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INTRODUCTION

In the Grödinge project pottery was recovered from the five Neolithic sites, totalling *c.* 280 kg (Table 9:1). A selected sample of pottery from four of these sites, *i.e.* the Eklundshov, Smällan, Kyrktorp and Kvedesta sites, has been studied more closely and also analysed technologically.

The sites were situated relatively close together, especially the Smällan and Kyrktorp sites (*cf.* Fig. 1:1), but despite this, the pottery appeared varied, both within and between the sites. This could be explained in several ways.

The relative dates of the pottery sampled at these four sites extend from the Early Neolithic to the Early Iron Age, with different periods represented in different sites and parts of sites (*cf.* Table 9:1). During this time the landscape changed from an open archipelago to an inland located close to the Baltic coast (*cf.* chap. 1, 3A:1, 10–11). Most of the Neolithic sites were situated by the Litorina sea shore, the exception being the Eklundshov site, which then was situated in the inland, like the sites from the Early Iron Age. Since people chose different locations for the sites during time, we assumed that an explanation for the variation of the pottery observed in the field could be changes in economy, from marine hunting to agriculture, and thereby associated household activities. For that reason pottery from the Early Iron Age, which occurred in small quantities at the sites was included in the microscopic study, as a comparison to the Neolithic ceramics.

The size of the Neolithic sites differed (*cf.* chap. 3A:1, 3B:3–4), as well as the amount of pottery occurring. The Smällan and the Kyrktorp sites were large sites, with high amounts of pottery. The Kvedesta site was a small site, with lesser amounts of pottery. The Eklundshov site only contained a very small find. These differences indicated that more or less contemporary sites might have been used in different ways (*cf.* chap 3A:2–3), the assumption being that this variation would reflect on the way more or less contemporary pottery was used.

AIMS AND OUT-LINE OF PRESENTATION

The aim of the pottery study is to document and explain variations observed in the pottery retrieved and provide a basis for interpretations in terms of cultural, chronological and/or functional differences. Previous analyses on pottery from the region had resulted in interpretations of pottery being produced according to specific cultural conventions (see below). Did these conventions dominate over specific functional properties? Is it possible to recognise craft traditions, possibly linked to typological groups and also trace further, functional, variation within these traditions?

These interpretations are further developed in chap. 3A:3, in which the absolute datings of the pottery finds is discussed.

In this article the typological aspects of the pottery combined with analyses of the ceramic technology, *e.g.* the composition of the ceramic ware, is discussed. The discussion is based on a relative, typological dating of the pottery. Both archaeological macroscopic as well as scientific microscopic methods are used. Descriptions on the macroscopic and microscopic methods applied, definitions and evaluation of methods are also included (see below and Appendix 9A). The article also includes short overviews on background data on regional typology and functional studies.

The pottery in this volume is presented mainly by drawings, enface and with a section (Fig. 9:1).

On a regional level our aim is to continue studies begun previously (see below) and:

1. using relative dating, complete descriptions of parts of the regional Neolithic ceramic sequence, with quantitative and qualitative data from both macro- and microscopic analyses.
2. test if it was possible to identify a local/regional manufacturing tradition and if this was visible over a longer time period (microscopic analyses).
3. correlate certain vessels with specific functions (macro- and microscopic analyses).
4. investigate if differences in economy could be correlated with different types of wares or shapes (macro- and microscopic analyses).

The first to third questions are discussed here while the fourth is commented on in chap. 3A:3. The second question is also discussed here but further developed in chap. 3A:3.

On the site level the aims are to use these data to gain information on:

1. dates and chronological depth
2. inner structure
3. contacts with other sites/regions.

In retrospect we conclude that the aims of the study were wide, compared with both the varying contexts sampled and the small quantity of samples chosen for analyses.

CHOICE OF METHODS AND COURSE OF THE INVESTIGATION

We chose a strategy that entailed working in three different steps: 1) A macroscopic recording of pottery at a basic level. 2) macroscopic special studies of samples of sherds 3) Technological investigation of a very small selected sample of sherds (*cf.* chap. 7).

The macroscopic recording of the pottery at a basic level aimed at giving an overview of all ceramic finds from each site and provides a basis for further sampling. One special recording made a basis for relative datings and interpretations based on comparison with published regional and non-regional investigations, another was focused on functional aspects. These data were a starting point in choosing the sherds for further, technological analyses, aiming at testing the macroscopic data and answering questions formulated. Other special recordings were carried out to answer site specific questions.

During this process the larger geographic scale (region, parts of region) was sought for. Neither different contexts within the sites, nor different vessel sizes or shapes were taken into consideration for the sampling. No search for suitable clay sources was carried out in the project, as the main focus was not the specific site (*cf.* chap. 7, see also below).

Initially, during 1986–1987 and 1989 all pottery from each site was recorded on a basic level (Appendix 9:A). Thereafter samples were recorded macroscopically on a more detailed level (*cf.* Appendix 9:A), resulting in descriptions of the pottery from each site (*cf.* chap. 16–19). After that a typological/contextual grouping and relative dating of the pottery, based on previous typological studies in the region was made. The description of each typological/contextual group (groups A–D) was then completed with macroscopic data.

Even more detailed studies of pottery were carried out on small samples from the Kyrktorp Site, studies on function, chronological differences, fragmentation, erosion and wave washing (*cf.* chap. 18, Table 9:1). These studies (except one on function) were combined with studies of internal structure (*cf.* chap. 18).

Agneta Scharp, in periods during 1988–1990, carried out the macroscopic studies and manuscripts on a site-specific level. Eva Olsson made the relative datings and typological/contextual grouping, during the same time.

After this, a sample of the pottery was selected for laboratory analysis and 30 pottery sherds were analysed by Ph.D. Anders Lindahl, the Laboratory for Ceramic analyses, Lund in 1991 (see below). The analysis was carried out in two steps.

PREVIOUS STUDIES OF NEOLITHIC POTTERY IN EASTERN MIDDLE SWEDEN

Typology

In the region four types of Neolithic pottery have been recognised for a long time (Stenberger 1979, Burenhult 1999*,* and *cf.* chap. 1). These types have been correlated with different archaeological cultures, some of which are estimated to be contemporary with each other (*cf.* chap. 2B, 3A:3).

The pottery represents the Early Neolithic Funnelbeaker Culture (TRB, the local group called the Vrå-culture), the Middle Neolithic Pitted Ware Culture (PWC) and Corded Ware/Battle Axe Culture (BAC) and finally pottery from the Late Neolithic (LN). Recently, a fifth, mixed, type from the Late MN–LN has been noticed, among others based on a find from the Grödinge excavations (*cf.* chap. 18, Edenmo & Olsson 1997, *cf.* Bagge 1951). Each of these types of pottery has been grouped by differences in decoration, vessel shape and to some degree the ceramic ware. Here the pottery from the two groupings relevant for this study is shortly described.

Pottery from the Vrå Culture (Early Neolithic TRB)

S. Florin (1958) made the first collected description of the TRB-pottery found in Eastern Middle Sweden. This TRB-pottery contains rounded funnel-beakers with rounded or flat bottoms, collared flasks and clay discs, common shapes in other parts of the TRB-culture in northern Europe as well (*cf.* Midgley 1992). **Ytbehandling** The frequency of decorated pottery varies between 2–3% to 10% and based on decoration the pottery can be put into two or possibly three groups:

1. Pots with sparse decoration around the rim, comprising various pits, impressions etc (ex. Malmahed south, Olsson & Hulthén 1986), Frotorp (Eriksson *et al.* 1994), *the Frotorp group*. No flasks have been found in this group (few finds altogether).
2. Pots with pits, impressions and horizontal cord-impressions (*e.g.* Mogetorp, S. Florin 1958), *the Mogetorp group.*
3. Pots with horizontal and/or vertical cord and twisted cord impressions, various comb-impressions, incised lines and line-bands placed over larger parts of the pot than just around the rim/neck (*e.g.* Östra Vrå, S. Florin 1958, Malmahed north Olsson & Hulthén 1986), *the Östra Vrå group*. This group contains funnel-beakers with longer necks than the others.

The ceramic ware has, on macroscopic basis, been described as manufactured by coiling in N-technique (*cf.* Appendix 9A). The vessels are often relatively thick-walled and sparsely tempered, mostly with coarse feldspar grains. The sherds are commonly light brown, with a darker core.

Pitted Ware Culture Pottery

Several collected description of the finds of PWC-pottery from Eastern Middle Sweden have been compiled, most of them describing a presumed chronological sequence. Bagge (1951) created the most used grouping of pottery, the Fagervik I–IV stages. Variation in ceramic ware and type of decoration is the base for this sequence. The PWC-pottery described comprises vessels with mainly rounded or pointed bottoms, which can vary widely in size.

1. *Fagervik I-pottery*: Decorated mainly at the rim–neck with twisted cord, whipped cord, stamps, vertical lines, rhombic checker, stab and drag. Vessel-wall pits occur. Fagervik I pottery is usually fairly uniform, with sparse and coarse temper. It should be noted that the Fagervik I pottery shares many characteristics with the Vrå-pottery, both regarding decoration and ware.
2. *Fagervik II-pottery*: The decorations are partly the same as in Fagervik I, although in lower frequency; twisted cord, whipped cord, vertical lines, rhombic checker. New decorations are horizontal zigzag lines, complex vertical decorations like fir twigs, and heavy comb stamp ornamentation. Vessel-wall pits are common. The temper of Fagervik

II pottery is considered varied in size, type and density (Olsson & Edenmo 1997).

3. *Fagervik III-pottery*: The decoration is more surface covering and mainly consists of oblique lines combined in vertical angles, *i.e.* zigzag and herring bone motifs, and made with line stamp or comb stamp impression. Horizontal angles occur as well. Vertical lines, bow and circle impressions, zones with rhombic checkers and horizontal zigzag bands, “hanging triangles” and filled rhombs are also present. The decoration is often combined with pits and pottery with only vessel-wall pits constitute about 40% of all pottery. In the Fagervik III stage both “dense ware” (with sand/rock temper) and “porous ware” (with calciferous temper) occur.
4. *Fagervik IV-pottery*: Surface covering decoration of tooth stamp and comb stamp impressions, mainly with a vertical orientation, but also as f. ex. “wolf-tooth pattern”. Vessel-wall pits don’t occur at the Fagervik site, but Bagge pointed out that local variations might exist. Fagervik IV is dominated by porous ware over dense ware.

Ceramic Technology

The aim of most previous studies, as well as this, has been to study variations observed in the pottery and provide a basis for interpretations in terms of cultural, chronological and/or functional differences (*cf.* Löfstrand 1974:112).

Studies of Neolithic pottery production in Eastern Middle Sweden have primarily been carried out by Hulthén in the 1980ies. Methods used have been macroscopic recording and grouping, laboratory analyses and experimental, simulated production, with interpretations based on ethnographic analogies (Hulthén 1974, 1977). A few earlier studies also exist, *e.g.* on density (S. Florin 1938, 1959:122 note 2) and on type of raw material used for temper (Modig 1970, Löfstrand 1974).

Technological investigations have been carried out on Vrå-pottery from the provinces of Närke (Hulthén in Hulthén & Welinder 1981) and Södermanland (Hulthén in Olsson & Hulthén 1986). Analyses of PWC pottery have been performed on pottery from Uppland and Södertörn in Södermanland (Löfstrand 1974:120, Hulthén 1982, Hulthén in Åkerlund & Olsson 1996).

Manufacture of Vrå- and PWC-pottery

According to previous studies, clays chosen for production of Vrå-pottery were ferriferous, non-calciferous and contained various amounts of silt. Temper used was crushed granite, in some cases perthithic, weathered, and more easily crushed. A few sherds differed, *e.g.* with plant temper, diorite temper or no added temper. The vessels were built by coiling in N-technique (common) or in U-technique (*cf.* Appendix 9A). Vessel sizes + . Common surface treatment was polish (*cf.* Appendix 9A). The light-brown colour of the sherd surfaces and in many instances grey or dark cores were taken to indicate that the pots had been fired in an oxidising atmosphere in an open fire at 400–600 °C, for a relatively short period of time. Sherds without dark cores were thought to have been fired secondarily.

The ware of the PWC-pottery appeared more varied than the Vrå-pottery. PWC-vessels were either made without calcareous components (dense ware) or with calcareous components (porous ware). Most of the dense ware was made of ferriferous, non-calcareous, sorted fine clays with mica, tempered with crushed, weathered granite (Hulthén 1998). Organic material occurred in some samples. Some vessels were also manufactured of ferriferous, non-calcareous, coarse, unsorted clays. The temper might be crushed granite, natural sand or no added temper. In one case the clay was calcareous. Some of these pots were probably made of clayey local till (Hulthén 1998).

Previous microscopic investigations determined that the porous ware was tempered with crushed limestone (Löfstrand 1974:120f). One exception, from the Korsnäs Site, was interpreted as possibly crushed mollusc shells (Modig 1970, *cf.* Löfstrand *op. cit.*). Most of the porous pottery later analysed technologically have been made out of more or less ferriferous, calcareous sorted fine clays with plant remains, and tempered with limestone (Hulthén 1998). Examples of calcareous, unsorted, coarse, sandy & silty clays, tempered with crushed rock, were also found. The component of plant remains found primarily in the calciferous ware has been explained as added to produce a reducing burning atmosphere and thereby countermand the effects of carbonate transformation (Hulthén 1998).

The PWC-vessels have been built by coiling, in N-technique. In some cases the clay had been poorly worked. Both mini vessels (*cf.* Appendix 9A), as well as small, medium and large sized vessels occurred. Common surface treatments were smoothed and slipped/polished (Löfstrand 1974:80).

To summarise: Vrå-pottery and PWC-pottery of dense ware appears to have much in common regarding production. There are variations in the dense ware, however, as evidenced by occasional sherds. This variation appears to be larger in the PWC-pottery.

Vessel Function

Relatively few functional interpretations have been made for vessels in the region. These interpretations have mainly been based on temper type and the size of the vessels. Of the dense ware, smaller vessels that can be held by one hand have been interpreted as used for milking (Hulthén 1986:22). Medium sized vessels, especially without the dark core, have been explained as cooking pots, while large vessels presumably have been used as water containers.

There are differing views on the suitability and function of limestone as temper. Löfstrand (1974:119) holds that measurements show no differences in strength between dense and porous ware. Hulthén (1977:25, 207; Hulthén & Janzon 1982:6, 18), however, argues that calciferous ware has less desirable qualities, among others that the lime is washed out when the vessel is used, f. ex. for cooking or fermenting. Arrhenius (1980) means that this quality in limestone might have been used as a way of keeping the pH value at a suitable level while f. ex. fermenting.

Hulthén argues that bone temper is a good example of calciferous temper, where the temper has a glue effect, which gives a light and stable ware (Hulthén 1982). Bone temper has not been identified in the region, though, but is considered to have a more westerly distribution (*cf.* Hulthén 1993). Tempering with mollusc shells has scarcely been discussed in the region (but see Modig 1970, Löfstrand 1974:120f).

Calciferous wares in general have been interpreted to be useful as storage containers, milking pots or glow pots. They have been interpreted as less durable to use directly over open fire, but perhaps suitable for boiling with heated stones (Hulthén 1998).

MACROSCOPIC STUDY OF POTTERY FROM THE GRÖDINGE PROJECT

Practical Procedure

At the *basic registration* pottery (tempered burnt clay) was distinguished from burnt clay (not tempered). The pottery was divided into vessel remains, figurines, pearls, clay discs. The data registered for vessel remains within each unit (square/feature/A. S.) was: number of sherds and weight per type of ware and decorated/undecorated respectively. The division into ware type was simple; dense ware (dw) or porous ware (pw) respectively (see Appendix 9A). Traces of wave washing, plant imprints, encrustations or deviating size, shape, decoration or ware were only occasionally noted.

At the *special recording for typology/chronology and function* we chose to use the system developed by Birgitta Hulthén (Hulthén 1974). We chose to record variables that earlier researchers have considered possible to connect to different chronological periods.

The recording was also complemented with extended special recordings for a small selection of pottery from different parts of Kyrktorp (*cf.* Table 9:1). One recording of further variables related to *vessel function* was based on the hypothesis that clay and temper were chosen taking the function of the vessels into consideration. A selection of pottery with different wares was chosen from Kyrktorp 8W. The selection consisted of 31 sherds (446 g) of pottery from 20 1 m^2 squares. Before the microscopic study the selected 30 sherds were also recorded at this detailed level.

For the other special recordings aimed at answering specific questions on the Kyrktorp Site, different variables were chosen (see Appendix 9A, *cf.* chap. 18). No estimations of the number of vessels per site have been made.

Results

The basis for the results presented here is the macroscopic investigation, both from the recording on a basic level of all pottery and from the special recordings of samples of pottery.

Representativity

The differences in the size of the sites studied, as well as the different size of the areas excavated and the amount of pottery recovered, need to be kept in mind as variables that probably reflect upon variation in settlement patterns (*cf.* chap. 3B:3–4, chap. 4). This variation, combined with small samples, makes comparisons between different sites and chronological periods more difficult.

Another factor is the degree of fragmentation. A high amount of very fragmented sherds makes estimations of vessel sizes and shapes as well as decorative motifs harder than a low amount. The degree of fragmentation is dependent on several factors: excavation methods, contemporary and later activities at the site and the quality of the ceramic ware. The pottery has mainly been retrieved by sieving the soil, exceptions being the Kvedesta Site and parts of Kyrktorp subarea 8W, with siltier soils (*cf.* chap. 4, chap 18, 19). All sites are relatively well preserved from modern activities like ploughing, so this factor can be disregarded.

The finds of ceramics are fragmented on all sites and only parts of vessels have been found. The degree of fragmentation can be exemplified by presenting the mean weight of sherds from different sites and subareas. It varies from 1.1 g at Eklundshov E to 3.9 g at Smällan 3 (pg 7) (*cf.* chap. 16–19). Compare this to the fact that the weight of a complete vessel would be measured in kilograms. There are examples of the mean weight being correlated with how the sherds have been recovered, as well as with the vertical location (*cf.* chap. 18). Other parameters such as the quality of the ceramic ware are discussed further below.

Typological and Contextual Grouping of Pottery Assemblages

The aim of the grouping was to recognise patterns possible to compare and discuss in cultural terms. Macroscopic data on seven parameters were used to group the pottery assemblages. The occurrence of three parameters with the same value was deemed sufficient to group an assemblage. This was done despite the fact that the pottery was found in open layers, with a risk of mixing different finds. It should be acknowledged that the descriptions compiled here refer to the assemblage, which might include certain “deviant” sherds. The parameters were vessel-shape, coiling technique, occurrence and type of decoration, type of ware and occurrence of other ceramic artefacts (Table 9:2). It has been strongly argued for archaeologists to use *e.g.* the difference between ordinary and porous ware as a typological/chronological element, as it is both possible to observe macroscopically and signals a technical/cultural change (Löfstrand 1974:72). The results are four main groups, groups A–D (Table 9:2).

Group A

These assemblages occurred at Eklundshov and at Smällan 2. All the pottery was recorded as being of dense ware. Dominating temper was crushed rock, but sand or sand mixed with crushed rock also occurred. The grain size of the temper varied between the sites, with uniform and small sized grains (<1 mm) at Eklundshov to larger (>2 mm) and more varied at Smällan 2a. The pottery appeared to have a ware of good quality, with very little sign of splitting (whole sherds were common and split sherds virtually absent). The vessels had primarily been built by coiling, mostly in N1 technique, often in combination with N2 technique (*cf.* Appendix 9A). Smaller vessels had been modelled. The sherds were 6–8 or 9–12 mm thick (Table 9:3).

The most common surface treatment of the finished vessels varied between a more or less smoothed surface and a polished surface. A characteristic appearance was that of a polished outside and an uneven, “bumpy” inside. The colour of the sherds was often light brown, with a light or grey core**.** Black encrustations were rare. The vessel shape appeared highly variable, but reoccurring traits were long necks, S-formed or slightly angled shoulders and rounded bottoms (*cf.* Fig 16:20, 17:21). Both small and medium sized vessels were present.

Decoration was present on 8–13% of the pottery (weight). The upper part of the vessels was most commonly decorated, especially at Eklundshov E. The type of decoration differed between the sites as Eklundshov E was dominated by various impressions by single-toothed stamp as well as cord impressions (*cf.* Table 9:4, Fig. 16:20). At Smällan 2a the most common decorations were comb-impressed lines (like whipped cord), short lines, whipped cord impressions and cord impressions (*cf.* Fig 17:22).

Group B

These assemblages were found at Smällan 3 and at Kvedesta II. About 85% of this pottery consisted of dense ware (I) and upwards of 14% of porous ware (II). A small number of sherds were recorded as having “mixed temper” (III), *i.e.* tempered with sand or crushed rock but with a certain porosity, due either to the admixture of calciferous temper or else to the use of calcareous clays. The dense ware was further divided into temper with crushed rock (dominating) or sand (common). The grain sizes varied somewhat. At Kvedesta a temper of uniform, fine crushed rock, about 1 mm in size, was most common. At Smällan 3 the grains were mostly <2 mm, but larger temper grains also occurred. Most of the sherds were tempered to a normal percentage (25%), but sherds with sparser or more abundant tempering were also present.

The dense ware appeared to be of good quality, with whole sherds dominating over split sherds and fragments. The porous ware was for the most part relatively sparsely tempered and mostly with fine grades and, therefore, did not show any great porosity. The vessel-forming technique was, when visible, dominated by N1-technique, in both dense wares tempered with crushed rock as well as porous ware. The sand-tempered pottery was dominated by N2-technique, however. The colour of the sherds was mostly light, but dark cores occurred, as well as black, sooty encrustations.

The vessel shapes also indicated great variety. A straight neck opening predominated, while everted neck openings also occurred (*cf.* Fig 17:14, 19:27 obs). The form of the rims varied, with flat, rounded or pointed rim profiles, swelled inwards or outwards, The overwhelming proportion of the classifiable shoulders were S-formed or slightly angled. Only a few rounded shoulders occurred. The few bottom pieces occurring were all rounded. The most common surface finish was smooth surface, both on the outside and inside. The rim diameters varied between 25 and 300 mm.

The amount of decoration, including vessel wall pits, varied, from 53% of the pottery at Smällan 3 (pg 7), to 23% of the pottery at Kvedesta II. Common location of the decoration was the upper part of the vessel, primarily the neck, but also shoulder and rim. Most common decoration was vessel wall pits, followed by rounded, oval, rectangular or irregular impressions by single-toothed tools, and short line impressions (*cf*. Fig. 17:15, 19:24–27).

