STANDARD GEOLOGICAL METHODS USED ON ARCHAEOLOGICAL PROBLEMS

P. NØRNBERG[1] and M.-A. COURTY[2]

[1] Institute of Geology, University of Aarhus,
DK-8000 Aarhus C

[2] Institute du Quaternaire, Université de Bordeaux I,
F 33400 Talence

Abstract

This paper presents some examples of geological methods applied to archaeological problems. The site is an Iron Age village at Heltborg, Thy, Northern Denmark. The very thick layer of occupation material found in this and other Iron Age villages in the area seems to come from the accumulation of grass turf walls of the houses. This explanation can be confirmed by the geological methods. The boundary between a brownish and a more gray horizon in the occupation material can be explained as a redox boundary. As such it is not related to any archaeological event and in fact crosses the archaeological horizons in the material. Micromorphological methods were used, especially on samples from a burnt house. Here it was possible to identify the floor material as till and to identify wattle and daub material. It proved possible even to give a likely estimation of the appearance of the wall and the technique used in preparing the inside of the house.

Introduction

An iron age settlement at Heltborg, North-West Denmark, was excavated by the Museum of Thy at Thisted (Beck, 1984). During the excavation several questions arose to which we tried to find answers by using some standard geological methods. From earlier studies we know that geological methods can give valuable information on prehistoric geomorphology (Nørnberg, 1979), the early environment (Nørnberg, 1980), buried soils (Dalsgaard and Nørnberg, 1980) (Nørnberg and Dalsgaard, 1982). In particular, soil micromorphology is a useful tool on solving archaeological problems (Courty and Fedoroff, 1983) and (Courty, 1984).

In the present case we have tried to combine a number of methods to gather geological/archaeological information from the site. The main question to be answered is the origin of the massive occupation layer. Secondly, in the occupation layer one can distinguise two horizons which differ slightly in colour. The question is whether the colour difference is due to some archaeological event or was caused by environmental differences. Finally, a few samples were taken from a burnt house to see what could be learnt about the house construction materials by means of mircomorphological methods.

Methods

As far as possible the description of the materials and the laboratory analyses were carried out according to the American Soil Taxonomy (U.S.D.A. 1975). Apart from bulk density, the laboratory analyses were carried out on material < 2 mm. Data given are based on 110°C dry samples. Texture analyses were carried out on 50 g samples treated with 6 % hydrogen peroxide to remore organic matter. The samples were separated by wet sieving at 38 μm. The > 38 μm fraction was dry-sieved for 20 minutes using ASTM standard 20 cm sieves and the < 38 μm fraction sedimented in Andreasen pipettes. Samples for bulk density were taken by means of steel tubes of known volume. pH was measured in a 1:1 soil/water mixture. Organic carbon was determined by dry combustion and weighing of the carbon dioxide generated. Nitrogen was determined by the Kjeldahl method. Free iron and aluminium were extracted by the dithionite-citrate method according to Mehra and Jackson, 1960. Ferrous iron was determined by the HF method by Begheijn (1979). Undisturbed samples were taken in Kubiena boxes (15 × 8 × 5 cm) or smaller metal boxes, and impregnated with polyester resin. From these 6 × 12 cm thin sections were prepared.

Thickness of the occupation layer

At a number of sites in the Thy area the Iron Age settlements have very thick occupation layers (Beck, 1984). At the Heltborg site the culture layer was about one metre

