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The Middle Neolithic settlement at Auve

Einar Østmo, Birgitta Hulthén & Sven Isaksson

The MN settlement site at Auve, Sandefjord, Vestfold, Norway was excavated in 1976–84. Large amounts of flint, worked slate, pumice, other stone artefacts, bone artefacts, amber, and potsherds were found. Radiocarbon dates range from 4980±70 BP to 3595±60 BP. Sea mammals dominate the bone material. Manifold investigations of the ceramics indicate a not previously identified ceramic complex, the SKK group. The definition includes special manufacturing methods and a vessel shaping and ornamentation of its own. Further studies of the relationship in time and space between the SKK group and other Neolithic ceramics producing units in Norway are important topics for future research. Organic remains adhering to some potsherds where analysed microscopically for visible structures, and chemically for lipids, proteins and trace elements. The remains where interpreted as being of food-origin, mainly terrestrial mammal with possible inclusions of vegetables. The discussion includes a comparison of the different resources utilized at Auve, as suggested by the organic remains and the osteological material.

Auve – an introduction

by Einar Østmo, Oslo

The Middle Neolithic settlement site at Auve was discovered in 1972. Following test excavations in 1976–77 (Haavaldsen 1978), the University Museum of National Antiquities in Oslo undertook excavation of the site in the years 1979–84. The results of the excavation and the subsequent investigations of the finds have been published preliminarily in several papers (Østmo 1981a; 1981b; 1983; 1984a; 1984b; 1993; Hulthén 1981). The excavations have met with considerable interest in several quarters, on account of the unusually rich and varied finds that were brought to light, not least concerning the pottery, which may be the richest and largest collection yet known from the Neolithic of south Norway. Thus the investigation of the charred food-remains from some of the potsherds are of major interest not only in themselves, but also because they can be viewed in the perspective of an elaborate material and, by inference, spiritual culture.

The Auve site takes its name from the farm on whose land it lies. Auve is situated in the archipelago forming the western littoral of the Oslo fjord. Due to the post-glacial land upheaval the place to-day lies approximately 24 m above sea-level, on the peninsula of Vesterøya which extends southward from the town of Sandefjord in Vestfold county (the finds were made from 2289 to 2519 cm above the present sea-level). The development of the relationship between land and sea in post-glacial times in this region is quite well known (Henningsmoen 1979), and there can be no doubt that when it was inhabitated, the Auve site was situated near the shore. Indeed, a sandy beach facing northwest and well sheltered from the prevailing southwesterly winds may have been the main attraction of the site.

One of the features of the Oslo fjord region landscape is a number of moraines that cross the direction of the fjord, curving north along the eastern coast of Østfold and towards the southwest along the Vestfold coast. They were deposited during the final stages of the last glaciation, mostly in the sea. As the land rose, the material of these moraine deposits was sorted, and among other things, large deposits of fine sand were formed on the southern slopes of the moraines. One such area can be found immediately to the southwest of the Auve site. During the Neolithic, which largely coincided with the first part of the comparatively hot and dry Sub-Boreal climatic chronozone, the southwesterly summer winds formed a fairly substantial sand dune just where the archaeological site at Auve was discovered. The archaeological finds were embedded in this aeolic sand, and this provided excellent preservation conditions which have kept much of the pottery, as well as bone material, amber beads and much else extremely well preserved right through to the present time.

During the 1976–93 excavations the following quantities of material were found: 92,405 pieces of flint, 379 pieces of worked slate, 125 pieces of pumice, 61 artefacts of other stone, 12 artefacts of bone, 72 pieces of amber, and in all 40,010 potsherds of which 28,503 can be described as small fragments according to Hulthén (1974:29). To this may be added a few fragments of ochre and other materials, and approximately 40,000 unworked bone fragments.

Table 1. Decorated potsherds from Auve.

Decoration	Number of sherds	Weight (g)
Pits	799	5443
Cord	21	107
Whipped cord	2022	8162
Rows of knots	97	912
Various impressions	177	1355

The cutting and piercing tools produced and used at the site were made from flint and slate. In general, the flint technology was based on blades produced from cylindrical cores. Flint artefacts obviously were also often made from fragments of polished axes. A few of the axe fragments preserved sufficient original features to allow the conclusion that they came from thick-butted flint axes. The knapped artefacts include tanged points of all the ordinary types A–D, but with a marked preponderance of type B. There were also a number of scrapers and borers.

Slate was used mainly for points. Stone artefacts otherwise include grinding and polishing slabs and a number of pumice polishing stones. Amber had been turned into beads and buttons, which were found in several shapes, in addition to waste pieces. The amber finds from Auve by far out-number those from any other Norwegian site so far known.

