NEWSLETTER

Department of Pottery Technology

VOLUME 14/15 - 1996/1997



LEIDEN UNIVERSITY - THE NETHERLANDS

NEWSLETTER

DEPARTMENT OF POTTERY TECHNOLOGY LEIDEN UNIVERSITY

VOLUME 14/15 - 1996/1997

Address: Faculty of Archaeology Department of Pottery Technology POB 9515 2300 RA LEIDEN The Netherlands

Fax: 0031 - (0)71 - 527 24 29

E-mail: secretary@arch.LeidenUniv.nl

ISSN 0168-7913

EDITOR:

Abraham van As

ADVISE:

Maria Beatrice Annis Wladimir Perizonius Margreet Steiner

Drawings:

B. Claasz Coockson (pp. 72-81)
P. Deunhouwer (p. 104)

A.E.A. van Driel (pp. 26, 50, 69)

O.P. Nieuwenhuyse (pp. 29-31) F. Renel and F. Genadt (pp. 55-63)

M. Sauvage (p. 26)

E. Smekens (pp. 88-93)

Photography:

H. Houben (p. 14)

E.P.G. Mulder (pp. 94-99)

J. Pauptit (pp. 32, 33, 109, 111, 113)

H. Gasche (p. 87)

Imaging:

J. Pauptit

Revision English texts:

Mrs. A. Bulles (pp. 13-15; 19-23; 25-47; 69-84)

Mrs. S. Mellor (pp. 103-120)

Mrs. K. Williams (pp. 49-67; 85-102)

Secretary/mailing:

E.P.G. Mulder

CONTENTS

	page
INFORMATION	
Annual report (1996/1997)	7
Announcement	10
PRELIMINARY/INTERIM REPORTS	
In preparation: a study on the use of tannin in earthen architecture R.E. Arkema	13
ARTICLES	
The study of clays and non-plastics in pottery and the history of an archaeological site (Jerusalem) H.J. Franken	19
The Transitional Fine Ware pottery of Tell Sabi Abyad, Syria. A pilot study A. van As, L. Jacobs and O. P. Nieuwenhuyse	25
A technological classification of the Early Dynastic and Old Akkadian pottery of Tell Beydar, Syria A. van As and L. Jacobs	49
Further technological research on the Chalcolithic pottery of Ilipinar, phase VB A. van As, L. Jacobs and MH. Wijnen	69
The manufacturing technique of the vessels from Late Bronze Age/ Early Iron Age graves at Akhtamir, Armenia A. van As and L. Jacobs	85
Sardinia (Italy): fieldwork and the laboratory in ceramic ethnoar-chaeology M.B. Annis	103



INFORMATION



ANNUAL REPORT (1996/1997)

Research projects in cooperation with:

Leiden University/Department of Archaeology:

Indian America:

- Pre-Columbian pottery from Guadeloupe (Dr. C.L. Hofman).
- Tannin-project (R. Arkema).

Methods and Theory:

- The Riu Mannu survey project, Sardinia/Italy (Dr. P. van de Velde).

Palestinian Archaeology:

- Bronze Age and Iron Age pottery from the British Museum excavations at Tell es-Sa'idiyeh, Jordan (Mrs. M.M.E. Vilders).

The Netherlands Institute for the Near East, Leiden:

- Neolithic/Chalcolithic pottery of Ilipinar hüyük, Turkey (Dr. J.J. Roodenberg).
- Islamic pottery of Tell Abu Sarbut, Jordan (H.E. LaGro).

The Netherlands National Museum of Antiquities, Leiden:

- Transitional pottery (5200-5100 B.C.) of Tell Sabi Abyad, Syria (Dr. P.M.M.G. Akkermans).
- Exhibition «List en bedrog. Vervalsingen in de Nederlandse archeologie»
 (L. Verhart).

Betuweroute

 Late Bronze Age/Iron Age pottery from Eigenblok West (S. Bloo and W. Schuiten).

Working Group on Mesopotamian Pottery:

- Second millennium B.C. pottery of Babylonia and adjacent regions (Dr. H. Gasche).

European Centre for Upper Mesopotamian Studies:

 Early Dynastic and Old Akkadian pottery of Tell Beydar, Syria (Dr. M. Lebeau and Prof. dr. K. van Lerberghe).

Joint Belgo-Armenian Archaeological Expedition to Armenia:

 Late Bronze Age/Early Iron Age pottery from the necropolis of Akhtamir, Armenia (Dr. H. Gasche and Dr. H. Simonyan).

Fieldwork:

13-30/07 1996	Joint Belgo-Armenian Archaeological Expedition to Armenia
	(A. van As and L. Jacobs).
09-30/09 1996	Dutch Archaeological Mission at Tell Sabi Abyad, Syria;
	Euro-Syrian Archaeological Mission at Tell Beydar, Syria
	(A. van As and L. Jacobs).
29/09-27/10 1996	The Riu Mannu survey project, Sardinia/Italy (M.B. Annis).
29/05-17/06 1997	Dutch Excavations at Ilipinar, Turkey (A. van As).
09/06-17/06 1997	Dutch Excavations at Ilipinar, Turkey (L. Jacobs).
17/09-08/10 1997	The Riu Mannu survey project, Sardinia/Italy (M.B. Annis).

Publications:

- Annis, M.B., P. van Dommelen and P. van de Velde (1995) [issued in 1996], Rural settlement and socio-political organization: the *Riu Mannu* survey project in Sardina. *Bulletin Antieke Beschaving* 70: 133-152.
- Annis, M.B. (1996), Appropriation and preservation: (built) heritage as a common good. *Archaeological Dialogues* 1996 (2): 123-126.
- Annis, M.B. (1996), Organisation of pottery production in Sardinia: Variability and change. In: H. Lüdtke and R. Vossen (eds.), *Töpfereiforschung zwischen Mittelmeer und Skandinavien* (Töpferei- und Keramikforschung Band 3), Bonn: 143-170.
- Annis, M.B., P. van Dommelen and P. van de Velde (1996), Insediamento rurale e organizzazione politica. Il projetto Riu Mannu in Sardegna. Quaderni della Soprintendenza Archeologica di Cagliari e Oristano 13: 255-286.
- Annis, M.B. and L. Jacobs (1997), Appendix 2 and passim. In: R.F. Docter, Archaische Amphoren aus Karthago und Toscanos, Ph.D. Dissertation, University of Amsterdam.
- Docter, R.F., M.B. Annis, L. Jacobs and G.H.J.M. Blessing (1997), Early Central Italian transport amphorae from Carthage. Preliminary results. *Revista di Studi Fenici* 25: 15-58, tavv. I-VIII.

Lectures:

	Cagliari/Oris-
tano, Italy.	

06/10 1997 A. van As: Aardewerk maken; Vrije Universiteit, Amsterdam.

28/10 1997 M.B. Annis: Kleinschalige aardewerkproductie; Vrije Universiteit, Amsterdam

18/11 1997 A. van As: Short visits to potters working nearby archaeological sites; Annual Meeting of the American Schools of Oriental Research (ASOR); Napa Valley, California, USA.

18/11 1997	M.B. Annis: Sardinia (Italy): fieldwork and the laboratory in ceramic
	ethno-archaeology; Annual Meeting of the American Schools of Orien-
	tal Research (ASOR); Napa Valley, California, USA.

15/12 1997 A. van As: The value of technological ceramic research to archaeology, Bilkent University; Ankara, Turkey.

17/12 1997 A. van As: The value of technological ceramic research to archaeology; Nederlands Historisch-Archeologisch Instituut (Dutch Historical-Archaeological Institute); Istanbul, Turkey.

Symposia/meetings:

10/02 1997

	ranea 2; Università Statale Cagliari (M.B. Annis).
08/03 1997	Crafts and Trade in the Roman West and East (ROCT); University of
	Leuven, Belgium (M.B. Annis and A. van As).
12/03 1997	Tell Beydar Lectures-Seminars Workshops; University of Leuven, Belgium
	(A. van As and L. Jacobs).
24/07 1997	Working Group on Mesopotamian Pottery; Paris, France (A. van As).
18-21/11 1997	Annual Meeting of the American Schools of Oriental Research (ASOR);
	Napa Valley, California, USA (M.B. Annis and A. van As).

Meeting in prepartation for the congress Antropologia Contempo-

Guests:

Until 15/08 1996	Hamed Salem, Birzeit University (PEACE programme).
01/01 1996-31/12 1997	Dr. Laia Colomer i Solsona, Universitat Autònoma de Bar-
	celona (Post-doc visiting research grant, Ministery of Science
	and Culture of Spain).
12-23/02 1996 and	Tom Broekmans, University of Leuven.
27-31/01 1997	
01/03-05/04 1997	Dr. Ian Edwards, Deacin University, Burwood, Australia

Dr. Ian Edwards, Deacin University, Burwood, Australia (Visitors grant of the Netherlands Organization for Scientific Research/NWO).

Visitors:

02/09 1996	Prof. dr. William A. Longacre and Marc Neupert; University of Arizona;
	Tucson, USA.
03/09 1996	Dr. Vishvas D. Gogte; Deccan College Research Institute; Pune, India.

ANNOUNCEMENT

Organization

The Department of Archaeology to which the Department of Pottery belongs and the Faculty of Pre- and Protohistory have been merged. From September 1st 1997 they form the Faculty of Archaeology of Leiden University.

PRELIMINARY/INTERIM REPORTS

IN PREPARATION: A STUDY ON THE USE OF TANNIN IN EARTHEN ARCHITECTURE

As part of my research on the use of tannin in earthen architecture for my Master's thesis at the Department of the Archaeology of Indian America a series of practical analyses and tests is being conducted in the laboratory of the Department of Pottery Technology¹. The aim is to gather some relative data on the effect of tannin on the properties of the original material. Since the methods of analysis and testing are largely similar to many procedures used on ceramics, the laboratory of the Department of Pottery Technology is consequently suitably equipped for these tests.

Within the world of archaeological heritage many structures can be found that are made of *mudbrick* or *adobe*² and are situated above ground. Preserving these buildings is a cause of constant care and research, for archaeologists as well as conservators. Whereas there seems to be an emphasis on modern synthetically produced chemicals, at least in the USA, not all people involved agree with this approach.

For example, in the state of New Mexico, USA, lies Jemez State Monument. This site contains the ancestral remnants of the Jemez tribe as well as structures from the colonial period. For the conservation of the ruins of colonial origin Rhoplex E330 is used, an acrylic polymer. The Jemez tribe, however, have a say in the choice of the method of conservation and refuse to have their ancestral architectural remains treated with synthetically produced materials such as Rhoplex. They insist on the use of more natural materials.

An example of a more natural material is tannin, a yellowish-brown powder extracted from trees and traditionally used to turn hides and skins into leather. In 1976 an empirical experiment was carried out by CRATerre (the International Centre of Earth Construction – School of Architecture Grenoble, Villefontaine, France) in Burkina Faso on a small mudbrick structure which had been finished off with several traditional types of plaster amended with tannin, shea butter, banana tree sap and a plaster applied without any additives. The tannin was produced locally in the traditional way by boiling the seeds of an Acacia tree, a species known for its high percentage of tannin (Fig. 1). The results suggested that a plaster amended with tannin does indeed improve the resistance to weathering. Photos taken after several years showed the tannin-amended plaster to have lasted better than the other types.

There is an abundance of information on tannin, a material known to man for at least six thousand years and possibly longer, used for turning hides into leather as well as for many other applications, but its use in earthen architecture is rather unusual and

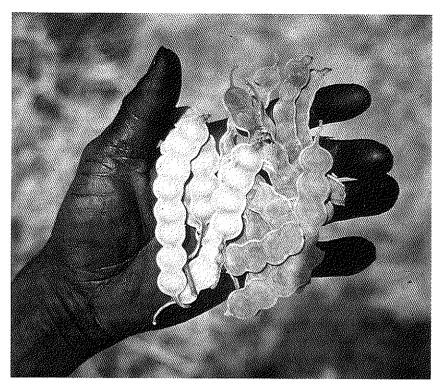


Fig. 1. Seeds from the Acacia tree. Left: plucked from the tree. Right: dried on the ground (best) (Foto: H. Houben, CRATerre).

no real research has ever been conducted so far. Laboratory analysis does not resemble real-life conditions but is as close as one can get in the first stage of the research.

A series of samples was made up based on the Fuller formula for grain-size distribution (optimum dry specific weight at a given maximum grain size) with 10% clay.

A first preliminary experiment showed percentages over 5% tannin to be already too much and to give a saturated specimen. The tannin percentage to be tried was therefore determined from zero (control sample) to four percent in steps of one, all measured in dry weight. The tannin used was produced in South Africa on commercial plantations from the Black Wattle and consists of 70% tannin, 29% wooddust and 1% other components. This resembles most closely the conditions in the field and it was not adapted in any way as is usual in the tannery industry to improve the tanning capacities.

The second step was to get some basic idea of the physical properties of the material. Samples were tested on tensile strength, a method resembling the ASTM (American Society for Testing and Materials) C 307-83 test but developed at the Department of Pottery Technology for clay to give values per cm², and on surface hardness using the Mohs test (test on hardness used in mineralogy). Adobe structures are subjected to

compression and values on tensile strength are therefore not really significant, but these two tests do provide some basic idea of the mechanical properties of the altered material.

A third range of tests is directed more towards the specific needs of an adobe material, such as: abrasion resistance, falling abrasive test (based on ASTM D 968-81); water resistance, drop test (CRATerre drop test); waterabsorption (RILEM Test Method No. II.4 / Réunion Internationale sur les Matériaux et les Constructions).

The test programme is still in progress. Therefore conclusions cannot yet be drawn to the practical side apart from the fact that with a very small amount of tannin the characteristics of the material change considerably. Even 1% of tannin gives the sample a dark brown colour and makes it much harder and much more resistant to water-uptake. Whether this makes tannin an appropriate amendment to adobe conservation, either in plaster, repair mortar or even complete blocks, is something that can only be judged after both the theoretical and the practical research have been completed.

Notes

- 1. Supervisor for this Master's thesis is H. Houben from the International Centre for Earth Construction School of Architecture Grenoble, Villefontaine, France.
- 2. The term adobe originally refers to rectangular building blocks made of a mixture of clay, silt and sand, naturally dried in the shade for several weeks, as used on the American continent. Mudbricks is a term commonly used in the Middle-East region for the same style of building. The term earthen architecture covers all aspects of building with earth: adobe, mudbricks, cob-walling, pisé, etc., as well as plasters. In American terminology it is customary to address all earthen architecture with adobe.

ARTICLES

THE STUDY OF CLAYS AND NON-PLASTICS IN POTTERY AND THE HISTORY OF AN ARCHAEOLOGICAL SITE (JERUSALEM)

The use that can be made of the information obtained by the study of clays and non-plastics in ancient pottery from Jerusalem, excavated by the late Dame Kathleen Kenyon and investigated at the Department of Pottery Technology, is not restricted to understanding the craft of the potters or the provenance of the raw materials. The following is an attempt to show connections between the history of an archaeological site and the potter's raw materials.

Introduction

Ancient Jerusalem, from its earliest occupation in the early third millennium B.C. to the first millennium A.D., provides the necessary information for the study of the relationship between the history of the site and the potter's raw materials. A technological study was made of pottery sherds, excavated in 1961-1967 by the British School of Archaeology in Jerusalem under the direction of the late Dame Kathleen Kenyon (see Franken and Steiner 1990: 1, 2). It is maintained here that each time archaeology finds a significant event in the history of the site, the raw materials used by the potters reflect that event. Looking at one period only one may not be alerted to such connections but in the study of longer periods the suggestion of such a relationship becomes stronger.

The potter's local raw materials

The best definition of the materials that were locally available to potters working close to the site comes from pottery produced in the Iron Age (ca. 1200-600 B.C.). Three distinctly different clays – clay A, B, and C – were used, which have been described in Franken and Steiner (1990: 78, 79)¹. When talking about clays in this study it should be noted that the emphasis is on the reconstruction of the potter's craft and not on a scientific analysis of the chemical composition of clays. Likewise, the description of the non-plastics found in the pottery could be much elaborated on by a mineralogist, but the minerals mentioned in this publication are what the name says, and calcite is indeed calcite and quartz is quartz. Thus the three clays may have had the same origin and basic chemical composition, but because of having been transported by natural agents, at least two of them did not only come from different find spots but had also obtained important differences in properties and had to be used in different ways by the potters.

Clay A that was probably available in the immediate environment of the site was a very silty, microfossiliferous and calcarious clay. Microfossils occur in large quantities

20

and their presence can be explained as having been washed out of the native rock on which Jerusalem stood. Together with clay that was washed away from its original bed it formed a silty soil, containing not only fossils but also extremely fine lime, soluble salt, extremely fine quartz particles and iron grains. This clay probably accumulated in the valleys south of the site where it easily could be obtained by the potters. It was not a good plastic clay and was never used on a thrower's wheel. It was obviously a clay that was suited for hand-built pottery with the use of a hand-operated turntable. When fired it has a pale reddish colour due to the lime contents and at temperatures above 1000°C the colour becomes greenish.

Clay B is a good red firing clay by itself and rather plastic, but it was mixed in nature with very large quantities of small carbonate rhombs, which derive from the dolomitic rock such as found in the Wadi Refaim, south-west from Jerusalem. The clay matrix still had enough plasiticity left to be used on a good potter's wheel. The clay contains small amounts of iron and quartz in silt fraction. The break of the fired sherd is smooth, in contrast to sherds from clay A. In both clays the carbonate inclusions are too small to cause damage to the pots when fired over 825°C, when lime turns into quick-lime. The fired colour is also pale reddish.

Clay C is poor in free carbonates but rather silty due to fine quartz and iron grains and other minerals. Lime grains occur in the fired products but they always come from other sources than the clay bed itself. This clay has good plastic properties so that it could be used to throw jugs with thin walls and it stood higher temperatures than the other clay mixtures. Its fired colour is dark reddish-brown and the origin of this clay may be the so-called motza clay that is found in the neighbourhood of Jerusalem.

The three clays dominate the ceramic picture in the Iron Age and the definition comes from the study of thousands of Iron Age sherds. They provide enough information to tell us what to expect when potters settle near the site and start exploring the possibilities of the local clay beds.

The history of the site and the potter's use of raw materials

The first settlement

The first settlement at the site is estimated to have occurred at the beginning of the Bronze Age I, about 3100 B.C. Very few building remains were excavated and the site is interpreted as a village (Auld and Steiner 1996). How long this occupation lasted is not known, but not much longer than two or three hundred years. Some sherds of this period were found in caves but most sherds were found in pockets in bedrock, or in ancient dumps. The total amount of sherds studied in Leiden is about 120, not enough for a reliable statistical evaluation of the various temper groups. Looking at the non-plastics we find the following picture.

One general feature is that all sherds contained organic matter and hair from herbivores which indicates that the clay was taken from the surface and not from deeper levels. In all later periods the clay came from well below the surface.

Nine different clay temper groups were distinguished in this assemblage and only one group, represented by seven sherds, is from a 'Jerusalem' clay. This is clay B. The other

eight groups point to other regions as the area of production. There is pottery containing igneous rock sand and sherds containing shale or lime without microfossils. Several sherds demonstrate very ancient traditional potter's habits such as using grog or pounded calcite as temper. Both temper materials were already found in Neolithic pottery from Tell es-Sultan or ancient Jericho.

So most pottery was not produced locally, which suggests that the population of the village or part of it led a rather nomadic existence, in contrast to the next period of habitation.

From the 18th century B.C. until 1200 B.C.

The beginning of the Middle Bronze Age II is characterized by a settlement dated to the 18th century B.C. of which a long stretch of defence wall has been excavated by Dame Kathleen Kenyon. More than five hundred rim sherds were preserved by her and the vast majority is made of clay B. Clay B was used for the production of Middle Bronze Age thrown pottery, with its thin walls and curved shapes. The cooking pots show that the potters knew how to make them heat shockproof by mixing clay with pounded calcite. The original clay for this kind of pottery may have been clay C. Some fifteen sherds show a different mixture. Storage jars predominate in the assemblage and the pottery suggests a comparatively well-to-do settled population. The site was abandoned in the next century.

The Iron Age (1200-587 B.C)

The first people that left more traces of their presence at the site than a few tombs came at the end of the thirteenth century B.C. From then on the site has been continuously inhabited till the present.

At the end of the 13th century B.C. a new period of building began, and a small settlement, or rather a fortress, was erected by people who were called Jebusite in the Biblical stories. When a new settlement starts this always attracts potters who are willing to migrate to the new market. However, there were still potters working in the Nahal Refaim, as is shown by their pottery. From the 710 rim sherds belonging to Iron Age I that were tested 71% were produced in the local clay B. Some new potters seem to have come from areas where quartz sand was used as a temper and continued using this. They may have found a source of sand nearby. However, it is possible that the sand was brought up from the western plains. Clay C was still used in the production of cooking pots. The new potters brought with them their own traditions of treating clays with additions such as organic matter or sands, and these traditions proved to be rather strong. Foreign and local potters were supposedly working side by side and they stuck to their own ways which did not change during the Iron Age. Statistically significant figures are available to demonstrate this.

Thus a large amount of pottery was made with clay B without further additions, while the other mixtures occur only in small quantities. The following wares are found right through the Iron Age: clay A occurs with a temper of lime sand, with a mixture

of lime and quartz sand or with only quartz sand; clay B also occurs mixed with quartz sand; and clay C is the regular cooking-pot ware mixed with pounded calcite. Clay C mixed with quartz sand is rare. Other clays were used in small quantities. The most likely explanation for their occurrence is that during the wet season pottery production in the mountains had to stop because neither the pottery nor the kilns were dry enough to be fired. In those unproductive periods pottery may have been imported from dryer areas. The point I am making here is that the site attracted potters who brought with them their own traditional methods of making pottery. The existence of the various potters' workshops in this period can be traced by the study of the use of non-plastic materials in the pottery.

In the tenth century new building activities took place and there is enough pottery preserved to be able to note some dramatic changes. 546 Sherds were tested for ware. The dolomite clay B had completely lost its dominance and represented only 20% of the total assemblage. The use of quartz sand in the fossiliferous clay had risen from 1% to 24% and the use of quartz sand in clay C, the cooking pot clay, had risen from 2% to nearly 15%. The use of clay B diminished during the following centuries and in the seventh century it is less than 5% whereas clay A makes up 90% of the production. It seems that the proximity of the clay beds to the site was a decisive element in the dominance of the use of clay A. The changes in the use of quartz sand as a filler in the clay probably reflects the political situation. If indeed it had to be brought to the site by caravan from the coastal regions, because it was not available locally, then the invasion of the Assyrian army in the late 8th century B.C. which resulted in the destruction of the entire country except for the town of Jerusalem, should have made the sources of quartz sand inaccessible and indeed sand temper practically disappears after that event.

The Exile (587-538 B.C.) and the post-exilic period

In 587 B.C. the town of Jerusalem was destroyed and the inhabitants including the potters went into exile. This information is confirmed by the study of the non-plastics. Archaeological dogma had it that after the return of the exiles to their home country, Iron Age pottery shapes were no longer produced. But in the ancient dumps from the sixth and fifth centuries B.C. pottery was excavated by Dame Kathleen Kenyon that was identical to the seventh century B.C. assemblage but for one feature: the temper materials. From all the possible combinations of non-plastics and clays that were used by the pre-exilic potters only three are found in post-exilic times. The use of quartz sand which had practically disappeared before the Exile is now a normal feature in clay A. Moreover, the use of clay B, the dolomite clay, dominates the pottery production. From 5% of the total production before the Exile it became 82% after that event. In pre-exilic times lamps were not produced in clay B but now it is normally used for the manufacture of lamps. This clearly indicates that the old potters and their families did not return. The old potters were replaced by new ones from the plains where quartz sand was the normal inclusion in potters' clays.

Another archaeological presumption about post-exilic pottery is invalidated by this study of the non-plastic minerals in potsherds. Long ago it was observed that post-exilic

pottery in Palestine looked very much like contemporary Greek pottery, but only decorated pieces like black slip-glazed wares and vessels like Greek wine storage jars were considered as imports. However, it has now been shown by the study of the wares that large quantities of plain kitchen wares were imported from the Greek mainland, mainly Corinth.

The composition of the wares of many sherds is comparable with those of red slip-glazed Corinthian wares rather than with anything in the local production. Plain wares that resemble those of Attic black slip-glazed wares were not found in the Jerusalem assemblage. A small number of sherds even suggests that some Greek potters settled in the country and started a search for suitable clays which would fit their ways of producing pottery. They must have found one that was similar to clay B but with far fewer or no dolomite rhombs or only extremely minute ones. From this local Palestinian clay they produced Corinth-like pottery. Slowly this "Greek" pottery began to dominate the ceramic scene in Palestine and during the Hellenistic period the last Iron Age pottery shapes disappeared from the markets.

Notes

1. See for a full report on the clays and temper materials used in the Iron Age: Franken and Steiner (1990), and for the other periods Franken (forthcoming).

References

- Auld, G. and M. Steiner (1996), Jerusalem, from the Bronze Age to the Maccabees (Cities of the Biblical World), Cambridge.
- Franken, H.J. (forthcoming), Excavations in Jerusalem 1961-1967. The History of Pots and Potters in Ancient Jerusalem.
- Franken, H.J. and M.L. Steiner (1990), Excavations in Jerusalem 1961-1967, Vol. II. The Iron Age Extramural Quarter on the South-East Hill, Oxford.



