

M_o = **-550 ft.lbs.**

V_o = vertical force at crown

$= \frac{W}{2} \times \frac{\Sigma zy}{\Sigma y^2}$

$V_1 = \frac{975}{2} \times \frac{92.00}{128.02}$ = 350 lbs.

$V_2 = \frac{1267}{2} \times \frac{42.67}{128.02}$ = 211 lbs.

$V_3 = \frac{1350}{2} \times \frac{13.02}{128.02}$ = 69 lbs.

V_o = **630 lbs.**

$H_o = 2 \times 763 = 1526$ lbs.

$M_o = 2 \times (-550) = -1100$ ft.lbs.

$V_o = 630 - 630 = 0$

Table 3:

Point	$y, \bar{y}$ ft.	x, ft.	$\bar{x}$, ft.	$\tan\theta = \bar{y}\ \sqrt{x}$	θ^o	$\cos\theta$	$\sin\theta$	$H_o x$, ft.lbs.
Crown	0	0	13.87	0	0	1.000	0	0
1	1.75	.42	13.45	.1301	7.4132	.9916	.1290	641
2	4.37	2.65	11.22	.3895	21.2801	.9318	.3629	4044
3	6.42	5.72	8.15	.7877	38.2286	.7855	.6188	8729
4	8.04	8.96	4.91	1.6375	58.5877	.5212	.8534	13673
Skewback	8.85	10.87	3.00	2.9500	71.2742	.3210	.9471	16588

$M_x = M_o + H_o x + V_o y - \Sigma Wz$

$V_x = V_o - \Sigma W$

$N = H_o \cos\theta - V_x \sin\theta$

$c_o = M_o / H_o$

$c_x = M_x / N$

Table 4:

Point	ΣWz,ft.lbs.	M_x,ft.lbs.	V_x,lbs.	$H_o\cos\theta$,lbs.	$V_x\sin\theta$	N, lbs.	c_x,ft.
Crown	0	-1100	0	1526	0	1526	-.721
1	0	-459	0	1513	0	1513	-.303
2	-2554	390	-975	1422	-345	1776	.220
3	-7150	479	-2242	1199	-1387	2586	.185
4	-12970	-397	-3592	795	-3065	3860	-.103
Skewback	-17363	-1875	-5425	490	-5138	5628	-.333

A = cross sectional area

$= 12 \times 15 = 180$ sq.in.

S = section modulus

$= \frac{12 \times 15^2}{6} = 450 \text{ in.}^3$

f = stress in extreme fibers

$= \frac{N}{A} \pm \frac{M}{S}$ lbs./sq.in.

Table 5:

Point	N/A	M/S	Compression	Tension
Crown	8	29	37	21
1	8	12	20	4
2	10	10	20	0
3	14	13	27	-1
4	21	10	31	-11
Skewback	31	50	81	19

Conversion Factors:

1 inch	= 2.54 cm	1 sq.inch	= 6.4516 cm^2	1 cu.inch	= 16.38706 cm^3	1 ft.lb.	= 1.355818 N-m
1 foot	= .3048 cm	1 sq.foot	= .092903 m^2	1 lb.	= 4.448222 N	1 lb/sq.inch.	= 6.894757 kPa

Chapter VI
Remarks on the Round Building

McGuire Gibson

In the previous two chapters, we have presented findings on the basic materials (mudbrick and mud mortar) with which the Round Building at Razuk was constructed and on the stress factors involved in the building. I will now use some previously unpublished photographs of structural features to give additional evidence of the vault and roof details in the Round Building. I do this in part as a response to two reviews of Uch Tepe I (Gibson 1981) by J.-D. Forest (1982) and D. Sürenhagen (1987). I have already discussed Forest's thoughtful piece (Gibson 1986) but some points will be reiterated here.

Forest has suggested that the Round Building may have had an upper story, and the evidence presented in the previous two chapters clearly shows that an upper story would have been no problem technically. My interpretation of the sections through the Round Building (Gibson 1981: Pls. 11-12 and 1986: 471) does not allow such a reconstruction, although I proposed in the original report (Gibson 1981) that the outer wall in at least its western part must have been carried up above the general level of the top of the building to allow the Stair to be covered.

Looking at the published sections of the Round Building (Gibson 1981: Pls. 11-12), one can see that pits and construction activity of later levels disturbed the fortress. But there is enough intact stratification to deny the suggestion that an upper story had existed but had been entirely removed. It should be noted that Walls G and X of Level II, which have a different orientation from the walls below them, were found resting directly on the Round Building, which had not been cut away here as far as we could determine (Gibson 1981: Pl. 43). It should be noted that in the meter or so of debris above the Round Building, although there was some mudbrick debris, there was no locus where there was a predominance of mudbricks that could be interpreted as the fallen walls of an upper story. From the debris of the entire upper story, we would have expected mudbrick scatters more extensive than the masonry from the vault that we found inside the rooms of the Round Building. We had no problem recognizing mudbrick of the vaults and would have had little difficulty in seeing the remnants of the upper story, had they been there. In Locus 47, for instance, a large block of mudbrick masonry was clearly a detached part of the vault (Gibson 1981: Pl. 11), and in Locus 68 (Gibson 1981: 53, Pl. 12) the uppermost floor was covered with up to 50 centimeters of red mudbrick debris, which was the same color as the remaining parts of the vault over the room. We interpreted the findings in this room as evidence that the vault had partially failed or had been deliberately pierced. The ashy debris that lay above the mudbricks had been poured into the locus through the hole in the roof, as shown by the sharply sloping tip-lines.

Forest's suggestion that the Round Building was a farm house, with animal stables on the ground floor and living space for humans on the supposed upper floor, although an interesting possibility, does not seem to hold in light of evidence in the rooms themselves. With one partial exception, all the rooms of the Round Building had evidence of hearths, layers of ash, smoke-blackened mudplaster on the walls, and other indications of activities not related to animals. In addition, there was little evidence of the greenish debris we have found in other sites where manure was arguably a factor, nor the red and yellow staining from urine that would be expected from the stabling of animals. The only room that may have been devoted originally to animals was the West Room, where the red stains did occur in the earliest level (VIB-VIA) in association with long mudbrick structures (mangers?) found along one wall (Gibson 1981: Pls. 14-18). I have acknowledged (1986: 469-70) my debt to Forest for his suggestion on this; but I also pointed out that very early in the life of the building, the original wide doorways of the Round Building were transformed into narrow ones, which would have made the passage of animals difficult. I also pointed out (1986: 470) that the inhabitants of the Round Building did not seem to have much interest in farming, since analysis of lithics (Thuesen 1981: 96) resulted in the conclusion that

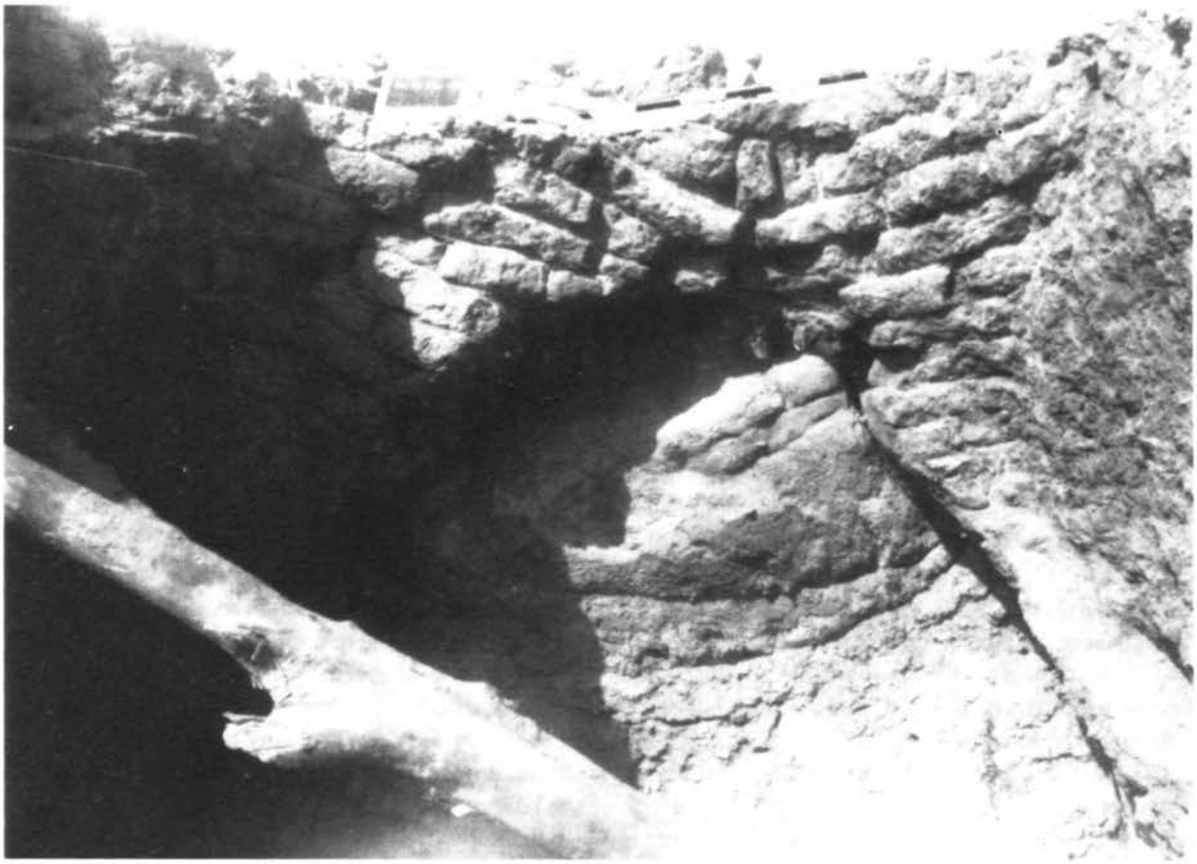


Figure 1. Vault in West Room, Locus 421, from South.

Figure 2. South of West Room, Locus 421, Level VB, showing abutment of vault with Wall FM.

"...all reaping activities were done by the inhabitants of the houses outside the Round Building".

Sürenhagen, in his review, expressed doubts as to the existence of the vaults, asking for more evidence. I had thought that anyone studying the sections through the Round Building (Gibson 1981: Pls. 11-12), with the floors inside the rooms, and structures built on those floors, curving up to increasingly closer wall faces, could not fail to see the evidence of vaults.

A dangerous collapse of the upper part of the vault on both sides of the West Room during excavation, showed that we had to be very careful in excavating the rooms. We therefore began to cut back the overhanging sections of the vaults in some places and to leave the debris intact under them in others. This procedure meant that we were not as able to rely on photographs to illustrate the vaults as we wished. We had recourse to the two main sections through the Round Building (Gibson 1981: Pls. 11-12) and less dramatic photographs to make the point. The lack of time at the end of our work at Razuk prevented us from articulating the mudbricks as completely as we would have liked, thus also reducing some of the impact that photographs might have had.

Any objection to the vaults based on the shape of the roof in the Entry Room has been accounted for through a slump caused by the failure of that part of the structure (Gibson 1981: 62, Pl. 12).

In the West Room, where the span was narrowed by the presence of the Stairway to the west, we found the most complete section of the vault (Fig. 1), here shown from the south side. This is the first time this photograph has been published. It's quality is a bit lacking because it is a copy of a Polaroid in the notebook of this room, a more permanent record photograph not having been successful. The photograph differs in one important detail from the artist's rendering (Gibson 1981: Pl. 13,1), in having one brick laid on edge above the crown. This fragment of roofing remained in place for several weeks, even with the debris removed from below it; workmen sometimes walked across it, despite our injunctions not to do so.

In the West Room, besides a remnant of the crown of the vault, we also found evidence for the abutment of the vaults with the segmental walls that divided the rooms from one another; for instance at the southern end of the Room (Fig. 2), a good part of the west section of the vault (Wall B) was still held by mud mortar to the face of Wall FM. To cut the costs of the publication, we omitted this photo from Uch Tepe I, assuming that the discerning reader would use the plan showing the top of the Round Building (Gibson 1981: Pl. 41) and the succession of other plans to judge the progressively incurving walls of the vault and the abutting of the vault to the segmental wall. It might be noted that this section of vault was first isolated on March 8, 1979 and was strong enough to remain in place until some time after we left the site at the end of the month.

In the case of the small piece of roofing over the Stair, Sürenhagen (1987: 317) is correct in questioning that the published photograph (Gibson 1981: Pl. 7,2) allows a statement that the vault was bonded into the eastern wall. He notes that at the junction of the roof and Wall DR, there are two bricks laid on edge. The photo of the northern side of the same bit of roofing (Gibson 1981 : Pl. 21,1) shows insufficient articulation to speak of bonding; we did not attempt to articulate this face of the fragment of roofing because we feared its collapse. In our original articulation on the southern side of this fragment of roofing, we could show true bonding, with flat courses passing across the stair and into Wall DR. But before we could photograph the bonding, the articulated face sheared off. The rearticulation that has been published (Gibson 1981: Pl. 7,2) is accurate, but is true only for the set of bricks shown. The existence of bricks on edge here, however, should be compared to the brick on edge over the West Room (Fig. 1). Such filling-in with fragments or with bricks on end at the crown of vaults was necessitated by the fact that during construction there would sometimes not be space enough to lay a brick flat. I would like to add that our fear of collapse in this place may have been unwarranted. The fragment of roof over the stair, although less than 20 centimeters thick after the loss of its originally articulated face, was strong enough to stand unsupported through the end of the 1979 season.

Sürenhagen, on viewing the roofing over the Stair on a visit to Razuk in our first season, 1978-79, indicated that he was dubious of the articulation because he could see ash where we had bricks. Sürenhagen himself, however, realized in his next season of work that his Early Dynastic I tombs at Ahmed al-Hattu were often made of bricks that included ash (personal communication).

I take this opportunity to present three previously unpublished photographs of the South Room at various stages of excavation. Nowhere was the vault easier to see than here, where two transverse walls were inserted under the vault at Level VA to subdivide the space into three smaller rooms, Loci 42, 68, and 75 (Gibson 1981: Pl. 33).