Group C

This assemblage was found at Smällan 3 and at Kyrktorp. The ware of this pottery, defined as the combination of clay, temper and firing atmosphere, was noted as varied, during the recording on a basic level. The amount of dense ware (I) versus porous ware (II) varied highly, from 85% dense ware to 85% porous ware. In the largest assemblage, at Kyrktorp 8W the variation was 61–85% porous ware, with a mean of 64%. The amount of mixed ware (III) was between 1 and 3%. The temper in the dense ware was mostly recorded as crushed rock, with only a small proportion of the pottery having been tempered with sand/gravel or a mixture of both. The grades of all wares were uniform and extremely fine, with a large proportion <1 mm or between 1 and 2 mm. The functional recording carried out on 30 sherds from Kyrktorp 8W resulted in a further division of the main group of the dense ware. The differences were probably the result of different amount of time kneading the clay.

The dense ware (I) could be further divided, by temper type and amount of pores, into four subgroups:
1. normal share (25%) of sand temper, varied grain size—mainly 2–3 mm, dense ware without pores.
2. normal share (25%) of crushed rock temper, partly mica, varied grain size—mainly 1–2 mm, dense ware without pores.
3. varied share of crushed rock temper, homogenous grain size 0–2 mm, mainly dense ware but with up to 5% porosity.
4. normal share (25%) of sand temper (mica), homogenous grain size 0–1 mm, 15% porosity.

The porous ware (II) was divided into four groups, based on temper type:
1. normally tempered porous ware, 1–2 mm large pores (originally grains of temper).
2. normally tempered porous ware + crushed rock temper, 1–2 mm large pores/grains.
3. normally tempered porous ware, part mica.
4. porous ware, small grades (calcic clay?), crushed rock temper 1–2 mm.

The fragmentation picture of the ceramic ware was not distinct, as the fragmentation, as well as the mean weight, varied a lot within the sites. However, the amount of fragments and split sherds was mostly higher than in the other typological/contextual groups described above (max 40% and 50% resp.).

The vessels had been manufactured by coiling in N-technique, where both N1 and N2 were present, in both crushed rock tempered and porous ware. Mini vessels had been modelled. The thickness of the sherds varies between 8–12 mm.

A lot of the sherds had a worn appearance. The dominating surface treatment of the vessels was a smoothed surface, both inside and outside. A grainy surface, polished surface and a surface brushed with grass were also common. The colours varied from reddish brown to brownish black. Many sherds had dark cores. Encrustations were present. One sherd of porous ware had traces of possible paint inside (*cf.* chap. 18).

The vessel shapes were varied (*cf.* Fig 18:48). The vessels had relatively long necks with varied mouths. The most common mouths were straight, but everted and reverted mouths also occurred. There were rounded, pointed and flat rim profiles, as well as rims, which were swelled outwards or inwards. Sharply angled shoulders, as well as more S-formed shoulders occurred. Both rounded and pointed bottoms occurred. Small, medium and large sized vessels were present (25–450 mm).

About 25–33% of the pottery was decorated (including vessel wall pits). The pottery in dense ware had a somewhat higher amount of decoration. The decoration was located to the upper parts of the vessels (rim-neck but also occurred inside the upper part). Pits and pit fragments are by far the commonest decoration, followed by impressions of short lines, comb impressions and bow impressions (*cf.* Fig 18:51). All decoration techniques and motifs were present in both wares, with different frequencies (*cf.* Löfstrand 1974:52, chap. 18).

Group D

The relatively thick-walled vessels had been built by coiling, in U-technique or in N-technique 2 (*cf.* Appendix 9A). The temper size was large, often with varied fractions. Differences in temper type existed, with both sand and crushed rock occurring. The ware split easily, as split sheds dominated. Certain vessels had been brushed on the inside with grass and at many a layer of gravel was present at the underside of the bottom. The colour of the core of the sherds was mostly dark and only a very thin layer on the surfaces of the sherd had a light colour. Some sherds had an encrustation inside the vessel, light in colour and with a runny appearance. The vessels had uniform shapes, with flat bottoms, short straight necks, S-formed shoulders and varied rims. They were undecorated.

Summary

After the macroscopic investigation it was apparent that there were both similarities and dissimilarities between the groups. The clay differed somewhat between the groups, as pottery from group A to a larger proportion appeared to be of finer quality than the more silty or sandy clays in the pottery of the other groups. In all four groups pottery made of dense ware occurred, *i.e.* the clay appeared to have been tempered with rock. This temper was mostly recorded as crushed rock in all groups. The amount of sand-tempered ware varied from small amounts in groups A and C, to larger amounts in groups B and D.

Porous, calciferous wares occurred in groups B and C, in varying amounts. The porous ware of group B differed somewhat from that of group C, as it was more sparsely tempered and mostly with finer grades and, therefore, did not show any great porosity. There were also small amounts recorded as mixed ware (rock/calciferous) in groups B and C.

Uniform and fine grades of temper (< 1 or 1–2 mm) dominated pottery of groups B and C, grades that were common also in some pottery of group A. Coarser grades of temper (2–3 or > 3 mm) were common in pottery of group D and also in some pottery of group A.

The vessels had primarily been built by coiling. The coils had mostly been joined in N technique, which was present on pottery in all groups. There were some variations of occurrence of different types of N-technique. N1 and N2 techniques were both present in groups A–C, while only N2 technique has been recorded for pottery of group D. N1 technique, often combined with N2, dominated pottery of group A. N1 *or* N2 techniques occurred in groups B and C. N1 occurring primarily in wares tempered with crushed rock as well as porous ware and N2 technique occurred primarily in sand-tempered ware. Some vessels in group D had been built by coiling in U-technique. Thus, two types of coiling have been recorded in all groups respectively. Smaller, modelled, vessels were also present in groups A–C.

The thickness of the sherds varied only slightly between, but also within groups. The quality of the wares differed, as visible in the fragmentation picture. Whole sherds were more common in groups A and B and split sherds in group D. Group C contained relatively high amounts of fragments.

The most common surface treatment of the finished vessels in all groups was a more or less smoothed surface, both on the outside and inside. Grainy surface, polished surface (mostly group A) and a surface brushed with grass (mostly group D) were also common. A surface with slipped gravel was found in group D.

The colour of the sherds varied both within, but also between, groups. Light coloured sherds, with light or grey-dark cores, were most common in group A. In groups B and C more sherds with dark-black cores, as well as surfaces, occurred. In group D the sherds had a dark or streaked colour, with only a thin light surface present out- and inside.

Black encrustations on the pottery were not present in group A, while black-sooty encrustations occurred in groups B and C. Some of the vessels in group D had a non-sooty, light, runny, encrustation inside.

The vessel shapes appeared highly variable in groups A–C, and uniform in group D. Reoccurring traits in group A–C were long necks, S-formed or slightly angled shoulders and rounded bottoms. The rims were varied in all groups, but many rim profiles occurred in all. Sharply angled shoulders and pointed bottoms were only recorded from group C and flat bottoms only from group D.

The amount of decoration varied between the groups (*cf.* Table 9:3) and also within them. In all three groups with decorated pottery it was usually the upper part of the vessels that was decorated (especially in group A1). Decoration on the inside of the mouth opening only occurred in group C.

Decoration with cord or twisted cord only occurred in group A (1 pc in group C) and vessel wall pits only occurred in groups B–C. Comb impressions (of different appearances) occurred in group A–C. Impressions made with various single tools were common in all three groups. Short line impressions also occurred in all three groups, with large amounts in group C. Bow impressions occurred only in groups B–C.

The Grödinge Typological/Contextual Groups versus the Regional Typology

When comparing the grouping of typological parameters with previous investigations it was obvious that the group A–C had parallels in the Neolithic typology of the region (Table 9:2).

Group A parallels Vrå-pottery. The decoration of the pottery from Eklundshov parallels it with the pottery of the regional Mogetorp group, while the pottery from Smällan 2 has most parallels with pottery of the younger group of Östra Vrå pottery.

The pottery in group B resembles earlier PWC-pottery (Fagervik I–II, II) and group C parallels later PWC-pottery (Fagervik III).

Group D had no certain parallels in the literature but the absence of decoration and the total dominance of flat bottoms led us to believe it was younger than the Neolithic. As it occurred in features with metal and from absolutely dated contexts it could be ascribed to the Early Iron Age (*cf.* chap. 16, 18).

Functional Grouping of Single Vessels

There were no pottery finds from features and few from other contexts that could be interpreted as being used for a specific function. However, the lower part of a vessel with a pointed bottom found standing upright in the find stratum at Kyrktorp subarea 8W, could be an indication of pots being dug down into the ground surface. This could indicate storage in large vessels (*cf.* Edgren 1982).

Observations on variation of certain variables during the macroscopic recording led us to a discussion on vessel function. For example, the temper size was smaller in small vessels than in large vessels at the Smällan Site (*cf.* chap. 17). This would indicate certain preparation of what kind of vessel to produce, and probably a choice of different types of vessels for different functions.

The results of this study are presented as a hypothetical grouping (Table 9:5) and some comments on observations made during recording. The hypothetical grouping is a mix of results from ethnographic analogies, interpretations made of previous analyses and our own observations of the recorded pottery. It is based on the hypotheses that the pots were fired long enough time in an oxidising atmosphere to result in a light colour (*cf.* Hulthén 1977).

The division of the wares into subgroups during the study of pottery from Kyrktorp subarea 8W indicated differences not previously noted. The ordinary wares with higher porosity (group C I:2–3) should be more suitable for heating or cooling liquids, *i.e.* cooking or water storage. On the other hand, the large amount of mica temper in one ware (C I:4) correlated with a high degree of split sherds. This might mean the porosity was secondary, a result of weathering. This ware might have been used for storage of dry goods instead, perhaps of some special kind as the ware has a unique glimmering appearance. Porous ware with larger grades might have been used for fermentation, while porous ware possibly made of calcareous clay (C II:4) might have been used for storing oil.

In one case we observed clear similarities of the ware, surface finish and colour between sherds from two vessels with different shape and decoration (No 3, 8) and attributed to two different typological groups (FIII and Early Iron Age, *cf.* chap. 18 8W). The function of these vessels ought to have been similar, cooking or water storage (see below).

Some of the Vrå-pots have relatively large temper grain size, compared with the other groups and could have been used as water containers or cooking pots. The Vrå-pots are, however, relatively small for water containers. If used for cooking, the mostly light colour of the pots would indicate that this activity took place outside houses. The Smällan 2 pottery contained sherds with an uneven, "bumpy" inside. It seems reasonable to interpret these sherds as remains from storage vessels. The flat, gravelly bottoms and grass brushed insides of the Early Iron Age vessels indicate a non-cooking function, as does the tendency of the ware to split easily. The colour (secondary burning? uncontrolled fire?) and uniform form of these vessels, especially of those found at Eklundshov, could support the contextual interpretation of the vessels having been used as grave urns. Against this speaks of course the fact that no bones were found (*cf.* chap. 3B:5), but also the special encrustations found inside at least one vessel. This might indicate a specialised storage function instead.

Discussion and Interpretation

The macroscopic study resulted in two subdivisions of the pottery from the Grödinge project, a typological/contextual of pottery assemblages (group A–D) and a functional of single vessels. The two subdivisions are of course discerning and the remains of a pot belong to at least one group within each set.

Some of the variables used for the typological/contextual grouping deserve further commenting on. The type of temper used, calciferous or not, has previously been considered one of the main typological variables for the PWC-pottery. In our recording we noted a sliding scale of the porosity, both between the FII and FIII ceramics and within the FIII ceramics. Was this the result of functional variation within a pottery tradition or were there other explanations?

Differing fragmentation of the wares has previously been thought to be a possible result of different pottery traditions (Baudou 1984). The study of the fragmentation picture of the ware here gave similar results. Disregarding secondary influences like differing excavation methods, weathering, trampling, ploughing etc. a difference was seen between ordinary ware and porous ware, as the latter had higher frequencies of fragmented sherds (*cf.* Löfstrand 1974). There were also differences between pottery assemblages of ordinary ware, like between the Vrå-pottery with many whole sherds and the Early Iron Age pottery with many split sherds.

The colour variation of the surface and the core of the wares, between light brown and dark/black, was at the beginning of the recording thought to be the result of the primary production only. Further discussions with

Lindahl added the dimension that the use of the pots changed the appearance of the ware (see below).

The typological/contextual groups show many similarities. Common traits are the uniform use of relatively pure clay, tempering with crushed rock of fine grades, coiling in N-technique, smoothing the vessel surfaces and of firing in an oxidised atmosphere. Even the use of varied vessel sizes and varied shapes and decorations of the upper part of the vessels is a reoccurring phenomenon, except in group D. Thus, many or most of the vessels in these groups could be interpreted as results of a common pottery tradition, probably a regional one and a tradition with a long chronological dimension (*cf.* chap. 3A:3). The variations in temper grain size, traces of coiling techniques etc., can be interpreted as functional (*cf.* Hulthén 1985). However, *e.g.* a certain coiling technique can of course also be seen as learned, manually within a pottery tradition. Specific traits, like the gravel slip on the bottom of Early Iron Age vessels (group D) found at two different sites, would indicate local, stylistic or functional, traditions.

One parameter, the calciferous temper in the two groups B and C (FI–II, II and FIII) is outstanding, however (see below and in chap. 3A:3).

Choice of Sample for the Microscopic Study

When choosing the sample of the technological analyses we based the selection on three parameters. We wanted to include sherds from the four typological/contextual groups to have a basis for a discussion on cultural and chronological variation. The second starting point, to choose pottery from all sites excavated, was based on interest to retrieve site specific data. And last, we selected pottery with specific characteristics noted in macroscopic recording, which could be used as a basis for a discussion on function.

The macroscopic registration also generated more specific questions:

a. What does the colour difference in the core of the ware represent (*e.g.* “dark” and “black”)?
b. Are the macroscopic classifications of temper material confirmed in the analyses?
c. Are those clays, classified as calciferous, confirmed in the analyses?

The sample was made up of 30 sherds, to give some statistical basis (Table 9:6, Fig. 9:7–11). The sample sherds (Grödinge Nos. 1–30) were all specially recorded with the same methods and variables used for the special recording on function (level 2) on the Kyrktorp sample (*cf.* Table 9:1, Appendix 9A).

The first part of the analyses was carried out “blindfolded”; *i. e.* 14 sherds were studied without given background information of typological grouping or site origin. After a preliminary result and MIPHO- grouping was presented the background information was provided and the remaining 16 sherds were analysed. The second sample also included sherds from the later excavated Kvedesta Site.

The 30 sherds investigated thus came from the four sites Eklundshov (5), Smällan (11), Kyrktorp (10) and Kvedesta (4). Six sherds represented

Vrå-pottery, eight sherds F I–II/II pottery, ten sherds F III pottery and five sherds pottery from the Early Iron Age. Of these 30 sherds 9 had been given a hypothetical vessel function after the macroscopic recording.

MICROSCOPIC STUDY OF POTTERY FROM THE GRÖDINGE PROJECT

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Introduction and Formulated Problems

The aim of the laboratory analyses of pottery is to study the raw material usage and to elucidate variations in the craft tradition. Hereby it is possible to present solutions to the archaeological problems that would otherwise be difficult to find.

The raw material (clay, temper etc) is the basis for the ceramic production, even though the study of vessel shape and decoration constitutes an important part of the ceramic investigation. They most often reflect ideas and fashions of a certain period and may be very easily copied over long distances. In general, the raw material tends to have a much more limited range of distribution. There are of course exceptions and they usually stand out at a close study of the pottery material.

The questions to which the laboratory investigation will help find an answer are:
1. Is it possible to trace local manufacture and imported vessels in the raw material?
2. Is it possible to make suggestions about which vessels originate in the same site?
3. Is it possible to determine which vessels are contemporary?
4. Is it possible to determine the function of the vessels (cooking vessels, storing vessels, vessels for burials etc)?

The macroscopic registration calls for more specific questions:
a. What does the colour difference in the core of the ware represent (*e.g.* “dark” and “black”)?
b. Are the macroscopic classifications of temper material confirmed in the analyses?
c. Are the clays classified as calciferous, confirmed in the analyses?

The Sample Analysed

The sample comprises 30 sherds from the four sites Eklundshov (5), Smällan (11), Kyrktorp (10) and Kvedesta (4). Within the sites three different archaeologically defined periods—Early Neolithic, Middle Neolithic and Early Iron Age—have been distinguished. All these periods are represented in the material (Table 9:6).

A better basis for selecting samples was sought by carrying out the investigation in two stages. In stage one 14 sherds were chosen from the sites Eklundshov, Smällan, Kyrktorp. Based on the results arrived at by the laboratory analyses of these samples an additional 16 sherds were sampled. In this second stage sherds from the site Kvedesta were also included. Due to alterations of the laboratory facilities it was not possible within the time-table to perform any chemical analyses on the samples of the second stage.

Methods

In order to provide an answer to the above questions a number of unambiguous methods have been used. Each individual method reflects a specific part of the ceramic process and only the combined analysis results will give a more complete picture of the ancient craft and its products.

In this investigation determination of major elements, petrographic microscopy, thermal analyses and the determination of density and water absorption have been considered the most useful. Each one of these gives a variety of data that can be interpreted.

Determination of Major Elements

The sample, dried to constant weight at 105 °C and ignited at 150 °C for two hours, was fused with B_2O_3 and Li_2CO_3. The ground fusion was dissolved in HNO3 (Thompson & Walsh 1983). The solution was analyzed for major constituents by plasma atomic emission spectrometry (ICP-AES ARL3520). The results expressed as common oxides have been recalculated to dry weight with a loss of ignition included in the total.

Petrographic Microscopy

Petrographic microscopy is carried out on thin sections of pottery, i.e. a piece of a sherd which has been ground to a uniform thickness of 30µm. The thin section is analyzed under a polarizing microscope in magnifications ranging from 25× to 1000×. This analysis makes it possible to identify different minerals within the silt and sand fractions. Furthermore remnants of organic matter, diatoms, accessory minerals and other impurities of the clay are studied.

Measurements and calculations performed on the tempering material are: 1) the maximum grain size (max. grain size), 2) the mean value of the five largest grains in the sample (mean max. grain size), 3) the mean value of the five smallest grains in a sample (mean min. grain size), providing these are considered to have been intentionally added to the clay (not possible to determine for all the samples), 4) estimate of the amount of added and natural temper (grains larger than 0.1 mm).

Particular observations of specific minerals, and other features concerning the temper and the clay, have been noted.

Microscopic colour photos of the thin sections provided a means to divide a large number of thin sections into groups (MIPHO-groups) by visual classification, *e.g.* group clays with a similar appearance. At least two photos from different parts of the thin section have been taken in order to minimize erroneous groupings due to local variations (Lindahl 1986:29).

Thermal analyses

The thermal properties of clays vary according to their composition*, i.e*. type of clay minerals, presence of fluxing ions, amount of quartz and feldspar, coarse fractions etc. The thermal properties of the clays are studied by means of Thermal Colour Test (TCT) and the sintering interval (Hulthén 1976, Lindahl 1986:31).

The determination of the colours is made according to Munsell Colour Chart System (Munsell 1942). The colour codes are transferred to diagrams which for each sherd are displayed by three curves, one for the hue (type of colour), one for value (lightness) and one for chroma (saturation).

The sintering interval is the interval of temperature where the clay changes phase from solid to liquid. The different stages of the sintering that are being noted are 1) a marked darkening of the colour, 2) shininess of the ware surface, 3) deformation of sharp edges, 4) total alteration of the shape of the sample (melting) and 5) liquid state.

Density and Water Absorption

The density and water absorption may be used to differentiate wares of different composition and firing conditions. Information concerning type of temper, homogenization of the ware and degree of sintering are parameters which are most likely to be disclosed by this method (Lindahl 1986:30).

Results

Determination of Major Elements

Chemical analyses were carried out on 14 samples (sample 1–14). 10 major elements were analyzed—Si, Al, Ti, Fe, Ca, Mg, Na, K, Mn, and P.

According to common practice the elements are presented as oxides. Providing that all the elements in a sample are analyzed, the sum of oxides will add up to *c*. one hundred percent. Trace elements are usually only present in amounts of ppm and their concentration does not affect the sum of oxides to a notable extent (Table 9:8).

The loss of ignition (LOI) is related to the loss of crystal bound water and the decomposition of organic matter in the sample. In calciferous samples the decomposition of carbonates contributes to the LOI.

SiO_2. As would be expected, silica (SiO_2) is the most abundant oxide in all the samples. The amount varies between 50% (samples 9 and 10) and 68% (sample 13). However, most of the samples lie within the boundaries of 55% to 60% (Fig. 9:12).

In order to eliminate the impact of silica and LOI on the samples, these values have been excluded when the amount of the other elements has been evaluated. The sum of oxides as well as the percentage values of the remaining oxides have been recalculated accordingly (Table 9:9) (Fig. 9:12–25).

TiO_2. Most of the samples have a value of TiO_2 of *c.* 2%. Four samples (Nos. 2, 3 7 and 9) show lower values—1.7% to 1.9% and one a higher value (sample No 1, 2.2%), (Fig. 9:13). The most common source of TiO_2 in soils is sphene, rutile and biotite.

Fe_2O_3. As in the former case there is little variation among the samples also where Fe_2O_3 is concerned. The majority of the samples have a percentage value of Fe_2O_3 varying between 21% and 24% (Fig. 9:14). Sample No 13 however, has a marked dip in the Fe_2O_3 content. This can reflect a large amount of Fe-poor minerals such as feldspars—usually coarse-grained—in the clay.

CaO. The CaO content varies among most samples between 2.8% and 4.2% (Fig. 9:15). Slightly higher values are noted for samples Nos. 13, 10 and 8 (4.9, 5.1 and 5.6 respectively). Sample No 9 has a very high CaO content with a percentage value of 7.7. A high content of CaO is most often due to calciferous clay, related to the carbonate content, either as a natural or deliberately added admixture of calcite, limestone, dolomite or marble to the clay or by a calcic plagioclase.

MgO. The value of MgO is evenly spread among the samples with a variation between 4.0% and 6.7% (Fig. 9:16). Sample No 9 has the highest MgO content which, in combination with the likewise high content of CaO indicates a dolomitic or skarn limestone.