The pottery, however, from several points of view constitutes the most significant part of the Auve finds. No completely preserved vessels were recovered, but several profiles have been reconstructed totally or, more often, in large parts. Many of the pots had a more or less marked shoulder and pointed bottoms, probably being intended to stand in the ground. Some vessels had flat bottoms also, and some had other shapes, such as biconical or rounded. The technical properties of the ceramics, including the matter, tempering, modes of production and so on, will be commented on by Birgitta Hulthén in the present paper. The vessels were mostly decorated. Undecorated vessels also existed, however, being sometimes small or perhaps having different functions; this still remains to be studied in detail. The decoration in most cases can be found on the upper parts of the vessels, where it could most easily have been seen when the pots were in use, i.e. when they stood in the ground. The decoration then could serve to identify the owners or different uses of different vessels. Decoration was stamped into the vessels prior to burning. The stamps used were of a number of different kinds. Some produced pits, and to judge from the numerous shapes of pits represented, many different pit stamps were in use, including a wide selection of sticks and bones. A few potsherds with cord impressions have been found too, most likely belonging to a single vessel. A cord tied into a row of knots seems to have been in quite frequent use. Most common, however, is the whipped cord stamp, which alone accounts for more than half the decorated potsherds. Table 1 gives rough numbers of the various types of decoration instruments represented, by number of sherds and by weight; "various impressons" covers such things as wedge signs, nail impressions and rings made with ends of bones. These instruments were used to produce a number of different patterns. Most are quite simple, consisting of different numbers of parallel, horizontal lines or, much more rarely, vertical ones. Slightly more complicated are combinations of horizontal and vertical lines, often with horizontal lines below the rim and vertical lines further down the side of the vessel. Horizontal criss-crossing or zig-zagging lines are quite common too, sometimes forming chevron patterns. The most complicated ornaments consist of lines in more than two, i. e. usually three directions, forming various angular patterns, or, curving, sometimes undulating lines.

Not all of these patterns occur with all of the instruments used. There are differences, too, concerning the types of pottery that have been decorated with the various types of ornament. This will be looked more closely into in the future.

Dating the Auve find along traditional archaeological lines is of course closely linked with the interpretation of the collection in cultural terms. However, the find is easily recognized as Middle Neolithic. It belongs to a rapidly growing group of south-Norwegian sites with similar pottery, decorated most often with pits and whipped cord ornaments, and connected with flint or quartzite artefacts made using the cylindrical core technique, and above all producing tanged points. This group of sites was connected with the then recently established Pitted Ware Culture by Hinsch (1955:94), an attribution which was repeated by Ingstad (1970) and renewed in quite comprehensive fashion by Skjølsvold (1977), who went to some length to date the entire group to a late part of the Middle Neolithic. To these scholars, the necessity for a late date was closely connected with the view that the dominating angular or criss-crossing, whipped cord ornaments were a cultural import from the Swedish-Norwegian Battle-Axe Culture, the so-called "J-pottery" of which was supposed to have been the source of inspiration for the Norwegian potters (Malmer 1962:29ff).

This interpretation was, however, viewed with some reluctance by such scholars as Bakka (1964a:163f; 1964b;1973:76f) and Indrelid (1972; 1994:296). To them, earlier possibilites for the origin of this cultural group, still mostly percieved as a Norwegian branch of the Pitted Ware Culture in most literature, had to be considered. This was supported when the surprisingly early radiocarbon dates from Auve (Østmo 1980) and certain Telemark sites (Mikkelsen 1975) began to appear, and even more so when Olsen considered the west-Norwegian sites belonging to this group in their entirety (Olsen 1992). Olsen suggested that the term "Pitted Ware Culture" be dropped throughout Scandinavia, and favoured the use of a wide concept of Middle-Neolithic Hunting Culture (Norw. *Mellomneolittisk fangstkultur*). This is however almost certainly too wide to be of much cognitive value, covering a very large and in several ways differentiated area. A somewhat more specific term, stressing the cultural elements rather than the purely economic ones, would be to use the term "Whipped Cord Ware Culture" (Norw. *Snorstempelkeramisk kultur*, abbreviated SKK), actually hinted at but rejected by Olsen (1992:147) for the Norwegian finds of this nature. It must be admitted that this culture has many links with the Swedish and (to some extent) Danish Pitted Ware Culture, above all concerning the flint technology and perhaps in some of the shapes of the ceramic vessels produced. But the geographical distribution of the sites, along with certain special developments in amber ornaments and the use of slate for points, and above all the quite independent style of pottery decoration provide the SKK with an archaeological identity of its own.

One main observation which has been a driving force behind establishing a separate SKK concerns the dating. The radiocarbon datings obtained from Auve certainly contribute to this. Pieces of charcoal from the cultural layer have been dated from 4380±200 BP (T-3437) to 3570±160 BP (T-3436). The larger part of the radiocarbon datings are however accelerator datings which have been carried out on charred food-remains taken from potsherds. The 35 accelerator dates so far obtained range from 4980±70 (TUa-137B) to 3595±60 (TUa-674), no fewer than 32 of these however lie within the range 4585±85 (TUa-740) to 4130±70 (TUa-673), which therefore probably represents the main period of occupation. This corresponds almost exactly with the range of datings obtained for the Middle Neolithic Funnel-Beaker Culture in Denmark (MN A), perhaps just touching the very beginning of MN B (cf. Tauber 1971:127; 1986; Østmo 1988:119).