It was in Locus 68 that we first became aware that we were dealing with a vaulted building, having first thought we were clearing a bell-shaped pit filled

Figure 3. Vault in Locus 68 with Locus 75 behind, from west, Level VA.

Figure 4. Vault and walls built under it in Locus 68, Level VA.

Figure 5. Locus 42, with doorway to Court, from south, Level VA. At left, Wall FQ, built under vault, that curves down from upper left. At right, Wall HE.

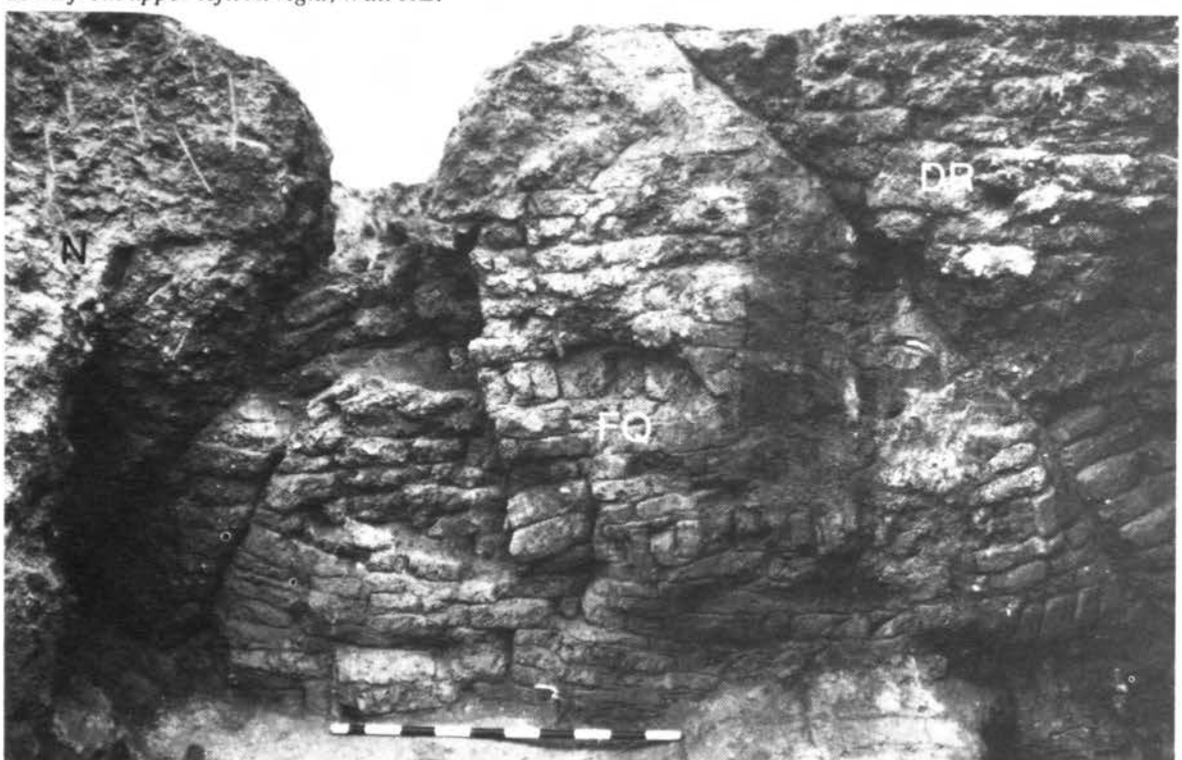


Figure 6. Locus 42, Level VA, from east. Wall FQ built under Vault. To left, southern jamb of blocked doorway. To right of doorway, veneer partly obscuring northern jamb of doorway.

with ash. It was only when that "pit" became progressively more rectangular and could be seen to have smoke-blackened mudplaster on the vault that we realized we were under a roof. I did not think it necessary to document the fire-blackened plaster other than by noting it in writing. Figure 3 shows Locus 68 with Locus 75 behind it. In Locus 68, to the left, we kept part of the debris of the room in place under the remnant of vault. Beyond the column of debris can be seen a veneer applied to the face of Wall FR; both Wall FR and the veneer were built under the vault. A closeup photograph (Fig. 4) shows the same locus in detail. On the right, Wall FN can be seen running under part of the vault. This wall was contemporary with the veneer of Wall FR and was apparently meant to hold up the roof after it had begun to fail (Gibson 1981: 53, Pls. 32-33).

In a previously unpublished photograph of the northwest corner of Locus 42 (Fig. 5), although the articulating is not complete due to lack of time, it is possible to see the vault curving down from the left. Wall FQ rests under it, clearly constructed under the vault. In the main part of the locus, the vault has collapsed or been removed by us; but the narrow, arched doorway from the Court can be visualized as continuing toward the viewer, its upper part passing through the vault of the room. At the right is Wall HE, built at the same time as Wall FQ against the original segmental wall FO (Gibson ed. 1981: Pl. 33).

Viewing the transverse walls FQ and HE, it is possible to see the same curving of the vault over constructed walls (Gibson 1981: Pl 36). As published, the photos of these walls were cropped at the edges, so their abutting with the vault is not as apparent as is the photograph of Wall FQ published here (Fig. 6). The junction of the vault and Wall FQ on the right, as well as the left jamb of the blocked doorway, is readily visible. The right doorjamb is somewhat obscured because we did not have enough time to articulate the bricks to find out more precisely how the greenish mudbricks of a veneer on the right were applied over part of the blocked doorway (Gibson 1981: 53).

Our work, and that of others in the Hamrin, showed that there can be extraordinary preservation of mudbrick architecture in central (and northern?) Iraq. As additional examples of well-preserved buildings are exposed, the Round Building at Razuk will appear less extraordinary, and very ancient mudbrick vaults and even mudbrick domes will be taken for granted.

Bibliography

Forest, J.-D.

1982 Review: Uch Tepe I. *Paléorient* 8/2: 113-15.

Gibson, McG.

1981 (Ed.) *Uch Tepe I.* Chicago and Copenhagen.

1986 The Round Building at Razuk: Form and Function. In J.-L. Huot (Ed.), *Préhistoire de la Mésopotamie.* Paris. Pp. 467-74.

Sürenhagen, D.

1987 Review: Uch Tepe I. *Zeitschrift für Assyriologie* 76: 314-18.

Thuesen, I.

1981 The Chipped Stone Industry of Tell Razuk. In *Uch Tepe I*, Gibson (Ed.) 1981 88-98.

Chapter VII
Differential Distribution of Faunal Material at Razuk

McGuire Gibson

At a conference in 1984, I presented a preliminary assessment of the information on function of the various loci at Tell Razuk that might be derived from the distribution of faunal samples (Gibson 1986). Using information in the manuscript of the report by Joachim Boessneck (1987), I concluded that the animal bones were not distributed in a uniform pattern throughout the excavation. There was, first of all, a predominance of specimens found in the Round Building, in comparison to the Corridor around the Round Building and the contemporary Houses. This distribution was to some extent the result of the much greater volume of earth removed from the Round Building: approximately 750 cubic meters, in contrast to about 200 cubic meters from the Corridor around the fortress and 200 cubic meters from the Houses.

If the distribution of animal bones were uniform throughout the excavation, we could expect there to be almost four times more bones inside the Round Building than in either the Corridor or the Houses. But, as will be seen, there were significantly greater numbers of bones of some species in the Round Building.

Using only the selection of bones analyzed in detail by Boessneck (1987), I derived some conclusions (Gibson 1986: 471-73) that must now be amended in light of the full sample, here listed in Appendix B.[1] For instance, the Court previously appeared to be the most important locus for animal bones. In the full sample (Tables 2, 5), the Court is seen to be secondary to the Entry Room, which served as the kitchen. It should be borne in mind, however, that the Court was a locus of cooking as well, with large, chambered ovens and tannurs. It might be thought that the secondary status of the Court resulted from the fact that, because of restricted time, we chose to excavate only two of its four quadrants floor by floor. By removing the other two quadrants in blocks of floors instead of by individual floors, we definitely reduced the Court's share of faunal samples. The excavation of blocks of floors also resulted in the combining of faunal samples from more than one level, when discrimination by floors and levels would have been preferable. Thus, in several of the tables here we list not only Level VIA and Level VIB, but also a combined VIA-B. In the Entry Room, a few samples collected from individual floors of Levels VA and VB were inadvertently combined and appear in my tables under the heading VA-B.

In contrast to the situation in the Court, the Entry was excavated floor by floor. Here, however, some portions of the accumulated floors had to be left in place to support the remnants of the vault, reducing the volume removed from the Entry Room. As a result of this procedure, the cubic meters of debris removed from the Entry Room were less than the total excavated from only the two meticulously excavated quadrants of the Court. But the Entry Room still contained a greater number of bones. The importance of the Entry Room as a location of activity involving animal preparation for food is, therefore, reinforced.

In the West Room,the vault had a span that was a meter less than elsewhere in the building; it could better withstand, therefore, the stress involved when the accumulated floor debris was removed from beneath it, allowing for a more complete excavation of this room than of others. Originally perhaps a stable, this room seems to have been given over to different activities by Level VB, if we may judge by the evidence of hearths, storage bins, and other evidence of human use during that phase.

The Stair was completely excavated. About mid-

1. In my tables, there are some differences from Boessneck's totals (Table 1). His total count of mammals, 927, is sixty more than my 867. Thirteen of the missing 60 are from loci above the Round Building and are not used by me. The remainder can be explained by my inability to determine when an item in the full list (Appendix 1) is to be counted twice (e.g., a mandible which may have an intact tooth)

way through the history of the Round Building (Level VB), access to the Stair was changed from the original (by then unusable) doorway at the west end of the Entry Room to a new doorway cut through the eastern wall of the West Room. The West Room then took on a different role than it originally had, becoming a thoroughfare as well as a large room tied in with activities on the roof. If, as I have suggested (Gibson 1981, 1986), the Round Building was a fortress with a garrison, and the roof was used as a lookout and a place for signal fires, the West Room would have been the logical room for the housing of those who manned the roof. By Level VA, the Stair was no longer in use (Gibson 1981: Pl. 32) and the function of the West Room must once again have changed. We have no evidence of any other stair to the roof from Level VA or above. The accumulation of debris within the Round Building was so high by this time that one could have leapt onto the roof from the courtyard or used a simple wooden ladder (Gibson 1981: Pl. 35,1).

In Level IV, the Round Building apparently ceased functioning for its original purpose (Gibson 1981: 65), and I have suggested that the remnants of intact structure became just a residence. Supporting evidence for this supposed shift appears in the faunal distribution, as I will show below.

The South Room could be exposed to only about half its depth, and the East Room and Northeast Room were likewise excavated only partially, due to lack of time.

Because of the differences in degree of excavation, the Court, the Entry Room, the West Room, and the Stair are overrepresented in the sample of bones. But some overrepresentation would have occurred, I think, even if all rooms had been excavated equally. The debris encountered in the three partially excavated rooms was significantly different from that in the Entry and in the West Room. Although there was ash in all rooms, the accumulated debris and floors in the Entry Room and the West Room were dirtier and much more greasy. In the East Room and South Room, there were mudbrick pavements and layers of clay (prepared floors?), indicating that these rooms may have served very different functions than the Entry Room, which was clearly the kitchen, and the West Room, which was originally probably a stable (Gibson 1986: 469-70). Throughout the history of the building, the Court served as an area of cooking and grain storage. In short, the Entry, the Court, and the West Room may have been the more utilitarian loci, resulting in a greater accumulation of bones there. I have indicated above that the West Room, in some phases, may have served to house soldiers. If so, the difference between the debris and the distribution in this room and in the other three rooms, that I have suggested may have been residential, could have been one of status.

Boessneck (1987, esp. Tab. 2; here, Tab. 1) noted that there was an unusually high proportion of equid bones at Razuk, predominantly of onager, with a much smaller representation of ass. In contrast to the normal proportional ranking of (1) sheep/goat, (2) cow, and (3) pig in Mesopotamian faunal assemblages, at Early Dynastic Razuk, equid bones (35.5%) ranked second behind sheep/goat. Boessneck concluded from the fairly uniform age of the onagers (c. 2 years) and from the marks on the bones that these were wild animals taken in the hunt. After computing the relative yield of meat from the various species of animals, he suggested that onager, rather than being second in importance, was the dominant meat source (56% of gross weight) at Razuk. Boessneck also called attention to the relatively high percentage of gazelle bones (5%), emphasizing the importance of hunting in Razuk's subsistence. The importance of onager and gazelle was seen as evidence of an open, steppe environment in the Early Dynastic Hamrin. The relatively low percentage of pig (c. 10%) in the assemblage and the fact that the specimens were of domestic pig support Boessneck's view of the ancient local environment. Anyone aware of the abundance of wild (feral?) pig in the recent Hamrin Basin marshes might be surprised by Boessneck's conclusions and his view of the ancient environment of the Hamrin. It must be concluded that the buildup of several meters of alluvium in the Hamrin Basin from the Early Dynastic period until recent times coincided with a transformation of the local environment from an open steppe to an inadequately drained area with extensive marshes that form in early winter and last for several months each year.

Boessneck (1987: 161) estimates that there were perhaps four times more sheep than goats, with the sheep clearly larger in size. Bovine specimens made up about 11 percent of the assemblage. Boessneck notes (1987: 161) that cattle specimens were much more frequent in Early Dynastic Razuk than in Akkadian Tepe al-Atiqeh, while there were more domestic pig bones at Tepe al-Atiqeh than at Razuk. This shift, thought to be a significant one, will be discussed below.

Viewing the tables (Tables 2-5) which I have worked out from Boessneck's full list of specimens found at Razuk (Appendix B), a number of observations can be made. It should be noted that I deal here only with the numbers of bones and make no attempt

to calculate meat yields; I am also discussing only the mammalian species; and the conclusions drawn from the full sample of bones differ in detail from my previous report (Gibson 1986: 72-73). Except in Table 1, which is an adaptation of one by Boessneck (1987: Table 2), I do not include any specimens found in the levels (I-III) above the Round Building and its associated Houses. I ignore the post-fortress levels because my purpose in this chapter is to compare the faunal remains inside and outside the Round Building during its periods of use (IV-VIB).