Na_2O. Three samples differ from the others in their content of Na_2O. Samples Nos. 9 and 10 have a comparatively low amount (3.4% and 2.7% respectively) whereas sample No 13 has a high amount (8.6%) of Na_2O. The variation among the other samples is between 4.2% and 6.4% (Fig. 9:17). The explanation to a high content of Na_2O is most likely a feldspar-rich coarse clay. A low content is mostly due to a fine clay poor in feldspar.

K_2O. The variation in the K_2O-content is much more limited than that of Na_2O. With the exceptions of Samples Nos. 8, 9 and 14 (10.5%, 9.5% and 10.6% respectively) the K_2O-content only varies between 11.5% and 13.2% (Fig. 9:18). The low values may, as in the former case, be accredited to fine clays poor in Feldspar.

MnO. The MnO content for the main part of the samples varies between 0.10% and 0.24%. Sample No 2 has an extremely high value compared to the others—1.1%. Sample No 9 has a somewhat lower value, 0.49% (Fig. 9:19). A high content of MnO may be caused by a clay or temper rich in ore material or a manganese rich carbonate.

P_2O_5. The majority of the samples have a low content of P_2O_5 with a variation between 0.5% and 2.0%. However, samples Nos. 6, 9, 10 and 14 show a much higher amount—8.3%, 7.3%, 12.4% and 7.5% respectively (Fig. 9:20). P_2O_5 is usually related to apatite, which occurs as a primary mineral and in bone. Apatite is a common accessory mineral in all types of igneous rocks and is also found in gneisses, schists and marbles of contact metamorphic origin. Another source of apatite, especially in pottery, is bone added as temper to the clay (Hulthén 1987). A high content of P_2O_5 may also be a result of contamination where phosphoric acid seeps into the pores of the ceramic ware (pers. comm. B Hulthén).

In order to obtain a more plausible explanation to the variation of elements in a sample it is sometimes necessary to calculate the quotient of and/or the correlation between two or more elements.

To evaluate the origin of CaO in a sample the CaO values are divided with the values of Na_2O. The two elements occur in plagioclase in various proportions. If the major constituent is albite it will be Na_2O-rich and if it is anortite it will be rich in CaO. As can be seen in Figs. 9:15 and 9:17 the samples Nos. 8 and 13 indicate high values. In Fig. 9:21 these peaks have been smoothened thus suggesting that the CaO and Na_2O is related either to a coarse clay rich in Plagioclase or by a comparatively high amount of temper rich in Plagioclase. The samples Nos. 9 and 10 stand out in the diagram Fig. 9:21. The explanation is a high CaO content most likely related to calciferous clay or a calciferous temper.

The quotient Fe_2O_3+MgO/Al_2O_3 is used to estimate the amount of dark minerals in a sample, either emanating from the temper or from the clay minerals. A fine or coarse clay may also influence the test. The comparatively much larger amount of quartz and feldspar in a coarse clay tends to decrease the importance of the clay minerals as source of dark minerals, whereas in a very fine clay the low amount of quartz and feldspar tends to increase the influx of the clay minerals. A clay tempered with, for instance, dolerite, basalt, gabbro or biotite will clearly stand out as a result of this calculation. The result, which is seen in Fig. 9:22, shows a high value for samples Nos. 1 and 9 and a low value for sample No 13.

The Na_2O/K_2O ratio is used in order to elucidate the coarseness of a clay. The result is about the same as when these elements were discussed independently above, but it is now more emphasized (Fig. 9:23). The samples Nos. 8 and 13 seem to consist of coarse clays and sample No 10 of a fine.

The plot between the quotients Na_2O/K_2O and SiO_2/Al_2O_3 is used to further illustrate differences in coarseness (Fig. 9:24). There should be a more or less positive correlation between the two quotients if the Na_2O/K_2O ratio is a result of the coarseness of the clay. The majority of the samples form a cluster in the lower middle of the plot. Samples Nos. 8 and 13 point to be formed out of coarse clays. Sample No 10, on the other hand, consists of a fine clay.

The ratio Fe_2O_3+MgO/Al_2O_3 and TiO_2 are most often related to the dark minerals. A positive correlation between the two generally indicates the source as being a mafic mineral, most likely biotite. The plot Fig. 9:25 does not show any clear correlation. This most probably reflects that several different clay sources are represented in the material.

As is obvious from the presentation above, the results of the chemical analyses can not produce a clear cut answer to why a sample contains this or that much of a certain element. The chemical analyses merely indicate anomalies within the total number of samples. To get a more accurate explanation, the results of the chemical analyses have to be compared to the results of the other tests, especially the petrographic microscopy.

Petrographic Microscopy

At the macroscopic registration great effort has been made in trying to identify temper materials, determine "main temper grain size" and estimating the amount of temper. These parameters have therefore been of fundamental importance when selecting the sample for the laboratory analyses.

As can be expected when the sample is based on such criterions the petrographic microscopy display a variety of temper materials, grain sizes and amount of temper.

The material can be divided into three groups—coarse, medium and fine grains—based both on the maximum grain size (Fig. 9:26) and the mean max. grain size (Fig. 9:27). Among the "porous" sherds the maximum grain size has been measured either on a grain that still remain in the sample or on a hole of a dissolved grain, depending on which one is the largest. The group with large grains consists of sherds with a maximum grain size larger than 3 mm. The medium grain size varies between 2 and 3 mm and the group with small grains has a maximum grain size of less than 2 mm (Table 9:10). The sherds are more or less evenly distributed among the groups (10, 8 and 12 sherds respectively).

There is a good correlation (r=0.87) between the parameters maximum grain size and the mean max. grain size (Fig. 9:28). However, the difference between the max. grain size and the mean max. grain size is much greater among the samples with a large max. grain size (approx. 2 mm), than among the finer grains (approx. 0.5 mm). This indicates that the very large grains in most cases are a more or less accidental admixture to the clay.

The correlation between the parameters mean max. grain size and mean min. grain size is quite low (r = 0.45) (Fig. 9:29). This may be an indication to the fact that the potters in most cases did not seek to have a uniform grain size of the temper.

The amount of temper is divided into three classes—more than 20%, between 10 and 20% and less than 10% (Fig. 9:30), (*cf.* Table 9:10). Two thirds of the material falls within the middle group, 5 sherds are rich in temper and 4 have a very low amount of temper. The reason for the low amount of temper in samples Nos. 2, 10, 17 and 20 may be due to the size of the sample in correlation to the size and type of temper being used and thus causing difficulties in correctly counting the amount.

At the primary microscopy three different types of temper were noted—sand/gravel, crushed rock (mostly granitic) and porous sherds that, judging by the shape of the pores, most likely had an original temper of crushed limestone/marble. The chemical analyses indicated yet another tempering material—bone. This was also confirmed by the microscopic investigation when the samples were carefully scrutinized at magnifications of 630×. However, the bone temper is always mixed with other types of temper materials.

Four samples (Nos. 2, 3, 6 and 7) contain remnants of diatoms.

All samples contain more or less organic matter. To measure the amount of organic matter in a sample in a thin section is not feasible. However, a rough estimate based on the visual appearance discloses three groups: 1) poor, 2) medium and 3) rich. Group 1 contains 6 samples (Nos. 7, 11, 12, 13, 27 and 30), group 2 contains 12 samples (Nos. 1, 2, 3, 4, 8, 9, 20, 21, 23, 24, 25, 26 and 29) and finally group 3 13 samples (Nos. 5, 6, 10, 14, 15, 16, 17, 18, 19, 20, 22, 28 and 29). The most probable sources of the organic matter are rootlets and bone temper. Apart from the bone, no proof of organic temper can be ascertained.

The comparison of microscopic photos (MIPHO) of the different thin sections offer a possibility to group the material according to the variation of grain sizes of the clay. In spite of identical values of the measured variables, two sherds may have a different appearance in thin section, probably reflecting different raw materials. The photos have been grouped solely on the grounds of visual observations.

According to MIPHO the material has been divided into six groups and four single sherds (Fig. 9:31–37, *cf.* Table 9:10). Four of the groups (MIPHO I–IV) consist of four sherds or more and two (MIPHO V–VI) consist of only two sherds. The differences between the MIPHO-groups are based on the visual impression of sizes and amount of grains in the primary material of the clay. This visual impression may sometimes prove difficult to translate into a clear cut verbal description.

MIPHO I (Fig. 9:31). The ware of all the sampled sherds consist of a medium–fine, silty clay. The coarse fraction appears to be either natural or consist of added sand/gravel. The max. grain size is quite large. The amount of temper, however, varies within the group. The number of grains used for the calculation of temper in samples Nos. 2 and 17 is very sparse. Sample No 2 show one larger grain and sample No 17 one very large grain. Apart from those grains there are very few grains larger than 0.1 mm in both samples. This may be due to the fact that both samples were very small. Thus the lack of coarse grains may be a result of a naturally tempered clay with very few scattered coarser grains or an added temper consisting of sorted coarse sand/gravel.

Samples Nos. 4 and 21 have a much larger amount of temper. The grain size of the coarser fraction is very uniform with a grain size distribution between 2.1 mm (mean max.) and 1.0 mm (mean min.) and 2.8 mm (mean max.) and 1.2 mm (mean min.) respectively.

MIPHO II (Fig. 9:32). A fine clay with a weak natural admixture of fine silt. Based on the max. grain size the samples are divided into two sub-groups (1–2 mm, samples Nos. 10, 14, 16, 19, and larger than 4 mm, samples Nos. 22 and 29). The grain size distribution confirm the same two sub-groups (1.3–0.2 mm and >2–0.2 mm respectively). The amount of temper classifies the material into three sub-groups—<10% (No 10), 10–15% (Nos. 14, 16, 19 and 22) and >25% (No 29). The group has one uniting tempering material—bone—which is combined with several different materials (Fig. 9:33). Sample No 10 has either a natural coarse fraction with sharp edges or an added temper of crushed rock. Samples Nos. 14, 16, 22 and 29 have an added temper of sand/gravel. Sample No 19 is a porous sherd. The shape of the pores indicates that it most likely has been tempered with crushed limestone.

MIPHO III (Fig. 9:34). The fine clay has a low amount of a natural admixture of coarse silt. The max. grain size varies between 1.8 mm and 2.9 mm whereas the mean max. grain size is more uniform—1.4–2.0 mm. Also the amount of temper varies very little within the group. Samples Nos. 3, 23 and 26 contain an added temper of sand/gravel. Sample No 11 has been tempered with crushed rock. Sample No. 24, a porous sherd, has probably been tempered with crushed limestone.

MIPHO IV (Fig. 9:35). The raw clay is fine with a very weak admixture of medium coarse silt. The max. grain size varies considerably within the group. This is most likely due to a variety of different temper materials. Samples Nos. 1 and 7 have the largest grains and are tempered with crushed rock. Sample No 5 has a max grain size of 2.5 mm and is tempered with sand. Samples Nos. 9, 18, 20 and 27 have a max. grain size between 1.6 mm and 2.0 mm. These latter samples are all porous and they also contain diopside. The mineral diopside usually occur in impure magnesian marbles, calc-schists, skarns and lime-silicate rocks of contact and regional metamorphic origin (Heinrich 1965, pp 211). The rhombic shape of the pores and the presence of diopside indicate skarn limestone/marble as a possible temper material. In samples Nos. 9 and 27 the amount of diopside is especially notable.

MIPHO V (Fig. 9:36). The clay consists of a fine matrix with a natural admixture of coarse and medium coarse silt. Sample No 12 is tempered with crushed rock and has a large max. grain size (4.3 mm). Sample No 30 is tempered with sand/gravel and has a max. grain size of 2.9 mm

MIPHO VI (Fig. 9:37). The group comprises two sample sherds made out of a silty clay. Both are tempered with a comparatively large amount of sand/gravel (25%). Although the max. grain size and the variation in grain size of the temper varies between the two samples the material of the primary clay fractions is very similar.

Single sherds. The material comprises four single sherds. The difference in size and amount of grains in the primary material of the clay of these sherds is striking, thus they can not be included in any of the existing groups or grouped with one another.

Sample No 6 consists of a clay with fine silt. It is tempered with a few grains of coarse sand/gravel. The amount of temper is in the middle group. The petrographic microscopy also confirms the indication of bone-temper in the sample, put forward by the chemical analyses.

The ware of sample No 13 consists of a very silty clay. The few coarse grains are either a natural component of the clay or added sand.

The clay of sample No 15 (a fine clay with a weak natural admixture of fine silt) resembles to some extent the clay of MIPHO II. Traces of what may be finely ground bone have also been discovered in the sample.

Sample No 28 finally, is made out of a fine clay. It is a porous sherd which contains a large amount of, from a normal appearance, physically deformed light mica or talc. It is possible that this mineral may be found in association with impure limestone/marbles of contact or regional origin (pers. comm. A Lindh). This implies that the pores are the remains of a limestone/marble temper.

Thermal Analyses

The results of the thermal analyses do not display a uniform material. There are very few samples with identical colour changes in TCT and the same sintering interval. However, this is by no means surprising. As mentioned above the thermal properties of a clay are dependant on several different factors—clay minerals, the balance between oxyhydroxides of iron and calcium carbonates, fluxing ions, the relative proportion of primary quartz and feldspar and not least the mineral content and grain size distribution of the coarse fractions. Due to differences in sedimentation of the clays it is difficult to achieve absolute identity even if the clays are from the same source, but quarried at different occasions. Furthermore if the raw clays are tempered in a different fashion the results of the thermal analyses vary even more.

In this particular investigation the bases for choosing the sample have been different sites and differences in the macroscopic appearance of the ware. Thus groups containing a large number of more or less identical samples would be most unlikely to find in this context.

Seven pairs of samples have been crystallized by means of the thermal analysis: 1) Nos. 1 and 7, 2) Nos. 2 and 4, 3) Nos. 3 and 11, 4) Nos. 6 and 17, 5) Nos. 9 and 14, 6) Nos. 23 and 26 and 7) Nos. 27 and 30 (*cf.* Table 9:10). There are several other samples that show similarities in either the TCT or the sintering interval, but not in both.

Density and Water Absorption

The density of the different samples varies between c. 1.3 and 1.9 g/cm^2 and the water absorption between 15 and 40%. The analysis indicate the possibility of four possibly five different groupings (Fig. 9:38, *cf.* Table 9:10). Group a) and b) are the most marked ones (samples Nos. 9, 19, 24, 27 and Nos. 18, 20, 28 respectively). Both comprise samples originally tempered with limestone/marble which now has been dissolved. The third group c) comprises the majority of the bone-tempered samples (Nos. 6, 10, 16 and 22). The forth d) and fifth e) groups are more loosely defined and contain a variety of tempering materials. Sample No 14, which has an additional temper of bone, fall slightly outside the above defined groups.

Discussion and Conclusions

The laboratory analyses provide the bases for classifying the material into groups. The different methods may sometimes give what appear to be contradictory groupings. Therefore one has to bear in mind that the results of each method reflect different parameters of the ceramic ware. That is, each individual method provides its particular bases for classification.

The determination of major elements is based on ICPS multi element chemical analysis. Large temper grains are avoided when the sample is prepared but it is feasible to assume that the resulting data are values of added and natural temper as well as of the clay. The majority of the 14 samples has a similar overall composition (one or two elements may differ). However, samples Nos. 9, 10 and 13 have a marked different chemical composition.

This type of chemical analysis has its great value in displaying, qualitatively as well as quantitatively, the variety of elements that normally make up a ceramic sample. Furthermore, it offers a method to determine those elements which are the only traces of more or less dissolved constituents of the ware. In so doing, the chemical analysis is a valuable aid to direct further laboratory analyses.

Fore example, to identify a bone temper can be rather problematic. This is due to the decomposition of the bone over the centuries leaving more or less empty pores as the only witnesses. Phosphorus and calcium, however, as constituents of bone mostly remain in the ware. In cases where a chemical analysis gives high values of phosphorus and calcium you may suspect the use of bone-temper. Further this can be confirmed by the results of a density/water absorption test. Thereafter one may search for and under favourable conditions detect remains of organic matter along the edges of the pores under a microscope at high magnification.

Without such foregoing analyses it may not be possible to identify the minor organic remains as the remnants of more or less decomposed bone-temper.

A further example is a case where the petrographic microscopy display a ware with empty rhombic pores (sample No 9), which indicate a lime-stone temper. The chemical analysis shows a high content of MnO as well as MgO which indicate a manganese rich dolomitic- or skarn limestone.

The MIPHO method, which visually divides the material according to size and distribution of grains of the clay, classifies the material into 6 groups and 4 single sherds. The sherds within each MIPHO-group have a similar, not necessarily identical, appearance in thin section. The variation is not greater than what would be expected in one and the same clay deposit. Within the MIPHO-groups there are several different temper materials, amounts of temper and grain sizes represented. These in turn indicate a material full of nuances in craft tradition, vessel function etc.

The MIPHO groups show a characteristic pattern when compared to the four sites. The sherds in the larger groups I, III and IV originate from different sites—group I Eklundshov, group III Kyrktorp and group IV Smällan.

The majority of group II, 4 sherds, were found at the site Kvedesta and two at Smällan. The sherds of group V were found at Smällan and the sherds of group VI as well as three single sherds (Nos. 6, 13 and 28) at Kyrktorp. One single sherd (No 15) was found at Eklundshov (Fig. 39).

The correlation between MIPHO and site indicate a local production of vessels within each site. The choice of raw clay has been stable over a longer period of time, but the choice of temper has been varied. Temper variations may be caused by changes in the ceramic tradition due to external influences, but more likely to vessel function (Hulthén 1985). A vessel of coarse-grained ware and richly tempered, which allow evaporation of a fluid is most appropriate for a water container since it keeps the water cool and fresh. A vessel suitable for cooking should have smaller grains than the water container and with a large amount of coarse silt and sand fraction in order to cope with a continuous thermal shock. Furthermore, it has been suggested that limestone temper may have an effect when preparing different foodstuff (Arrhenius 1980).

A further indication of cooking vessels is the occurrence of completely reduced sherds. Even a fully oxidized pot turn black all through the ware after it has been used as a cooking vessel for only a few times (Lindahl 1991a, 1991b).

Three sherds (samples Nos. 3, 13 and 14) emanate most likely from cooking pots. They are either richly tempered and/or are made out of a more or less coarse clay and the large grains are of a medium size. Furthermore, they are all reduced all through the ware. Clay and temper of sample No 8 is very similar to what is likely for a cooking pot but the sherd has an oxidized outer surface.

The sherds that have a raw material composition that meet the criteria of a water container are samples Nos. 4, 6, 7, 12, 25, 29 and possibly 30.

The 7 thermal-groups have been correlated to other sets of groups presented in Fig. 9:40. This indicates a good correlation between thermal-groups, MIPHO-groups, type of temper, period and site. The sherds within each of the thermal-groups 1, 2, 3, and 6 have so much in common with other groupings that the vessels they represent most likely are made of the same clay and in the same ceramic tradition.

The determination of density and water absorption is a non destructive method that easily can be used on large quantities of sherds. The analysis demonstrates suitability when tracing and distinguishing different temper materials and amount of temper. This is clearly illustrated by comparing the samples Nos. 9 and 27 with the Nos. 18 and 20. They are all grouped into the same MIPHO and they are all tempered with limestone/marble. The difference is the amount of pores which is a reflection of the amount of original temper. The method also provides a basis to distinguish the semi-porous bone-tempered sherds, which were not possible to spot at the macroscopic registration.

The results of the macroscopically registered data of the "main temper grain size", type of temper and the amount of temper constitute one basis to divide the material into groups and serve as criteria when selecting the sample. It is therefore of major importance to elucidate the problems involved when recording these data and to compare the results with the more accurate data arrived at by the *microscopic* investigation.

A comparison between the "main temper grain size" and the microscopic max. grain size discloses that 17 samples differ (Fig. 9:41). With one exception the microscopic max. grain shows the higher value. In 12 cases it is only one step difference, but in 3 cases 2 steps and in 2 cases 3 steps.

The comparison between the "main temper grain size" and the microscopic mean/max. grain size show that 15 samples differ (Fig. 9:42). In 14 cases it is 1 step difference and in one case 2 steps difference.

When calculating the amount of temper the difference between macroscopically and microscopically recorded data 13 samples differ. In all cases with only one step (Fig. 9:43).

Macroscopic and microscopic determinations of type of temper are in accordance in 2/3 of the material. A result that must be considered as most acceptable.

The result of the comparison is that the macroscopic values differ in half the cases from the microscopic values.

The definition of the macroscopically "main temper grain size" is a vague and statistically questionable definition and may also be difficult to determine correctly. It is statistically safer and faster to just measure the maximum grain size, even if this grain in some rare cases may be a stray one.

It is very difficult to determine the type of temper and also estimate the amount on a sherd surface and rough fracture, especially when the temper is fine-grained. Even at a microscopic investigation it may sometimes prove difficult to decide if the coarse fractions are a natural component of the raw clay (natural temper) or intentionally added as temper. This taken into consideration, the result of the comparison between the two ways to calculate the amount of temper must be considered satisfactory.

The correlation between a macroscopic and a microscopic registration would probably be much closer if the calculation of grains and grain sizes in the specialized macroscopic registration is carried out on a polished fracture.

The red and black colours of pottery are due to the degree of oxidation and reduction of the ceramic ware. In an open air firing, which is the fashion in which this investigated material has been fired, the duration of firing is 30 to 60 minutes. In this short firing time only the surface of the pot will achieve a reddish colour. The core of the ware, even though it is fired to a temperature of c. 650ºC, will turn greyish-black since there is not enough time, in relation to the thickness of the vessel wall, to reach an oxidation all through the ware. The difference between a grey and a black core is due to the time/thickness factor, thus a light colour indicates a more oxidized ware. If the unfired clay contains organic matter this has a reducing effect on the clay, thus the time to get a fully oxidized ware will be extended.

The macroscopic registration of surface treatment and vessel forming technique is very detailed. The results are in most cases verified by an examination under a stereo microscope. However, in order to determine surface treatment in such detail it is, for comparative reasons, advised to manufacture test sherds treated in all these various manners. Otherwise the recordings should be kept in more general terms.

The analyses results strongly indicate a local manufacture within each site used. Kvedesta and Eklundshov show a very limited range of raw material. Providing the area of a settlement movement is limited, the same clay source can be used over several generations by means of inherited tradition. In the case of Eklundshov where the archaeological dating divide the material into Early Neolithic and Early Iron Age (Table 9:6) there is no reason to believe that the potters have used the same clay source on terms of direct inherited tradition. It is more likely that the potters have had a good knowledge concerning where to find a suitable ceramic clay and thus arriving to the same clay deposit. This tells us something about the skilfulness of the ancient potters.