A. van As L. Jacobs O.P. Nieuwenhuyse

THE TRANSITIONAL FINE WARE POTTERY OF TELL SABI ABYAD, SYRIA. A PILOT STUDY

The Department of Pottery Technology is involved in the study of the pottery excavated by the Dutch Archaeological Expedition under the direction of dr. P.M.M.G. Akkermans (National Museum of Antiquities in Leiden) at Tell Sabi Abyad in northern Syria (Fig. 1). This pilot study presents the results of a technological analysis of the Fine Ware pottery from the Transitional levels of Tell Sabi Abyad (ca. 5200-5100 B.C.). This Transitional period of Tell Sabi Abyad precedes the Halaf period. The ceramic-technological study of the Transitional pottery seeks to elucidate the origins of the Halaf pottery and its relations with other, contemporaneous ceramic traditions in Late Neolithic Mesopotamia¹.

Introduction

Among the thorniest problems in Near Eastern prehistory is the question of the so-called origins of the Halaf culture. This Late Neolithic culture (ca. 5100-4700 B.C.) is named after the site of Tell Halaf in northeastern Syria, where in the early thirties of our century the German aristocrat Baron Von Oppenheim started the excavation of the magnificent Iron Age palace of ancient *Guzana*. As an unexpected by-product, his excavations yielded an impressive collection of prehistoric (Late Neolithic), decorated pottery (Von Oppenheim and Schmidt 1943). It is no doubt the painted pottery that has made the Halaf culture most famous. Later excavations and surveys show that Halaf pottery has an unprecedented wide distribution over much of northern Mesopotamia, including the northern Levant, southeast Anatolia, northern Syria and Iraq (Fig. 2). According to Huot (1994: 63), the Late Neolithic period is "l'ère de la céramique peinte".

Initially, the seemingly sudden appearance of Halaf pottery over such a vast area gave rise to numerous hypotheses with respect to the location of the origins of the Halafian "tribes". Recent archaeological excavations in combination with surveys now suggest that the Halaf pottery style arose gradually out of a variety of Pre-Halaf ceramic assemblages. This process appears to have taken place — simultaneously — over much of the area subsequently covered by the Halaf phenomenon (Akkermans 1991, 1993, 1997; Campbell 1992, 1997; Nieuwenhuyse 1995, in press, in prep.; Le Mière and Nieuwenhuyse 1996). The key-site where this process is being documented is Tell Sabi Abyad, situated in the Balikh valley of the north-Syrian Jezirah (Figs. 1 and 2).

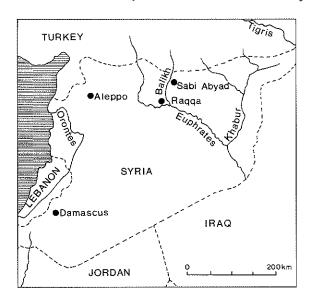


Fig. 1. Map showing the location of Tell Sabi Abyad, Syria.

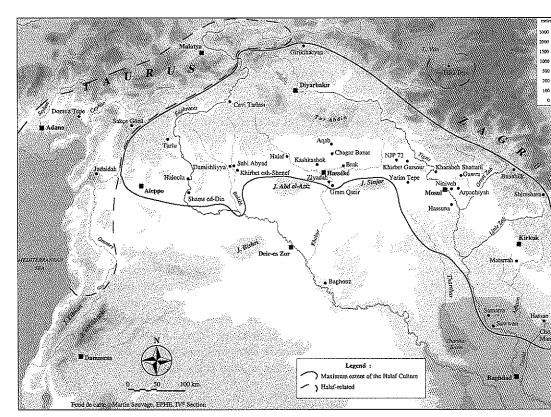


Fig. 2. Late Neolithic (Halaf) sites in northern Mesopotamia.

The Transitional pottery of Tell Sabi Abyad

The Late Neolithic mound of Tell Sabi Abyad covers about 4 hectares. Excavations down to virgin soil, some four metres below modern plain level, have exposed eleven superimposed building levels (Akkermans and Verhoeven 1995; Verhoeven and Kranendonk 1996). The site was occupied for almost a millennium (ca. 5700 B.C. to 5000 B.C.)². The sequence has enabled the reconstruction of the chronological framework for the region, which is divided into a number of major cultural-chronological periods (Table 1). The excavations document the crucial transition from the Pre-Halaf period, termed *Balikh IIIC*, via the short-lived period of transition termed *Balikh IIIA* to the Early Halaf of the *Balikh IIIB* period (Akkermans 1989, 1991, 1993, 1996).

Tell Sabi Abyad levels	Regional period	Period	Approximate date
1 2 3	Balikh IIIB	Early Halaf	5100-5000 B.C.
4 5 6	Balikh IIIA	Transitional	5200-5100 B.C.
7 8 9 10 11	Balikh IIC	Pre-Halaf	5700-5200 B.C.

Table 1. Chronological framework of Tell Sabi Abyad.

Although Tell Sabi Abyad is thus far the only site where this transition is being excavated, recent surveys in other regions of northern Mesopotamia (Campbell 1992; Wilkinson and Tucker 1995) show that the Balikh sequence may be used as a frame of reference on a wider, inter-regional scale (Nieuwenhuyse 1996).

The major ceramic innovation which signals the beginning of the Transitional period at Sabi Abyad, is the introduction in level 6 of a new category of ceramics: (decorated) Fine Ware. "Ware" is here defined as a class of pottery that shares a similar fabric, technology and surface treatment (Rice 1987: 484). This Fine Ware pottery shows a characteristic combination of a predominantly mineral-tempered fabric and a light-coloured surface. Fine Ware is much more often decorated than any other group, by means of painting, impressing or both. Introduced in small numbers in level 6, Fine Ware pottery rapidly increases in importance. By the time of level 3 it dominates all other ceramic categories (Le Mière and Nieuwenhuyse 1996). The high degree of decoration on the Fine Ware and its strong stylistic elaboration of vessel shape suggest that

this category functioned as a new and increasingly popular medium for the transmission of social messages (Campbell 1992: 212-218; Akkermans 1993: 318-321). During the Transitional period, the pottery is characterised by strong influences from the Hassuna and Samarra pottery styles, which were previously thought to be largely restricted to northern and central Iraq, respectively (Akkermans and Le Mière 1992; Le Mière and Nieuwenhuyse 1996).

Traditionally, Late Neolithic pottery in Mesopotamia has been primarily studied from a typo-chronological perspective. A basic problem here is how to define the ceramic categories (Campbell 1997). The traditional cultural framework of the Late Neolithic of northern Mesopotamia includes three distinct ceramic categories: Hassuna, Samarra, and Halaf. The Hassuna is found in the northern Jezirah, and the Samarra occurs in central Iraq. Both are ultimately replaced by the Halaf. According to this framework, Samarran pottery was exported from the Samarra "homelands" in central Iraq into the Hassuna communities up north, where, moreover, Samarran pottery was often copied (Llovd and Safar 1945; Mortensen 1970; Munchaev and Merpert 1971).

In the past, however, the distinctions between these various ceramic categories were not made on the basis of technological analyses. Today, it has been increasingly recognised that these distinctions are blurred (Bernbeck 1994; Campbell 1992, 1997; Gut 1995; Nieuwenhuyse in press; see already Braidwood 1945; Braidwood *et al.* 1952). Thus, at Tell Sabi Abyad, there appears to be no sharp boundary between the Hassunal Samarra-style pottery from the Transitional levels and the pottery from the Early Halaf levels. Moreover, a first examination of the Transitional pottery has suggested the existence of at least three sub-groups of Fine Ware, termed Standard Fine Ware (Figs. 3 and 4), Orange Fine Ware (Fig. 5) and Fine Painted Ware (Fig. 6) (Le Mière and Nieuwenhuyse 1996). These groups all combine Hassuna and Samarra stylistic and technological traits to various extents. While some Standard Fine Ware vessels at Tell Sabi Abyad are suspiciously similar to 'classic' Samarra pottery from central Iraq (*e.g.* Fig. 4), others are clearly not (*e.g.* Fig. 3). The variation in technological and stylistic aspects is such, however, that at present no clear boundary can be drawn in the field to distinguish one group of 'classic' Samarra pottery from other groups.

A ceramic-technological pilot study

The present study gives the first results of a ceramic-technological pilot study of a sample of 224 sherds of (decorated) Fine Ware pottery from the Transitional levels of Tell Sabi Abyad currently stored at the National Museum of Antiquities in Leiden³.

The aims of the present ceramic-technological pilot study are to gain a first insight into the changes in pottery technology and resource selection during the Transitional period, and to evaluate the potential for further work. Following the categorization of Le Mière and Nieuwenhuyse (1996), the sample consisted mostly of Standard Fine Ware (Figs. 3 and 4), but included Orange Fine Ware (Fig. 5) and Fine Painted Ware as well (Fig. 6)⁴. The Standard Fine Ware consisted of both Standard Fine Ware decorated in a presumably local style (Fig. 3) and Standard Fine Ware decorated in the Samarra style (Fig. 4; see also Fig. 7).

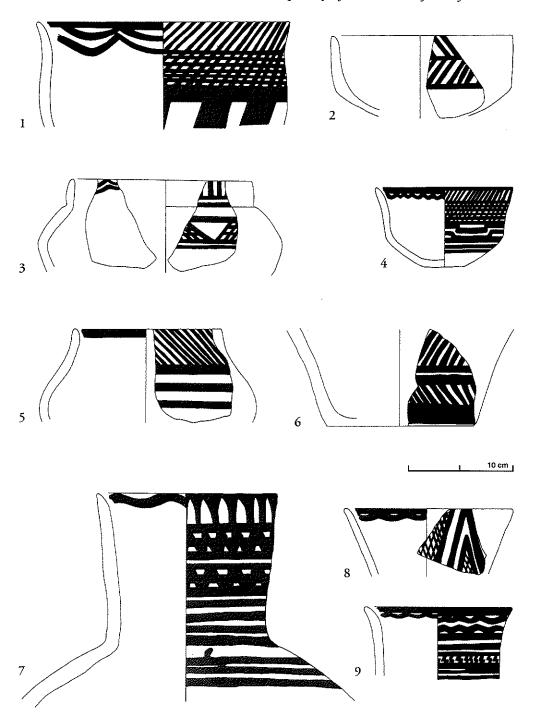


Fig. 3. Selection of Standard Fine Ware ("Local Style") used in this study.

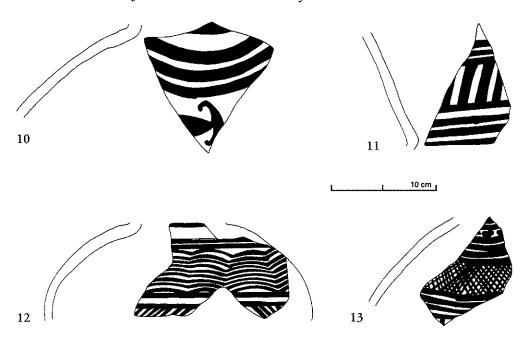


Fig. 3 (continued). Selection of Standard Fine Ware ("Local Style") used in this study.

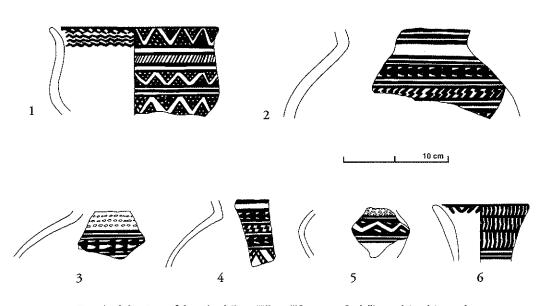


Fig. 4. Selection of Standard Fine Ware ("Samarra Style") used in this study.

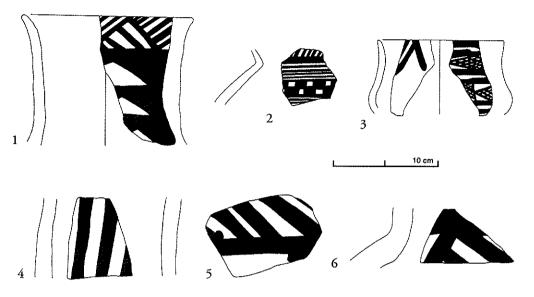


Fig. 5. Selection of Orange Fine Ware used in this study.

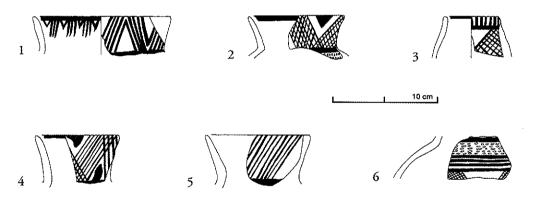


Fig. 6. Selection of Fine Painted Ware used in this study.

This study follows in the footsteps of earlier research on this pottery along these lines by the Department of Pottery Technology (van As and Jacobs 1989) and by the *Maison de l'Orient* of the University of Lyon (Le Mière 1989; Le Mière and Picon 1991). Rather than the purely 'high tech' approach adopted by many researchers (e.g. Davidson 1977; Davidson and McKerrel 1976; Le Mière and Picon 1987; Bader, Bashilov, Le Mière and Picon 1991), the Department of Pottery Technology emphasizes a 'low tech' approach as a basis for such 'high tech' ceramic studies (van As 1995).



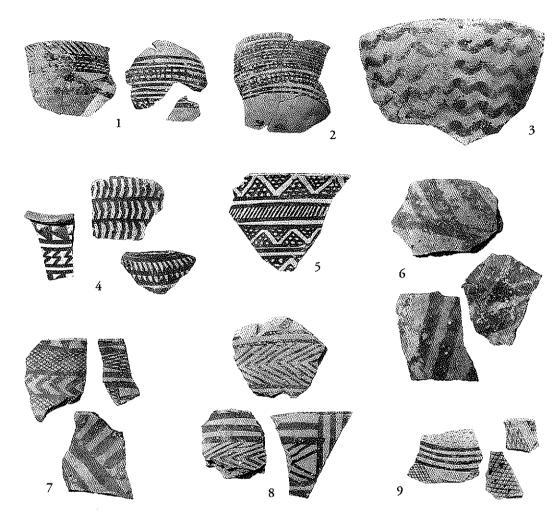


Fig. 7. Examples of Standard Fine Ware ("Local Style") (nos. 1-3), Standard Fine Ware ("Samarra Style") (nos 4-5), Orange Fine Ware (nos. 6-8), and Fine Painted Ware (no. 9) used in this study (not on scale).

The shaping technique

The sample of Fine Ware being studied included both flat and convex base fragments. The flat bases of the vessels were made by pressing out a slab of clay either between the hands or on a flat basis. Next the vessel was made by using the coiling technique. The convex bases, in contrast, were made by pressing soft clay into a mould. As a next step, the clay was spread out and the surplus was scraped away. Some convex bases seem to have been made in little holes in the ground. Characteristic indications of moulding are

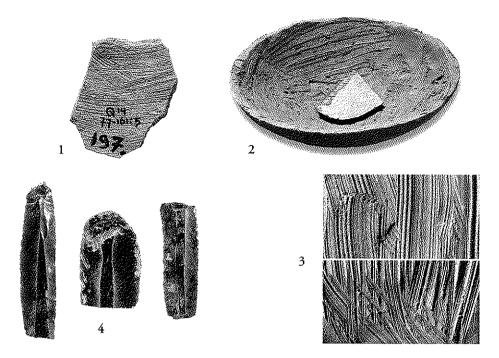


Fig. 8. Reconstruction of traces of scraping on Fine Ware pottery:
(1) Standard Fine Ware jar with the interior surface scraped; (2) reconstruction of Standard Fine Ware jar base with interior scraped by using a flint tool; (3) simulation of scraping a fine clay using Late Neolithic flint and obsidian tools from Tell Sabi Abyad;
(4) flint and obsidian tools used in the simulation experiment.

the exterior smooth and regular surface and the marks of pressing, spreading and scraping on the inside. On some base fragments the finger impressions are rather deep. This indicates that the clay was firmly pressed into the mould. Using a mould made it also possible to scrape the inside of the base more strongly. In some cases it seems that blades of flint or obsidian were used as scrapers. In fact, these scraping marks fully resemble those left behind during a simulation experiment using Late Neolithic blades from Tell Sabi Abyad (Fig. 8)⁵.

As to the convex bases, after a short period of drying, the base taken out of the mould was strong enough to build up the vessel. The vessels were built using the coiling technique. One after the other, the coils were added and pressed upwards. A potsherd or a scraper must have been used to give counterpressure. However, since the surface on the outside was finally made as smooth and even as possible, the traces of the use of this tool have mostly been erased⁶. During the building up of the vessel by coiling, the thickness of the body was controlled. If necessary, the thickness was slightly reduced or a little bit of clay was added. Generally, however, the clay must have been strong enough not to collapse when coils of clay were being added.

In some cases, where subsequent smoothing of the surface had not obliterated the traces of shaping, the coiling technique was still clearly identifiable by the thickenings due to the fastening of the coils. Wherever the coils had not been carefully attached, the vessel broke easily along the attachment. Many fragments show such a pattern of breaking. The body of the vessel made by coiling was evidently less regular than the part shaped in a mould.

After the vessel had been formed, the exterior of the body was smoothed with a spatula of wood or bone and then by rubbing over the surface with the hand or a piece of leather. Mostly, the open shapes were also smoothed on the inside. In these cases, the traces on the interior surface indicating that the base was made in a mould were less clearly visible.

Only one small fragment was found of which the neck was made by adding a coil of clay to the lower half of the vessel that had been formed by pinching a ball of clay.

Finally, it should be mentioned that, considering the irregular thickness of the wall and the badly sorted coarse tempering material, the Orange Fine Ware in general seems to have been less carefully made than the other Fine Ware groups.

Decoration and firing

The decoration of the Standard Fine Ware and the Fine Painted Ware consists of painting and, to a lesser degree, of painting in combination with impressions and incisions. The decoration of the Orange Fine Ware consists exclusively of painting.

The horizontal painted lines are in most cases very even and uninterrupted and were carried out in a very regular manner. The thickness of these lines is also very regular (Fig. 7). This suggests that a rotating surface, probably a turntable, was used for painting these lines⁷.

The three groups (viz. Standard Fine Ware, Orange Fine Ware, Fine Painted Ware) differ in paint colour. The painting of the Standard Fine Ware is predominantly dark. A weak red (Munsell Soil Color Charts: 2.5YR 5/2, 5/3 and 6/3) or a dusky red (2.5YR 4/2, 4/3) paint is observed occasionally, but dark grey (5YR 4/1, 4/2 and 10YR 4/1), dark greyish brown (10YR 4/2) or dark brown (10YR 3/3) is more characteristic. In contrast, the surface of the Standard Fine Ware is very light and varies from pale brown (10YR 8/4, 8/3 and 7/4, 7/3) to pale yellow (2.5Y 7/3, 8/2 and 8/3) and pink (7.5YR 8/4). In this way, Standard Fine Ware is characterised by a reasonable to good contrast between the dark paint and the light background (Fig. 7). The painting consists of a clay slip which was applied with a fine paintbrush on the vessel after drying.

The painting of the Fine Painted Ware is of a red (2.5YR 5/8 and 5/6) and dark red (2.5YR 4/8) colour. The surface of the Fine Painted Ware varies from weak red (2.5YR 6/4) to very pale brown (10YR 7/2, 7/3 and 8/2, 8/3) and light grey (10YR 7/2). Sometimes, the painting showing a gloss of sintering was burnished. Wherever the painting of the Fine Ware has crumbled off by its long stay in the ground, the painted lines are only visible as relatively light stripes against the dirty background of secondary deposits.

The painting of the Orange Fine Ware varies from weak red (2.5YR 5/4, 5/3 and 6/2) to red (2.5YR 5/6). The surface of this ware is of a lighter colour and varies from reddish yellow (5YR 6/8, 7/6 and 7/8) to pink (5YR 7/3).

In order to gain an understanding of the genesis of the dark colour of the painting of the Standard Fine Ware, the elementary composition of both the unpainted surface and the painting of two sherds – one of the Standard Fine Ware ("Samarra Style") and one of the Orange Fine Ware – has been analysed by using the Scanning Electron Microscope (SEM) microprobe (Figs. 9-12)9.

The microprobe-spectra of the surface of both wares (Figs. 9 and 11) show, apart from the normal clay components (Al and Si), also a high proportion of calcium (Ca) that is common in the montmorillonite clay of Northern Mesopotamia (Schneider 1991). To a lesser degree, the microprobe-spectra show magnesium (Mg) and potassium (K). The Standard Fine Ware ("Samarra Style") shows sulphur (S) as well. In combination with calcium, the sulphur forms gypsum (CaSO₄), which, together with magnesium, is present as a "scum" on the surface.

In both wares iron (Fe) was measured as the only colouring element. From the presence of iron (Fe) we may conclude that the orange-red colour of the Orange Fine Ware has arisen by firing in an oxidizing atmosphere. Pottery made of iron containing clay becomes orange-red if fired in an oxidizing atmosphere in which the iron (Fe) forms Fe₂O₃. This holds also for the painting of the Orange Fine Ware. Both the sherd and the surface of the Standard Fine Ware ("Samarra Style"), where not painted, are of a very pale brown, pale yellow and pink colour. These light colours are characteristic of most pottery made of clay from the Balikh, Euphrates and Tigris basins, and arise as a consequence of a neutral firing atmosphere. Light surface colours are obtained especially in a kiln in which the combustion gas is being retained for some time. Under such circumstances, any iron component possibly present in the clay cannot easily combine with oxygen, prohibiting a red surface colour to form. The following happens with the iron in the clay. Part of it combines with chlorine vapour and evaporates, particularly when the clay contains salts like NaCl, KCl, CaCl and MgCl. The possibly still remaining iron is combined with calcium silicates already formed at a low temperature (from 750°C onwards) contributing to a relatively light surface colour.

The dark red to dark grey colour of the painting of the Standard Fine Ware ("Samarra Style") can be explained by the forming of FeO as a result of firing in a slightly reducing atmosphere and at sufficiently high temperatures (900-950°C). Since some sintering had already taken place because of the rather high firing temperature, the already reduced iron (FeO) could not be oxidized again at the end of the firing process. At the painted places a fusion of FeO with magnesium-, potassium- and calcium salts developed. The varying calcium, potassium, iron and magnesium contents together with the firing circumstances in a rather acid (SiO₂) atmosphere explain the dark-red to dark-grey colours of the painting. Occasionally, the colour of the painting shades into purple. This colour is probably caused by the fact that the iron is not quite pure, but occurs in combination with non-measurable traces of manganese. Like in glazes, these traces, in combination with the potassium salts in concentration at the surface explain the purplish-brown colour. Potassium salts may have been obtained by the burning of vegetable material like salicornia and prosopis. The resulting ash is called potassium and can be added to the clay slip (Steinberg and Kamilli 1984).

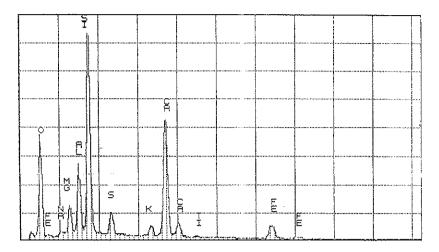


Fig. 9. Element spectra of the surface of Standard Fine Ware ("Samarra Style").

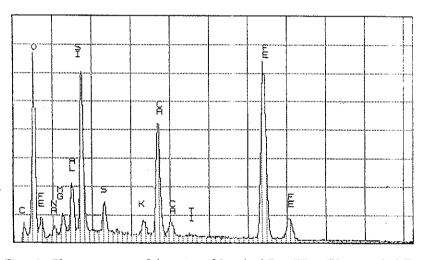


Fig. 10. Element spectra of the paint of Standard Fine Ware ("Samarra Style").

The fabric

In order to give a more detailed description than was made in the field (Le Mière and Nieuwenhuyse 1996), the fabric was analysed. At the same time, the aim was to gain a clear understanding of the similarities and differences of the fabric of the various categories of Fine Ware.

Out of the total number of 224 sherds of Fine Ware being studied, a sample of 82 sherds was analysed, divided over the various sub-categories: 53 sherds of Standard Fine

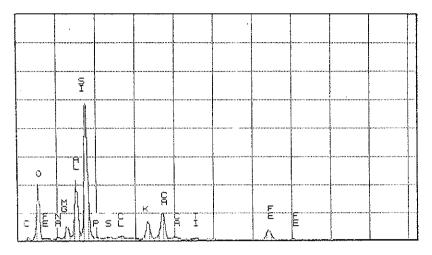


Fig. 11. Element spectra of the surface of Orange Fine Ware.

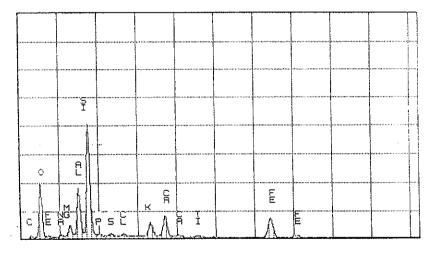


Fig. 12. Element spectra of the paint of Orange Fine Ware.

Ware ("Local Style"); 8 sherds of Standard Fine Ware ("Samarra Style"); 12 sherds of Orange Fine Ware; 9 sherds of Fine Painted Ware.

First of all, in order to standardise differences in colour due to firing, the sherds were refired in an oxidizing atmosphere at 750°C, the raised temperature being maintained for 30 minutes. After recording the colour, the non-plastic inclusions were analysed by binocular microscopy (40× magnification) (types, size, quantity, shapes, sorting, colour). At the same time, attention was paid to the pores and the matrix. The fabric analysis yielded six fabric groups.