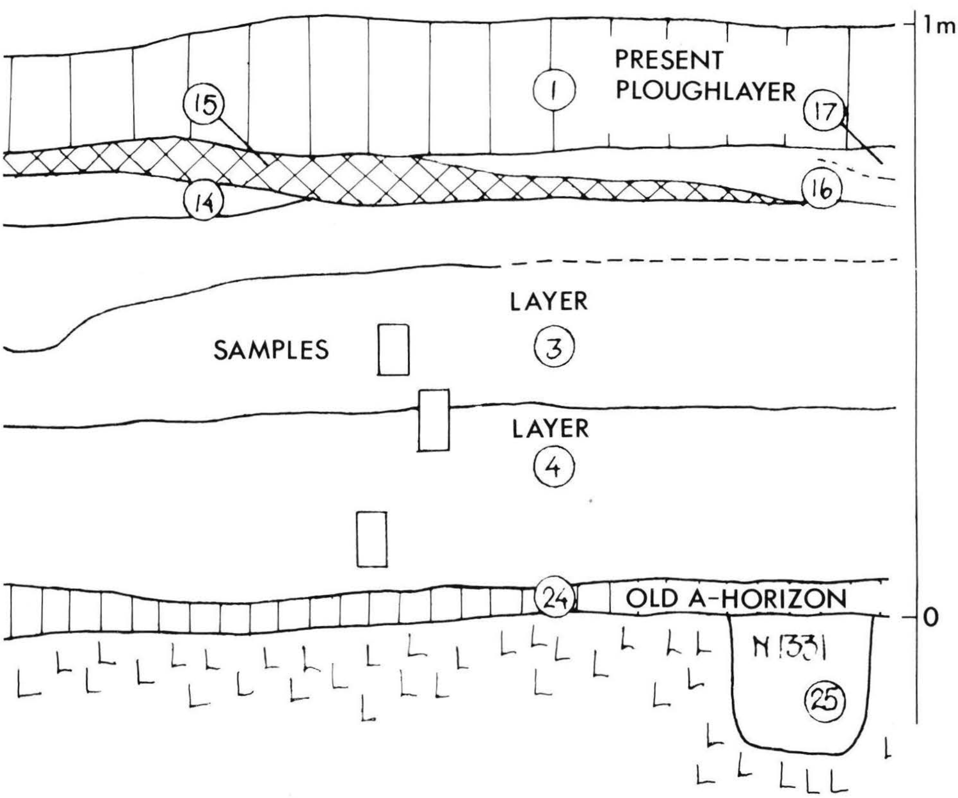


Fig. 1. Profile section of occupation material showing the thickness of the occupation layer and the brownish (3) and the grayish (4) horizons. Partly after Beck 1984.

Table 1, General analysis

Horizon	Texture, % of material <2 mm											Bulk dencity g/cm^3	Org. C %	C/N	pH		Free oxides		HF
	2-1 mm	1-0,5	0,5-0,25	0,25-0,125	0,125-0,063	0,063-0,032	0,032-0,016	0,016-0,008	0,008-0,004	0,004-0,002	<0,002				H_2O 1:1	KCl 1:1	DCB %Fe	DCB %Al	FeO%
layer 3	1,15	2,70	11,22	14,73	15,55	16,70	7,31	7,06	4,91	4,32	14,38	1,59	0,89	9,2	5,60	4,18	0,917	0,347	0,0245
layer 4	0,74	2,14	9,29	13,40	14,96	17,51	8,57	7,43	6,06	5,11	14,79	1,63	0,89	8,5	5,38	3,89	0,905	0,329	0,0238
																			0,0272
																			0,0317