Kyrktorp and Smällan have a more varied composition of both clays and temper materials. This variation may be due to 1) the usage of different contemporary clay sources, 2) the change of clay sources over a period of time and 3) “import” of vessels from outside the settlement area.

It is not possible by means of the above analyses to date the material. Therefore it is not possible to determine if vessels made out of different raw materials are or are not contemporary. The term contemporary is also vague and archaeologically it covers a several interpretations even when discussing the time of manufacture of pottery: a) made by one potter at the same occasion, b) made by the same potter at separate times, c) made in the same ceramic tradition, d) made during the same, archaeologically defined, period etc. The technological analyses indicate which vessels are made out of the same or similar clays, which have a similar temper (material and size) etc. When most, preferably all, of these similarities coincide it is a great possibility for these vessels to be contemporary. In this material samples Nos. 1 and 7, 2 and 4, 3 and 11, 9 and 27, 23 and 26 are most probably contemporary.

If vessels made at the same archaeologically defined period are contemporary the sherds from Kyrktorp illustrate that the same clay source has been used for the majority of the vessels (the same MIPHO), but that different temper materials and/or size have been used for vessels of different function. Furthermore, the change of clay sources over time is illustrated by the difference between the majority of the MN sherds and the EIA sherds from Kyrktorp. The "import" of vessels is best illustrated by sample No 10 from Smällan, but also by the existence of single sherds from Kyrktorp.

To recapitulate the above discussion and conclusions and to give direct answers to the questions put forward in the beginning the following summary can be made:

1. It has been possible to trace local manufacture in the material and to some extent the "import" of vessels.
2. It has been possible to determine which vessels are likely to be from the same site.
3. It has been possible to determine which vessels have the same or similar raw material composition and thus determine them to be contemporary.
4. It has to some extent been possible to determine the function of vessels.

The more specific questions concerning the macroscopic registration have also been explained in as full detail as possible.

In spite of the most varied composition of the sampled material and the fact that each individual method reflects a special part of the ceramic complex, the synthesis of the results is unambiguously demonstrating the following ceramic picture:

Each investigated site has its own local production of storage vessels/ water containers and cooking pots, based on local raw materials. Observed variations may originate in interaction between sites, chronological differences and/or a varied vessel function.

DISCUSSION OF COMBINED RESULTS

As a result of the microscopic analyses the focus shifted somewhat from a general regional scale to the site level. Also the variation in temper made it feel necessary to discuss craft tradition more and cut off from the cultures

Four different types of temper were thus identified in the microscopic study: crushed rock, sand, limestone/marble and bone. The bone temper had not been possible to observe by macroscopic determination. We had noted variation in the porosity of the sherds (see above). This had been a special trait at the Kvedesta Site, from which many of the sherds analysed came from. In the technological analysis the bone was signalled by the differing chemical composition and water absorption and verified by the petrographic microscopy. The bone had in all six (or seven) cases been combined with another temper (mostly sand, but also crushed rock or lime).

It was interesting to see that the macroscopic recording of sand temper, as opposed to crushed rock, was confirmed. During discussions the less cohesive force of the rounded grains had been used as argument that sand had not been used. The sand temper was, however, even in the technological analysis hard to separate from crushed rock or natural grains of the clay.

In the macroscopic investigation most sherds were recorded as having dark/black cores. In the microscopic investigation it was recorded that all sherds contained organic matter, probably from rootlets in the clay. Apart from the bone, no organic temper was found. When the amount of organic matter is compared with colour it is clear that there is little correlation between amount of organic matter and colour, as *e.g.* sherds with high amount organic matter might have dark cores or be fully oxidised (Nos. 10, 17). Can the vessels still be estimated to have been fired in open air for a short time (<1 hour)? Or might the firing times in a wide sense have varied considerably, including secondary burning during cooking, *e.g.* out of doors resulting in oxidised ware despite high amount of organic matter, or in-doors resulting in dark ware despite low amount of organic matter?

Thus, the first assumption, that we could identify vessels produced in a reducing atmosphere by their primary dark colour was lost (see above). The second interpretation, of secondary dark colours as indicators of cooking vessels, especially indoors, is also hard to argue, as the possibility of organic matter controlling the colour must be taken into account.

The Typological/Contextual Groupings and Production

Vrå-pottery (group A)

Six sherds were sampled from this group (Nos. 1–2, 7, 12, 15 and 17). The composition of the ware differed, with tempering of both crushed rock, sand, possibly natural and also possibly fine-crushed bone (1 sherd). All sherds contained organic matter, though two only in small amounts.

At Smällan 2 the pots were tempered with relatively large grains of crushed rock, as recorded from previous investigations of this kind of pottery (see above). Two sherds shared so many characteristics that they had to have been produced of local clay and produced in the same ceramic tradition (see above). The decorative motives of vessels were different however (cord, twisted cord). The third, a cord decorated sherd, differed as regard to the clay source (No 12).

At Eklundshov E, where all finds came from one feature, two vessels were tempered with sand grains, possibly natural sand of the clay (Nos. 2 and 17). The clay source was the same (MIPHO I, see above), but TCT-groups differed for some reason. These vessels should have been produced locally. The grain size as well as the vessel forms differed (flask, beaker) and also the decorations (nail impressions, cord). The third vessel (No 15) was also the remains of the upper part of a cord decorated beaker, but the temper was fine crushed rock and organic matter, possibly fine-crushed bone, and the clay was without parallels in the project. This vessel therefore seems to be of non-local origin.

PWC-pottery Fagervik I–II, II (Group B)

Eight sherds were sampled from this group, four from Smällan 3 and four from Kvedesta II. The tempers of this group mostly consisted of sand, in several cases combined with bone. Crushed rock and lime were also present. All but one sherd had high amounts of organic matter. The sherds from Kvedesta (Nos. 16, 19, 22 and 29) were more homogenous than the sherds from Smällan (Nos. 5, 10, 14 and 30).

All sherds from Kvedesta came from the same clay source (MIPHO II). The grains sizes of the temper varied somewhat. Three of the sherds were tempered with sand, in two cases also with crushed bone. The fourth sherd, with a deviant decoration, was tempered with lime and bone. The vessels are interpreted as of the same local production.

The clay in the four sherds at Smällan 3 came from three sources even if three of the sherds had the same temper grain size. Two of the sherds from Smällan 3 (No 10 and 14) came from the same clay source as those from Kvedesta (MIPHO II) and both had also been tempered with bone (+ sand or crushed rock/natural). These sherds can originate from the same production as those from Kvedesta. The two remaining sherds were both sand tempered, but of clays of different origin (MIPHO IV and V). Since MIPHO IV and V occurs in sherds from other groups at Smällan (see above and below), these sherds are probably locally produced.

PWC-pottery Fagervik III (Group C)

Ten sherds were sampled from this group, four from Smällan 3 and the remaining six from Kyrktorp 8W. The determination of tempers suggested variation within the group. Occurring tempers were crushed rock, sand, limestone, limestone/marble and bone. The amount of organic matter in the sherds varied. The sherds sampled at Smällan 3 were relatively homogeneous, while there was more variation within the sample from Kyrktorp.

The sherds from Smällan 3 (Nos. 9, 18, 20 and 27) had all been recorded as porous. They were all determined as coming from the same clay source (MIPHO IV) and were all tempered with limestone/marble. The temper size was relatively fine in all cases. Two of the sherds also belonged to the same TCT-group, indicating even more strongly the same ceramic tradition (see above). Three of the sherds were decorated with comb impressions. All this suggests a local production.

The six sherds from Kyrktorp 8W were Nos. 3, 6, 11, 24, 26 and 28. The temper grains size was mostly fine, between 1 and 2 mm. Four of the sherds were from the same clay source (MIPHO III), which indicates production from local clays. These had been tempered with different raw materials however, crushed rock, sand or limestone. The sherds 3 and 11, as well as 23 and 26 also had similar temper and made up pairs in the TCT-grouping, which indicates that they were made within the same ceramic tradition. These sherds were decorated with ring or herringbone motif as well as short lines in different patterns.

The clay of the remaining two sherds differed and none of them had a parallel within the project (Nos. 6 and 28. These sherds also differed from the others as regards to temper, sand and bone or limestone/marble. The decoration consisted of bow impressions or comb-stamped herringbone motif.

Early Iron Age Pottery (Group D)

Of the five reference samples from this period, two vessels were from Eklundshov (Nos. 4, 21) and three from Kyrktorp (No 8 from Kyrktorp 8W and Nos. 13 and 25 from Kyrktorp 9B). The samples were all determined to have been tempered with sand and/or crushed rock, in three cases with grains hard to separate from natural grains of the clay. Most sherds contained medium amount of organic matter.

The two vessels from Eklundshov had the same kind of temper (S/N) and clay (MIPHO-group I) and should be considered of local origin, produced within the same cultural tradition. Of the three vessels from Kyrktorp two share the same parameters, temper (S/C), amounts of organic matter and clay (MIPHO VI) and also should be considered produced within the same local tradition. The third vessel (No 13) differs in regard to temper (C/N) and organic matter and the clay has no parallel in clays from this project. It could originate from a further distance away, like a third site in the vicinity. Interestingly enough the two sherds of local origin at the Kyrktorp Site were found in different subareas, Kyrktorp 8W and Kyrktorp 9B. The differing sherd also came from Kyrktorp 9B (*cf.* chap. 18).

The Typological/Contextual Groups and Function

Petrographic microscopy as well as determination of colour was used to identify vessels produced for different functions. Functional interpretations were possible to make for eleven samples. Six or seven vessels, of coarse-grained ware and richly tempered, were interpreted as water containers (Nos. 4, 6, 7, 12, 25, 29 and possibly 30). Three or four vessels, with smaller temper grains but more silty sandy clays and mostly dark/black colours have been interpreted as cooking vessels (Nos. 3, 8? 13 and 14).

How about vessels with sooty encrustations? Since we in this project normally did not record the position of the encrustation on the vessel (see above), it is hard to use the general notes for a discussion here. One example will be discussed, however, the only sample sherd with encrustation in the microscopic study (No 5). The encrustation was located on the outside, by the rim. The appearance did not suggest a painted pattern, but rather over-cooked food. The vessel belonged to the F I–II/II group (B) and the sherd suggested a pot with a slightly everted mouth opening, a shape that facilitates stirring the contents within and pouring from. Was this the remains of a cooking pot? It is not suggested in the microscopic study, but there is nothing in temper type or grain size that contradicts it.

The similarities between two vessels of ordinary ware from different typological/contextual groups from Kyrktorp 8W lead to a discussion of similar functions: cooking or water storage (No 3, 8). Both these were after the technological analysis interpreted as cooking vessels. The remaining vessels interpreted as cooking pots in the technological analyses were also of ordinary ware. The vessels interpreted as water containers were all of ordinary ware, in some cases also with bone temper added, and they had relatively larger temper grain size. The mica rich ware from Kyrktorp 8W (No 28), which we macroscopically saw as brittle, was not commented on in the technological analysis, neither were the sampled lime tempered vessels.

Functional interpretations were made for two vessels of Vrå- pottery (water), one of FII pottery (water), two vessels of FIII-pottery (water and cooking) and three vessels from the Early Iron Age (water and cooking).

Local and Non-local Production

The technological analyses yielded information of pottery production on a detailed, local scale that we had not anticipated, but which is very interesting. Laboratory analyses of the clays of the pottery indicate that the composition of clay varied between the sites implying that the pottery was produced locally, but can not be more precisely determined as to provenance without prospecting in the area.

The correlation between the individual MIPHO-groups and the sites investigated was interpreted as of different and probably local clay sources have been used for production of vessels at each site. The choice of raw clay had been stable over a longer period of time on some sites. The Kvedesta and Eklundshov sites show a very limited range of raw material whereas Kyrktorp and Smällan sites have a more varied composition of both clays and temper materials. A combination of methods also indicated that some vessels were produced in the same pottery tradition, the samples Nos. 1 and 7, 2 and 4, 3 and 11, 9 and 27, 23 and 26.

No finds were made that could be associated with actual manufacture of pots on the sites themselves. Despite this, the weight of pottery argues against transport. Pots were probably manufactured at all sites, during the warm season. If the pots were fired in open air, no features like firing-pits have existed. If large amounts of pottery are interpreted as the results of non-successful firings, the amount itself might then be the only indication of manufacture. The explanation of the varying amounts of pottery has many other dimensions, however (see chap. 3A:3, 3B:3–5 for further discussions).

The technological analyses provided the quantifiable data on manufacture, but interpretations also have to include site contexts. In this project the correlation of certain clay types with sherds from specific sites strongly indicates that clay sources in the vicinity of each site were used (see above). This does not necessarily imply that different people made the vessels. Above (*cf.* chap. 3B:3–4) we have argued for an interpretation of Neolithic settlement patterns based on a mobile lifestyle within delimited areas, resulting in site-clusters. The same group of people might have moved between *e.g.* the Kyrktorp and Smällan Sites, only taking the occasional vessel with them. The two sample sherds recovered at Smällan 3 (No 10, 14), which shared so many characteristics with the sherds from the Kvedesta Site, are examples of this.

The few vessels from the Early Iron Age totally found, at the Eklundshov and Kyrktorp Sites, might be explained in different ways. For the Eklundshov Site we suggested that people from a farm situated in the vicinity had used the area as out-laying land. The use of the same site-specific clay as during the Neolithic supports this interpretation. The special use of the whole Kyrktorp Site during the Early Iron Age could indicate that the vessels were produced at other places than the site itself (*cf.* chap.

3B:5, 18). The results of the technological analysis, with finds of different non site-specific clays, are interpreted that vessels were brought to the Kyrktorp Site from at least two farms, situated some distance away.

Another argument for the use of local clays close to each site is of course the long-time perspective. At two of the sites the same site-specific clay(s) had been used to produce pots classified as belonging to different typological groups.

At the Smällan Site two different clays re-occurred as both Vrå- and Fagervik II-pottery was made out of the same clay type (MIPHO V) and vessels from all three typological groups Vrå-, FI–II/II and FIII out of another clay (MIPHO IV). The relatively large amount of samples, resulting in the two main clays, argues for the interpretation of use of two local clay sources.

At the Eklundshov Site both Vrå- and Early Iron Age pottery had been made of the same type of clay (MIPHO I).

Non-standard Vessels

At three of the sites sherds were recovered that deviated technologically from the other sherds and which have been interpreted as produced of non-site specific clays. Four of the sherds had no match in the clays of the project at all. These sherds derived from the Vrå-group (Eklundshov E), the F III group (Kyrktorp 8W) and the Early Iron Age (Kyrktorp 9B). The vessels could be imports, from other sites in the close vicinity or in the region.

The Early Neolithic vessel from Eklundshov E (No 15) had the same shape and decoration as most of the other vessels. Apart from the unique clay the temper strongly signalled a different ceramic tradition. Was this a vessel imported from another part of the region or from further away?

In the case of the Kyrktorp subarea 8W, with large amounts of Neolithic pottery, the deviant Neolithic sherds possibly might be signals of yet more clay sources and tempers used at this site. Interestingly enough however, the lime/mica-tempered ware previously mentioned was one of the wares made of different, unique clay. In our view this enhances the interpretation of a special function for these vessels. As for the sherd from Kyrktorp 9B dating to the Early Iron Age, it might be, as stated above, a product from another home farm than the other two vessels.

Comparing the other way around, certain sherds differed typologically from the main assemblage and they were thought to have different origin. One such sampled was the small flask with short neck from Eklundshov E (No 2). It was presumably contemporary with the other vessels (by context) and turned out to have been manufactured of local clay. It is common that flasks have different decorative motives than other vessels, *e.g.* the collared flasks from the Mogetorp Site (*cf.* S. Florin 1958, Fig. 16:20).

Another was the single sherd with more angled shoulder and a rhombic decoration from the Kvedesta Site (No 19), that was thought to be slightly younger than the other vessels. It turned out to be manufactured by the same clay as the other vessels, with one specific temper component similar to the others and one different. It is interpreted as locally produced, as a contemporary or slightly later, innovative vessel, made within a local society with continuity in pottery tradition and depositional use of the site.

FINAL REMARKS ON THE MANUFACTURE AND FUNCTION OF POTS DURING THE NEOLITHIC AND EARLY IRON AGE IN EASTERN MIDDLE SWEDEN

The Neolithic

- Vessels have been produced with three different types of temper
- Vessels with similar macroscopic appearances have been produced with similar type of temper and from the same clay
- Vessels with similar macroscopic appearances have been produced with similar type of temper but from different clays
- Vessels with similar macroscopic appearances have been produced with different types of temper
- Vessels with similar macroscopic appearances have been produced with different types of temper, but from the same clays
- Vessels with deviant appearances have been produced from the same clays and with similar temper as the main group of vessels
- One vessel with a macroscopically deviant ware was made of a unique clay
- Vessels were produced from site-specific, probably local clays, with re-occurring use of certain clay sources over time
- The function of specific vessels has been identified, *e. g.* for containing water and cooking
- Some vessels have been moved between the different sites, for specific use?
- Some vessels, with special functions? might have been brought in from other parts of region.

The Early Iron Age

- Vessels were produced with one type of temper only
- Vessels, *e.g.* for water storage and cooking, were probably produced at the single local farm and not centrally
- Vessels from different farms in the area were quite similar as regarding ware and shape, but manufactured from different clays
- Vessels produced at the local farm had been left in out-lying areas
- Vessels produced at different farms had been deposited together in out-lying areas, in special places

TABLES

Table 9:1. The pottery retrieved in the Grödinge project.

Site/Subarea	*Total amount of pottery (kg)*	*Mean weight*	*Period*	*Special recording, level 1 (kg)*	*Type of special recording, level 2*	*No. of sherds analysed microscopically*
Eklundshov	7	-		xx	-	
Eklundshov E	xx	1,1	E Neol		-	3
Eklundshov A-D	xx	xx	E Iron Age		-	2
Smällan	13,5	-	E-M Neol	xx	-	
Smällan 2	2,5	2,8	E Neol		-	5
Smällan 3	11	1,7-3,9	E-M Neol		-	6
Kyrktorp	250	-		xx	-	
Kyrktorp 8W	244	2,2	E-M Neol + (EIA)		Dating, function, fragmentation and wave-washing	8
Kyrktorp 9B	5,4	2,3	EIA+ (M Neol)		Dating	2
Kyrktorp 9A:1	0,3	3,4	EIA		Fragmentation and wear	-
Kyrktorp 9A:2	xx	xx	EIA		Fragmentation and wear	
Kvedesta	9,7	-		xx	-	
Kvedesta I	0,1	1,3	M Bronze Age		-	-
Kvedesta II	9,6	2,7	E-M Neolithic		-	4
	280	-				

Table 9:2. Parameters used for classifying the pottery into different typological or contextual groups.

Parameters	*Group A*	*Group B*	*Group C*	*Group D*
Vessel-shape	Beaker, flask, collared flask	Shoulder type B	**Shoulder type C, mini vessel**	Flat bottom
Ware	Thick-walled, crushed rock temper	Crushed rock, calciferous, sand	Calciferous	Crushed rock, sand
Coiling technique	N1	N1 or N2, modelling	N1 or N2, modelling	N2 or U
Decoration	Present	Present	Present	Absent
Decoration type	Cord, twisted cord	Vessel-wall pits, incised lines	Vessel-wall pits, comb-impressions,	
Non-pot	Clay disc		Figure, bead	Fire dog?
Context				Certain features

Table 9:3. Data on the different typological/contextual pottery groups recorded macroscopically.

Parameters	*Group A*	*Group B*	*Group C*	*Group D*
Clay	Finer	Coarser	Coarser	Coarser
Wares	Dense	Dense, porous	Porous, dense	Dense
Temper	Crushed rock, sand	Crushed rock, calciferous, sand	Calciferous, c. rock, sand	Crushed rock, sand
Grades	Uniform/Varied	Uniform	Uniform	Varied
Grain sizes	Fine/Coarse	Fine	Fine	Coarse
Coiling-technique	N1, N1+N2, modelling	N1 or N2, modelling	N1 or N2, modelling	N2 or U
Sherd thickness				
Fragmentation pattern	Whole sherds common	Whole sherds common	Fragments common	Split sherds common
Surface treatment	Smoothed, polished	Smoothed	Smoothed, grainy	Smoothed, grass brushed, gravel slip
Colour				
Encrustation	Occasional	Occurring	Common	Occasional
Vessel shape	Varied	Varied	Varied	Uniform
Vessel size	Varied	Varied	Varied	Uniform
Amount of decoration	8–13 %	23–53 %	25–33 %	0 %

Table 9:4. Data on decoration from the different typological/contextual pottery groups.

	Pottery assemblages					
Decoration type	***Eklundshov E***	***Smällan 2a***	***Kvedesta II***	***Smällan 3 (7–9)***	***Kyrktorp 8W***	***Smällan 3 (6,10) & Smällan 4***
A incised lines	4	X	3 (6)	-		X
B crossed lines	-	-	1 (2)	X		X
C single-toothed imp.	49	X	4 (8)	X	X	X
D Short-line imp.	4	XX	9 (18)	X	X	X
E two-toothed imp.	-	X	5 (10)	X		-
F Multi-toothed imp.	-	XX	4 (8)	X		X
G bow imp.	-	-	1 (2)	-		X
H1 cord imp	44	X	-	-	-	(X)
H2 twisted cord	-	XX	-	-	-	-
I, J vessel wall pits	-	-	50 (=0)	X	X	X

Table 9:5. Hypothetical combination of variables related to different vessel functions.

	Cooking	***Water storage***	***Other fluid storage /fermentation***	***Dry storage***
Temper: grain size	Medium	Large	Small	All
Temper: amount	Medium—high	High	Low	High
Temper: type	Cr. rock, sand	Cr. rock, sand	Calciferous, plant	Plant
Colour inside/core	Dark	Light	Light	Light
Colour outside	Flammig	Light	Light	Light
Encrustation	Black, inside/around rim	Non	Possible (light?)	Non or “paint”
Surface finish inside	Smooth	Smooth	Smooth	”Bumpy” possible
Surface finish outside	Coarse bottom?	All, bumpy possible	Coarse?	All
Vessel size	Medium (large?)	Large	Small—large	Small—large
Vessel shape	Rounded bottom, everted mouth	Pointed bottom, large rim diam.	Small rim diam., swelled rim	All

Table 9:8. Table of major elements.

