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DEPARTMENT OF POTTERY TECHNOLOGY

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A. van As

POTTERY TECHNOLOGY: THE BRIDGE BETWEEN ARCHAEOLOGY AND THE LABORATORY*

Introduction

In this paper I would like to present some considerations, which already for some time have kept me occupied at the Institute of Pottery Technology at the University of Leiden where I succeeded professor Franken as director. These considerations stem from certain publications of archaeological ceramics, but above all from discussions with colleagues visiting the Institute.

At present, there are archaeologists who are, in my opinion, too easily inclined to resort to scientific analyses of a small sample of pottery. I appreciate laboratory analysis of excavated pottery as useful for archaeological interpretation. I think, however, that technological investigation of pottery as developed by H.J. Franken and J. Kalsbeek in their study of the early Iron Age pottery of Deir Alla (Franken 1969) is the principle bridge between archaeology and the laboratory because of its explicative character.

Archaeological pottery studies

Descriptive studies

Formerly, the archaeological research of pottery focussed above all on the study of ceramic shapes. For a long time archaeologists were mainly interested in pottery because they recognized it to be chronologically important. Besides colour and texture, the shape of the pottery was the main characteristic for dating. It would not be difficult to mention examples of these typo-chronological studies. Most of the archaeological typological studies of pottery are descriptive. In such a descriptive study, the pottery is classified on the basis of various characteristics or attributes with no attempt to explain those features. Specifically, the shape, being described and drawn, is not explained in terms of manufacturing technique. For example, a round base of a pot, could have been thrown and scraped afterwards, thrown closed, or made in a mould. In a descriptive typology this is not reflected explicitly.

Explicative studies

Speaking of archaeology as a science, the observed phenomena have to be explained. Attempts have been made in the past to explain certain characteristics of pottery technologically. For example, the study of J.L. Kelso and J.P. Thorley was one of the first attempts to examine the manufacturing techniques of Iron Age pottery from Palestine at W.F. Albright's request (Kelso and Thorley 1943). H.J. Franken and J. Kalsbeek elaborated on this kind of approach systematically to make it generally applicable (Franken 1969). The development of technological ceramological research in archaeology helped to change the mainly typo-chronological descriptive kind of study. The maker behind the pot became visible.

Pottery technology tries to explain the various aspects of the potter's craft within the framework of the archaeological discipline by means of studying the relationships between technical, functional and scientific aspects of ancient pottery. An explicative analysis of the observed phenomena can be made. A reconstruction of the manufacturing technique of the pottery from the preparation of the clay up to, and including, the firing is the aim and is the basis for the pottery classification (Franken 1983; van As 1984).

In the technological analysis at the Institute of Pottery Technology, the observed features of the pottery are explained by themselves as well as in relation to each other. In some cases the shapes can be explained by the raw materials, the related manufacturing technique and/or the function. As a result, the shapes are no longer accidental. In other cases the various shapes within a pottery repertoire can be considered as variants of one and the same manufacturing technique, but the differences apparently reflect among other things chronological or regional distinctions. For example, we are now preparing a corpus of Mesopotamian pottery (van As 1989). The diversity of shapes within the second millennium B.C. repertoire from four archaeological sites in Iraq can be reduced to a very few technological types (van As and Jacobs in prep.). Nevertheless, recording of the various shapes is important for trying to establish tendencies of change through time or local variancy. In the same second millennium B.C. pottery repertoire we explain how and why the bases of the goblets were tempered with abundant organic material to best resist cracking (van As and Jacobs 1987). In the first half of the second millennium B.C. (Old Babylonian period) base cracks were repaired with an extra organically tempered clay body added after drying. In the subsequent Kassite period the technology changed: the extra organically tempered clay body was used during the manufacturing technique in order to prevent cracks.

With respect to decorative motives, the tradition plays an important part. Changes in the techniques of decoration, however, can often be explained through technological analysis. The relationship between painted Neolithic A pottery and Neolithic B pottery decorated with 'herringbone' incisions from Jericho can be explained on technological grounds (Franken 1974:204,205). Each decoration coincides with a particular raw material. The pottery decorated with 'herringbone' incisions is coarsely minerally tempered in contrast to the organic temper of the painted pottery. Large amounts of coarse temper reduce the porosity of the sherd thereby making painting more difficult. Another example of a possible technological explanation of a change in decoration technique comes from Ta'as in northwestern Syria in the early Islamic period (van As 1984:138). During this period painting on jars disappears. The jars were painted with a brush and an iron-oxide (red colour) diluted with water before firing. The colour of the decoration is not bright because of the high percentage of lime present in the clay. For this reason the iron becomes volatile above a certain temperature which causes the pale surface colours. People probably thought the painted decoration not successful enough and returned to a decoration of incisions, as used before.

Pottery technology: its methods

To give a technological interpretation of the characteristics of pottery requires knowledge of the various aspects of the potter's craft. The cooperation with a potter is essential for a thorough technological analysis of excavated pottery. Because of practical experience, potters know how to interprete the various technological features which have been left in the pottery. Potters are also able to verify the reconstructed technique, by practical experimentation with clays of a quality which is comparable with that used in antiquity. For this reason it is important to take samples of clays found in the vicinity of the excavation - clays which could have been used for pottery production in antiquity. So called 'workability tests' are carried out with these clays. These are experiments to determine the behaviour of clays in relation to the potter's craft, e.g. the firing colour, the measure of shrinkage when dry or fired, porosity and so on. A visit to local potters, if present in the vicinity of the excavation, is useful for an understanding of the possibilities of the local raw materials. Even short visits to the potter of Dimini (Greece) (van As, Jacobs and Wijnen 1988) and the potter of Örnekköy (Turkey) (van As and Wijnen 1989/90) yielded useful information for our technological analysis of Neolithic pottery from Sesklo and from Ilipinar Hüyük respectively (van As and Jacobs 1988; van As and Wijnen in prep.). The observations of the potter's workshops near Baghdad were also relevant to the archaeological-ceramological research of Mesopotamian pottery (van As and Jacobs 1986).

Today not only the purely technological concerns of the production of pottery, but also other aspects such as production-organization, function and distribution of the products can still be taken in consideration. M.B. Annis (1983:13,14) pointed out that with respect to archaeological-ceramological research the heart of the question is: the explanation of the interplay of determinants of the features that characterize a production. It is, in her opinion, the archaeologist's task to distinguish between the various aspects, to define these aspects and finally to reconstruct these features in order to make the latter explainable and render to them their own historical value. Towards this goal dr. Annis started her ceramological ethno-archaeological research in Sardinia with the aim of the investigating of a complete entity, not a fragmentary one like the ancient finds (see the annual contributions on this subject in the *Newsletter*, *Department of Pottery Technology (Leiden University)*.

Besides the reconstruction of the techniques (forming, decoration, firing), the analysis of the raw materials used forms an important part of the technological investigations of the Institute of Pottery Technology. It involves the macroscopic analysis of the quantity, the grain size and the quality of the (added) non-plastics present in the clay body (Stienstra 1986). But the first mentioned aspects are more important for the potter than the latter. Following the successive steps in the process of potmaking, Y. Hemelrijk classified the so-called non-diagnostic pottery sherds from Lehun on criteria based on elements that are progressively less fundamental for the potter (Hemelrijk 1987). The study of the size and quantity of the mineral inclusions was the first step. A later step was the determination of the non-plastic inclusions, both mineral and organic. The investigation of both aspects can be achieved within a reasonable time and does not demand costly laboratory research equipment. Only a precise identification of the non- plastics, necessary in provenience studies, requires a analysis of thin sections under a polarization microscope.

Above, the main research methods of the Institute of Pottery Technology have been described: research methods which can be used by archaeologists with simple technical devices. However, analyses executed with costly laboratory research equipment also form an integrated part of the technological research program to solve archaeological problems. These analyses take place in specialized laboratories outside the Institute of Pottery Technology, when needed.

The laboratory

It is not the place here to present a complete survey of the various modern advanced laboratory analysis techniques used for archaeological ceramics. Most of them are applied in mineralogical and chemical characterization studies of pottery: X-ray diffraction, thermal analysis, optical emissions spectroscopy, neutron-activation analysis, X-ray milliprobe, electron microprobe and so on (Rice 1987:375-405). Furthermore, there are analyses to determine the physical, mechanical and thermal properties of pottery (Rice 1987:347-370). Xeroradiography is a powerful method of establishing the manufacturing technique (Rye 1977).

The above-mentioned laboratory analysis methods are an important help within the archaeological-ceramological research. But in the research concept of the Institute of Pottery Technology they are not more than an aid. The laboratory analyses alone, unless integrated within the technological research, do not give any explanation for understanding of the pottery product. The results of the analyses give precise data (quantitatively or qualitatively) on separate pottery characteristics. At this point I want to make a few remarks.

1. From a potter's view the precise results of modern laboratory analyses are not always relevant. Dilatometer measurements are often too precise.
2. Chemical analyses of potsherds, when done with a very small sample are often, archaeologically speaking insignificant. The results are, except in provenience studies, of no archaeological/technological importance.
3. Different methods of characterization result in different classifications of potsherds. In her study of Terra Sigillata Africana from the San Sisto Vecchio in Rome J.M. Schuring could find support for the division based on optical characteristics in the porosimetrical data, but the groups based on chemical composition

were problematic (Schuring 1988:26).

4. Xeroradiography is a useful test for the reconstruction of the manufacturing techniques made on various significant features. But unlike the interpretation of the relevant characteristics, xeroradiography does not give an explanation of the manufacturing technique.

Conclusions

In archaeology a description of the material remains is not sufficient. Only in the explanation of the material remains a vivid (although sometimes vague) picture of life in antiquity comes up.

Pottery technology in the broadest sense of the word - meaning the study of all possible aspects of pottery - is an explicative archaeological study. Modern laboratory research forms part of it, but is relevant only in the light of the above-mentioned understanding of archaeology. If not, one runs the risk that modern laboratory analyses of pottery yield only foot-notes in archaeological publications. I have tried to indicate that pottery technology is the bridge between archaeology and the laboratory. It is a *conditio sine qua non.* The results of the technological analysis of pottery form the basis for the selection of laboratory samples.

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* This article is a lecture delivered during the Fifth International Conference on the History and Archaeology of Jordan which was held at the Jordan University of Science and Technology at Irbid. The conference lasted from the 12th - 17th April, 1992.

L. Jacobs

CAUSES FOR THE PALE COLOUR OF IRON-CONTAINING, SECOND MILLENNIUM B.C. POTTERY FROM THREE ARCHAEOLOGICAL SITES IN MESOPOTAMIA*

Introduction

One of the characteristics of the second millennium B.C.(the Old Babylonian and Kassite periods) pottery from the Mesopotamian archaeological sites Tell ed-Dēr, Nippur and Isin (Fig. 1) is the predominantly pale colour (see also van As and Jacobs 1992)[1]. The pale colour is considered to be striking because the clays which were used often contained a considerable amount of iron. The pottery is not the red colour which normally occurs when clays are fired with similar amounts of iron. The following is an explanation of the prevalently pale colour of this pottery.

Some general remarks on the colour of pottery

Firing conditions apart, the colour of pottery is determined by the composition of the raw material. The raw material for pottery (clay) is a mixture of the real plastic clay mineral (a hydrated aluminium silicate) and non-clay components (non-plastic minerals). This mixture occurs naturally (natural clay). If necessary, it can also be prepared in a certain way by the potters (clay body). The non-clay components consist of coarse-grained to very fine material. The coarse-grained material does have its influence on the colour of the sherd as a whole but not on the colour of the matrix. The colour of the matrix is determined by the colour of the very fine-grained material in the clay and by well-distributed impurities, which are mostly metal compounds in more or less dissolvable form.

White clay contains no impurities or combinations of impurities that affect the colour, and any impurities which may be present in small quantities do not really affect the white colour. Impurities that directly affect the firing colour are compounds of Fe (iron), Mn (manganese), Cu (copper), Co (cobalt) and Cr (chromium). Iron, because it is widespread, is the most important. A wide range of possible discolorations occur caused by various combinations of the polluting substances. Discolorations that are much in evidence are red, brown, grey and black tints, as a result of iron compounds; and brown, grey, black- and purple-like colours as a result of manganese compounds. In their natural state copper, chromium and cobalt compounds usually only occur in small amounts in clay and are not as widespread as the other substances mentioned. When found separately and in sufficient amounts they cause green and blue discolorations respectively. Combinations of chromium, manganese, copper, titanium and cobalt with iron usually cause brown discolorations. Impurities which do not affect the colour separately can play an important part in certain combinations. This way, combinations of calcium, silicon and iron give yellow hues, provided no other

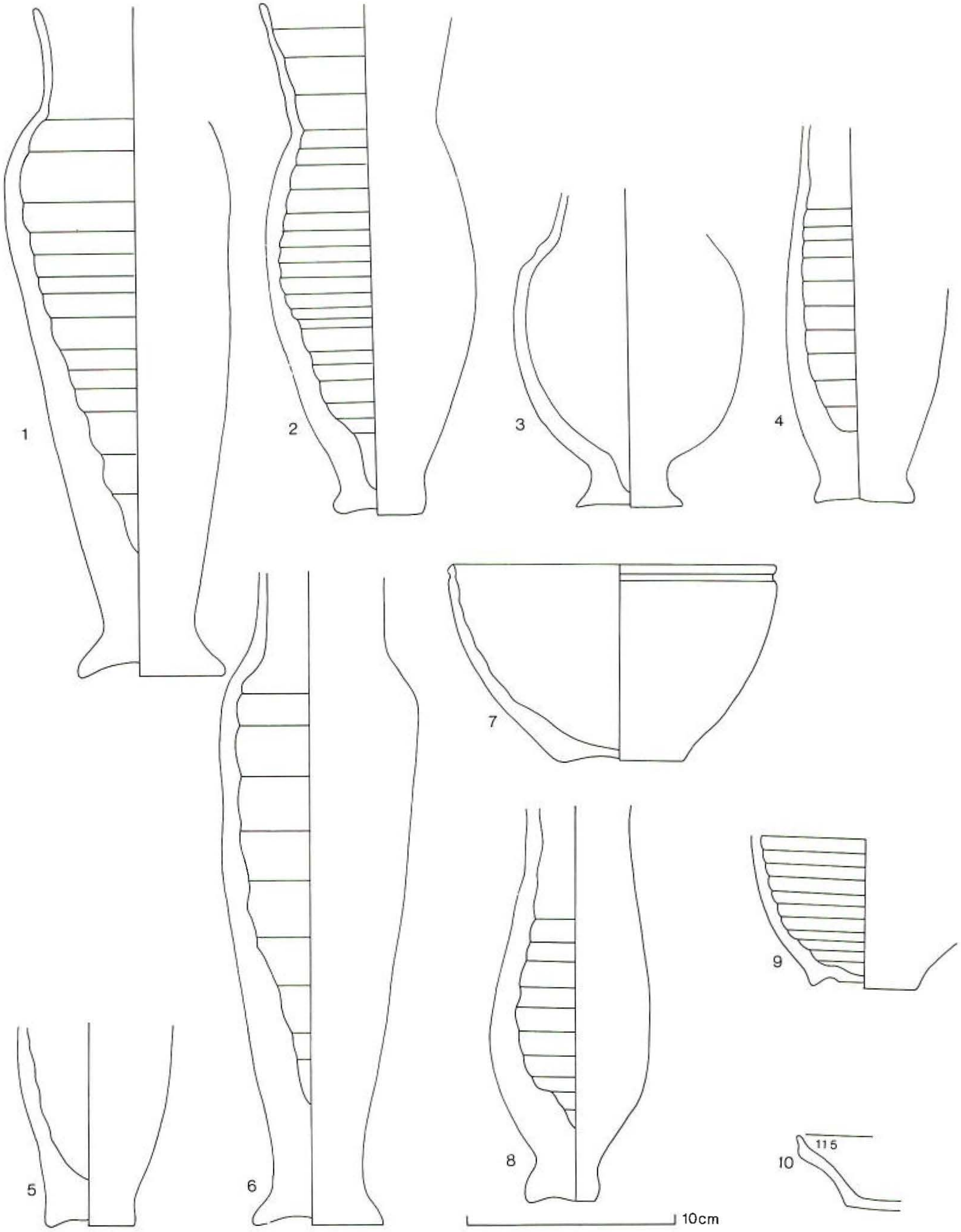


Fig. 1. Second millennium B.C. pottery (fragments) from Tell ed-Dēr (1-5), Nippur (6-8), and Isin (9-10).

contaminants are present, or, alternately, when there is a surplus of iron. Yellow tints can also originate from combinations of Mg (magnesium) and Sn (tin) with small amounts of iron. The discoloration of light clays at relatively high firing temperatures caused by calcium compounds is of further importance. Above 1000°C this causes an olive-green colour.

Apart from this there is the influence of C (carbon). It can already be present in the clay or it can occur during the firing process by burning organic material. Carbon causes light grey to black discolorations. However, this can only occur when the process takes place in an atmosphere with a low oxygen content.

Microprobe-analyses and (re)firing experiments

The research into the pale colour of certain samples of Mesopotamian pottery focused on explanations in terms of raw materials and the firing conditions. For this reason, microprobe-analyses and (re)firing experiments have been executed using sherds of the second millennium B.C. pottery from Tell ed-Dēr, Isin and Nippur, clay samples taken at the same sites and north-east of Baghdad, and test bars made of clay of which the composition was known[2].

In a *microprobe* the preferably smooth surface of a sample is bombarded by electron rays. As a result, the atoms of the sample material emit röntgen rays. The various elements can be determined with the help of the specific energy levels of this emission. The height of the different peaks is an indication of the relative quantities of the elements[3]. Sometimes one can deduce from these data which compounds are present. A great advantage of the method is the scope it offers for measuring the sample in several places. This made it possible to establish the composition of pottery sherds in several places of the cross section.

Firing experiments were executed in order to gain insight into the influence of the firing conditions on the colour of the pottery. The firing tests were always carried out under controlled conditions. The heating path, the rate of temperature increase, the maximum temperature and the time it was maintained were adjusted. Also the firing conditions - oxidizing, neutral or reducing - could be fixed. In an electric oven the firing conditions caused oxidizing. In this type of oven, the samples were placed under covers in order to create neutral conditions. A reducing atmosphere was achieved by using a gas oven.

Sherds of pottery from the second millennium B.C.

In total 50 microprobe-analyses were executed with 20 sherds. The three spectra representative for the occurring situations are presented here below.

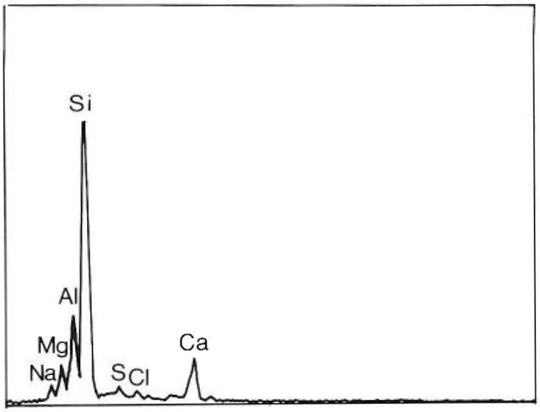


Fig. 2. A spectrum of 300 microns in the middle of sample D 7501 (white: 2.5 Y 8/2) (Fig.1.1). Iron is lacking here completely. In this case there are two possibilities: there was either no iron present in the clay or any iron present became volatile during the firing process and subsequently disappeared from the sherd. Also small amounts of sodium and chlorine are present. These are possible remnants of NaCl which was present in the clay itself. Above a temperature of about 850°C chlorine gradually separates from this connection. Consequently the height of the Cl peak does not represent the original amount of chlorine that was present.

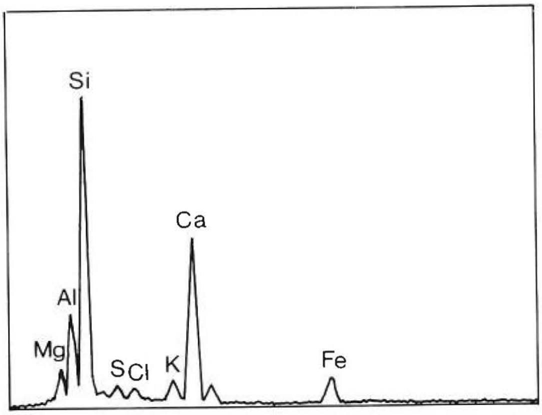


Fig. 3. A spectrum of 300 microns in the middle of sample D 8532 (pink: 7.5 YR 8/4)(Fig. 1.2). With this amount of iron, part of Fe has been absorbed by the calcium silicates.

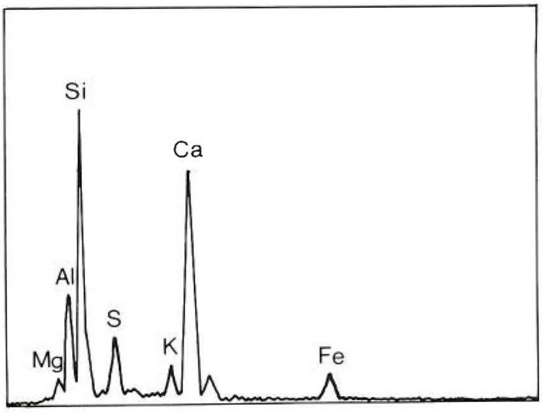


Fig. 4. A spectrum of 20 microns on the surface area of sample D 8532 (pale yellow: 10 YR 8/3) (Fig.1.2). The obvious difference with the previous spectrum is the amount of sulphur and calcium. The high calcium and sulphur content in spectrum two is related to the forming of a scum of gypsum on the surface[4].

Under oxidizing conditions 120 sherds were heated at temperatures ranging from 650°C to 1100°C with 50°C intervals. This way insight was gained into the behaviour of the colour of this pottery if subjected to high temperatures. It was noted that pottery which had faded, did not revert back to red under oxidizing conditions.