These datings strongly support the idea that the SKK as represented in the Auve find should be considered a separate cultural entity from the Battle-Axe Culture. The origin of the SKK is still shrouded in some mystery, but it would seem reasonable to assume some kind of connection with the introduction of pottery to this part of Scandinavia at the latest during the early Middle Neolithic by the Funnel Beaker Culture (Østmo 1986). The SKK pottery emphatically is not TRB pottery, however, but must be considered as a separate development only originally inspired in as yet unknown ways by the TRB. One place to look for its early stages might be the settlement find from Hæstad, Høvåg, Aust-Agder county (Skjølsvold 1977:236f; the site was fully excavated after Skjølsvold finished his book), although this remains unpublished to date. There, pottery decorated in the main with cord impressions could represent one of the steps leading to the fully developed SKK.

A few comments concerning economic conditions are in order. From the situation of the Auve site one would generally assume hunting and fishing at sea to have been of prime importance, and this is amply confirmed by the bone fragments recovered during the excavation (Hufthammer in press). Sea mammals dominate, including seals and small whales. Fish bones are numerous too, with cod and haddock dominating. Several birds occur, mainly various species of duck. Among terrestrial animals, those bearing useful furs appear to have been most important, such as otter and perhaps also beaver. Importantly, no domesticated animals have been found; the pigs presumably were wild.

It has to be said that the strong maritime impression left by the bones from Auve does not seem to be confirmed by the analyses of the food-remains on the pottery. This calls for careful consideration. Preliminary thoughts about this might concern such topics as the representativity of bones as well as of charred food-remains. It must be remembered that settlement finds such as those from Auve, rich as they are, are only segments of what existed, and perhaps biased by unknown practices and conditions. It would seem likely that the food that was cooked in the vessels formed only part of the diet. Other foods may have been fried, grilled, consumed raw or cured in different ways as is still popular in Norway.

The ceramics at Auve

by Birgitta Hulthén, Lund

The most extensive artefact category at Auve, as mentioned above, consisting of pottery sherds, is a weathered and highly fragmented material. There are very few possibilities for reconstructing vessel shapes (mean value 1.74 g per sherd); 26% by weight consist of sherd fragments, i.e. sherds <1 cm^2 or sherds without their original surfaces.

In spite of these investigative obstacles the ceramics have been subjected to manifold analyses in order to establish the possibilities of local manufacture, the presence of special technological features and functional-related properties. Furthermore, the studies were focused on tracing and characterizing the nature of possible contacts between the Auve frequenters and the people of neighbouring areas.

The investigation has revealed information about the people at Auve and the peculiarities of their pottery craft. The lack of suitable clays, established through clay prospecting, indicates that the pots were most probably made at some other site than Auve. This in turn supports the hypothesis that Auve was a seasonal hunting station.

The manufacturing technique as it appears from the sampled material, when compared to the Swedish Pitted Ware ceramics, constituted a know-how of its own. The petrographic microscopy of thin sections has shown that most of the pottery was made out of sorted, somewhat silty, ferruginous and not calciferous clays tempered with crushed granite and/or bone. Tempering with burned, crushed bone in pottery has been observed at ten different sites in this part of Norway (Hulthén 1981).

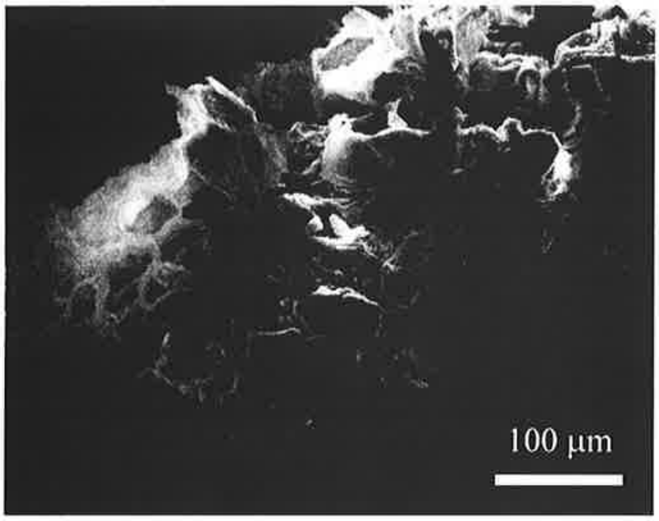

Figure 1. Scanning electron micrograph of vegetable cell structures in sample 8004. Collected from an ISI-III A SEM using PGT IMIX-system. Photo by the author.

The specific craft tradition, combined with the characteristic way of ornamenting the vessels, constitutes the quintessence of the new concept SKK (Norw. *Snorstempelkeramisk kultur*).

An important task for future research will be to shed light on the distribution and the origin of the SKK pottery. Is this a ceramic complex based on a more or less uniform economic structure or did variations regarding subsistence occur as a function of time and space? An answer to this question may yield important knowledge of the Norwegian Neolithic.

