CHEMICAL ANALYSES OF ORGANIC REMAINS IN ARCHAEOLOGICAL CONTEXT

BIRGIT ARRHENIUS

The archaeological research laboratory, University of Stockholm,
S-106 91 Stockholm

The study of organic remains on pottery is a part of a more general interdisciplinary work on "Diet and Nutrition in ancient time" which we are doing in the Archeological research laboratory at the University of Stockholm.

The work started with analyses of cultural deposits, where it appeared that layers with a high phosphate content had also increased percentages of other elements as Cu, Zn and Fe. It could be demonstrated that in cultural layers from Stone age settlements in Northern Sweden there were high copper percentages the values often being more than 3 or 4 times the highest known value for undisturbed soils in Sweden (Arrhenius, et al., 1981).

The cultural deposits with a high phosphate content seem mainly to consist of feces and other organic waste material and I have therefore hypothesed that the high copper percentages may derive from an intake of copperrich food. It has earlier been shown that soil samples from shale middens from Florida had high copper content (Sokoloff and Carter, 1952). As mollusces are generally known to have a high content of copper it is in this case natural to assume that the copper derives from a high intake of mollusces. In Northern Sweden is however a larger intake of mollusces rather unlikely although shales of Mytilus edulis have been found (Broadbent, 1979). I have therefore proposed that the high copper content (Arrhenius, 1981, 39) derives from heamocyte based on copper and characterizing the blood of insects. In Norrland maggots from mosquitos, found in great abundance in the stremlets in spring and early summer as well as larvae found behind the birch bark could have been the actual food.

Another part of this study was to trace the copperrich diet in the bone samples. As there has been raised some doubts about copper being suspect as dietary discriminants in bone (Lambert et al., 1984) because of the influence of the surrounding soil we have added another element, selen to our analyses. In Sweden the soil is in general very poor in selen and the selen found in the bone would therefore be of dietary origine. With the selen we hope also to be able to discriminate between an intake of sea food and freshwater fish. We also would like to link our studies to Taubers important work on stable isotopes in the bones (Tauber, 1981).

We already know that cultural layers from the early urban sites usually have a high zinc content, probably because an important protein resource consisted of fish. Our work with analyses of human bones is a research which is still in progress.

Another line of our studies has been to examine how the trace element concentrations got fixated in the cultural deposits. We made in this connection several analyses of a heap of manure from cattles to learn what is happening when the manure is de-

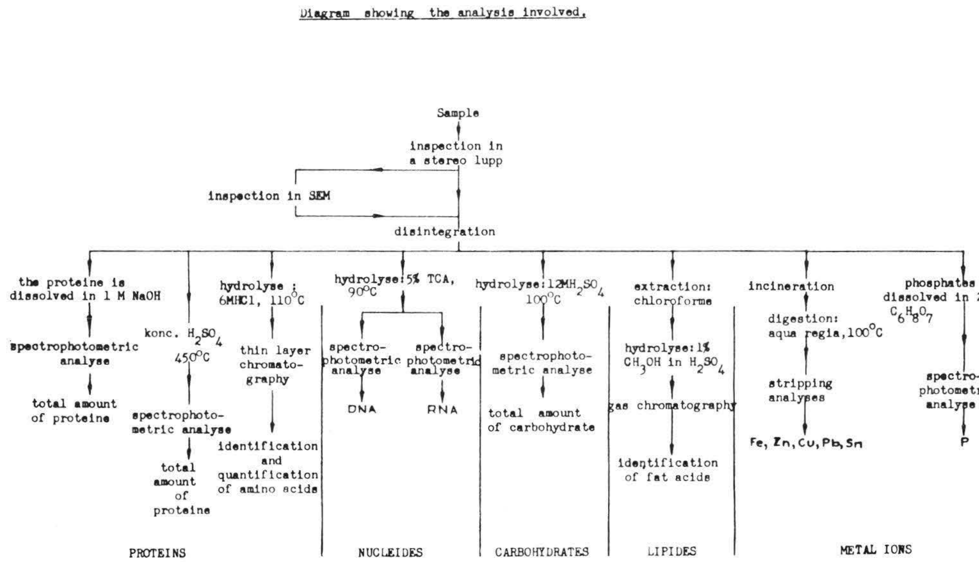

Fig. 1. Scheme showing the analysis used for the organic residues found on pottery sherds.

caying. These studies (Arrhenius 1981, 73—79) showed that the trace elements and amino acids got highly concentrated during the fermentation process.

With these experiences in mind I determined to examine the organic remains often found on pottery sherds. I had earlier done preliminary analyses of such remains from Birka, a Viking age trading post and knew that these remains contained proteins with clearly distinguishable amino acids. Several archaeological publications have notes on organic remains found on pottery, but these analyses gives mainly the inorganic components as carbon and it has generally been assumed that these remains come from food which has been burned on the inside of the pot.