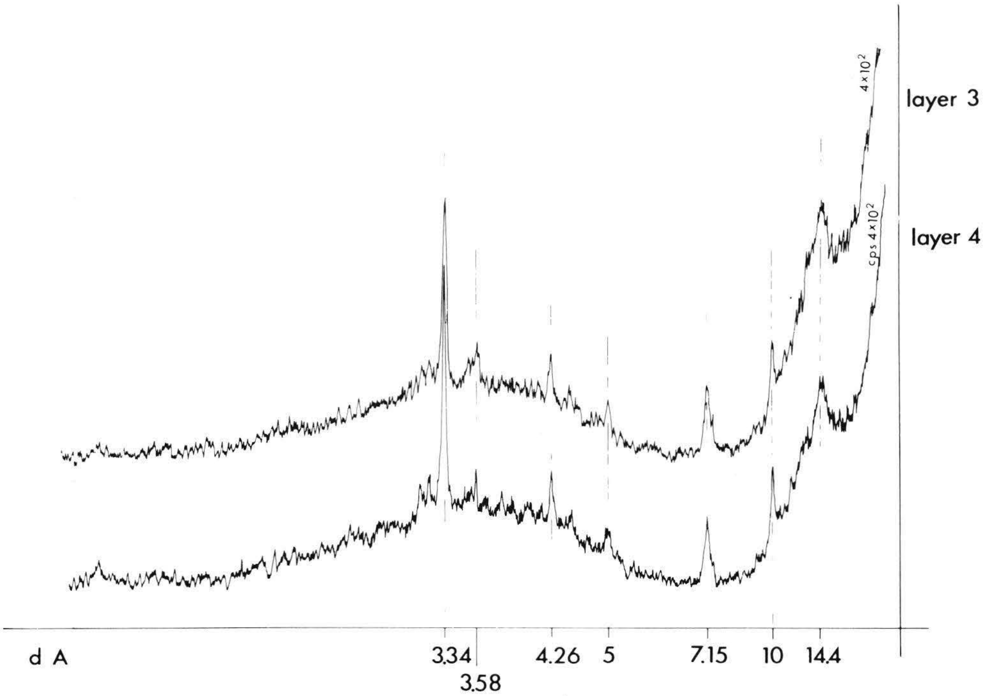


Fig. 2. X-ray diffractograms of the two samples from layers 3 and 4. The characteristic d values in Ångstrøm for a number minerals are indicated. 14.4, 10, 7.15, 5, 3.58 and probably part of 3.34 represents different clay minerals; 4.26 and 3.34 represents quarz. At 3.18, 3.24 there are small feldspar peaks.

thick over an area of more than one ha, fig. 1. The settlement was situated at the top of a rounded hill, and it was therefore impossible that natural slope processes could be responsible for the accumulation.

Bulk density of the material showed that compaction was insignificant, table 1. Organic carbon and C/N ratio showed that there has been almost no destruction of organic matter. The occupation layer is most likely of about the same thickness as it was at the end of the Iron Age occupation. According to Beck (1984) this occupation lasted as a very stable state for about 300 years. We discussed at the site whether it was likely that a large part of the occupation layer was wall material from demolished houses and reached the conclusion that it was. If one assumes that within an area of one ha there were 20 houses with an average wall length of 25 metre and that the grass turf walls were 1 metre thick and 1.5 metre high, the walls' total volume was 750 m^3. With a life time for houses of 20 years and 300 years for the settlement, this adds up to 11.250 m^3 of wall material equivalent to an average thickness of about 1 m. The micromorphology of samples from a burnt house within the excavation area shows that the material just outside the floor edge can be interpreted as grass turf material (see the micromorphological descriptions below).

Colour differences between two layers of occupation material

In many parts of the excavation area it was possible to see a difference of colour between two horizons in the occupation material. Usually, this colour change takes

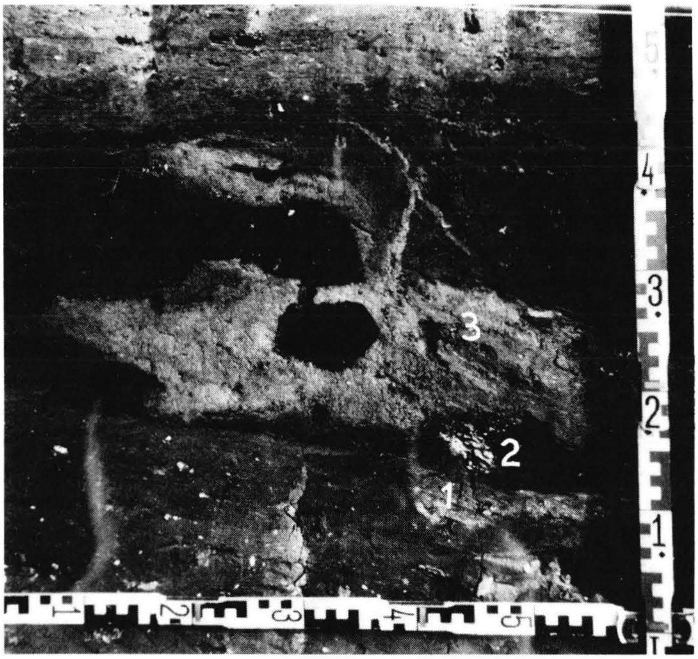


Fig. 3. Photograph of a section through the corner of a burnt house. 1. the floor of the house, 2. burnt wattle, 3. the red and black burnt parts of the wall.

place at a depth of just over half a metre. The Munsell colour of the upper horizon, layer 3, is dark yellowish brown 10YR 3/4 and the lower one, layer 4, dark grayish brown to very dark grayish brown 10YR 4/2—3/2.