Samp No	SiO_2 (%)	TiO_2 (%)	Al_2O_3 (%)	Fe_2O_3 (%)	CaO (%)	MgO (%)	Na_2O (%)	K_2O (%)	MnO (%)	P_2O_5 (%)	LOI (%)
1	57,35	0,83	17,55	8,88	1,29	2,27	1,63	4,32	0,09	0,62	5,2
2	55,83	0,73	18,20	8,13	1,36	1,83	1,73	4,98	0,41	0,55	6,3
3	52,89	0,64	16,96	7,55	1,27	1,91	2,12	4,21	0,04	0,26	12,1
4	58,19	0,73	16,90	7,66	1,49	1,60	2,10	4,60	0,07	0,18	6,5
5	56,07	0,74	17,23	7,98	1,19	1,74	1,76	4,37	0,04	0,55	8,3
6	57,20	0,78	16,45	7,54	1,46	1,74	2,01	4,71	0,06	3,14	4,9
7	56,16	0,61	17,49	7,48	0,98	1,93	1,69	4,54	0,04	0,25	8,8
8	59,45	0,67	15,42	6,97	1,81	1,77	2,06	3,41	0,08	0,17	8,2
9	50,03	0,80	17,94	8,97	3,29	2,84	1,46	4,06	0,21	3,12	7,3
10	49,96	0,94	18,19	8,97	2,33	2,07	1,24	6,00	0,10	5,66	4,5
11	62,29	0,69	16,07	7,82	1,17	1,69	1,90	4,13	0,05	0,39	3,8
12	56,90	0,71	17,06	7,28	1,26	2,14	1,86	4,42	0,06	0,70	7,6
13	68,55	0,52	13,49	4,36	1,31	1,06	2,27	3,09	0,06	0,31	5,0
14	54,57	0,67	15,20	7,31	1,10	1,64	1,42	3,55	0,05	2,52	12,0

Table 9:9. Table of elements. Recalculation after SiO2 and LOI has been excluded.

Samp. No	TiO_2 (%)	Al_2O_3 (%)	Fe_2O_3 (%)	CaO (%)	MgO (%)	Na_2O (%)	K_2O (%)	MnO (%)	P_2O_5 (%)
1	2,23	46,81	23,69	3,44	6,07	4,34	11,53	0,24	1,65
2	1,93	48,00	21,43	3,58	4,83	4,56	13,14	1,08	1,45
3	1,84	·48,50	21,60	3,62	5,47	6,07	12,04	0,10	0,75
4	2,08	47,83	21,68	4,21	4,52	5,95	13,02	0,20	0,51
5	2,07	48,42	22,41	3,33	4,88	4,93	12,29	0,13	1,54
6	2,05	43,43	19,90	3,85	4,59	5,30	12,43	0,16	8,29
7	1,75	49,96	21,37	2,80	5,51	4,83	12,96	0,12	0,70
8	2,07	47,65	21,53	5,60	5,46	6,37	10,53	0,24	0,53
9	1,87	42,02	21,01	7,70	6,66	3,43	9,52	0,49	7,31
10	2,06	39,97	19,72	5,12	4,55	2,73	13,18	0,23	12,44
11	2,04	47,38	23,05	3,45	4,99	5,60	12,16	0,16	1,15
12	2,00	48,07	20,50	3,54	6,03	5,25	12,46	0,17	1,97
13	1,95	50,95	16,49	4,93	4,02	8,59	11,66	0,22	1,18
14	1,99	45,43	21,84	3,30	4,92	4,24	10,62	0,14	7,52

Table 9:10. Table of the result of the technological analyses.

Samp No	Site	Max. gr. mm	Mean max. gr. mm	Mean min. gr. mm	Temper type	Temper %	MI-PHO grp	Thermal grp	Dens. g/cm³	Wat. abs. %	Dens Wat. abs. grp	Org mat grp	Note
1	SM	3,2	2,7	0,90	C	13	IV	1	1,77	20,95	d	O	
2	E	1,0	0,6		S/N	5	I	2	1,73	19,91	d	O	
3	KY	1,8	1,5	0,25	S/C	17	III	3	1,77	16,26	e	O	
4	E	3,6	2,1	1,00	S/N	18	I	2	1,84	16,71	e	O	
5	SM	2,5	1,3	0,28	S	12	IV		1,72	19,35	d	O+	
6	KY	4,2	1,9	1,13	S	17			1,63	23,04	c	O+	B
7	SM	4,3	2,4	0,45	C	23	IV	1	1,76	17,44	e	O-	
8	KY	1,9	1,7	0,20	S/C	25	VI	4	1,86	15,16	e	O	
9	SM	1,6	1,3		L/M	17	IV	5	1,34	36,30	a	O	Δ
10	SM	1,9	1,3	0,20	C/N	8	II		1,66	24,02	c	O+	B
11	KY	1,9	1,4	0,14	C	15	III	3	1,79	19,09	e	O-	
12	SM	4,3	2,6	0,44	C	15	V		1,78	17,56	e	O-	
13	KY	2,6	1,9	0,25	C/N	15			1,85	16,34	e	O-	
14	SM	1,5	1,3	0,20	S	14	II	5	1,72	15,68		O+	β
15	E	2,4	1,6	0,23	C	21			1,83	17,06	e	O+	β?
16	KV	1,3	1,2	0,17	S	13	II		1,66	20,90	c	O+	B
17	E	4,1	2,5		S/N	6	I	4	1,81	18,41	e	O+	
18	SM	2,0	1,3		L/M	13	IV		1,46	30,24	b	O+	δ
19	KV	2,0	1,3		L	12	II		1,35	37,07	a	O+	B
20	SM	1,6	0,9		L/M	8	IV		1,53	28,15	b	O+	δ
21	E	4,1	2,8	1,20	S/N	12	I		1,79	19,18	e	O	
22	KV	4,1	2,0	0,17	S	13	II		1,67	22,24	c	O+	B
23	KY	2,7	2,0	0,12	S	14	III	6	1,78	16,06	e	O	
24	KY	1,9	1,5		L	11	III		1,32	38,52	a	O	
25	KY	4,1	2,1	0,07	S/C	25	VI		1,83	17,68	e	O	
26	KY	2,9	1,6	0,26	S	14	III	6	1,78	17,49	e	O	
27	SM	1,6	1,1		L/M	17	IV	7	1,33	38,45	a	O-	Δ
28	KY	1,8	1,3		L/M	13			1,49	28,73	b	O+	Θ
29	KV	4,5	2,4	0,18	S	27	II		1,81	15,03	e	O+	β
30	SM	2,9	2,0	0,17	S	11	V	7	1,83	17,15	e	O-	

E = Eklundshov
SM = Smällan
KY = Kyrktorp
KV = Kvedesta

O = Organic matter (medium)
O+ = Organic matter (rich)
O- = Organic matter (poor)

S = Sand/gravel
C = Crushed granitic rock
L = Limestone (crushed)
M = Marble (crushed)
N = Natural temper

B = Bone (rich)
β = Bone (poor)
Δ = Diopside (rich
δ = Diopside (poor)
Θ = Light mica/talc (rich)

FIGURES

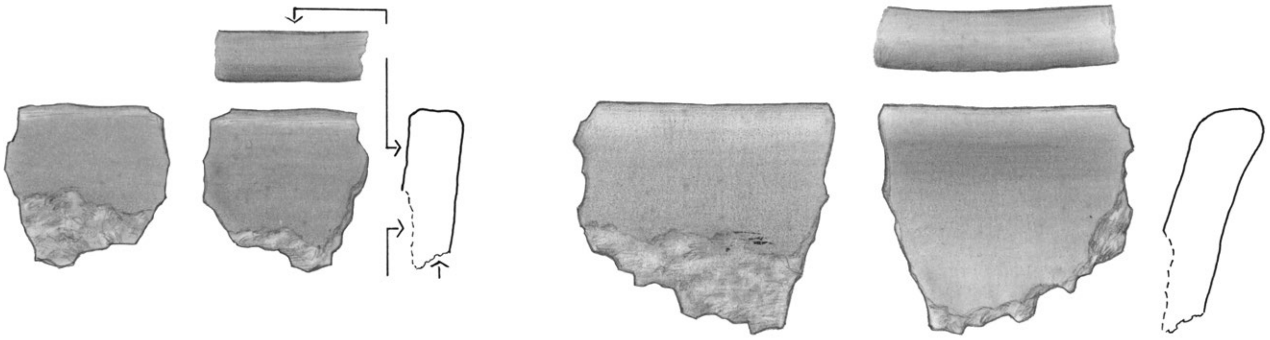


Fig. 9:1. Principal drawing of pottery sherd. Drawing by Eide.

Fig. 9:2. Drawings of typological example sherds, ,Mogetorp (Kihlstedt et. al 1997:114).

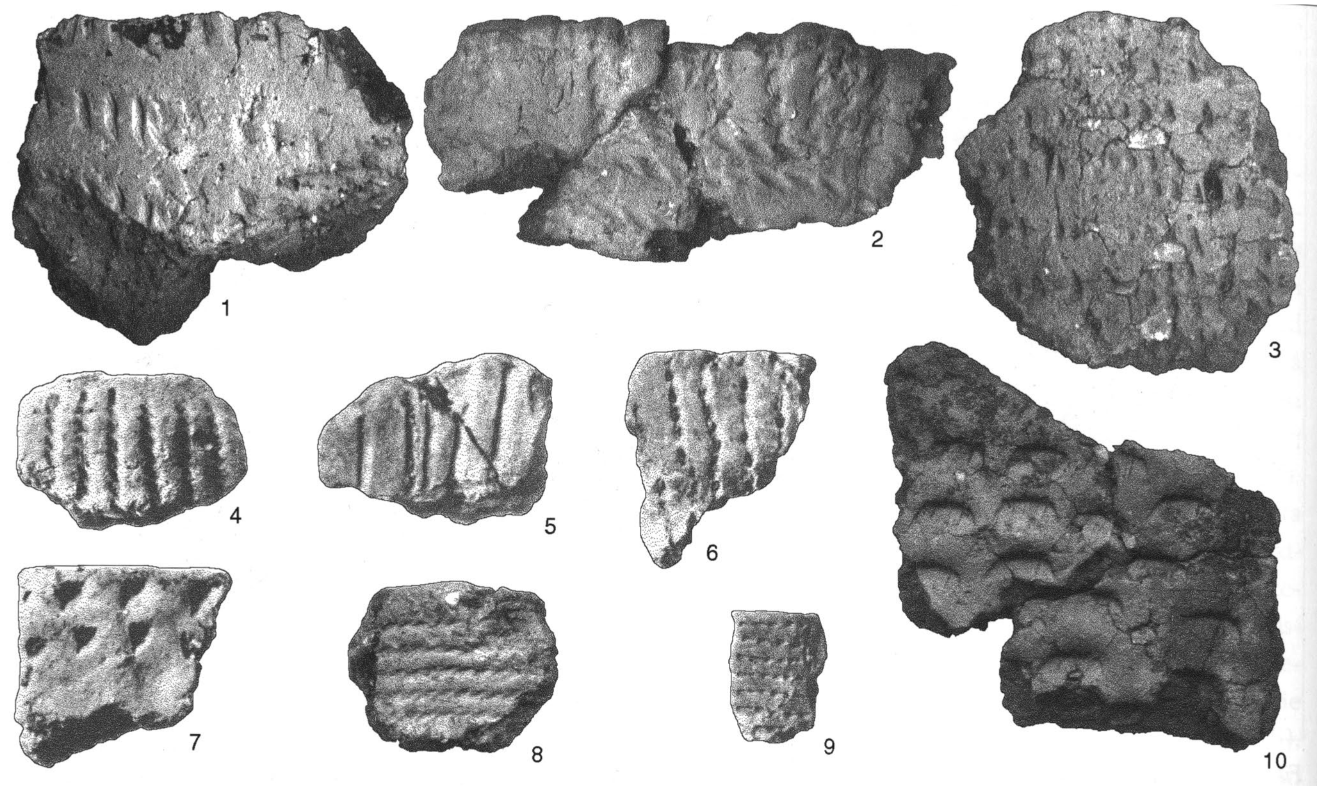


Fig. 9:3. Drawings of typological example sherds, Ö Vrå (Kihlstedt et.al 1997:115).

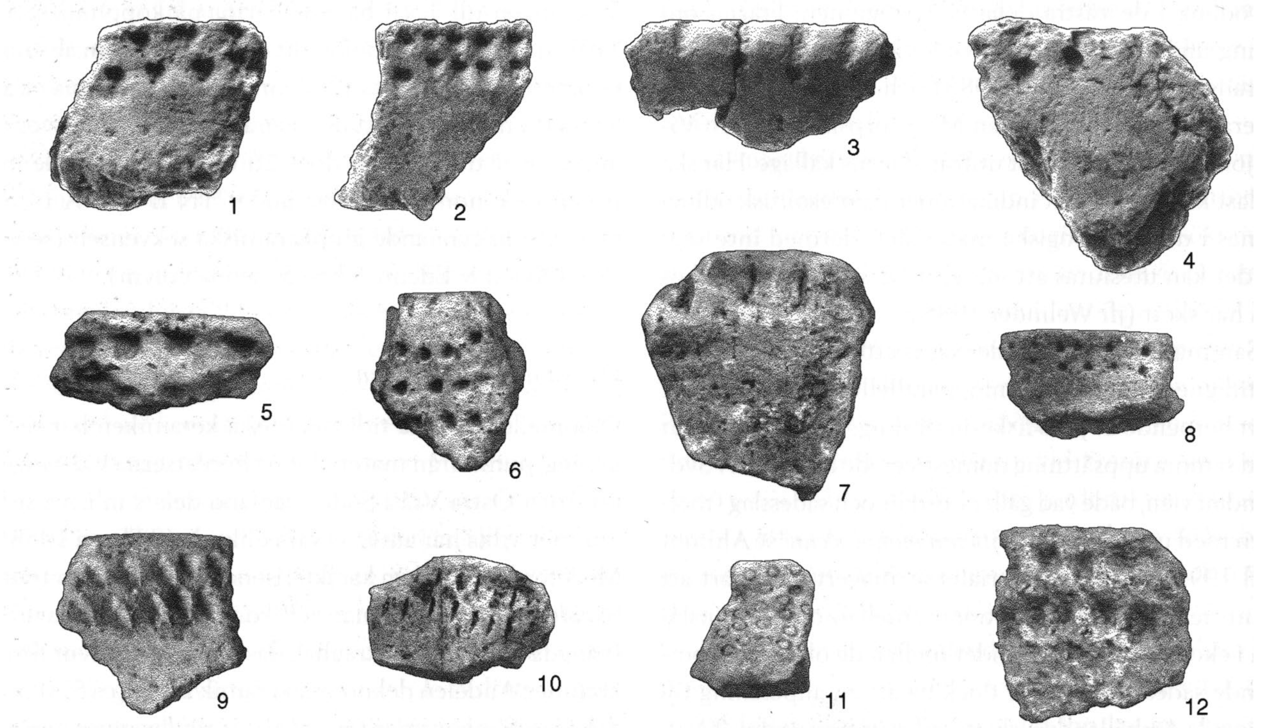


Fig. 9:4. Drawings of typological example sherds, Malmahed and Finntorp (Kihlstedt et. al 1997:115).

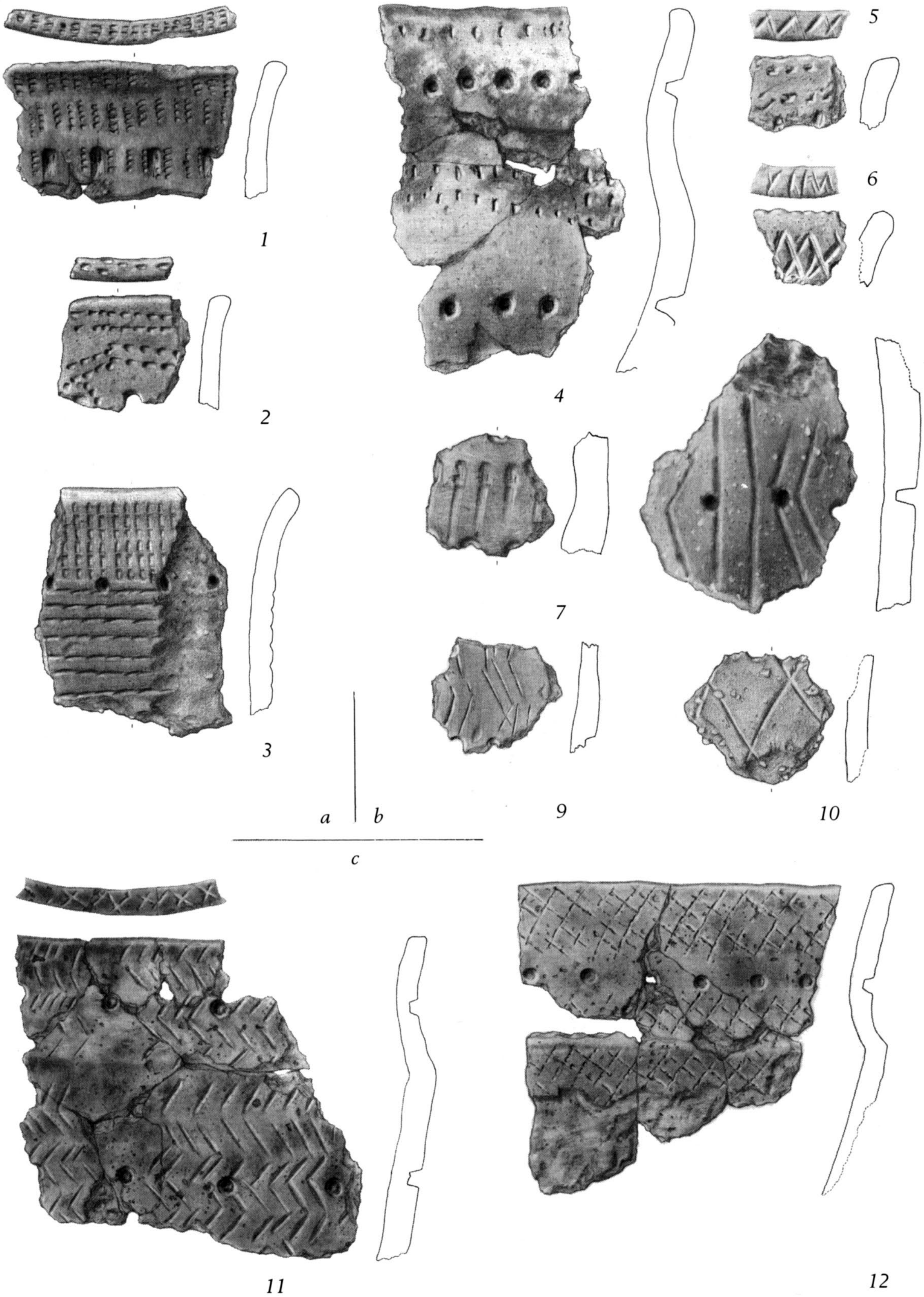


Fig. 9:5. Drawings of typological example sherds, Fagervik I/I–II. Drawing by Eide.

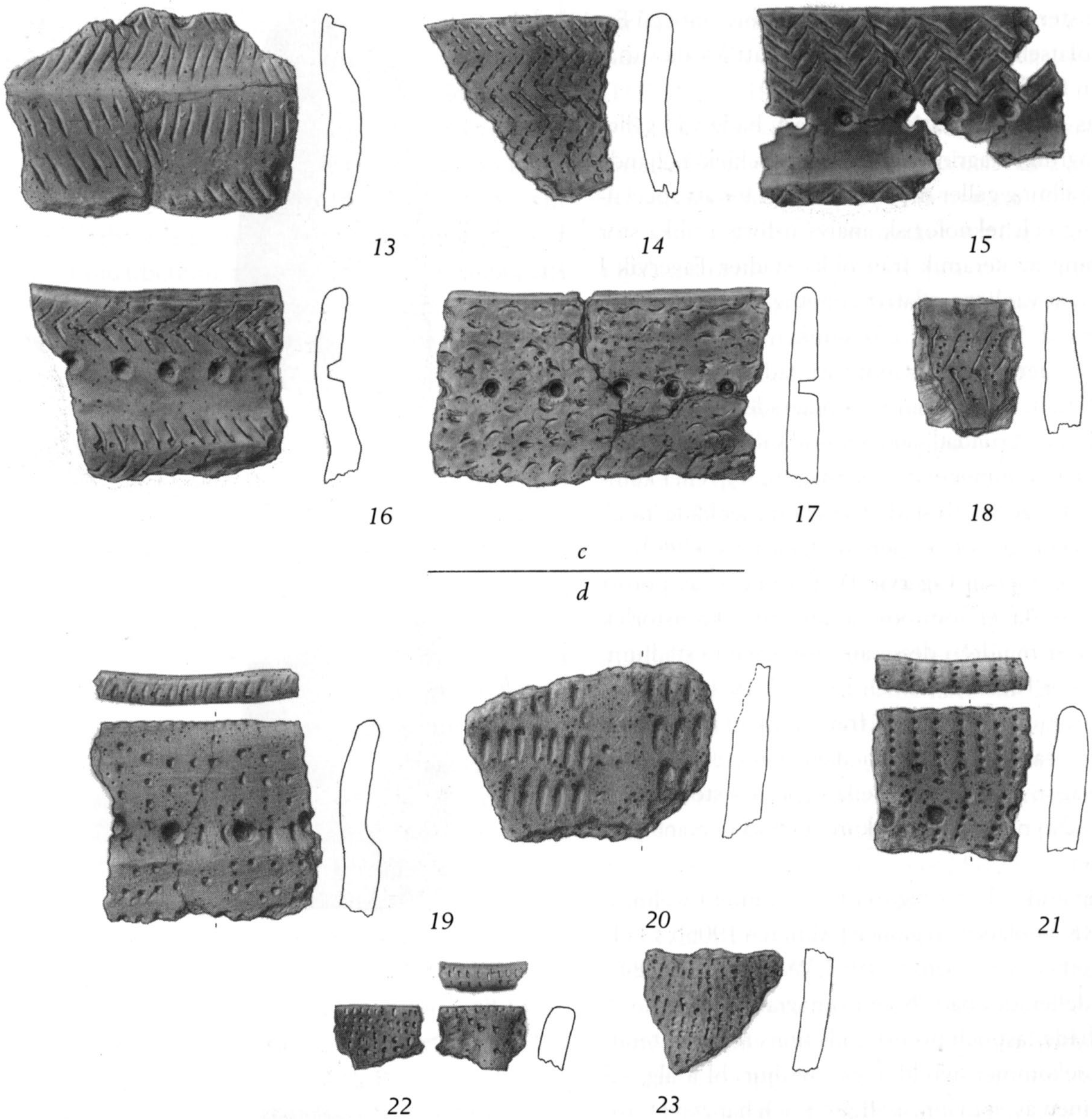


Fig. 9:6. Drawings of typological example sherds, Fagervik III–IV. Drawing by Eide.