The occurrence of several amino acids as well as lipides which I also had found showed that the burning temperature must have been rather low as e.g. the amino acids decompose around 200°C. A characteristical trait on these remains is also that no cellular structures are found. The remains are built up of charred material with no structure inside but a surface showing minor depressions of a kind found for example on a pudding getting stiffened, cf. fig. 2. I therefore felt that the charring of the remains must have happened in another way than simply by burning. My hypothese based on several analyses which we carried out in the laboratory on finds from the following sites:

Analysed organic remains (Several sherds in each place).

Löddesborg, Scania	Early neolithic (Late mesolithic)
Ire, Gotland	Middle neolithic
Hallunda, Södermanland	Late Bronze age
Björklinge, Uppland	Early Iron age
Birka, Uppland	Viking period

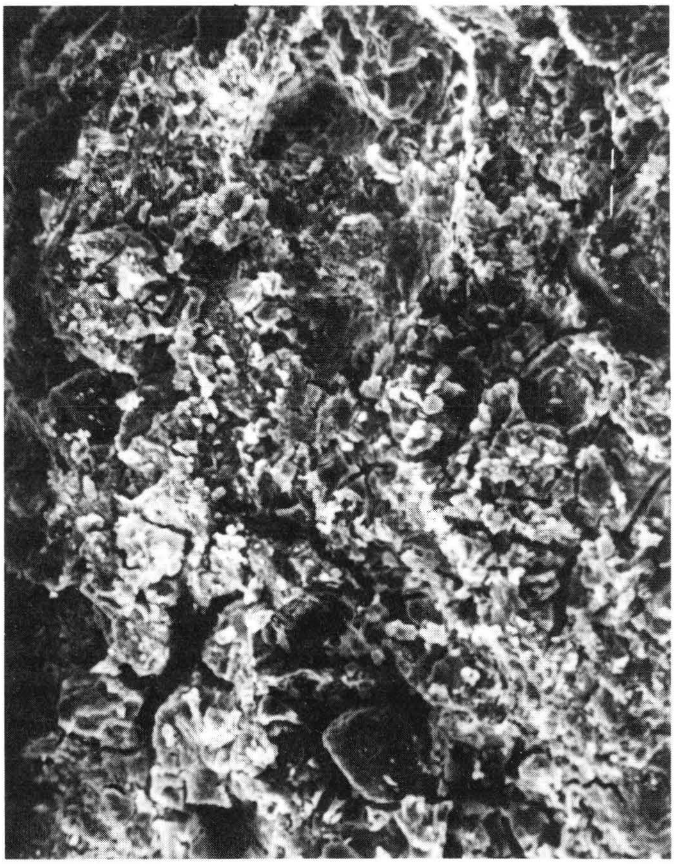

Fig. 2. Sem 700× from an organic residue from a potsherd from Löddesborg, early neolithic period.

The analyses made, are demonstrated on the following scheme (cf. fig. 1).

The amount of protein found on the sherds can vary from 1—20 per cent of the remains depending on the decomposition rate and the size of the sample. We have found that a sample which contains less than 5 mg protein does not give a relevant spectra of amino acids. In general it also seems as if the protein is better conserved when also lipides were found.

I should also add that according to my experiences analyses or remains on one or two pot sherds give very little relevant informations in comparison with what you can get if you scan through a larger number to find residues with a fairly high protein content.

Using these methods we found 13 different amino acids with varying concentrations. Of these 7 belong to the essential amino acids. In all our analyses the amino acid, glutamine, had one of the highest values. Another acid which occurred rather frequently although with much lower values was lysine. Glutamine and lysine are found in both animal tissues and vegetabiles. The quotinent is however different as lysine occurs with a frequency which is almost double in animal tissues compared with what is known from vegetables, corn and nuts. I have therefore taken the quotinent between glutamine and lysine as a method to discriminate between animal protein and vegetabile protein.

Other interesting amino acids in the analysed proteins were alanine, aspargine and arginine. Alanine, although frequent in animal protein also have a rich occurrence in vegetables, specially in different kind of cereales. This is of special importance as we did not find alanine in the oldest analysed residues from Löddesborg in Scania, a site from the transition period from mesolithic to neolithic time (Jennbert, 1984). In a later period, e.g. the middle neolithic period alanine occurs relatively frequently and is thereafter found in all our analysed samples.

Aspargine is an amino acid that among vegetables occurs specially frequent in hazelnuts. This is also characteristic to arginine which has one of its largest frequencies in hazelnuts. As both these aminoacids had a high frequency in our analyses it seemed probable that both hazzelnuts and cereals were important parts of the residues.