Texture analysis of the two horizons showed that the particle size distributions were not significantly different, table 1. The organic carbon content was the same in both layers. The C/N-ratio in the upper horizon is slightly below that in the lower one.

pH was slightly lower in the lower layer and so were total extractable free oxides, DCB iron and aluminium. There was slightly more FeO in the lower horizon which is in agreement with the grayish appearance. X-ray diffractometry of the clay and fine silt fractions $< 20\ \mu m$, fig. 2 showed that the two layers had the same mineralogical composition. The colour difference is therefore most probable caused by differences in the water saturation conditions, which gives rise to lower redox conditions in the lower layer. This in turn causes a slight difference in the iron compounds which is responsible for the yellowish brown or grayish brown staining.

The burnt house

Three samples were taken in the remnants of a burnt house. In the field four types of material belonging to the house were clearly distinguished:

— a grayish deposit at the bottom of the burnt house and assumed to be the floor, fig. 3,1
— a very dark material looking like charcoal and interpreted as burnt wattle, fig. 3,2
— a brownish red and a brownish black material interpreted as the baked remnants

of clay walls, the difference in colour resulting from differential baking, fig. 3,3. In this last material one can see alternating orange and black straight lines. These were provisionally interpreted as burnt clay daub overlying a small burnt branch (the black line).

The structures observed in the field were clear, while their interpretation was not correspondingly obvious. Soil analyses were therefore carried out on samples from the house in order to obtain more information on the nature and the origin of the materials used for the construction. We wanted to see whether it was possible to identify the wattle, some kind of daub, remnants of walls and any other materials, to see what influence the burning had on these materials, and how deeply they were affected by natural aging.

1) The greyish deposit

It consists of poorly sorted, well rounded quartz sand grains (200—700 μm) and silt mica flakes associated with a micaceous fine fraction with some patches of non birefringent brown fine fraction. This last is very rich in organic matter and strongly reworked by biological activity. A few limestone sand grains, strongly etched were observed. Some diatoms were also determined in the fine fraction. The upper millimetre of the deposit have a reddish colour and the fine fraction is thus enriched in microparticles of calcium carbonate. Some hydromorphic features were observed in this deposit and interpreted as channels impregnated by iron.

The micaceous sandy material seems to have a till origin. It is mixed with organic matter the origin of which is not clear. It does not seem to be anthropic as no typical charcoal was observed; it could be some kind of grass turf mixed with till. The diatoms and remnants of calcareous fragments indicate the presence in the till material of chalk which is now completely dissolved, leaving only a few ghosts and the silica fossils.

The hydromorphy observed is the consequence of strong compaction. It is likely that this compaction is the result of some kind of trampling during the occupation. Taken together the observations confirm the grayish deposit as the house floor. This floor has only been slightly affected by the burning: only the very upper part is burnt, the calcium carbonates is the result of transformation of organic matter through the burning, while the reddish colour results from the transformation of clay.

2) The very dark material

It consists of burnt organic matter mixed with a few fine sand grains (bottom of plate 1); plant structures are very badly preserved. This layer is probably some kind of wood structure, perhaps partly of wattle, burnt under reducing conditions.

3) The brownish red and the brownish black materials

The transition between the very dark material and the brownish red material is marked by a thin (5 mm) light grayish layer (plate 1). This is very rich in amorphous fragments of silica, many of which are diatoms about 30 μm wide and 100 μm long, see plate 2. Others are phytoliths (plates 3 and 4) whose characteristic shapes allow us to determine them as remnants of straw. From these features it is possible to interpret this fine layer as the remnants of completely burnt organic materials under oxidizing conditions. The absence of calcareous ashes (Courty, 1984) does not exclude the possibility that wood was also burnt. Such ashes could have been dissolved by decalcification processes. The presence of diatoms could also be related to the dissolution of some calcareous material.

The layer is completely invaded by very dusty reddish brown organo-clay coatings with poor birefringence and a wavy extinction; they infill all the small pores (plate 1). These coatings are the result of particle translocation occurring after the burning, probably when the archaeological layers were already buried and infiltrated by percolating water. This kind of coating has frequently been observed in archaeological sites (Slager and van de Wetering, 1977; Courty and Féderoff, 1983). It seems to be related to a temporary mineral enrichment of the local environment because of the abundance of ashes. The abundance of coarse micro-contrasted particles (few μm) and the absence of lamination indicates that they might be formed very quickly and all at the same time.