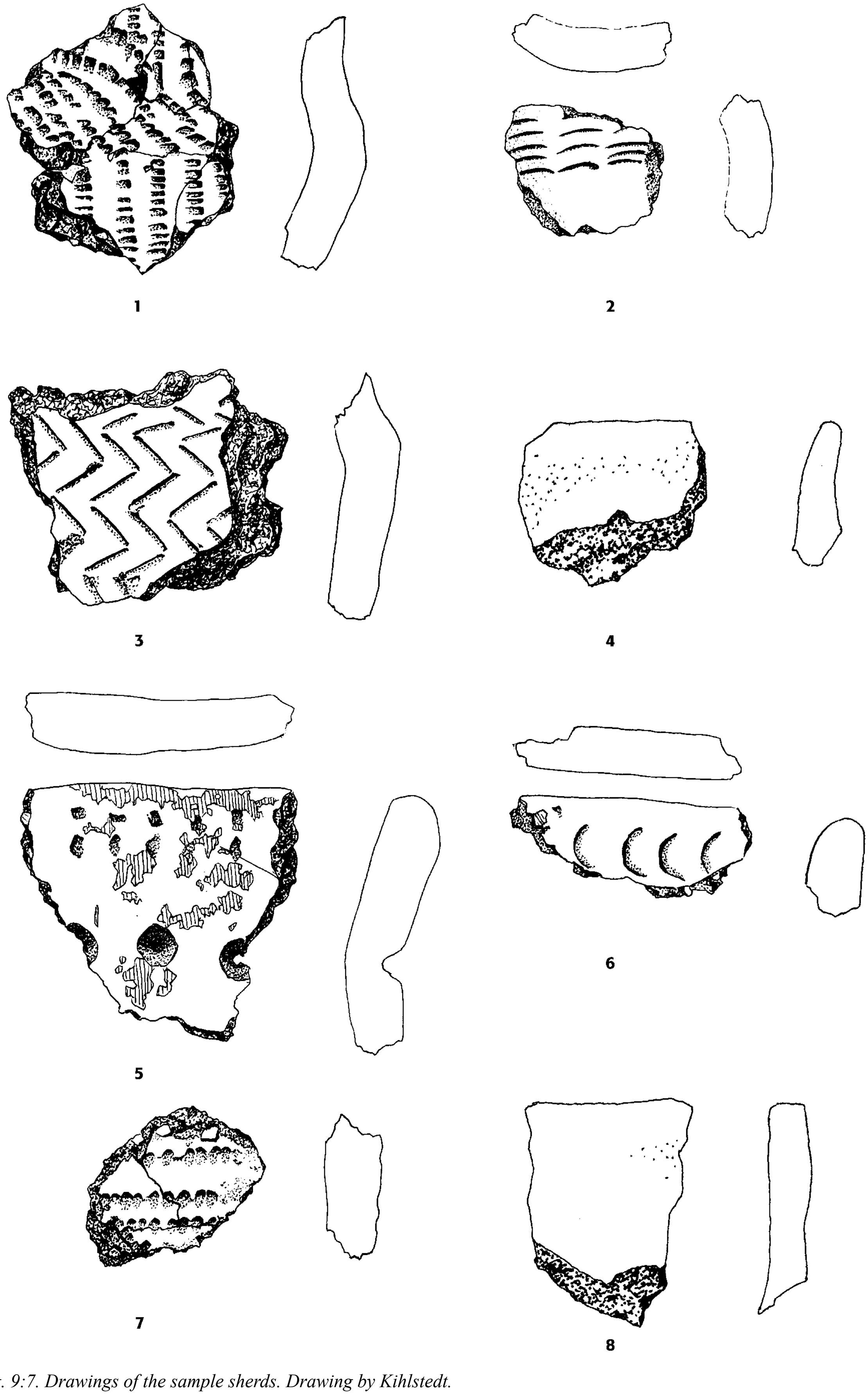
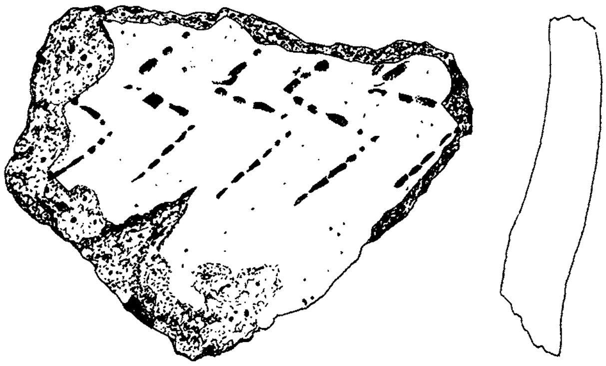


Fig. 9:7. Drawings of the sample sherds. Drawing by Kihlstedt.



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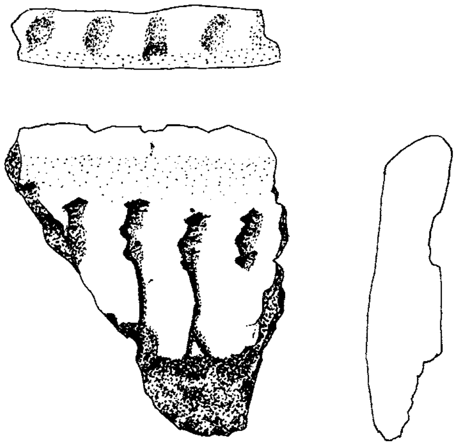

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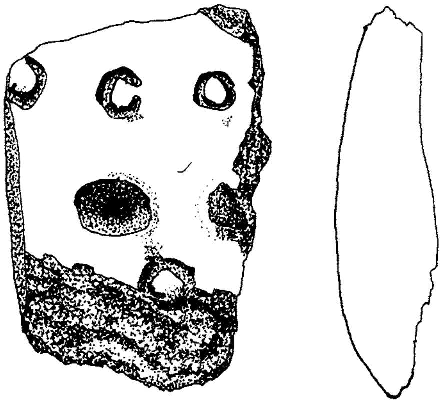

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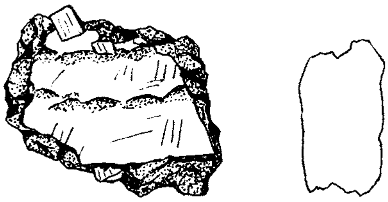

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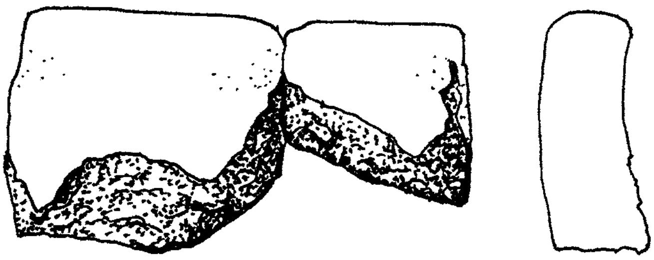

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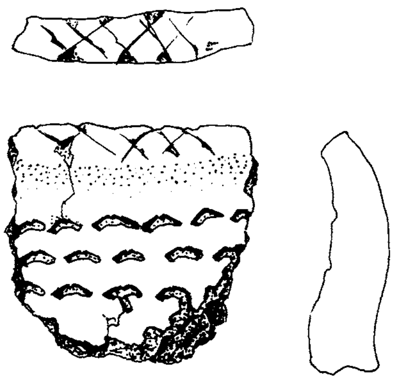

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Fig. 9:8. Drawings of the sample sherds. Drawing by Kihlstedt.

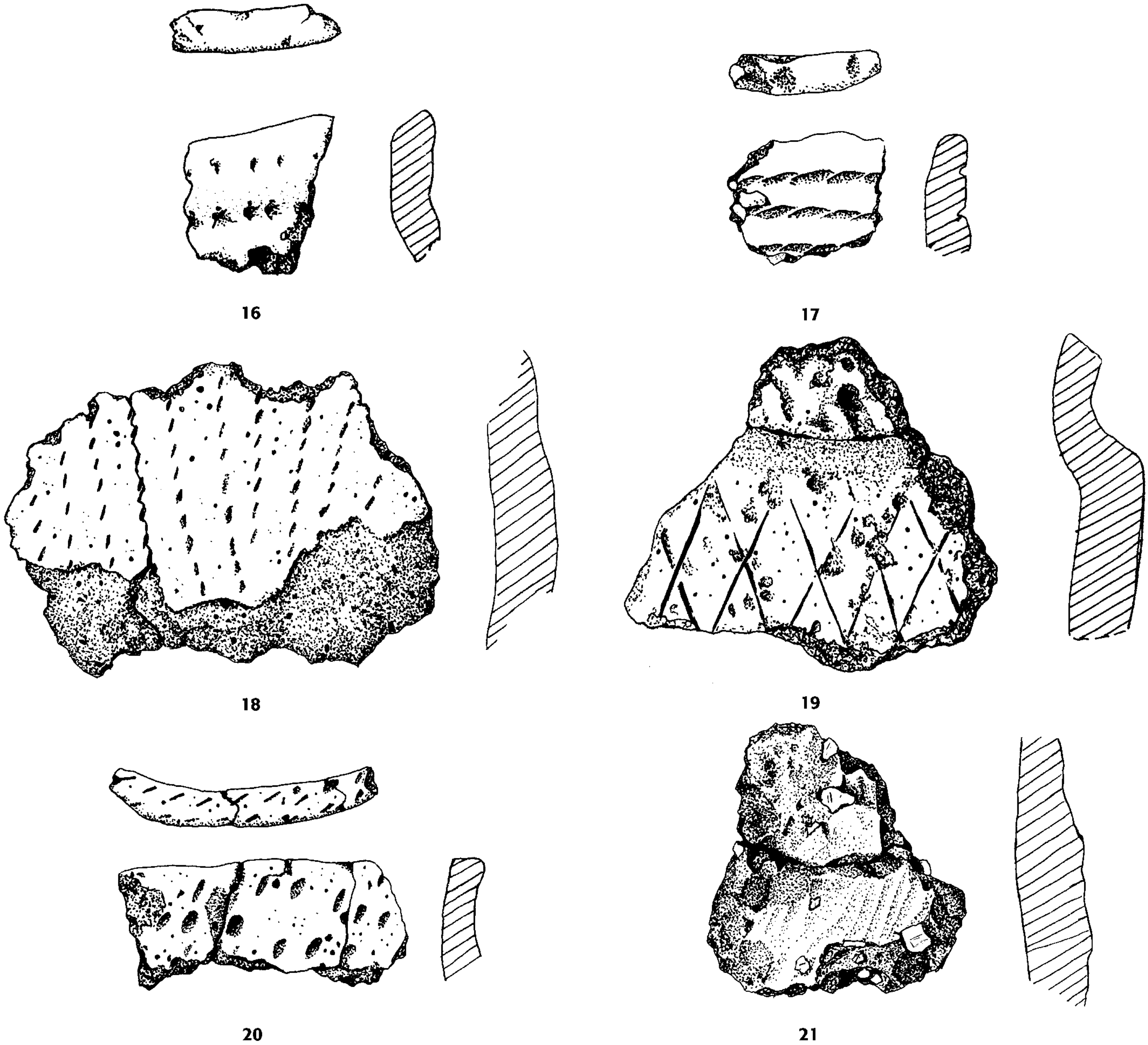
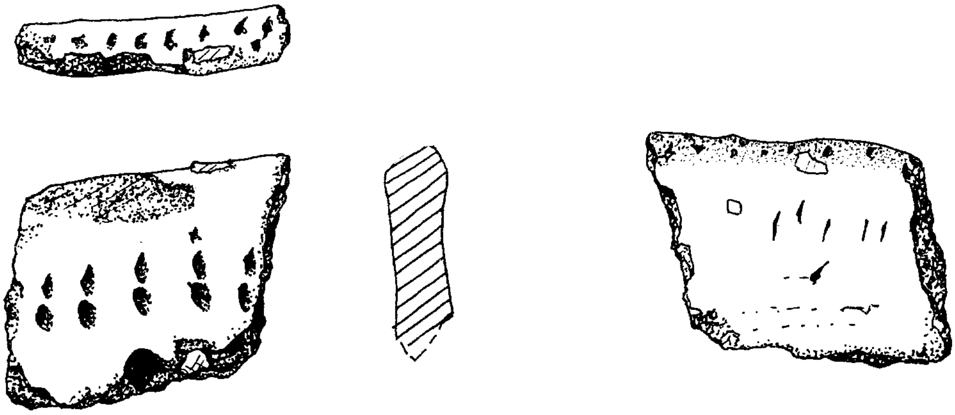


Fig. 9:9. Drawings of the sample sherds. Drawing by Kihlstedt.



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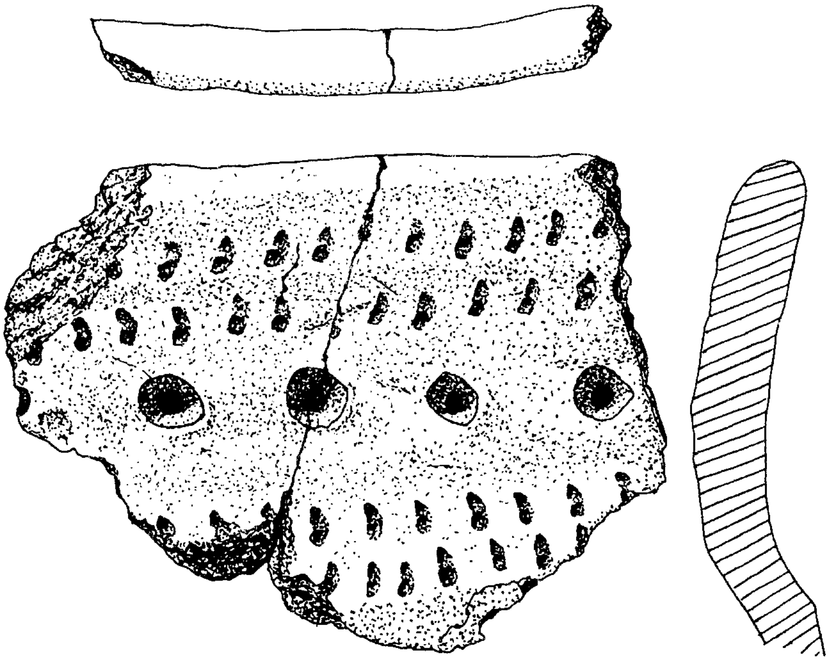

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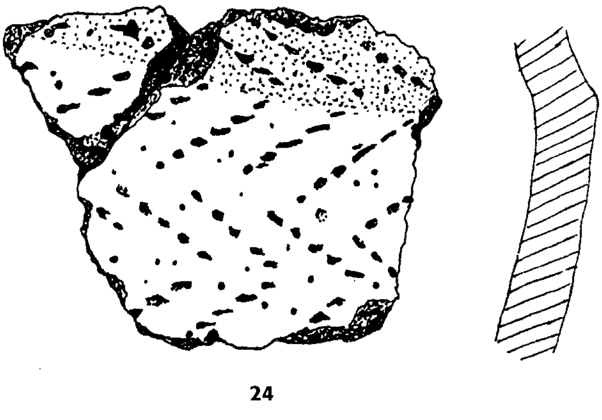

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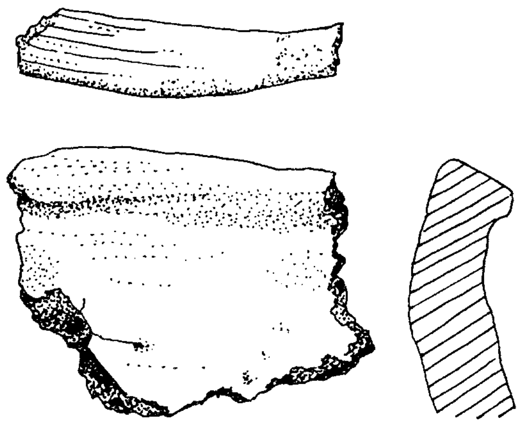

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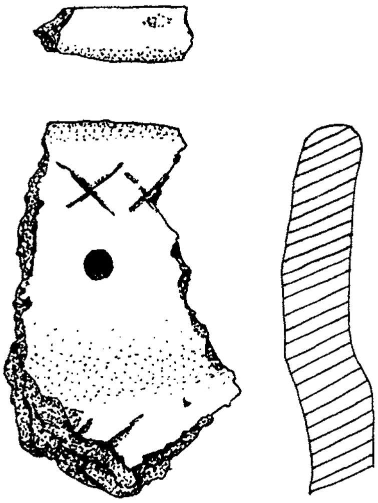
Fig. 9:10. Drawings of the sample sherds. Drawing by Kihlstedt.



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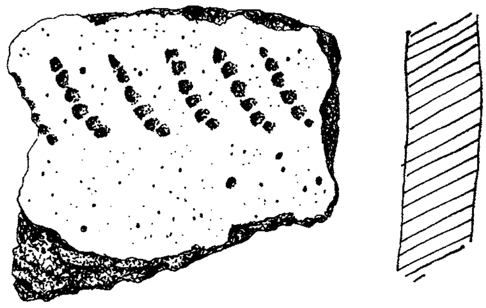

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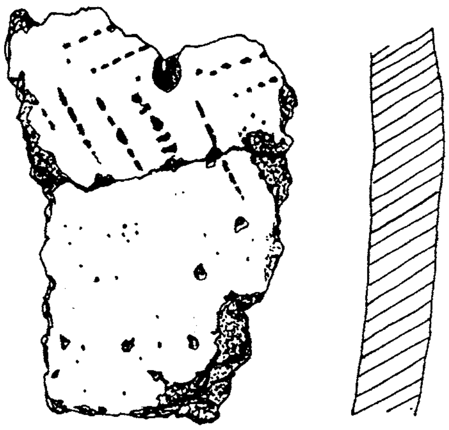

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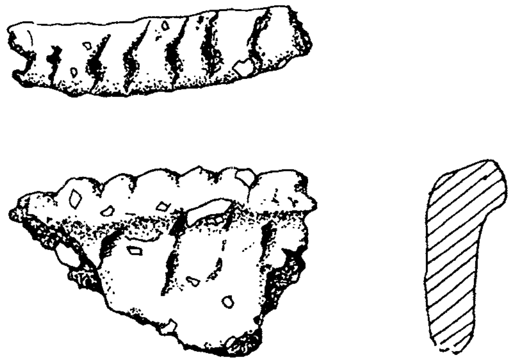

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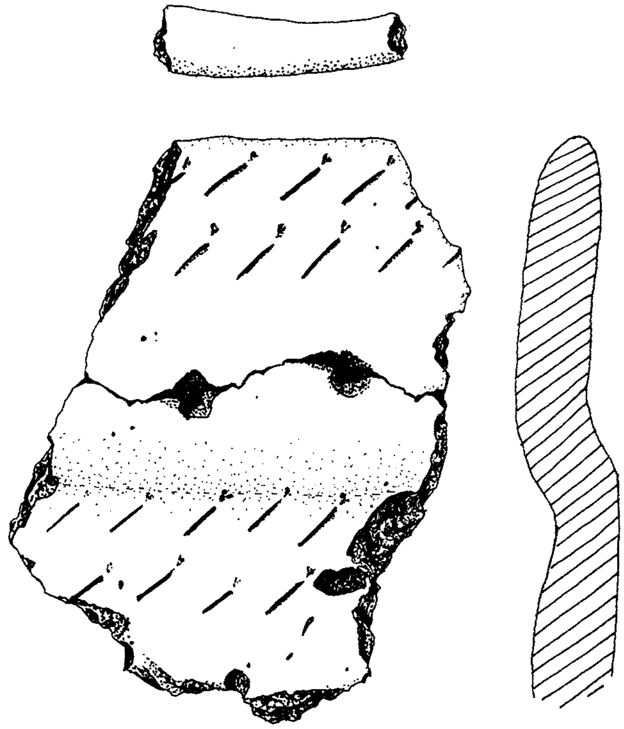

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Fig. 9:11. Drawings of the sample sherds. Drawing by Kihlstedt.

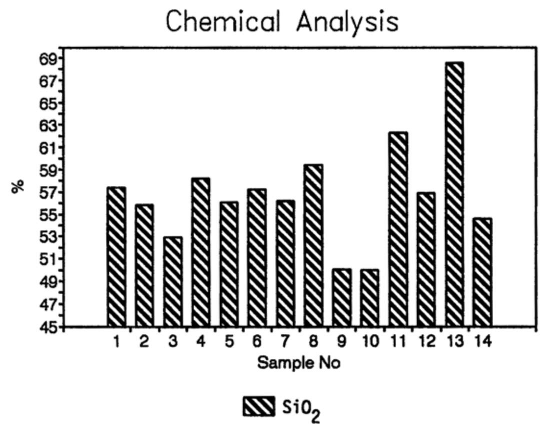

Fig. 9:12. Chemical analyses, the content of silica expressed as percentage of the oxide

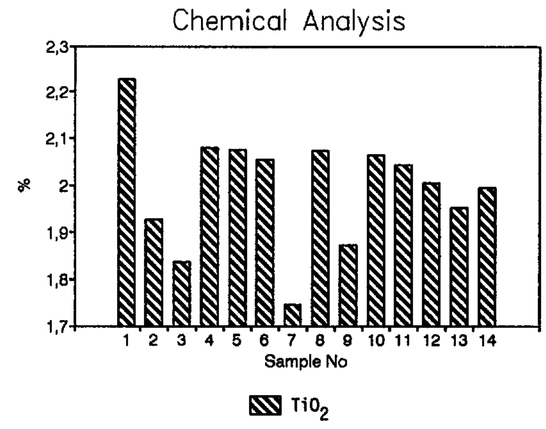

Fig. 9:13. Chemical analyses, the content of titanium expressed as percentage of the oxide.