Eighty-six percent of equid bones (Table 3) found in levels VIB up to IV were from the Round Building, predominantly from the Entry Room/kitchen (Tables 2, 4). The Court yielded the next largest number, followed by the West Room (Tables 2, 4). The Corridor, including the Space directly outside the Entry door, had a percentage (11.3%) almost four times that of the houses, where only 2.7 percent of the equid bones were found. I have suggested (1986: 462) that the bones in the Corridor and the Space outside the doorway were discards from the Round Building, although we might assume that some of them were derived from the Houses. Above, I estimated that the Corridor and the Houses each accounted for about 20 percent of the total of excavated material at Razuk. The 11.3% of equid bones from the Corridor and the 2.7% found in the Houses indicates a non-uniform distribution of equid bones.

There is a similar patterning in the gazelle bones, with more than 82 percent found in the Round Building (Table 3), mostly from the Entry Room and the Court (Tables 2,4). Less than 7 percent of the gazelle specimens were found in the Houses, and just over 11 percent were from the open space around the fortress (Corridor/ Space outside door).

Although listed separately in Tables 1 and 2, according to Boessneck's full catalogue (Appendix B), sheep and goats are best combined for my purposes here. At 37.7 percent of all bones from Razuk (Table 1), sheep/goat make up the largest single category; but, as mentioned above, when meat yield is calculated, equids were more important in the overall Razuk diet, with cattle closely following sheep/goat. Taking only those sheep/goat bones from Levels VIB to IV (Table 3), 68.3 percent came from the Round Building itself, and the distribution within the structure (Table 4) is much more even than the distribution of equids and gazelle. However, once again the percentage in the Entry Room is greatest. In the Corridor, there is a sizable percentage of sheep/goat (23%), which is about what would be expected from the amount of earth removed here. When compared to other species, sheep/goat comprise the most numerous species in the Houses (Table 2), but their number there represents only 8.7 percent of total sheep-goat bones (Table 3), less than half of their theoretical value if there were uniform distribution in the excavated area.

Cattle (Table 3) were also found mainly in the Round Building (71.7 %), mostly in the Court and the Entry Room. From the surrounding Corridor came slightly more than the expected 20 percent of cattle bones (25.3%); but only 3 percent were found in the Houses.

Pig presents a slightly different pattern (Table 3). Although also mostly from the Round Building (68.2%), there is a somewhat higher percentage (14.8%) for this species in the Houses when compared to the other species.

The additional mammalian species recovered at Razuk, hyena and cat, were represented in three exemplars only, two from the Round Building, one (the cat) from the Houses.

It should be noted that when comparing the Round Building with the Corridor and with the Houses, the domestic animals — sheep, goats, cattle, and pigs — were found at or near the theoretical percentage (20%) in the Corridor around the Round Building (Table 3). The wild animals, onager and gazelle, were found in the Corridor at about half that percentage. In all categories, wild and domestic, the finds in the houses did not exceed ten percent, with the exception of pig (Table 3).

In Tables 2-4, I have listed the numbers and percentages of mammalian species by locus and then summarized the percentages in Table 5, in order to see if there are significant differences in the pattern of bone discard among loci within the Building and within the two classes of loci (Corridor, Houses) outside it. Tables 6 to 12 present the raw counts in each locus. Table 13 gives the total number of bones of all species in each level by locus within the Round Building.

When one compares the percentages of numbers of bones by species per locus (Table 5), the Entry Room and Court differ markedly only in the category of cattle, with a larger representation of this species in the Court than in the Entry. The West Room, which underwent structural (and functional) change, has a higher percentage of sheep/goat than equid and a somewhat elevated percentage of pig. The sample from the South Room is too small to yield meaningful percentages, so its results in Table 5 are probably to be discounted. The Stair also has a higher percentage of sheep/goat than equid, and a high percentage of cattle (16%). The Corridor has many more sheep/goat

than equid and about the same percentage of cattle as the Stair and Court. The Houses have more than 50 percent sheep/goat, a low percentage of cattle (5.3%), and an elevated percentage of pig (22.8%). In terms of Table 5, the Houses share similar percentages of sheep/goat with the West Room and Stair of the Round Building as well as with the Corridor. But the Houses have the lowest relative percentages of equid and cattle and a much greater percentage (22.8%) of pig.

The somewhat more even distribution of sheep/goat and fairly uniform percentages of pig bones within the Round Building (Table 5) and in the Corridor may be accounted for by the fact that these smaller animals are often, today and presumably in ancient times, cooked whole. The carcass is normally dismembered by hand and the flesh adheres to the bones. Morsels of these kinds of meat are easily transportable and can be eaten anywhere, even at one's work. Persons on duty anywhere in the Round Building could have eaten and discarded bones in their sleeping quarters, in the Stair on the way to the Roof, and over the side of the building, into the Corridor.

I would suggest that Table 5 illustrates the greater importance of pig in the diet of the inhabitants of the houses than in that of the occupants of the Round Building. I would also suggest that the low percentage of cattle bones relates to a preference on the part of the inhabitants of the Houses to keep their cattle alive for their dairy products. The relatively uniform percentages of gazelle in the excavated loci may indicate that this animal was equally available to all residents of Razuk.

The distribution of gazelle bones deserves some further discussion; it seems to share features with that of the larger animals (onager, cattle), being most numerous in the Entry Room and Court (Table 2). In terms of relative percentages, however, (Table 5), gazelle is fairly evenly distributed throughout the Round Building, with a slightly higher value in the West Room. This pattern is similar to that for pig, which also has a fairly even distribution except in the West Room, where it approaches 12 percent (Table 5). It should be noted that in the West Room (Table 8) gazelle bones were overwhelmingly from Level VIA, while pig bones were mainly from Level IV. The significance of this difference is that the gazelle bones came from the time when the Round Building was functioning at its best, while the pig specimens were mostly from Level IV, when the Round Building ceased being a fortress and became merely a residence. The West Room, rebuilt with upright walls, seems to have served as the main room of the structure at that time (Gibson 1981: 61).

Table 14 gives the numbers and percentages of pig bones in the Round Building by level. The figures for Levels VIA and IV are almost identical and might be thought to imply that Level IV did not present a different picture. But when one compares these figures with the number of all bones (Table 13) found in each level of the Round Building, the shift to pig becomes more apparent. In Level VIA the total number of bones is 246, with pig amounting to 18. Level IV yielded only 116 bones, of which 19 were pig. Thus the relative frequency of pig bones in Level IV (16.4%) is much greater than in Level VIA (7.3%). The figures for Level VA (84 total, 13 pig=15.5%)) are not much lower, however, perhaps implying that the changes in the function of the Round Building were underway already by that stratum.

The predominance of the Entry Room and the Court (Tables 6-7) as the loci with the greatest numbers of large animal bones (onager, cattle) may reflect cooking procedures. A large part of the meat from these animals can be cut from the bones for primary cooking, and the bones can then be used for secondary purposes, such as soups, stews, and so forth. The bones, once most of the meat had been removed, may have served as a basic component of the diet of the cooks and servants and many were discarded, as a result, in their loci of activity.

The fact that pig was the second most important species in the Houses (Table 12) may be related to the idea of a difference between the occupants of the Round Building (a garrison) and the town. But could this difference have resulted from the occupation of the Round Building not by a garrison but by a local lord?

One can make a case for the Round Building's being the stronghold of one of a number of small rulers to the north and east of the Hamrin Ridge, facing an enemy to the south (the Diyala kingdoms), rather than as a outlying point in a system of defence built by a southern kingdom to protect access to the vital waters of the Diyala and the Narin. However, I have argued (1986: 473) against the interpretation of the Round Building as the seat of a local lord, partly because the architecture of the building was too sophisticated to have been the work even of an important tribal chief or a minor prince. The results of neutron activation analysis (Thuesen and Heydorn, this volume) tend to indicate that the pottery at Razuk and other Hamrin sites is related to that in the Diyala, implying a dependence on that region that I propose was political as well as economic.

I would add that Razuk was unlikely to have been the seat of a minor king because it was contemporary, for a time, with Suleimeh, arguably the most important Hamrin center, as well as other fortresses (Gubba, Yelkhi?, Abqa?). I do not think that a marginal area such as the Hamrin Basin, even with a more productive environment than that of recent times, could have supported several local rulers. It could, however, have sustained a number of tribally organized settlements, with chiefs or headmen possessing various degrees of real power. But I doubt that even a paramount chief could have afforded to hire an architect and builders capable of planning and erecting the Round Building.

Although the exposure of private houses at Razuk was limited, it is clear that the consumption of meat was overwhelmingly the privilege of those persons occupying the Round Building. It is unlikely, in my opinion, that on the level of social organization possible in the ancient Hamrin, a chief would have been so conspicuous a consumer. He would have been living within a settlement consisting of his own kinsmen, whose loyalties he must keep through the sharing out of tribal goods.

I can envision, however, one situation in which a local chief could have occupied the Round Building. Intervention by an outside power would change the traditional role and status of a local chief (Gibson 1974, following Rosenfeld 1965). In being treated by an outside ruler as if he had real power, the local chief would attain real power, instead of remaining merely a concensus figure with prestige. If the chief gathered around himself, or were provided with, a body of men who would be loyal only to him and not his tribal group, he could violate traditional modes of behavior with impunity. This body of retainers would have consisted of remnants of other tribal groups, outcasts, slaves, or other persons outside the local kin-based system. The chief, in this case, no longer would have been acting as a chief but instead as a non-kin-based ruler. In short, though still probably calling himself a chief and proclaiming that he was representing his kinsmen, he would be acting in a similar manner to an outside military leader with a garrison.

A kingdom outside the Hamrin could very well have incorporated one or more local chiefs into their system of frontier administration; and such a person, with his nuclear family and retainers, could have occupied the Round Building, ruling over his own kinsmen as a vassal of a more powerful ruler. An outside power might send the transformed chief a bolstering force. It might also send him an architect or, more likely, a team including expert bricklayers to construct the fortress, with his local people as labor. In any variation on this model, the Round Building would have exhibited in its artifactual distribution a pattern different from that in the Houses.

We can bring to bear on the question of the nature of the Round Building's occupants the evidence noted by Boessneck (1987) of a contrasting distribution of cattle and pig between Early Dynastic Razuk and Akkadian Tepe al-Atiqeh. At Tepe al-Atiqeh, we excavated a large house with rectangular rooms in each of two levels. Each of these houses appeared to be more substantial than a normal house and would be closer, in my conception, to the residence of a chief or local lord than the Round Building would be, since it would be much easier to build and maintain. How does the faunal sample in these Tepe-al-Atiqeh houses compare to that in the Round Building and in the Houses at Razuk?

Boessneck (1987: Table 2, our Table 1) noted that when comparing numbers of specimens, cattle (10%) and pig (11%) had similar percentages at Razuk, but at Tepe al-Atiqeh cattle (3.9%) and pig (16.3%) differed. At Razuk, sheep/goat (37.7%) were considerably less important than at Tepe al-Atiqeh (57.4%), as were pigs. On the other hand, equids at Razuk (35.5%) were far more important than at Atiqeh (16.1%). These are, taken as a whole, sharply contrasting patterns. But, if one compares the Atiqeh figures with the faunal remains in only the Round Building or only the Houses at Razuk, different and revealing patterns emerge.

In the comparison of the Atiqeh sample (Table 15, total of 460) with the finds in the Round Building alone (total 655), Boessneck's statement holds; there are large differences between percentages of each species found at each site, with the exception of gazelle, the distributions of which are relatively similar. In this comparison, sheep/goat and pig seem considerably more important in the diet of Atiqeh than of Razuk. If we compare only the total of bones (56, admittedly a small sample) found in the Houses at Razuk with the bones from the much grander houses at Tepe al-Atiqeh (460), the similarity between percentages of species is much closer (Table 15). Equid, sheep/goat, cattle and gazelle have comparable percentages in both the Razuk Houses and the houses at Atiqeh. Only the pig percentages are much different, with Razuk Houses showing 23.2 percent while Atiqeh has 16.3 percent. These figures for pig are the opposite of the result using the sample from Razuk as a whole.

I would suggest that the the kinds and relative percentages of most animals being consumed by the ordinary townspeople at Early Dynastic Razuk were

not very different from those in the more impressively built rectangular houses at Akkadian Tepe al-Atiqeh. The drop in the percentage of pig being consumed in the buildings at Atiqeh, when compared to the Houses at Razuk, may indicate merely a change in dietary preference with time. But I would suggest that the existence of the Round Building at Razuk distorted the normal diet of the townspeople there and made them more reliant on pig than they would have been otherwise.

In contrast to the situation with pig, I would like to call attention, once more, to the high percentage of equid remains (mostly onager) in the Round Building at Razuk (Table 15). The lower and comparable percentages of equids found at Atiqeh and in the Houses at Razuk are, in my view, the normal pattern for consumption of this hunted animal by local people.

The relatively less important percentage of sheep/goat in the Round Building (Table 15), when compared to the Houses at Razuk and the buildings at Atiqeh, argues for a significant difference between the local people and the occupants of the Round Building. Sheep is today, and probably was in most ancient periods, the meat of preference. If a local ruler or chief resided in the Round Building, I would expect more sheep/goat than onager to have been consumed there. Such a dependence on onager suggests to me the provisioning of troops.

In summary, I see the evidence of the faunal remains at Razuk as indicating a marked difference between the occupants of the Round Building and those of the Houses. Given the resource limitations of the Hamrin, even if it were a somewhat better drained basin than it has been in recent history, I cannot see its potential for supporting a number of local rulers, any two or three of whom would have been obliged to construct elaborate fortified centers at any given time during Early Dynastic I-II.

The Round Building at Razuk, like its counterparts elsewhere in the Hamrin, is best seen as a stronghold manned by a garrison, positioned on the frontier of some larger political entity, and fed in part either by hunters under contract or by the garrison itself. The infusion of supplies, at least in the form of grains and weapons, from a power outside the Basin would seem necessary to sustain the set of fortifications evidenced in the Hamrin.