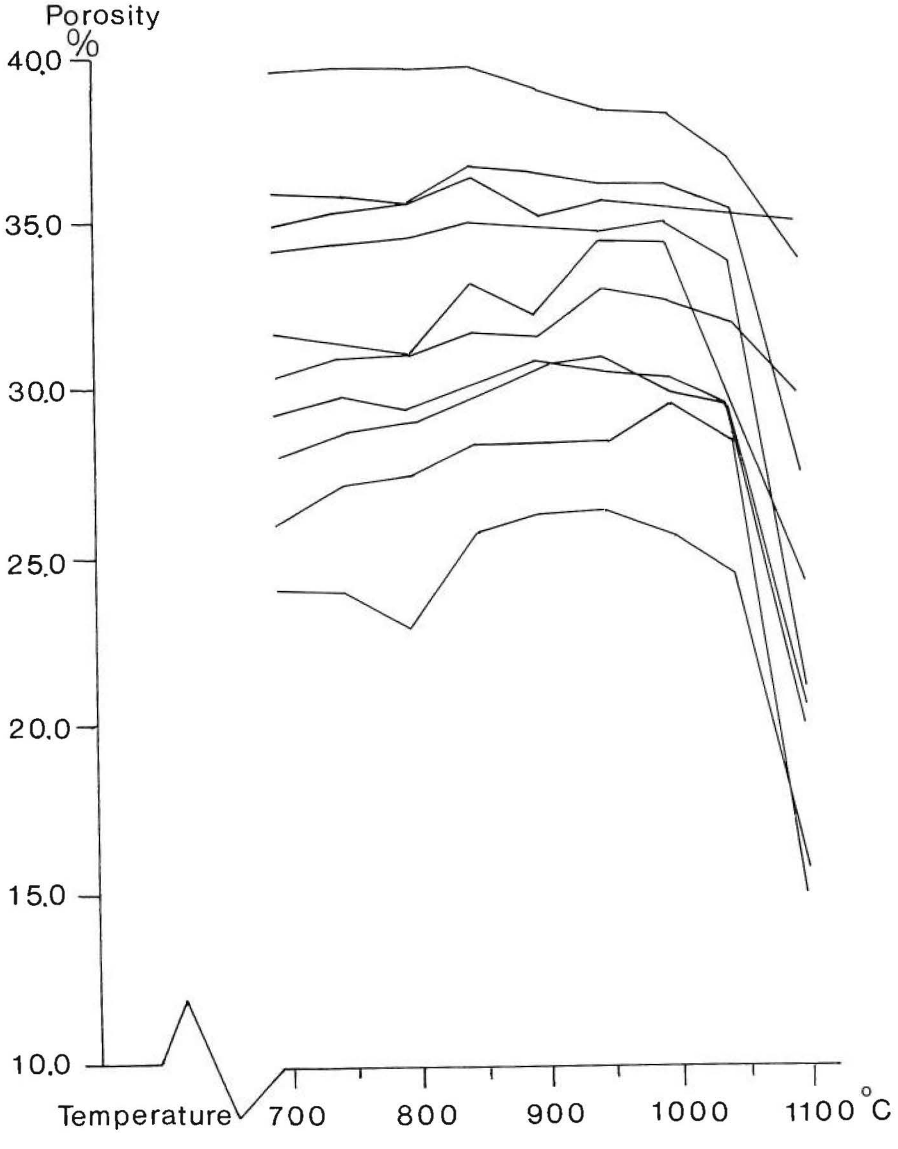


Fig. 5. Ten sherds from Tell ed-Dēr: diagram of the apparent porosity percentages. In most cases a sharp decrease in porosity occurs around 1050° C.

The presence of calcium in the clay is a factor which, when other conditions are also met, counteracts the red coloration of pottery which contains iron (Peacock 1984). The formation and sintering action of calcium silicates is demonstrated by the following experiment.

The porosity of more tan 120 sherds found at Tell ed-Dēr was measured after firing under controlled conditions at 50°C intervals. Graphics were made of these measurements. Ten of these are represented at page 5 (Fig. 5). This figure shows that the average porosity of the sherds lies between 20 and 40%. It is also quite clear that, in most cases, there is a sharp decrease in porosity at around 1050°C. This must be contributed to the high calcium content of the clays and the well distributed form in which calcium occurs. The calcium silicates that have been formed are the cause of an early sintering of the sherds above 1050°C. Due to this, the faded pottery turns to a light olive green colour which becomes darker and darker as the temperature rises. Eventually deformation of the sherds occurs at around 1150°C. By then the colour is dark olive green. The fact that these temperatures were reached in the Old Babylonian and Kassite periods is apparent from the fact that some spots were found which had a light green to olive green colour. Occasionally, completely deformed misfires with a dark olive green colour were found too.

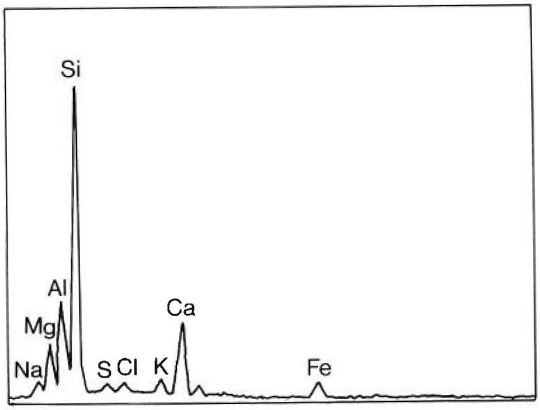
Clay samples

In total 19 microprobe-analyses have been executed with 9 clay samples.

During the sampling the usefulness of the clay as a raw material for potters was observed. Several of the clay samples were taken from sedimentary deposits of clay at a depth of a few metres, which during the second millennium B.C. must have been on, or close to, the surface. The clay sample taken north-east of Baghdad on the road to Baquba is a clay which is being used nowadays by potters still using the traditional methods of potmaking. These potters produce pottery which has a pale colour. Though situated near the Diyala these pottery workshops are in the basin of the Tigris. The pattern does not differ considerably from the ones collected from the other clays. It is also a clay with a high calcium content.

The representative spectra are given here below.

Fig. 6 (see next page). A spectrum of 300 microns of a clay sample taken on the surface from the foot of the dike around Tell ed-Dēr. Iron is present. Sodium (Na), potassium (K) and Calcium (Ca) are present in the clay.



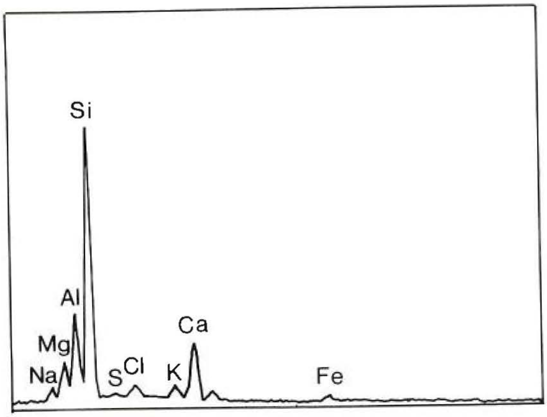


Fig. 7. A spectrum of 300 microns of clay taken north-east of Baghdad. This clay contains relatively little iron. The quantity, however, would be sufficient to bring about a red colour if there were no fading factors. The clay also contains enough chlorine components to cause fading.

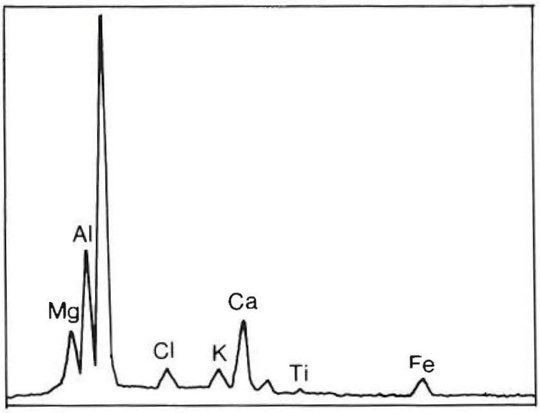


Fig. 8. A spectrum of 300 microns of a clay sample taken from a dated layer in an excavation pit at Nippur. This spectrum shows that iron in the form of iron sulphate does not occur in this clay. One possible form is iron chloride. This sample contains 3 to 4% of iron. There is, however, also a lot of chlorine present which causes fading. During the firing process any sulphur which is not already present in the clay itself may be absorbed from the combustion gasses.

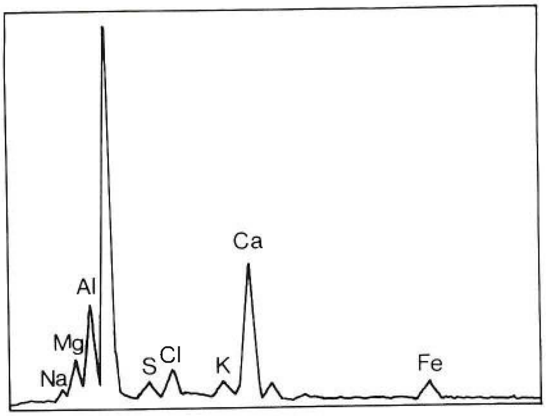


Fig. 9. A spectrum of a clay that is currently being used by workers of a brickyard not far from Nippur. Contrary to the previous one, this sample does contain sodium and sulphur. The calcium content is somewhat higher. The percentage of iron is almost the same. The amount of chlorine is adequate to make iron completely volatile in neutral conditions and if the temperature is high enough. In addition to this there are also components which cause the formation of a scum.

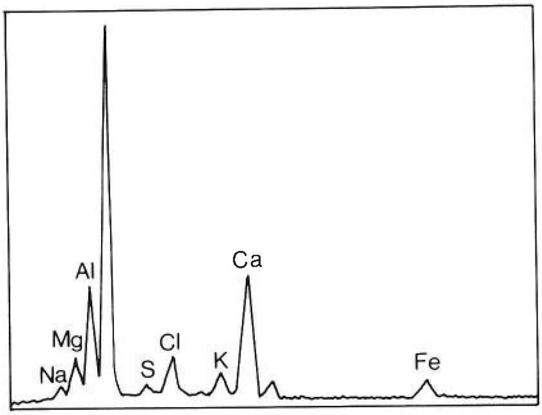


Fig. 10. A spectrum of 300 microns of a clay sample taken from a dated layer in the profile of a canal near Tell Isin. This clay shows a remarkable resemblance to clays from Nippur (compare e.g. the previous spectrum). The Fe peak indicates a percentage of 3 to 4% of iron.

Over 20 clay samples were used to do tests under oxidizing and neutral conditions. Some results of baking under oxidizing conditions are given in Table 1. Likewise, using these and other clays from the area, firing tests were done in the field which resulted in the clays becoming pale red under oxidizing conditions. Differences in the baking colour of a number of clay samples represent differences in the iron content of the clay. However, under neutral conditions complete colour fading occurred.

The raw material: an evaluation of the spectra

In examining the spectra, the following should be considered. The Al and Si peaks are an indication for the actual clay component i.e. an aluminium silicate. The Si peak, however, is relatively high which points to a considerable amount of extra silicic acid in the analysed sherds and clays. The affinity between free silicon and calcium is

Clay sample	Colour in unfired (dry) condition	Firing colour at 850°C under oxidizing conditions	Number of spectrum if represented
Taken from the foot of the dike around Tell ed-Dēr	light grey 10 YR 7/2	light reddish brown 2.5 YR 6/4	17
Clay used nowadays by the potters north-east of Baghdad	light grey 10 YR 7/2	light reddish brown 2.5 YR 6/4	18
N 11, taken from a dated layer in an excavation pit at Nippur	pinkish white 7.5 YR 8/2 to pinkish grey 7.5 YR 7/2	light red 2.5 YR 6/6	19
N 8, being used in a brick yard not far from Nippur	very pale brown 10 YR 7/3	light reddish brown 2.5 YR 6/4	20
Taken from a dated Isin layer in the profile of a canal nearby the tell	light grey 10 YR 7/2	pink 5 YR 8/3 partly white	21
D 27, taken from a depression within the dike around Tell ed-Dēr at a depth of 3.20 m.	light grey 10 YR 7/2	light red 2.5 YR 6/4	Fe peak as spectrum number 17
D 27, taken from a depression within the dike around Tell ed-Dēr at a depth of 4.30 m.	light grey 10 YR 7/2	light red 2.5 YR 6/4	Fe peak as spectrum number 17

Table 1. Clay samples from Tell ed-Dēr, Nippur and Isin: colours before and after firing under oxidizing conditions. In all these cases iron is demonstrable with a microprobe.

No.	Addition	Temperature	Climate	MSCC
1 a	Fe_2O_3 4% $CaCO_3$ 15%	850°C	oxidizing	5R-5/3 weak red
b	Fe_2O_3 4% $CaCO_3$ 15%	950°C	oxidizing	5R-5/4 weak red
c	Fe_2O_3 4% $CaCO_3$ 15%	1120°C	oxidizing	7.5YR-5/2 brown
2 a	$CaCO_3$ 15% Fe_2O_3 4% NaCl	750°C	Fired in a gas oven (the surface shows calcium/salt "scum")	2.5Y-6/4 light yellowish brown
b	$CaCO_3$ 15% Fe_2O_3 4% NaCl	800°C	fired in a gas oven	2.5YR-6/2 pale red
c	$CaCO_3$ 15% Fe_2O_3 4% NaCl	900°C	oxidizing (sharply edged hollows of cubic salt crystals are visible as white points)	7.5YR-5/4 weak red
d	$CaCO_3$ 15% Fe_2O_3 4% NaCl	1050°C	neutral	2.5Y-8/4 pale yellow
e	$CaCO_3$ 15% Fe_2O_3 4% NaCl	1100°C	oxidizing (the surface shows a calcium/salt "scum")	2.5Y-8/6 yellow
3	$CaCO_3$ 15% Fe_2O_3 4% $CaSO_4.2H_2O$ 10%	900°C	oxidizing	7.5R-5/4 weak red
4	Fe_2O_3 4% $CaSO_4.2H_2O$ 15%	1100°C	oxidizing	7.5YR-5/4 brown

Table 2. Test bars made from a white baking clay to which several components were added. In test bar no. 2d there is a complete fading of red. When clays contain, next to calcium compounds, also iron oxide, then the colour does not become olive-green at higher temperatures, but brown (see test bars numbers 1c and 4).

White baking clay with additional Fe_2O_3 in %	Colour (MSCC)	name
	5 YR 8/1	white
0.1; 0.2; 0.3; 0.4; 0.5		shades ranging from white to pale red
	5 R 6/3	pale red
1; 1.5; 2; 2.5		shades of pale red
	5 R 6/4	pale red
3; 3.5; 4; 4.5; 5; 6		shades between pale and weak red
	5 R 5/3	weak red
7; 8; 9; 10		shades of weak red

Table 3. The colour of white-baking clay as a function of rising amounts of iron oxide. The test bars used were fired in oxidizing conditions at 850°C and 1050°C. The maximum temperature was always maintained for thirty minutes. The difference in temperature only had a very slight influence on the firing colour. Because of the very small differences, the shades have been taken together. In fact there is a gradually increasing intensity. Discoloration is clearly visible above 0.1%. The increase in intensity above 6% is negligible.

considerable, and consequently calcium silicates are readily formed during the firing process. In clays rich in calcium, complex calcium silicates are formed at low temperatures from 600°C due to the presence of small quantities of Na and K (Lehnhäuser 1983:24,31). A comparison of the spectra of the Mesopotamian clays which were analysed indicates that the iron content can differ, but in general amounts to 2 to 3%. Concerning the iron content of the sherds, it should be noted that it is generally lower near the edge than in the centre. Especially when there is little oxygen, iron can readily form a compound with other components. In these circumstances there is not much reduction. When the absorbed quantity of iron is relatively low the formed calcium silicates have a light colour. For example wollastonite, a calcium silicate, turns yellowish when it incorporates small quantities of iron. This is enhanced by the presence of Na and K, the quantities of which, as of iron, all remained below 5%. In pottery of the Old Babylonian and Kassite periods part or all of the iron forms a compound with the calcium silicates. If there is a surplus of oxygen, however, these compounds are only formed at higher temperatures. When ever Fe_2O_3 has been formed, not all of the iron will form a compound with calcium silicates anymore. That is the reason why a pink colour may occur.

According to Buringh (1960) the Euphrates and Tigris clays are rich in calcium. In these clays calcium occurs in several different forms: calcium carbonate; calcium magnesium carbonate; calcium chloride; and calcium sulphate (gypsum). The clay also contains sodium compounds such as NaCl and Na_2SO_4 and magnesium compounds such as $MgCl_2$ and $MgSO_4$. Apart from these there is also KCl.

Because of strong evaporation and small amounts of rainfall the ground water in large parts of Iraq moves upwards. Ground water always contains salts. As a result of the accumulation of salts the clays become brackish.

The accumulation of relatively large amounts of chloride compounds (salts) such as NaCl, KCl, $CaCl_2$ and $MgCl_2$ in the surface area of the sherd contributes to the fact that iron becomes volatile. On top of that, in the combustion gasses, chlorine fumes are often present e.g. in the form of HCl. In these conditions iron forms a compound with chloride which results in $FeCl_2$, which is volatile. This way iron can evaporate from the surface area.

The firing process

Like the composition of the raw material, the firing condition is also of influence on the colour of the pottery.

In some cases iron chloride, as a vapour, partly precipitates on the surface during the firing process. Later on it may be oxidized into red iron oxide. Most of the time, however, iron has completely or partly disappeared in vaporized form from the sherd. The exhaust fumes should not contain too much oxygen, but they are permitted to contain chlorine fumes. The ideal would be a situation where the chlorine fumes linger for some time and where there is no large gas flow. Fading is stronger when the temperature exceeds 850°C. An atmosphere in which, at least for some time, there is little or no oxygen is therefore a condition for the origin of pale colours. In places where oxygen was present the chlorine fumes were diluted and transported. Under these circumstances iron is bound to oxygen or is maintained as iron oxide. The result is often a pale yellow surface with pink to pale red spots. The fact that in pale parts of a similar surface iron has indeed disappeared is apparent from a comparison of the measurements using a microprobe. In the pink areas of the sherd, iron is present partly in the form of Fe_2O_3 and partly in a compound with a calcium sodium silicate. In the pale areas iron has disappeared. This feature is known as "mottling" (Grimshaw 1980:927).

Test bars made of clay of which the composition was known

The interplay of the factors causing the pale colour of the pottery were investigated with help of test bars. These test bars were manufactured from a white-baking clay (under oxidizing conditions) to which known quantities of several minerals were added in powdered form (see also Jacobs 1987:55). These additives were expressed in a percentage of the dry weight. The following minerals were added in several combinations: gypsum, limestone, iron oxide and common salt (NaCl). Under neutral firing conditions, when using certain mixtures, a complete fading of the red colour was achieved (Table 2; p. 9).

Also, apart from the above-mentioned test bars, a series of test bars was manufactured made from the same white-baking clay to which increasing quantities of iron oxide (Fe_2O_3) were added. Iron oxide was always mixed through the clay in a ball mill for a period of two hours, because the distribution is an important factor in coloration. This way insight was obtained into the colouring effect of iron oxide under oxidizing conditions (Table 3; p. 10).

In total 11 analyses were made with 6 test bars. The following three spectra are representative.

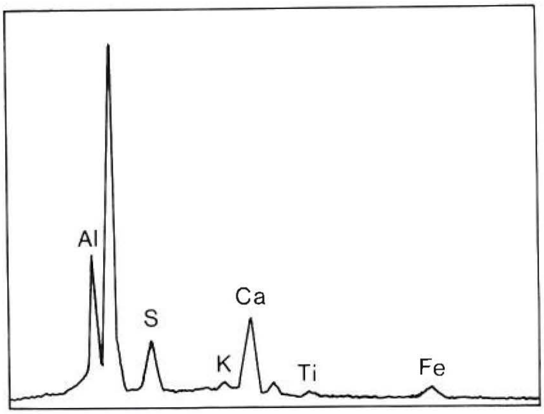


Fig. 11. A spectrum of 300 microns from a test bar made from a white baking clay to which 4% of Fe_2O_3, and 15% of $CaSO_4$ (gypsum) were added. This was then fired under a hood up to 900°C. The temperature was maintained for 30 minutes. Afterwards the colour was weak red and there was no trace of scum formation. This shows that the presence of well- distributed calcium is not sufficient by itself to cause the fading of a colour. (When $CaCO_3$ was added there was no fading either.) The Fe peak is representative for about 2.8% of iron and the S peak for about 5% of sulphur. The clay that was used does not contain any sulphur itself.

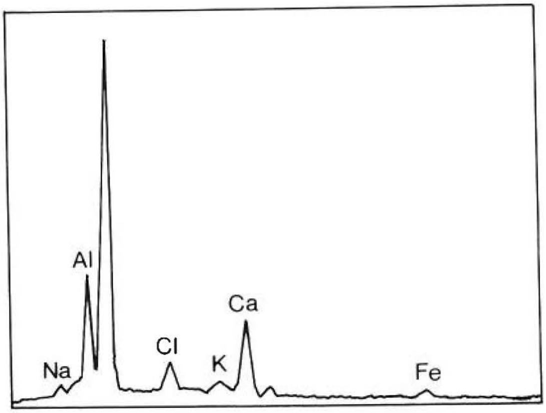


Fig. 12. A spectrum of 300 microns of a test bar which was made from a white baking clay to which 4% of Fe_2O_3 and 15% of $CaCO_3$ were added. It was made with water that was saturated with NaCl. The firing process was executed under oxidizing conditions up to 850°C, maintained for 30 minutes. The baking colour was weak red and there was no sign of fading. There was a small salt scum but this was not included in the measurement because the spectrum was taken from the middle area of the sherd. Sodium chloride can be traced back in the Na and Cl peaks. The height of the calcium peak represents a content of about 15%, half of which was added

as $CaCO_3$, and half of which was natural to the clay.

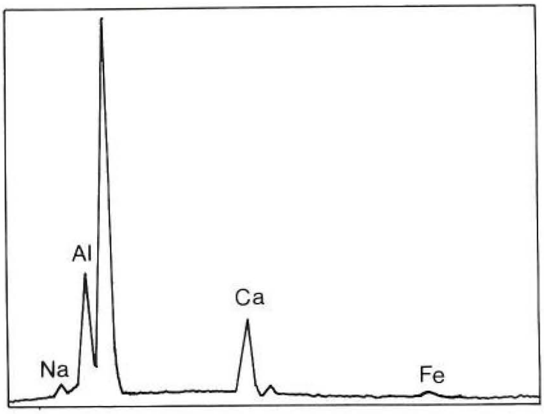


Fig. 13. A spectrum of 300 microns of a test bar made from a white- baking clay to which 4% of Fe_2O_3 and 15% of $CaCO_3$ were added (see also Table 1 no. 2d). It was made with water that was saturated with NaCl. Contrary to the preceding test bar, this test bar was fired under a hood at 1050°C, maintained for 30 minutes. This way the chlorine fumes set free above 850°C could not easily escape. Consequently there was no oxygen surplus. This created the conditions for fading. The spectrum indicates that part of the iron has become volatile, and another part has combined with calcium silicate. The colour of the test bar is pale yellow through and through (2.5 Y 8/4). There is a thin layer of scum on the surface. The colour is identical to that of the sherd.

Conclusions

All clays and sherds analysed contained calcium in a well distributed form. This is supposed to decrease or prevent the red coloration of pottery by iron oxide. The experiments, however, show that this is not the only factor necessary for the pale colour of pottery made of an iron-containing clay. When a test bar containing 4% of Fe_2O_3 and 15% of $CaCO_3$ in a well distributed form is fired at a temperature of 950°C for thirty minutes, it turns red. This indicates an interplay of the following factors:

1. the presence of calcium in the clay;
2. the salt content of the clay;
3. the firing conditions.