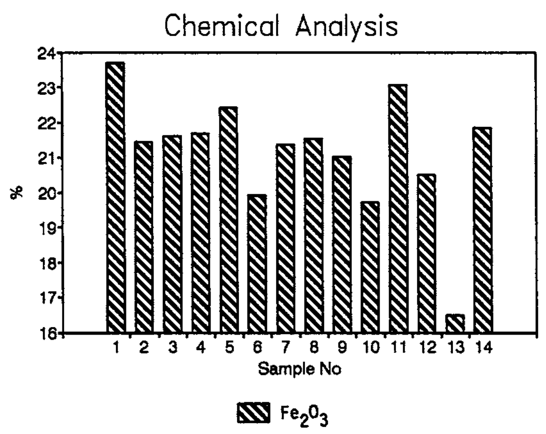

Fig. 9:14. Chemical analyses, the content of iron expressed as percentage of the oxide.

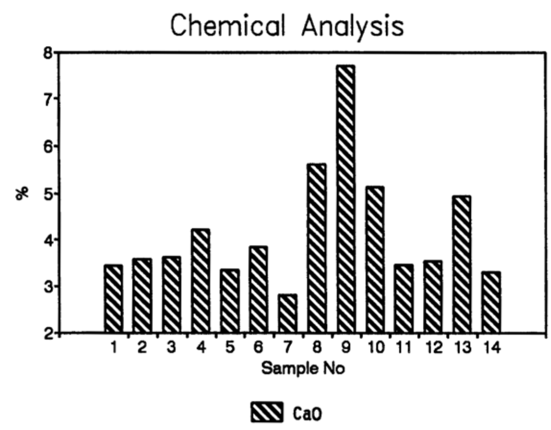

Fig. 9:15. Chemical analyses, the content of calcium expressed as percentage of the oxide.

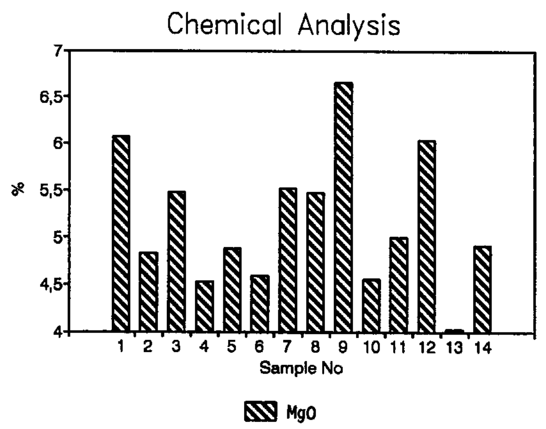

Fig. 9:16. Chemical analyses, the content of magnesium expressed as percentage of the oxide.

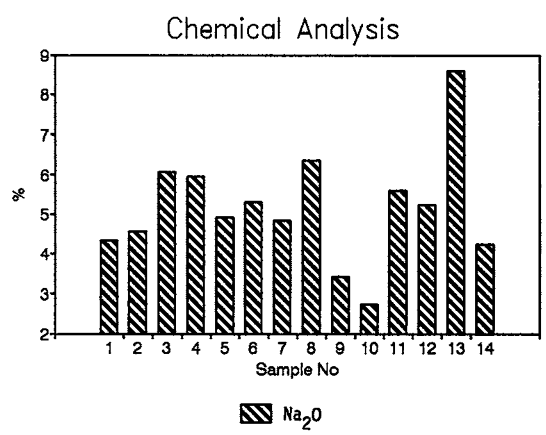

Fig. 9:17. Chemical analyses, the content of sodium expressed as percentage of the oxide.

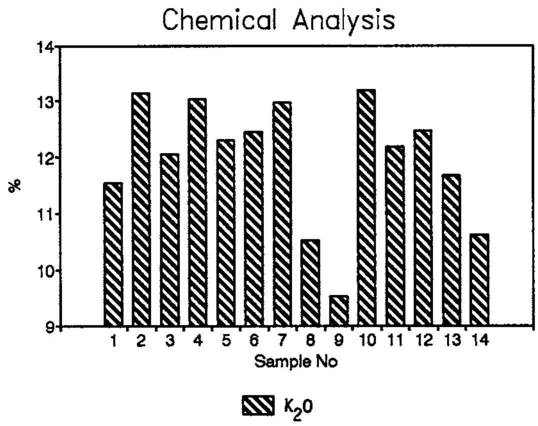

Fig. 9:18. Chemical analyses, the content of potassium expressed as percentage of the oxide.

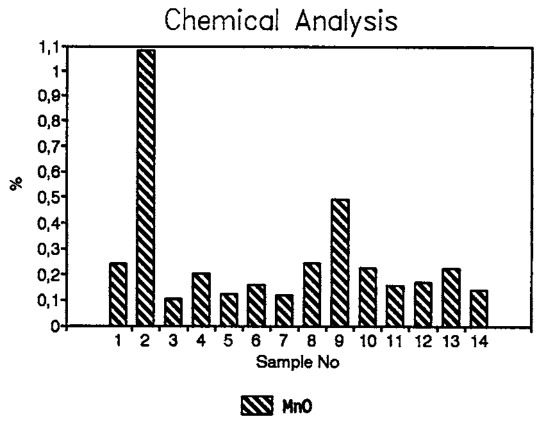

Fig. 9:19. Chemical analyses, the content of manganese expressed as percentage of the oxide.

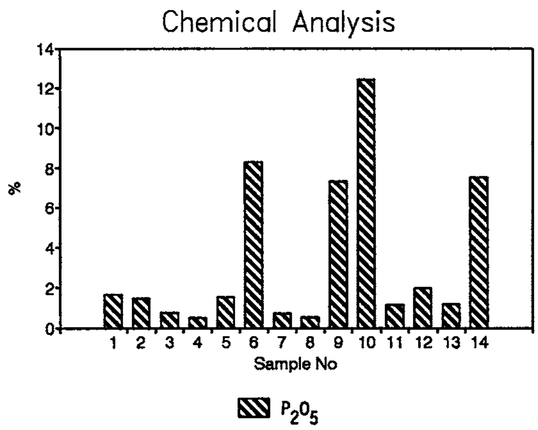

Fig. 9:20. Chemical analyses, the content of phosphorus expressed as percentage of the oxide.

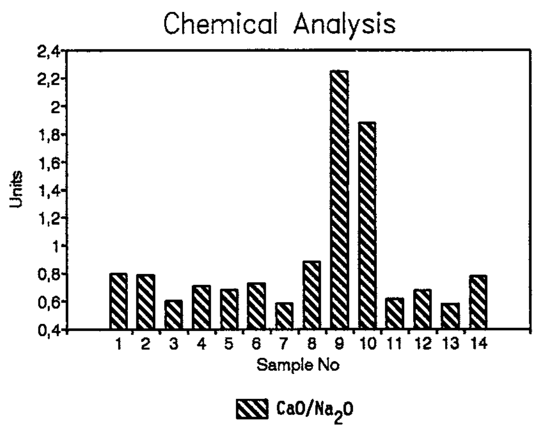

Fig. 9:21. Chemical analyses, the ratio of CaO/Na_2O.

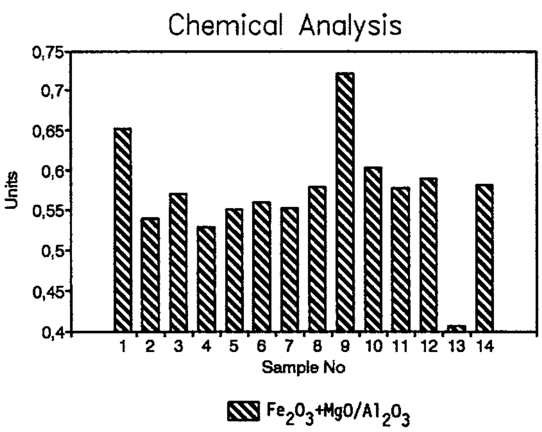

Fig. 9:22. Chemical analyses, the ratio of Fe_2O_3+MgO/Al_2O_3.

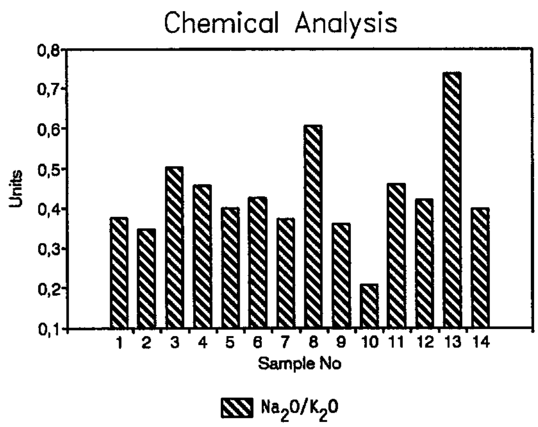

Fig. 9:23. Chemical analyses, the ratio of Na_2O/K_2O.

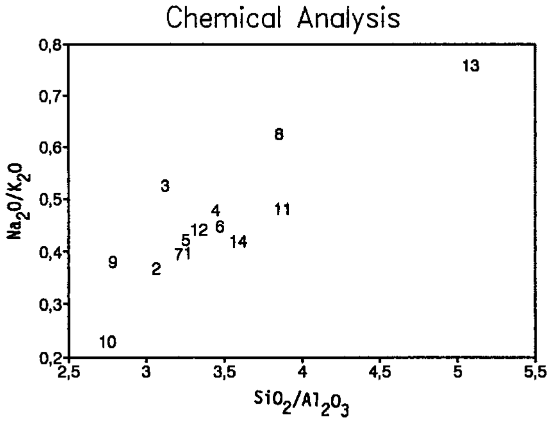

Fig. 9:24. Chemical analyses, the ratio of Na_2O/K_2O and SiO_2/Al_2O_3.

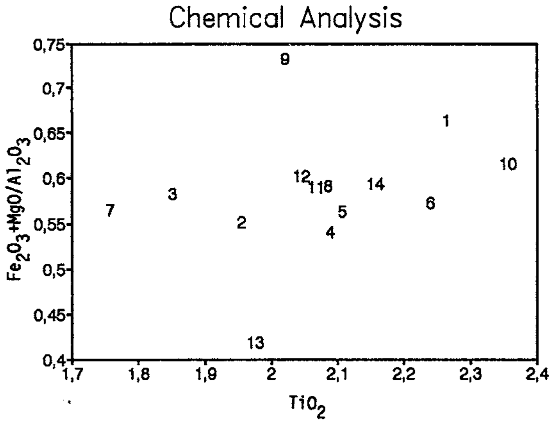

Fig. 9:25. Chemical analyses, the ratio of Fe_2O_3+MgO/Al_2O_3 and TiO_2.

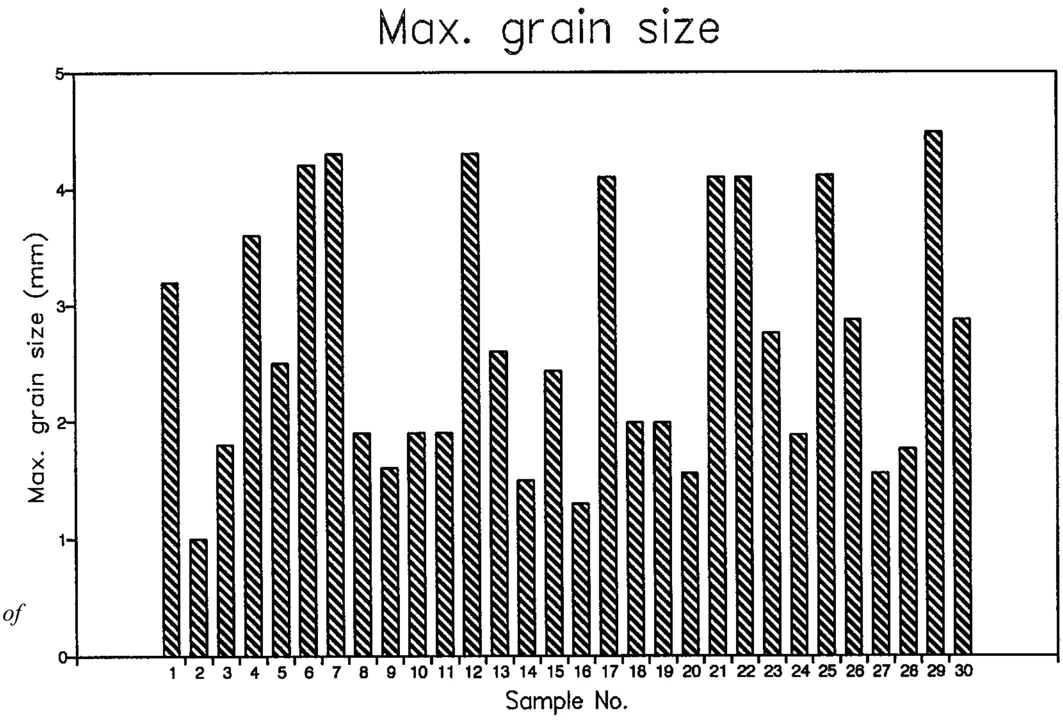

Fig. 9:26. Distribution of the max. grain size.

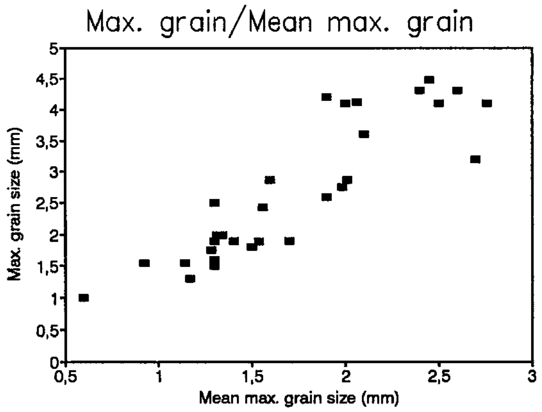

Fig. 9:28. Plot of the max. grain size/mean max. grain size.

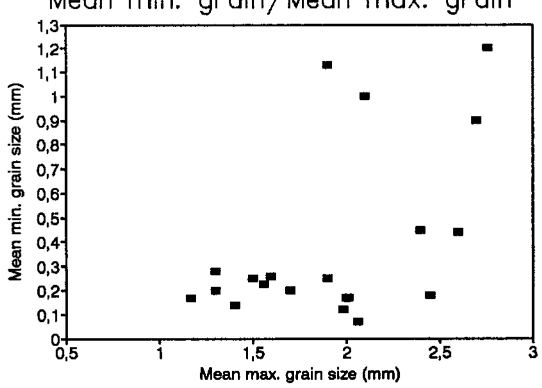

Fig. 9:29. Plot of the mean max. grain size/mean min. grain size.

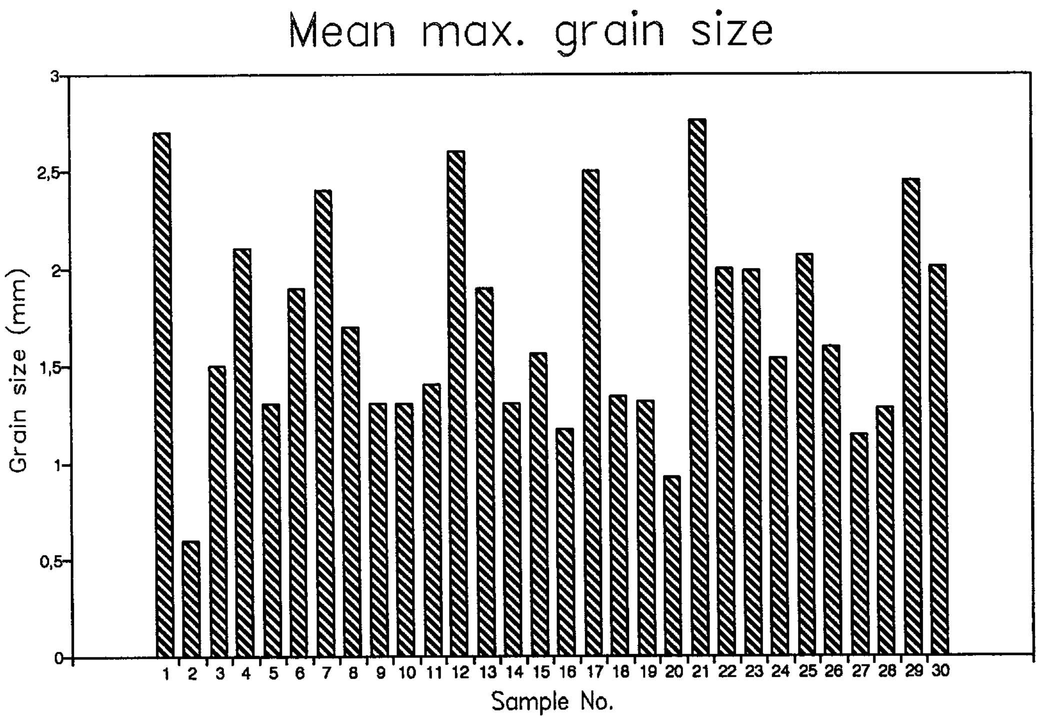

Fig. 9:27. Distribution of the mean max. grain size.

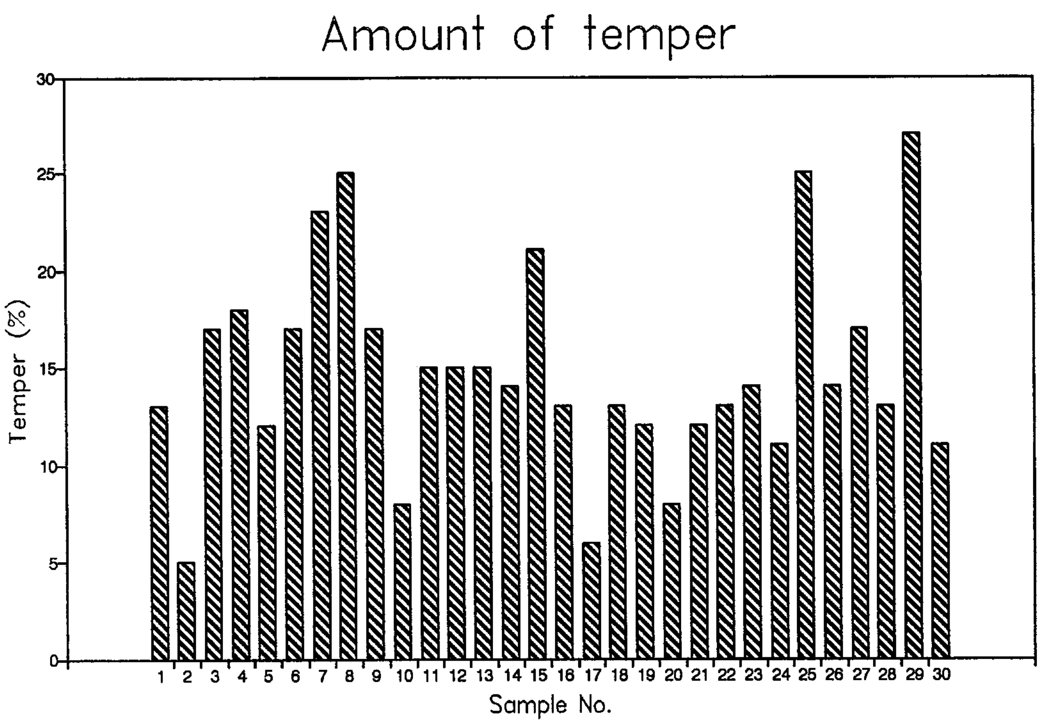

Fig. 9:30. Distribution of the amount of temper.

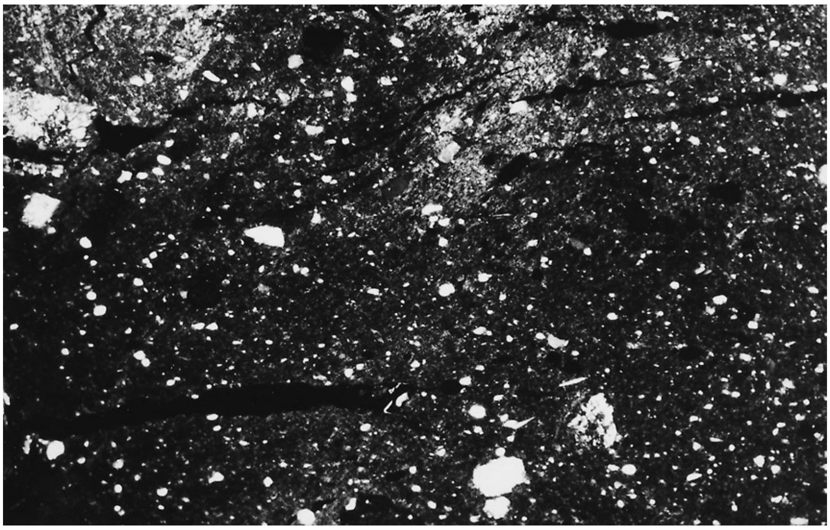

Fig. 9:31. MIPHO-group I, microscopic photo polarized light, 25×.

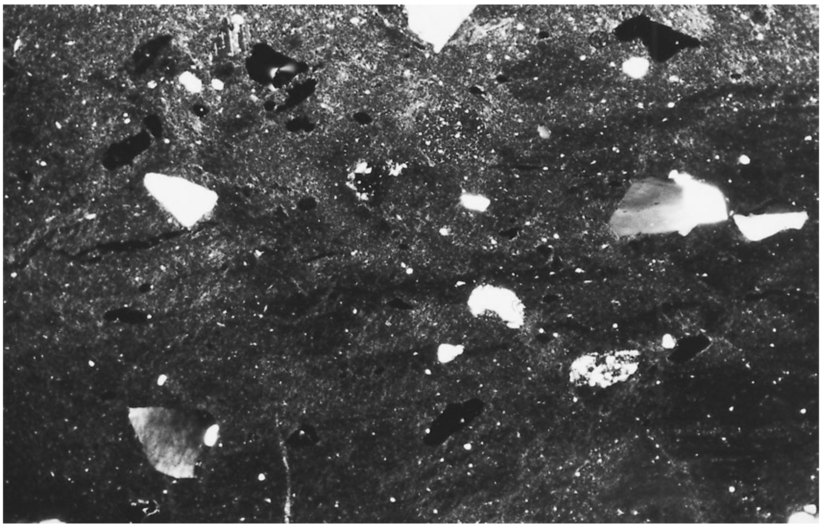

Fig. 9:32. MIPHO-group II, microscopic photo polarized light, 25×.