Fabric 1

38

14 sherds Standard Fine Ware ("Local Style")

Colour:

surface:

2.5Y 8/2 (pale yellow).

core:

10YR 7/4 (very pale brown) and 5YR 7/6 (reddish yellow).

paint: 5YR 5/4 (reddish brown).

Grains:

dominant types:

burnt-out micro-fossils.

a few types:

mudrock; undissolved grains of clay (sometimes rather large). calcium (residues of micro-fossils/partly secondary); iron-oxide silt-

sporadic types: calciu

stone; (very small) quartz grains.

dominant size:

 \leq 500 μ ; sometimes larger grains.

quantity:

5-10%.

dominant shapes:

sub-rounded; some rounded.

sorting:

moderate/good. mainly light.

colour:

small.

Pores: Matrix:

compact; hard; zoned clay deposit; rather plastic and therefore some-

times not very homogeneous.

Fabric 2

30 sherds Standard Fine Ware ("Local Style")

Colour:

surface: 2.5Y 7/3 (pale yellow) and 10YR 7/4 (very pale brown).

core:

2.5Y 7/3 (pale yellow) and 10YR 7/4 (very pale brown).

paint:

5YR 6/6 (reddish yellow) and 10YR 3/2 (very dark greyish brown).

Grains:

dominant types:

transparent quartz; burnt-out grains of carbonate (partly micro-

fossil to light brown crust of a residue/partly calcium).

a few types:

none

sporadic types:

rock fragments (including quartz); siltstone; compounds of iron;

micas; undissolved grains of clay.

dominant size:

≤ 500µ.

quantity:

5-20%, mainly around 10%.

dominant shapes:

sub-angular to sub-rounded; some angular.

sorting:

good.

colour:

mainly light.

Pores:

very small.

Matrix:

compact; some very compact.

Fabric 3 9 sherds Standard Fine Ware ("Local Style")

Colour:

surface: 5YR 7/4 (pink) and 10YR 7/4 (very pale brown).

5YR 7/4 (pink). core:

5YR 6/8 (reddish yellow) and 5YR 7/4 (pink). paint:

Grains:

calcium (partly micro-fossil); burnt out grains (micro-fossil). dominant types:

sometimes grains of quartz; undissolved grains of clay. a few types:

compounds of iron; quartz grains; siltstone; undissolved grains of sporadic types:

clay; micaceous schists; micas.

 $\leq 500\mu$; sporadically grains ≤ 2 mm. dominant size:

10-20%; mainly around 15%. quantity: dominant shapes: sub-angular to sub-rounded.

very small.

moderate/bad. sorting:

colour: mainly light.

Matrix: compact.

Fabric 4 8 sherds Standard Fine Ware ("Samarra Style)"

Colour:

Pores:

2.5YR 7/3 (pale yellow) and 10YR 8/4 (very pale brown). surface:

2.5Y 7/3 (pale yellow), 5YR 8/3 (pink) and 10YR 7/3 (very pale brown). core: 10YR 4/4 (dark yellowish brown) and 10YR 3/6 (dark yellowish brown).

paint:

Grains:

transparent quartz (sometimes relatively much in relation to Fine dominant types:

Painted Ware); burnt-out carbonate grains (crust of a light red residue of a more or less globular shape); (more or less burnt-out)

calcium carbonate.

iron-oxide sandstone; sandstone. a few types:

dark grains (pyroxene). sporadic types:

dominant size: $\leq 500 \mu$.

10-20%, mainly around 15%. quantity:

dominant shapes: angular to sub-angular.

sorting:

good; moderate.

various; mainly light. colour:

very small; hollow spaces with an elongated shape (burnt fibres of Pores:

organic origin).

Matrix: compact. Fabric 5 12 sherds Orange Fine Ware

Colour:

surface: 2.5YR 6/6 (red) and 5YR 8/3 (pink). 2.5YR 6/6 (red) and 5YR 8/3 (pink). core:

2.5YR 5/8 (red). paint:

Grains:

dominant types: mudstone/mudrock: limestone/micro-fossils.

a few types: siltstone; limestone (in some sherds the limestone content is rather

low).

sporadic types: compounds of iron; a little quartz.

dominant size: ≤ 2 mm; sometimes larger.

quantity:

15-20%. dominant shapes: sub-angular to sub-rounded.

sorting: colour:

moderate/bad. mainly light.

Pores:

normal; sometimes holes from burnt fibrous material of organic

origin, orientated in several directions.

Matrix:

normal; sometimes normal to compact.

Fabric 6 9 sherds Fine Painted Ware

Colour:

surface: 10YR 7/3 (very pale brown) and 5YR 7/3 (pink).

core:

10YR 6/3 (pale brown), 10YR 8/6 (yellow) and 5YR 7/3 (pink).

2.5YR 6/6 (red) and 5YR 5/4 (reddish brown). paint:

Grains

dominant types: burnt-out carbonate grains (most of micro-fossil origin); calcium

(from micro-fossil origin; partly secondary); clear quartz; quartz

sandstone may occur.

other types:

grains containing iron-oxide; mudrock may occur; micaceous schists

may occur.

sporadic types:

grains containing iron-oxide (e.g. iron siltsone).

dominant size:

 $\leq 500\mu$; sometimes larger grains, up to 2 mm.

quantity:

5-10%.

dominant shapes:

sorting:

angular to sub-angular and/or sub-rounded.

good.

colour:

mainly light.

Pores:

very small, sometimes elongated, with a flat fibrous shape orientated

in several direction: caused by burnt-out organic material.

Matrix:

compact.

The Standard Fine Ware ("Samarra Style"), the Orange Fine Ware, and the Fine Painted Ware formed the fabric groups 4, 5 and 6, respectively. The examination of the fabric of the Standard Fine Ware ("Local Style") suggested the presence of three different fabric groups (fabric groups 1-3).

It should be noted that after refiring, the colours of the sherds <u>within</u> each fabric group vary strongly. On the other hand, there are several overlaps <u>between</u> the various groups. The *a priori* differences between the various wares appear to be mainly based on decorative characteristics. In particular, the distinction based on style between "local" and "Samarra Style" Standard Fine Ware does not reveal itself in a mere fabric categorization. Based on the composition of the fabric of the Standard Fine Ware ("Samarra Style") we may not assume that this ceramic category is of non-local origin. Only the Orange Fine Ware (fabric 5) clearly contrasts with the other fabric groups. The difference consists of the kind of inclusions (more limestone and mudrock), the amount and largeness of the grains. At the same time, the matrix is less compact. In general the material is coarser.

Summary and conclusions

Some aspects of continuity as well as of innovation are becoming apparent regarding Fine Ware production at Tell Sabi Abyad. Continuity is certainly visible in the methods of shaping. Shaping techniques for Fine Ware production during the Transitional stage appear to be similar to the shaping techniques for the Early Halaf Fine Ware pottery (van As and Jacobs 1989). Coiling seems to have been the major shaping technique employed for all Transitional Fine Ware groups. In addition, pinching was used for the production of small vessels¹⁰. Thus, it appears that the evolution from the Samarra/ Hassuna-influenced Transitional Fine Ware to the Early Halaf Fine Ware at Tell Sabi Abyad was not characterised by the introduction of new shaping methods.

However, some small changes perhaps suggest modifications in the organisation of pottery production. Convex bases, which were made by using moulds, became more common during the Transitional Period and, in particular, the Early Halaf period (Le Mière and Nieuwenhuyse 1996). Using moulds increases the output per unit of time and this suggests, perhaps, an intensification of production during the Transitional period (Rice 1987: 190). To paint the regular horizontal lines that are at the basis of the decoration of the Fine Wares from the Transitional period, the potters probably used a rotating device. Such horizontal lines are not regularly part of the stylistic conventions of the Pre-Halaf painted pottery at Tell Sabi Abyad. Evidently, the use of a simple turning device does not reflect changes in the organisation of the pottery production of a similar impact as does the introduction of the potter's wheel, which in Mesopotamia takes place much later during the Uruk period. It may indicate, however, a more rationalised production of painted pottery. It can be suggested that one characteristic in particular of the transition in Syria and northern Mesopotamia is that the painted pottery traditions from various regions became increasingly similar to each other, eventually culminating in the strong stylistic unity of the Halaf period. In this respect, Peter Akkermans (1997) recently spoke of the Halaf as a "cultural umbrella" affecting numerous

groups. This trend may have been facilitated by the adoption of standardised techniques of decoration.

A major technological innovation seems to be represented by the development of a better control over firing conditions. Rather than using special pigments for black paint, it appears that in order to produce the new, black-on-buff painted Standard Fine Ware, the potters at Tell Sabi Abyad experimented with varying oxygen conditions in the oven¹¹. It has convincingly been shown that superior control over reduction and reoxidation stages during the firing process produced the lustrous, dark-painted Fine Wares of the Halaf period (van As and Jacobs 1989; Matson 1983; Noll 1976a, 1976b, 1991; Steinberg and Kamili 1984). As several of these writers have emphasised (e.g. Noll 1991), the Halaf potters used firing strategies that resemble those used by the potters of classical Greece. Compounds such as potassium may have been added to the clay slip in order to facilitate the sintering process needed to keep a dark paint and to produce a desirable light surface (Rice 1987: 116; Jacobs 1991/1992). At the same time, salts, like NaCl, KCl, and MgCl, in lower contents natural to the clay would have counteracted the tendency of the calcite inclusions (lime to spall and thus causing damage to the surface (Klemptner and Johnson 1986; Rice 1987: 116).

At Tell Sabi Abyad, we may place these observations in an evolutionary perspective. The Pre-Halaf pottery is painted exclusively with reddish paint (Le Mière and Nieuwenhuyse 1996: 138, 155), whereas the earliest Halaf pottery is already painted with dark colours in a rather standardised way (Le Mière and Nieuwenhuyse 1996: 178); Nieuwenhuyse 1997). The necessary steps towards mastering this new technique of firing pottery thus appear to have been taken during the Transitional period. Perhaps significantly, in northern Iraq it is at precisely this time (the Standard Hassuna phase) that 2-stage updraught kilns appear at Yarim Tepe 1 (Merpert and Munchaev 1973: 102). These updraught kilns have not yet been attested at Tell Sabi Abyad, but it is reasonable to suggest that such kilns were used for the Fine Ware production. Although it is not excluded that less complex types of kilns were used, the even paint colour observed on most of the sherds suggests well-controlled firing conditions¹². However this may be, small numbers of wasters and warped vessels excavated at Tell Sabi Abyad attest to the fact that Fine Ware pottery was being produced on or near the site (Le Mière and Nieuwenhuyse 1996: 158, 178, Fig. 3.32:1).

Evaluating the results of the present pilot study, it is too preliminary to answer with certainty the question whether a 'classic' Samarra group can be differentiated on technological grounds from the rest of the decorated Standard Fine Ware pottery. One shortcoming includes the small size of the present sample and the fact that most of the sample comes from the end of the Transitional period (level 4), when Standard Fine Ware had already evolved to become very similar to the Early Halaf pottery in technological aspects (Le Mière and Nieuwenhuyse 1996). The sample is much less representative for the start of the Transitional period (level 6), when the Samarra-style pottery was first introduced.

Nevertheless, the results of the pilot study support the impression gained in the field, namely that there is at present insufficient evidence to distinguish such a 'classic' Samarra group on technological grounds.

The lack of a clear differentiation between 'local' and 'imported' Samarra pottery at Tell Sabi Abyad is in agreement with other recent studies that question whether the 'classic' Samarra pottery was distributed outside the Samarra heartland (Bernbeck 1994; Blackham 1996; Gut 1995). For the moment, the small differences in fabric between the Standard Fine Ware ("Samarra Style") and Standard Fine Ware ("Local Style") may well be attributed to subtle variations in the local clays that are available. The Balikh river is nearby, within the 7 km distance that is often seen as the maximum resource area for clays preferred by traditional potters (Arnold 1985: 50)¹³. There is, therefore, no strong reason to doubt that Samarra-style Standard Fine Ware pottery was made locally. In this respect, Neutron Activation Analyses currently carried out by the *Maison de l'Orient* are eagerly awaited.

The Orange Fine Ware, in contrast, seems to differ in terms of fabric as well as in firing procedures from the Standard Fine Ware. Although based on this pilot study, it may eventually be possible to separate this minor category of decorated Fine Ware more clearly from the majority of Standard Fine Ware. This is further suggested by a chemical pilot-study carried out by the *Maison de l'Orient* which suggests that Orange Fine Ware may be of non-local origin, although its location of production remains uncertain (Le Mière pers. comm.). Recent survey work suggests that Orange Fine Ware may have had a wide distribution over northern Mesopotamia (Le Mière in press; Nieuwenhuyse in press). Orange Fine Ware even occurs in the 'classic' Samarran assemblage of Tell Baghouz (Nieuwenhuyse in prep.). Ironically, however, while Orange Fine Ware shows Samarran vessel shapes as well as Samarran decoration, its technological characteristics put it clearly aside from what is commonly seen as 'classic' Samarra pottery.

As Blackham (1996: 13) recently emphasised, systematic ceramological-technological research is essential at this stage to examine how to define and to interpret the distribution of Samarra-style pottery over Mesopotamia. In a wider sense, such research must help us to come to a better understanding of the enormous changes in the technology and production of pottery that characterise the transition from Pre-Halaf to Early Halaf in Syria and northern Mesopotamia. This quest has only just begun.

Notes

- 1. This study would not have been possible without the support of the following institutions and persons: the National Museum of Antiquities (Leiden), Peter M.M.G. Akkermans, Marc Verhoeven and Eric Mulder. The SEM analyses have been made available by Gerrit Hamburg of the *Energie Centrum Nederland*, for which we are most grateful. We thank dr. Rijpkema of the Amsterdam police for his fingerprint inspection. The drawings have been made by Erick van Driel (Fig. 1), dr. Martin Sauvage (Fig. 2), and Olivier Nieuwenhuyse (Figs. 3-6).
- 2. This is based upon uncalibrated radiocarbon dates. Using calibrated dates (Stuiver and Reimer 1993) the occupation at Tell Sabi Abyad falls in between ca. 6100 B.P. and 5850 B.P.
- 3. The available sample included 24 Fine Ware sherds from level 6, 15 Fine Ware sherds from level 5, and 135 Fine Ware sherds from level 4.

44 A. van As, L. Jacobs and O.P. Nieuwenhuyse

- 4. The sample consisted of 178 Standard Fine Ware sherds, 37 Orange Fine Ware sherds, and 9 Fine Painted Ware sherds.
- 5. The lithic tools used in this experiment are blades, scrapers made of flint and obsidian, and a flint scraper known as "tile knife" (Copeland 1996: 294).
- 6. A sample of Transitional sherds from Tell Sabi Abyad, including 25 Fine Ware sherds, was closely inspected for the presence of fingerprinting by dr. Rijpkema of the Department of Dactyloscopie of the Amsterdam police. No single fingerprint could be identified.
- 7. Turntable or tournette: a small hand-operated wheel. It was rotated at slow speeds and did not continue to rotate under its own momentum.
- 8. Throughout the Transitional period at Sabi Abyad, the use of a dark paint for Standard Fine Ware increases, whereas the use of a light, reddish paint decreases (Le Mière and Nieuwenhuyse 1996: 163).
- 9. De SEM analyses have been carried out by G. Hamburg in the *Energie Onderzoekscentrum* in Petten (the Netherlands).
- 10. No evidence was found for sequential slab construction, a shaping technique that has been attested for the Neolithic period in the Zagros region (Vandiver 1987).
- 11. The other strategy for producing a dark-coloured paint on a light background would consist of using special pigments, such as manganese-rich iron oxide or bitumen. As a matter of fact, bitumen painting may have been present at Tell Sabi Abyad, but not on the Fine Wares (Le Mière and Nieuwenhuyse 1996: 156, 157, Fig. 3.17:1-4). Manganese paint seems exceptionally uncommon in northern Mesopotamia. In southern Mesopotamia, however, and broadly contemporary with the Transitional period at Tell Sabi Abyad, the Samarra-related 'Ubaid 0 pottery from Tell 'Ouweili was painted with manganese paint (Huot 1989: 33). Closer to the Balikh valley, but from a much later date, is a (single) 'Ubaid-period sherd from Ras Shamra on the Syrian coast that was painted with a manganese-rich paint (Courtois and Velde 1984: 90).
- 12. At Tell Sabi Abyad, large key-hole shaped ovens have been found (Verhoeven and Kranendonk 1996: 81-83, 108-111, Fig, 2.32). Although Verhoeven and Kranendonk suggest that these were not used for pottery production (*ibid.*: 82), they appear to be remarkably similar to pottery kilns found at Late Halaf Tell Ziyada (Buccellati, Buia and Reimer 1991).
- 13. A geological survey of the available clays surrounding Tell Sabi Abyad and their ceramological characteristics is planned for the 1998 field season.

References

- Akkermans, P.M.M.G. (ed.) (1989), Excavations at Tell Sabi Abyad. Prehistoric Investigations in the Balikh Valley, Northern Syria. BAR Int. Series 468.
- Akkermans, P.M.M.G. (1991), New radiocarbon dates from the later Neolithic of Northern Syria. *Paléorient* 17/1: 121-125.
- Akkermans, P.M.M.G. (1993), Villages in the Steppe: Later Neolithic Settlement and Subsistence in the Balikh Valley, Northern Syria, Michigan.

- Akkermans, P.M.M.G. (ed.) (1996), Tell Sabi Abyad: the Late Neolithic Settlement. Report on the Excavations of the University of Amsterdam (1988) and the National Museum of Antiquities (1991-1993) in Syria, Istanbul.
- Akkermans, P.M.M.G. (1997), Old and new perspectives on the origins of the Halaf culture. In: O. Roault and M. Wafler (eds.), La Djéziréh et l'Euphrate syriens de la Protohistoire à la fin du second millénaire av. J.C. Tendances dans l'interprétation historique des données nouvelles, Actes du colloque international organisé au Collège de France, 21-24 juin 1993, Paris: 55-68.
- Akkermans, P.M.M.G. and M. Le Mière (1992), The 1988 excavations at Tell Sabi Abyad, a Later Neolithic village in Northern Syria. *American Journal of Archaeology* 96: 1-22.
- Akkermans, P.M.M.G. and M. Verhoeven (1995), An image of complexity: the burnt village at Late Neolithic Sabi Abyad, Syria. *American Journal of Archaeology* 99/1: 5-32.
- Arnold, D.E. (1985), Ceramic Theory and Cultural Process, Cambridge.
- As, A. van (1995), Pottery technology: the bridge between archaeology and the laboratory. In: Khairieh 'Amr, Fawzi Zayadine and Muna Zaghloul (eds.), Studies in the History and Archaeology of Jordan V, Amman: 541-544.
- As, A. van and L. Jacobs (1989), Technological aspects of the prehistoric pottery. In: P.M.M.G. Akkermans (ed.), Excavations at Tell Sabi Abyad. BAR Int. Series 468: 215-232.
- Bader, N.O., V.A. Bashilov, M. Le Mière and M. Picon (1994), Productions locales et importations de céramique dans le Djebel Sinjar au VI millénaire. *Paléorient* 20/1: 61-68.
- Bernbeck, R. (1994), Die Auflösung der häuslichen Produktionsweise Berlin.
- Blackham, M. (1996), Further investigations as to the relationship of Samarran and Ubaid ceramic assemblages. *Iraq* LVIII: 1-15.
- Braidwood, R.J. (1945), Prefatory remarks. In: S. Lloyd and F. Safar, Tell Hassuna. Excavations by the Iraq Government Directorate General of Antiquities in 1943 and 1944. *Journal of Near Eastern Studies* IV: 255-259.
- Braidwood, R.J., L.S. Braidwood, J.G. Smith and C. Leslie (1952), Matarrah: a southern variant of the Hassunan assemblage, excavated in 1948. Journal of Near Eastern Studies 1: 2-70.
- Buccellati, G., D. Buia and S. Reimer (1991), Tell Ziyada: the first three seasons of excavation (1988-1990). Bulletin Canadian Society for Mesopotamian Studies 21: 31-61.
- Campbell, S. (1992), Culture, Chronology and Change in the Later Neolithic of North Mesopotamia. Ph.D. thesis, University of Edinburgh.
- Campbell, S. (1997). Problems of definition: the origins of the Halaf in North Iraq. Subartu IV-2: 39-52.
- Copeland, L. (1996), The flint and obsidian industries of the Halaf in North Iraq. In: P.M.M.G. Akkermans (ed.), Tell Sabi Abyad: the Late Neolithic Settlement. Report on the Excavations of the University of Amsterdam (1988) and the National Museum of Antiquities (1991-1993) in Syria, Istanbul: 285-338.
- Courtois, L. and B. Velde (1984), Recherches comparées sur les materiaux et les techniques de peintures céramiques de Mésopotamie (VI-V millénaire). *Paléorient* 10/2: 81-93.
- Davidson, T.E. (1977), Regional Variation within the Halaf Culture. Ph.D. thesis, University of Edinburgh.
- Davidson, T.E. and H. McKerrel (1976), Pottery analysis and Halaf trade in the Khabur headwaters regions. *Iraq* 38: 45-56.
- Gut, R.V. (1995), Das Prähistorische Nineveh. Zur relativen Chronologie der frühen Perioden Nordmesopotamiens, Mainz.
- Huot, J.L. (1989), 'Ubaidan villages of lower Mesopotamia. Permanence and evolution from 'Ubaid 0 to 'Ubaid 4 as seen from Tell 'Ouweili. In: E.F. Henrickson and I. Thuesen (eds.), Upon this Foundation the 'Ubaid Reconsidered, Copenhagen: 18-40.

- Huot, J.L. (1994), Les premiers villageois de Mésopotamie: du village à la ville, Paris.
- Jacobs, L. (1991/1992), Causes for the pale colour of iron-containing, second millennium B.C. pottery from three archaeological sites in Mesopotamia. Newsletter of the Department of Pottery Technology (Leiden University) 9/10: 7-21.
- Klemptner, L.J. and P.F. Johnson (1986), Technology and the primitive potter: Mississippian pottery development seen through the eyes of a ceramic engineer. In: W.D. Kingery (ed.), Technology and Style. Ceramics and Civilization vol. II, Columbus: 251-271.
- Le Mière, M. (1989), Clay analyses of the prehistoric pottery: first results. In: P.M.M.G. Akkermans, (ed.), Excavations at Tell Sabi Abyad. BAR Int. Series 468: 233-235.
- Le Mière, M. and M. Picon (1987), Production locales et circulations de céramiques au VI millénaire au Proche Orient. Paléorient 13/2: 133-147.
- Le Mière, M. and M. Picon (1991), Early Neolithic pots and cooking. In: R.B. Wartke (ed.), Handwerk und Technologie im alten Orient: ein Beitrag zur Geschichte der Technik des Altertums, Mainz: 67-70.
- Le Mière, M. and O.P. Nieuwenhuyse (1996), The prehistoric pottery. In: P.M.M.G. Akkermans (ed.), Tell Sabi Abyad: the Late Neolithic Settlement. Report on the Excavations of the University of Amsterdam (1988) and the National Museum of Antiquities (1991-1993) in Syria, Istanbul: 119-284.
- Lloyd, S. and F. Safar (1945), Tell Hassuna. Excavations by the Iraq Government Directorate General of Antiquities in 1943 and 1944. Journal of Near Eastern Studies IV: 259-284.
- Matson, F. (1983), The Banahilk potter. In: L.S. Braidwood et al. (eds.), Prehistoric Archaeology along the Zagros Flanks, Chicago: 615-623.
- Merpert, N.Y. and R.M. Munchaev (1973), Early agricultural settlements in the Sinjar plain in Northern Iraq. Iraq XXXV: 93-113.
- Mortensen, P. (1970), Tell Shimshara, the Hassuna Period, Copenhagen.
- Munchaev, R.M. and N.Y. Merpert (1971), The archaeological research in the Sinjar Valley. Sumer XXVII: 23-32.
- Nieuwenhuyse, O.P. (1995), The Transitional Fine Ware pottery of Tell Sabi Abyad. Orient Express 1995/1: 15-16.
- Nieuwenhuyse, O.P. (1996), Late Neolithic settlement in the Upper-Khabur, Syria. A regional survey project. Orient Express 1996/1: 16-17.
- Nieuwenhuyse, O.P. (1997), Following the earliest Halaf: some later Halaf pottery from Tell Sabi Abyad, Syria. Anatolica XXIII: 227-242.
- Nieuwenhuyse, O.P. (in press), Halaf settlement in the Khabur headwaters. In: B. Lyonnet, (ed.), Prospection archéologique dans le Haut-Khabur, vol. 1: méthodologie, paléolithique et néolithique, Paris, Editions Recherches sur les civilizations.
- Nieuwenhuyse, O.P. (in prep.), Tell Baghouz reconsidered. A collection of 'Classic' Samarran sherds from the Louvre.
- Noll, W. (1976a), Techniken antiker Töpfer und Vasenmaker. Antike Welt 8/2: 2-36.
- Noll, W. (1976b), Mineralogie und Technik der frühen Keramiken Grossmesopotamiens. Neues Jahrbuch für Mineralogie 127: 261-288.
- Noll, W. (1991), Alte Keramike und ihre Pigmente. Studien zu Material und Technologie, Stutt-
- Oppenheim, M. von and H. Schmidt (1943), Tell Halaf I: die prähistorischen Funde, Berlin.
- Rice, P.M. (1987), Pottery Analysis: a Source Book, Chicago.
- Schneider, G. (1991), Rohstoffe und Brenntechnik von Keramik in Nordmesopotamien. In: R.B. Wartke (ed.), Handwerk und Technologie im Alten Orient, Mainz: 99-110.