Notes

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1. The following situations occur:

1. The whole sherd has a homogeneous pale colour all the way through, for example white (5 Y 8/2).
2. Only the skin has a pale colour e.g. white or pale yellow, for the rest the sherd is pink, for instance 5 Y 7/4.
3. The sherd has a pale colour as deep as 0.5 to 4 mm under the surface. Deeper down the colour gradually turns pink.
4. The pottery is spotted. At some place the surface is white or pale yellow, and at other places it is pink. The changes are gradual.

2. The microprobe-analysis were executed at the Kamerlingh Onnes Laboratory of Leiden University with the very helpful cooperation of Mr. T.J. Gortenmulder who is attached to the working party "Materials Mt IV".

3. The spectra do not indicate absolute percentages of frequency. The percentages mentioned in the text are conversions of the spectra.

4. Scum formation as a fading factor is a phenomenon which occurs in a number of cases in the pottery of the Old Babylonian and Kassite periods. Components such as NaCl, $CaCl_2$, $MgCl_2$ etc ., which emanate from the clay and are soluble in water, are deposited at places where the water evaporates during the drying process. On the surface, especially on prodtruding parts, there is accumulation of similar components. With closed shapes this does not happen or it occurs to a lesser extent on the inner surface. Subsequently, during the firing process, chemical reactions take place. When, for example, there is calcium on the surface this can react with sulphur fumes that are present in the burning gasses and thus form gypsum ($CaSOa_4$). In the same way a scum of magnesium sulphate can be formed which, contrary to the scum of gypsum, is soluble in water. In the pottery of the Old Babylonian and Kassite periods, it usually is a mixture of both scum formations which can affect the surface.

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CHALCOLITHIC POTTERY FROM ILIPINAR (PHASES VIII-V) IN NORTHWESTERN ANATOLIA

Introduction

This article is the sequel to the study of the Neolithic and Early Chalcolithic pottery from Ilipinar (phases X-VIII) in northwestern Anatolia (van As and Wijnen 1989/1990). In the present preliminary report we will discuss the technique and shape of the Chalcolithic pottery (Ilipinar, phases VIII-V) which was analysed in 1990[1;2].

A total of 2852 diagnostic sherds were investigated (Table 1)[3]. The sherds came from the excavation squares X13, Y13, U13 and S9. For the specific location and stratigraphy of the excavation squares we refer the reader to Roodenberg (1989/1990:71,fig.1).

		Excavation squares:				
Phase	Dating	X13	Y13	U13	S9	Total
V	c. 6400 BP				815	815
VI	6750-6550 BP			89		89
VII			724			724
upper VIII	6900-6750 BP	720				720
lower VIII		504				504
Total		1224	724	89	815	2852

Table 1. Amount of sherds analysed.

The technological analysis of the pottery aimed at the reconstruction of the various aspects of its production (raw materials, forming, firing). The analysis of the shape included the assignment of the sherds to complete vessel forms, as far as possible, the recording of the thickness of the wall fragments and the various shapes of rims, bases, handles and lids. The data collected were processed quantitatively using a SPSS/PC+ computer programme.

During our research-work in 1990, clay samples were taken again in the immediate surroundings of Ilipinar. This was done to find out more about the provenance of the raw materials used for the production of the pottery. The results of the analysis of the non-plastics of these clay samples and the results of the workability tests are included in the present article.

Research into the shape and decoration of the pottery, as well as a comparative study of the Chalcolithic pottery from Ilipinar and contemporary pottery from other Anatolian and Balkan sites, is being carried out by L. Thissen (Thissen 1989/1990).

The analysis of the raw materials

The analysis of the non-plastics

The following groups of non-plastics could be distinguished. These groups are broadly the same as the ones established in the study of the pottery from the phases X-VIII (van As and Wijnen 1989/1990:23,24).

1. Sand

The largest category of non-plastics is sand consisting of several minerals and different sorts of rock. As far as one can determine without using thin sections, the non-plastic material in this group includes schist, quartz, quartzite, limestone, gneiss, shale, feldspar, and jasper. The grains earlier identified as small pieces of iron or pieces of grog (van As and Wijnen 1989/1990:24) appeared to be haematite nodules (see p. 3). Several sizes and shapes of grains occur together. As for the amount of sand and the predominant grain size the following distinctions could be made:

1a. Small amounts of sand: quantities between 15% and 20%, and a predominant grain size ranging from 38 to 250 µm.
1b. Medium amounts of sand: quantities between 20% and 30%, and a predominant grain size ranging from 250 to 600 µm.
1c. Large amounts of sand: quantities between 20% and 40%, and a predominant grain size ranging from 600 to 4000 µm. Some sherds in this category contain even larger quantities of sand.

2. Calcite

This category contains 20 - 30% of mainly calcareous sandstone. The calcite was particularly apparent after the sherds had been refired in oxidizing conditions at 800° C for half an hour. The grains of calcite then became quite obvious and the sherd turned to powder after some time. Initially this category was labelled as "white chalk" (van As and Wijnen 1989/1990:24).

3. Limestone

Sherds belonging to this category contain grains of limestone visible on the surface of the sherds in addition to sand or sand and organic material. This category was initially labelled as "yellow grain" due to the yellow colour of the grains of limestone caused by firing in a reducing atmosphere (van As and Wijnen 1989/1990:24).

The analysis of the thin sections (by C. Overweel)

Apart from the 18 thin sections (16 sherds from Ilipinar level X-VIII and 2 clay samples) (van As and Wijnen 1989/1990:25,26) another 45 thin sections (36 sherds from Ilipinar level VIII-V and 9 clay samples) were analysed. This analysis provided the following information about the clay and non-plastics (see also van As and Wijnen 1989/1990:25,26).

Three types of clay could be distinguished:

I sericite-bearing clay;
II sericite and micrite-bearing clay;
III isotropic clay.

As for the non-plastics four groups were distinguished:

1. sherds containing:
    - small grains of quartz;
    - fragments of schist: (a) quartz-feldspar schists and (b) epidote-mica schists;
    - monomineral types of grain: epidote, quartz, albite, quartzite and magnetite;
    - haematite nodules, caused by the precipitation of dissolved iron compounds.
2. micrite
   Like group 1, but also containing micrite. Micrite is a microcrystalline sort of calcareous sandstone.
3. sparite
   Sparite is a pure crystalline calcite of coarser grains than micrite. Apart from the sparite fragments, one of the non-plastics from the main group (1) was occasionally found.
4. grains and aggregates with oolithic coatings
   These are mono- or compound grains surrounded by a concentric chalk coating. This category was not found in the thin sections analysed earlier.

The following combinations of clays and non-plastics could be distinguished: I/1, I/2, II/2, II/3, II/4, and III/1 (see Table 2).

Phase	Square	Clay/non-plastics					
		I/1	I/2	II/2	II/3	II/4	III/1
V	S9	5	3	1	4	3	1
VI	U13				1		
VII	Y13	4					
upper VIII	X13	7					
lower VIII	X13	5	1				
Clay samples		7	1		1		

Table 2. The number of sherds and clay samples analysed by thin section analysis and results.

Workability tests with the clay samples (by L. Jacobs)

The clay samples taken in the immediate vicinity of Ilipinar hüyük were tested for their workability for handforming techniques such as coiling and pinching. After adding water to the dry clay, the samples were shaped into coils. The plasticity could be estimated visually by bending the clay coils (piglet's tail test). The following results could be established:

Clay sample no.	Result
41	++
42	+
43	+
44	+
47	+
40	#
63	#
45	-
46	-

	Workability:	Plasticity:
++	very good	high
+	good	medium
#	reasonable	low
-	bad	too low

It is not necessary to use a very plastic clay for the handforming technique prevalent among the pottery from Ilipinar. A medium plastic clay can very well be used too and in fact it even has certain advantages. It is easier to join the coils and the clay does not shrink very much. Potters can reduce the likelihood of cracks during the drying process by using this type of clay.

The technological analysis

All the pottery analysed was handmade. Both techniques which could be distinguished (1. pinching and 2. building in sections) correspond with the ones established in the pottery from the phases X-VIII (van As and Wijnen 1989/1990:27). If the first technique (pinching) was used the size of the small pots was limited by the size of the potter's hands. If the second technique (building in sections) was used the base was made first, either by flattening a piece of clay, or in a mould. Next the pot was built up in coils of clay.

The pots were often provided with preshaped handles. The repertoire analysed also includes twenty sieve-fragments. For the forming techniques of both we refer the reader to van As and Wijnen (1989/1990:28).

With respect to the finishing and decoration techniques, the same phenomena could be observed as in the Neolithic and early Chalcolithic pottery repertoire from the phases X-VIII (van As and Wijnen 1989/1990: 27,28).

Five types of surface-finish were distinguished:

1. rough;
2. smooth;
3. low/medium burnish;
4. high burnish;
5. slip layer[4].

Four types of decorations were distinguished:

1. lines incised into the clay;
2. impressions of the fingernails;
3. excised decoration;
4. appliqué decoration.

Hardness and colour are aspects of pottery which point to the original firing conditions. Hardness was measured using the Mohs' scale. Mohs' hardness numbers 2 and 3 are prevalent.

The colour of the inner/outer surface and core of the sherds was recorded according to the Munsell Soil Color Charts. Most of the sherds are a blackish/brown colour. When the sherds were refired under oxidizing conditions at 800°C for half an hour, all of the sherds turned completely red (10R-5YR 5-7/6-8). For this reason it can be concluded that the pottery was fired in reducing to neutral conditions. The original firing temperature of the pottery could be estimated at approximately 700-850° C by measuring the shrinkage behaviour of the sherds after refiring in steps of increasing temperature.

The analysis of the shapes

The following distinctions were made with respect to the vessel's shape, size, wall-thickness, rim, base, handles and lids.

Vessel-shape[5]

1. (restricted) pots;
2. (un)restricted bowls:
    a. deep;
    b. shallow;
3. dishes:
    a. platters;
    b. basins/trays;
4. collared-jars.

Size

Since few complete pots were found, the best method for discussing pot-size is by referring to the diameter of the rim. In total, eight groups were distinguished, with diameters smaller than 5 cm and between: 5 to 10 cm, 10 to 15 cm, etc.

Wall-thickness

1. smaller than 4 mm;
2. between 4 and 6.9 mm;
3. between 7 and 9.9 mm;
4. between 10 and 15 mm;
5. larger than 15 mm.

Rim-shape

1. straight;
2. bent outwards immediately below the lip;
3. thinned;
4. thickened;
5. bent outwards some two to four cm below the lip;
6. collar (lower than 5 cm).

Base-shape
1. low ring-base;
2. (moderate) ring-base;
3. straight/flat;
4. flat/concave;
5. rounded (planoconvex).

Handles
1. pierced knobs;
2. knobs;
3. ribbon handles;
4. flat handles;
5. pierced, flat handles;
6. pierced, twin lugs.

Lids
1. flat, round lid;
2. "basin"-shaped lid.

Quantitative processing of the data

In Tables 3-17 the quantitative ceramic data are given[6]. Like the Tables in van As and Wijnen (1989/1990:37-57) they are recorded in the *Newsletter* as documentation for the final publication (van As and Wijnen in prep.). A short commentary on the Tables follows below.

1. Non-plastics (Table 3)

A clear change can be noted after phase VII. The percentage of group 1c (large amounts of sand) increases and 1a (small amounts of sand) decreases. This is also true for the groups with grains of limestone. Group 2 (calcite) increases remarkably after phase VII.

2. Surface-finish (Table 4)

The percentage of group 3 (low sheen-burnish) for the exterior surface is invariably high. The same applies for the interior surface, be it lower than the one for the exterior surface. We noticed a strong increase in the percentage of group 2 (smooth exterior surface) in phase V. In this phase the percentages for smooth interior surface are even higher than for low burnish. Also noteworthy is the increase in the percentage of sherds with fairly high glossy-burnished exterior and interior surface in phases VII and VI which, however, decreases again in phase V.

3. Vessel-shape (Table 5)[7]

The restricted bowl is the most frequent shape throughout the whole sample, but the general percentage diminishes in phase V. The percentage of restricted pots diminishes gradually from phase VIII to V. In phase V the percentage of open shapes (unrestricted bowls and basins) is relatively high, whereas in phase VI the introduction of the collared-jar (with a collar exceeding 5 cm in height) may be noticed.

4. Size (Table 6)

In general it can be noted that the diameters become gradually larger. Like in phases X and IX, in phase VIII group 3 (10-15 cm) is the most frequent, followed by group 4 (15-20 cm). Groups 2 (5-10 cm) and 5

(20-25 cm) only occur in low frequencies and 1 (1-5 cm) and 6 (25-30 cm) only sporadically. In phase VII group 4 (15-20 cm) is the most common, followed by group 3 (10-15 cm). In phase VI and V group 5 is the most common, followed by group 4. Group 7 (30-35 cm) occurs first in phase VII and group 8 (>35 cm) in phase VI.

5. Wall-thickness (Tables 7 and 8)

Like in phases X and IX, from phase VIII-VI the group which occurs most frequently is group 2 (4-7 mm), followed by group 3 (7-10 mm). Group 4 (10-15 mm) increases from phase VI on. In phase V group 3 occurs most frequently, followed by groups 4 and 2. Group 5 (> 15 mm) appears first during phase VI.

As to be expected, the group containing large amounts of mainly coarse sand (group 1c) has a somewhat thicker wall than the group containing small or moderate amounts of sand (groups 1a and 1b). Finer sand enables the potter to produce a thinner wall.

6. Rim-shape (Table 9)

In phase V the plain rim (straight, thinned, and thickened, resp. groups 1, 3, and 4 together) is by far the most common for all shapes.

7. Base-shape (Table 10)

The fairly flat base is by far the most common throughout all phases. The low ring occurs only sporadically. It only becomes more common in phase V, which also sees the introduction of the higher ring base.

Table 3

Occurrence of non-plastics through phases

	large amounts of sand	**medium amounts of sand**	**small amounts of sand**	**calcite**
Phase l. VIII	26 ¦ *5.2%*	204 ¦ *40.5%*	37 ¦ *7.3%*	5 ¦ *1.0%*
Phase u. VIII	73 ¦ *10.1%*	360 ¦ *50%*	80 ¦ *11.1%*	3 ¦ *0.4%*
Phase VII	74 ¦ *10.2%*	499 ¦ *68.9%*	89 ¦ *12.3%*	14 ¦ *1.9%*
Phase VI	17 ¦ *20%*	19 ¦ *22%*	--	5 ¦ *6%*
Phase V	267 ¦ *32.8%*	263 ¦ *31.3%*	14 ¦ *1.7%*	94 ¦ *11.5%*
	limestone/large amount of sand	**limestone/med. amount of sand**	**limestone/small amount of sand**	**limestone/calcite**
Phase l. VIII	26 ¦ *5.2%*	186 ¦ *36.9%*	19 ¦ *3.8%*	--
Phase u. VIII	26 ¦ *3.6%*	143 ¦ *19.9%*	34 ¦ *4.7%*	--
Phase VII	3 ¦ *0.4%*	35 ¦ *4.8%*	8 ¦ *1.1%*	--
Phase VI	27 ¦ *32%*	16 ¦ *19%*	1 ¦ *1%*	--
Phase V	82 ¦ *10.1%*	70 ¦ *8.6%*	2 ¦ *0.2%*	21 ¦ *2.6%*

Table 4

Occurrence surface-finish through phases

a. Exterior

	smooth	**rough**	**low/med. burnish**	**high burnish**
Phase l. VIII	117 ¦ *23.2%*	4 ¦ *0.6%*	369 ¦ *73.2%*	10 ¦ *2%*
Phase u. VIII	132 ¦ *18.3%*	10 ¦ *1.4%*	550 ¦ *76.4%*	18 ¦ *2.5%*
Phase VII	123 ¦ *17%*	6 ¦ *0.8%*	489 ¦ *67.5%*	100 ¦ *13.8%*
Phase VI	15 ¦ *17%*	--	61 ¦ *68%*	13 ¦ *15%*
Phase V	303 ¦ *38.2%*	6 ¦ *0.8%*	456 ¦ *57,4%*	29 ¦ *3.6%*

b. Interior

	smooth	**rough**	**low/med. burnish**	**high burnish**
Phase l. VIII	215 ¦ *43.4%*	6 ¦ *1.2%*	269 ¦ *54.3%*	5 ¦ *1.1%*
Phase u. VIII	246 ¦ *35.1%*	11 ¦ *1.6%*	438 ¦ *62.5%*	6 ¦ *0.9%*
Phase VII	254 ¦ *36.2%*	7 ¦ *1%*	393 ¦ *56.1%*	47 ¦ *6.7%*
Phase VI	39 ¦ *44%*	1 ¦ *1%*	43 ¦ *49%*	5 ¦ *6%*
Phase V	480 ¦ *62.5%*	29 ¦ *3.8%*	246 ¦ *32%*	12 ¦ *1.6%*

Table 5 a

Occurrence vessel-shape through phases

	restr.pot. small	restr.pot. med/large	restr.bowl. small	restr.bowl. med.large	unrestr. bowl.small	unrestr. bowl.med/l.
Phase l. VIII	8 *3.4%*	71 *30,7%*	10 *4.3%*	104 *45%*	--	12 *5.2%*
Phase u. VIII	4 *1.1%*	99 *27.3%*	12 *3.3%*	88 *24.3%*	10 *2.8%*	26 *7.2%*
Phase VII	--	44 *19.6%*	3 *1.3%*	87 *38.8%*	--	15 *6.7%*
Phase VI	--	9 *18%*	--	31 *63%*	--	2 *4%*
Phase V	3 *0.8%*	40 *10.6%*	12 *3.2%*	88 *23.2%*	4 *1.1%*	55 *14.5%*

	basin	platter	coll.jar	bottle	miniature	restr.bowl. undef.
Phase l. VIII	--	--	--	--	1 *0.4%*	25 *10.8%*
Phase u. VIII	1 *0.3%*	--	--	--	4 *1.1%*	118 *32.6%*
Phase VII	1 *0.4%*	1 *0.4%*	--	--	1 *0.4%*	72 *32.1%*
Phase VI	1 *2%*	--	2 *4%*	--	--	4 *8%*
Phase V	30 *7.9%*	--	24 *6.3%*	3 *0.8%*	1 *0.3%*	118 *31.1%*

Table 5 b

Occurrence vessel-shape throughout phases. simplified version

	restr.pot	restr. bowl	unrestr.bowl	coll. jars	dishes
Phase l. VIII	78 ¦ *34.1%*	139 ¦ *60.7%*	12 ¦ *5.2%*	--	--
Phase u. VIII	103 ¦ *28.8%*	218 ¦ *60.9%*	36 ¦ *10%*	--	1 ¦ *0.3%*
Phase VII	44 ¦ *20.2%*	157 ¦ *72%*	15 ¦ *6.9%*	--	1 ¦ *0.9%*
Phase VI	9 ¦ *18%*	35 ¦ *71%*	2 ¦ *4%*	2 ¦ *4%*	1 ¦ *2%*
Phase V	43 ¦ *11.4%*	218 ¦ *58.3%*	59 ¦ *15.8%*	24 ¦ *6.4%*	30 ¦ *8.0%*

Table 6

Occurrence diameter rim throughout phases

	5-10	**10-15**	**15-20**	**20-25**	**25-30**	**30-35**	**>35 cm**	**Oval**
Phase l. VIII	13 *8.3%*	79 *50.3%*	48 *30.6%*	8 *5.1%*	1 *0.6%*	--	--	8 *5.1%*
Phase u. VIII	17 *9.1%*	82 *43.8%*	58 *31%*	10 *5.3%*	2 *1.1%*	--	--	18 *9.6%*
Phase VII	12 *7.9%*	39 *25.7%*	69 *45.4%*	12 *7.9%*	4 *2.6%*	3 *2%*	--	13 *8.6%*
Phase VI	1 *2%*	4 *9%*	9 *21%*	15 *35%*	5 *12%*	5 *12%*	1 *2%*	3 *7%*
Phase V	14 *6.4%*	42 *19.3%*	54 *24.8%*	55 *25.2%*	27 *12.4%*	9 *4.1%*	9 *4.1%*	8 *3.7%*

Table 7

Occurrence wall-thickness through phases

	< 4mm	**4-7 mm**	**7-10 mm**	**10-15 mm**	**>15 mm**
Phase l. VIII	2 ¦ *0.4%*	242 ¦ *48.4%*	225 ¦ *45%*	31 ¦ *6.2%*	--
Phase u. VIII	3 ¦ *0.4%*	381 ¦ *54.3%*	284 ¦ *40.5%*	34 ¦ *4.8%*	--
Phase VII	2 ¦ *0.3%*	422 ¦ *59.6%*	251 ¦ *35.4%*	33 ¦ *4.7%*	--
Phase VI	1 ¦ *1%*	42 ¦ *47%*	31 ¦ *35%*	14 ¦ *16%*	1 ¦ *1%*
Phase V	5 ¦ *0.6%*	187 ¦ *23.7%*	368 ¦ *46.6%*	198 ¦ *25.1%*	31 ¦ *3.9%*