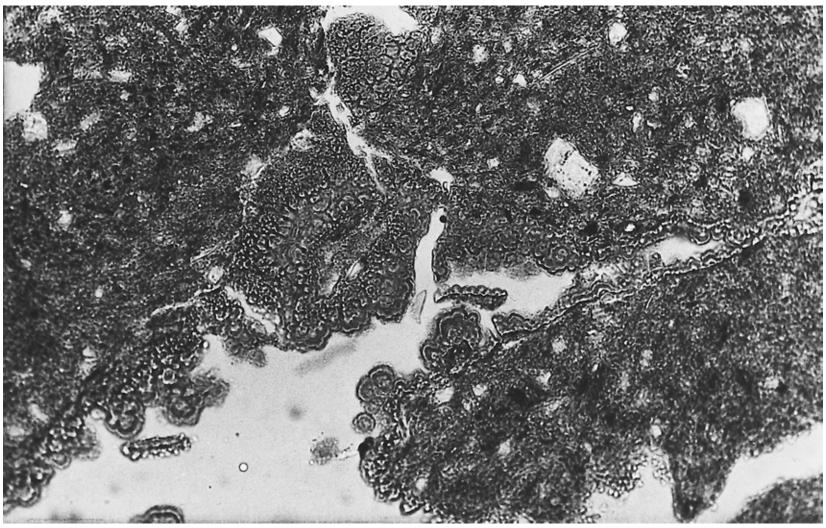

Fig. 9:33. Remains of bone temper, 630×.

Fig. 9:34. MIPHO-group III, microscopic photo polarized light, 25×.

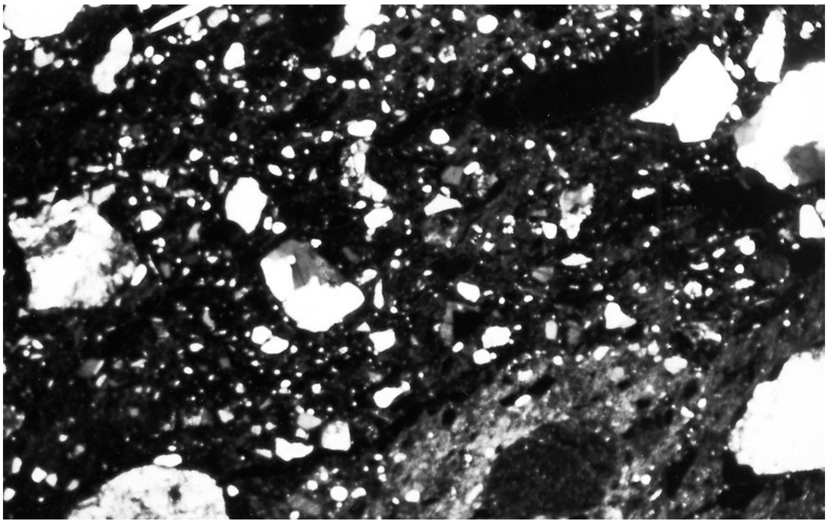

Fig. 9:35. MIPHO-group IV, microscopic photo polarized light, 25×.

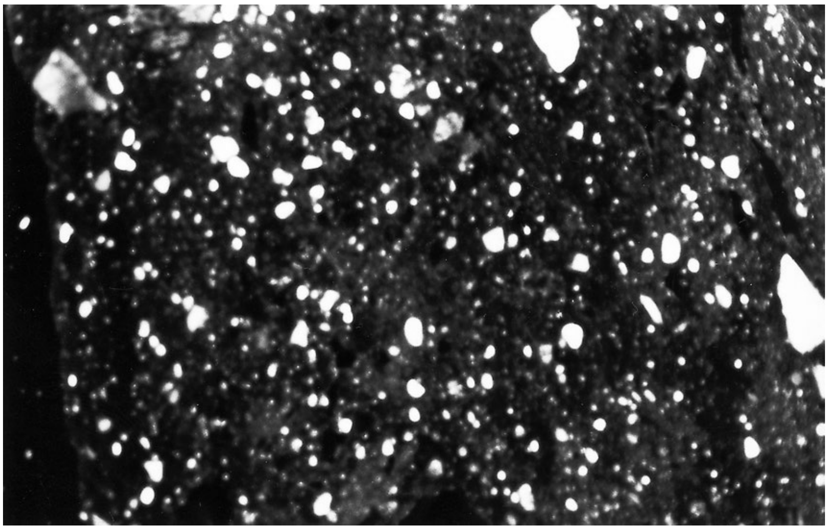

Fig. 9:36. MIPHO-group V, microscopic photo polarized light, 25×.

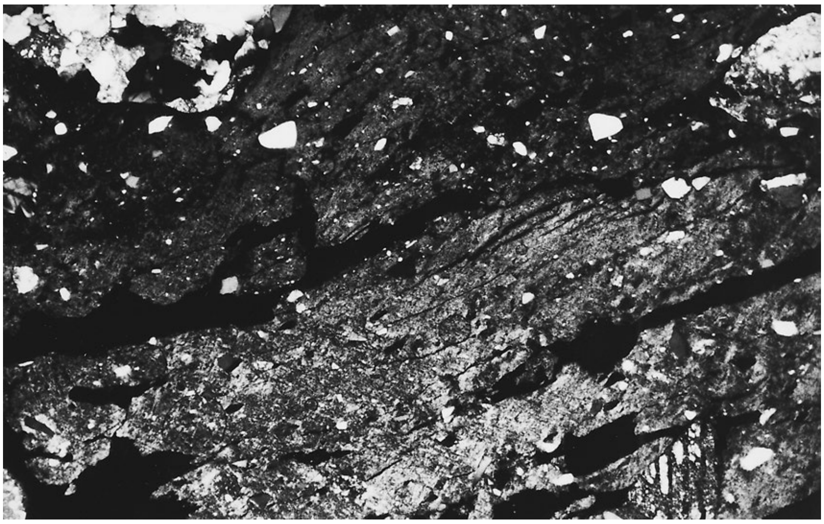

Fig. 9:37. MIPHO-group VI, microscopic photo polarized light, 25×.

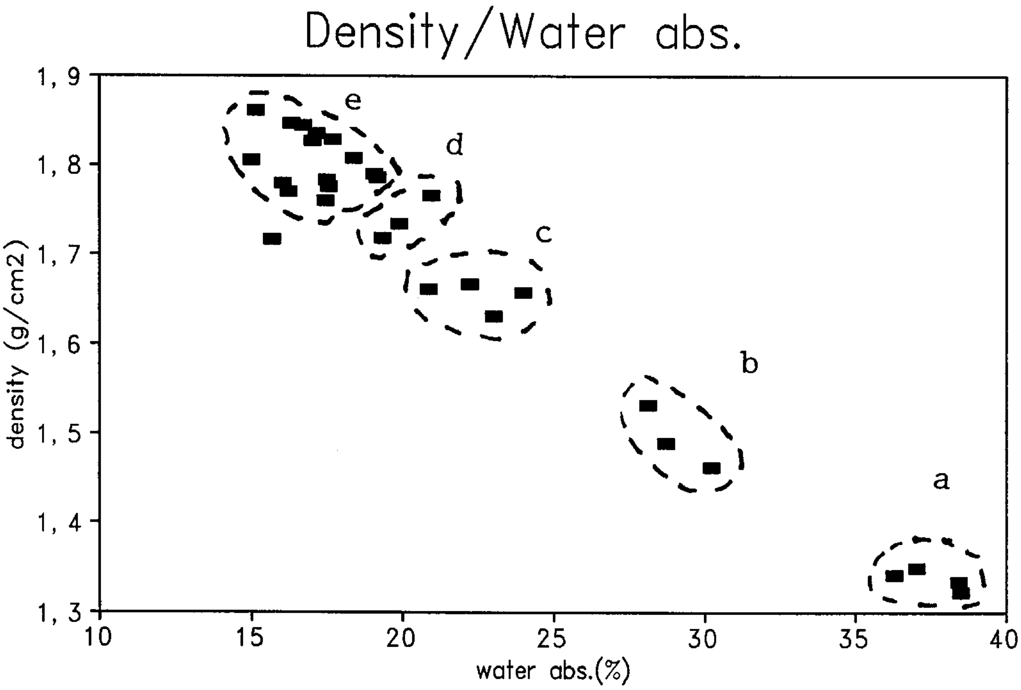

Fig. 9:38. Plot of the density/water absorption

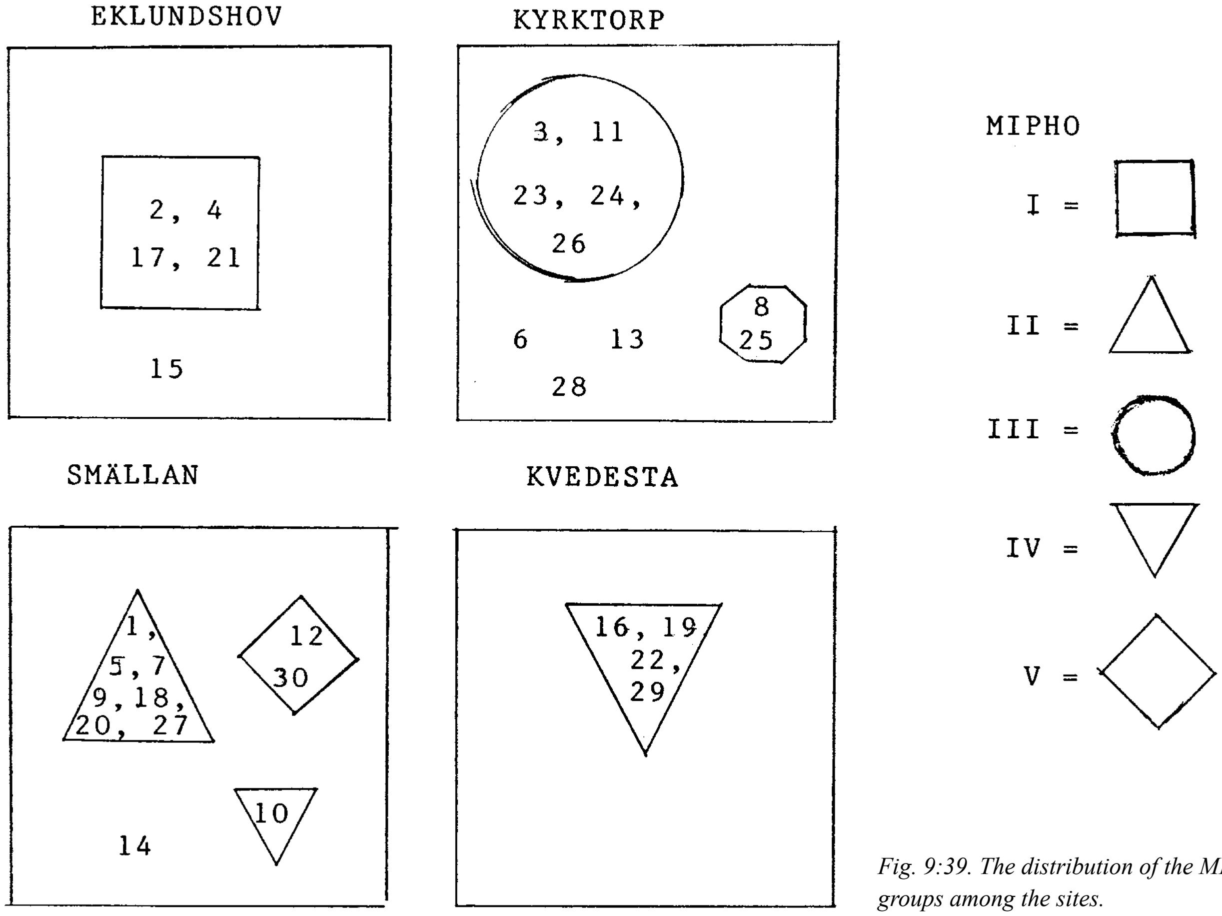

Fig. 9:39. The distribution of the MIPHO-groups among the sites.

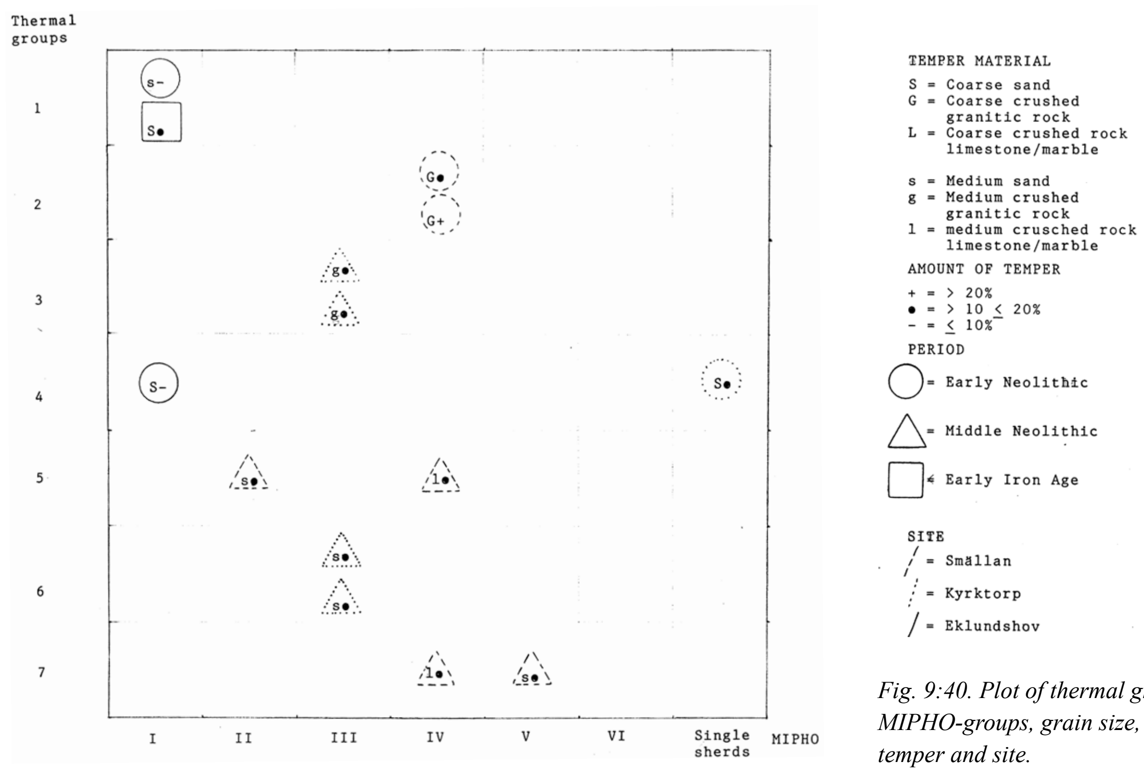

Fig. 9:40. Plot of thermal groups, MIPHO-groups, grain size, amount of temper and site.

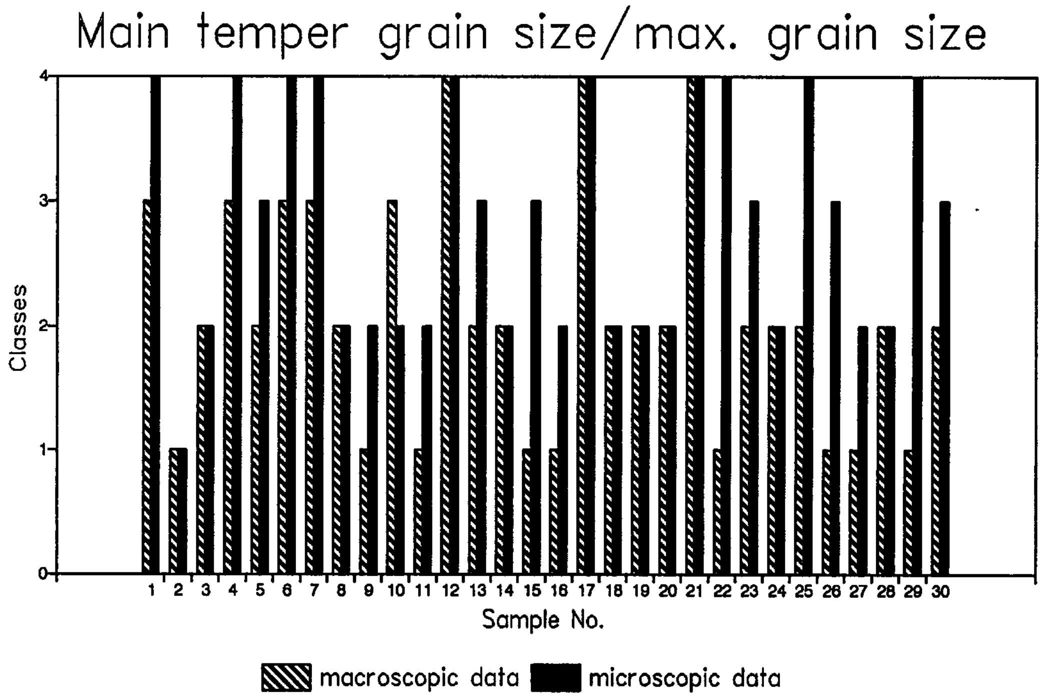

Fig. 9:41. Distribution of the "main temper grain size" and the max. grain size.

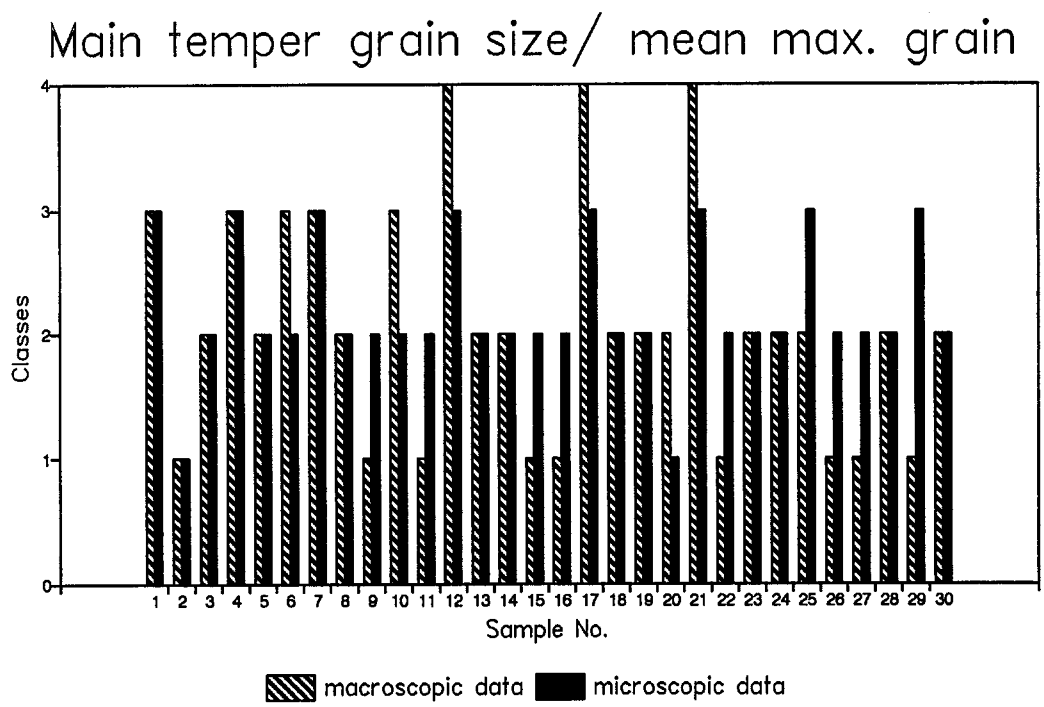

Fig. 9:42. Distribution of the "main temper grain size" and the mean max. grain size.

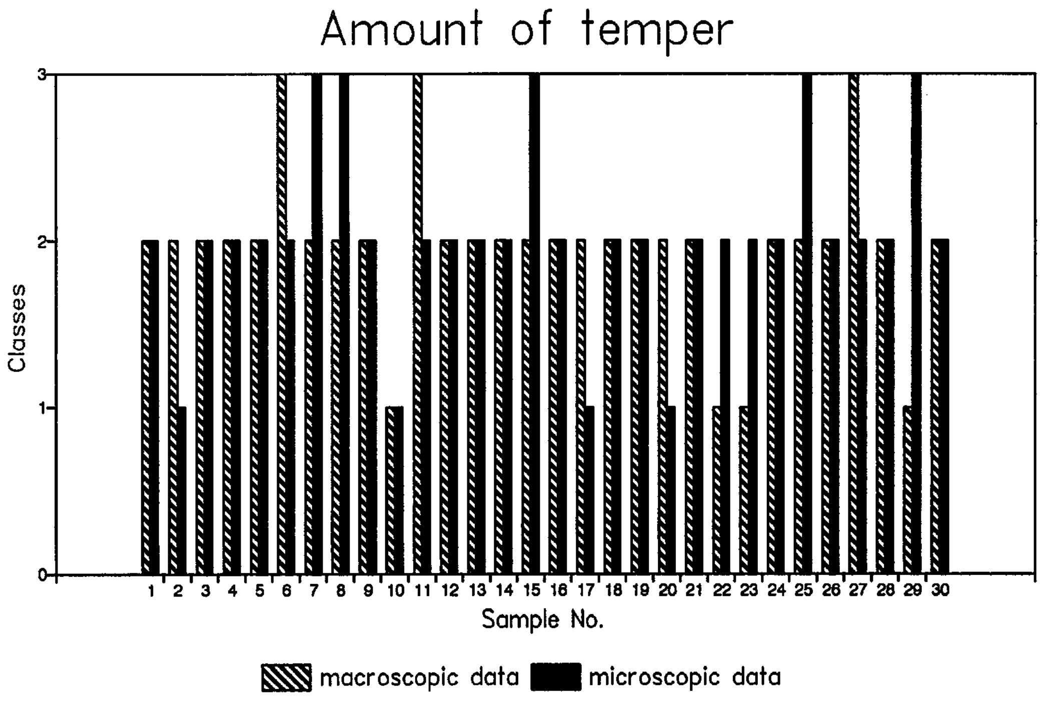

Fig. 9:43. Distribution of the macroscopically estimated amount of temper and the microscopically estimated amount of temper.