The transition from the thin layer to the brownish red material is gradual. The latter appears as a microaggregated layer with a very open structure (plate 5). It consists of fine sand mixed with an isotropic fine fraction composed of burnt organic matter mixed with silty clay. As in the gray layer, the material is also invaded by reddish brown organo-clay coatings on the walls of the voids (plate 5). The material gradually becomes darker towards the top, the organo-clay coatings becomes very rare and the micro-aggregated structure is better (plate 6). The coarse fraction, however, is the same. The same features, are recognizable in the brownish black material and we can conclude that the brownish red and the brownish black materials have the same origin. However, the first red material was burnt under oxidizing conditions and the dark in reducing ones. In this last case only charcoal is produced and the translocation of organic clay does not occur.

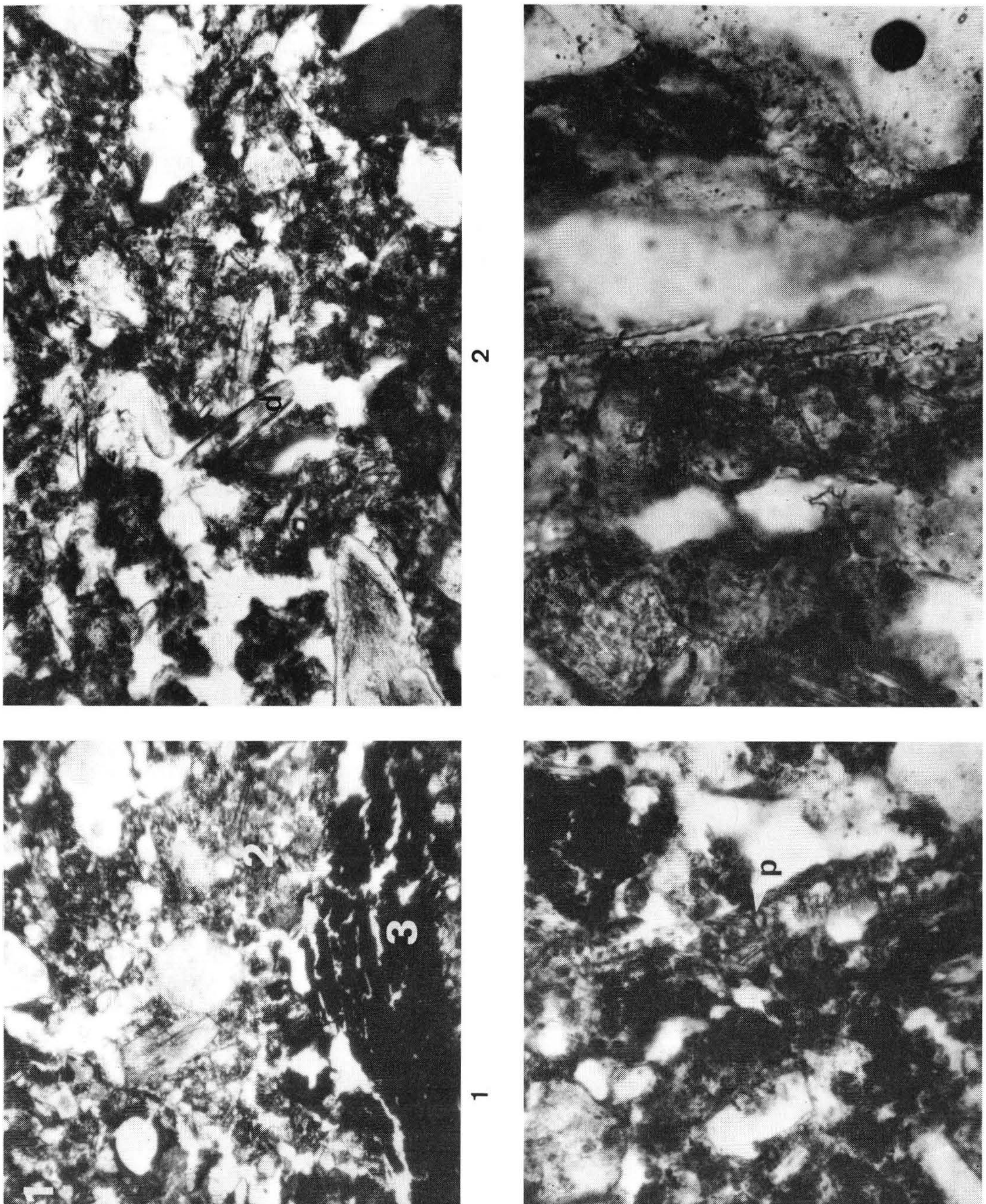
The abundance of sands, the microaggregated fabric and the very humic aspect of the burnt organic matter all suggest that these layers are the remnants of some kind of burnt turf wall.