Table 8

Comparison non-plastics - wall-thickness through phases

	< 4 mm	4 - 7 mm	7 - 10 mm	10 - 15 mm	> 15 mm
Phase l. VIII					
Large am.sand	--	1 ¦ *4%*	19 ¦ *73%*	6 ¦ *23%*	--
Med. am.sand	1 ¦ *0.5%*	100 ¦ *49,5%*	92 ¦ *45.6%*	9 ¦ *4,4%*	--
Small am.sand	--	32 ¦ *86%*	5 ¦ *14%*	--	--
Limest/l.a.s.	--	8 ¦ *32%*	15 ¦ *60%*	2 ¦ *8%*	--
Limest/m.a.s	--	92 ¦ *49.7%*	82 ¦ *44.3%*	11 ¦ *6%*	--
Limest/s.a.s	1 ¦ *5%*	7 ¦ *37%*	9 ¦ *47%*	2 ¦ *11%*	--
Calcite	--	2 ¦ *40%*	3 ¦ *60%*	--	--
Phase u. VIII					
Large am.sand	--	20 ¦ *28%*	41 ¦ *58%*	10 ¦ *14%*	--
Med. am.sand	2 ¦ *0.6%*	189 ¦ *54.1%*	149 ¦ *42.7%*	9 ¦ *2.6%*	--
Small.am.sand	1 ¦ *1%*	59 ¦ *75%*	17 ¦ *21%*	2 ¦ *3%*	--
Limest/l.a.s.	--	8 ¦ *31%*	14 ¦ *54%*	4 ¦ *15%*	--
Limest/m.a.s.	--	77 ¦ *54.6%*	55 ¦ *39%*	9 ¦ *6.4%*	--
Limest/s.a.s	--	26 ¦ *76%*	8 ¦ *24%*	--	--
Calcite	--	2 ¦ *100%*	--	--	--
Phase VII					
Large am.sand	--	30 ¦ *41%*	31 ¦ *42%*	13 ¦ *17%*	--
Med. am.sand	1 ¦ *0.2%*	291 ¦ *60.1%*	175 ¦ *36.1%*	17 ¦ *3.5%*	--
Small am.sand	1 ¦ *1%*	63 ¦ *72%*	23 ¦ *26%*	1 ¦ *1%*	--
Limest/l.a.s.	--	--	3 ¦ *100%*	--	--
Limest/m.a.s.	--	21 ¦ *60%*	14 ¦ *40%*	--	--
Limest/s.a.s.	--	8 ¦ *100%*	--	--	--
Calcite	--	8 ¦ *57%*	4 ¦ *28%*	2 ¦ *15%*	--
Phase VI					
Large am.sand	--	5 ¦ *29%*	7 ¦ *41%*	4 ¦ *24%*	1 ¦ *6%*
Med. am.sand	--	12 ¦ *63%*	5 ¦ *26%*	2 ¦ *11%*	--
Limest/l.a.s.	--	10 ¦ *37%*	12 ¦ *44%*	5 ¦ *19%*	--
Limest/m.a.s.	--	11 ¦ *69%*	3 ¦ *19%*	2 ¦ *12%*	--
Limest/s.a.s.	1 ¦ *100%*	--	--	--	--
Calcite		1 ¦ *20%*	4 ¦ *80%*	--	--
Phase V					
Large am.sand	2 ¦ *0.8%*	47 ¦ *18.6%*	125 ¦ *49.6%*	65 ¦ *25.7%*	13 ¦ *5.1%*
Med. am. sand	2 ¦ *0.8%*	84 ¦ *32.9%*	115 ¦ *45%*	51 ¦ *20%*	3 ¦ *1.2%*
Small am.sand	--	5 ¦ *36%*	7 ¦ *50%*	2 ¦ *14%*	--
Limest/l.a.s.	--	8 ¦ *10%*	40 ¦ *49%*	30 ¦ *37%*	3 ¦ *4%*
Limest/m.a.s.	--	18 ¦ *26%*	30 ¦ *43%*	16 ¦ *23%*	6 ¦ *8%*
Limest/s.a.s.	--	1 ¦ *50%*	--	1 ¦ *50%*	--
Limest/calcite	--	1 ¦ *5%*	15 ¦ *71%*	4 ¦ *19%*	1 ¦ *5%*
Calcite	1 ¦ *1%*	23 ¦ *25%*	34 ¦ *37%*	29 ¦ *31%*	5 ¦ *5%*

Table 9

Occurrence rim-shape through phases

	straight	**thinned**	**thickened**	**bent outwards**	**collar**	**bent outwards 2 cm below lip**
Phase l. VIII	63 *26%*	40 *16.5%*	20 *8.3%*	2 *0.8%*	48 *19.8%*	69 *28.53%*
Phase u. VIII	88 *21.5%*	64 *15.6%*	12 *2.9%*	45 *11%*	118 *28.9%*	82 *20%*
Phase VII	39 *10.6%*	72 *19.6%*	12 *3.2%*	38 *10.3%*	84 *22.8%*	123 *33.4%*
Phase VI	5 *10%*	9 *17%*	4 *8%*	--	9 *17%*	25 *48%*
Phase V	118 *27.8%*	100 *23.5%*	84 *19.8%*	28 *6.6%*	39 *9.2%*	56 *13.1%*

Table 10

Occurrence base-shape throughout phases

	low ring	**straight**	**mod. ring**	**planoconvex**	**flat.concave**
Phase l. VIII	1 ¦ *1%*	79 ¦ *91%*	--	7 ¦ *8%*	--
Phase u. VIII	2 ¦ *3%*	75 ¦ *95%*	--	1 ¦ *2%*	1 ¦ *2%*
Phase VII	--	69 ¦ *100%*	--	--	--
Phase VI	--	10 ¦ *100%*	--	--	--
Phase V	12 ¦ *10.2%*	98 ¦ *83.8%*	6 ¦ *5.1%*	--	1 ¦ *0.8%*

Table 11

Occurrence handles through phases

	pierced knob	knob	flat handle	pierced flat handle	pierced twin lug	ribbon handles	scar
Phase l. VIII	59 *54.6%*	6 *5.6%*	8 *7.4%*	7 *6.5%*	3 *2.8%*	--	25 *23.1%*
Phase u. VIII	52 *33.1%*	6 *3.8%*	16 *10.2%*	6 *3.8%*	3 *1.9%*	2 *1.3%*	72 *45.9%*
Phase VII	62 *32.8%*	3 *1.6%*	24 *12.7%*	5 *2.6%*	4 *2.1%*	5 *2.6%*	86 *45.5%*
Phase VI	12 *40%*	--	7 *23%*	4 *13%*	4 *13%*	2 *7%*	1 *3%*
Phase V	21 *12.4%*	22 *12.9%*	18 *10.6%*	--	4 *2.3%*	77 *45.2%*	28 *16.5%*

Table 12

Occurrence hardness through phases

Moh's hardness	**2**	**3**	**4**	**5**
Phase l. VIII	233 *46.4%*	268 *53.4%*	1 *0.2%*	0
Phase u. VIII	330 *46%*	385 *53.7%*	2 *0.3%*	0
Phase VII	290 *40.2%*	430 *59.5%*	1 *0.1%*	1 *0.1%*
Phase VI	64 *73%*	24 *27%*	0	0
Phase V	321 *39.5%*	480 *59.1%*	6 *0.7%*	5 *0.6%*

Table 13

Occurrence colour through phases

a. Core

	black	**l.grey**	**d.red brown**	**dark brown**	**dark red**
Phase l. VIII	120 ¦ *24.6%*	120 ¦ *24.6%*	41 ¦ *8.4%*	142 ¦ *29.1%*	14 ¦ *2.9%*
Phase u. VIII	169 ¦ *23.7%*	139 ¦ *19.5%*	25 ¦ *3.5%*	181 ¦ *25.4%*	99 ¦ *13.9%*
Phase VII	166 ¦ *23%*	70 ¦ *9.7%*	36 ¦ *5%*	240 ¦ *33.3%*	116 ¦ *16.1%*
Phase VI	33 ¦ *38%*	4 ¦ *5%*	19 ¦ *21%*	16 ¦ *18%*	5 ¦ *6%*
Phase V	434 ¦ *55.8%*	31 ¦ *4%*	15 ¦ *1.9%*	171 ¦ *22%*	23 ¦ *3%*
	grey brown	**oxid/bl**	**oxid/grey**	**oxid/brown**	**br/bl**
Phase l. VIII	16 ¦ *3.3%*	9 ¦ *1.8%*	6 ¦ *1.2%*	19 ¦ *3.9%*	--
Phase u. VIII	8 ¦ *1.1%*	30 ¦ *4.2%*	9 ¦ *1.3%*	53 ¦ *7.4%*	--
Phase VII	6 ¦ *0.8%*	39 ¦ *5.4%*	8 ¦ *1.1%*	39 ¦ *5.4%*	--
Phase VI	--	11 ¦ *12%*	--	--	--
Phase V	4 ¦ *0.5%*	9 ¦ *1.1%*	4 ¦ *0.5%*	65 ¦ *8.4%*	21 ¦ *2.7%*

Occurrence colour through phases
b. Exterior

	black	**l. red brown**	**d.red brown**	**d.brown**	**dark red**
Phase l. VIII	37 ¦ *7.3%*	41 ¦ *8.2%*	8 ¦ *1.6%*	19 ¦ *3.8%*	1 ¦ *0.2%*
Phase u. VIII	124 ¦ *17.4%*	30 ¦ *4.2%*	54 ¦ *7.6%*	100 ¦ *14%*	11 ¦ *1.5%*
Phase VII	116 ¦ *16.1%*	27 ¦ *3.8%*	81 ¦ *11.3%*	139 ¦ *19.3%*	34 ¦ *4.7%*
Phase VI	36 ¦ *41%*	8 ¦ *9%*	6 ¦ *7%*	17 ¦ *19%*	--
Phase V	169 ¦ *21.4%*	9 ¦ *1.1%*	235 ¦ *29.8%*	145 ¦ *18.4%*	5 ¦ *0.6%*
	mottled br/bl	**mott. red/br.**	**mott.red/bl.**	**red/br/bl**	**grey brown**
Phase l. VIII	269 ¦ *53.7%*	42 ¦ *8.4%*	4 ¦ *0.8%*	35 ¦ *7%*	45 ¦ *9%*
Phase u. VIII	263 ¦ *36.9%*	23 ¦ *3.2%*	17 ¦ *2.4%*	17 ¦ *2.4%*	73 ¦ *10.2%*
Phase VII	189 ¦ *26.2%*	37 ¦ *5.1%*	31 ¦ *4.3%*	10 ¦ *1.4%*	56 ¦ *7.8%*
Phase VI	11 ¦ *13%*	7 ¦ *8%*	1 ¦ *1%*	--	2 ¦ *2%*
Phase V	65 ¦ *8.2%*	56 ¦ *7%*	21 ¦ *2.6%*	82 ¦ *10.4%*	2 ¦ *0.3%*

c. Interior

	black	**l.red brown**	**d.red brown**	**dark brown**	**dark red**
Phase l. VIII	39 ¦ *7.9%*	37 ¦ *7.5%*	5 ¦ *1%*	14 ¦ *2.8%*	--
Phase u. VIII	119 ¦ *16.9%*	26 ¦ *3.7%*	26 ¦ *3.7%*	86 ¦ *12.2%*	7 ¦ *1%*
Phase VII	139 ¦ *19.3%*	44 ¦ *6.1%*	71 ¦ *9.9%*	130 ¦ *18.1%*	33 ¦ *4.6%*
Phase VI	35 ¦ *41%*	5 ¦ *6%*	7 ¦ *8%*	22 ¦ *26%*	--
Phase V	146 ¦ *18.8%*	15 ¦ *1.9%*	251 ¦ *32.2%*	141 ¦ *18.1%*	6 ¦ *0.7%*
	mottled br/bl	**mott.Red/br.**	**mott.red/bl**	**red/br/bl**	**grey brown**
Phase l. VIII	260 ¦ *52.6%*	34 ¦ *6.8%*	2 ¦ *0.4%*	10 ¦ *2%*	93 ¦ *18.8%*
Phase u. VIII	287 ¦ *40.8%*	17 ¦ *2.4%*	17 ¦ *2.4%*	9 ¦ *1.3%*	110 ¦ *15.6%*
Phase VII	147 ¦ *20.5%*	22 ¦ *3%*	35 ¦ *4.9%*	2 ¦ *0.3%*	94 ¦ *13.1%*
Phase VI	10 ¦ *11%*	7 ¦ *8%*	--	--	--
Phase V	85 ¦ *10.9%*	53 ¦ *6.8%*	5 ¦ *0.6%*	17 ¦ *2.2%*	59 ¦ *7.6%*

Table 14

Comparison non-plastics - hardness through phases

Mohs' hardness	2	3	4	5
Phase l. VIII				
Large am. sand	12 ¦ *46%*	13 ¦ *50%*	1 ¦ *4%*	--
Medium am.sand	79 ¦ *39.1%*	123 ¦ *60.9%*	--	--
Small am. sand	15 ¦ *40%*	22 ¦ *60%*	--	--
Limestone/l.a.s.	9 ¦ *35%*	17 ¦ *65%*	--	--
Limestone/m.a.s.	108 ¦ *58.1%*	78 ¦ *41.9%*	--	--
Limestone/s.a.s.	8 ¦ *42%*	11 ¦ *58%*	--	--
Calcite	2 ¦ *40%*	3 ¦ *60%*	--	--
Phase u. VIII				
Large am. sand	31 ¦ *42%*	40 ¦ *55%*	2 ¦ *3%*	--
Medium am. sand	163 ¦ *45.4%*	196 ¦ *54.6%*	--	--
Small am. sand	34 ¦ *43%*	46 ¦ *57%*	--	--
Limestone/l.a.s.	14 ¦ *56%*	11 ¦ *44%*	--	--
Limestone/m.a.s.	67 ¦ *46.9%*	76 ¦ *53.1%*	--	--
Limestone/s.a.s	19 ¦ *56%*	15 ¦ *44%*	--	--
Calcite	2 ¦ *67%*	15 ¦ *33%*	--	--
Phase VII				
Large am. sand	30 ¦ *41%*	44 ¦ *59%*	--	--
Medium am. sand	189 ¦ *38%*	306 ¦ *61.6%*	1 ¦ *0.2%*	1 ¦ *0.2%*
Small am. sand	42 ¦ *47%*	47 ¦ *53%*	--	--
Limestone/l.a.s.	1 ¦ *33%*	2 ¦ *66%*	--	--
Limestone/m.a.s.	14 ¦ *40%*	21 ¦ *60%*	--	--
Limestone/s.a.s.	4 ¦ *50%*	4 ¦ *50%*	--	--
Calcite	9 ¦ *64%*	5 ¦ *36%*	--	--
Phase VI				
Large am. sand	9 ¦ *53%*	8 ¦ *47%*	--	--
Medium am. sand	17 ¦ *89%*	2 ¦ *11%*	--	--
Limestone/l.a.s.	17 ¦ *63%*	10 ¦ *37%*	--	--
Limestone/m.a.s.	14 ¦ *87%*	2 ¦ *13%*	--	--
Limestone/s.a.s.	1 ¦ *100%*	--	--	--
Calcite	4 ¦ *80%*	1 ¦ *20%*	--	--
Phase V				
Large am. sand	107 ¦ *40.1%*	158 ¦ *59.2%*	1 ¦ *0.4%*	1 ¦ *0.4%*
Medium am. sand	95 ¦ *36.5%*	161 ¦ *61.9%*	1 ¦ *0.4%*	3 ¦ *1.1%*
Small am. sand	9 ¦ *64%*	4 ¦ *29%*	1 ¦ *7%*	--
Limestone/l.a.s.	35 ¦ *43%*	46 ¦ *56%*	1 ¦ *1%*	--
Limestone/m.a.s.	31 ¦ *44%*	38 ¦ *54%*	1 ¦ *1%*	--
Limestone/s.a.s.	--	2 ¦ *100%*	--	--
Limestone/calcite	7 ¦ *33%*	14 ¦ *67%*	--	--
Calcite	36 ¦ *38%*	56 ¦ *60%*	2 ¦ *2%*	--

Table 15

Comparison non-plastics - surface finish exterior through phases

	smooth	rough	low/med. burnish	high burnish
Phase l. VIII				
Large am. sand	6 ¦ *23%*	1 ¦ *4%*	19 ¦ *73%*	--
Med. am. sand	49 ¦ *24.4%*	1 ¦ *0.5%*	148 ¦ *73.6%*	3 ¦ *1.5%*
Small am. sand	8 ¦ *22%*	--	28 ¦ *78%*	--
Limestone/l.a.s.	6 ¦ *23%*	1 ¦ *4%*	19 ¦ *73%*	--
Limestone/m.a.s.	44 ¦ *23.7%*	1 ¦ *0.5%*	135 ¦ *72.6%*	6 ¦ *3.2%*
Limestone/s.a.s	4 ¦ *21%*	--	14 ¦ *74%*	1 ¦ *5%*
Calcite	--	--	5 ¦ *100%*	--
Phase u. VIII				
Large am. sand	18 ¦ *26%*	5 ¦ *7%*	45 ¦ *64%*	2 ¦ *3%*
Med. am. sand	74 ¦ *20.8%*	4 ¦ *1.1%*	271 ¦ *76.3%*	6 ¦ *1.7%*
Small am. sand	13 ¦ *16%*	--	66 ¦ *82%*	1 ¦ *1%*
Limestone/l.a.s	5 ¦ *20%*	--	20 ¦ *80%*	--
Limestone/m.a.s.	18 ¦ *12.7%*	--	118 ¦ *83.1%*	6 ¦ *4.2%*
Limestone/s.a.s.	3 ¦ *9%*	1 ¦ *3%*	27 ¦ *79%*	3 ¦ *9%*
Calcite	1 ¦ *33%*	--	2 ¦ *66%*	--
Phase VII				
Large am. sand	23 ¦ *31%*	2 ¦ *3%*	44 ¦ *59%*	5 ¦ *7%*
Med. am. sand	84 ¦ *16.9%*	4 ¦ *0.8%*	343 ¦ *69.1%*	65 ¦ *13.1%*
Small am. sand	8 ¦ *9%*	--	62 ¦ *72%*	16 ¦ *19%*
Limestone/l.a.s.	2 ¦ *66%*	--	1 ¦ *33%*	--
Limestone/m.a.s.	4 ¦ *11%*	--	23 ¦ *66%*	8 ¦ *23%*
Limestone/s.a.s.	--	--	5 ¦ *62%*	3 ¦ *38%*
Calcite	2 ¦ *14%*	--	9 ¦ *64%*	3 ¦ *21%*
Phase VI				
Large am. sand	2 ¦ *12%*	--	11 ¦ *65%*	4 ¦ *23%*
Med.am. sand	4 ¦ *21%*	--	13 ¦ *68%*	2 ¦ *11%*
Small am. sand	--	--	--	--
Limestone/l.a.s.	3 ¦ *11%*	--	21 ¦ *78%*	3 ¦ *11%*
Limestone/m.a.s.	4 ¦ *25%*	--	11 ¦ *69%*	1 ¦ *6%*
Limestone/s.a.s	--	--	--	1 ¦ *100%*
Calcite	2 ¦ *33%*	--	2 ¦ *33%*	2 ¦ *33%*
Phase V				
Large am. sand	105 ¦ *40.4%*	2 ¦ *0.8%*	147 ¦ *56.5%*	6 ¦ *2.3%*
Med.am. sand	123 ¦ *47.8%*	4 ¦ *1.5%*	122 ¦ *47.4%*	8 ¦ *3.1%*
Small am. sand	9 ¦ *70%*	--	4 ¦ *30%*	--
Limestone/l.a.s.	13 ¦ *17%*	--	61 ¦ *78%*	4 ¦ *5%*
Limestone/m.a.s.	9 ¦ *13%*	--	52 ¦ *76%*	7 ¦ *10%*
Limestone/s.a.s.	--	--	2 ¦ *100%*	--
Limestone/calcite	4 ¦ *19%*	--	16 ¦ *76%*	1 ¦ *5%*
Calcite	39 ¦ *42%*	--	51 ¦ *55%*	3 ¦ *3%*

Table 16

Comparison vessel-shape - surface-finish interior through phases

	smooth	**rough**	**low\med. burnish**	**high burnish**
Phase l. VIII				
Restr. pot	12 ¦ *15%*	--	66 ¦ *85%*	--
Restr. bowl	60 ¦ *43.2%*	--	77 ¦ *55.4%*	2 ¦ *1.4%*
Unrestr. bowl	5 ¦ *42%*	--	7 ¦ *58%*	--
Miniature	1 ¦ *100%*	--	--	--
Phase u. VIII				
Restr. pot	23 ¦ *22.2%*	--	77 ¦ *74.7%*	3 ¦ *2.9%*
Restr. bowl	75 ¦ *34.4%*	5 ¦ *2.3%*	136 ¦ *62.4%*	2 ¦ *0.9%*
Unrestr.bowl	11 ¦ *31%*	--	24 ¦ *69%*	--
Basin	1 ¦ *25%*	--	3 ¦ *75%*	--
Miniature	3 ¦ *75%*	--	1 ¦ *25%*	--
Phase VII				
Restr. pot	9 ¦ *20%*	--	32 ¦ *73%*	3 ¦ *7%*
Restr. bowl	33 ¦ *21.1%*	--	103 ¦ *66%*	20 ¦ *12.8%*
Unrestr. bowl	3 ¦ *20%*	--	12 ¦ *80%*	--
Basin	--	--	--	1 ¦ *100%*
Miniature	1 ¦ *100%*	--	--	--
Phase VI				
Restr. pot	5 ¦ *55%*	--	4 ¦ *45%*	--
Restr. bowl	14 ¦ *41%*	--	20 ¦ *59%*	--
Unrestr. bowl	--	--	1 ¦ *50%*	1 ¦ *50%*
Coll. jar	1 ¦ *50%*	--	1 ¦ *50%*	--
Basin	--	--	1 ¦ *50%*	1 ¦ *50%*
Phase V				
Restr. pot	23 ¦ *53%*	3 ¦ *7%*	16 ¦ *37%*	1 ¦ *2%*
Restr. bowl	134 ¦ *61.7%*	1 ¦ *0.5%*	79 ¦ *36.4%*	3 ¦ *1.4%*
Unrestr. bowl	17 ¦ *29%*	--	39 ¦ *67%*	2 ¦ *3%*
Coll. jar	14 ¦ *54%*	2 ¦ *8%*	10 ¦ *38%*	--
Basin	13 ¦ *42%*	--	15 ¦ *48%*	3 ¦ *10%*
Miniature	1 ¦ *100%*	--	--	--

Table 17

Comparison vessel-shape - rim-shape through phases

	straight	**thinned**	**thickened**	**bent out**	**collar**	**bent out 2cm below**
Phase l. VIII						
Res.pot	4 ¦ *5%*	9 ¦ *12%*	4 ¦ *5%*	--	36 ¦ *47%*	23 ¦ *30%*
Res. bowl	47 ¦ *34.6%*	24 ¦ *17.6%*	15 ¦ *11%*	1 ¦ *0.7*	9 ¦ *6.6%*	40 ¦ *29.4%*
Unr. bowl	4 ¦ *33%*	1 ¦ *8%*	--	1 ¦ *8%*	2 ¦ *17%*	4 ¦ *33%*
Phase u. VIII						
Res. pot	2 ¦ *2%*	3 ¦ *2.9%*	--	3 ¦ *2.9%*	82 ¦ *79.6%*	13 ¦ *12.6%*
Res. bowl	67 ¦ *31.3%*	31 ¦ *14.5%*	10 ¦ *4.7%*	20 ¦ *9.3%*	27 ¦ *12.6%*	57 ¦ *26.6%*
Unr. bowl	9 ¦ *26%*	11 ¦ *31%*	2 ¦ *6%*	1 ¦ *3%*	2 ¦ *6%*	10 ¦ *28%*
Basins	1 ¦ *33%*	1 ¦ *33%*	--	--	--	1 ¦ *33%*
Bowl(?)	8 ¦ *16%*	13 ¦ *27%*	--	21 ¦ *43%*	7 ¦ *14%*	--
Phase VII						
Res. pot	1 ¦ *2%*	2 ¦ *5%*	1 ¦ *2%*	5 ¦ *12%*	25 ¦ *60%*	8 ¦ *19%*
Res. bowl	9 ¦ *5.8%*	21 ¦ *13.5%*	3 ¦ *1.9%*	20 ¦ *12.8%*	39 ¦ *25%*	64 ¦ *41%*
Unr. bowl	1 ¦ *20%*	4 ¦ *80%*	--	--	--	--
Basin	--	--	2 ¦ *20%*	--	3 ¦ *30%*	5 ¦ *50%*
Bowl(?)	28 ¦ *18.4%*	43 ¦ *28.3%*	5 ¦ *3.3%*	13 ¦ *8.6%*	17 ¦ *11.2%*	46 ¦ *30.2%*
Phase VI						
Res. pot	--	--	--	--	3 ¦ *37%*	5 ¦ *63%*
Res. bowl	4 ¦ *11%*	6 ¦ *17%*	2 ¦ *6%*	--	4 ¦ *11%*	19 ¦ *54%*
Unr. bowl	--	2 ¦ *100%*	--	--	--	--
Coll. jar	--	1 ¦ *50%*	1 ¦ *50%*	--	--	--
Basin	1 ¦ *50%*	--	1 ¦ *50%*	--	--	--
Phase V						
Res. pot	2 ¦ *5%*	3 ¦ *7%*	2 ¦ *5%*	6 ¦ *14%*	13 ¦ *31%*	16 ¦ *38%*
Res. bowl	59 ¦ *29.3%*	44 ¦ *21.9%*	41 ¦ *20.4%*	14 ¦ *7%*	14 ¦ *7%*	29 ¦ *14.4%*
Unr. bowl	21 ¦ *37%*	19 ¦ *33%*	15 ¦ *26%*	2 ¦ *4%*	--	--
Coll. jar	11 ¦ *41%*	12 ¦ *44%*	2 ¦ *7%*	1 ¦ *4%*	--	1 ¦ *4%*
Basin	10 ¦ *32%*	11 ¦ *35%*	9 ¦ *29%*	1 ¦ *3%*	--	--
Bowl(?)	15 ¦ *23%*	11 ¦ *17%*	14 ¦ *21%*	4 ¦ *6%*	12 ¦ *18%*	9 ¦ *14%*

8. Handles (Table 11)

The percentage of pierced knobs remains fairly constant from the beginning of phase VIII. In phase V it diminishes strongly, whereas the pierced flat handles disappear completely. In phase V there is an increase of ribbon handles.