We found traces of fats in almost all residues but the fat content was usually very small — around 1 per cent or less. With these small values we could only use a gas

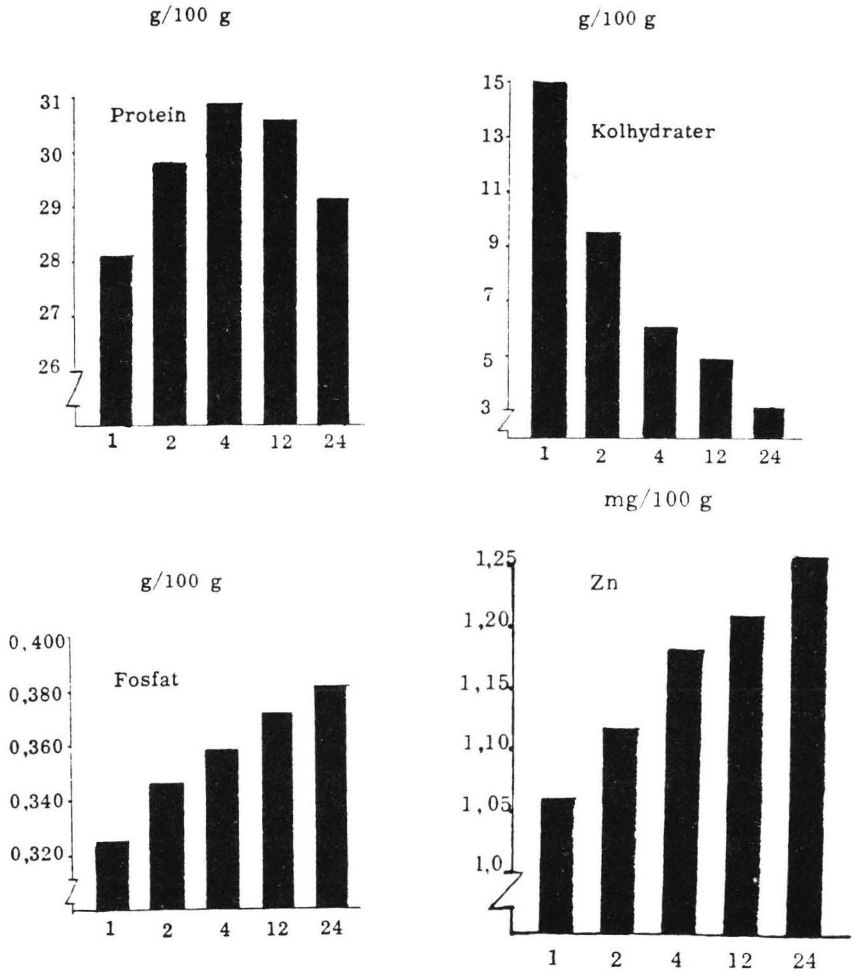

Fig. 3. Diagrams showing the increase and decrease of different elements during the fermentation process. Horizontal axis = number of weeks. Vertical axis = amount of element in g or mg/100 g of sample.

chromatograph for identification. We have found traces of saturated fatty acids as palmitine and stearine which may derive from animal substances but also from unsaturated acids as linol and linolen, which could have a vegetabilic origine. It should also be added that we only found very small traces of cholesterol, probably due to that the cholesterol had decomposed through oxidizing.

Finally our analyses of the trace elements showed a fairly high iron content and this made us guess that an important component in our mixtures were blood which also would explain the minor occurrence of the saturated fatty acids.

Hypothesing that the analysed remains were organic residues from a fermentation process we determined to produce porridges of these types and let them fermentate to see if we would get results which could be compared with the ancient residues.

We followed these porridges for 24 weeks, e.g. 1/2 a year and in this period our porridges after a horrible stinking got an appearence which indeed was very close to the ancient remains. Like these we got charred residues with no cellular structures but with minor depressions in the surface.

In our analyses (fig. 3—4) we could note how the organic material got very concentrated during the fermentation process. In this microbiological activity the carbohydrate was used whereas the acidity decreased and all other elements increased.

Of great importance was however that the fermentation process did not alter the relations between the different amino acids — the increase in per cent had solely to do with the consumption of the carbohydrates cf. fig. 4.