- Steinberg, A. and D.C. Kamili (1984), Paint and paste studies of selected Halaf sherds from Mesopotamia. In: P.M. Rice (ed.), Pots and Potters. Current Approaches in Ceramic Archaeology. Monograph XXIV, Institute of Archaeology, University of California, Los Angeles: 187-208.
- Stuiver, M. and P.J. Reiner (1993), Extended 14C database and revised calib 3.0 14C age calibration programme. *Radiocarbon* 35/1: 215-230.
- Vandiver, P.B. (1987), Sequential slab construction: a conservative Southwest Asiatic ceramic tradition. *Paléorient* 13/2: 9-35.
- Verhoeven, M.H. and P. Kranendonk (1996), The excavations: stratigraphy and architecture. In: P.M.M.G. Akkermans (ed.), *Tell Sabi Abyad: the Late Neolithic Settlement. Report on the Excavations of the University of Amsterdam (1988) and the National Museum of Antiquities (1991-1993) in Syria*, Istanbul: 25-118.
- Wilkinson, T.J. and D.J. Tucker (1995), Settlement Development in the North Jazira, Iraq. A Study of the Archaeological Landscape. British School of Archaeology in Iraq.

A. van As L. Jacobs

A TECHNOLOGICAL CLASSIFICATION OF THE EARLY DYNASTIC AND OLD AKKADIAN POTTERY OF TELL BEYDAR, SYRIA

At the request of dr. Marc Lebeau, director of the European Centre for Upper Mesopotamian Studies, the Department of Pottery Technology made a technological classification of the Early Dynastic and Old Akkadian pottery of Tell Beydar (Syria) during the 1996-campaign of the Euro-Syrian Archaeological Mission to Tell Beydar. The technological classification is based on both the reconstruction of the manufacturing technique and the analysis of the nonplastic inclusions in the clay body used to make the pottery.

Tell Beydar

Tell Beydar is situated in northeastern Syria, ca. 35 km north of the town of Hassake and ca. 80 km south of the Syrian-Turkish border (Fig. 1). Since 1992 excavations have been carried out by the Euro-Syrian Archaeological Mission to Tell Beydar under the direction of Marc Lebeau and Antoine Suleyman. The preliminary results of the excavations have been published in the American Journal of Archaeology, Ugarit Forschungen and in Subartu.

Tell Beydar is a fortified circular settlement (*Kranzhügel*) (Fig. 2). The top of the tell is 27.5 m higher than the surrounding area. The central tell has a diameter of ca. 200 m. To the east of the tell runs the Wadi 'Awasj.

So far, at Tell Beydar Mitanni, Neo-Assyrian and Seleuco-Parthian occupational remains have been excavated. The best represented phase of occupation, however, is the 3rd millennium B.C. (Early Dynastic and Old Akkadian periods).

Aims

Our ceramic study aims at a technological classification of the Early Dynastic and Old Akkadian pottery from Tell Beydar in order to be compared with a morphological classification in preparation by Marc Lebeau.

A technological classification distinguishes between the manufacturing techniques and the composition of the clay body used to make the pottery. The forming technique includes the primary forming technique, the secondary or finishing technique as well as the firing technique. Consequently, a technological class is understood to mean a group of vessels made of the same clay body in a similar primary manufacturing- and firing technique. On account of the various secondary forming techniques subclasses or technological variants can be distinguished. Since archaeological pottery is generally



Fig. 1. Map showing the location of Tell Beydar, Syria.

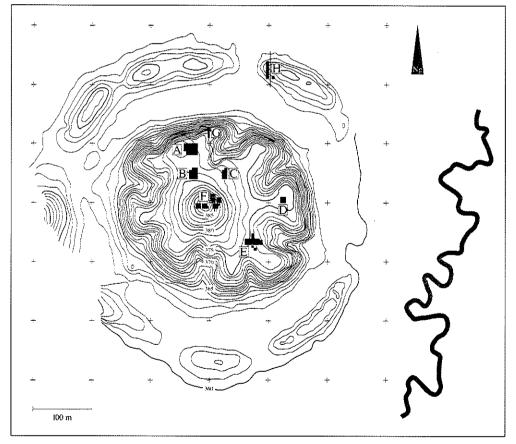


Fig. 2. Topographical ap of Tell Beydar (situation 1994) (courtesy Tell Beydar Expedition).

not a factory product the forms of vessels manufactured in the same way are not identical. On the contrary, the application of a similar forming technique results in a number of slightly different shapes. An exception is formed by pottery made in a mould. In a technological classification the shapes of pottery are therefore variants belonging to a specific technological (sub)class.

Material and methods

The more than 180 vessels being investigated have been excavated in the buildings and graves dating from the Early Dynastic and Old Akkadian periods at Tell Beydar (Lebeau and Suleiman 1997).

At the beginning of our technological investigations the pottery was divided into a number of categories, mainly based on the form and function of the vessels. The majority of the ceramic repertoire being investigated consisted of bowls (Figs. 3; 4: 1-4; 5: 1-14; 7: 1-7), globular pots (Figs. 4: 5-7; 5: 15-18; 6: 1-4; 7: 8-11; 9), and globular flasks (Figs. 4: 8-11; 6: 5; 7: 12-13). The remaining vessels included cooking pots, trays (Fig. 11: 2-3), and storage jars (Fig. 11: 4.). Furthermore, a category of potstands could be distinguished (Figs. 10: 1 and 11: 1)¹. The so-called "metallic ware" (Kühne 1976) or "stone ware" (Fielden 1977 and Oates 1982) was taken in a separate category (Fig. 7: 14-16 and Fig. 8). Finally, a few miscellaneous vessels were left (Figs. 10: 2 and 11: 5). It should be noticed that Broekmans (1997: 58-83) made a morphological classification of the same collection of pottery according to the classification criteria used by Holthoer (1977: 50-54).

The techniques were identified on the basis of the marks left behind by the potter. Though the earlier traces have often been erased by later operations during the forming process such as smoothing, the shaping technique could nevertheless be reconstructed. The firing atmosphere was determined by interpreting the colours of the pottery (inside, outside, core).

For the study of the quantity, size, shape, and quality of the non-plastic inclusions in the clay body, small pieces were snapped off 51 vessels (spread over the various reconstructed forming techniques). The non-plastic inclusions in fresh and polished breaks from these sherds were analysed using a binocular microscope (20× magnification). After refiring the same sherds at 800°C (in an electric kiln; the raised temperature being maintained for 30 minutes) in the Department of Pottery Technology at Leiden, the fabric was analysed again (40x magnification).

Not until the evaluation of the technological study the periodization of the pottery was taken into account: Early Dynastic II (2700-2650/2625 B.C.), Early Dynastic IIIA (2650/2625-2500 B.C.), Early Dynastic IIIB (2500-2350 B.C.), and Old Akkadian (2350-2300 B.C.)².

The forming technique

The clear evidence of the throwing spiral and traces of the rib, indicates that the majority of the pottery was thrown on the potter's wheel. Where rather small vessels are concerned,

we may assume that they were thrown from the cone. In those cases where on the inside of the globular flasks and metallic ware the throwing spiral was clear, the throwing direction of the wheel must have been anticlockwise. The globular pots, the globular flasks, the bowls and metallic ware were cut off the cone. By using a twisted wire, the vessels could not easily attach itselfs firmly to the cone again. The marks of the twisted wire are only visible on the bowls of which the base was not scraped after drying (Fig. 3). Therefore, due to the difference in thickness between the base and the wall, some of the bowls show cracks formed during drying and firing. Since the small diameter of the base however, *i.e.* little total shrinkage, the damage generally remained limited.

Like the traces of cutting off, the traces of lifting up the vessels have mostly been erased by later treatments. After a brief period of drying the vessels were usually finished by scraping the outer surface (Figs. 4-9). Sometimes the inner surface was scraped too (Figs. 8 and 9). The direction of the traces indicates whether the scraping of the outside was done by hand (several directions) (Figs. 4, 6 and 9) or upside down on the potter's wheel (concentric circles) (Figs. 5 and 7). After scraping, the outside was in some cases more or less smoothed with the wet hand (Figs. 6; 7 and 9) or burnished (Fig. 8: 3). The inside of some globular pots shows an uneven surface. This seems to indicate that after the pot had been given its more or less spherical shape the wall was pressed out from the inside (Fig. 9). In case of the larger pots this probably happened in a basin-shaped pit for support. By pressing out, the wall became thinner, the circumference of the body increased and the pots developed a somewhat asymmetrical form. Next, the shape of the pots was corrected slightly by scraping and tapping them on the outside. Finally, the surface was smoothed.

A part of the potstands was thrown on the potter's wheel (Fig. 10: 1). First, a cylinder was thrown. After a brief period of drying the cylinder with its outwards bending rim profile was turned upside down and with a little clay was fastened to the wheelhead. Next, the thick soft base was opened and the potstand was finished on the wheel. Besides these potstands there were also handmade potstands, sometimes formed with use of a turntable (Fig. 11: 1). One potstand was decorated with painted lines.

The trays (Fig. 11: 2, 3) show traces of smearing, pushing, tapping and scraping. We may assume that the soft clay was first shaped in a depression in the ground or a mould (e.g. a bowl). Then, the trays were build to the desired size by smearing, pushing and tapping, alternated by phases of drying. Some trays show traces of slow rotation at the rim. These seem to indicate that a turntable was used.

Within the repertoire occurs a slightly asymmetrical spherical pot made in a very similar technique to that used for the manufacture of the trays. However, no marks of rotation were found. First, the clay was kneaded into a massive cylinder. In this cylinder a hole was pressed with the fist from the top downwards. Then, the wall was squeezed out, tapped and smeared into a roughly spherical shape. During this treatment the pot probably stood in a depression in the ground. The neck was kept narrow. After a short period of drying the pot was scraped by hand on the inside as on the outside. Clay was then scraped from the base in order to obtain a convex shape. The rim and the neck were finished by a back and forward going movement of the hand.

Two techniques were used for the manufacture of the cooking pots: handforming and shaping with help of a turntable³. The latter left behind traces of rotation both on the inside of the shoulder and on the outside of the rim. Furthermore, marks of handscraping, tapping and pressing are visible on the inner surface of the body at the bottom. The outer surface was scraped by hand and flattened.

The large storage jars (Fig. 11: 4) were handmade⁴. First, the clay was flattened in a depression in the ground into a base. In some cases the base was very thick (ca. 3 cm). Then, the body was built up by adding and fastening together pieces of clay, alternated with phases of drying. The breakage pattern does not indicate that the storage jars were coiled. No clear marks of rotation were found. Only the rim seems to have been finished by a turning movement of the hand. The inner surface was scraped by hand.

Besides the basic categories already mentioned, a few other miscellaneous vessels were found. Apart from the pinched pots and the pots thrown in coils (Fig. 10: 2), this pottery was made by techniques similar to some of the techniques previously described. Remarkable is a vessel made of pre-shaped parts (Fig. 11: 5). The foot consists of a conical thrown cylinder. Now, the rim of this cylinder forms the bottom of the foot. The body was thrown. Marks of hand-scraping were found on the inside. The outer surface was flattened slightly. After a phase of drying, both parts were fastened together. Finally, the protruding little "saucer" was fastened to the outside.

It is worth mentioning that a number of the vessels show a potter's mark (Fig. 9: 1-3).

Summarizing, the following shaping techniques could be distinguished (see also Table 1):

- 1. Wheelmade (from the cone).
- 1.1. Wheelmade (from the cone) without finishing (Fig. 3).
- 1.2. Wheelmade (from the cone) and finishing:
 - 1.2.1. outer surface hand-scraped (Fig. 4);
 - 1.2.2. outer surface scraped on the wheel (Fig. 5);
 - 1.2.3. outer surface hand-scraped and flattened (Fig. 6);
 - 1.2.4. outer surface scraped on the wheel and flattened (Fig. 7);
 - 1.2.5. outer surface scraped and sometimes burnished; inner surface hand-scraped (Fig. 8);
 - 1.2.6. pressed out from the inside; inner surface hand-scraped; outer surface hand-scraped, tapped and flattened (Fig. 9).
- 2. Wheelmade (Fig. 10: 1).
- 3. Wheelmade in coils (Fig. 10: 2).
- 4. Handmade (Fig. 11: 3, 4).
- 5. Handmade with help of a turntable (Fig. 11: 1, 2.
- 6. Combination of techniques: pre-shaped parts (Fig. 11: 5).

	bowls	glob. pots	glob. flasks	cooking pots	trays	storage jars	pot- stands	metallic ware	miscel- laneous	total
technique 1.1. EDII/III ED III	22 1 21									22 1 21
ED II ED III O. Akk.	24 2 18	5 3 1	<u>13</u> 3 9						1	43 8 28
3	4	1	1							6
1.2.2. ED II EDII/III ED III	<u>16</u> 15	5 1 1							<u>2</u> 2	23 1 1 17
O.Akk.	1	3							2	4
1.2.3. ED II EDII/III		3 Z 7	Z 1					2	1	17 1 7
ED III			6					2	1	9
1.2.4. ED II EDIII O. Akk.	<u>17</u> 17	<u>3</u> 2	<u>2</u> 1 1					8 3 2	<u>2</u> 2	32 7 3 18
?		1						3		4
1.2.5. ED II ED III								4 3 1		4 3 1
1.2.6 ED II EDIII ?		11 6 3 2							<u>2</u> 2	13 6 5 2
<u>2.</u> ED III O. Akk.							2 7 2			2 7 2
3. ED III O.Akk.									<u>2</u> 1 1	<u>2</u> 1
4 <u>.</u> ED II				1	<u>4</u>	1	1		5	12
ED III				1	4	1	I		1 4	7 5
<u>5.</u> ED III ?				<u>1</u> 1	3 3					4 1 3
6. ED III									<u>3</u> 3	<u>3</u> 3
total	79	31	22	2	7	1	10	14	18	184

Table 1. The number of vessels (different categories) made in the various forming techniques (see p. 53). The period allocation was made by Marc Lebeau. In this Table no distinction has been made between ED IIIA and ED IIIB. Most ED III vessels, however, date from the ED IIIB period.

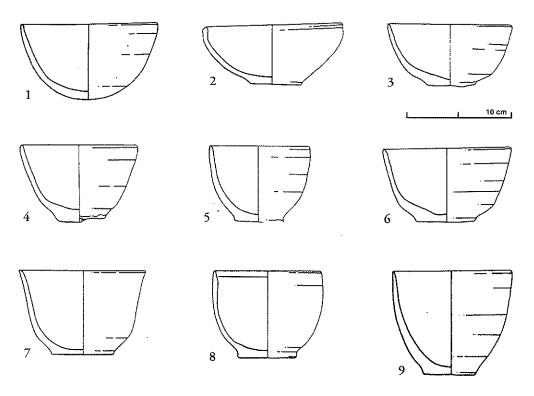


Fig. 3. Wheelmade (from the cone) without finishing. Bowls.

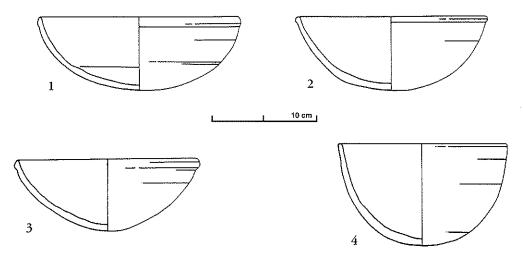


Fig. 4. Wheelmade (from the cone); outer surface hand-scraped. Bowls (1-4).

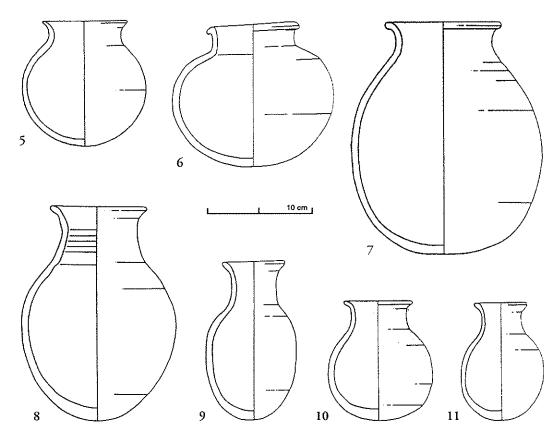


Fig. 4 (continued). Wheelmade (from the cone); outer surface hand-scraped. Globular pots (5-7); globular flasks (8-11).

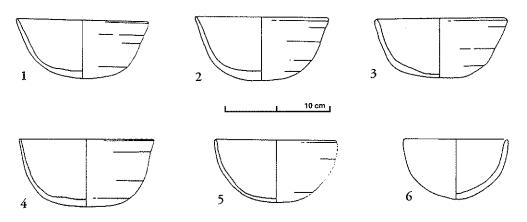


Fig. 5. Wheelmade (from the cone); outer surface scraped on the wheel. Bowls (1-6).

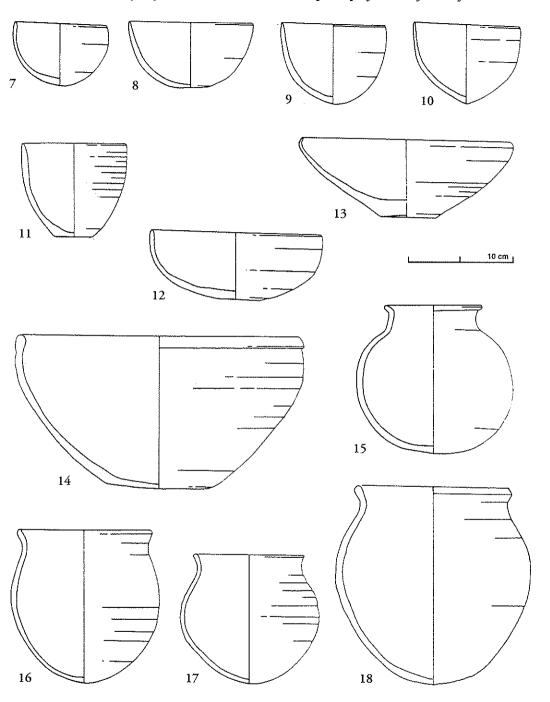


Fig. 5 (continued). Wheelmade (from the cone); outer surface scraped on the wheel. Bowls (7-14); globular pots (15-18).

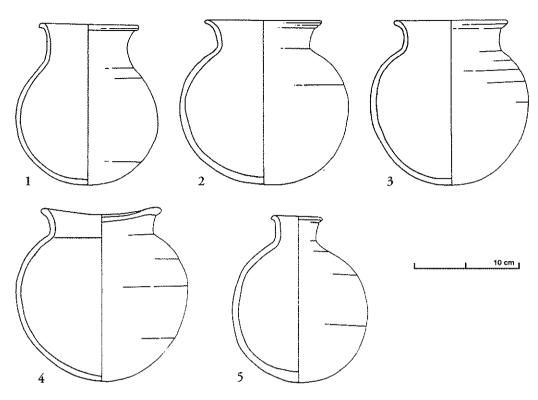


Fig. 6. Wheelmade (from the cone); outer surface hand-scraped and flattened. Globular pots (1-4); globular flasks (5).

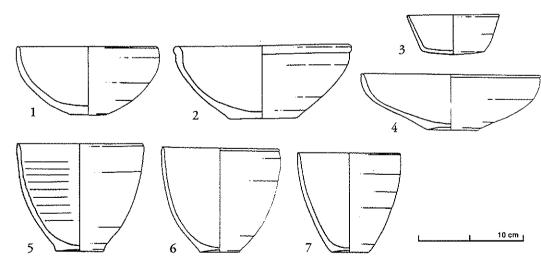


Fig. 7. Wheelmade (from the cone); outer surface scraped on the wheel and flattened. Bowls (1-7).

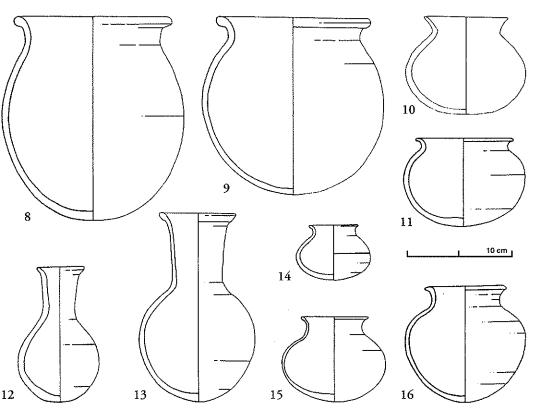


Fig. 7 (continued). Wheelmade (from the cone); outer surface scraped on the wheel and flattened. Globular pots (8-11); globular flasks ((12-13); metallic ware (14-16).

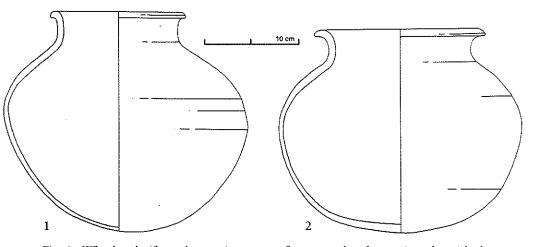


Fig. 8. Wheelmade (from the cone); outer surface scraped and sometimes burnished; inner surface hand-scraped. Metallic ware.

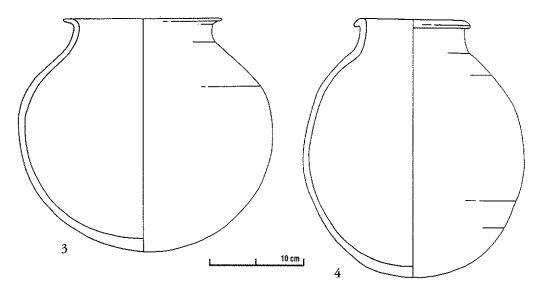


Fig. 8 (continued). Wheelmade (from the cone); outer surface scraped and sometimes burnished; inner surface hand-scraped. Metallic ware.

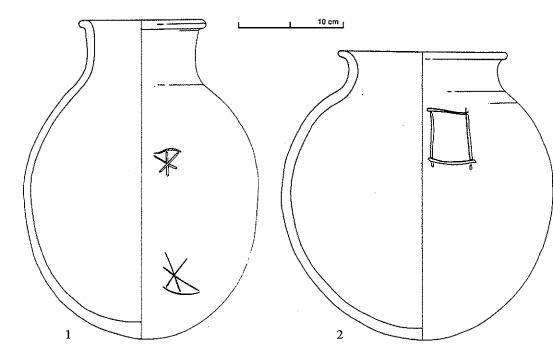


Fig. 9. Wheelmade (from the cone); pressed from the inside; inner surface hand-scraped; outer surface hand-scraped, tapped and flattened. Globular pots.

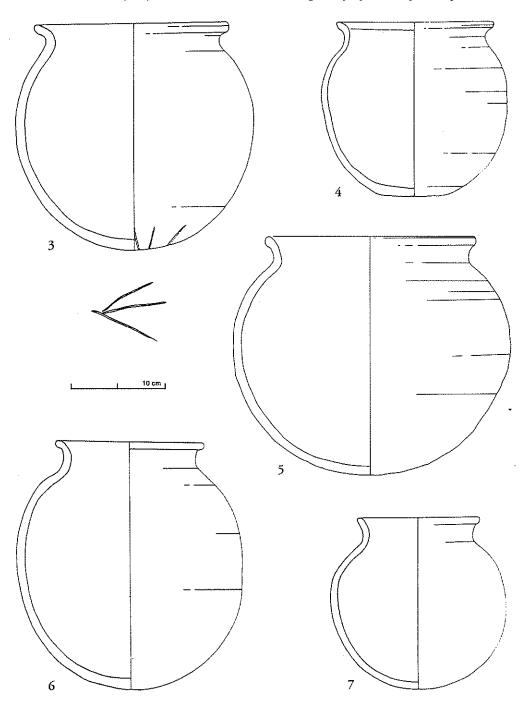


Fig. 9 (continued). Wheelmade (from the cone); pressed from the inside; inner surface hand-scraped; outer surface hand-scraped, tapped and flattened. Globular pots.

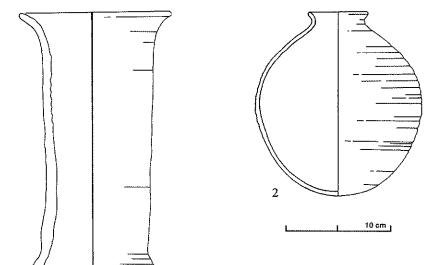


Fig. 10. Wheelmade potstand (1); vessel: wheelmade in coils (2).

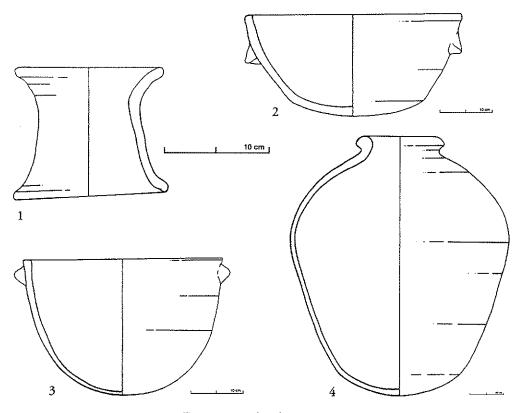
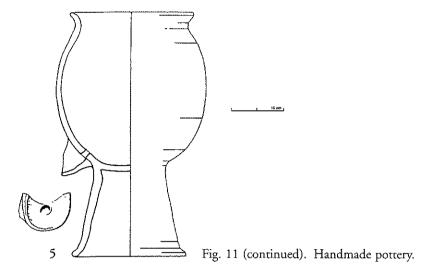


Fig. 11. Handmade pottery.