The development of the hardness (Table 12) and colour (Table 13) of the sherds through the Ilipinar phases VIII-V is not such that conclusions can be drawn with respect to a development in firing techniques.

In Tables 14-17 the comparison between the different features of the sherds (non-plastics/hardness; non-plastics/surface finish; vessel-shape/surface finish; vessel-shape/rim-shape) is recorded. There are no striking correlations between these features.

The Chalcolithic pottery from Ilipinar (phases VIII-V): an overview

Phase VIII

Sandy-ware is almost the only ware type used. It may contain a fair amount of limestone. Calcite-ware is extremely rare.

The restricted bowl with a plain rim is the most common shape, followed by the restricted pot with an up/out-turned rim (S-shape profile and pseudo-collars) two to four cm below the lip. Next is the restricted bowl with the same rim type. The hole-mouth shape, the unrestricted plain-rimmed bowl, the S-shaped unrestricted bowl and the restricted bowl with an out-turned rim directly below the lip, are relatively rare.

Phase VII

Once again sandy-ware is by far the most common. Occasionally some grains of limestone are included. Calcite-ware is rare.

The restricted bowl with a S-shaped profile is by far the most common shape. Next is the plain-rimmed restricted bowl and the restricted pot with an up/out-turned rim two to four cm below the lip. Both restricted pots and restricted bowls with other rim shapes are relatively rare, as are unrestricted bowls. The calcite-ware consists of restricted bowls, which may have any of the three rim types.

Phase VI

The sample for this phase is very small. For the first time in the category "large amounts of sand" a number of sherds were observed, to which an extra amount of sand seems to have been added on purpose. This group also occurs with grains of limestone. The last ware type seems to be the most common. Calcite-ware also occurs.

The most common shape for both sandy-wares is the S-shaped restricted bowl, followed by the plain-rimmed restricted bowl and the restricted pot with an up/out-turned rim two to four cm below the lip. Plain-rimmed basins and collared jars occur only in the very sandy-ware. The calcite-ware consists of restricted bowls, either S-shaped or plain- rimmed.

Phase V

Three ware types can be discerned in this period: the normal sandy-ware; a ware to which extra sand had been added as temper; and a calcite-tempered-ware. Both sandy-wares may include a certain amount of limestone grains.

For the sand-tempered ware the plain-rimmed restricted bowl is by far the most common vessel-shape. It is followed by the plain-rimmed unrestricted bowl and then the restricted bowl with an out-turned rim two to four cm below the lip. Next is the plain-rimmed collared jar and basin. Restricted pots, be it with a pseudo-collar or a hole-mouth shape, and restricted bowl with an out-turned rim directly below the lip are relatively rare.

For the normal sandy-ware, the plain-rimmed restricted bowl is by far the most common shape, followed by the plain-rimmed unrestricted bowl. Next are plain-rimmed basins and restricted bowls with an out-turned rim two to four cm below the lip and the plain-rimmed collared jar. Again restricted pots with a pseudo-collar or a hole-mouth shape, and restricted bowls with an out-turned rim directly below the lip are relatively rare.

The plain-rimmed restricted bowl is the most common for the calcite-ware, followed by the restricted pot with an up/out-turned rim (pseudo-collar) two to four cm below the lip. Next are the slightly S-shaped restricted bowl, the plain-rimmed unrestricted bowl and the plain-rimmed basin. Restricted pots with the two other rim-shapes are rare, as are collared jars and restricted and unrestricted bowls with other than the already mentioned rim-shapes.

Conclusions

Preliminary remarks

In the present and earlier analyses (van As and Wijnen 1989/1990) the pottery of Ilipinar that was studied was selected from the different building phases, regardless of the specific contextual provenance (building phases, plain occupation level, pit etc.). We realize that this might have consequences for the results of our study. Another disturbing factor, especially for the later Early Chalcolithic horizons, was the decorated pottery: most of this had been removed prior to our analysis. At the moment of our selection for analysis, a large part of the ceramic material from phase VI was rather deformed, since it came from a heavily burnt area. For this reason our sample was small. At present, better material is available. Concerning phase V we should remark that there is no certainty whether there exists any continuity between this phase and the previous phase VI. The material analysed from phase V came from a pit, cut into a phase X occupation level. The phase V material, discovered elsewhere on Ilipinar hüyük came from pits dug into phase VI occupation levels.

Ilipinar phases VIII-V

The Ilipinar phases VIII-V cover a short period. It may be concluded that the development of the pottery throughout these phases is a continuous one next to the earlier phases X-IX. The forming techniques do not change, only a shift in the use of raw materials in phase VI can be noticed. The pottery containing very much sandy non-plastic material increases and an increase of (added?) calcite to the clay is also evident.

Analysis of the sherds and clay samples as well show that the potters used raw materials taken from the direct surroundings of Ilipinar.

As for the pottery shapes, the most obvious caesura is to be found between phases VII and V. Phase V has pottery shapes differing quite strongly from those found in phases X-VII, and possibly VI. Whereas in the lower building horizons S-shaped pots and bowls are prevalent, this is no longer the case in phase V. Here we see plain-rimmed bowls, collared jars, restricted pots with a hole-mouth shape and basins. Also, where in the previous phases the exterior surface of the pots was mostly slightly burnished, a smooth surface becomes popular in phase V, which on the other hand has also some decorated vessel types with highly-burnished surfaces (Thissen 1989/1990:92). However, as far as the continuity/discontinuity is concerned, we are bothered in the first place by the undersized sample from phase VI, where some of these shapes were already introduced, and in the second place by the uncertainty of whether there was or was not a continuity of occupation between phases VI and V.

Notes

1. The investigations were carried out between 17 May and 11 June 1990 at the excavation house of the Ilipinar expedition at Gölyaka, and they were financed by the Foundation for Archaeological Research (ARCHON) which is part of the Netherlands Organization of Scientific Research (NWO). Staff members working on the project were: Dr. A. van As, A.E.A. van Driel, E.P.G. Mulder and Dr. M.-H. Wijnen.

2. The final results of our research on the Neolithic and Chalcolithic pottery from Ilipinar will be published in *The excavations at Ilipinar I*, *Publications de Stamboul NINO*, Leiden.

3. No statistical formula was used to establish the minimal amount of sherds necessary to get a reliable answer to the research question. The sample of phase VI is small, since the largest part of the ceramic material coming from a heavily burnt area was rather deformed. Opposite to van As and Wijnen (1989/1990) a distinction was made between phase lower VIII and phase upper VIII. The excavator had the impression that it concerned two different habitation phases. For this reason a large sample of sherds from phase (lower and upper) VIII has been investigated.

4. This category has been omitted in Tables 3, 15, and 16. Only two sherds with a slip-layer were found (one in phase lower VIII and one in phase VII).

5. For a definition of these categories, see van As and Wijnen (1989/90:29-31).

6. In all cases the percentages are recorded together with the amounts on which they are based. In some cases the amount of sherds was too small to get reliable results.

7. Opposite to the categories deep and shallow (un)restricted bowls (see p. 5), in Table 5 a division has been made in small, medium, and large (un)restricted bowls.

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J. Kalsbeek
(with an introduction by H.J. Franken)

MEDIEVAL POTTERY FROM THE LEVANT ENTIRELY OR PARTLY MADE IN MOULDS

Introduction

In 1976 Mr. A. Zaqzuq from the Museum in Hama (Syria) submitted a collection of sherds from Qalaat Jaber, close to Tabqa on the Euphrates, for technical research at the Institute of Pottery Technology. This collection contained a number of fragments of small drinking-jars made in a white-firing ware - often with moulded decoration - and a sieve (Fig.1). In this article the results of the technological investigation of this category of pottery are given. Fragments of similar small jugs that were studied came from the excavations at Tell Taa‘s (van As 1987:165-168), now submerged in Lake Assad, and from a few other sites such as the Amman Citadel in Jordan (Franken in prep.). Fragments of moulds showing simple relief decoration were found near a potter's workshop at Tell Ta‘as.

The *floruit* of the production of the pottery discussed here seems to have been in Ayyubid and Mameluke times, and the production technique was known throughout the entire Levant.

The small jugs are always pale yellow or off-white in colour, and a short discussion of how this colour was obtained may be in place here. Nowadays potters would use ball clays which have excellent properties. They are highly plastic and usually fire to a cream colour because they contain a high proportion of kaolinite and little or no iron. However, this ware is not to be found in the Institute's collection. Rather it would seem that local, somewhat dry, red-firing clays were used for the production. The light colour is the result of an excess of added salts. The chemistry involved in the process of turning a red-firing clay into a pale cream-coloured ware has been described by L. Jacobs, who refers to several earlier studies (see this *Newsletter*, pp. 1-25).

There is no reason to believe that these jugs were produced in only a few workshops. The technique may have been widely practised and consisted of two elements. The first was the use of a double set of moulds as had been used since Hellenistic times in the production of ornate lamps. The second was the ‘secret’ of obtaining the light-firing colour. In the plains of the Euphrates or Tigris this change from red to very light colours was not necessary because the natural state of earth and water produced this colour in kiln firing. However, if it were from the coastal plains this would have been quite different. Yet the secret may have been discovered at the sea shore. A modern potter working near Rash Shamra on the Syrian coast produces both red and pale creamy coloured wares. When making the former he uses sweet water from a well. When producing the latter he works with very salty sea water, using the same clay. Sources of saline water are ubiquitous in the limestone areas in the Near East. Some modern wells in the area drilled for irrigation purposes first produced sweet water which after a short period of time turned into brackish water

Fig. 1. Some fragments of small Medieval drinking-jars from Qalaat Jaber (Syria).

not suited for irrigation. No red-fired jugs of the type under discussion have come to our attention, and it may well be that the combination of the two techniques was part of a recipe that was always applied in the production.

Another question to be mentioned in passing is that Medieval pottery in Mesopotamia is not decorated by means of paints made from metal oxides, but by application of incised motifs, or combing, or moulded ornaments. An excess of salts or chlorides in the clay body will always bleach such paints.

The shaping technique

Decoration in relief can only be produced by using a mould, engraved with the decoration. The relief pattern is made on the inside surface of the shaping dish.

If the decoration is applied on isolated areas of the pot, the potter will use a small 'mould', in other words, a stamp. But if the decoration is to be applied over the entire circumference of the pot and over a broad area, the potter has to use large forms known as shaping dishes. The part of the pot on which the decoration occurs is created in this mould with the decoration already in place.

Shaping dishes can be made from plaster, pottery or other materials. The material from which the shaping dish is made has to comply with only one requirement. The soft clay which is pressed into the mould must not adhere to the wall, but should shrink away from it during the drying process without cracking. Hence, materials are used for shaping dishes which have a great capacity for absorbing moisture. The shape of such a mould must be such that the dried clay vessel does not get trapped in it. It is essential to be able to lift it out.

In the Qalaat Jaber collection this relief decoration is found on small jugs. Sometimes the wall and shoulder are decorated; sometimes only the shoulder. This is done in the following way.

A decorative pattern is scratched or impressed on the inner surface of the shaping dish (see below). After firing this pattern will show up on the outside of the dish. It is the positive pattern of what is negatively engraved in the shaping dish.

Two identical shaping dishes are used, each with its own engraved decoration (Fig. 2:1,2). In both dishes a thin layer of clay is applied by hand on the inside. In order to get the best results a very wet clay is used. This clay is capable of penetrating into the engraved lines of the decoration without much pressure. Clay which contains a surfeit of water shrinks heavily during drying. The bowl which is being formed easily comes away from the shaping dish. In cases when the clay was not clearly wet enough the decoration has lost much of its sharp contours.

After the clay has been applied to the shaping dishes it is left for a while to dry and to stiffen up. The two shaping dishes are fitted together (Fig. 2:3), the upper one is removed leaving the moulded bowl on top of the lower one. Then the other shaping dish is also removed.

Next the two halves are properly adjusted to each other and placed on a cylindrical support which has been fitted onto the wheel (Fig. 2:4). In

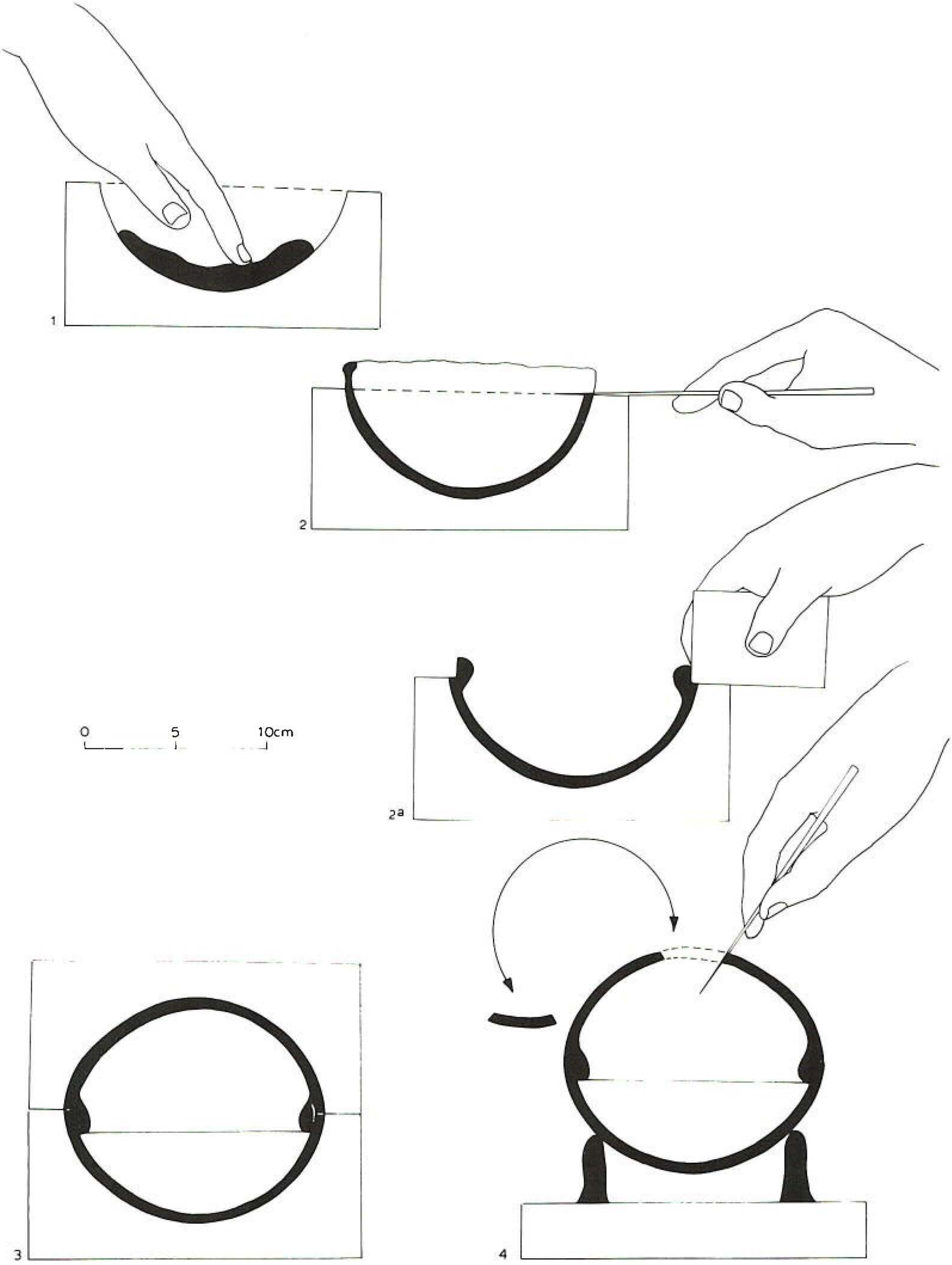

Fig. 2. Construction drawing of a small drinking-jar from Qalaat Jaber.

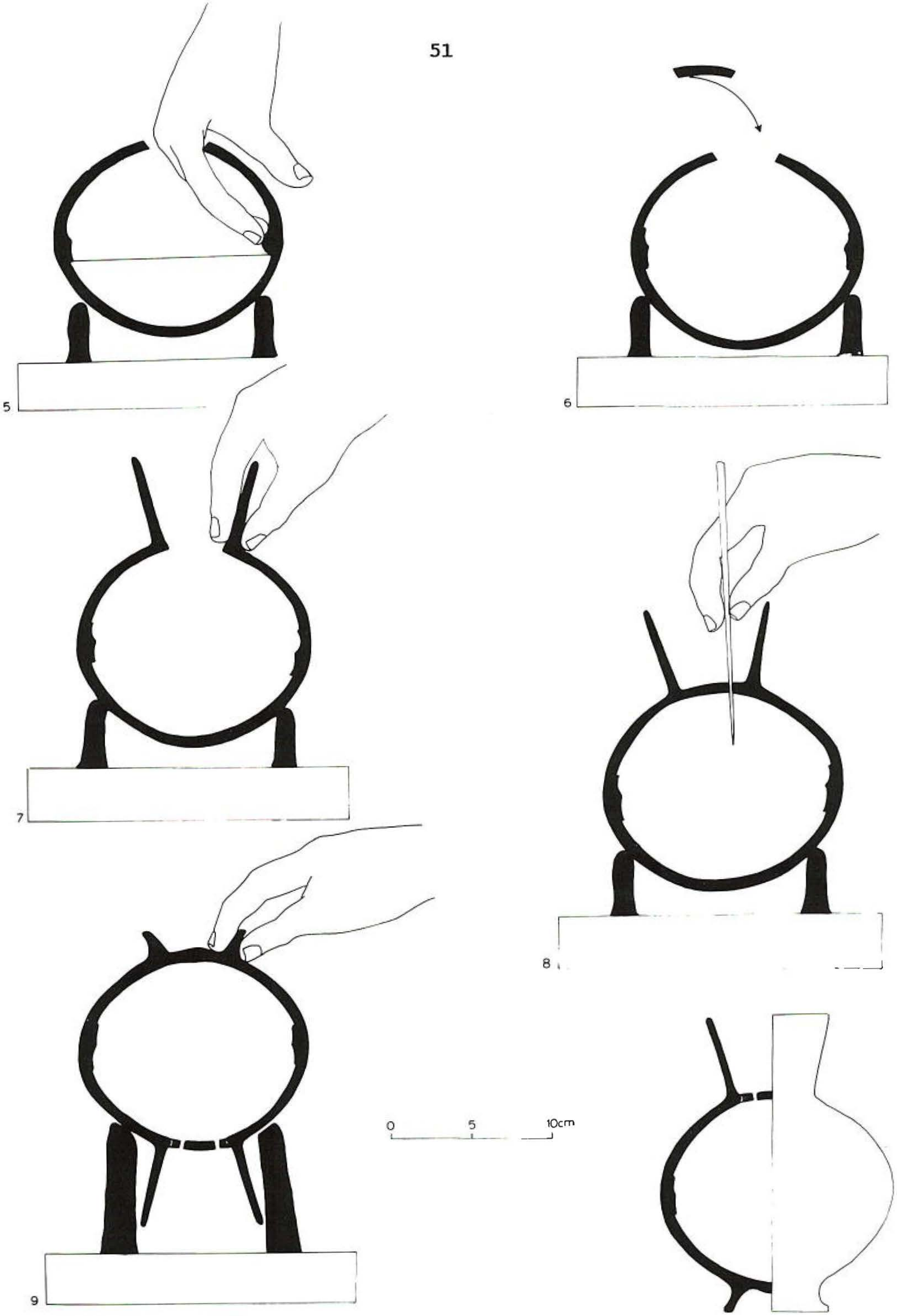

Fig. 2. (cont.). Construction drawing of a small drinking jar from Qalaat Jaber.

a turning movement the potter, using a needle, cuts a circular segment out of the bowl which is designed to become the upper part of the juglet. To prevent this circular segment from dropping into the juglet the needle is held obliquely. The segment is put aside and kept to be placed back into the hole.

Using his forefinger and middle finger, the potter is then just able to reach the joint of the two parts on the inside in order to strengthen this weak spot in the construction (Fig. 2:5). For reasons of efficiency, the potter has already attached a roll of clay along the inside edge of the upper half, before putting it on the lower half. This clay is still moist, and since the pressure from the fingers on this clay roll comes from above, this clay is pushed over the joint which gives it extra strength.

Then the circular segment cut out earlier, is put back into place again (Fig. 2:6). A neck is placed and fixed on the circular cut in a turning movement. At the same time, this fixes the circular section, and closes the juglet (Fig. 2:7). The neck was made on the wheel and was so dry that it could be handled without distorting the shape.

Then, using a needle, perforations are made inside the neck in the clay section which had since been put back into place. The perforations are usually triangular holes: thus it becomes a sieve (Fig. 2:8).

After a short period of drying the juglet is put on the wheel again, upside-down this time. A circular roll of clay is attached to the part which is to become the base, and a ring is made in a turning movement (Fig. 2:9). One pulled handle is attached to the juglet; it runs from the neck to the middle of the shoulder.