The charred remains on pottery at Auve

by Sven Isaksson, Stockholm

As mentioned earlier in this paper, organic residues were found adhering to some of the potsherds excavated at Auve. Five of these (nos. 2735, 4421, 5724, 8002 and 8004) were sent to the Archaeological Research Laboratory, Stockholm University, Sweden, for analysis. In connection with the ^{14}C-dating of some organic remains on the pottery mentioned above, $\delta^{13}C$ measurements were conducted. These proved to have terrestrial values, and it became important to establish whether the organic residues were of food-origin and also whether the type of food could be accurately determined.

An attempt was made, therefore, to extract and classify the various compounds present in most kind of food. The compounds to be targeted must have a fair chance of surviving the time in the soil and also have such properties that classification to different food sources is possible. The samples were investigated chemically for major elements, certain trace elements, lipids and proteins. Due to very small sample amounts in some cases, some discriminations had to be made. The analysis of lipids was given the highest priority, due to the preservation and classification potentials of lipids (Heron & Evershed 1993; Heron et al. 1991). All samples were investigated microscopically for visible morphological features prior to chemical analysis. The approach of using several parameters when analysing organic remains in pottery has become a sort of "trademark" for the work of the Archaeological Research Laboratory (Slytå & Arrhenius 1979; Arrhenius 1985; 1987; Hansson & Isaksson 1994; Hansson et al. 1993; Isaksson 1995).

As the amount of organic remains on sherd 4421 was found to be too small, this sample was taken out of the analysis. Sherd 2735 was found to consist of several pieces, of which three had substantial amounts of organic residues adhering. Samples were taken from all of these three sherds, named 2735I, 2735II and 2735III. The residue on sherd 5724 was very thin but enough for most analyses. Sherds number 2735II and 5724 were found to have been glued, and threads of glue was visible on several areas of the residues, something that complicated the sampling. Sample 8004 was adhering to the outside of the potsherd, judging by the curvature of the sherd. It also differed morphologically from the other samples. Sample 8004 lacked, to a great extent, the crackled surface often characteristic for food-remains. It also had a more grainy consistency than the other samples.

Samples were also taken for a closer examination in the scanning electron microscope (SEM). As yet unidentified vegetable structures were also found in sample 8004 (fig. 1). All investigated samples, with the exception of sample 8004, had a blistery inner structure, proving gas-formation (fig. 2). This may be the result of fermentation (Arrhenius & Slytå 1981:80–108). In every sample, except 8004, a grainy yellowish material was observed, embedded in the organic residues. To investigate the nature of this material and to compare it with the organic residues, samples were prepared for major element analysis using energy dispersive spectrometry (EDS). The instrument used is an ISI Super-IIIA scanning electron microscope and an analogue PGT energy dispersive spectrometer with a beryllium window detector end-cap. Analysis of collected X-ray data was done on the PGT integrated microanalyser for imaging and X-ray (IMIX).

From spectrum matching, using chi-squared comparison of the X-ray spectra, it appeared that the yellowish material embedded in the organic residue is most probably pieces of ceramic. They may have entered the organic material during use, for example as a result of stirring. In several samples of the organic remains high levels of iron were detected. This might be the result of leaching of iron from the soil, or from the ferruginous clay of the ceramic, into the organic material. If the iron originates from the food, this is an indication of blood or entrail food-stuff (*Statens Livsmedelsverk* 1988:196–219). Some samples had high levels of calcium. If not the result of leaching from the burial matrix or the bone temper of the ceramic, this might represent an addition of milk or bone, for example bone powder, to the food.

All samples of organic remains were characterized by high levels of phosphorus, which is in line with the accumulation of phosphorus shown in ceramic during use (Cackette el al. 1987). Again, some phosphorus may have been leached from the hydroxyapatite of the bone temper of the ceramic.

Due to lack of material only two samples were analysed for trace elements. Two elements, copper and zinc, were selected as they have proved to give characteristic signals. Zinc may be used to discriminate between animal and vegetable food; copper provides a signal for special animal food, such as crustaceans, shellfish and insects, having high levels of copper in their body-fluids. It is also reported that animal viscera, including guts, liver, kidney and brain, have high copper levels (see Lidén 1995a & b and references cited therein).

The samples were dissolved in acid and analysed by polarography, an analysis performed by Malgorzata Wojnar Johansson at the Archaeological Research Laboratory. No copper was found in sample 2735I, but 667.5 ppm was discovered in sample 2735III. Zinc was found in both samples at a level of 323.5 ppm in 2735I and 302.0 ppm in 2735III. The relatively high levels of zinc in samples 2735I and 2735III indicate an animal origin, and the very high level of copper in 2735III may indicate viscera food or crustaceans/shellfish/insects.

Lipids were extracted by chloroform and methanol (2:1, volume) in ultrasonic (2×15 minutes). The class-separation was done according to Henderson & Tocher (1992) on 10×10 cm silica gel 60 high-performance thin-layer chromatography plates (Merck 5631). The separated lipid classes were visualized by charring, using an oxidizing agent (5% sulphuric acid in ethanol).