There is a question of where the "outside power" lay. I have assumed that the Diyala Region, specifically Eshnunna, is the most likely candidate for this role. The pottery analyses tend to support this assumption. There is a possibility that to the northeast (toward Kirkuk) there may have existed a heretofore unexcavated and unappreciated center of power that maintained the Hamrin fortresses as a frontier against the Diyala and other southern kingdoms. Lacking evidence of such a new power center, however, it is more reasonable to assume that Razuk and the other sites in the Hamrin depended on Eshnunna or another southern center.

Bibliography

Boessneck, J.

1987 Tierknochenfunde vom Uch Tepe. *Acta Praehistorica et Archaeologia* 19: 131-63.

Forest, J.-D.

1982 Review: Uch Tepe I. *Paléorient* 8/2: 113-15.

Gibson, M.

1974 Violation of Fallow and Engineered Disaster in Mesopotamian Civilization. In T. E. Downing and M. Gibson, (Eds.) *Irrigation's Impact on Society*. Tucson.

1981 (Ed.) *Uch Tepe I*. Chicago and Copenhagen.

1986 The Round Building at Razuk: Form and Function. In J.-L. Huot, *Préhistoire de la Mésopotamie*. Paris. Pp. 467-74.

Rosenfeld, H.

1965 The Social Composition of the Military in the Process of State Formation in the Arabian Desert. *Journal of the Royal Anthropological Institute of Great Britain and Ireland* 91: 75-86, 174-93.

Table 1.

Percentages of species in total mammal sample (927) from Early Dynastic Razuk and Akkadian Tepe al-Atiqeh (adapted from Boessneck 1987: Tab. 2)

	Razuk		Atiqeh
Equid	35.5		16.1
Sheep	17.3	}	
Sheep or goat	16.7	} 37.7	57.4
Goat	3.7	}	
Cattle	11.1		3.9
Pig	10.0		16.3
Gazelle	5.3		6.3
Other	0.3		
	100.0		100.0

Table 2.

Number of specimens of mammalian species at Razuk, by findspot in levels related to RB (IV-VIA)

	Eq.	Sh.	Sh/Gt.	Gt.	Catt.	Pig	Gaz.	Other	Totals
Entry	146	27	70 34	9	25	25	17	1	284
Court	67	27	50 18	5	32	16	12	1	178
W.Rm.	28	25	54 20	9	6	13	8	—	109
S.Rm.	—	22	34 10	2	—	2	—	—	36
Stair	18	10	20 9	1	8	4	—	—	50
Corr./Space	34	31	77 39	7	25	15	5	—	156
Houses	8	12	29 14	3	3	13	3	1	57
Totals	301	154	344 144	36	99	88	45	3	870

Table 3.

Numbers and percentages of mammalian bones by species from RB, the Corridor including space outside the doorway, and Houses. Levels IV-VIA. (Omitting "other" = two hyena and one cat).

	Eq.		Sh./gt.		Catt.		Pig		Gazz.	
	n	%	n	%	n	%	n	%	n	%
RB	259	86.0	228	68.3	71	71.7	60	68.2	37	82.2
Corr./space	34	11.3	77	23.0	25	25.3	15	17.0	5	11.1
Houses	8	2.7	29	8.7	3	3.0	13	14.8	3	6.7
	301	100.0	334	100.0	99	100.0	88	100.0	45	100.0

Total Number 867

Table 4.

Percentages of species of mammals from each locus during life of RB, Levels IV-VIB.

	Equid	Sh./gt.	Catt.	Pig	Gaz.	Other
Entry	48.5	26.9	25.3	28.4	37.8	33.3
Court	22.3	15.0	32.3	18.2	26.7	33.3
W. Rm.	9.3	16.2	6.0	14.8	17.8	—
S. Rm.	—	10.2	—	2.3	—	—
Stair	6.0	6.0	8.1	4.5	—	—
Corr./space	11.3	23.0	25.3	17.0	11.1	—
Houses	2.7	8.7	3.0	14.8	6.6	33.3
	100.0	100.0	100.0	100.0	100.0	100.0

Table 5.

Relative percentage of species within each locus.

	Entry	Court	West	South	Stair	Corr./Sp.	Houses
Equid	51.4	37.6	25.7	—	36.0	21.8	14.0
Sh/gt.	24.6	28.1	49.5	94.4	40.0	49.4	50.8
Catt.	8.8	18.0	5.5	—	16.0	16.0	5.3
Pig	8.8	9.0	11.9	5.6	8.0	9.6	22.8
Gaz.	6.0	6.7	7.4	—	—	3.2	5.3
Other	0.4	0.6	—	—	—	—	1.8
	100.0	100.0	100.0	100.0	100.0	100.0	100.0

Table 6.

Number of bones of each mammalian species in Entry Room, by level, and totals and percentages in each level.

	Equid	Sh.	Sh/gt.	Gt.	Catt.	Pig	Gaz.	Other	Totals	%
Level										
IV	12	5	12	2	7	5	2	—	45	15.8
VA	10	—	1	—	3	3	—	—	17	6.0
VA-B	5	2	—	—	1	—	1	—	9	3.2
VB	8	—	1	—	6	2	2	—	19	6.7
VIA	102	19	19	7	8	14	12	1	182	64.1
VIB	9	1	1	—	—	1	—	—	12	4.2
	146	27	34	9	25	25	17	1	284	100.0

Table 7.

Number of bones of each mammalian species in Court by level, and totals and percentages in each level.

	Equid	Sh.	Sh/Gt.	Gt.	Catt.	Pig	Gaz.	Other	Totals	%
Level										
IV	7	8	7	2	—	5	4	—	33	18.5
VA	9	9	2	—	3	8	—	—	31	17.4
VB	—	—	3	—	—	—	1	—	4	2.2
VIA	10	3	1	—	3	2	3	—	22	12.4
VIA-B	29	6	2	—	14	1	3	1	56	31.5
VIB	12	1	3	3	12	—	1	—	32	18.0
	67	27	18	5	32	16	12	1	178	100.0

Table 8.

Number of bones of each mammalian species in West Room by level, and totals and percentages in each level.

	Equid	Sh.	Sh/Gt.	Gt.	Catt.	Pig	Gaz.	Other	Totals	%
Level										
IV	7	11	5	3	3	9	—	—	38	34.9
VA	—	—	—	—	—	—	—	—	—	—
VB	7	9	7	2	1	2	1	—	29	26.6
VIA	14	5	8	4	2	2	7	—	42	38.5
VIB	—	—	—	—	—	—	—	—	—	—
	28	25	20	9	6	13	8	—	109	100.0

Table 9.

Number of bones of mammalian species in South Room by level, and totals and percentages in each level.

	Equid	Sh.	Sh/gt.	Gt.	Catt.	Pig	Gaz.	Other	Totals	%
Level										
IV	—	—	—	—	—	—	—	—	—	—
VA	—	22	10	2	—	2	—	—	36	100
VB	—	—	—	—	—	—	—	—	—	—
VIA	—	—	—	—	—	—	—	—	—	—
VIB	—	—	—	—	—	—	—	—	—	—
	—	22	10	2	—	2	—	—	36	100

Table 10.

Number of bones of mammalian species in Stair by level, and totals and percentages in each level.

	Equid	Sh.	Sh./Gt.	Gt.	Catt.	Pig	Gaz.	Other	Totals	%
Level										
IV	—	—	—	—	—	—	—	—	—	—
VA	—	—	—	—	—	—	—	—	—	—
VB	6	7	6	—	3	—	—	—	22	44.0
VIA	—	—	—	—	—	—	—	—	—	—
VIA-B	10	3	3	1	5	3	—	—	25	50.0
VIB	2	—	—	—	—	1	—	—	3	6.0
	18	10	9	1	8	4	—	—	50	100.0

Table 11.

Number of bones of mammalian fauna in Corridor/Space in front of Entry Door by level, and totals and percentages in each level.

	Equid	Sh.	Sh/gt.	Gt.	Catt.	Pig	Gaz.	Other	Totals	%
Level										
IV	2	3	5	3	—	6	1	—	20	12.8
VA	1	5	5	2	—	4	1	—	18	11.5
VB	7	3	3	1	2	—	—	—	16	10.3
VIA	8	10	14	—	7	2	2	—	43	27.6
VIB	16	10	12	1	16	3	1	—	59	37.8
	34	31	39	7	25	15	5	—	156	100.0

Table 12.

Number of bones of mammalian fauna in Houses by level, and totals and percentages in each level.

	Equid	Sh.	Sh/gt.	Gt.	Catt.	Pig	Gaz.	Other	Totals	%
Level										
IV	3	1	3	—	—	2	—	—	9	15.8
VA	—	—	—	—	—	1	—	—	1	1.8
VB	4	9	10	3	2	9	2	1	40	70.1
VIA	1	2	1	—	1	1	1	—	7	12.3
VIB	—	—	—	—	—	—	—	—	—	—
	8	12	14	3	3	13	3	1	57	100.0

Table 13.

Total number of mammal bones in Round Building by Locus and Level.

	Entry	Court	West R.	South R.	Stair	Totals
Level						
IV	45	33	38	—	—	116
VA	17	31	—	36	—	84
VA-B	9	—	—	—	—	9
VB	19	4	29	—	22	74
VIA	182	22	42	—	—	246
VIA-B	—	56	—	—	25	81
VIB	12	32	—	—	3	47
	284	178	109	36	50	657

Table 14.

Number and Percentage of pig bones in RB by level.

Level	n	%
IV	19	31.7
VA	13	21.6
VB	4	6.7
VIA	18	30.0
VIA-B	4	6.7
VIB	2	3.3
	60	100.0

Table 15.

Comparison of numbers and percentages of mammalian bones from Atiqeh with the samples from the Round Building and the Houses at Razuk. (Omitting "other" = 2 from RB, 1 from Houses).

	Equid	Sh/gt.	Catt.	Pig	Gazz.	Totals
	n %	n %	n %	n %	n %	n %
RB	259=39.5	228=34.8	71=10.8	60= 9.2	37=5.7	655=100
Atiq.	74=16.1	264=57.4	18= 3.9	75=16.3	29=6.3	460=100
Rz. Hs.	8=14.2	29=51.8	3= 5.4	13=23.2	3=5.4	56=100

APPENDIX A
Catalogue of Pottery and Clay Samples Analyzed

The Hamrin Basin

Tell Razuk, Ancient Clay[1]

0011-
0013 natural clay

Uch Tepe Village, Natural clay

0053-
0065 natural clay from pit outside village

Tell Razuk, Early Dynastic Pottery

NO	WARE	SLIP	TYPE[2]	POS[3]	THICK[4]	DIAM[8]	PROV[6]	STR[7]	PL[8]
0101	buff	-	11b	rim	4	110	1.47 fl.3-6	V	III.1
0120	buff	-	6b	shoulder	5	100	1.49 fl.8	VB	III.16
0121	buff	-	6a	neck	8	70	1.47 fl.5	VB	III.22
0130	buff	-	8	shoulder	9	90	1.49 fl.7	VB	III.14
0140 0141 0142	buff	-	15a	shoulder	8	160	1.47 fl.5	V	
0143	buff	+	15a	shoulder	5	100	1.16 fl.3-8	VA	III.9
0144	buff	-	15b	shoulder	7	90	1.47 fl.6	VB	III.8
0150	buff	-	15b	shoulder fl.5	8	100	1.23	VB	III.7
0160	buff	-	5c	shoulder	5	70	1.49 fl.2	VA	III.11
0170	buff	-	13f	stand	13	120	1.403 fl.1d	III	III.28
0180	buff coarse	-	12a	rim	20	120	1.47 fl.2-3	IV-VA	III.27

1. Sample from clay deposit underneith round building.
2. For type codes see Thuesen 1981.
3. Sample position on vessel.
4. Thickness of sherd in mm.
5. Sherd size measured on diameter chart.
6. Provenience: l.: locus; fl.: floor.
7. Stratum.
8. See pages 127-130.