Differences from the method described above

a. Some small fragments show that the clay layer was not always put into the shaping dish with a free movement of the hand. The alternative for the clay is to be applied while the shaping dish is being turned on the wheel. In cases like these the clay may have had a different composition.
   This juglet is smaller than the others.

b. The sieve is attached to the neck higher up. The neck was attached to the juglet first. The opening is now too narrow to put the circular segment back into its original position.

c. The opposite also happened: the neck was narrower than the opening, which had been closed up again. By adding some clay to the joint and pressing some circular grooves with the rib over and around it, the joint becomes fixed. Here the sieve is lower than the neck.

d. The lower part of the juglet is not made in a mould but thrown on the wheel. There is no decoration on this part. But the upper part is decorated and comes from a mould. The upper part is put upside-down on the lower part, which is still wet and on the wheel. The joint is strong enough and does not need an extra clay roll on the inside. The upper part of the thrown piece is widened to make the two parts fit well. They did not need to have exactly the same circumference.

The base ring is not attached but is cut out of the thicker part near the base, which has to be thinned while the juglet is standing upside-down on the wheel. There is no sieve in this juglet.

Further remarks concerning the relief pattern

One can distinguish various elements from which the pattern is composed.

a. Mechanically made lines.
   The shaping dish is put on the wheel. While the wheel is turning a blunt pin is used to make a groove. The groove (or grooves) will always run horizontally and parallel to each other.

b. Freely-formed lines.
   1. Straight lines, usually running more or less vertically.
   2. Lines serving to delineate motifs like leaves, or more abstract designs. Lines for stems, animals or lettering are wider. In section they may be convex, or flattish, depending on the point of the engraving needle.
   3. Impressions of small stamps, for instance rosettes, stars, rings, or pendant motifs. The impression is always in negative. Stamp impressions can only be made on a soft substance.

The pattern nearly always consists of a combination of the techniques described above. The result depends on how dominant one of the techniques is over the others. Combinations:

a. Lines drawn mechanically combined with small circles (3);
b. Freely-engraved lines (1) with leaves, animals, garlands (2) together with impressions of small stamps (3);
c. Engraved letters (2) with small circles (3). The space between the letters is filled with circle impressions. They are densely packed together and the lettering stands out against this rough background. It reminds one of certain techniques employed in chase work on metal objects.

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H. de Haas

SYRUP JARS AND SUGAR POTS: A PRELIMINARY STUDY OF A CLASS OF MEDIEVAL INDUSTRIAL POTTERY FROM TELL ABU SARBUT, JORDAN, PART II.

The following short article is a sequel to an earlier article on the subject of pottery used in the production of cane sugar (LaGro and de Haas 1988; 1989/1990). Like the material studied in the article mentioned, the pottery under discussion was found at Tell Abu Sarbut during excavations in 1989 and 1990 (de Haas, LaGro and Steiner 1989; 1992). The excavated material of the last and final season (1992) is still being studied and could therefore not be included in its entirety. The first part of this article deals with the syrup jars (SPII), analogue to the description of the sugar pots (SPI) in the previous article. The second part gives some additional information on the sugar pots. It contains descriptions of two new rim varieties and drawings of some complete pots.

Syrup jars

The class of syrup jars was used in the production of sugar cane in combination with the sugar pots. After the sugar cane was pressed, the resulting juice was reduced by boiling. The end product was a thick syrup, which was then poured into a conical-shaped sugar pot. After having solidified, the remaining syrup was drained off through a hole in the base of the sugar pot and dripped into the syrup jar. How these two were combined in practice is not clear. The obvious assumption that the pot was standing on the jar is not as likely as it seems. The pot would be rather top-heavy in combination with the jar, making it an unstable combination in danger of falling off or toppling over. One solution would be to place the two close together, leaning against each other to offer support. This system was used in Amsterdam in the 17th century, where the combinations were placed next to one another on the floor of a "drying room" (Fig. 1).

Within this class of syrup jar only one production method has been identified, and it is one which runs parallel to the method of SPI/A (Lagro and de Haas 1989/1990). This method of making syrup jars is identical with the method described by dr. H.J. Franken in his publication on the medieval pottery from Tell Abu Gurdan (Franken and Kalsbeek 1975)(Fig. 2). First the upper half of the jar was modelled. This part consisted of a succession of coils, possibly in combination with turning. The pronounced turning marks indicate the pressure exerted on the coils rather than the imprints of regular throwing marks. After finishing the upper part, the jar was placed upside down. Then the rest of the wall was finished and the base was formed. The shape of the base is concave, leaving a foot-ring on the outside of the base which must have contributed to the stability of the jar, specially if a conical

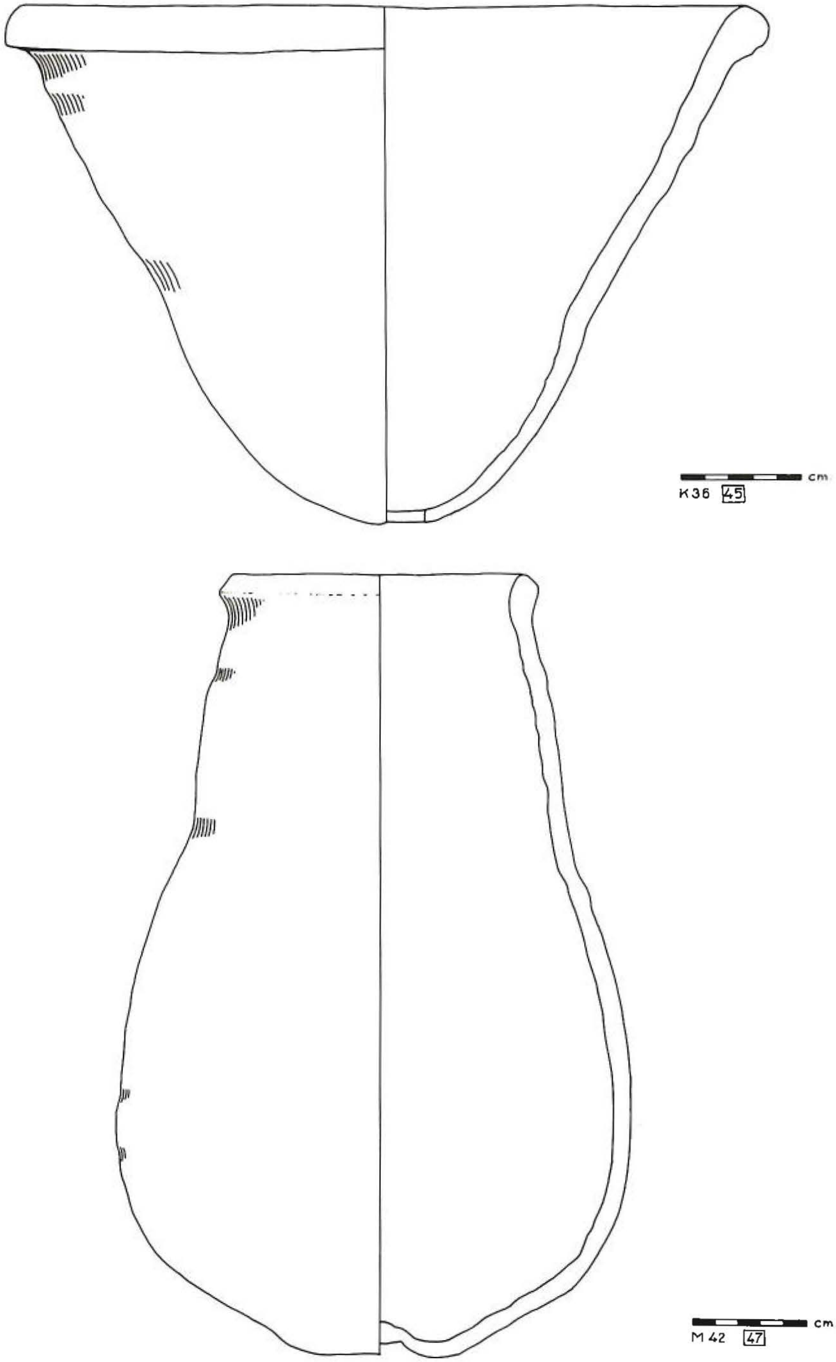


Fig. 1. Sugar pot (a) and syrup jar (b) found at Tell Abu Sarbut.

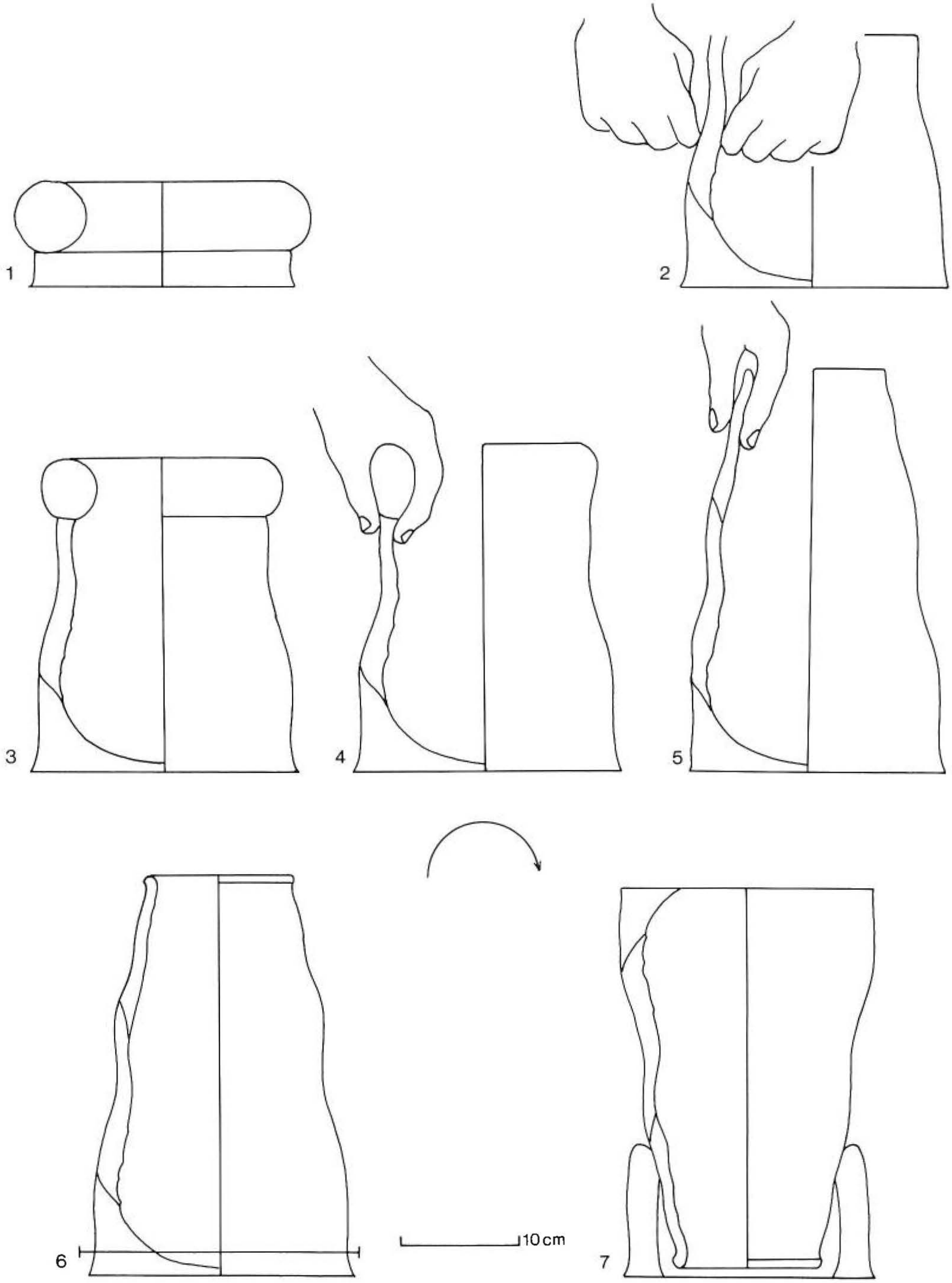


Fig. 2. Construction drawing of a syrup jar (according to Franken and Kalsbeek 1975, p. 148-149).

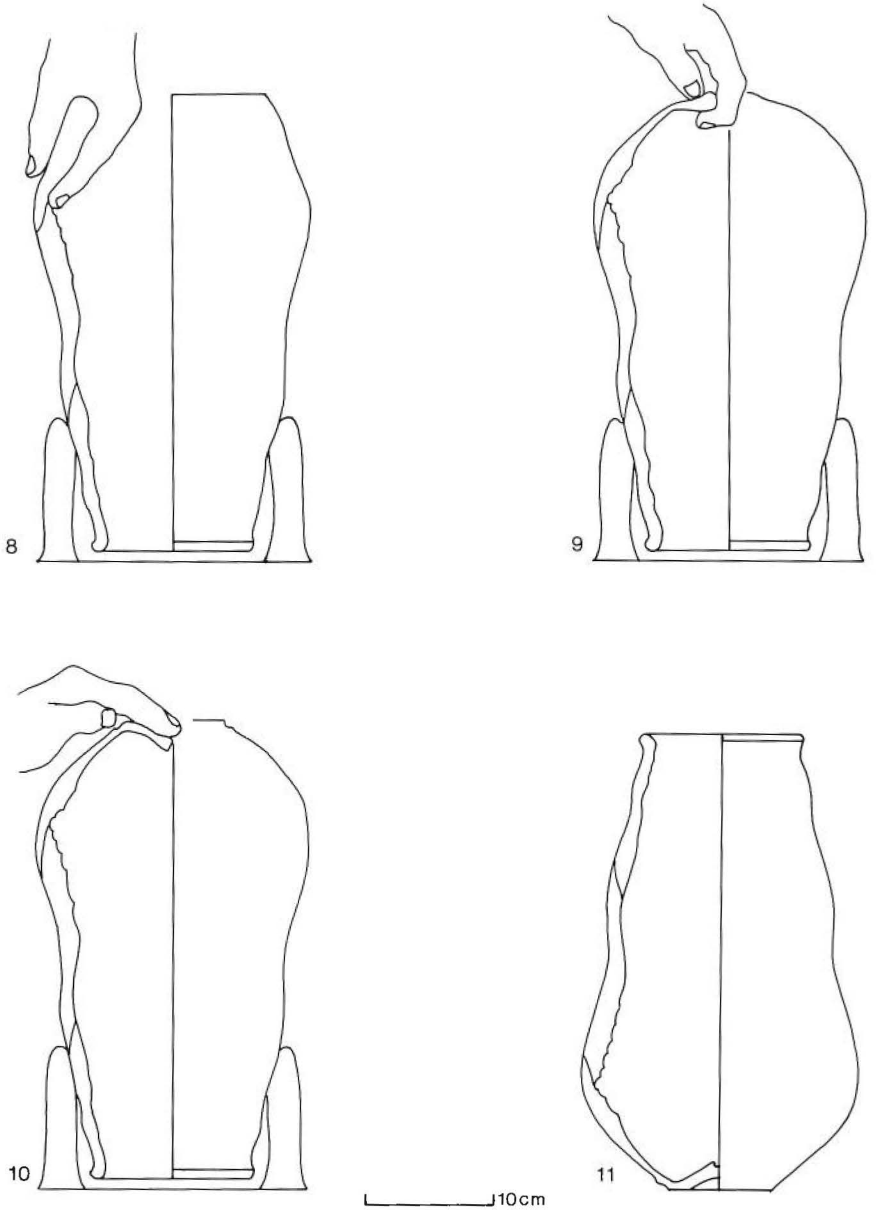


Fig. 2 (cont.). Construction drawing of a syrup jar (according to Franken and kalsbeek 1975, p. 148-149).

form was put on top of it. No finishing touches were applied to the inside or outside edge, thus fragments of clay remained on the outer edge near the rim, where the clay would have supported the jar if turned upside down.

Some restored syrup jars

During previous seasons of excavations at Tell Abu Sarbut a thin deposit containing sherds had been observed along the watersides of the small canal running south of the Tell. During the 1992 season it was decided to make a sounding to obtain information about this deposit and establish the relationship between this deposit and the actual Tell. As fortune would have it, six restorable and nearly complete syrup jars were found, grouped together (Fig. 3). Unfortunately bad weather conditions prevailed after the find and prevented an extension of the sounding to establish the reason for the jars being there, because the deposit turned out to be a washlayer from the actual tell.

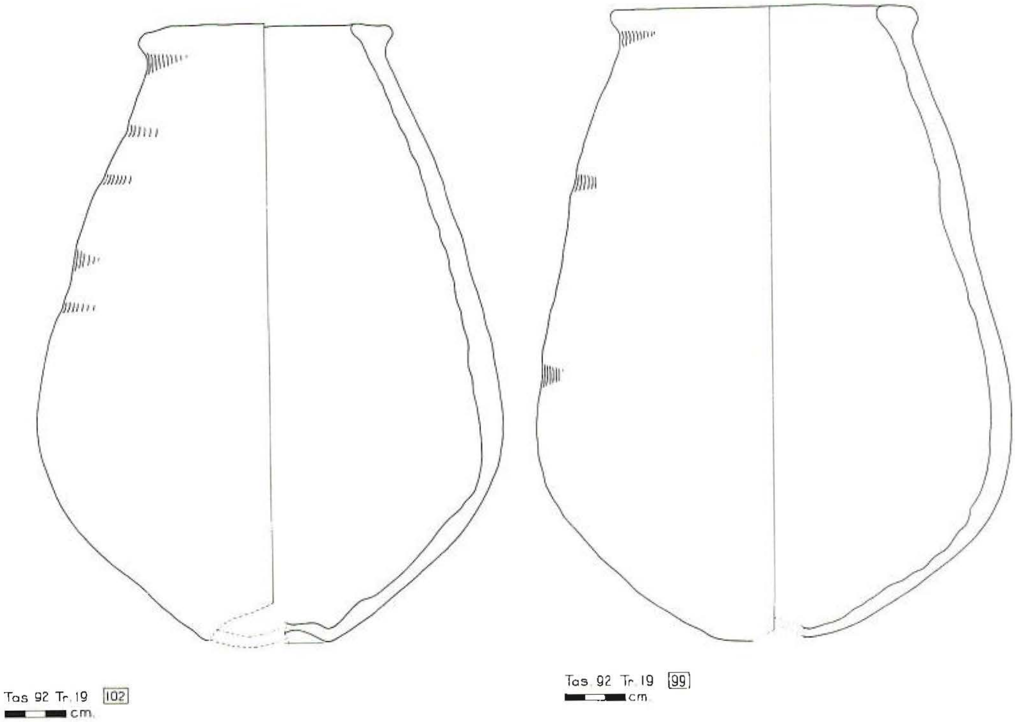


Fig. 3. Some restored syrup jars (SPII).

Rims

SPII/0X (total number of rims: 318)(Figs. 4-8)
The rim was *folded outwards*.

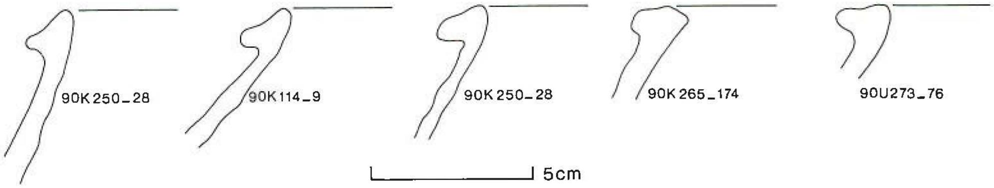


Fig. 4. SPII/01 (subtotal: 23).
The rim was folded outwards, after which the top/outside of the fold was pressed between two fingers. The fold is not pressed against the wall and sticks out somewhat. The transition between the rim and the inside is often rather sharp, due to the pressure of the fingers.

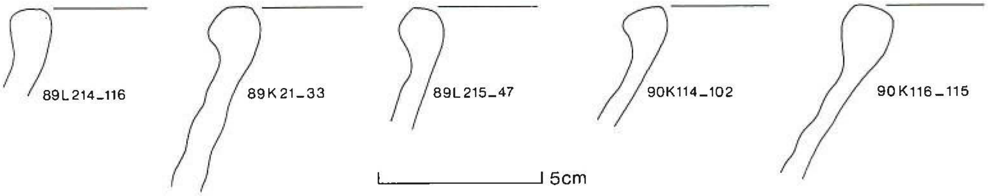


Fig. 5. SPII/02 (subtotal: 109).
The rim was folded outwards and the top was made round. The outside of the fold was pressed against the wall and neatly finished. Sometimes traces of finishing with a sharp instrument like a piece of wood or maybe a nail are observed. The transition between the rim and the inside is round.

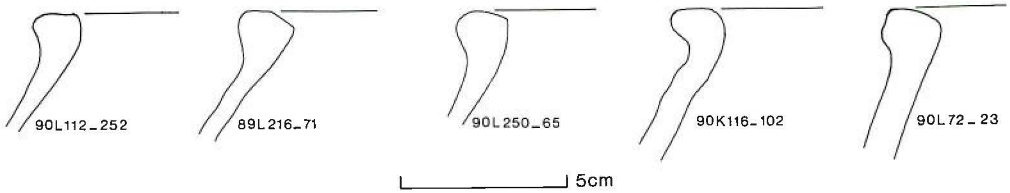


Fig. 6. SPII/03 (subtotal: 98).
The rim was folded outwards. The top is flattened and sometimes protruding outwards. The transition between the inside and the rim is sharp.

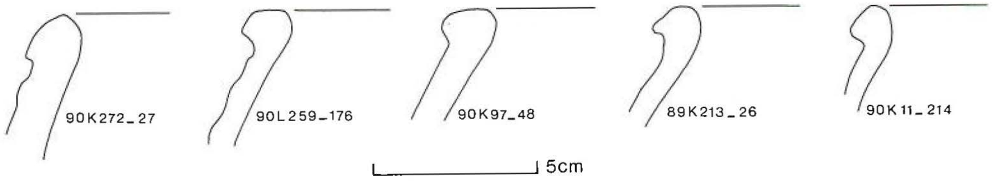


Fig. 7. SPII/04 (subtotal: 69).
The rim was folded after the top of the wall had been rounded. The fold was pressed against the wall, directly above the shoulder of the jar. The lower part of the fold was finished either by smoothing with a finger, or by using a sharp instrument, which left traces directly under the rim. The transition between the inside and the rim is round.

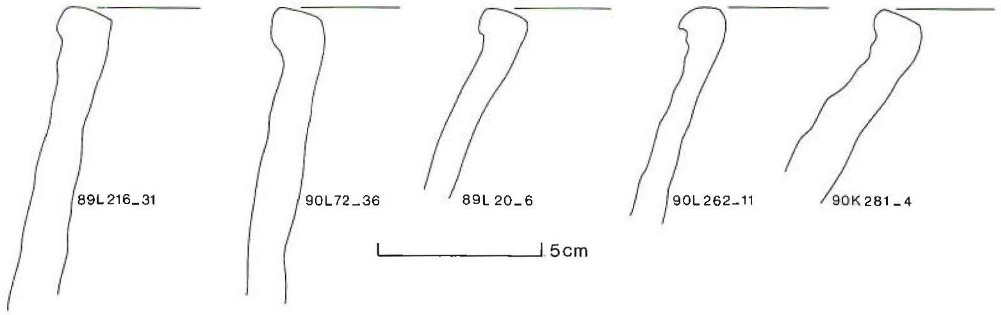


Fig. 8. SPII/05 (subtotal: 19).
After the fold was, made the top of the rim was flattened and the lower part was finished carefully, obliterating the traces of the fold on the outside. Occasionally traces of a sharp instrument or a nail can be observed. The transition between the rim and the inside is sharp.