The plate was scanned in an HP Scan Jet IIP, providing a 843×657 resolution image with 256 grey levels. The image was then analysed in the IMIX-system. The grey-scale image was converted to a colour-scale (pseudocolour) image. The significance of this is that the human eye can only discriminate about 20 grey levels at the same time, but about 350,000 different shades of colour. The pseudocolours thus convey details that otherwise would be lost in the grey scale image. On the IMIX system 11,000 colours can be displayed simultaneously (*PGT* 1994). The line profile function of the IMIX provides a presentation of grey levels along a line. Putting a line along the migration-path of a sample and acquiring a line

Table 2. Neutral lipid class composition of the samples. Rf=retention factor of standards (see main text), –=absence of class, +=presence of class.

Lipid compounds	Rf	2735I	2735II	2735III	5724	8002	8004
Polar lipids	0.00	–	–	–	+(?)	–	–
1,2-diacyl glycerols	0.21	+	–	+	–	–	–
1,3-diacyl glycerols	0.24	–	+	–	+	–	–
Sterols	0.24	–	+	–	+	–	–
Fatty alcohols	0.28	–	–	+	+	+	+
Fatty acids	0.33	–	+	+	+	+	+
Triacyl glycerols	0.73	–	+	+	+	+	+
Wax esters	0.92	+	+	+	+	+	+

Figure 2. Scanning electron micrograph of blisters in sample 2735III. Collected from an ISI-III A SEM using Polaroid 545 Land Film Holder. Photo by the author.

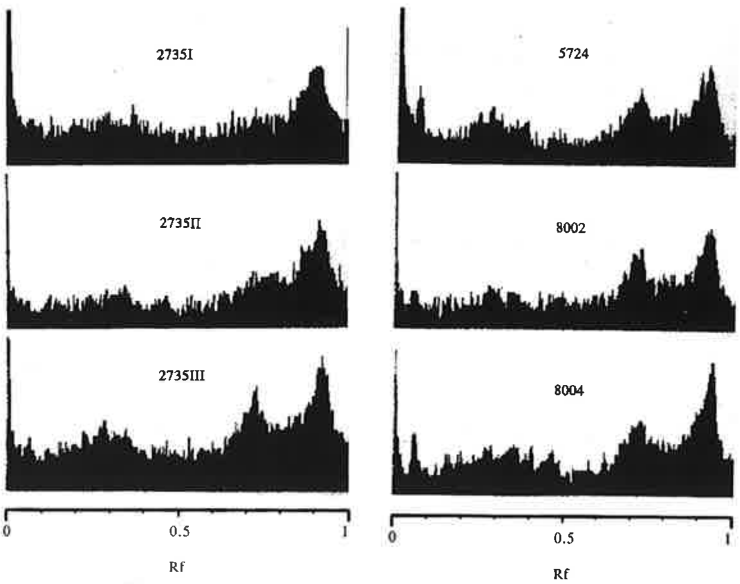

Figure 3. Line profiles from HPTLC plates.

profile provides a documentation of both intensity and retention of the different lipid classes in the sample (fig. 3).

The line profiles of the samples were compared with a wide range of standard materials, including tars, pitches, resins, waxes, and fats and oils of animal and vegetable origins. This helped to rule out some of the natural products possible. Being convinced of the lipid nature of the material, the lipid classes were identified by retention factor (Rf) comparison to standards. All samples contained wax esters in abundance. Also, quite high levels of triacylglycerols was detected, being the major component of natural fats and oils. Other classes are presented in table 2 and figure 3.

Comparison of the samples to modern storage lipids (like beef tallow), revealed signs of decomposition in the samples, mainly as higher levels of free fatty acids, resulting from hydrolysis. The relatively high levels of triacylglycerols indicated that the hydrolysis was incomplete.

Fatty acids present in the samples were converted to their corresponding methyl esters by acid-catalysed esterification and transesterification using 1% sulphuric acid in methanol. By this method both free fatty acids and *o*-acyl lipids are targeted (Christie 1989). After extracting the methyl esters by hexane, the samples were injected into a temperature programmed (fig. 4) HP 5890 gas chromatograph, equipped with a capillary HP-FFAP column (HP Part No. 1901F-115). In table 3 the result of the fatty-acid analysis is presented. The detector (FID) available during this analysis only provides a relative identification, so the identifications have to be carefully scrutinized. The two polyunsaturated fatty acids, linoleic (C18:2) and linolenic (C18:3) acid, proposed in table 3 are thus marked with question marks.