0181	buff coarse	-	-	body	16	110	1.52	I	
0190	buff	+	11b	body	6	100	1.50	I	III.3
0201	pink	-	1a	base	8	80	1.47 fl.2-3	IV-VA	
0202	pink	-	3	body	5	90	1.47 fl.3-6	V	III.24
0210	pink	-	7	neck	6	80	1.54 fl.2	VIA	III.20
0220	pink	-	6a	rim	11	80	1.8 fl.5-6	VB	III.19
0230	pink	-	8	shoulder	8	120	1.49 fl.4	VB	III.15
0231	pink	-	8	shoulder	10	100	1.54 fl.2	VIA	
0260	pink	+	5a	neck	6	100	1.54 fl.1	VB	III.12
0261	pink	+	5a	neck	6	110	1.47 fl.2-3	IV-VA	III.5
0262 0263 0264	pink	-	5a	rim shoulder body	6	100	1.33 fl.5	TW	III.10
0270	pink	-	15c	handle	35	100	1.49 fl.6	VB	III.26
0280	pink	-	11b	body	7	80	1.69	II	III.2
0301 0302 0303	green	-	1	rim body base	6-8	120	1.47 fl.4	VB	III.23
0304	green	-	I	body	7	100	1.49 fl.8	VB	III.25
0320	green	-	6a	neck	10	140	1.79 fl.1	IV	III.17
0321	green	-	6a	neck	8	110	1.47 fl.2-3	IV	III.18
0322	green	-	6a	shoulder	8	120	1.404 fl.1	IV	III.21
0350	green	-	15b	spout	9	130	1.49 fl.6	VB	III.6
0360	green	-	5a	shoulder	9	120	1.478 fl.2-3	IV	III.13
0361	green	-	5a	shoulder	5	80	1.5 fl.3-4	VB	III.4
0362	green	-	5a	body	6	140	1.5 fl.3-4	VB	
0410 0411 0412	gray	-	7	body	5	110	1.47 fl.4	VB	IV.9
0413	gray	-	7	body	5	60	1.49	VB	IV.7

							fl.8		
0414	gray	-	7	shoulder	5	80	1.79	IV	IV.6
							fl.1		
0415	gray	-	7	shoulder	6	100	1.23	VB	IV.8
							fl.5		
0416	gray	-	7	shoulder	6	40	1.49	VB	IV.3
							fl.8		
0417	gray	-	7	body	5	80	1.421	VA	IV.5
							fl.1		
0418	gray	-	7	neck	5	70	1.23	VB	IV.1
							fl.1.		
0419	gray	-	7	base	6	110	1.403	III	
							fl.1d		
0480	gray	-	7	base	6	50	1.57	IV	IV.2
							fl.1		
0481	gray	-	7	shoulder	5	80	1.44	II	IV.4
							fl.1		
0510	scarlet	-	7	neck	7	100	1.49	VB	IV.13
				buff			f1.6		
0511	scarlet	+	7	body	6	60	1.49	VB	IV.12
				buff			f1.6		
0512	scarlet		7	body	5	60	1.47	VB	IV.15
				buff			f1.5		
0513	scarlet	-	7	body	7	100	1.421	VB	IV.16
				buff			f1.1		
0514									
0515	scarlet	-	7	body	6-	110	1.48	VIA	IV.10
0516	buff			shoulder	10		fl.2		
0517	scarlet	-	7	body	8	80	1.34	VB	IV.19
	buff						fl.1		
0518	scarlet	-	7	shoulder	8	100	1.52	I	VI.11
	buff						pit		II
0519	scarlet	-	7	neck	6	60	1.49	VA	
	pink						f1.2		
0540	scarlet	-	7	shoulder	9	70	1.47	VB	IV.17
						fl.6			
0541	scarlet	+	7	body	6	50	1.5	VA	IV.18
	pink						f1.1		
0542	scarlet	+	7	neck	8	70	1.23	VB	IV.14
	green						f1.5		
0580	scarlet	+	?	shoulder	8	110	1.89	I	II
	buff							pit	
0583	scarlet	-	?	body	8	60	1.34	VB	
	pink						fl.4		

Modern Pottery, Uch tepe Village

0900								
0901	coarse	-	?	body	13	70-130	village	Fig.3 p.68
0902	green							

Tell Madhhur, Early Dynastic Pottery

NO	WARE	SLIP	TYPE	POS	THICK	DIAM	ID.NO.	STR	
1640	scarlet buff	+	?	shoulder	8	70	TM7503		IV.21
1680	scarlet pink	+	?	body	7	65	TM6503.		IV.27
1681	scarlet buff	+	?	body?	8	55	TM8503		IV.29
1682	scarlet pink	+	?	base	7	120	TM8503		IV.26
1683	scarlet buff	+	?	shoulder	7	100	TM8503		IV.25
1684	scarlet buff	-	?	shoulder	8	100	TM8503		IV.24
1685									
1686	scarlet	-	?	body	6	170	TM5649		IV.20
1687	buff								II
1688	scarlet buff	+	?	shoulder	6	90	TM5679		IV.22
1689	scarlet buff	+	?	body	4	70	TM6501		IV.28
1690	scarlet buff		?	shoulder	6	100	TM7535		IV.23

Tell Gubba, Early Dynastic Pottery

NO	WARE	SLIP	TYPE	POS	THICK	DIAM	PROV	STR	PL
2810	scarlet	+	7	neck	6	80	VII-VIII	IV	V.1
2811	buff						13-14		
2880	scarlet buff	+	?	shoulder	7	80	VIII 10	V	V.2
2881	scarlet buff	+	?	base	6	90	VII-VIII 13-14	IV	V.3

Kheit Qasim, cemetery, Early Dynastic Pottery

NO	WARE	SLIP	TYPE	POS	THICK	DIAM	PROV	STR	PL
3710	scarlet buff	-	7	rim	6	50			
3780	scarlet buff	+	?	?	7	80			
3781	scarlet buff	+	?	?	11	80			
3782	scarlet buff	-	?	?	7	70			
3783	scarlet buff	-	?	?	6	50			
3784	scarlet buff	-	?	?	6	50			

The Lower Diyala Region

Khafajah, Early Dynastic Pottery

NO	WARE	SLIP	TYPE	POS	THICK	DIAM	PROV	ID.NO.	PL
4580									
4581	scarlet	+	?	body	9	180	KhIII	A21287	V.10
4582	buff						592		
4583	scarlet	+	?	body	7	90	KhV	A21309	V.12
	buff						186		

Tell Asmar, Early Dynastic Pottery

NO	WARE	SLIP	TYPE	POS	THICK	DIAM	PROV	ID.NO.	PL
4584	scarlet	+	?	body	9	180	As34	A17191	V.4
	pink						225a		
4585	scarlet	+	?	shoulder	9	60	As33	A17204	V.7
	pink						531		
4586	scarlet	+	?	body	9	60	As34	A17129	V.8
	pink						225f		
4587	scarlet	+	?	shoulder	8	110	As34	A17173	V.5
	buff						129		
4588	scarlet	+	?	body	9	90		A21771	V.9
	buff								
4589	scarlet	+	?	shoulder	6	50		As390	V.6
	buff								

Tell Agrab, Early Dynastic Pottery

NO	WARE	SLIP	TYPE	POS	THICK	DIAM	PROV	ID.NO.	PL
4590	scarlet	+	?	body	10	90	Ag36	A21769	V.11
	buff						525a		

The Deh Luran Plain

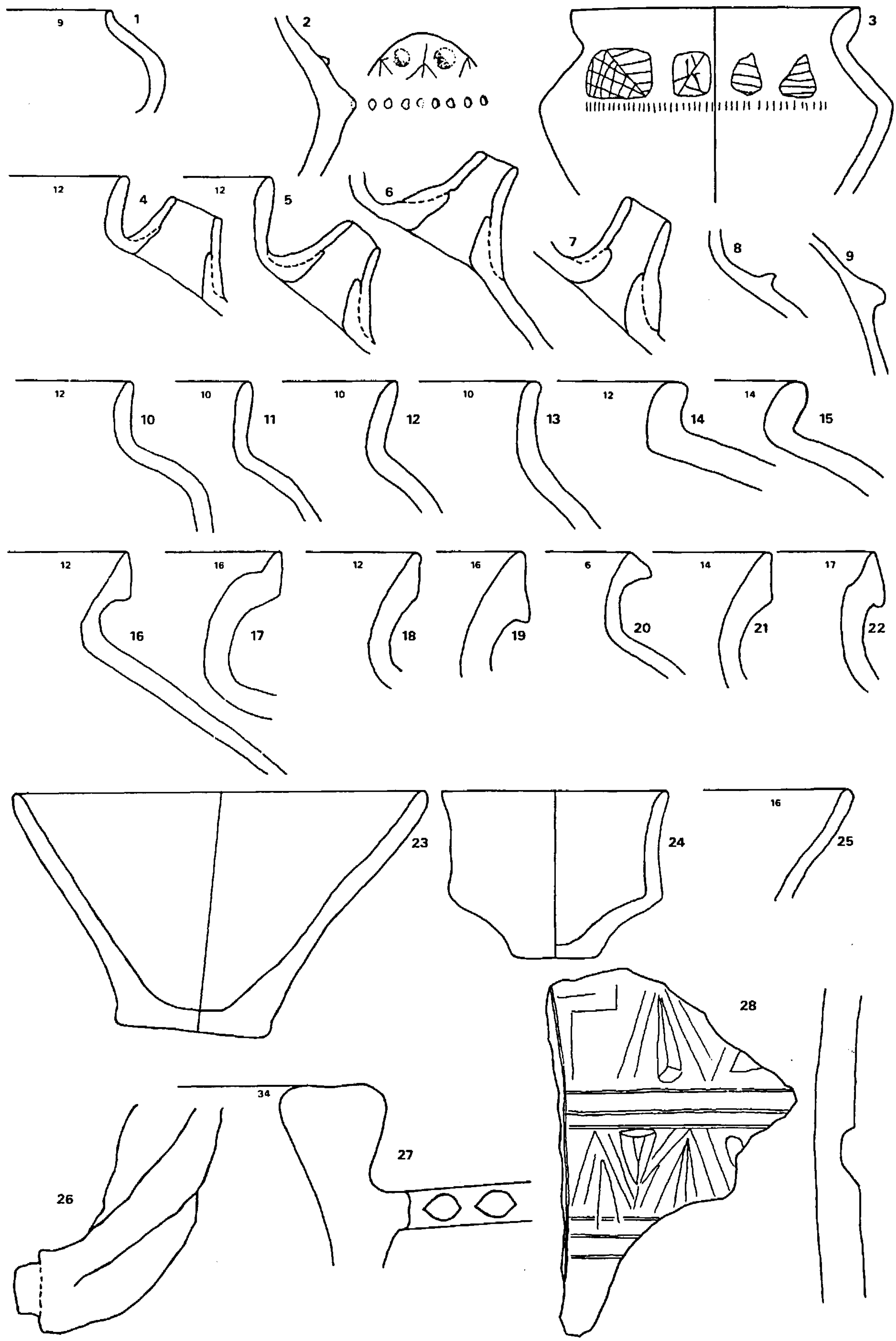
Farukhabad, Polychrome Ware

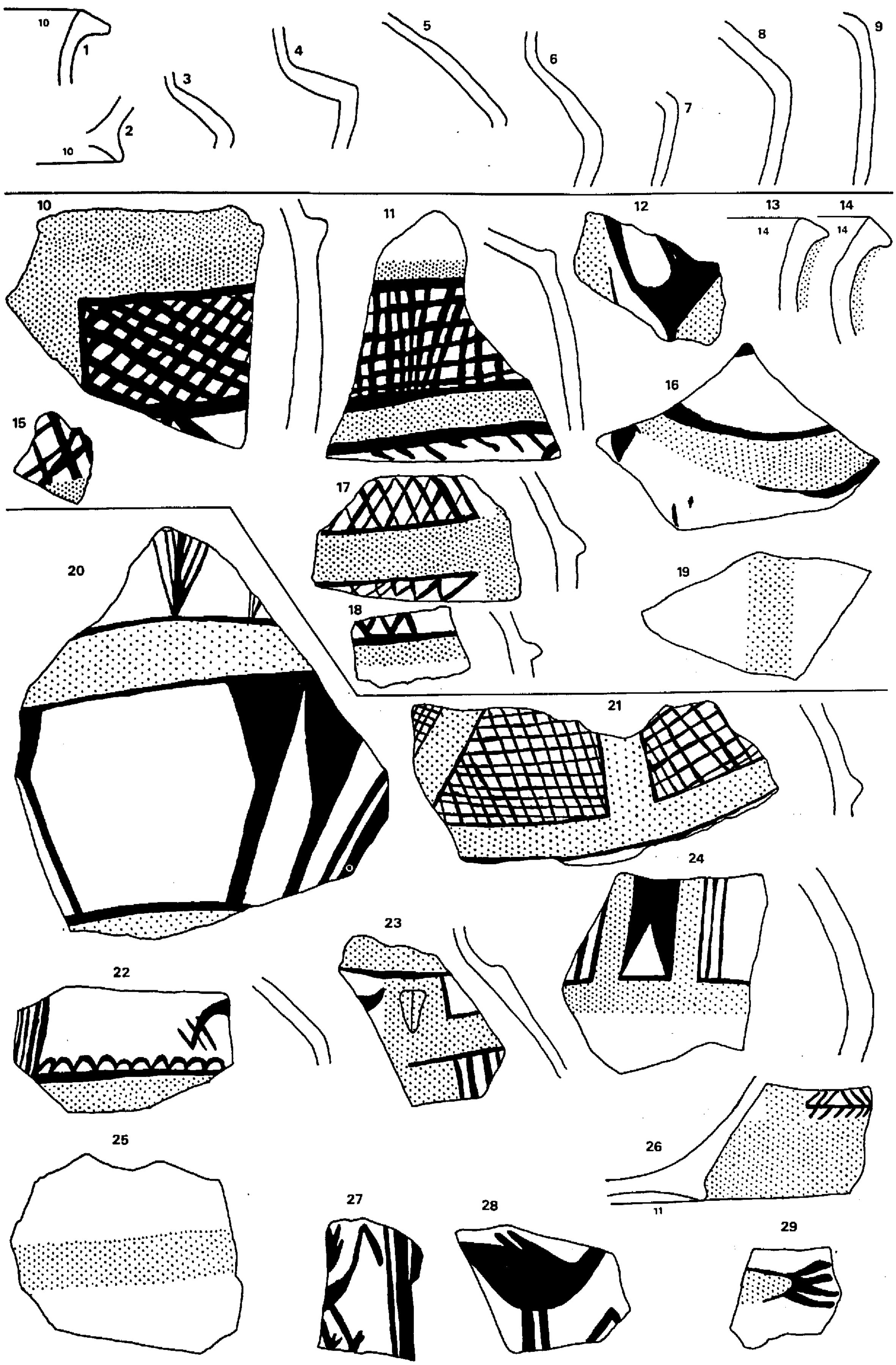
NO	WARE	SLIP	TYPE	POS	THICK	DIAM	PROV	ID.NO.	PL
5580	buff	-	?	body	12	80	Exc.A	x041	V.16
							1.1-2		
5581	buff	+	?	body	6	50	Exc.A	x041	V.15
							1.1-2		
5582	pink	+	?	body	8	70	Exc.A	x061	V.18
							1.5		
5583	buff	+	?	shoulder	8	70	Exc.A	x064	V.19
							1.5b		
5584	buff	+	?	shoulder	9	50	Exc.B	x131	V.13
							1.20		
5585	buff	+	?	?	6	60	Exc.B	x131	V.14
							1.20		
5586									
5587	pink	?	?	?	6	80	Exc.A	x069	V.17
5588							1.6		