SPII/10 (total number of rims: 18; Fig. 9)

The rim was *folded inwards*, leaving an indention, which would be difficult for the potter to remove within the narrowness of the neck. The transition between the inside and the rim is round.

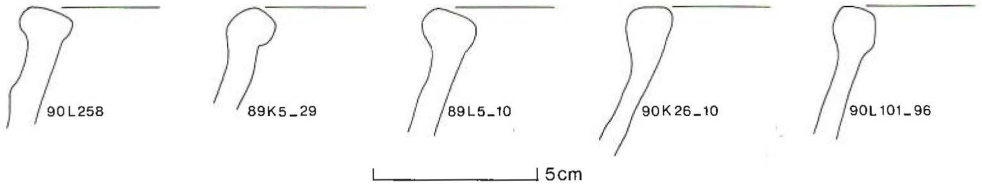


Fig. 9. SPII/10.

SPII/2X (total number of rims: 589)(Figs. 10-12)

The rims are *straight*, i.e. of an even thickness.

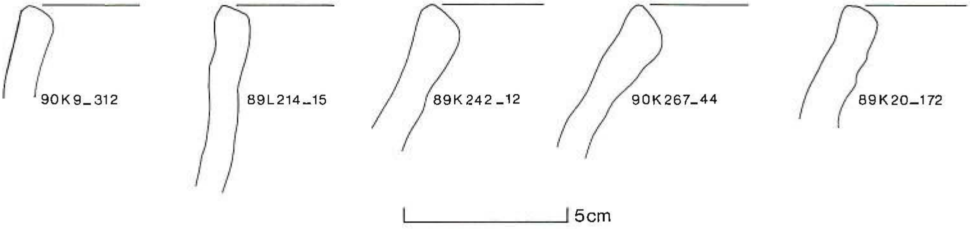


Fig. 10. SPII/20 (subtotal: 76).
Straight rim with top sloping inside. The shoulder of the jar begins directly under the rim. To make the rim slope inside, the potter pressed the clay downwards, sometimes causing the rim to protrude outwards somewhat.

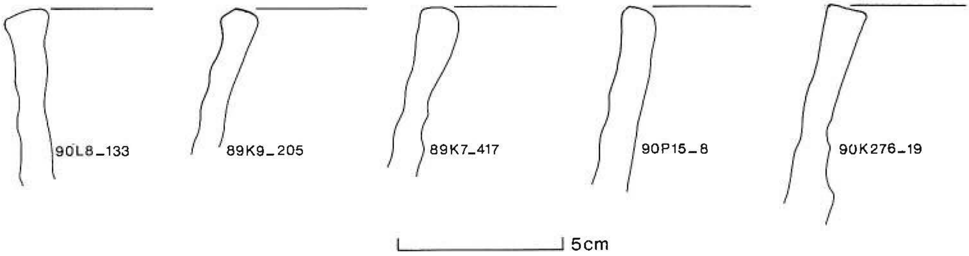


Fig. 11. SPII/21 (subtotal: 133).
Straight rim with flattened top.

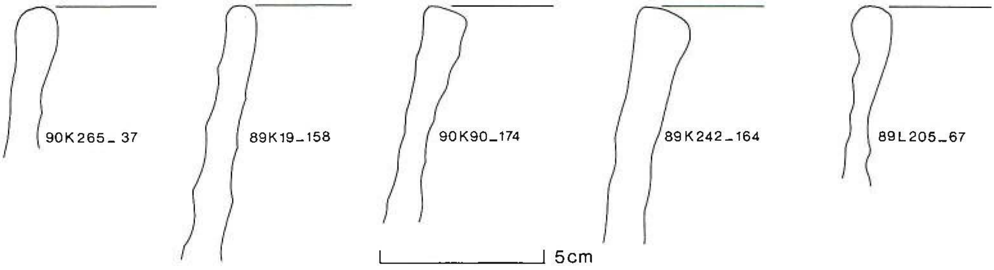


Fig. 12. SPII/22 (subtotal: 380).
Rather straight shape with rounded top.

SPII/30 (total: 199; Fig. 13)

A *coil of clay* was put against the outside, on a level with the top of the wall. An indention on top of the rim often indicates where the coil was attached to the wall. The transition between the inside and the rim is mostly round.

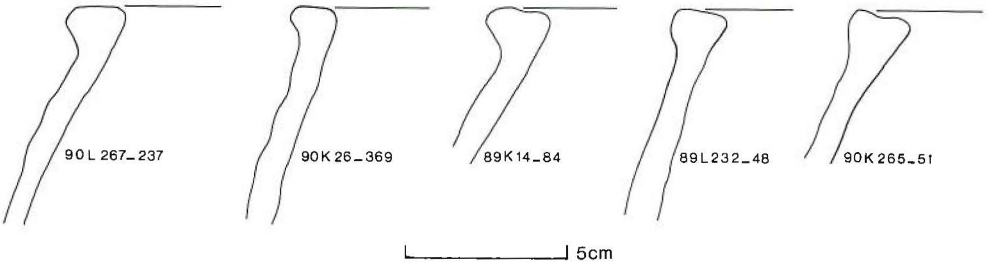


Fig. 13. SPII/30.

SPII/4X (total number of rims: 418)(Figs. 14-15)
The rim was formed by *pushing clay downwards*. This group comprises a large number of sherds, which is in fact the main reason why the two subgroups have been kept separate thus far. The difference between the two subdivisions is small and at a later stage they might be put together again.

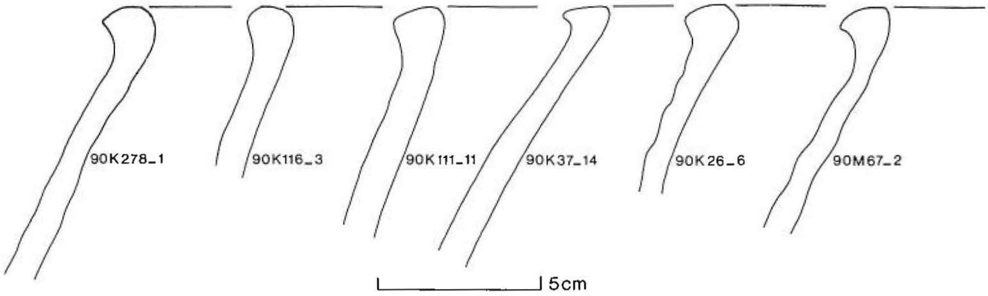


Fig. 14. SPII/40 (subtotal: 238).
The clay on top of the wall was pushed downwards and outwards. The outside of the rim is sharp. The top of the rim is usually rounded, but sometimes flat. The transition between the inside and the rim is round.

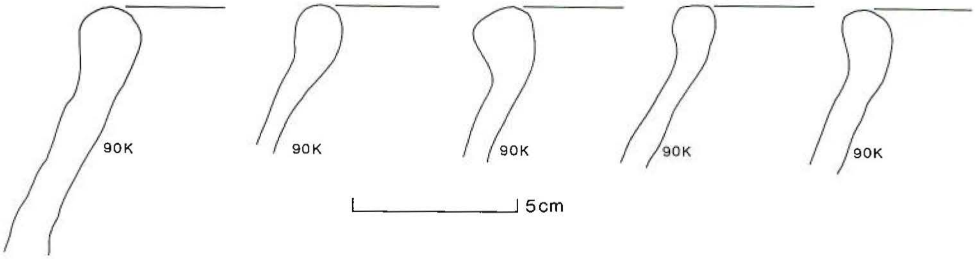


Fig. 15. SPII/41 (subtotal: 180).
The clay was pushed downwards and outwards. The outside of the rim is usually rounded. Strongly related to SPII/40.

SPII/50 (total number of rims: 48; Fig. 16)
The construction method is *not clear*. A coil of clay could have been put against the outside and then smoothed in such a way that the coil was no longer visible. Another possibility is that the clay on top of the wall was just pushed downwards and outwards. The outside of the rim was finished between two fingers, e.g. thumb and index finger.

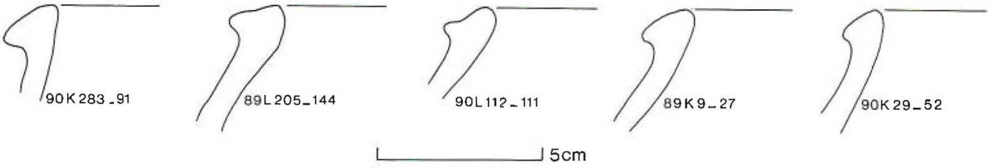


Fig. 16. SPII/50.

SPII/Y (total number of rims: 158)
The sherds in this group are not assignable at present to any of the above-mentioned groups. After the study of the sherds found in the 1992 season has been completed, it is likely that some new groups will be identified to which part of these sherds can be assigned.

Comparison between rim construction of sugar pots and syrup jars

Table 1 represents a comparison in percentages between the sugar pots and the syrup jars as regards the way the rim was constructed. Although it could have been expected that the percentages would run parallel to each other to a certain degree, this overall comparison shows no parallels between the rim construction. A probable conclusion would be that various methods were in use simultaneously and that the choice between the various methods was guided by the requirements of either pot or jar. To what extent this is actually the case might become clear when the stratigraphy is available.

	Sugar pots	Syrup jars
folded outwards	36.94%	20.2%
folded inwards	17.78%	1.13%
straight	5.38%	36.96%
coil of clay	24.43%	12.48%
pushing clay downwards	3.39%	26.22%
not clear	8.71%	3.01%

Table 1. A comparison in percentages between the sugar pots and the syrup jars as regards the way the rim was constructed.

Some restored sugar pots

During the 1992 season part of the sugar-processing plant, which had been uncovered in 1990 was further excavated. From it were retrieved a large number of sherds belonging to sugar pots. Most of the rims can be fitted in the system published previously. However two new clearly distinguishable variants were discovered.

SPI/A/00 (total number of rims: 180; Fig. 17)
The rim was folded outwards and was then pressed against the wall leaving a small indention where the fingers had pressed. The fold is smoothed in such a way that any traces of it are usually obliterated.

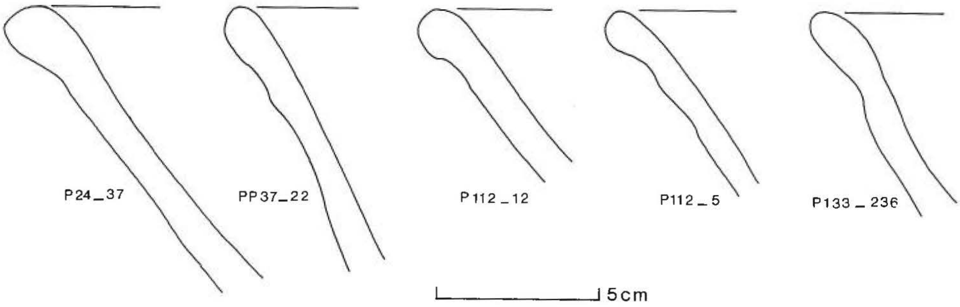


Fig. 17. SPI/A/00.

SPI/A/06 (total number of rims: 203; Fig. 18)
The rim was *folded outwards*, whereby the lower part of the fold was carefully smoothed against the wall of the vessel. The inside of the rim is rounded.

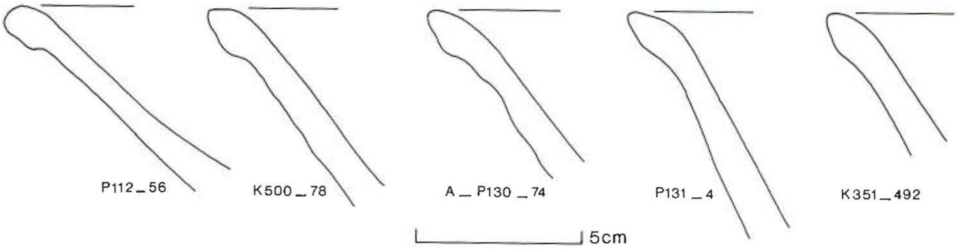


Fig. 18. SPI/A/06.

SPI/A/22 (total number of rims: 260; Fig. 19)
The rim is formed with *equal thickness* and rounded at the top. Subsequently the top of the rim was slightly bent outwards and finished on the inside with a scraping tool.

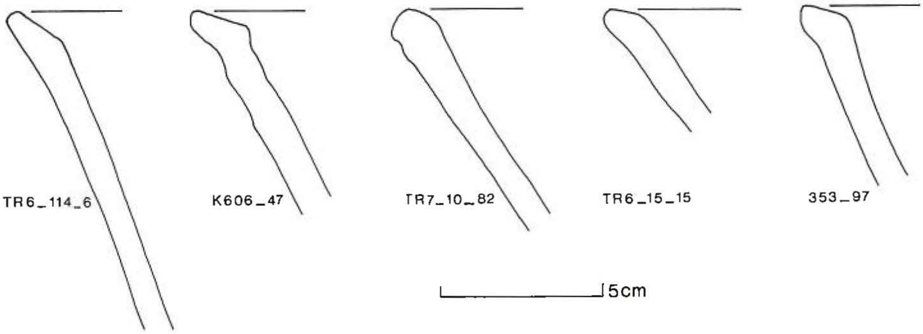


Fig. 19. SPI/A/22.

In the phases belonging to the sugar-production plant, three reconstructable and complete forms of sugar pots were found (Fig. 20). These, together with other reconstructable forms, give an impression of the various forms being used.

The cane sugar production plant extended beyond, and probably well beyond the squares in which excavations took place during the 1989, 1990 and 1992 seasons (Fig. 21). Because no further excavation seasons are planned for the near future, it will not be possible to obtain a complete layout of the plant. However, the various phases which have been distinguished will provide an insight into local changes in this layout and into variations in the pottery repertoire used during the periods the plant was in function.

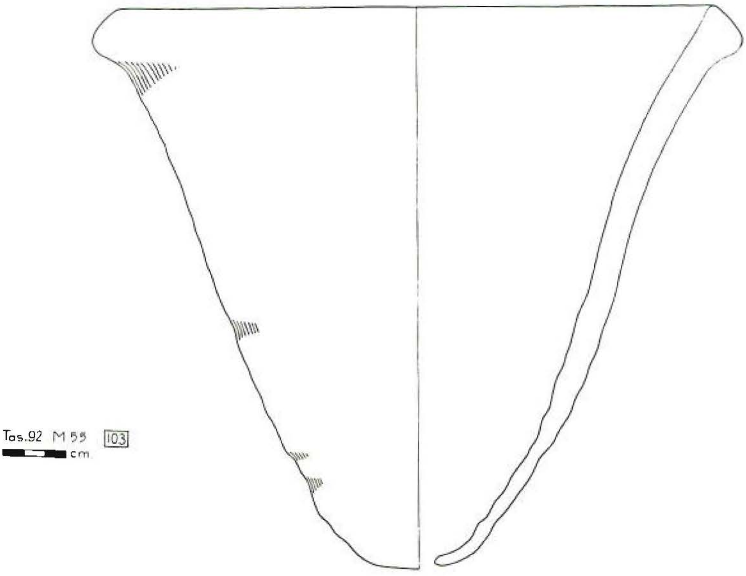
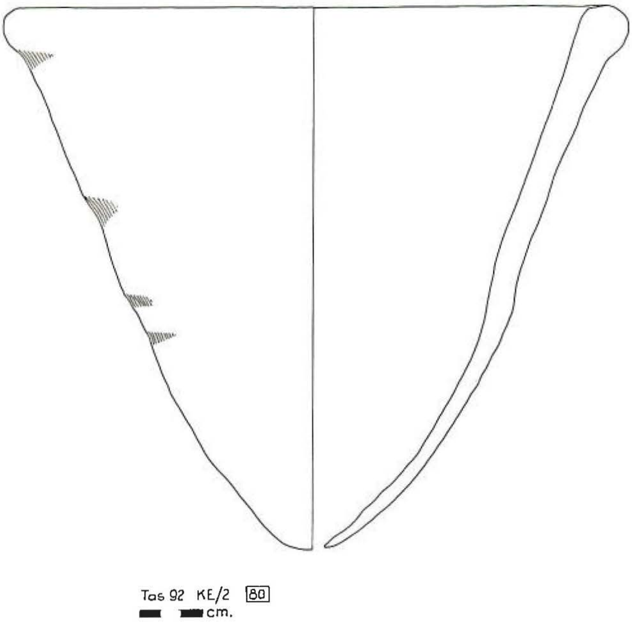


Fig. 20. Sugar pot, find number 80.



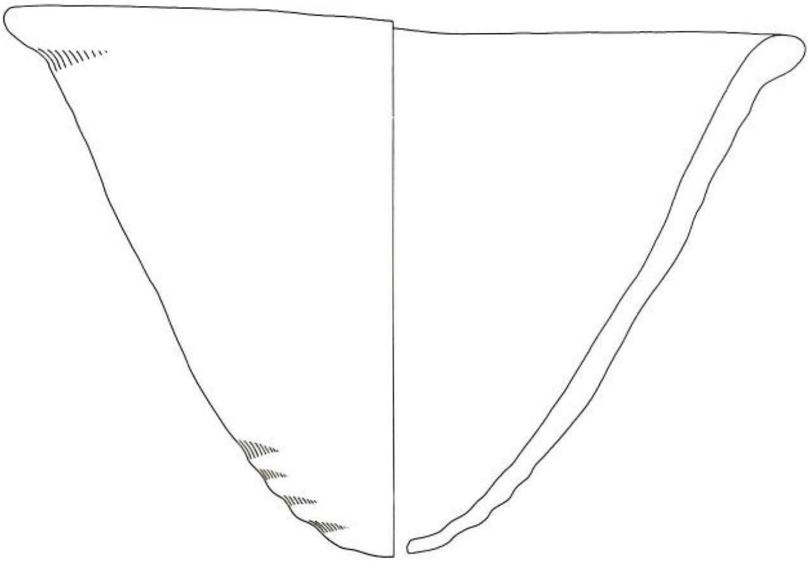


Fig. 20 (cont). Sugar pots, find numbers 103 and 106.

Fig. 21. Part of the sugar factory found at Tell Abu Sarbut.

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M.M.E. Vilders

SOME TECHNOLOGICAL FEATURES OF THE LATE BRONZE AND IRON AGE COOKING POTS FROM TELL ES-SA'IDIYEH, JORDAN

Introduction[1]

In order to gain an insight into some socio-economic processes in the Central Eastern Jordan Valley during the Late Bronze III-Iron Age II period (ca. 1150-600 B.C.) a technological analysis of pottery from Tell es-Sa'idiyeh and Tell Deir 'Alla has been initiated. Working within this framework, this article presents the preliminary results[2] of an analysis of a few technological characteristics of cooking pots from Tell es-Sa'idiyeh dating to the above-named period. The emphasis within this analysis is on making a description of the composition and the shaping technique in such a way that comparison with chronologically comparable material from the other two sites will be possible.

The large double mound of Tell es-Sa'idiyeh is situated in the Central Jordan Valley, 1.8 km. east of the river Jordan, and is one of the larger sites in the Jordan Valley. The site was first excavated by J.B. Pritchard of the University Museum, Pennsylvania (Pritchard 1980; 1985), In 1985 Jonathan Tubb of the British Museum started the renewed excavations in several areas on both mounds (Tubb 1988; 1990; 1991; 1992) and up-to-date six excavating seasons have been carried out.

Cooking Pots

A number of morphological (e.g, round base and wide orifice: see Fig. 1) and technological characteristics (see below) plus the occurrence of soot on the bases point to them having been used to cook with. The fact that they are sometimes found in what could be identified as kitchen areas (van der Steen 1991:Pl.I,1; Tubb 1990:Fig. 13) only tends to confirm this interpretation.

The most essential characteristic sought for in a vessel used for cooking is its thermal-shock resistance i.e. its ability to endure sudden changes of temperature without cracking. Thermal-shock resistance is affected favourably by the choice of composition, relative high porosity and shape (Rice 1987:229; Rye 1976:114; 1981:27).

Calcite and organic material, as well as any other non-plastic, increase the workability (Rye 1981:39; Steponaitis 1984:112) of the clay and its porosity (Skibo 1989:131). An important characteristic of calcite is that it has almost the same expansion coefficient as clay thereby reducing cracking both during the firing process as during usage (Rice 1987:105,229; Rye 1976:117-18; Schuring 1989:185; Steponaitis 1984:112). This reduction is further enhanced by the plate-like shape (Steponaitis 1984:112) and the size of the calcite (Braun 1983: 123; Bronitsky and Hamer 1986:94).

Porosity, the presence of pores and voids (Rice 1987:231), mainly caused by burned out organic material, arrest cracks generated by

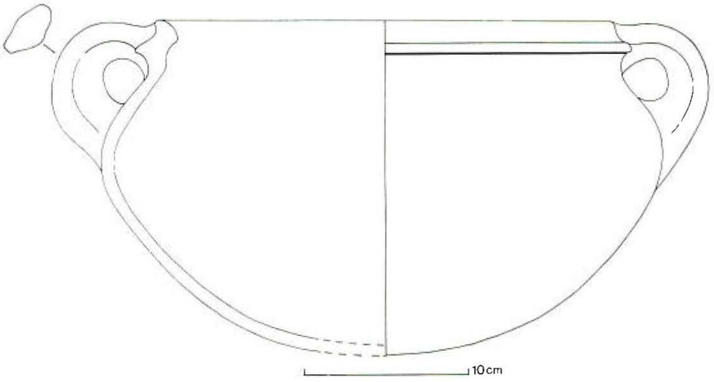

Fig. 1 An example of an Iron Age cooking pot.

thermal shock (Rye 1976:115; Skibo et al. 1989:123). Besides reducing thermal stress, porous walls gradually absorp fluid and since fluids are good conductors of heat, a saturated pot heats its contents faster that a dry pot (Schiffer 1990:377).

Regarding the vessel shape; the thin wall of the base reduces the thermal gradient and hence the stress (Rice 1987: 229), conducts heat more efficiently implying faster cooking, economic use of fuel and an increase in thermal-shock resistance (Rice 1987: 231; Rye 1976: 114). Also, the absence of angles prevents moisture from collecting and reduces stress (Rice 1987: 229).