Using general patterns of stable, saturated fatty acids, it is possible to classify lipids to general categories of food (Isaksson 1996). Quantitative data on saturated fatty acids are used in a principal component analysis (PCA), using the *Statgraf* 3.0 software package. The approach is not free from problems. One is the use of modern foodstuffs as standards for the interpretation of prehistoric food-remains. But aiming at general categories like vegetables, animal and marine food is possible. Another problem is that the decomposition of unsaturated fatty

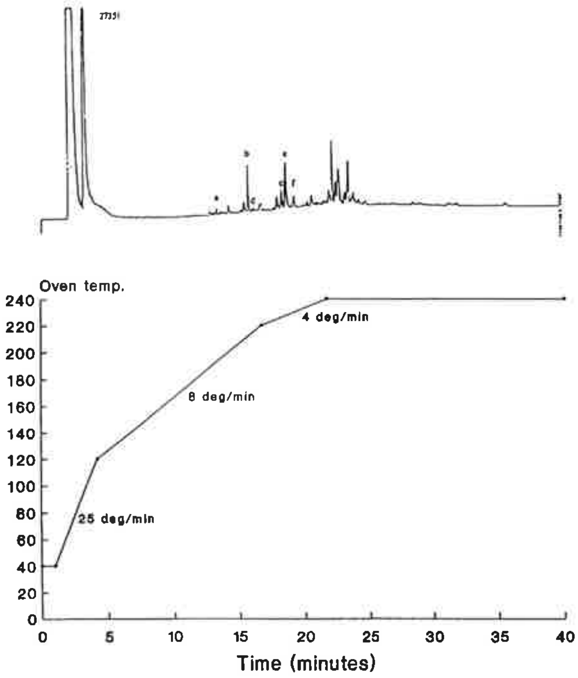

Figure 4. Top: Chromatogram of sample 2735I. Marked peaks are (a) myristic acid (C14:0); (b) palmitic acid (C16:0); (c) stearic acid (C18:0); (d) palmitoleic acid (C16:1); (e) oleic acid (18:1); and (f) linoleic acid (C18:2)(?), as their corresponding methyl esters. Bottom: Temperature-sequence of gas chromatograph. Injector temperature was set to 300°C and the detector temperature was set to 250°C.

acids may effect the composition of saturated fatty acids. Under waterlogged, anaerobic conditions the conversion of oleic acid (C18:1) to palmitic acid (C16:0) by the influence of soil micro-organisms has been observed (den Dooren De Jong 1961). The general environment of the site is not of this type, but again, this may have changed over time and the micro-environments of the depositions are unknown factors. In the case of charred deposits, the carbonization itself provides a protective wall of inert carbon protecting encrusted compounds (Evans 1990:8).

The amounts of the three most common saturated fatty acids, myristic (C14:0), palmitic (C16:0) and stearic (C18:0) acids, are used in the ratios C14:0/C18:0, C14:0/C16:0 and C18:0/C16:0. In figure 5 the first two

*Table 3. Results of the fatty acid analysis. The amount of the fatty acids are given in per cent of the total amount of fatty acids. *=unreasonably high value, due to colloidal particles in extract. – =absence, + =presence.*

Sample	Lipid content (µg/mg)	C14:0	C16:0	C18:0	C16:1	C18:1	C18:2?	C18:3?	C14:0/ C18:0	C14:0/ C16:0	C18:0/ C16:0
2735I	11.0	2.35	20.4	19.7	+	47.7	11.8	–	0.119	0.115	0.966
2735II	12.6	4.06	35.7	47.0	–	–	–	13.3	0.0864	0.114	1.32
2735III	11.9	+	51.2	48.8	–	–	–	–	–	–	0.953
5724	14.9	–	55.1	44.9	–	–	–	–	–	–	0.815
8002	19.0	–	50.2	49.8	–	–	–	–	–	–	0.992
8004	25.5*	47.0	43.5	9.54	–	–	–	–	4.93	1.08	0.219