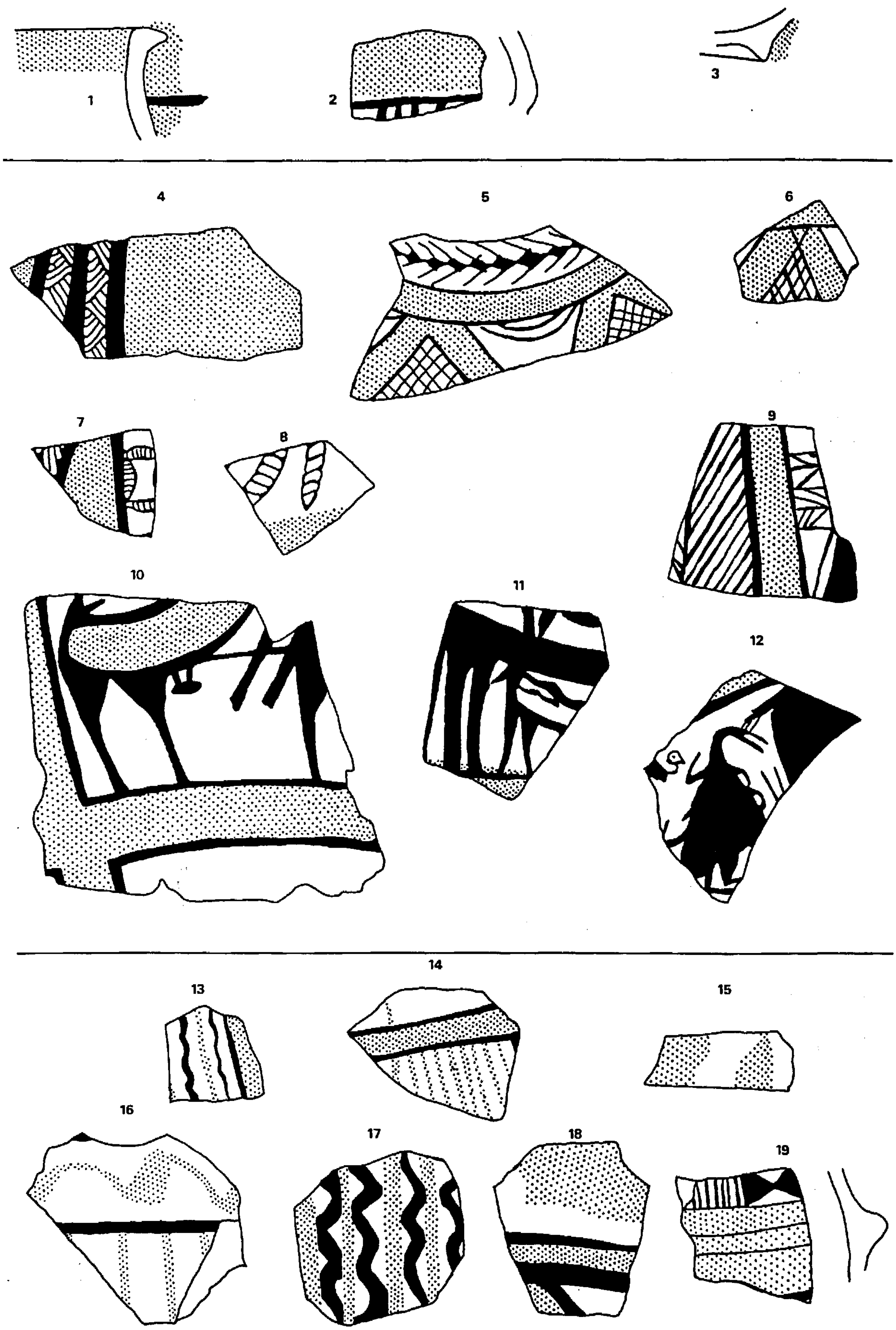
The Round Building near the end of the excavation. Looking south-east.

Pl. I

Scarlet Ware sherds from Tell Razuk and Tell Madhhur
Upper left: **0580** *Upper right:* **0518** *Lower:* **1585-87**


9
1
2
3
12
4
12
5
6
7
8
9
12
10
10
11
10
12
10
13
12
14
14
15
12
16
16
17
12
18
16
19
6
20
14
21
17
22
23
24
16
25
34
26
27
28


1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22
23
24
25
26
27
28
29


1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19

APPENDIX B
Complete list of Faunal Specimens from Uch Tepe

Joachim Boessneck

Editors Note:

In the Nippur recording system, used at Uch Tepe, lot numbers are numbers given to objects or a group of similar objects (e.g. sherds, animal bones) as they are being excavated. Most items are processed in the field and discarded, meaning that they never receive more than a lot number. Some objects may receive catalogue numbers if judged of sufficient quality to be turned over to the Iraq Museum. In the case of faunal samples, almost never is anything given a catalogue number. After initial light cleaning, the lots of bones are packed and shipped to Prof. Boessneck where he analyzes them and incorporates them into his study collection at the Institute für Palaeoanatomie, Domesticationsforschung und Geschichte der Tiermedizin, University of Munich. Boessneck has already published a report on the Uch Tepe material (1987), including the samples from Tepe al-Atiqeh and Ahmed al-Mughir. In that publication and in this one, some lot numbers have an asterisk (*) behind them. This is to indicate that these lots were collected in the second season of work at Uch Tepe, not in the first season.

In the following list, the descriptions include information on the locus and the floor on which or above which the lot was collected (e.g. 455, 1 = Locus 455, Fl. 1). Each locus is given a short description, e.g. West Room, which can be related to the plans in the first Uch Tepe report (Gibson 1981: esp. Pl. 10 reproduced here, p. 96, Fig. 1).

RB = Round Building at Razuk
Entry Room = room between the entrance and the court in RB; this room also served as a kitchen.
Court = Courtyard of the Round Building
South Room = room to the south of the court in RB
East Room = room to the east of the court in RB
Space outside dr. = Locus 479 and other loci directly outside the only door to the RB
Corridor = narrow space around the outside of the RB, separating it from the houses; excavated on the west, southwest, and the north.
Houses = houses to the west, northwest, and north of the RB, mainly to the west.
Town Wall Trench = a trench at the western edge of Razuk intended to define the town wall.
Akkadian Burial = Burial 12 at Razuk, intrusive into RB.
Above RB = levels III, II, and I, all above the top of the RB. Level III consisted of large pits, datable to ED II, as far as could be ascertained. Level II was a set of rectilinear walls, perhaps again a large building (not round) with houses around it, datable still to the Early Dynastic, apparently II. Level I was a mix of Akkadian burials, Islamic burials, and modern burials.

Abkürzungen

'	= Bruchstück
Acet	= Acetabulum
ad	= adult
ant	= anterior
Atl	= Atlas
Bwb	= Brustwirbel
C	= Carpale
Calc	= Calcaneus
Corp	= Corpus
Ct	= Os centrotarsale (=centroquartale)
dist	= distal (Distalende)
Epistr	= Epistropheus
Fe	= Femur
Hu	= Humerus
Hwb	= Halswirbel
Hz	= Hornzapfen

Indet = unbestimmt
inf = inferior
juv = juvenil
Lwb = Lendenwirbel
M = Molar
Mand = Mandibula
Max = Maxilla
Mc = Metacarpus
Mt = Metatarsus
Ncr = Neurocranium
P = Praemolar
Pe = Pelvis
Phal = Phalanx
post = posterior
prox = proximal (Proximalende)
Ra = Radius
Ri = Rippe
Scap = Scapula
sup = superior
S/Z = Schaf oder Ziege
Tal = Talus
Tc = Os tarsi centrale
Ti = Tibia
Ul = Ulna
Vcr = Viscerocranium

Tell Razuk

Lot 57*, Locus 453, 1. ? City Wall Trench.
Esel: Phal 2 post
Indet: Röhrenknochenwandstück (Equide oder Rind)

Lot 62*,Locus 455, 6. VIA. RB. Court.
Onager: P inf; Atl; Hu'; Ra'; 2 Pe''; Ti-Corp'; Tal'; Calc; Phal 1 ant
Rind: Mc, dist; Tal; Mt-Corp
Schaf: Kalotte ♀ , unbehornt; Scap'; Mt, dist
S/Z: Orbita'
Gazelle: Hz; Kalotte mit Hz; Fe-Corp'
Schwein: 2 Mand

Lot 67, Locus 4, 1. II. Above RB.
Schaf: Epistr ♂
S/Z: Ra, prox; Ul'
Ziege: Hu-Corp
Schwein: Kalotte', juv; Hu, dist; Ra-Corp

Lot 73,Locus 5, 1. VA. Corridor.
Schaf: Hu, dist; Tal

Lot 83, Locus 11, 1-2. III. Above RB, pit.
Onager, Atl; Hwb'

Lot 94*, Locus 415. I. Burial 12. Early Akkadian.
Onager: 6 Schwanzwirbel; Ra'; Mc, prox (Esel?); Fe'
Rind: Phal 1 post
Schaf: Hu'; 2 Ra-Corp; Mc, dist; Ti-Corp.
S/Z : M^3; M_3; Scap', Lamm
Gazelle: Bwb'
Schwein: 3 Ncr''

Lot 95*, Locus 455, 7-12. VIB. RB.Court.
Onager: P/M sup; Fe, prox; Fe, dist; Ti', juv; Ph 1 ant; Ph 2 ant
Rind: Max'; Epistr; 2 Scap''
Ziege: Pe ♀
Gazelle: Lwb

Lot 114*, Locus 48, 3. VIB.Corridor.
Onager: M/P sup; Mand', juv; Bwb-Corp; 2 Ri''; Fe, prox'
Rind: Hwb; 2 Pe''; Ul'
Schaf: Hu, dist; Mc-Corp; Pe ; 2 Fe-Capita; Ti, Tal, Calc und Mt, ad, zusammengehörig
S/Z: 5 Mand''; Hwb'; 3 Bwb''; 3 Ri''; Ra-Corp
Gazelle: Hu, dist
Schwein: Vcr' ♀
Indet.: 2

Lot 125*, Locus 48, 2. VIA Corridor.
Onager, Phal 1 ant
Rind: Mt'
Gazelle: Ti-Corp
Schwein: Max' ♀

Lot 133*, Locus 48, 4. VIB. Corridor.
Rind Ncr ♀ ; M^3; Lwb'; Mt-Corp
S/Z: Hu'; Fe'; 2 Ti-Corp'

Lot 134*, Locus 485, l. IV. House west of RB.
Onager: M/P inf; Ti-Corp; Tc
Schaf: Ra, prox'
S/Z: M^2; 2 Mand
Schwein: Mand'; Mt III

Lot 135*, Locus 48, 4. VIB. Corridor.
Schaf: Mc; Mt-Corp

Lot 136*, Locus 47, 7. VIA. West Room.
Onager: 2 Hwb'; Ri'; Lwb'; Hu, dist; Ra, prox; 2 Ul'; 4 Fe''
Esel: M sup; p^2
Rind: Pe'

Schaf: Mc-Corp
S/Z: M^3; M_3; Hu, dist; Ra-Corp; Pc' ♂ ; Fc-Corp; Ti-Corp
Ziege: Pc ♀ ; Pc ♂ ; Tal
Gazelle: Mand'; Bwb; Hu; dist; Mc, prox
Schwein: Max, juv; Mand, juv

Lot 141*, Locus 47, 7. VIA. West Room
Ziege: Mc ♀

Lot 159*, Locus 79, 1. IV. Entry Room.
Onager: Mand, juv; Epistr; Patella
Rind: Ri'; Ra, prox
Schaf: Mt, dist
S/Z: M sup; M' inf; 2 Bwb'; Ra-Corp'; Ti'
Gazelle: Ti-Corp'
Indet: 1 (Equide oder Rind)

Lot 161*, Locus 446, 1. VA. Corridor
Onager: Calc
Schaf: Ra, prox; Pc ♂ ; Tal
S/Z: M^3; Lwb; Ra', 2 Ti-Corp.
Ziege: Hz ♀ ; Phal 1 ant
Gazelle: Ra-Corp.
Schwein: Ra, prox; Ul

Lot 162*, Locus 447, 1. VIA. Corridor.
Onager: M sup
Rind: 2 Ri"
S/Z: Mand-Condylus

Lot 168*, Locus 79.1, IV. Entry Room
Onager: Ncr'; Sacrum'; Hu-Corp; Tal; Mt-Corp; Mt, dist
Rind: C2+3; Phal 2 post
Schaf: Hu, dist; Mc-Corp; Pc ♂ ; Fe, prox
S/Z: Max; M^2; 3 Mand'; Ri'; Scap'
Ziege: Ti, dist
Gazelle: Mand; Hu-Corp
Schwein: Ncr, juv; Mand, juv; Scap, juv; Ul'; Tal

Lot 172*, Locus 96, 3-4. VA. Entry Room.
Onager: Bwb-Dornfortsatz; Ri'; Scap'; Fc'; Ti'
Indet: 1

Lot 173*, Locus 438, 1. VB. Entry Room.
Rind: M_3; Ti, lose prox. Epiphyse
Gazelle: Mand'

Lot 174*, Locus 438, 2. VB. Entry Room.
Onager: Vcr'; Bwb'; Hu, dist; Fc, dist'
Rind: Ct; Mt, prox

Lot 175*, Locus 96, 3-4. VIA. Entry Room.
Onager: Tal
Rind: Ul'
S/Z: Lwb'; Pc'
Schwein: Ncr'; Max'

Lot 177*, Locus 96, 2-4/438, 1-2. VA-B. Entry Room.
Onager: M^1; Cr; Tal; Phal 2 ant; Phal 3 ant'
Rind: Hu-Corp, juv
Schaf: Hu, dist; Ra, prox
Gazelle: Mc, dist

Lot 178*, Locus 79, 1. IV. Entry Room.
Onager: Bwb-Dornforfsatz
Rind: Ti-Corp, juv
Ziege: Tal

Lot 182*, Locus 438, 4. VB. Entry Room.
Onager: C; Pc'
Esel:; Ra, prox; Phal 1 ant
Rind: M^3; Mand'
S/Z: Mand'; Hu-Corp'
Schwein: Mand; Scap

Lot 183*, Locus 444, 2. VIA. Entry Room.
Onager: Occiput'; 2 Vcr; P^2; M/P sup; Mand; 2 Atl; 6 Bwb''; Lwb'; 2 Scap, Gelenkteile; Hu-Corp'; Hu, dist'; Ra-Corp; Ra, lose dist Epiphyse; 2 Pc'; 3 Fc''; Patella'; Ti, dist; Mt, dist; 3 Phal 1 ant; 2 Phal 1 post; Phal 2 post
Rind: M_2; Phal 1 post
Schaf: Mand; Epistr; Ilium'; Ti, dist
S/Z: 2 M_3; Ra-Corp; Ti-Corp
Ziege: Hz ♀
Gazelle: 2 Mand; Scap'; Hu, dist; Calc
Schwein: 2 Kalotten'', juv; Mand juv; Scap', juv
Hyäne: Ul'

Lot 184*, Locus 443, 2-3. VIA. Entry Room.
Onager, Fc, dist; Tc; Phal 1 ant; Phal 2 ant
Rind: Ti-Corp'
Schaf: Hu, dist; Mt, dist; Mt, dist (verbrannt)
S/Z: Ilium'

Lot 185*', Locus 444, 2-3. VIA. Entry Room
Onager: Vcr; M/P sup; 2 Mand''; M/P inf; 3 Hwb''; 2 Bwb''; 5 Ri''; Scap, Gelenkteil; Hu-Corp'; Hu, dist; 3 Ra, dist; Ul'; C_3; 3 Pe''; Fe'; 2 Ti, prox; 2 Ti, dist; 2 Tal; 3 Mt''; Mt, Nebenstrahl; Phal 3 ant
Esel: M^1; Ra und Ul, prox, Ra, dist, zusammengehörig?