A few very thin gray layers, comparable to the gray layers described above were observed throughout this material. They were also very rich in phytoliths and are probably the mineral remnants of completely burnt grasses.

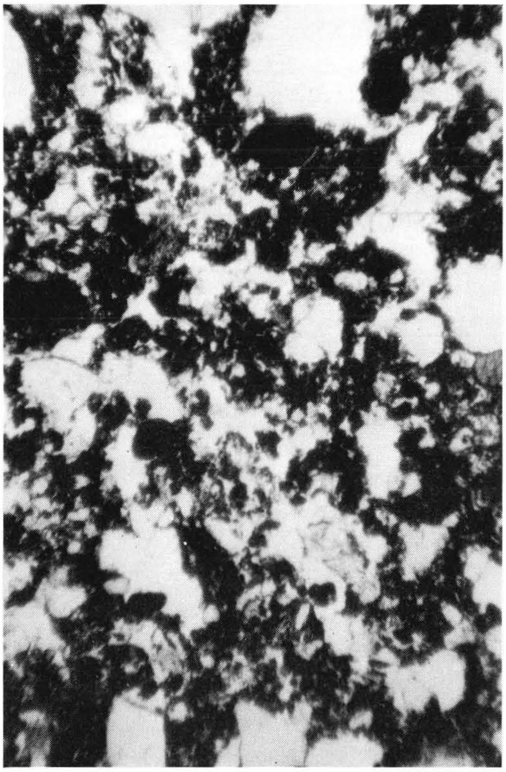
The orange and black lines observed in the field have a complex structure. Two different types of fabric can be distinguished:

a) Thin (1 mm to 500 μm) yellowish pans (plate 7) consisting of an isotropic fraction with a few very fine silt particles (plate 8); sometimes two or three pans are superimposed (two on plate 7). When found in the brownish black turf material this pan is dark in plain light which indicates a very high content of organic matter. The yellowish colour observed when burnt under oxidizing conditions, and the isotropism, could be related to a very high phosphate content which has been confirmed by chemical analysis (13 ‰ P), table 2.

b) Sandy clay material with a very organized structure: sands and clay are thoroughly mixed and the porosity is due to abundant elongated voids. This material is juxtaposed to the yellowish pan and ranges from orange up to black; in the black part remnants of plants can be observed in some voids. The total thickness varies from 1 cm up to 3 cm. Organo-clay coatings can be observed on the walls of the voids of the orange fabric.

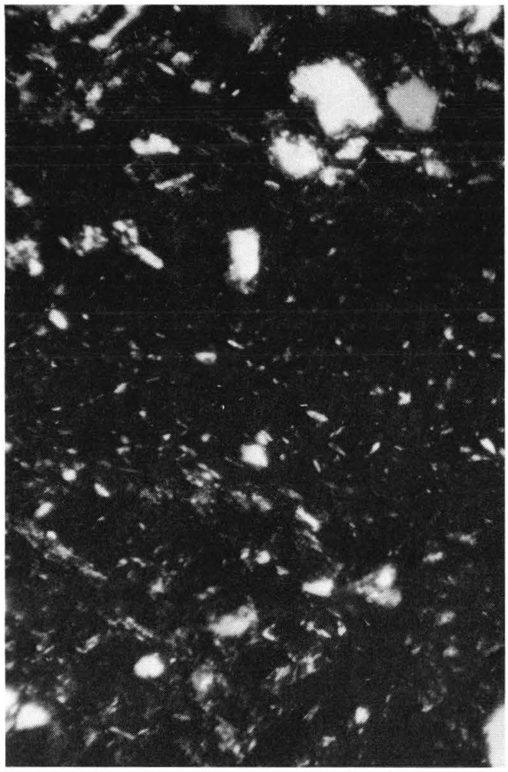

1
2
3
d
p
1
2
3
4

5



6

7



8

Conclusions

In the occupation layer there has been very little compaction or change in the organic matter. Both the micromorphological observations on the use of grass turf in the construction of walls, and the calculations of the volume of grass turf wall material, lead us to conclude that the grass turf walls are responsible for the thickness of the occupation layer.