The firing technique

Apart from the cooking pots and the metallic ware the colour of the pottery varies from 2.5Y8/3 (pale yellow) and 10YR7/4 (very pale brown) to 7.5YR7/4 (pink), 7.5YR6/4 (light brown), 7.5Y6/6 (reddish yellow) and 5YR6/4 (light reddish brown)⁵. This means that the pottery was kiln-fired in a neutral to oxidizing atmosphere. In some cases traces of stacking the pottery in the kiln are visible.

The cooking pots are all the same grey/brown colour. Here and there they show deposits of soot caused by postfiring use. Because of the presence of unchanged calcite crystals in the clay we can infer that the original firing temperature has not been higher than ca. 750°C. For the same reason the firing atmosphere must have been more or less reduced (cf. Rye 1976).

The metallic ware was mostly subjected to a reduction atmosphere at the end of the firing process. In these cases, the surface is a dark grey/black and the core a red colour. Sometimes the vessels were completely reduced or completely oxidized. The reduced ware is harder than the oxidized ware. This can be explained by the effect of FeO acting as a flux. According to Kühne and Schneider (1988) and Schneider (1989) the metallic ware was fired at temperatures between 1000 and 1100°C.

The clay body

At first sight, it was striking that the majority of the vessels showed evidence of having contained fibrous organic material. It mostly concerns fibrous material of small dimensions (till 3 mm). The orientation is mainly parallel to the surface of the pottery. It was added as dung or chopped straw in order to improve the cohesion of the clay. Some vessels seemed to be made of a finer clay body than most of the others. This is especially

true for the bowls thrown from the cone, scraped on the wheel, flattened, and provided with an impressed base (Fig. 7: 5-7). The metallic ware seems to have been made of a very fine, rather fat clay. The cooking pots were tempered with calcite.

The fabric of the 51 samples can be split up in three groups: (1) the carbonate-quartz group, (2) the calcareous group, and (3) the group with very little nonplastic inclusions (see Table 2)⁶.

	carbo/quartz	calcareous	compact	total
bowls	6	5	7	18
globular pots	5	4	1	10
globular flasks	2	3	4	9
cooking pots		2		2
trays	1	4		5
wheelmade potstands		I		1
metallic ware	1	1	3	5
miscellaneous	1		1	
total	15	21	15	51

Table 2. The fabric of the various categories of pottery. Number of samples.

The carbonate-quartz group is characterized by dominant burnt out fossil carbonate grains and/or quartz grains. Besides these, variable amounts of grains of iron-oxide silt-stone occur. Magnetite, siltstone, pyroxene and amphibole were found sporadically. The shape of the grains is mainly sub-rounded to sub-angular. Sometimes sub-rounded to sub-angular grains were found in combination with rounded grains. The size of the grains is generally limited to 250 μ . The upper limit is sometimes lower (200 μ or even 150 μ). Below this limit almost all sizes to the silt fraction were found. The latter was left out of the reckoning of the amount of grains. The number of grains mainly varies from 10 to 20%. Sometimes the quantity is larger (up to 25%). In some cases the amount of grains is lower, close by the quantity of the group with very little nonplastic inclusions (the compact group). No big differences in type, size and shape of the grains could be observed. The fabric is rather homogeneous, probably caused by the preparation of the clay. The matrix is for the most part normal. This means that the small pores are clearly visible. The apparent porosity is ca. 20%.

The calcareous group is characterized by dominant grains of lime. A clearly observable reaction with HCl could be noticed. Furthermore, this group contains grains which were also found in the the carbonate-quartz group⁷. Besides the grains of lime the following grains were more or less present: grains of burnt carbonate, quartz, feldspar, iron-oxide siltstone, iron nodules and small flakes of biotite. Sometimes a single grain of pyroxene and amphibole could be observed. Once or twice a poorly dissolved lump

of clay was found. In this group too, the shape of the grains is mainly sub-rounded and sub-angular. Sometimes the grains were rounded. The upper limit of the size of the grains approaches 250 μ . Below this limit almost every size was found. The amount of the grains varies between 15 and 30%. Sometimes, however, the amount does not excede 5%. The fabric is homogeneous. The matrix is normal and the apparent porosity is ca. 20%.

The last group is characterized by a compact dense sherd, caused by hardly any nonplastic inclusions larger than the silt fraction. Sometimes a few burnt out carbonate grains and/or quartz grains and/or iron-oxide siltstone grains are still present. Once or twice not more than 2% of magnetite was found. The size of these grains, however, is very small (≤150µ). This observation is important because it indicates that the clay with very little nonplastic inclusions is basically the same as the clays mentioned before. Because of its compact fabric the average apparent porosity is rather low (ca. 16%).

A technological classification

In Table 3 a technological classification of the Early Dynastic and Old Akkadian vessels of Tell Beydar is presented. This classification is based on the composition of the clay body and the manufacturing technique (forming and firing)⁸. A technological class is a group of vessels made of the same clay body in a similar primary forming and firing technique.

technological class	clay body	body forming firing technique atmosphere		category	
1	carbo/quartz, calcareous, or compact	wheelmade (from the cone)	neutral oxidizing	bowls, globular pots globular flasks	
2	fine carbo/quartz, fine calcareous, or compact	wheelmade (from the cone)	reducing	metallic ware	
3	carbo/quartz or calcareous	wheelmade	neutral oxidizing	potstands	
4	carbo/quartz or calcareous	handmade (turntable)	neutral oxidizing	trays storage jars potstands	
5	calcareous	handmade (turntable)	reducing	cooking pots	

Table 3. A technological classification of the Early Dynastic and Old Akkadian pottery of Tell Beydar

Summary and conclusion

Different forming techniques can be distinguished (Table 1). Most of the investigated Early Dynastic and Old Akkadian pottery repertoire from Tell Beydar has been thrown on the potter's wheel. The bowls, globular pots, globular flasks and the metallic ware were thrown of one piece of clay. Where small vessels are concerned, they were thrown from the cone. Striking are the many variants in the finishing technique. A few vessels were thrown in parts (coils). The potstands were either thrown on the potter's wheel or handmade. The cooking pots, trays, large storage jars and some miscellaneous vessels were handmade, sometimes with help of a turntable.

Most of the pottery was kiln-fired in a neutral to oxidizing atmosphere. Only the cooking pots and the metallic ware were fired in a reducing atmosphere.

Three categories of clay bodies (fabric) (Table 2) can be distinguished: (1) a carbonate-quartz group, (2) a calcareous group, and (3) a group containing hardly any non-plastic inclusions (the compact group). There is a smooth transition between the different clay bodies. Essentially, there is not much difference. Every clay body was used for the manufacture of the bowls, globular pots, globular flasks and the metallic ware. The metallic ware seems mainly to be made of the compact clay body containing hardly any non-plastic inclusions. Two out of five samples of the metallic ware consist of a carbo/quartz and calcareous clay body. The amount of grains in these cases, however, is close by the quantity of inclusions in the compact clay body. The majority of the bowls made of a compact clay body date from the Old Akkadian period. The other Old Akkadian bowls (see Table 1) were made of a fine carbo/quartz or fine calcareous clay body. The potstands, trays and storage jars were made of a carbo/quartz or calcareous clay body. The cooking pots were exclusively made of a calcareous clay body.

As far as can be concluded from our technological study of the vessels from Tell Beydar, no important changes in the development of the potter's craft seem to occur during the Early Dynastic and Old Akkadian periods (Table 1).

The technological classification shows that a certain technique can be used for the manufacture of different ceramic forms. On the other hand, certain forms can be made in different techniques. The technological classification gives a solid basis for a further morphological study of the Early Dynastic and Old Akkadian pottery of Tell Beydar.

Notes

- 1. The drawings of the pottery (Figs. 3-11) have been made by Francois Renel and Fabienne Genadt.
- Absolute dates according to the Middle Chronology.
- 3. Only two cooking pots were found in the repertoire. A third cooking pot found in Early Dynastic I context was imported from Trans-Caucasia. This cooking pot with a thin base was made of micaceous clay by coiling on the turntable.
- 4. Since much plaster was used for restauration, it was difficult to reconstruct the shaping technique of the large storage jars.

- 5. Munsell Soil Color Charts 1992 revised edition.
- 6. Tom Broekmans (Louvain) has attributed the Early Dynastic/Old Akkadian sherds from Tell Beydar to our technical categories. He selected 200 sherds for further fabric analysis (see Broekmans 1997). This analysis affirms the results of our fabric analysis
- 7. The vessels belonging to the calcareous group have apparently been fired for a relative short time in an oxidizing atmosphere not rich in sulphur. The temperature must have been not too high (<800°C). If otherwise, the lime grains should have been burnt out and converted into calcium oxide or calcium sulphate. The difference between the calcareous group and the carbonate-quartz group characterized by the burnt out carbonate grains must probably be sought in the different firing conditions.</p>
- 8. The composition of the clay body of technological classes 3 and 4 are based on the analysis of Broekmans (1997). The technological variants caused by the various finishing techniques have not been included in this classification.

References

- Brockmans, T. (1997), Studie van het aardewerk uit het derde millennium v. Chr. te Tell Beydar (Master thesis), Leuven.
- Fielden, K. (1977), Tell Brak: the Pottery. Iraq 39: 245-255.
- Holthoer, R. (1977), New Kingdom Pharaonic Sites. The Pottery, Stockholm (The Skandinavian Joint Expedition to Sudanese Nubia 5:1)
- Kühne, H. (1976), Die Keramik vom Tell Chuera und ihre Beziehungen zu Funden aus Syrien-Palästina, der Türkei und dem Iraq, Berlin.
- Kühne, H. and G. Schneider (1988), Neue Untersuchungen zur Metallischen Ware. Damaszener Mitteilungen 3: 83-139.
- Lebeau, M. and A. Suleiman (eds.) (1974), Tell Beydar, Three Seasons of Excavations (1992-1994), Turnhout (Subartu 3).
- Oates, J. (1982), Some late Early-Dynastic III pottery from Tell Brak. Iraq 43: 205-219.
- Rye, O.S. (1976), Keeping your temper under control. Archaeology and Physical Anthropology in Oceania 11(2): 106-137.
- Schneider, G. (1989), A technological study of North-Mesopotamian Stone Ware. World Archaeology 21(1): 30-50.



A. van As L. Jacobs M.-H. Wijnen

FURTHER TECHNOLOGICAL RESEARCH ON THE CHALCOLITHIC POTTERY OF ILIPINAR, PHASE VB

In 1989 and 1990 the Department of Pottery Technology investigated the Neolithic and Chalcolithic pottery of Ilipinar (phases X-V) in northwestern Anatolia (Fig. 1). Unfortunately, the sherds of phase V came from an unreliable archaeological context. Meanwhile, however, pottery of this phase from a more reliable context has been excavated. This has enabled us to carry out further technological research on the Chalcolithic pottery of Ilipinar phase V. The following article gives the results of this technological ceramic study, executed in June 1997.

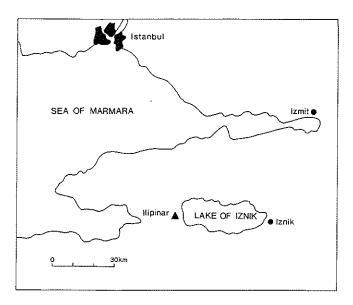


Fig. 1. Map showing the location of Ilipinar, Turkey.

Introduction

Although the first publication on the excavations at Ilipinar hüyük in the years 1987-1991 (Roodenberg 1995) focussed on phases X-VI, our technological ceramic study included pottery of phase V as well (van As and Wijnen 1995). Chronologically, Ilipinar phase V follows on phase VI, for which an absolute date is available, *viz.* ca. 6750-6550 B.P.

Newsletter of the Department of Pottery Technology (Leiden University) 14/15, 1996/1997: 69-84.

(Roodenberg 1995: 172). This gives us a *terminus post quem* for phase V. The pottery of phase V came from square S9 (Roodenberg 1995: Fig. 1). However, since this pottery was mainly found in refuse pits, the archaeological context must be regarded as unreliable. During later excavations in 1996-1997, pottery of phase VB, a new denomination for phase V, has been excavated in square M9 (Roodenberg and Gérard 1996). The floor levels which this pottery mainly came from formed a much more reliable archaeological context than the one encountered in previous fieldwork. Therefore, the technological study of this pottery has enabled us to reconsider our earlier observations of the pottery of this phase!

Material and methods

The pottery from Ilipinar phase VB that was studied, included 3100 sherds (1327 rim fragments, 366 base fragments, 517 fragments of handles, and 890 body sherds) and four complete vessels found *in situ* (Fig. 2)². The sherds also included decorated sherds (Fig. 7). After a first technological inspection of the entire ceramic repertoire, a sample of 562 sherds (268 rim fragments, 157 base fragments and 137 fragments of handles) was taken for a more detailed study. In our opinion, the size of this sample was large enough to form a solid base for reliable conclusions with respect to the technological aspects of the pottery of phase VB.

The rim fragments gave us an impression of the various shapes of the vessels represented in the repertoire. Using various critera, such as colour, texture and size, we were able to make a further basic general classification of the pottery of phase VB. Starting from this subdivision, the forming, finishing and decoration technique was reconstructed on the basis of the marks left by the potters. A sample of 215 sherds out of the total amount of sherds under investigation (562 sherds), representing all basic categories, was taken for the study of the firing conditions and the fabric. The firing conditions were identified by interpreting the colours of the sherds (inside, outside and core) before and after refiring in an electric kiln (at 800°C in an oxidising atmosphere, the raised temperature being maintained for 30 minutes). For the same reason, the hardness of the sherds was also measured by using the Mohs scale. The fabric was investigated by analysing the non-plastic inclusions in fresh and polished breaks of the refired sherds by binocular microscopy (40 × magnification).

Results

General classification of the ceramic repertoire

The repertoire included four complete vessels (Fig. 2). The rim fragments could be divided into fragments belonging to open and to closed shapes (Figs. 3-4). On the basis of various criteria, such as colour, texture, size, and body or rim profile, both the open and closed shapes could in turn be classified into a number of basic categories.

The open shapes included black dishes with various rim profiles (Fig. 3: 1-9), small black burnished dishes (Fig. 3: 10), red dishes (Fig. 3: 11-12), fine bowls (Fig. 3: 13),

bowls with sharply curved body-profiles (Fig. 3: 14), and miscellaneous open shapes (Fig. 3: 15-30). The closed shapes mainly included large vessels with handles (Fig. 4: 1-2) and necks of various sizes (Fig. 4: 3-36).

The majority of the base fragments consisted of fairly flat bases varying in diameter and thickness (Fig. 5: 1-15). They often show signs of wear underneath. The low ring base occurs sporadically (Fig. 5: 16-18).

The large storage vessels have big lug handles of which the position on the vessel is not always clear (Fig. 6: 1-3). Smaller handles of the same kind were attached to smaller vessels (Fig. 6: 4-7). Besides these handles, there is evidence of knob handles (Fig. 6: 8-11), pierced knob handles (Fig. 6: 12), and handles with a bulge (Fig. 6: 13).

The manufacturing technique

As a matter of fact, complete vessels give fuller evidence of the manufacturing technique (forming, decorating and firing) than can be obtained on the basis of the study of pottery fragments. Therefore, the complete vessels within the repertoire will be discussed first.

All vessels were made by using the coiling technique. First, a flat base was formed by pressing out a slab of clay. Next, coils of clay were added one after the other and pressed upwards, interrupted by short periods of drying. Since the exterior surface of the leatherhard vessels was scraped, the marks of attachment of the coils could only be observed on the inside. By scraping the wall of the vessels was given a regular thickness. In the case of the vessel illustrated in Fig. 2: 1, scraping also resulted in a slightly oval and asymmetrical base. After scraping, the exterior surface of the vessels was burnished either in a horizontal direction (Fig. 2: 1 and 2) or in various directions (Fig. 2: 3). Even the heavily eroded exterior surface of the vessel with a smoothed inside illustrated in Fig. 2: 4, shows traces of burnishing. The vessel illustrated in Figs. 2:1 also shows traces of superficial burnishing on the inside of the rim. This vessel was the only decorated one. With a pensel dipped in clay slib three vertical lines were drawn on the vessel's shoulder. The range of colours (varying from 10YR 3/2 to 10YR 4/1, 7.5 YR 5/4, 5YR 5/6 and 2.5YR 4/6, respectively very dark grayish brown, dark gray, brown, yellowish red, and dark red) visible on the surface of the vessels and Mohs hardness numbers 2 and 3 point to the use of a open kiln fire. Two vessels (Fig. 2: 1 and 2) show signs of wear underneath the base.

The use of the coiling and finishing technique as described above was confirmed by the technical characteristics of the sherds being studied, such as marks of attaching the coils of clay, an irregular surface due to pressing out the clay, and traces of scraping, smoothing or burnishing the surface. Striking is one flat base fragment with the impression of a reed-mat underneath. In order to prevent the clay from sticking to the flat surface on which the clay was pressed out to form the base of the vessel, a reed-mat was used. After drying, the vessel would be lifted up, and the reed-mat would easily be removed. Since the reed-mat is flexible, the danger of shrinkage cracks would be avoided.

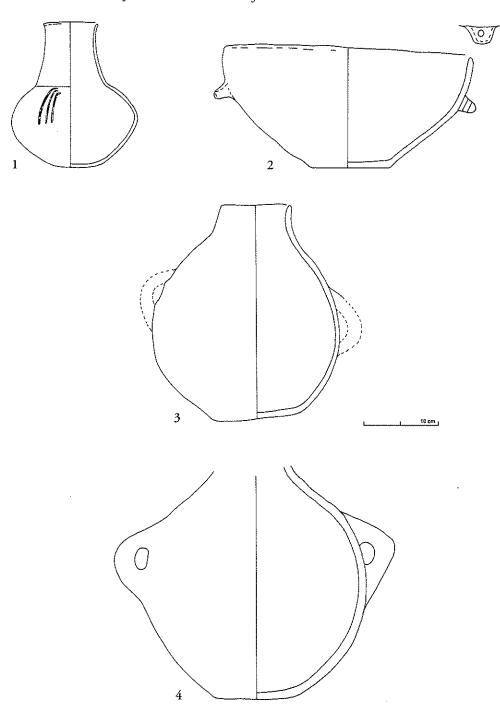


Fig. 2. Complete vessels.

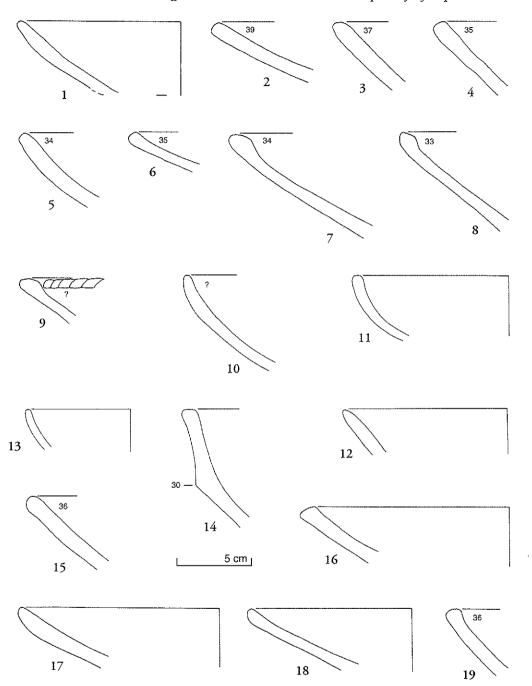


Fig. 3. Open shapes: black dishes with various rim profiles (1-9); small black burnished dishes (10); red dishes (11-12); fine bowls (13); bowls with sharply curved body profiles (14); miscellaneous open shapes (15-19).

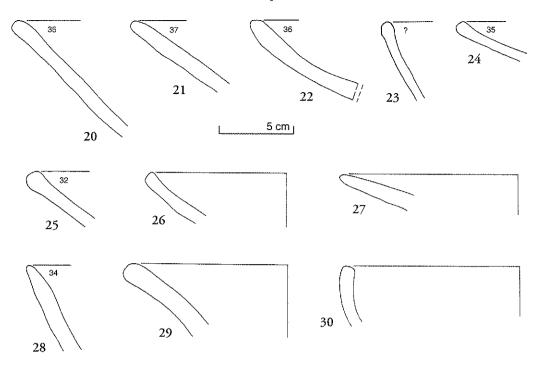
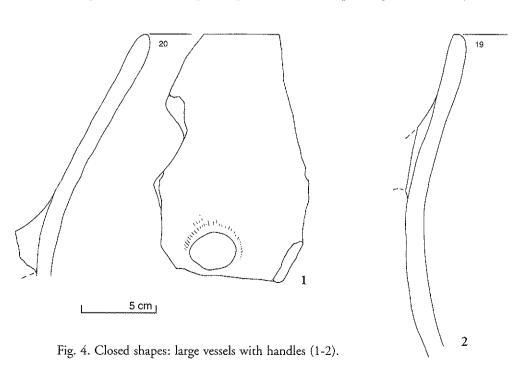


Fig. 3. (continued). Open shapes: miscellaneous open shapes (20-30).



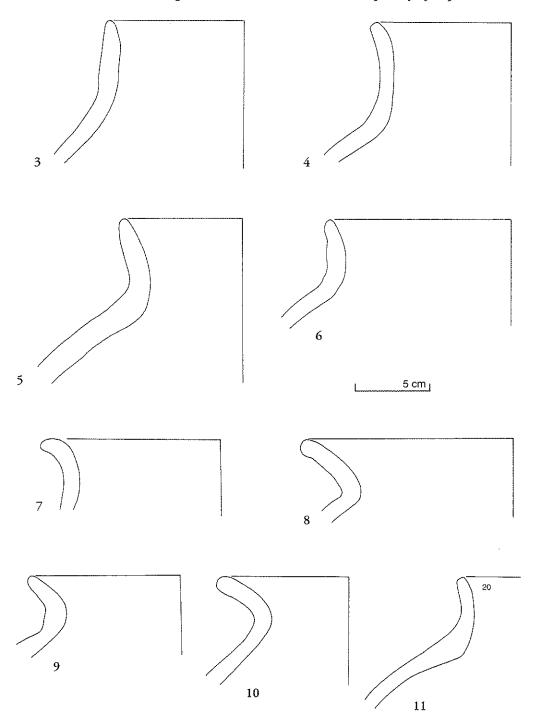


Fig. 4. (continued) Closed shapes: various necks (3-11).

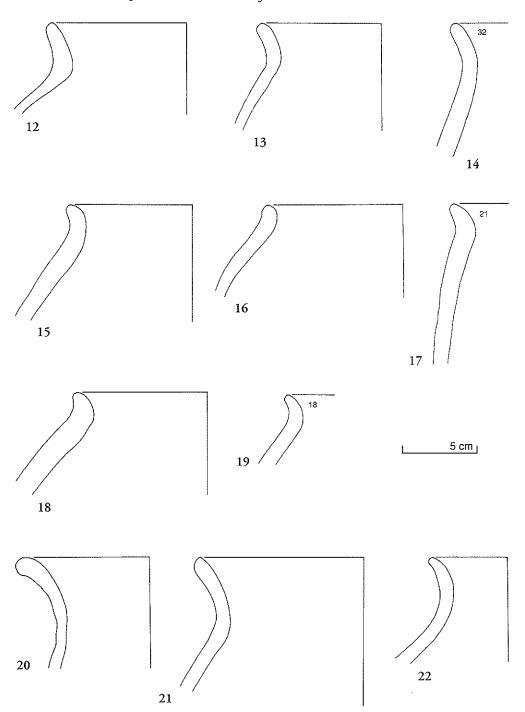


Fig. 4. (continued) Closed shapes: various necks (12-22).

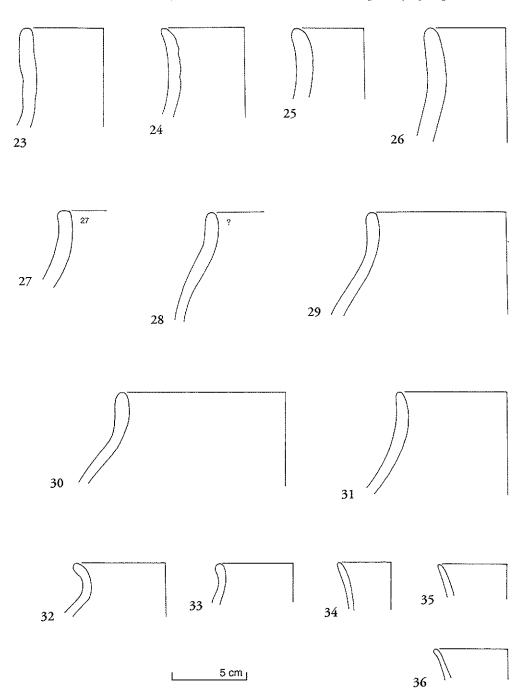


Fig. 4. (continued) Closed shapes: various necks (23-36).