Rind: Incisivus; Phal 3
Schaf: Kalotte', unbehornt, ♀ ; Ncr' ♂ ; Hz'; Epistr; Hwb; Hu, dist; Ra, prox; Ilium ♀ ; Ti, dist
S/Z: Ncr'; 2 Mand''; Hwb'; 2 Lwb'; Ul'; Pc; 2 Ti-Corp
Ziege: Kalotte' ♀ ; Ra, dist; Mt-Corp
Gazelle: Hz-ende; Fe, dist
Schwein: 2 Kalotten''; Max'; Mand'; Scap, juv; Hu, dist
Indet: 1

Lot 186*, Locus 444, 3. VIA. Entry Room.
Onager: Max'; P^2'; 2 M/P sup; Mand'; Epistr; 2 Hwb'; Bwb'; Ri'; Hu, dist; Ra, lose dist. Epiphyse (zu Lot 185 Ra, dist. passend); Pc'; Fe-Corp; Tal; 2 Mt, dist
Esel: Tal
Rind: Fe-Corp; Tal; Phal 2 ant'; Phal 2 post
Schaf: Mand; Ilium ♂ ; Ilium ♀
S/Z: 2 Mand; Bwb-Dornfortsatz; Lwb'; Pc'
Ziege: 2 Hu-Corp; Mt-Corp
Gazelle: Mand'; Hwb; 2 Ra, dist; Fe, prox
Schwein: Pc'
Indet: 1 (Ri)

Lot 188*, Locus 449, 3. VIB. Entry Room.
Onager: Epistr'; Lwb'; 3 Ri''; Hu'; Ra'; Calc'
Esel: C_3
Schaf: Mt, dist
S/Z: Fe-Corp
Schwein: Mc II

Lot 190*, Locus 444, 4. VIA. Entry Room.
Onager: Mt, prox; Phal 1 post
Schwein: Mand, juv

Lot 191*, Locus 479, 3. VIB. Space outside door to RB.
Onager: Hu'
Rind: Phal 1 post
Schaf: Ra und Ul-Corp; Tal
S/Z: Mand'

Lot 192*, Locus 479, 2. VIB. Space outside door to RB.
Onager: P^2; Hwb'; Lwb'; Mt'; Phal 3 ant
Rind: Hyoid
Schaf: Mc, dist
Schwein: Calc, juv

Lot 193*, Locus 479, 3. VIB. Space outside door to RB.
Rind: 3 Mand'
Schwein: Scap'

Lot 194*, Locus 479, 1-3. VIB. Space outside door to RB.
Onager: Phal 2 post
Rind: Bwb'; Pubis ♀ ; Mt, dist
S/Z: Pc ♂

Lot 203*, Locus 421, 2. VB. West Room.
Ziege: Hz ♂

Lot 207*, Locus 421, 3. VB. West Room.
Onager: Hu, Dist; Fe'; Phal 3 Ant
Schaf: Mc
S/Z: M^2; M^3; Ri'; Fe, Lamm
Ziege: Hu -Corp

Lot 208*, Locus 75, 1. VA. South Room.
Schaf: Mc

Lot 210*, Locus 421, pit in fl.3. VB. West Room.
Schaf: Pc'

Lot 211*, Locus 421, 4. VIA. West Room.
Schaf: Mand; Ra-Corp; Mt, dist
Gazelle: Hz

Lot 217*, Locus 421, 5. VIA. West Room.
Rind: Ra, dist
Schaf: Hu, dist
S/Z: Fe, prox, juv
Gazelle: Hz'

Lot 254*, Locus 49, 1d. IV. House West of RB.
Onager: Scap, Gelenkteil
Schaf: Phal 1 ant

Lot 257, Locus 455, 3-4, IV. Court.
Equide: Ri'
S/Z: Hu-Corp'
Gazelle: Hu, dist; Ra, prox
Schwein: 2 Hu''

Lot 257,Locus 8. VA. Corridor.
Onager: Ncr; P/M inf; Atl; Scap'; Ul'; Tal
Schaf: Mand; Lwb; Ra, dist; Mc-Corp; 4 Tal
S/Z: Fe, dist
Schwein: Vcr; Mand; Bwb; Scap, juv; 2 Ul; Ti-Corp, juv

Lot 258*, Locus 456, 2. VB. Court.
S/Z: 3 M sup''
Gazelle: Scap, Gelenkteil

Lot 261, Locus 20, pit III. Above RB.
Schaf: Pc' ♂
S/Z: M3; Atl; Ra-Corp; Pc'
Schwein: Mand'; Scap', juv; Ilium, juv

Lot 264*, Locus 455, 3. VA. Court.
Onager: Scap'; Ra und Ul, prox
Rind: M sup; Pc'; Ti, prox
Schaf: Hu-corp
S/Z: Mand
Schwein: Scap'

Lot 271*, Locus 455, 9-12. VIB. Court.
Onager: M^3; Hwb'; 2 Hu, dist; Ul'
Rind: P sup; Mand'; Mc-Corp; Ti, dist; Tal; 2 Phal 1 ant
Schaf: Calc
S/Z: 2 Mand
Ziege: Hz ♂; Mand

Lot 274*, Locus 455, 6-13. VIA-B. Court.
Onager: Hu, dist; Ra-Corp, Fohlen; Ra, prox; Ra, dist; Mc, dist; 2 Pc''; Tal
Rind: Hu, prox; Ra, dist; Acet ♂; Tal
Schaf: Scap, Gelenkteil

Lot 276*, Locus 455, 6-13. VI A-B. Court.
Onager: Ncr'; 3 Mand'; 2 M inf; Atl'; Ri'; Lwb; Scap'; Hu, prox; Ra'prox; Ra-Corp; Ul'; Mc, prox; Acet; Mt, dist; Phal 1 ant (zu Mc, dist Lot 274*)
Esel: 2 Phal 1 ant; Phal 2 ant
Rind: Vcr'; M^1 und M^2; 2 Bwb''; Ri'; Scap'; Tal; 2 Phal 3
Schaf: Ra-Corp'; Mc-Corp'; Ilium'; 2 Mt
S/Z: M3; Fe, prox
Gazelle: Kalotte ; Hz-ende; Mc, dist
Schwein: Ul'
Hyäne: Mand
Indet.: 1

Lot 276, Locus 26, VIA-B. Stairs
Onager: Phal 1 post'
Rind: Mt, prox
S/Z: Ncr, juv

Lot 282, Locus 20, pit III. Above RB.
Rind: Ul-Corp

Lot 289, Locus 22, 2. IV. Corridor.
Onager: P sup
S/Z: Mand'; Ra, prox'
Ziege: Ra, dist
Schwein: Ncr'

Lot 298, Locus 22, 4. VA. Corridor.
Schwein: Ul', juv; Pc'

Lot 303*, Locus 479, 9. VIB. Space outside door to RB.
Onager: M1; Bwb, 4 Lwb und Sacrum', zusammengehörig; Patella; Phal 2 ant
Esel: Hu, dist
Rind: Ncr'; Max'; Ri'; Ti, prox
Schaf: Espistr; Ra, prox; Mc-Corp
S/Z: Max'; 4 Ra-Corp; Hwb
Ziege: Ra, prox
Gazelle: Lwb'
Schwein: Mand, juv

Lot 304*, Locus 487, 3. VB. House Northwest of RB.
Onager, Hu, dist
S/Z: Mand'
Ziege: Mc
Gazelle: Ri' (Gattungsbestimmung unsicher); Ra-Corp; Ti, dist

Lot 352*, Locus 455, 12. VIB. Court.
Onager: Ra, dist

Lot 354*, Locus 455, 14. VIB. Court
Rind: Mand'

Lot 368, Locus 31. Town Wall Trench.
Rind: Hwb'
Schaf: Tal, juv
Schwein: Ncr
Datierung unsicher, nicht gezählt !

Lot 373, Locus 33. Town Wall Trench.
Schaf: Mand'
S/Z: Lwb (verbrannt)
Schwein: Scap, juv (angebrannt)

Lot 377, Locus 23, 2. VB. House west of RB.
Kalb: Hu-Corp
Schwein: Scap' (verbrannt)

Lot 393, Locus 33. Town Wall Trench.
Onager: Scap'; Hu-Corp'

Lot 394, Locus 49, lc. IV. House W of RB.
Onager: Phal 1 und 2 post
Schaf: M2 und M3; Ra-Corp

Lot 400, Locus 39, I. Pit. Above RB.
Pferd oder Onager: P sup
Datierung ungewiss, nicht gezählt !

Lot 452, Locus 37, cut. I. Above RB.
Rind: Phal 3
S/Z: Ilium'
Hund: Mt II
Nicht zu datieren, nicht gezählt !

Lot 465, Locus 39, cut. I. Above RB.
Pferd oder Onager: 2 Hu'' (wertlos !)
Schaf: Ilium, Lamm
S/Z: Mand'
Mittelalter, nicht gezählt !

Lot 476, Locus 35, cut. I. Above RB.
Schaf: Ilium, 2 Mc''
S/Z: Mand; Lwb
Schwein: Mand'; Pe'
Nicht zu datieren, nicht gezählt !

Lot 481, Locus 8, below 5. VB. Corridor.
Onager: Mand', juv; Ti'; Mt'
S/Z: Mand'; Fe-Corp

Lot 491, Locus 47, 1. IV. West Room.
Onager: 2 P/M sup; Tc; Phal 3 post
Schaf: Fe, dist
Ziege: Hu, dist
Schwein: Scap', juv; 2 Fe-Corp, juv

Lot 555, Locus 23, 5. VB. House West of RB.
Onager: Scap'
Rind: Mand-Corp
Schaf: Ra, prox
S/Z: Hwb'

Lot 565, Locus 47, 1. IV. West Room.
S/Z: 2 Hwb

Lot 570, Locus 34, 2. VB. West Room
Onager: M sup
Schaf: Scap, Gelenkteil; Hu-Corp, juv; Mc, dist; Ti, dist
S/Z: Lwb'; Hu-Corp; Mt, Lamm
Schwein: Ti-Corp'

Lot 572, Locus 47, 1. IV. West Room.
Schaf: Scap'; Tal (verbrannt)
S/Z: Hu'; Ti'
Ziege: Fe-Corp

Lot 577, Locus 49, 3. VA. House West of RB.
Schwein: Max, juv

Lot 578, Locus 34, 3. VB. House West of RB
Onager: Mc, dist; Phal 1 post (Esel ?)
Esel: Tc
Schaf: Hz ♀ ; Scap'; Ilium ♀ ; Mt, dist
S/Z: M_3
Schwein: Mand, juv; Hu-Corp, juv
Katze: Pe-Hälfte

Lot 585, Locus 47, 1. IV. West Room.
Onager: P_2
Rind: Ri'; Cr; Mc, prox
Schaf: Kalotte ♀ ; Scap'; Hu, dist; 2 Pe'' ♂ ; Fe, dist; Ti, dist; Mt
S/Z: Mand', Lamm
Ziege: Atl ♂
Schwein: 2 Max; Mand, juv; Hu-Corp; Ra, prox; Ti-Corp.

Lot 588, Locus 34, 5. VIA. House West of RB.
Rind: Calc'
Schaf: Atl
S/Z: Bwb
Gazelle: Hu, prox
Schwein: Acet

Lot 590, Locus 34, 6. VIA. House West of RB.
Onager: Mc-Corp
Schaf: Acet ♀

Lot 598, Locus 49, 5. VB. House West of RB.
S/Z: Ra-Corp, Lamm
Ferkel: Kalotte'

Lot 607, Locus 421, 1. VB West Room.
Onager: Hu, dist
Rind: Mand-Corp'
Schaf: Mand; Fe-Corp; 2 Ti, dist
Gazelle: Hz ohne Basis
Ferkel: Mand

Lot 608, Locus 68, fill under roof. IV ? South Room.
Schaf: Epistr ♂ , 2 Hwb, dazugehörig; Ti, dist
S/Z: Hu, dist, juv
Schwein: Fe', juv
Datierung ungewiss, nicht gezählt !