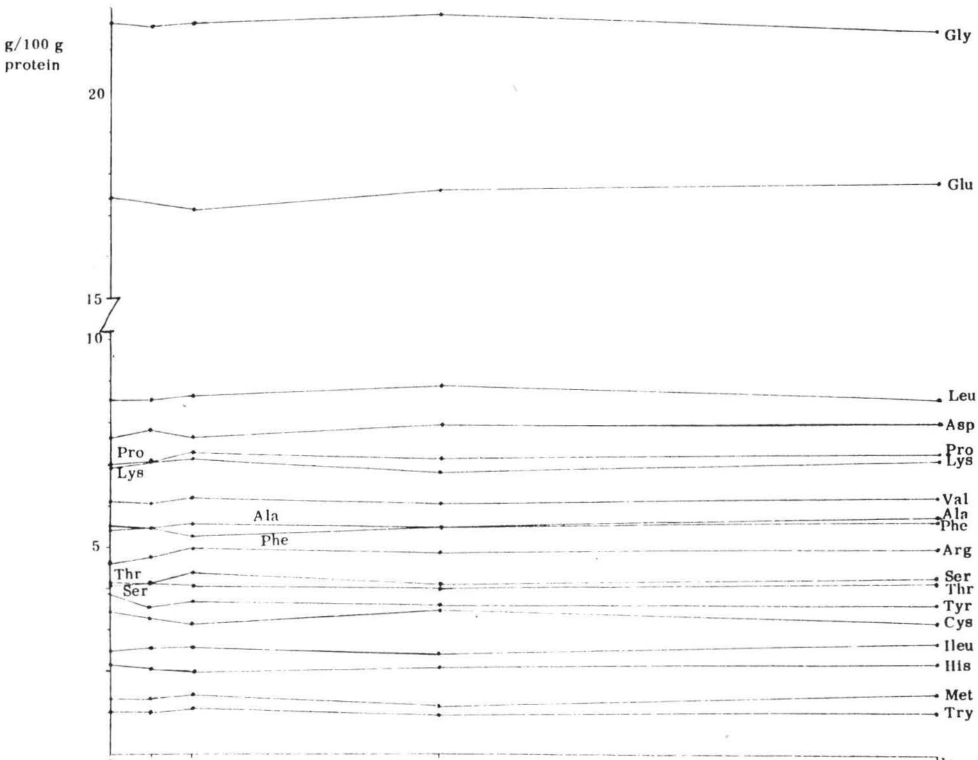

Fig. 4. Diagram showing the stabile concentration of different amino acids during a fermentation process of up to 24 weeks.

There is one difference between our modern porridges and ancient and that is that the lipids were more distroyed in the ancient porridges. Specially this could be notised with cholesterol which easily get oxidised and decomposed, a tendency which we as a matter of fact already could trace in the modern porridges. Altogether it seemed that the modern porridges corresponded well with the ancient residues.

Let me finish this presentation with quoting a recipe from the Swedish folklore called "blodpalt". You take salted blood and mix it with rye flower and leave it to ferment in three weeks. Then you bake them to long rolls and eat them with a milk gravy.

You may notice that in this recipe the blood was salted. The salt is a technique to keep the pH at the right level to get a fermentation with the right microbes. Another way to get this (well known when you do sour milk or leavened bread) is to keep a little piece from an older production. The ideal pot in which you get this is unglazed ceramics where the microbes can be kept in the pores.

I would believe that this capacity was a very important promotion for the introduction of ceramics as food containers as we know of this kind of porridges from early neolithic — a period when also pottery manufacture started.

REFERENCES

Arrhenius, B., 1981. Analys av fermenterade blodgrötar, Spårämnesanalyser av organiskt material från arkeologiska undersökningar, Rapport från Stockholms universitets arkeologiska forskningslaboratorium, Nr 1, 1981. Stockholm.

Arrhenius, B., Slytå, K., Sundlin, H., 1981. Fosfat och spårämnesanalyser av arkeologiska jordprover från Åsele sn. Spårämnesanalyser av organiskt material från arkeologiska undersökningar. Rapport från Stockholms universitets arkeologiska forskningslaboratorium, Nr 1, 1981. Stockholm.

Broadbent, N., 1979. Coastal Resources and Settlement Stability. Aun 3. Uppsala.

Jennbert, K., 1984. Den produktiva gåvan, Tradition och innovation i Sydskandinavien för omkring 5300 år sedan. Lund.

Lambert, J. B., et. al., 1984. Copper and barium as dietary discriminants. The effects of diagenesis. Archaeometry, Vol. 26. Oxford.

Slytå, K., Arrhenius, B., 1979. Organiska analyser, årsredogörelse 1976—1979, Rapport från Stockholms universitets arkeologiska forskningslaboratorium, Nr 3, 1979. Stockholm.

Sokoloff, V. P. and Carter, G. F., 1952. Time and Trace Metals in Archaeological Sites, Science 116, 1—5.

Tauber, H., 1981. ^{13}C evidence for dietary habits of prehistoric man in Denmark, Nature, Vol. 292, july 23, 1981.

Wigglesworth, V. B., 1972. The principles of Insect Physiology. London.