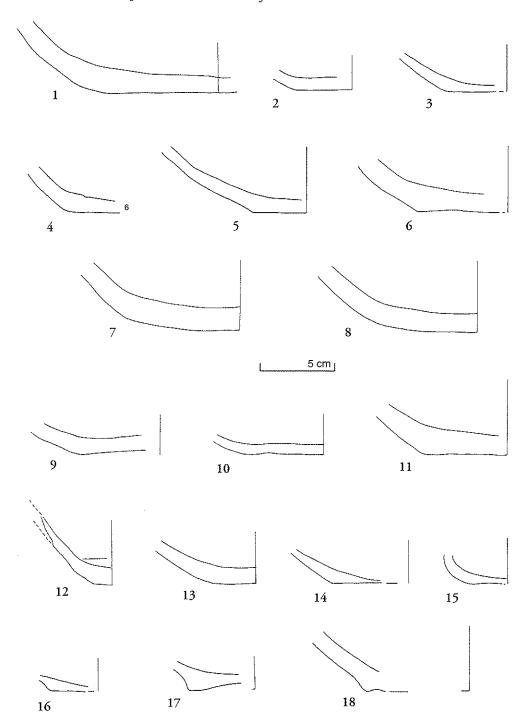


Fig. 5. Bases: flat bases (1-15); low ring bases (16-18).

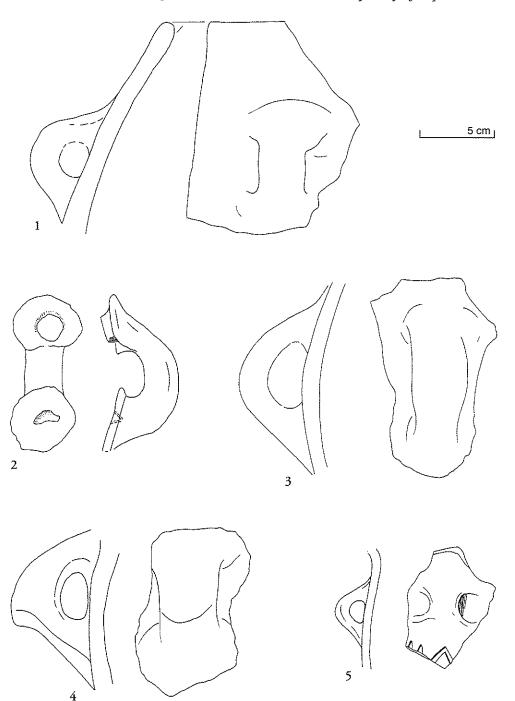


Fig. 6. Handles: Large lug handles (1-4); small lug handle (5).

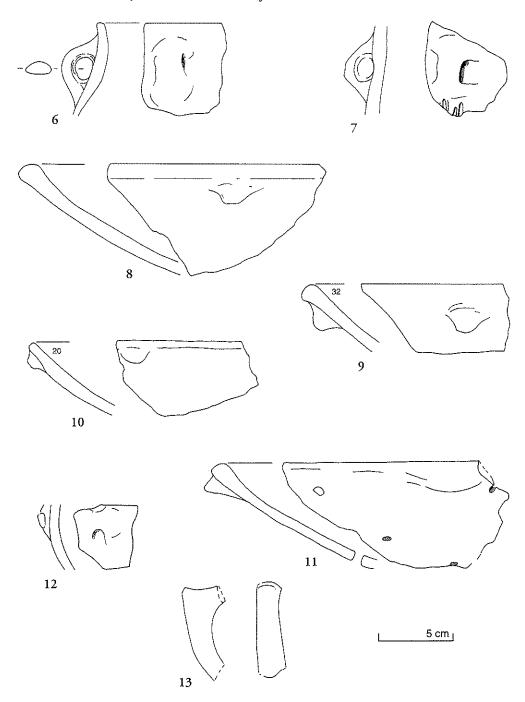


Fig. 6. (continued) Small lug handles (6-7); knob handles (8-11); pierced knob handle (12); handle with a bulge (13).

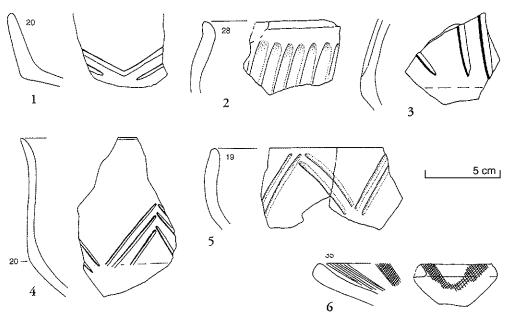


Fig. 7. Decoration.

Most lug handles were rolled. They were fastened by pressing them against the vessel's body. In general, the attachment was strengthened by adding a piece of clay around the place of attachment. The dowelled joint as observed in the Early Bronze Age ceramic repertoire of Hacilartepe (van As, Jacobs and Wijnen 1993/1994: 64) was also found, although less frequently.

Apart from burnishing, there is evidence of attached and scratched decoration (Fig. 7: 1-5). After these decorations had been applied, the vessels were sometimes burnished as well. Furthermore, pierced decoration occurs. Finally, it should be mentioned that we found sherds with a decoration of red and black-coloured zones (Fig. 7: 6). The differences in colour must be explained by the firing conditions (cf. Franken and Jacobs 1983). In order to prevent oxidation in places intended to black, these zones were covered before firing with, for example, dung. In this way, the red firing clay, if fired in an oxidising atmosphere, became black. The use of this decoration technique implies that the potters attended to the regulation of the atmosphere during the firing process.

Colour and hardness give indications about the original firing conditions. The sherds, like the complete vessels being studied, are often in mottled colours and have Mohs hardness numbers 2 and 3. After refiring them under oxidising conditions at 800°C for half an hour, they turned completely red (10R-5YR 5-7/6-8). For these reasons, we may conclude that the vessels to which these sherds belonged were fired in an open bonfire. On the other hand, there were also sherds in the ceramic repertoire of a uniform black or red colour. It took some extra effort to make pottery of such a colour. In order to produce dishes of a uniform black colour, the potters had to ensure that the

fire was smothered at the right moment when the pottery was very hot (see also van As, Jacobs and Wijnen 1993/1994: 70-72). For the production of the dusky red dishes (Fig. 3: 11-12), the potters must have taken care to create a completely oxidising firing atmosphere.

The fabric

The fabric analysis included the recording of the colour after refiring and the study of the non-plastic inclusions, the pores and the matrix. With respect to the non-plastic inclusions, attention was paid to the type, shape, colour, sorting, size and quantity of the grains present in the clay. Based on these criteria, the following fabric classes and subclasses could be distinguished. A comparison of the fabric groups with the various basic ceramic categories shows that no correlation between them can be established.

Fabric 1 (a, b, c, d)

Colour after refiring:

red

Non-plastic inclusions

type: dominant shapes:

mixed sand including a lot of quartz3 angular to subangular and subrounded

colour:

varying, mainly light moderate/bad

sorting: dominant size:

a. fine: $\times < 1000 \mu$

b. medium: $500\mu \le x \le 2000\mu$

c. coarse: $\leq 500\mu \times \leq 3000\mu$, some up to 5000μ d. bimodal: $\times < 500\mu$ and $500\mu \le \times \le 3000\mu$

quantity:

20% to 35%

Matrix/pores:

normal/open

Fabric 2

Colour after refiring:

red

Non-plastic inclusions

type: dominant shapes: crushed calcite added to mixed sand, quartz included

colour:

angular, sharp and subangular to subrounded

sorting:

varying, mainly light

dominant size:

moderate × ≤ 2000µ

quantity:

15% to 30%

Matrix/pores:

normal

Fabric 3 (a, b)

Colour after refiring:

red

Non-plastic inclusions

type:

mixed sand without quartz

dominant shapes:

a. subangular to subrounded; some rounded and some angular

b. rounded to subangular; some angular

colour:

varying

sorting:

a. moderate h. moderate/had

dominant size:

a. $50\mu \le x \le 5000\mu$

b. 500μ ≤ × ≤ 3000μ

quantity:

25% to 35%

Matrix/pores:

normal

Conclusion

Further research on the pottery from Ilipinar phase V has not led us to change our opinion on the technological aspects of the pottery of this phase as recorded in our study of 1995 (van As, Jacobs and Wijnen 1995). The present study of pottery from a more reliable archaeological context than was available at that time confirms our earlier conclusions.

Notes

- 1. The investigations were carried out by the authors between 2 and 15 June 1997 at the excavation house of the Ilipinar expedition at Gölyaka. The drawings were made by B. Claasz Coockson. Travelling expenses and subsistence were financed by the Foundation for History, Archaeology and Art History (SHW) which is part of the Netherlands Organization for Scientific Research (NWO).
- 2. In total, 16 restorable vessels were found in situ in a courtyard. Only the restored vessels stored in the Archaeological Museum in Iznik have been investigated.
- 3. Mixed sand included: schists, siltstone, sandstone, feldspar, calcium grains, mica, haematite nodules.

References

As, A. van, L. Jacobs and M.-H. Wijnen (1993/1994), The production sequence of pottery dating from the Early Bronze Age excavated at Hacilartepe in Northwestern Anatolia. *Newsletter of the Department of Pottery Technology (Leiden University)* 11/12: 54-73.

- As, A. van and M.-H. Wijnen (1995), The Neolithic and Chalcolithic pottery from Ilipinar's phases X-V: a technological study. In: J. Roodenberg (ed.), *The Ilipinar Excavations I. Five Seasons of Fieldwork in NW Anatolia, 1987-91*, Uitgaven van het Nederlands Historisch-Archaeologisch Instituut te Istanbul LXXII, Leiden.
- Franken, H.J. and L. Jacobs (1983), Decorated pottery from the Early La Tène period from Friesland, the Netherlands. *Newsletter of the Department of Pottery Technology (Leiden University)* 1: 27-30.
- Roodenberg, J. (ed.) (1995), *The Ilipinar Excavations I. Five Seasons of Fieldwork in NW Anatolia, 1987-1991)*, Uitgaven van het Nederlands Historisch-Archaeologisch Instituut te Istanbul LXXII, Leiden.
- Roodenberg, J. and F. Gérard (1996), The southwest flank of Ilipinar: The 1994 and 1995 seasons. *Anatolica* XXII: 33-48.

THE MANUFACTURING TECHNIQUE OF THE VESSELS FROM LATE BRONZE AGE / EARLY IRON AGE GRAVES AT AKHTAMIR, ARMENIA

As part of a joint project involving the Belgo-Armenian Expedition to Armenia and the Department of Pottery Technology technological ceramic research has been carried out at the expedition house at Voskevaz, Armenia (July 13-30, 1996). The vessels being investigated were dated from the Late Bronze Age and Early Iron Age and came from several graves at Akhtamir. The manufacturing technique has been determined on the basis of the marks left behind by the potter and other related characteristics. In Leiden the reconstructed forming technique has been simulated and the fabric of the pottery has been analysed by using the binocular microscopy method¹.

The site

Akhtamir is situated not far from Oshakan on the Khasach river, a tributary of the Aras river (ancient Araxes) within a volcanic area mainly consisting of basalt and tuff (Fig. 1). The site includes a settlement, an acropolis, and several necropoleis, most of them on the eastern side of the river (Fig. 2).

In 1973 at the acropolis some test trenches have been excavated by Emma V. Khanzadayan (not published). Since 1993 excavations have been carried out by the Joint Belgo-Armenian Expedition to Armenia under direction of Hermann Gasche and Hacob Simonyan. Since the area of the settlement has been cultivated nowadays, the archaeological research is mainly focused on the acropolis and the necropoleis.

A survey carried out at the beginning of the excavations demonstrates that the acropolis of Akhtamir probably goes back to a period preceding the Early Bronze Age. The Early Bronze Age, the Late Bronze Age and the Early Iron Age are all well represented in the survey material. To a lesser degree, this also pertains for the Middle Bronze Age, the Urartian, Hellenistic and Partho-Roman periods. The Middle Ages (5th-16th century A.D.), on the contrary, cover the whole area.

Up till now, fourteen graves dating from the Early Iron Age or the end of the Late Bronze Age have been excavated (Fig. 3). These tombs contain fragments of skeletons of men, women and nea-nates, weapons, parts of clothes, jewels and pottery.

The vessels

In total, 27 more or less complete Late Bronze Age / Early Iron Age vessels have been studied (Figs. 4-6). Most of the vessels came from graves 100, 200, and 300, respectively belonging to necropoleis N2, N10, and N11 (Fig. 2). For a detailed description of the necropoleis, the reader is referred to Gasche (forthcoming).

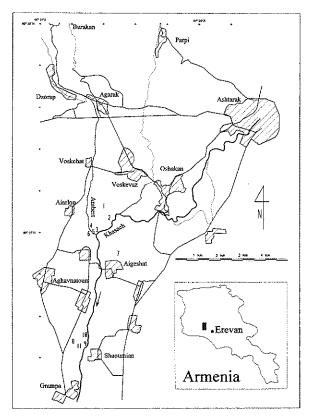


Fig. 1. Map showing the location of Akhtamir, Armenia. Location of the clay samples in the direct vicinity of Akhtamir (nos. 1-10) (courtesy H. Gasche).

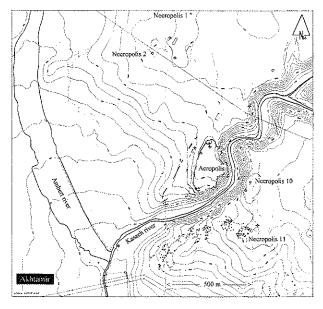


Fig. 2. Topographical map of the ancient site of Akhtamir (courtesy H. Gasche).

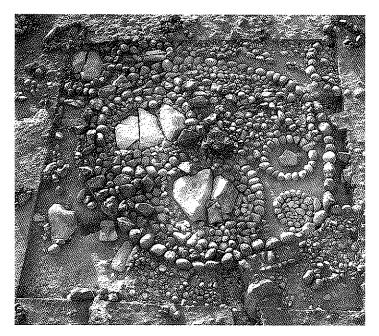


Fig. 3. A Late Bronze Age/Early Iron Age grave at Akhtamir (photo: H. Gasche).

The forming technique

Since the vessels have been carefully finished on the outside it was not easy to reconstruct the forming technique. In some cases the pattern of breaking indicates the forming technique, particularly the coiling technique. The following forming techniques could be distinguished: pinching; coiling without the help of a turntable; and coiling with the help of a turntable.

Pinching

The body of the small vessels was made by using the pinching technique (Fig. 4). Next, a coil was added and the neck was formed. On one of the vessels a decoration was scratched (Fig. 4: 1). The surface of both vessels was burnished by hand in a vertical direction.

Coiling without the help of a turntable

The base of the vessels (Fig. 5) was formed by pressing out a slab of clay. In two cases a mould was probably used (Fig. 5: 4 and 5). The body was built on the base by adding and pressing out two or three coils of clay interrupted by a short period of drying. The last coil served to make the rim. Next, the lower part of the pot was scraped, tapped and flattened. Usually, a scratched decoration was made on the shoulder, sometimes completed with finger impressions (Fig. 5: 6). Thereafter, the vessels were often bur-

nished on the outside and just over the rim on the inside. Consequently, a soft gloss is visible. In some cases, it could be observed that the pots were burnished in various directions. Once, the body was vertically burnished and the shoulder horizontally (Fig. 5: 7). It was clear that the vessel shown on Fig. 5: 4 was horizontally burnished on the

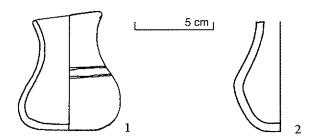


Fig. 4. Vessels made by using the pinching technique.

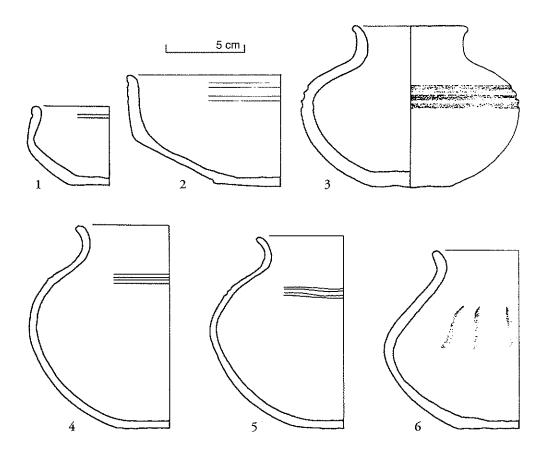


Fig. 5. Vessels coiled without the help of a turntable.

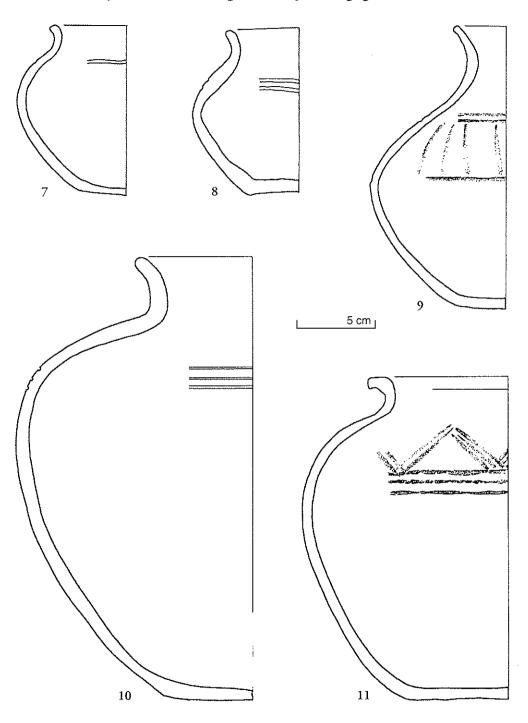
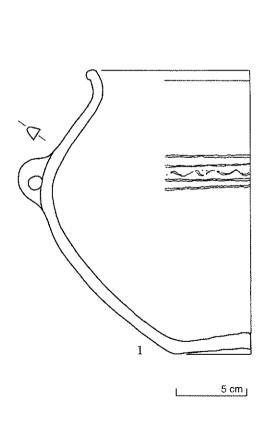


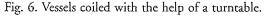
Fig. 5 (continued). Vessels coiled without the help of a turntable.

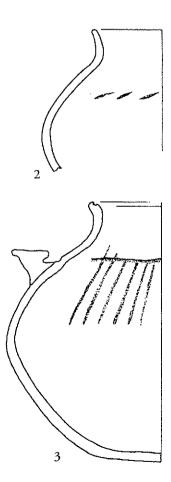
inside. Possibly caused by wear and tear, the vessels shown on Fig. 5: 2 and 9 did not have traces of burnishing below the base on the outside. Finally, the rim and the upper part of the shoulder was finished by a turning movement of the hand.

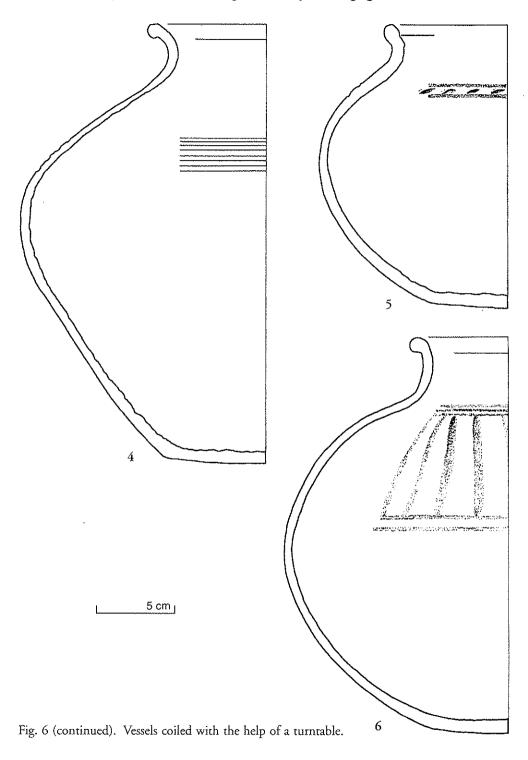
Coiling with the help of a turntable

The base of the vessels (Fig. 6) was formed by pressing out a slab of clay on the turntable. Upon this, a coil of clay was fastened and pressed upwards. Next, the body was coiled until halfway. After a short period of drying during which the body became hard, the pot was finished by adding and pressing out some coils of clay again. The rotating capacity of the turntable was used to give the shoulder and rim a symmetrical form. In most cases, the shoulder was decorated: a scratched decoration (Fig. 6: 1-4), sometimes completed with fingernail or finger impressions (Fig. 6: 5-6), an impressed decoration (Fig. 6: 7-9), an incised decoration (Fig. 6: 10-11), or both a scratched and impressed decoration together (Fig. 6: 12). Next, the pot was taken from the turntable. By scraping, the body was made thinner and the convex base was shaped. As soon as









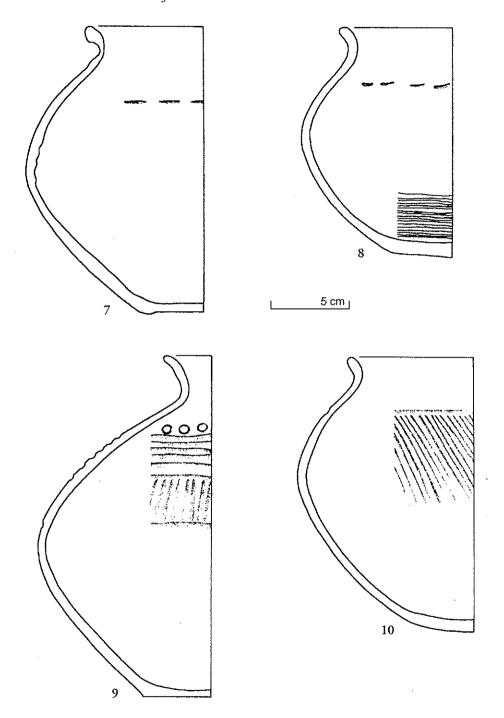


Fig. 6 (continued). Vessels coiled with the help of a turntable.

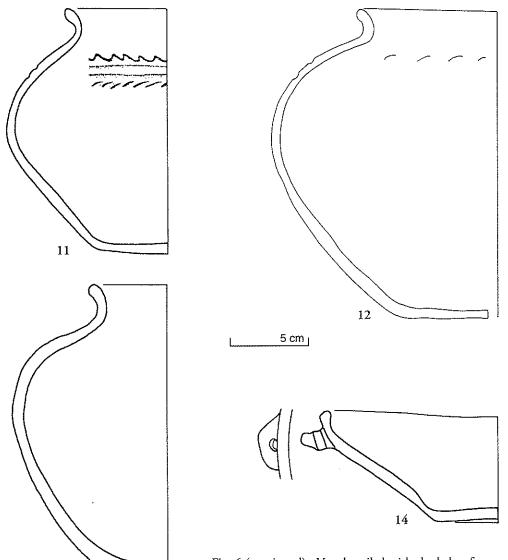


Fig. 6 (continued). Vessels coiled with the help of a turntable.

the clay was leatherhard to bone dry, the surface of most of the pots was burnished on the outside. Some pots have been burnished to just over the rim on the inside (Fig. 6: 1, 6, 10, 13, 14). The pots shown on Fig. 6: 2, 7, 8, 11, 12 have not been burnished. Some pots had small handles (Fig. 6: 1, 3, 14).

13

For the simulation of coiling with the help of a turntable a factory clay (Delfos 3018; chamotte fine) was used mixed with ca. 25% fine river sand. The various successive steps of the forming process have been illustrated in Fig. 7.



Fig. 7:1. A coil of clay is attached to the base made of clay pressed on the the turntable.

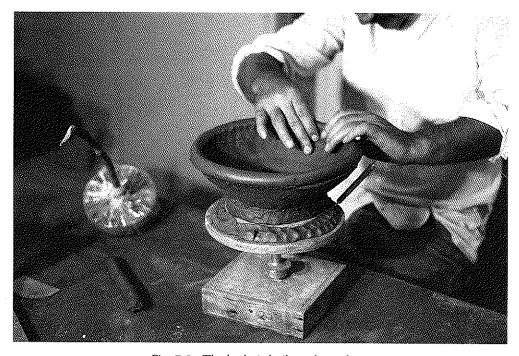


Fig. 7:2. The body is built up by coiling.

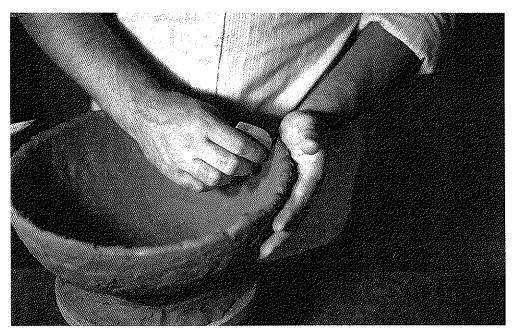


Fig. 7:3. The coil is fastened by scraping. As a result the wall becomes thinner.

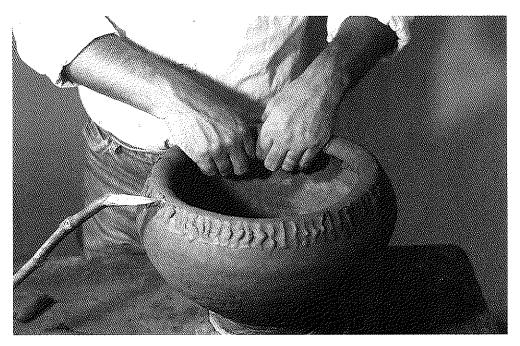


Fig. 7:4. The shoulder is made by further coiling. The use of a stick fastened next to the turntable proves to be useful for controling the symmetry and roundness of the vessel.