Lot 756, Locus 49, 6. VB. House West of RB.
Schaf: Scap', Lamm; Calc'
S/Z: Orbita; M^3; Bwb'; Ri'; Lwb; Sternum'
Ziege: Ti-Corp', Spatel !; Tal
Schwein: 2 Ri''; Ul', juv; ; Mc IV, juv

Lot 763, Locus 49, 7. VB. House West of RB.
Schaf: Atl'; Pc', juv
S/Z: Hwb
Gazelle: Sacrum; Mt, dist
Schwein: Hu-Corp'

Lot 769, Locus 54, 1. VIA-B. Stair.
Onager: P inf; Hwb', Ra, prox; Mc'; Calc'; Mt, dist; Phal 1 post (Esel ?); Phal 2 ant
Rind: Mand'; Bwb; Pubis ♀ ; Mt, Spatel !
Schaf: Hu-Corp; Hu, dist; Ra-Corp
S/Z: M^2; Hu-Corp'
Ziege: Mt, prox
Schwein: 2 UK''; Scap, juv

Lot 795, Locus 68, 1. VA. South Room.
Schaf: Kalotte' ♀ ; Atl; Lwb; 2 Scap, Gelenkteile; Hu, prox; 2 Hu, dist; Ra, prox; 2 Ra, dist; 2 Mc; Ilium; 3 Ti'';
Mt; 2 Phal 1
S/Z: M^3; Os incisivum; 3 Mand''; Bwb'; 3 Ri''; Lwb'
Ziege: Scap, Gelenkteil; Fe, dist
Ferkel: Max; Mc IV

Lot 798, Locus 70, 1. IV. Corridor.
Onager: Hu, dist
Schaf: Ra, prox; Mc-Corp; Pc'♂
S/Z: Mand'; Hwb; Lwb
Ziege: Hz ♂ ; Pc' ♀
Schwein: Scap', juv; Hu-Corp, juv; Hu, dist; Ul'; Fe, dist, juv
Datierung ungewiss, nicht gezählt !

Lot 857, Locus 67, 1. IV. Corridor.
Gazelle: Hz ohne Basis

Lot 868, Locus 5, 3-4. VB. Corridor.
Onager: Mand'; Epistr; Fe'; Phal 1 post (Esel ?)
Rind: M sup; Mc, dist
Schaf: Kalotte' ♀ , Scap'; Tal
S/Z: Mand'
Ziege: Scap, Gelenkteil
Indet.: 1 (Equide oder Rind)

Lot 899, Locus 404, 1. IV. Court.
Onager: M/P sup; Hu-Corp'; Pc'; Ti, dist
Esel: Phal 1 ant; Phal 2 ant
Schaf: Ra, prox; Mc-Corp'
S/Z: M_3; Ti-Corp
Schwein: Ncr, juv; Scap', juv

Lot 897, Locus 47, 4. VB. Stair.
Onager: Hu'; Fe', dist; Ti, dist; Mt, prox; Phal 1 ant; Phal 3 ant
Rind: Ci; Mc, prox; Mc, dist
Schaf: Mand'; Epistr ♂ ; Scap, Gelenkteil; Hu, dist; 2 Ra''; Ti, dist
S/Z: Occiput; Mand'; Ra, prox; Pc'; Ti-Corp, juv; Mt, juv

Lot 934, Locus 26, tread. VIB. Stair.
Onager: Hu, dist; Phal 2 ant
Schwein: Kalotte, juv

Lot 948, Locus 76, 1. VA. Space outside door to RB.
Onager: M/P sup
S/Z: M_3
Schwein: Tal

Lot 952, Locus 79, 1. IV. Entry.
Onager: Hwb'; Fe, prox
Rind: Fe, dist

Lot 980, Locus 93, 1-5. VA. Entry.
Onager: Scap'; Ra; Fe-Corp; Phal 1 ant
Rind: Ti-Corp'; Tal
Schwein: Mand, juv

Lot 980a, Locus 438, 1. VB. Entry.
Gazelle: Hz

Lot 984, Locus 55, pit. III. Above RB.
Onager: Mc, dist'
Rind: Mc, dist
Schaf: Hu, dist; Ra, prox

Lot 989, Locus 441, 1. II. Above RB.
Onager: Epistr'; Ul'; Mc, dist
Schwein: Mand'

Lot 991, Locus 85. III. Above RB.
Onager: J inf; Epistr'; T_3; Mt, prox
Ziege: Mc

Lot 1103, Locus 404, 2. IV. Court.
Onager: C_3
Rind: Hwb; Bwb
Schaf: Ti, dist
S/Z: Scap'
Gazelle: Hz
Ferkel: Scap

Lot 1105, Locus 406, large oven. IV. Court.
Onager: P^2
Esel: Ra
Rind: Atl'
Schaf: Mt, prox
Ziege, Ti, dist

Lot 1107, Locus 404, 1. IV. Court.
Schaf: Ti

Lot 1114, Locus 404, 2. IV. Court.
Onager: Phal 3 post
Rind: Mand'
Schaf: 2 Ra, dist; Mt
S/Z: 3 M inf
Gazelle: Hz

Lot 1115, Locus 47, 3-6- VB. West Room
Onager: Hwb'; Fe'

Tepe al-Atiqeh

Lot 218, Locus 128
Onager: M/P sup; Mand'; Atl'; Lwb'; Pe'; Ti'; Phal 1 post
Schaf: Kalotte' ♀ (unbehornt); Hz ♂ ; 2Atl; 2 Epistr; Hwb; 2 Scap''; 5 Hu, dist; Ra, prox; 2 Ra dist; Mc, prox; Mc, dist; Pe' ♀ ; 3 Ti-Corp; 2 Ti, dist
S/Z: Ncr'; M^3; 5 Mand; Lwb'; Scap'
Gazelle: 2 Lwb
Schwein: Mand'; Scap'; Ri'; 3 Hu, dist; Ti-Corp; Tal

Lot 222, Locus 128
Onager: Mand', juv; M/P inf; 3 Ri''; Tal, juv; Mt'
Schaf: Ncr' ♂ ; Hz' ♂ ; Hu, dist; Ti, dist
S/Z: M^2 und M^3; Hwb'; Pe'
Ziege: Tal
Schwein: 2 Ncr'; Mand'; Fe'; Ti-Corp
Indet: 2 (Equide oder Rind)

Lot 239, Locus 162
S/Z: Ra, prox
Ziege: Mc, prox
Gazelle: Mc dist

Lot 317, Locus 106
Onager: 2 Ra''; Ul'
Schaf: Scap, Gelenkteil; Hu, dist; Ra, prox; Ul'; Mc, dist; Pubis ♀ ; Mt, dist
S/Z: M_2; Lwb'; 2 Ra-Corp

Lot 324, Locus 120
Rind: Tal
Schaf: M_3; Mc
S/Z: Ra, prox
Ziege: Ra, prox
Gazelle: Hu, dist

Lot 327; Locus 102
S/Z: Mand (zerbröckelt)

Lot 350, Locus 119
Schaf: Ra, prox
S/Z: 3 Mand''

Lot 505, Locus 105
Schaf: Hz ♀ ; Mc, prox
S/Z: Mand'; M_3
Ziege: Ncr' ♂ , Hz abgeschlagen
Gazelle: Hz; Ti, dist; Calc; Mt
Schwein: 2 Scap, Gelenkenden

Lot 507, Locus 105
Schwein: Hu-Corp; Ra, prox

Lot 511, Locus 105
Onager: Fe', prox; Te
Schaf: Ncr ♂ ; Hu-Corp
S/Z: Mand; Mc'; Ti-Corp'
Ziege: Hu, dist
Schwein: Mand' ♀

Lot 516, Locus 125
Gazelle: Hz, dist. Hälfte

Lot 527, Locus 128
Esel: Phal 2 ant
Onager: Ncr'; M/P' sup; 3 M/P inf; 3 Bwb''; 5 Ri''; Ra, dist; Mt'II-IV
Rind: Ncr'; Bwb'; 2 Hu, dist; 2 Phal 2
Schaf: Kalotte ♂ , Hz abgeschlagen; Epistr ♂ ; Hwb ♂ ; Hu; 5 Hu, dist; 6 Ra, prox; 2 Ul'; Ra-Corp; Ra, dist; 3 Mc'; 2 Ilium ♀ ; Ti, prox; Ti-Corp; 3 Ti, dist; 2 Tal; 2 Calc; Mt, prox
S/Z: M^2; 3 Mand''; 2 Hwb'; Bwb; Ri'; 3 Lwb; 2 Hu-Corp; 2 Ra-Corp''; Mc-Corp'; Ilium'; Fe-Corp; 3 Ti-Corp; Mt-Corp
Ziege: Hz ♂ ; Mand'; Scap'; Mc-Corp'; Phal 1
Gazelle: Hwb; Lwb; Scap'; Hu; Hu, dist; Ra, dist; Fe, prox; 3 Fe, dist; Ti, prox'; Ti, dist mit Tal und Ct zusammenklebend; Mt, dist
Schwein: Kalotte'; 6 Mand''; Atl; Bwb; 2 Hu-Corp, 4 Hu, dist; Ul'; 4 Pe'; Fe, prox; Ti dist; Tal; Mt III
Indet: 5

Lot 531, Locus 122
Onager: Calc (verbrannt)
Rind: Epistr
Schwein: Kalotte mit tiefer Hiebspur

Lot 540, Locus 128
Onager: Fe; Tal und Calc; Phal 2 ant
Ziege: Hu, Ra und Mc, Lamm
Schwein: Max'; Hu, dist; Fe, dist

Lot 547, Locus 128
Onager: Ti, dist.
Rind: Petrosum; 2 Mand'; Ri'; Scap'; Hu, dist
Schaf: M_3; Hwb; Lwb; Ra, prox; 2 Ti, dist; Mt-Corp
S/Z: Ncr; Os incisivum; P sup; 2 Mand; Hwb; Bwb; Sacrum'; Hu, dist; Ra-Corp; 3 Pe'; Ti-Corp
Ziege: Scap, Gelenkteil, Mt ♀
Gazelle: Scap, Gelenkteil
Schwein: Kalotte, 2 Max''; Scap, Gelenkteil; 2 Scap''; Hu, prox; Hu-Corp; 3 Hu, dist; Mc IV; Ilium, Ferkel; Fe-Corp; 2 Ti-Corp
Indet: Ri'

Lot 548, Locus 128
Onager: Bwb'; Ri'; Hu, dist; Pe'
Schaf: Ncr ♂ ; Scap, Gelenkteil; 2 Hu, dist; Ra, prox; Pe ♂; Fe, dist
S/Z: Mand'; Hwb; 2 Ri'', Lwb
Ziege: Scap', Ra und Ul, prox; Ul'
Schwein: Mand; 3 Hu-Corp; Ti, dist

Lot 712, Locus 128
Onager: Ncr'; Mand'
Schaf: Scap'; Ilium ♀
S/Z: Max. juv; Mand' ad; Lwb
Ziege: Scap'; Hu, dist

Lot 713, Locus 128
Onager: Max'; M^1; M_3; Fe'
Rind: Ri'
Schaf: Hu-Corp; Ul'; Pe' ♀ ; Ti, prox; Ti, dist
S/Z: Mand'; 2 Lwb''; Scap
Ziege: Kalotte ♂ , juv; Epistr; Ra, prox; Ilium ♀
Schwein: Ncr'

Lot 715, Locus 128
Onager: Lwb und Sacrum (zerbröckelt) ♂

Lot 725, Locus 134
Schaf: Kalotte ♀ , juv; Hu; 2 Ra; 2 Mt
S/Z: Mand'; 2 Hwb; Bwb; 2 Lwb
Ziege: Pe ♂ ; Tal

Lot 726, Locus 134
Gazelle: Occiput
Schwein: Hu-Corp'

Lot 748, Locus 143
Equide: Mand', Fohlen
Onager: M/P sup; M/P inf; Fe-Corp, juv; Phal 1 ant
Schaf: Scap'; Pe ♀ (angebrannt)
S/Z: Ti-Corp'
Ziege: 2 Hz ♂
Schwein: Ncr'

Lot 803, Locus 143
Onager: P 4 und M^1; 2 M/P inf; Hwb; Ri'; Lwb'; 2 Scap''; Hu-Corp; Ra'; Ul, prox
Rind: Ri'; Ra, prox
Schaf: M_3; Atl; Hu, dist; Fe, dist; Ti, dist; Mt, prox
S/Z: Mand; Hwb (Verbrannt), 2 Lwb
Ziege: 2 Hz ♂ ; 2 Epistr ♀ ; Ra, prox (angebrannt)
Schwein: Mand ♀

Lot 1005, Locus 143
Equide: Ri'
Schaf: Mc ad; Mc, prox; Mc, neonat; Patella; Tal; Mt, Lamm; Ti und Mt neonat
S/Z: M^1 und M^2; Hwb; Bwb; 2 Ri''; Hu-Corp; Lamm; Fe und Ti, Lamm
Gazelle: Scap'

Lot 1009, Locus 148
Schaf: Letzter Lwb und Sacrum; Ra, prox; Ti-Corp
S/Z: 2 Hwb
Ziege: Hu, prox
Gazelle: Hz
Schwein: Sacrum, Ti-Corp

Lot 1067, Locus 137
Gazelle: Hz-ende

Lot 1096, Locus 164
Onager: Ischium
Rind: Ul'

Lot 1098, Locus 164
Schaf: Mand'; Pe ♀ ; Fe-Corp
S/Z: Ri'
Schwein: Ti-Corp

Tell Ahmed al-Mughir

Lot 409, Locus 305
Schaf: Scap, Gelenkteil; Hu, dist (verbrannt); Ti, dist mit daranklebendem Tal (verbrannt)
S/Z: Scap, Gelenkteil (zerbröckelt)
Schwein: Lwb'; Scap, Gelenkteil; Pe' (verbrannt)

Lot 410, Loci 306-307
Rind: M^2; Acet ♀
Schwein: Scap'

Lot 417, Locus 306
Esel: Phal 1 ant

Lot 428, Locus 302
Rind: Ri-abschnitt
Schaf: Kalotte' ♂ ; Mc, juv

Lot 444, Locus 302
Equide: Pe', ad; Fe eines Fohlens; Ti, prox, juv
Rind: Ri-abschnitt
S/Z: Ri-abschnitt

ISBN 87-500-2909-6 (Denmark)
ISBN 0-918986-61-3 (USA)