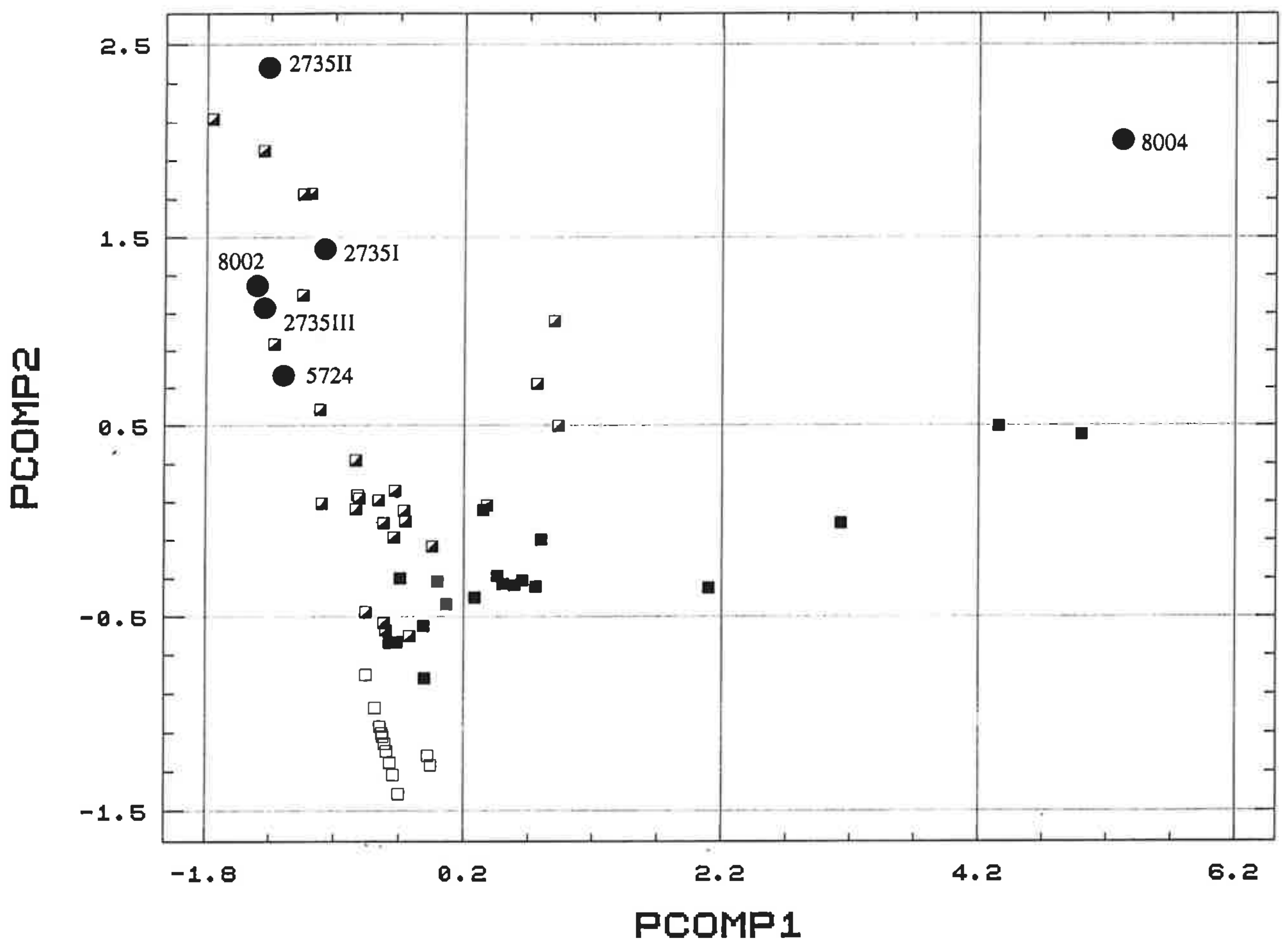

Figure 5. Graph of two first principle components, representing 89.9% of the variance. Samples are marked with filled circles and references with squares; filled squares are marine lipids, half-filled are terrestrial animal and unfilled squares are terrestrial vegetable lipids.

principal components are presented for the samples, compared with 59 modern food-stuffs collected from *Statens Livsmedelsverk* (1988). All samples fall within the terrestrial animal region, with the exception of sample 8004 which is not classified. Furthermore, the region in which the samples fall is dominated by viscera food, like liver, kidney and heart.

If conversion of C18:1 to C16:0 had occurred in these samples the C18:0/C16:0 ratios would have been unreasonably low. No such signs were observed.

Monounsaturated fatty acids autoxidize rapidly at elevated temperatures (Kumarathasan et al. 1992). The lack of monounsaturated fatty acids in most samples may indicate that they have been exposed to heat, if not the result of decomposition.

The protein content analysis was conducted according to Lowry et al. (1951). The proteins were extracted by 1.0 M sodium hydroxide and coloured by Folin phenol-reagent. The reading was done spectrophotometrically at 500 nm and the quantification was made using a standard series of bovine serum albumin.

The proteins were hydrolysed by 6 M hydrochloric acid, and the free amino acids were separated on cellulose HPTLC plates (Merck 5787). The separation was conducted in two dimensions according to Heathcoat & Hawort (1969). Colouration of separated amino acids was made with 0.1% ninhydrin (Merck 6758), and the identification was done by standard comparison. Scraped-off acids were extracted by a methanol/Cd-solution, and quantified spectrophotometrically at 494 nm using standard-curves.

The protein content of 2735II was too low to be analysed for amino acids, and of 8002 there was not enough material. In general, the amino acid compositions of the samples are incomplete, and several common amino acids are missing (table 4). Many of these are seldom or never found in archaeological samples, because of their instability.

An indication of the degree of decomposition of the proteins may be achieved by the amount of amino acids per total protein content. A yield of about 20 mg amino acids per 100 mg protein is relatively good under archaeological circumstances. This provides certain confidence for the results of sample 2735I and 2735III. It is not likely

Table 4. Results from the protein analysis. The amount of each amino acid is given in milligrams.

Amino acids	2735I	2735III	5724	8004
Leucine (Leu)	3.48	12.5	2.98	-
Glycine (Gly)	-	-	0.65	-
Glutamic acid (Glu)	1.42	0.06	0.28	0.28
Methionine (Met)	0.24	+	0.72	-
Serine (Ser)	10.8	-	0.62	0.45
Alanine (Ala)	0.92	4.42	0.41	0.16
Phenylalanine (Phe)	-	2.29	0.58	-
Aspartic acid (Asp)	2.82	0.82	0.75	0.51
mg a.a./100mg protein	19.7	20.1	6.98	1.41
Glu/Met	5.94	-	0.39	-
Glu/Ala	1.54	0.0138	0.696	1.76
mg protein/100 mg sample	2.87	2.53	3.19	5.08

that these have been exposed to any extreme conditions. Sample 5724, with 6.98 mg amino acids per 100 mg protein, is much worse preserved. The ratio of sample 8004, being only 1.41 mg amino acids per 100 mg protein, confirms it as being heavily decomposed.