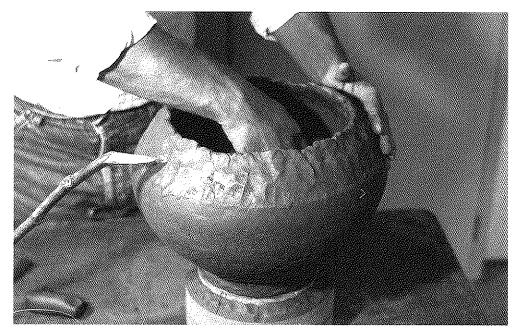


Fig. 7:5. The coil is pinched upwards.



Fig. 7:6. The symmetry is controlled.

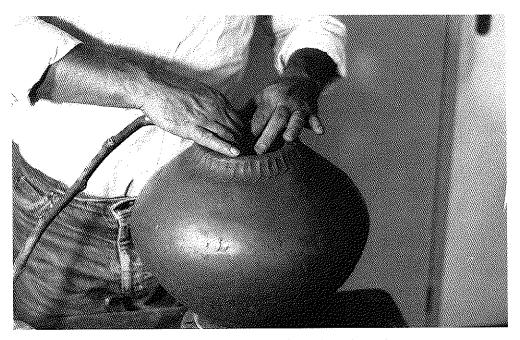


Fig. 7:7. The last coil is used for making the neck.

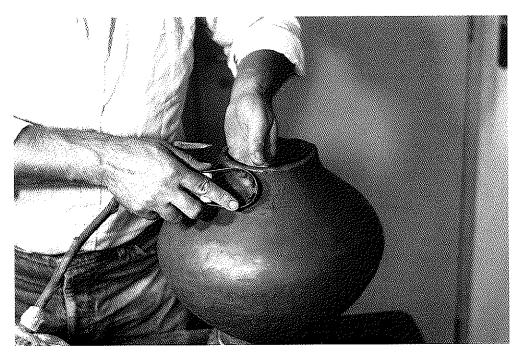


Fig. 7:8. The neck is scraped.

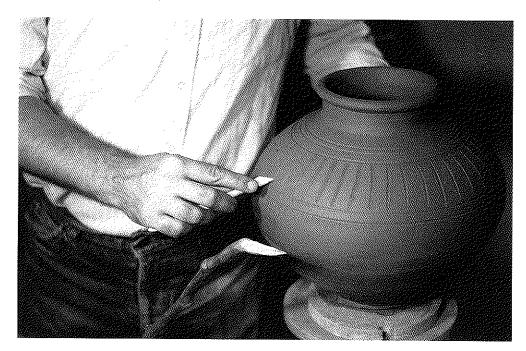


Fig. 7:9. The decoration is incised.

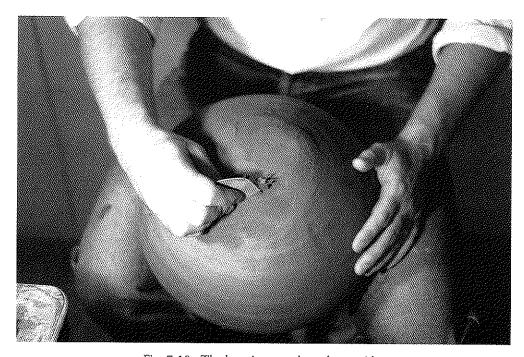


Fig. 7:10. The base is scraped on the outside.



Fig. 7:11. The wall is burnished with a pebble on the rotating turntable.



Fig. 7:12. The base is burnished with a pebble on the rotating turntable.

Fabric	ic 1		3	
Colour	yellowish red - reddish yellow	yellowish red - reddish brown	yellowish red	
Grains				
colour	various	various	black	
shape	A-SA, SR, R	A-SA	A-SA	
size	$50\mu \le x \le 1500\mu$ $50\mu \le 1000$		50μ ≤ 1500μ	
quantity	15-25%	20-25%	ca. 20%	
sorting	moderate/bad moderate/goo		moderate/good	
dominant types	rock fragments basalt obsidian siltstone (several types)	rock fragments basalt obsidian	obsidan basalt	
a few/sporadic other types	(a few:) feldspar quartz quartzite tuff mica	(a few:) feldspar quartz siltstone	(sporadic): rock fragments siltstone	
Samples AKH 318 AKH 332 6 extra sherds		AKH 326 1 sherd	AKH 331 1 sherd	

Table 1. The fabric analysis (after refiring at 750°C in an oxidizing atmosphere) of twelve samples (five samples of the vessels being investigated and seven samples of a collection of sherds belonging to the same kind of Late Bronze Age / Early Iron Age pottery.

A= angular; SA= sub-angular; R=rounded; SR- sub-rounded.

The firing technique

The colours of the pottery on the surface and in the core (black 5YR 2.5/1; dark grey 5YR 4/1; light brown 7.5YR 6/4; brown 7.5YR 5/4; reddish brown 2.5YR 4/4; pinkish grey 7.5YR 7/2; light grey 10YR 7/1) indicate that the vessels had been fired in a reducing atmosphere in a bonfire covered with fuel, ashes and sherds. Refiring tests show that the original firing temperature did not go beyond 900°C. We may assume that the vessels were fired at temperatures between 700° and 900°C. The dark colour of the vessels caused by much carbon present in the clay body used by the potters seems to indicate that the original firing temperature did not even exceed ca. 800°C.

The fabric

The fabric of four vessels described above was analysed. Furthermore, eight samples of a collection of sherds belonging to the same kind of pottery was analysed. After refiring the test sherds at 750°C in an electric kiln, the following three fabric groups could be distinguished (under 10×, 40×, and 50× magnification): (1) mixed coarse/fine grains, (2) mixed

clay sample no.	water absorbing capacity	workability	clay sample no.	water absorbing capacity	workability
1	19.85%	+/++	6	44.56%	 organic mat. silty
2	23.55%	- silty	Z	18.08%	4
3	35.16%	-/ silty	8	29.39%	+ organic mat.
4	20.48%	sample too small	9	14.77%	 sandy
5	17.51%	- silty	10	21.14%	- silty

Table 2. Water absorbing capacity in optimal plastic condition and workability properties (+ = good; ++ = very good; - = moderate; -- = bad). Since clay sample no. 2 proved to be very brittle after firing, only the underlined numbers printed in bold are suitable for pottery production.

fine grains, and (3) mainly dark grains (see Table 1). Group 3 is almost mono-mineral. The other groups consist of several types of grains. The grains $\leq 50\mu$ (silt fraction) of the test sherds consist of mixed sand (composition: see dominant grain types).

The clay samples

Ten clay samples were collected in the direct vicinity of the site (see Fig. 1). The water absorbing capacity was measured and the workability was tested (see Table 2). Next, the linear shrinkage was determined (see Table 3). Finally, the fabric was analysed (after firing the clay samples at 750°C) and compared with the fabric analysis of the sherds.

The clay samples nos. 1, 2, 5, 7, 8, and 10 (see Table 2: workability in plastic condition) were suitable for handforming techniques. The other clay samples (nos. 3, 4, 6, and 9) were not usable for pot making. The fired test bars made of the clay samples nos. 2, 3, and 6 proved to be very brittle. Therefore, only the clay samples nos. 1, 5, 7, 8, and 10 were suitable for pottery production.

Clay sample no. 8 shows the highest total linear shrinkage (see Table 3), caused by the large amount of organic material present in the clay (see Table 2). Clay sample no. 6 contains also a large amount of organic material. On the other hand, its silt content is very high. For this reason, the total linear shrinkage is lower than for clay sample no. 8. and the workability properties are bad.

Since the total linear shrinkage of the clay samples between 700° and 900°C is almost nothing (see Table 3), we may conclude that they do not contain components that start to sinter at these temperatures in an oxidizing atmosphere. For this reason, there is no point to fire pottery made of these clays much higher than 700°C. The total linear shrinkage increases only above 900°C (see Table 3). According to the refiring tests, however, the vessels from Akhtamir have not been fired above 900°C.

clay sample no.	dry	700°C	750°C	800°C	850°C	900°C	950°C	1000°C
1	5.5%	7%	7%	7%	7%	7%	8%	8%
2	3.5%	5.5%	5.5%	5.5%	5.5%	5.5%	12%	12%
3	5%	6%	6.5%	6.5%	6.5%	6.5%	12.5%	12.5%
4	sample too small for linear shrinkage tests							
5	3.5%	4%	4%	4%	4%	4%	6.5%	6.5%
6	4.5%	7%	7%	7%	7%	7%	11%	11%
Z	7.5%	8%	8%	8%	8%	8.5%	12.5%	12.5%
<u>8</u>	10%	11%	11%	11%	11%	11.5%	16%	16%
9	2%	2%	2%	2%	2%	2%	2.5%	2.5%
<u>10</u>	4.5%	5%	5%	5%	5%	5%	8.5%	8.5%

Table 3. Total linear shrinkage of the clay samples at various temperatures. The underlined numbers printed in bold proved to be suitable for pottery production.

The fabric of the clay samples fired at 750°C compared with the refired test sherds (750°C) show that most of the clay samples (nos. 2, 3, 4, 5, 6, 7, 9, and 10, but especially nos. 4, 5, and 7) belong to fabric 1 (see Table 1). The remaining clay samples (nos. 1 and 8) belong to fabric 2 (see Table 1). Fabric 3 (see Table 1) is not represented in the clay samples. Assuming that the clay samples are representative, this might indicate that the black minerals have been added to the natural clay.

Conclusions

A comparison of the fabric of the vessels with the fabric of the clay samples from the direct vicinitiy of the site seems to justify that the pottery has locally been made. The sharp obsidian present in the clay body makes it unlikely that the vessels were thrown on the potter's wheel, as it would have badly injured the potter's hands. The marks on the pottery indicate that the pottery has been made by hand with use of a turntable. This way, it was possible to make very symmetrical vessels which looked as if they were made on a potter's wheel.

Notes

1. The drawings of the pottery in this article (Figs. 4-6) have been made by E. Smekens. The simulation experiments have been photographed by E.P.G. Mulder (Fig. 7).

References

Gasche, H., R.Y. Vardanyan and N. Pons (eds.) (forthcoming), Akhtamir. Recherches dans la vallée de l'Ararat. Les vestiges de la fin du 2e et du début du 1er millénaire av. n. ère.

SARDINIA (ITALY): FIELDWORK AND THE LABORATORY IN CERAMIC ETHNOARCHAEOLOGY

Technology, aimed at the reconstruction of the potter's craft, plays an essential role in the ethnoarchaeological research into pottery production in Sardinia. One of the aspects of the investigation is to try to establish the relationships between raw materials, manufacturing techniques and function of the products under the simulated conditions of an archaeological investigation, *i.e.* without delivering any knowledge of the ethnographic situation to the analyst. The approach of the Department of Pottery Technology integrates technological analyses of sherds and raw materials, laboratory experiments and ethnoarchaeological research. This seem to offer good possibilities for the interpretation of the interaction between people and material culture in the past.

Introduction

One of the objectives of the ceramic ethnoarchaeological research in Sardinia¹ is to establish the relationships between the properties of the raw materials, the manufacturing technique and the function of the products from a potter's point of view. To this end, over the past years several samples of Sardinian pottery and raw materials have been analysed according to the usual 'low tech' methods of the Department of Pottery Technology of Leiden University².

The analyses were carried out under the simulated conditions of an archaeological investigation: it was assumed that only a limited number of samples were available, from which conclusions on the properties of the raw materials, the manufacturing technique and the function of the products were to be drawn without any knowledge of the ethnographic situation. Sherds, clays, tempers and glazes were analysed with the aid of a binocular microscope and the same materials were subjected to a number of experiments (Annis and Jacobs 1986; 1989/1990).

The results of these analyses were considered quite successful. We realized, however, that without the availability of the raw materials – in other words, if we had had to rely on the sherds only –, the resultant picture would have been far less complete and convincing. This underlines the importance of collecting clays in the vicinity of archaeological sites, a practice which is usual within the Department of Pottery Technology of Leiden University (see *e.g.* van As, Jacobs and Wijnen 1995; van As and Jacobs 1995).

Unfortunately, in archaeological investigations, site-related problems or restraints imposed by time and budget often preclude the possibility of obtaining samples of the raw materials used in the manufacture of the ancient pottery, whether excavated or collected from the surface. This is the reason why more recently, the same questions concerning the aforementioned relationships between raw materials, manufacturing techniques and

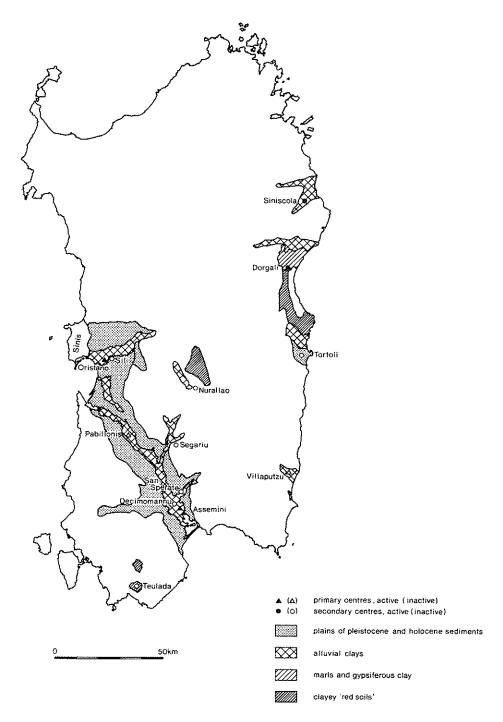


Fig. 1. Sardinia, centres of pottery production and clay sediments.

function of the products, were posed to only a small number of sherds which was submitted to thin section analysis by a petrologist. Other research questions concerned the archaeological evidence, in a limited number of thin sections, of the information obtained in the ethnographic research and the possibility of correctly interpreting the observed characteristics of the samples.

Research plan

A number of sherds from the three production centres Oristano, Assemini and Pabillonis (Fig. 1) were selected for analysis³. It was ensured that the range of samples represented different workshops, clays and tempers mined from different locations, different manufacturing techniques and different vessel functions. In total, eight sherds from Oristano, five from Assemini and three from Pabillonis were analysed.

The thin sections were examined by the geologist Geerten Blessing of the Dutch State Service for Archaeological Investigations (ROB), who systematically described the fabrics, divided the samples into groups and provided some general comments⁴. As in the previous investigations, the ethnographic information was not conveyed to the geologist, who hence only knew that the samples came from different locations within the Campidano, the largest plain of Sardinia which also contains the most extensive clay beds (Fig. 1).

Thin-section analysis

The determination of the minerals contained in the samples showed that the compositions of the various fabrics did not differ much as far as the types of inclusions were concerned. Quartz, feldspar and mica constituted the bulk of the inclusions. The most common non-plastics were quartz grains, mainly monocrystalline with undulose extinction, but occasionally also polycrystalline, angular/sub-angular in shape, with a low sphericity. Alkalifeldspars, mostly orthoclase and incidentally of a microcline variety, were also found, along with some small crystals of an andesitic plagioclase. All the sherds contained mica flakes – of the varieties muscovite, biotite and chlorite – but in different frequencies and sizes.

Epidote, zoisite, zircon and some opaque grains were observed in far lower frequencies. Fragments of rock – mostly phyllite – and iron oxide concretions were encountered sporadically.

Having established that the mineral composition of all the samples was more or less the same in qualitative terms, we shifted our attention to the quantitative aspects of the fabrics, in search of distinctive features. The quantitative aspects considered were the percentages of the grains and their sizes and shapes (Folk 1974); the sorting of the grains and the grain size distribution (Pettijohn, Potter and Siever 1973; Middleton, Freestone and Leese 1985); the percentages of pores; the frequency of the mica flakes. Quantitative differences that were considered distinctive were only observed in:

- a) the percentages of the grains;
- b) the grain size distribution;
- c) the frequency of mica flakes.

The refractivity of the clay matrix was also considered a potentially distinctive property. Under crossed nicols some of the matrices of the examined samples were found to be anisotropic (*i.e.* mainly birefringent), cryptocrystalline or microcrystalline, while others were isotropic (*i.e.* having the same optical properties in all directions), possibly as a result of the firing conditions, but also of the composition of the clay (Rice 1987: 378-79 and 431). On the basis of the aforementioned differences the samples were divided into three groups. A survey of this classification is shown in Table 1. Sample N1 could not be classified. It differed from all the other samples on account of the extreme fineness of its (isotropic) matrix and the virtual absence of inclusions.

Division into groups

Group 1

Most of the sherds of Group 1 contained high concentrations of both sand grains (>10%) and mica flakes. Sample I1 contained a lower percentage of grains, but it was included in this group because of its high mica content and isotropic matrix. The fabric of I3 also differed with respect to the frequency of mica flakes, but it contained a large amount of grains and its matrix was isotropic. S1 and S2 were particularly homogeneous and their inclusions were particularly well sorted, whereas M1 was less homogeneous and its inclusions were poorly sorted. The grain size distribution was mainly unimodal and possibly bimodal in the case of M1 and I3.

All the samples had homogeneous matrices. Those of I1, I3 and M1 were isotropic, those of S1 and S2 cryptocrystalline and that of I2 microcrystalline.

Group 2

The sherds of Group 2 contained moderate amounts of sand grains (5-10%) and high concentrations of mica. C1 and I4 were found to be very similar. D2 and D3 contained smaller amounts of mica flakes and D3 showed a lower frequency of grains.

All the samples had homogeneous matrices; some were cryptocrystalline (D2 and D3), others microcrystalline (C1 and I4).

Group 3

The samples of this group were characterized by a moderate frequency of sand grains (5-10%), small amounts of mica and a homogeneous, cryptocrystalline matrix. EU1 and D1 were found to be almost identical. They contained large, elongated pores, probably caused by shrinkage. Their grain size distribution was possibly bimodal. Pb3, Pb4 and Pb 10 also resembled one another and contained large grains of orthoclase and polycrystalline quartz and some fragments of phyllite.

Comments

The combined presence of such minerals as epidote and zoisite together with phyllite is indicative of disintegration of a pelitic rock in a rather low-grade metamorphism (phyllites and greenschists). Minerals such as quartz, orthoclase and mica are very common

		Grains			Matrix	
Group Sam	Sample	%	grain size distribution	Mica	optical properties	
1	I 1 I 2 S 1 S 2 M 1 < I 3 >	5-10 >10 >10 >10 >10 >10 >10	unimodal unimodal unimodal unimodal possibly bimodal possibly bimodal	+++++++++++++++++++++++++++++++++++++++	isotropic microcrystalline cryptocrystalline cryptocrystalline isotropic isotropic & vitreous	
2	C 1 I 4 D 2 D 3	5-10 5-10 5-10 < 5	possibly bimodal possibly bimodal unimodal unimodal	+ + + -+ -+	microcrystalline crypto- & microcrystalline cryptocrystalline cryptocrystalline	
3	EU 1 D 1 PB 3 PB 4 PB 10	5-10 5-10 5-10 5-10 5-10	possibly bimodal possibly bimodal bimodal bimodal bimodal		cryptocrystalline cryptocrystalline cryptocrystalline cryptocrystalline cryptocrystalline	

Legends:

++ = very abundant

-+ = moderate

+ = abundant

- = sparse

Table 1. Classification of the thin-sectioned samples according to the percentage of sand grains; grain-size distribution; frequency of mica flakes and refractivity of the clay matrix.

in this kind of lithologies. Andesitic plagioclase, however, is rarely encountered in low-grade metamorphic rocks; it is more commonly found in higher-grade metamorphic rocks or as an intrusive or extrusive component of igneous rocks. The dominant types of minerals identified in the samples (quartz, orthoclase and mica) are however also typical components of granitic rocks. This is in accordance with the lithology of the Sardinian Campidano. To the northeast and southwest, the southern part of the Campidano is bordered by greenschist facies containing small outcrops of granitic intrusive rocks and basalt. Consequently, its sediments are unlikely to contain a wide variety of minerals (Exel 1986).

Ethnographic context and previous research

Oristano

Until the beginning of the 1950s the master potters of Oristano were full-time specialists associated in the Società della Santissima Trinità (Association of the Holy Trinity), which had replaced the former Medieval guild that had been abolished in 1864. This 'urban workshop industry' (Peacock 1982: 38-43) was characterized by uniformity in both output and technology. Oristano's ordinary production consisted mainly of sets of

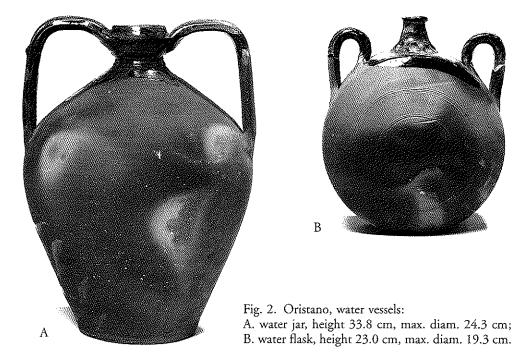
water vessels, for which the town was renowned. They accounted for approximately 60% of the total output; the rest consisted of pots intended for other uses, in particular the preparation and storage of food (Figs. 2 and 3). These artefacts were partially glazed and were fired once. In 1953 the Società was abolished and the mode of production of the potters who remained active became more and more that of 'individual workshop' (Peacock 1982: 31): in the changed social and economic situation each craftsman had to find his own technical and economic solutions. So, whereas in the old situation all the members of the organization had mined their clay from the quarries that were owned by the Società and were exploited on a communal basis, in the 1970s and 1980s no more than two potters still mined their clay from the traditional clay-beds. The others preferred to be supplied by firms digging pits for the building industry.

As regards the preparation, the clay was accurately purified, especially of limestone, and was then mixed with water and kneaded by foot or with the aid of a machine, whichever the workshop owner preferred. Three different types of 'earth' were distinguished and blended at Oristano: a basic clay, from the centre of the sediment, a fat one from above it and a sandy one from below. The quality of the basic clay determined how much fat or sandy clay had to be added in order to obtain the most suitable blends for artefacts with different functions. If the basic clay was 'good enough' it could be used without further additions.

The experiments carried out at the Department of Pottery Technology (Annis and Jacobs 1986) showed that the basic clay, reaching its point of water saturation too quickly, tends to lose its cohesion and is also rather short. These properties make this substance far from ideal for throwing on the wheel. The difficulties can be alleviated to a certain extent by adding fat clay, but there are limits to the amount of fat clay that can be added because of its high degree of shrinkage during drying and firing. This has consequences for the forming technique and the size and shape of the pots. The clay has to be lifted very rapidly and the pots have to be shaped by pressing the clay between the knuckles and pushing it up rather than pulling it.

Consequently, Oristano's repertory lacks particularly large vessels and the water jar, the town's product par excellence, is rather squat, with a gradual and restricted widening of the belly and a short neck. The handles, on the contrary, which were thrown because they could not be pulled, are widely curved (Fig. 2A). The addition of fat clay to the basic clay also leads to a less porous product, which is of particular importance in the case of water vessels. The function of water vessels is twofold: cooling of the water through the permeability of the fabric and purification through a natural process of ion exchange between the water and the bare pot wall (Annis 1984; 1985b). However, the fabric must not be so permeable as to allow the water to leak through the wall.

A different blend is required for basins – wide vessels with thick walls that are used for different purposes (Fig. 3). These vessels have to be strong, which necessitates the use of a clay-body with a sufficiently high content of clay minerals, but at the same time the wall thickness and the considerable width pose problems of shrinkage during drying and firing (Jacobs 1983; Rice 1987: 226-228). These somewhat conflicting requirements were met by adding a small amount of sandy clay to the fairly fat basic



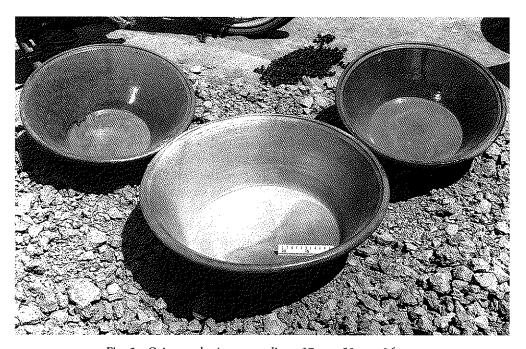


Fig. 3. Oristano, basins, max. diam. 37 cm, 53 cm, 36 cm.

clay. The porosity of the vessels did not constitute any problems as the insides of the basins were completely glazed (Fig. 3).

The thin-sectioned sherds of Oristano came from four different workshops: I(ncani), S(anna), M(anca) and C(arta). The clay of sample M1 only had been mined from the original quarries; that of the other samples had been obtained from different locations in the vicinity of the town. S1 and S2 had been kneaded mechanically, all the others by foot. Samples M1, I1, I2, S1 and S2 were blends intended for water vessels, both jars (M1, I1, S1) and flasks; C1 and I4 were blends for basins. I3 was a special mixture for a completely glazed pot of the category of the 'festive ware' that was produced on special occasions. It had been fired twice.

Assemini

Of the three centres under consideration Assemini is the only one whose pottery production can still be defined a 'village industry'. In this prosperous village situated near the capital Cagliari each workshop is independent and the potters own their own means of production, including clay beds. Being the only centre of production to have embraced technological innovation since the early 1930s, Assemini was able to continue pottery-making in the changed Sardinian context and is now a kind of pilot centre for ceramic industry on the island (Annis 1985b; 1996).

The potters of Assemini manufacture two different types of pottery: the traditional terracotta and table ware and ornamental ware. The latter categories can be produced thanks to the nature of the local clays, which can be successfully coated with a tin glaze, whereas the clays of Oristano and Pabillonis repel tin glazes during firing. The formal and functional repertory of the terracotta artefacts of Assemini is the same as that of Oristano: water vessels and pots intended for other domestic uses, which are partially glazed and fired once (Figs. 4 and 5).