Material and methods

The first six seasons of renewed excavations yielded a total of 261 rim sherds[3] and ten complete cooking pots, which were all found in areas AA and EE. Stratigraphically, the material belongs to strata XII-IV, which are dated to ca. 1150-600 B.C. (Tubb and Dorrell 1991: 69). Owing to the limitations of the small number of sherds available, no attention has been paid to the diachronic development; and the remarks proposed here are to be considered preliminary until comparative studies have been done.

The technological study of the Tell es-Sa‘idiyeh cooking pot sherd material comprised three parts:

1. Analysis of the fabric: a small sample was refired for 30 minutes in an oxidizing atmosphere at 750°C as a first step towards recognizing the composition of the clay body which was used. Also, a small piece was broken off each sherd to obtain a fresh break. These were then studied macroscopically (40x) for:

a. relative identification of the clay and the non-plastic inclusions (Stienstra 1986:46);

b. the quantity and size of the non-plastic inclusions. In order to determine the quantity, use was made of a reference collection of test bars of fired clay. These bars contain known quantities and sizes of non-plastics given in percentage of dry weight (Jacobs 1983).

2. Description of the colour of the surface and the core using the Munsell Soil Color Charts (1954).

3. Analysis of the shaping technique of the vessel and the rim by studying the traces left on the pottery.

The technological features

Fabrics

The term fabric is used here as the combination of clay and non-plastic inclusions (both mineral and organic) after firing (Rice 1987:476). The refiring test resulted in the distinction of two clays: clay "A" fires red and clay "B" fires pale-red yellowish. The macroscopic study resulted in the distinction of four types of non-plastics: calcite, quartzsand, organic material and black sand-size inclusions (in Table 1 marked as "black"). The combination into fabrics is seen in Table 1.

	CLAY A	**CLAY B**	**ORG.MAT**	**CALCITE**	**QUARTZ-S.**	**BLACK**
			ca. 500μ	> 380μ < 750μ	> 240μ < 480μ	> 80μ < 500μ
			25%	20-25%	< 2%	< 2%
FABRIC						
1	x		x	x		
2	x		x	x	x	
3	x		x	x		x
4		x	x	x		

Table 1. The four fabrics. Fabric 1 is clay "A" mixed with calcite and organic material (e.g., dung) and occurs in 77% of the repertoire. Fabric 2 is clay "A" mixed with calcite, organic material and quartzsand and was found in a small number of sherds (3%). Fabric 3 contains calcite, organic material and unidentifiable inclusions in clay "A" and is, therefore, considered separate (5%). Fabric 4 is a mixture of clay "B" with calcite and organic material (15%).

Firing conditions

In general, the prevailing colouring agent of a pot is iron, which will fire to different colours depending on the amount and size distribution, other minerals present and the temperature and atmosphere in the kiln (Grimshaw 1971:910-911; Jacobs 1987:49). The study of the colour of the sherd material showed that the majority has a weak red (7,5R 5/4 - 10R 5/3) surface and core colour pointing towards an oxidizing to neutral atmosphere in the kiln. Also, if compared with the yellowish-grey colour of the rest of the domestic repertoire (Vilders 1991b:141) the cooking-pot colour possibly indicates the presence of a higher percentage of iron oxide (Grimshaw 1971:910). The presence of calcite implies that a kiln temperature under ca. 750°C was preferred to avoid lime popping[4], but in 11.3% (39 sherds) evidence of popping was found.

Basic shaping technique

Body

In all cases, a slab of clay was pressed into a mould (which could have been made of lime, clay or basketry) positioned on a turntable (Rye 1981:147), for the shaping of the base (Fig. 2:1). The advantage of the mould being that the potter had sufficient control over the thickness of the wall. In addition, the base was sometimes scraped, a conclusion based on scrape marks on one of the complete pots (Fig. 2:6). The shoulder and neck were formed on the base with coils resulting in a sharp carination between the base and the shoulder(Fig. 2:2-5). The last step was the attachment of the handles. Usually, the handle was attached to the rim and the carination, and only in a few cases was the handle attached halfway down the rim. One of the finishing touches was the smoothing of the exterior of the vessel with a piece of cloth, which removed the construction marks, i.e. made the carination between shoulder and base less distinct. This procedure has been deduced from the study of the complete pots and the supposition here is that this also holds good for the rim-sherds. All of the cooking pots were produced in this fashion allowing one to conclude that a single basic shaping technique characterizes this repertoire.

Rim

To finish the rims, two techniques were used (Fig. 3):

Technique 1.

A coil was added to the neck, which was then flattened and folded to the outside resulting in a profiled rim twice the thickness of the wall. After this either of the following steps was taken:

Variant A.

The rim was again pressed flat and turned upwards. The protruding lip, resulting from the folding and the squeezing was maintained.

Variant B.

The procedure was the same as with A, but the seam of the lip has disappeared by smoothing the clay out against the wall while the pot was rotated. During this process the wall was supported from the inside by one or more fingers. Then the rim was squeezed flat and turned upwards, thus erasing the protruding lip.

Variant C.

By pressure of the fingers further profiling was obtained. The seam of the lip was smoothed away by smearing the clay

along the wall of the body. During this, the wall was supported on the inside by one or more fingers, and in a few cases this rim was then pushed outwards.

Variant D.

The same as C, but by putting more pressure on the inside of the wall, by one or more fingers, a distinct ridge on the inside was obtained. The rim was then thickened by pushing it down after which the rim was further profiled with the point of a rib or some sort of similar instrument.

Variant E.

The same as C, but the rim was then thickened once again by pressing it down.

Technique 2.

The rim was formed by pressing the surplus clay of the last coil upwards producing a mildly rectangular shape. The result is an unprofiled rim. After this the following steps were taken:

Variant A.

By pressing a finger on the top of the rim it was thickened.

Variant B.

The same as A, but the top of the rim was cut off with a sharp instrument, e.g., a needle resulting in an equal thickness of neck and rim. Finally, the rim was pushed outwards creating a flaring rim.

The forms

The form is the result of the combination of technological factors such as fabric, shaping technique and firing, functional requirements and tradition. In our case the sum of these factors resulted in the differ-entiation of two forms on the basis of a number of morphological characteristics.

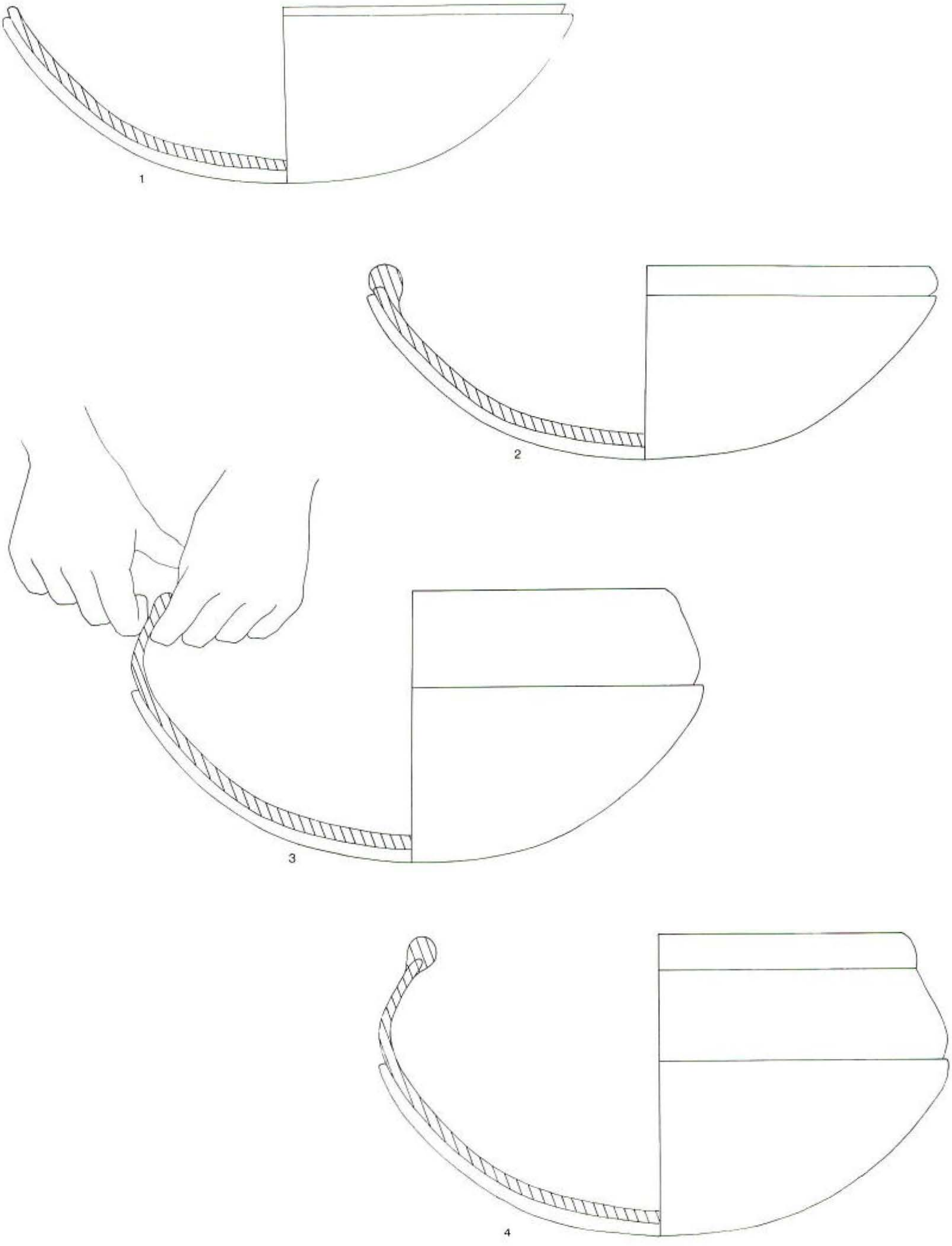

Fig. 2. A reconstruction of the shaping technique.

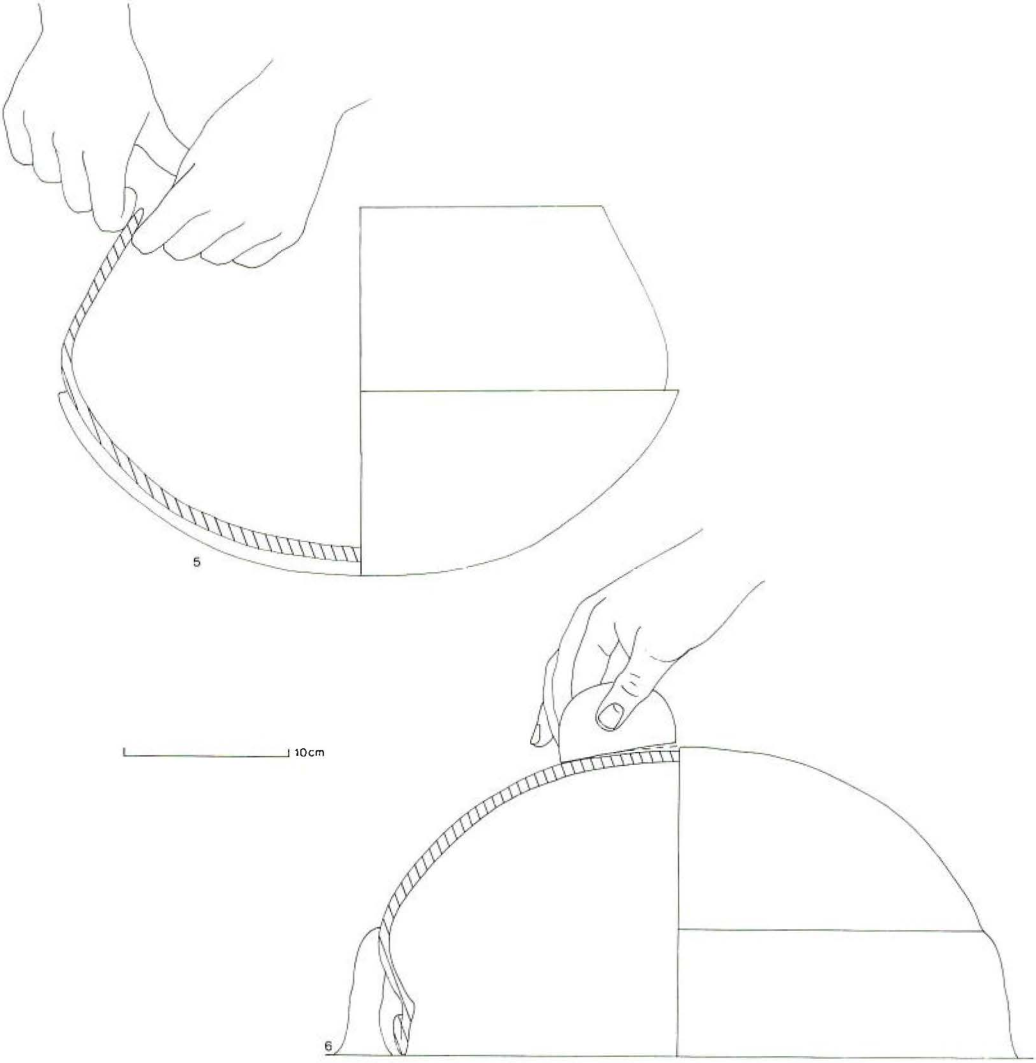

Fig. 2 (cont.). A reconstruction of the shaping technique.

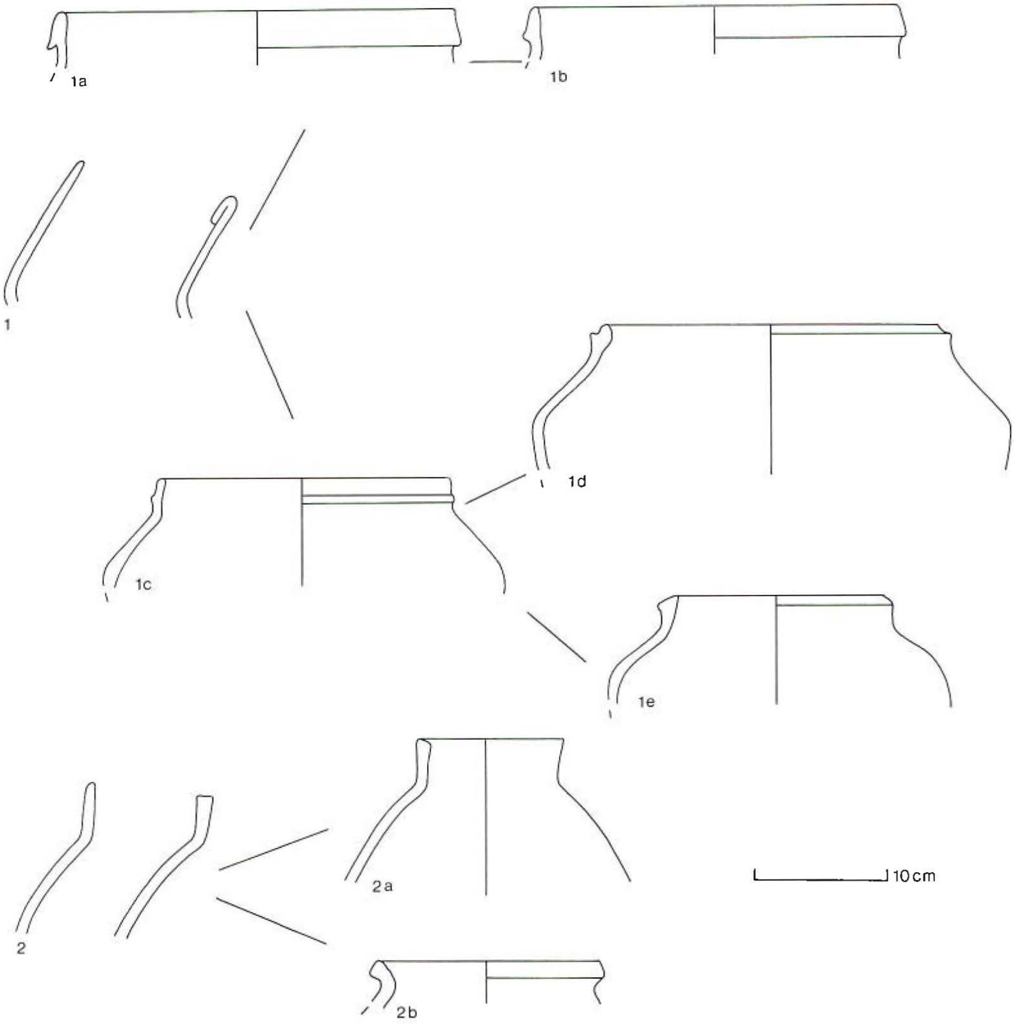

Fig. 3. A reconstruction of the shaping technique of the rims.

Wide-mouthed pot (WM)

This pot is ca. 20 cm. in height and is subdivided into two variants on the basis of the diameter of the rim:

Variant I : has a diameter between 26-36 cm and no handles (Fig. 4:1);

Variant II : has a diameter between 16-22 cm. and two handles (Fig. 4:2).

Narrow-mouthed pot (NM)

An approximately 25 cm. high, so-called cooking jug with a rim diameter between 10-14 cm., and one or two handles (Fig. 4:3; Fig. 5).

Summary

Recapulating the information the following picture emerges:

1. Four fabrics were distinguished (Table 1);
2. All the cooking pots were manufactured using one and the same basic shaping technique (Fig. 2), resulting in two forms: wide-mouthed and narrow-mouthed (Fig. 4);
3. Defining a technological type by two attributes - its fabric and its shaping technique (Rice 1987:286) - implies four different technological types (from here on called Type).
4. Two techniques were used to finish the rims (Fig. 3).
5. As Table 2 shows, the differentiation in forms is further strengthened by the distribution of the various rim variants over the two forms. The wide-mouthed pot variant I only occurs with rims 1A and 1B; variant II only occurs with rims 1C, D and E, and 2B; the narrow-mouthed pot was only found with rim 2A.

Type 1 only occurs with both wide-mouthed variants; type 2 only occurs with the narrow-mouthed form; type 3 occurs with both wide-mouthed variants. Type 4 only occurs with the wide-mouthed variant II rim 1E.

FORMS TYPE	RT	RV	WMI	WMII	NM
1	1	A	x		
1	1	B	x		
1	1	C		x	
1	1	D		x	
1	2	B		x	
2	2	A			x
3	1	A	x		
3	1	B	x		
3	1	C		x	
3	1	D		x	
4	1	E		x	

Table 2.
Combination of the technological and the morphological features. Abbreviations: RT= rim technique; RV= rim variant; WM= wide-mouthed; NM= narrow-mouthed.

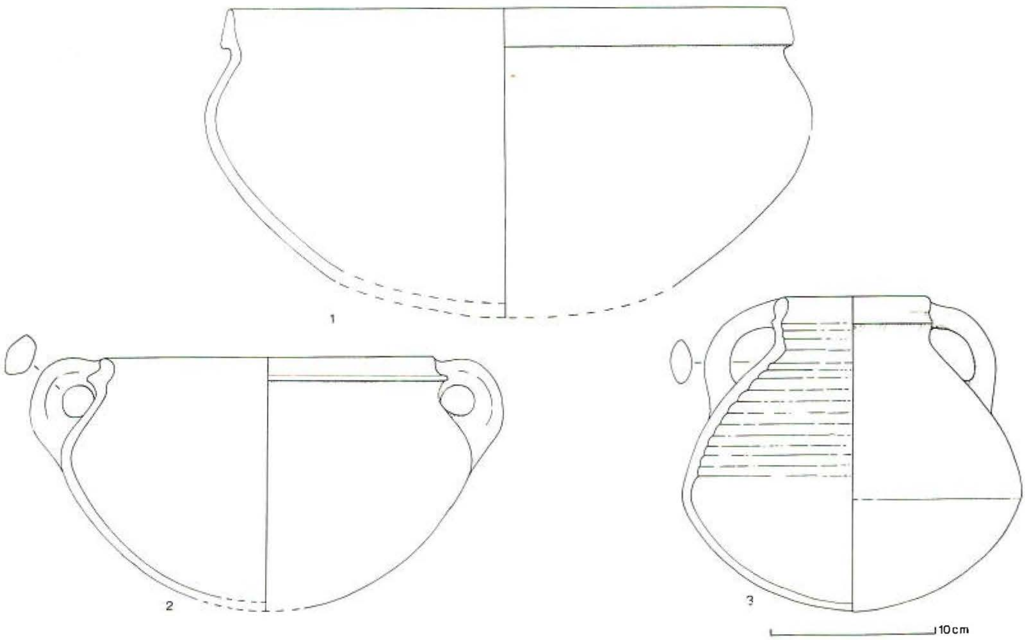

Fig. 4. The wide-mouthed (1,2) and narrow-mouthed (3) cooking pot.

Fig. 5. The narrow-mouthed cooking pot.

A comparison

Technological and form analyses have already been carried out on the Late Bronze and Iron Age material from Tell Deir ‘Alla (Franken 1969, 1992; Vilders 1989, 1992a). When we now compare Table 2 with Tell Deir ‘Alla we can conclude that, on the one hand, only Tell es-Sa‘idiyeh Type 1 in both wide-mouthed variants, but with a different rim technique, occurs at Tell Deir ‘Alla, and that, on the other hand, the Tell Deir ‘Alla repertoire has one type not found at Tell es-Sa‘idiyeh. All in all, the Tell es-Sa‘idiyeh repertoire has proven to be richer in variety of types and shapes.

Discussion

Previous technological studies of pottery from the Jordan Valley (Franken 1969; 1976; 1992; McGovern 1986; Vilders 1989, 1992a) have shown that during the whole of the Late Bronze and the Iron Age I-II period the cooking pots were mould-made and calcite tempered so the Tell es-Sa‘idiyeh cooking pots are no exception. The small amount of quartz in Fabric 2 could be interpreted as being already present in the clay, but the fact that the rest of the material shows no sign at all of quartzsand makes me believe this was added intentionally.

An explanation suggested here for the introduction of quartzsand as a non-plastic in Type 2, is that during the period described here the potters experimented with this type of non-plastic in order to be able to throw the cooking pot. Throwing of coarsely calcite-tempered clay is not easy: both the coarseness of the calcite and the considerable quantity of the non-plastics inclusions make the clays less plastic, i.e., difficult to throw.

Somewhere in the second half of the eighth century B.C. calcite was completely replaced by quartz as the main tempering agent in the production of cooking pots and these pots were thrown (Franken 1976:87). Supposing now that the presence of quartzsand as a non-plastic in Type 2 is an indication of experiments by the potter; can we then see this as an early predecessor of the thrown cooking pot?

Notes

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2. In cooperation with the Department of Science of the British Museum, petrographic analysis and X-radiography will be performed and it is hoped that this will complete the picture presented here.

3. In regard to the diagnostic sherds, no base sherds were recovered.

4. Calcium decomposes at ca. 750°C forming lime (CaO). When fired over this temperature the lime absorbs the atmospheric moisture and forms into quicklime ($Ca(OH)_2$) and releases heat. This is accompanied by volume expansion causing cracking during the cooling process (Rice 1987: 98).

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