To use amino acids for classification of ancient food is problematic and in some cases even doubtful. Too little is known of the decomposition processes involved and of the effects of migration in the soil. It is important to have this in mind when considering the following interpretation attempt. This is based on unchanged modern reference material, where it has been observed that the relations of glutamic acid (Glu) to methionine (Met) and alanine (Ala) are low (Glu/Met <6, Glu/Ala <2.5) in animal proteins, while they are high (Glu/Met >7, Glu/Ala >3) in vegetable proteins (Arrhenius & Slytå 1981:89; Lidén & Isaksson 1993).

It is not possible however to separate between marine and terrestrial sources by these means. Only samples 2735I and 5724 contained measurable amounts of all three amino acids, then being of animal origin.

Conclusion

The presence of several compounds common in nutrients is evidence for the organic residues to be of food origin. Through the neutral lipid class separation it was possible to rule out certain natural products, such as tars, resins, bees wax and so forth. The elemental analysis provided proof for the inclusion of pottery fragments in the organic residue. This indicates some mechanical treatment, like stirring, giving clues as to the consistency of the original content being soup-, stew- or porridge-like. The organic remains contained high levels of phosphorus.

The results concerning classification are summarized in table 5. Most samples analysed for lipids, proteins and trace elements (Zn, Cu) show terrestrial animal characteristics. The copper level in sample 2735III and the fatty acids of all samples except 8004 indicates viscera food. The presence of iron in most samples may indicate the same, and a high level of calcium in sample 2735I might indicate addition of milk or bone powder. These two last elements are more likely the result of leaching from soil-minerals or ceramics.

All samples, except 8004, show a morphology that may indicate fermentation. Through experiments it has been shown that fermentation is a way to increase the nutritious value of food (Arrhenius & Slytå 1981). It also improves the keeping qualities of the food, and is still a method used for curing, and to attain the special taste. The most commonly and easily used fermentative bacteria are the lactic-acid bacteria, like *Lactobacillus* and *Pedicoccus*. These bacteria are naturally present in most food, and are commercially important today in the dairy industry as well as in sausage pickle and sauerkraut production. By changing the environment in the food, the desired organisms attain an ecological advantage which enables them to outdo competing, undesired organisms. During lactic-acid fermentation the micro-organisms use up carbohydrates (sugars), forming lactic acid. When fermenting meat and meat products one normally has to add carbohydrates (Molin & Ternström 1978). Since carbohydrates (such as monosaccharides and polysaccharides) are most common in vegetables (fruits, nuts, acorns, seeds and roots) it may be that some vegetables were included in the original dish, without leaving any trace. Experiments conducted by Arrhenius and Slytå (1981) showed destruction of vegetable cell structures during lactic-acid fermentation. The vegetable structures found in the unfermented sample 8004 may support this interpretation.

Sample 5724 has most probably been exposed to heat, and the same may also be true of samples 2735II and 8002. This might have happened if fermented food was heated before

Table 5. Summary of the results. B=blisters detected, C=presence of charcoal, V=other vegetable remains, A=animal origin (trace elements and proteins), TA=terrestrial-animal origin (lipids), -=no result, n=not analysed, ×=classification not possible.

Sample	Morph. features	Trace elements	Lipids	Proteins	Notes
2735I	B/C	A	TA	A	Terrestrial animal. Fermented. No heat.
2735II	B/-	A	TA	n	Terrestrial animal. Fermented. Heat(?).
2735III	B/-	n	TA	(A)	Terrestrial animal. Fermented. No heat(?).
5724	B/-	n	TA	A	Terrestrial animal. Fermented. Heat.
8002	B/-	n	TA	n	Terrestrial animal. Fermented. Heat(?).
8004	NB/V	n	×	(A)	Not fermented. Heavily decomposed. Heat.

eating; the cooking of fermented food is known from ethnological records in Sweden (Keyland 1919:49). It is also possible that the food-stuffs were exposed to heat after being taken from use. Sample 8004 was suspected to have adhered to the outside of the pot, and differs also from the others in most analyses. It is most probably a strongly charred foodspill.

To make the cultural historical inferences of these results is challenging. The topic of representativity has already been mentioned by Østmo, and as he discusses, some answers may lie hidden in the divergent subsistence data provided at Auve, by the osteological material on one hand and by the composition of the organic remains on the other. One possible interpretation of this variation is differing culinary practices for different raw materials. Another, not in diametrical opposition of the first one, is that the food in the pots are not to be connected directly with the activities at Auve. Hulthén's statement that the place of pottery manufacture was at some other site than Auve, and the curing of food by lactic-acid fermentation may indicate that the food in the pots constitutes provisions brought to this coastal site from a more inland one.

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