The potters of Assemini use two different types of clay, notably a yellow and a red clay, which are obtained from different locations. The yellow clay, which is both ferruginous and calcareous, contains small amounts of inclusions and is well workable on the wheel. This property enables skilled craftsmen to throw very large vessels which are also of a considerable strength after firing. Indeed, the vessels produced at Assemini, in particular the water jars, are much larger than those of Oristano; they are slender (Fig. 4) and generally have a longer life. The largest capacity attainable at Oristano is about 18 l, whereas at Assemini it is 25 l or more. On the other hand, due to the clay's plasticity, not every craftsman is capable of throwing large vessels on the wheel: some simply lack the specific physical characteristics required. The physical aspects, which can be determinative in the wheel-throwing technique, were highlighted by Valentine Roux and Danièla Corbetta in their research in India (1989). The yellow clay moreover requires slow and careful drying and firing. That is the reason why only a few staunch adherents of the old tradition still use this clay by itself. The red clay is a ferruginous, very silty material that contains a larger amount of inclusions than the yellow clay. Due to the higher frequency of non-plastic inclusions this substance is less stiff and has a lower drying and firing shrinkage. Most potters mix the two clays (mostly 1/4 red,

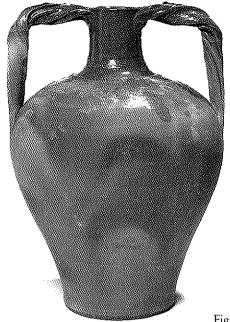


Fig. 4. Assemini, water jar, height 43.0 cm, max. diam. 29.4 cm.



Fig. 5. Assemini, basin, max. diam. 44.4 cm.

3/4 yellow) to obtain a blend that is easier workable on the wheel and less demanding with respect to drying and firing.

The thin-sectioned sherds of Assemini were obtained from three different workshops: D(eidda), E. U(sai) and N(ioi). D2 and D3 were of a water jug and a basin, respectively, both of which had been produced from the yellow clay; EU 1 and D1 were sherds of a colander and a flower pot, respectively, both of which had been produced from a blend of yellow and red clays. The clays had all been mechanically prepared. The clay of N1 was of the same blend, but had been thoroughly purified to make it suitable for the production of glazed table ware; it had been biscuit fired.

Pabillonis

Pabillonis is a small, essentially cereal-growing community whose pottery-production activities came to an end in 1973. The ceramic production of this centre was a part-time 'rural workshop industry', as the workshop owners were also small farmers or day labourers.

The pottery consisted exclusively of cooking ware (Fig. 6), which was distributed all over Sardinia, where the village was better known as 'the pan village' than by its proper name. The cooking pots of Pabillonis were primarily renowned for their resistance to thermal shocks, but also for their light weight and practical shape. According to the producers and the distributors it was essentially the peculiar properties of the specific combination of clay and temper used that made the products of this village so unique.

The 'earth to be soaked', *i.e.* the clay, was dug from an uncultivated area between two rivers to the south of the village. Great attention was paid to its mining and selection: whenever a lump of clay was found to contain limestone or too much sand, the entire lump was immediately discarded. The 'earth to be crushed', *i.e.* the temper, was dug from the lowest strata of the banks of one of the two rivers in the middle of the summer, when the water level was lowest.

One of the aims of the analyses and experiments to which the sherds, clays and tempers from the different workshops were subjected (Annis and Jacobs 1989/1990) was to find out whether the materials used at Pabillonis indeed possessed the 'special' qualities attributed to them. In other words, we wondered whether we were dealing with a case of 'resource specialization' (Rice 1987: 191; 1989). If this proved to be the case, it would mean that some factor connected with the physical environment was largely responsible for the village's monopoly position in Sardinia as a production centre of cooking pots.

The highly ferruginous clay was found to contain a fairly high frequency of non-plastic inclusions, mainly angular grains of quartz and feldspar ranging in size from silt fraction to 2 mm, with the odd larger inclusion (of 4-5 mm). Small amounts of mica flakes were also encountered. The temper proved to have the same composition as the clay, but the proportions of the individual constituents differed: a small quantity of a clayey substance, a large amount of mica and more or less the same frequency of quartz and feldspar grains (of the same shapes and sizes) as the clay. The clay and the temper were both ground, cleaned and sieved by hand, which was a particularly heavy, time-consuming and unhealthy task. The pots were thrown upside down, which resulted in

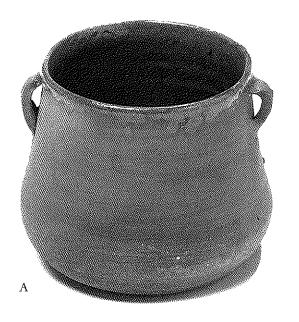


Fig. 6. Pabillonis, cooking ware: A. cooking pot, height 12.1 cm, max. diam. 13.4 cm; B. casserole, height 6.6 cm, max. diam. 14.7 cm.



a thin, well controlled wall thickness. This implied a faster and more equal distribution of heat and, consequently, a smaller risk of the pot cracking. Also advantageous in this respect was the smooth shape of the pot, without angles or sharp bends, which minimized the strains caused by heating (Kingery 1955).

The clay used at Pabillonis was a highly thixotropic material: when soaked in water and left to rest, it formed a thick slurry in which the coarse inclusions remained suspended instead of being deposited (Grimshaw 1980: 473-475; Hamer 1983: 295; Bronitsky 1986). This made it necessary to knead the clay thoroughly on the bench so as to remove

as many coarse grains as possible. Grains of 1 mm and larger are not desirable in the wheel production of thin-walled pottery of the kind that was made at Pabillonis. Moreover, inclusions of such dimensions can cause problems during firing, particularly if their thermal expansion coefficient is substantially higher than that of the clay (Rye 1976; Jacobs 1983). The pots were glazed on the interior to ensure effective heating (Schiffer 1990) and were fired twice.

All the potters agreed that it was absolutely essential to add the 'golden and silvery' temper to the clay in order to obtain the excellent resistance to thermal shock for which their products were so renowned. In Quinua (Peru) Dean Arnold was faced with an almost identical situation: the potters who manufactured cooking ware looked for a clay with 'golden particles', which were considered essential for obtaining resistance to thermal shock (Arnold 1993: 73-80). The Sardinian potters specified a clay/temper ratio of 50: 10 kg. In our experiments the basic clay of Pabillonis was found to have considerable resistance to tensile stress, which implies a good initial strength. However, in order to ensure that the pots would be able to withstand both sudden changes in temperature and repeated cycles of heating and cooling (thermal stress), the porosity of the fabric had to be increased by adding fine temper to the clay. Several studies have shown that temper and porosity are key factors in microcracking (Rye 1976; Grimshaw 1980: 934-943; Braun 1983; Steponaitis 1984; Bronitsky 1986; Schuring 1989: 158-207). The plasticity of the clays of Pabillonis was good, but not excellent. For that reason it was not possible to use a temper consisting exclusively of quartz: quartz sand would have reduced the cohesion of the clay too much. On account of their platy shape, flakes of muscovite, on the contrary, have a positive effect on the cohesion of the blend and improve its workability. Muscovite is moreover elastic and has a damping effect, which are favourable properties with respect to resistance to thermal shock and impact resistance in general (Wallace 1989; Arnold 1993: 73-74). The ratio of clay and temper specified by the potters of Pabillonis proved to be correct: a greater amount of temper would not have increased the product's resistance and would instead have made it weaker and more susceptible to thermal fatigue (Rice 1987: 407). To return to the term 'resource specialization', the raw materials of Pabillonis do not possess peculiar mineralogical properties; their mineral content is very common and does not differ from that of the clays of Oristano and Assemini. It would seem that the village's specialization was not primarily the result of the unique properties of the raw materials used, but rather the consequence of social, economic and historical factors, as is explained in the conclusions below.

The results of the thin-section analysis reconsidered

The classification of the samples into three groups on the basis of differences in the frequency of sand grains and mica flakes (Table 1) – according to the geologist the two most relevant distinguishing features – is only partly in accordance with the actual origins of the sherds. Of course it should be added that the analyst, having at his disposal only a limited number of thin sections and no information whatsoever on the ceramic material from which they were obtained, faced a difficult task, though one that is not uncommon

in archaeological research. A few years ago I myself was faced with the task of having to infer indications of the area of production, the employed manufacturing techniques and the products' functions from a small number of thin sections of sherds from different excavations in Rome that were found to have qualitatively comparable mineral contents. In that investigation the composition of the clay matrix and its characteristics, complemented by the grain size distributions of the individual samples, proved to be more informative than the frequencies of the different types of inclusions (Annis 1992).

Similarly, in the present research, the results of the thin-section analysis indicated that it was also possible to classify the samples on the basis of certain characteristics of the matrices, in particular their fineness and mineral contents (Table 2).

A first group was characterized by a 'fine-grained' matrix that contained remarkably high concentrations of mica, in particular chlorite, but also biotite, and minute grains of quartz and feldspar. The provenance of these sherds was Oristano.

A second group was characterized by a 'very fine-grained' matrix that contained only a very small amount of mica, in particular muscovite. These sherds came from Assemini.

A third group was characterized by a 'fine-grained' matrix that contained moderate amounts of feldspar, quartz and chlorite. These sherds came from Pabillonis.

It hence proved possible to attribute the samples to their respective places of origin by classifying them on the basis of their matrices (Table 2). This is not surprising, as it is in particular from the clay matrix that information on the original sediments may be expected.

As regards the other features: the sherds from Oristano were characterized by a relatively low percentage of pores. They were found to contain a high percentage of non-plastic inclusions, both sand grains and mica flakes. Along with the other minute inclusions observed in the matrix, these non-plastic inclusions are indicative of a lean clay. No clear indications of the differences in the quarries and the employed preparation methods were observable in the fabrics, though it should be noted that in three of the four cases in which the grain size distribution was described as 'possibly bimodal' sandy clay had been added to a fat basic clay with a view to the vessel's function (C1, I4, I3).

The sherds from Assemini contained smaller amounts of inclusions than the sherds from Oristano. The percentage of pores was higher: mainly about 5%. The very fine-grained matrix without grains and the elongated shrinkage pores may indicate a plastic substance. The grain size distribution of samples D1 and EU1, which had been produced from a blend of two clays with different compositions, was described as 'possibly bimodal'. Sherd N1 differed from the others in many respects and could not be classified. This is in accordance with the different manufacturing technique and function of the vessel. As for its optical properties: the perfectly oxidized condition of this sherd suggested that the firing temperature was the cause of its isotropy.

The sherds from Pabillonis contained the highest percentages of pores (5-10%), which is in accordance with the function of these cooking pots. Some of the pores were found to be remarkably large, but they may have been formed at the time of thinsectioning, as a result of the detachment of large inclusions from the matrix. The 'definitely bimodal' grain size distribution of these sherds was due not only to the addition

116 M.B. Annis

Sample	Matrix			Pores	Grains				Provenance
	fineness	composition	optical properties	%	%	size	grain size distribution	Mica	& Function
1 1	fine	feldspar, quartz chlorite +	isotropic	2	5–10	0.06-0.30	unimodal	+	Oristano water jar
I 2	fine	feldspar, quartz chlorite +	microcrystalline	2–5	>10	0.10-0.60	unimodal	++	water flask
S 1	fine	feldspar, quartz chlorite ++ biotite ++	cryptocrystalline	< 2	>10	0.150.60	unimodal	++	water jar
S 2	fine	feldspar, quartz	cryptocrystalline	2–5	>10	0.10-0.30	unimodal	+	water flask
M 1	fine	feldspar, quartz chlorite +	isotropic	<2	>10	0.15-0.40	poss.bimodal	+	water jar
I 3		feldspar, quartz	isotropic &	<2	>10	0.150.60	poss.bimodal	-	festive ware
C 1	fine	feldspar, quartz chlorite ++	microcrystalline	2	5–10	0.15-2.00	poss.bimodal	++	basin
14	fine	feldspar, quartz chlorite +	crypto- & microcrystalline	<2	5–10	0.10-0.80	poss.bimodal	+	basin
D 2 D 3 EU 1 D 1 <n 1=""></n>	very fine very fine very fine very fine very fine	muscovite – muscovite – muscovite – muscovite –	cryptocrystalline cryptocrystalline cryptocrystalline cryptocrystalline isotropic	2–5 5 5 5–10 <2	5–10 <5 5–10 5–10 <2	0.050.30 0.050.60 0.10-0.70 0.150.30 0.030.20	unimodal unimodal poss.bimodal poss.bimodal unimodal	+ + 	ASSEMINI water jar basin colander flowerpot biscuit-fired table ware
PB 3	fine	feldspar, quartz	cryptocrystalline	5–10	5–10	0.20-1.00	bimodal	_	Pabillonis cooking pot
PB 4	fine	feldspar, quartz	cryptocrystalline	5	5–10	0.20-1.00	bimodal		cooking pot
PB 10	fine	feldspar, quartz chlorite	cryptocrystalline	5–10	5–10	0.30-1.50	bimodal		cooking pot

Legends : ++ =

++ = very abundant

-+ = moderate

+ = abundant

- = sparse

Table 2. Classification of the thin-sectioned samples according to fineness and mineral composition of the clay matrix.

of temper, but also to the (thixotropic) nature of the clay. As already mentioned, the high thixotropy of the clay also explains the presence of very coarse grains (up to 1.50 mm), which are not desirable in throwing and firing. What was surprising was the relatively low frequency of micas in the sherds from Pabillonis, where the addition of highly micaceous temper was of such fundamental importance in view of the manufacturing technique employed and the function of the products. A possible explanation for this observation is a change in the optical properties of mica during firing (Williams 1983: 305).

Some concluding remarks

To conclude, I would like to make a few points on the relevance of this kind of ethnoarchaeological investigations to archaeology.

A first consideration concerns the results of the thin-section analysis. The remarkably high degree of homogeneity of the mineral compositions of the various samples is in accordance with the lithology of the region of their provenance: the Campidano, where clayey quaternary alluvial soils predominate (Pecorini 1971: 9-11). Further information obtained from the analysis of the clay matrix complemented by the grain size distribution has also shed some light on certain differences between the raw materials of the three production centres, the manufacturing techniques and the functions of the products.

With due allowance for the limitations imposed with respect to the number of samples and the employed research means, which were among the least sophisticated of those currently available for ceramic analysis, the results do not seem discouraging. However, when compared with the ethnographic information and with the information obtained in the analyses of the artefacts and, in particular, the clays and tempers, their narrow scope and – often – ambiguity become apparent.

A second point I would like to make is that the properties of the clays and the manufacturing techniques in relation to the function of the vessels, do not seem to be determined by environmental factors only. Recent archives research on the period of Spanish domination in Sardinia (14th-17th century) has shown that the ceramic production of the island was organized according to Spanish models (Marini and Ferru 1993: 61-139). Today too, formal, technical and organizational characteristics of the traditional Sardinian production bear close resemblances to those of certain productions investigated by Rüdiger Vossen in Spain in terms of shapes, technology and equipment, systems of production in series and units of sale (see e. g. Vossen, Seseña, Köpke 1981, Vossen 1984: 341-364). Although archaeological evidence is still lacking, it is possible that the Spanish workers who came to the island opportunely selected the raw materials and that the organization of the production and the 'specialization' of some centres in the manufacture of specific products was the consequence of administrative measures. The introduction of pottery-making technologies by colonists into conquered territories has been attested on several occasions. Well-known examples concern, for instance, the Phoenician, Punic and Greek colonisation of the Mediterranean, the Roman conquest and the Spanish domination of the New World. An interesting case in point has been recently discovered by Prudence Rice during her archaeological investigation in the Moquegua valley in Peru (Rice 1994). This is to say that possible historical factors such as selection of the raw materials, regulation of the production and legislation should be taken into consideration in the interpretation of the material phenomena.

This once again stresses the importance of the integration of archaeometrical techniques with other means of studying the archaeological materials (see *e.g.* Henderson 1989: xvii; Franken 1995: 96; Tite 1995: 171-172). In the archaeological project which is called 'Riu Mannu Survey' and is carried out in the same Sardinian region where the ethnoarchaeological investigation has taken place the knowledge of the study

area and of its raw materials built up through my ethnoarchaeological research, is proving extremely useful in the analysis of the ancient pottery collected, which constitutes 75% of the finds (Annis, van Dommelen and van de Velde 1995; Annis in press).

To sum up, the approach of our Department which integrates technological analyses

To sum up, the approach of our Department which integrates technological analyses of sherds and raw materials, laboratory experiments and ethnoarchaeological research seems to offer good possibilities for the interpretation of the interaction between people and material culture in the past.

Notes

- 1. The ethnoarchaeological research into pottery production in Sardinia which has been carried out since 1975 is a regional, in-depth study covering the span of two generations (1920-1990). This study concentrates on the economics of pottery making aiming at more plausible interpretations of the phenomena observable in ancient pottery, particularly in times of radical transformations. Annual reports on the investigation have been published in: *Newsletter of the Department of Pottery Technology (Leiden University)* from Vol. 1 (1983), to Vol. 7/8 (1989/1990). See also Annis (1985a; 1995; 1996).
- For an overview of the methods see van As (1991/1992).
- 3. Fig. I has been drawn by P. Deunhouwer. The photos (Figs. 2-6) have been taken by J. Pauptit.
- 4. The thin sections have been made by E.P.G. Mulder.

References

- Annis, M.B. (1984), Pots in Oristano: a lesson for the archaeologist. Newsletter of the Department of Pottery Technology (Leiden University) 2: 32-51.
- Annis, M.B. (1985a), Resistance and change: pottery manufacture in Sardinia. World Archaeology 17: 240-255.
- Annis, M.B. (1985b), Ethnoarchaeological research: water vessels in Sardinia. Newsletter of the Department of Pottery Technology (Leiden University) 3: 43-94.
- Annis, M.B. (1992), Ricerche mineralogico-petrografiche e analisi fisico-chimica di campioni ceramici provenienti da diversi contesti Romani. In: L. Paroli (ed.), *La ceramica invetriata Tardoantica e Altomedievale in Italia*, Firenze: 603-620.
- Annis, M.B. (1995), Economia di una produzione ceramica: ricerca etno-archeologica nell'Oristanese. In: Atti del convegno 'La ceramica racconta la storia'. La ceramica artistica, d'uso e da costruzione nell'Oristanese dal neolitico ai giorni nostri, Oristano 1994, Oristano: 295-329.
- Annis, M.B. (1996), Organization of pottery production in Sardinia: Variability and change.
 In: H. Lüdtke and R. Vossen (eds.), Töpfereiforschung zwischen Mittelmeer und Skandinavien (Töpferei- und Keramikforschung Band 3), Bonn: 143-170.
- Annis, M.B. (în press), Paesaggi rurali nella Sardegna centro-occidentale: il Progetto Riu Mannu dell'Università di Leiden, Paesi Bassi. In: P. Ruggeri and C. Vismara (eds.), *L'Africa Romana XII. L'organizzazione dello spazio rurale nelle province del Nord Africa della Sardegna*, Sassari.
- Annis, M.B. and L. Jacobs (1986), Ethnoarchaeological research: pottery production in Oristano (Sardinia). Relationships between raw materials, manufacturing techniques and artifacts. Newsletter of the Department of Pottery Technology (Leiden University) 4: 56-85.

- Annis, M.A. and L. Jacobs (1989/1990), Cooking ware from Pabillonis (Sardinia): relationships between raw materials, manufacturing techniques and function of the vessels. *Newsletter of the Department of Pottery Technology (Leiden University)* 7/8: 75-130.
- Annis, M.B., P. van Dommelen and P. van de Velde (1995), Rural settlement and socio-political organization: the Riu Mannu survey project in Sardinia. *Bulletin Antieke Beschaving* 70: 133-152.
- Arnold, D.E. (1993), Ecology and Ceramic Production in an Andean Community, Cambridge.
- As A. van (1991/1992), Pottery technology: the bridge between archaeology and the laboratory. Newsletter of the Department of Pottery Technology (Leiden University) 9/10: 1-6.
- As, A. van and L. Jacobs (1995), An examination of the clays probably used by the ancient potters of Lehun (Jordan). Newsletter of the Department of Pottery Technology (Leiden University) 13: 15-25.
- As. A. van, L. Jacobs and M.-H. Wijnen (1995), Archaeo-ceramological research: a contribution to the study of the development of early farming cultures in Northwestern Anatolia. In: A. Lindahl and O. Stilborg (eds.), *The Aim of Laboratory Analyses of Ceramics in Archaeology*, (Konferenser 34 KVHAA), Stockholm: 63-75.
- Braun, D.P. (1983), Pots and tools. In: A.S. Keene and J.A. Moore (eds.), Archaeological Hammers and Theories, New York: 107-134.
- Bronitsky, G. (1986), The use of materials science techniques in the study of pottery construction and use. In: M.B. Schiffer (ed.), *Advance in Archaeological Method and Theory* 9, Orlando: 209-276.
- Exel, R. (1986), Sardinien, Geologie, Mineralogie, Lagerstätten, Bergbau. Sammlung Geologischer Führer 80, Berlin.
- Folk, R.L. (1974), Petrology of Sedimentary Rocks, Austin Texas.
- Franken, H.J. (1995), Theory and practice of ceramic studies in archaeology. Newsletter of the Department of Pottery Technology (Leiden University) 13: 81-102.
- Grimshaw, R.W. (1980), The Chemistry and Physics of Clays and Allied Ceramic Materials (4th edition revised), New York.
- Hamer, F. (1983), The Potter's Dictionary of Materials and Techniques, London.
- Henderson, J. (1989), Introduction. In: J. Henderson (ed.), Scientific Analysis in Archaeology and its Interpretation, (Oxford University Committee for Archaeology, Monograph No. 19. UCLA Institute of Archaeology, Archaeological Research Tools 5), Oxford, Los Angeles: xvii-xix.
- Kingery, W.D. (1955), Factors affecting thermal stress resistance of ceramic materials. *Journal of the American Ceramic Society* 38: 3-15.
- Jacobs, L. (1983), Notes about the relation between filler and clay, and filler and shrinkage, respectively. Newsletter of the Department of Pottery Technology (Leiden University) 1: 6-12.
- Marini, M. and M.L. Ferru (1993), Ŝtoria della ceramica in Sardegna. Produzione locale e importazione dal Medioevo al primo novecento, Cagliari.
- Middleton, A.P., I.C. Freestone and M.N. Leese (1985), Textural analysis of ceramic thin sections: evaluation of grain sampling procedures. *Archaeometry* 27: 64-74.
- Peacock, D.P.S. (1982), Pottery in the Roman World: An Ethno-archaeological Approach, London, New York.
- Pecorini, G. (1971), Litologia. In: R. Pracchi and A Terrosu Asole (eds.), *Atlante della Sardegna* I, Cagliari: 9-11.
- Pettijohn, F.J., P.E. Potter and R. Siever (1973), Sand and Sandstone, Berlin.
- Rice, P.M. (1987), Pottery Analysis. A Sourcebook, Chicago.
- Rice, P.M. (1989), Ceramic diversity, production and use. In: R.D. Leonard and G.T. Jones (eds.), *Quantifying Diversity in Archaeology*, Cambridge: 109-117.

- Rice, M.P. (1994), The kilns of Moquega, Peru: technology, excavations and function. *Journal of Field Archaeology* 21: 325-344.
- Roux, V. and D. Corbetta (1989), The Potter's Wheel. Craft Specialization and Technical Competence, New Delhi, Bombay, Calcutta.
- Rye, O.S. (1976), Keeping your temper under control: materials and manufacture of Papuan pottery. Archaeological and Physical Anthropology in Oceania 11: 106-137.
- Schiffer, M.B. (1990), The influence of surface treatment on heating effectiveness of ceramic vessels. *Journal of Archaeological Science* 17: 373-381.
- Schuring, J.M. (1989), Experimental Studies on Roman and Medieval Ceramics: Pottery from the San Sisto Vecchio in Rome, Ph.D. Dissertation, Leiden University.
- Steponaitis, V.P. (1984), Technological studies of prehistoric pottery from Alabama: physical properties and vessel function. In: S.E. van der Leeuw and A.C. Pritchard (eds.), *The Many Dimensions of Pottery. Ceramics in Achaeology and Anthropology*, (Albert Egges van Giffen Instituut voor Pre-en Protohistorie Cingula 7), Amsterdam: 79-127.
- Tite, M.S. (1995), Summary of comments of participants at the summing-up session of the Lund workshop (7-9 april 1995). In: A. Lindahl and O. Stilborg (eds.), *The Aim of Laboratory Analysis of Ceramics in Archaeology*, (Konferenser 34 KVHAA), Stockholm: 171-172.
- Vossen, R. (1984), Towards building models of traditional trade in ceramics: case studies from Spain an Morocco. In: S.E van der Leeuw and A.C. Pritchard (eds.), *The Many Dimensions* of Pottery. Ceramics in Archaeology and Anthropology, (Albert Egges van Giffen Instituut voor Pre-en Protohistorie Cingula 7), Amsterdam: 341-397.
- Vossen, R., N. Seseña and W. Köpke (1981), Guia de los alfares de España, Madrid.
- Wallace, D. (1989), Functional factors of mica and ceramic burnishing. In: G. Bronitsky (ed.), Pottery Technology: Ideas and Approaches, Boulder, San Francisco, London: 33-39.
- Williams, D.F. (1983), Petrology of ceramics. In: D.R.C. Kempe and A.P. Harvey (eds.), Petrology of Archaeological Artefacts, Oxford: 301-329.