The colour differences between the two horizons in the occupation material are probably not due to any archaeological event. As in many soils, the higher water saturation of the lower horizon here causes a more grayish colour. This is the result of reduction of iron compounds and thus explains the colour difference.

The study of different parts of the burnt house has produced very detailed information on the nature of the building materials: their origin, their transformation through burning, and their alteration after the burning. It is possible to make a schematic reconstruction of the house.

The floor was composed of till material covered with a thin organic layer, probably straw. The walls were made of turves and plastered with a carefully prepared daub,

Table 2, Chemical analysis of clay daub

Oxides normalized to 100 %

MgO	1.86 %
Al_2O_3	27.74
SiO_2	45.08
K_2O	0.49
CaO	2.77
TiO_2	0.34
MnO	0.23
Fe_2O_3	7.80
P_2O_5	13.69

Legend of the plates

1. From top to bottom: brownish red material with organo-clay coatings (1), the greyish layer (2) and the wood charcoal (3). ×50, plain light.

2. Detail of the greyish layer showing the abundance of diatoms (d). ×130, plain light.

3. Detail of the greyish layer showing the ashes and the phytoliths (p), ×130, plain light.

4. Phytoliths. ×300, plain light.

5. The brownish red material with the organo-clay coatings (c). ×50, plain light.

6. The brownish black material with the typical micro-aggregated structure and the abundance of organic matter. ×50, plain light.

7. The yellowish pans. ×50, plain light.

8. Detail of the components of the yellowish pan: an isotropic fine fraction mixed with fine silt ×130, polarized light.

probably of a yellowish brown colour. The upper structure was some kind of thatched roof supported by wooden posts.

We have observed ghosts after calcareous material. The lime has now completely dissolved and it is not possible to say from which structure it came.

The natural transformation processes after the burning (decalcification, translocation of clays and organic matter) have to some extent blurred the evidence but many of the details of the construction and the materials are still clear.

The yellowish pans can be interpreted as some kind of daub plastering the turf walls. From the relative organization of the different fabrics it appears that the yellowish pan was on the inside of the wall, probably to make a smooth surface. The main part of this daub has been carefully prepared by the same techniques as those used for ceramics. The superimposition of the turf material and of the daub indicates that wattle was used for the wall. The differences in colour observed are, as in the turf material, the consequence of differential burning.

Acknowledgement

The authors wishes to thank lecturer C. Aub-Robinson for his improvement of the English.

REFERENCES

Beck, J.-H., 1984. The Iron Age Village Mound at Heltborg, Thy. Journal of Danish Archaeology. 3. in press.

Courty, M.-A. and Fédoroff, N., 1983. Micromorphology of a Holocene dwelling. PACT 7, T. II, p. 257—277.

Courty, M.-A., 1984: Formation et évolution des accumulations cendreuses. Approche micromorpholoique. Actes du 8° Colloque Interrégional sur le Néolithique, le Puy 1981, CREPA, p. 341—353.

Dalsgaard, K. and Nørnberg, P., 1980. Begravet jordbund. Et fælles interesseområde for arkæologer og pedologer. Antikvariske studier, 4, p. 135—142.

Nørnberg, P., 1979. Paypyt i Ribe, Geologiske Vidnesbyrd. Mark og Montre, p. 45—61.

Nørnberg, P., 1980. Mineralogical alterations in a concretion from a 14th century ship, caused by environmental changes. Mineralogical Magazine 43, p. 1048—50.

Nørnberg, P. and Dalsgaard, K., 1982. A comparative study of present and ancient dark-coloured topsoil for the purpose of evaluating soil fertility in the past. PACT 7/II, p. 247—256.

Slager, S. and van de Wetering, H. T., 1977. Soil formation in archaeological pits and in adjacent loess soils in Southern Germany. Journal of Archaeological Science, n° 4, p. 259—267.

United States Department of Agriculture, 1975. Soil Taxonomy Agricultural Handbook No. 436. U. S. Govt. Printing Office, Washington D.C.