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Identification of activity area signatures in a reconstructed Iron Age house by combining element and lipid analyses of sediments

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One promising analytical method used in household archaeology in addition to inorganic (element) geochemical analysis is that of organic (lipid) analysis applied to anthropogenic sediments. We use both methods here to review chemical imprints that might be useful for recognizing space use and identifying daily activities in a reconstructed Iron Age village at Lejre, Denmark. As documented in many previous studies, element analysis enabled separate activity areas to be distinguished, but the results could not be used to identify the specific activities pursued in the areas. A more qualitative identification of activity areas was possible through lipid analysis, however. The carbon chain distribution, studied for Average Chain Length (ACL), Carbon chain Diversity Index (CDI) and Carbon Preference Index (CPI), enabled a similar separation to be achieved as by element analysis, so that the same areas could be discerned in addition to the reference samples. The stable was distinguished by a substantial input of coprostanol and even more so by 24-ethylcoprostanol, indicating a faecal input from herbivores. Trace levels of these markers were also identified at the entrance, where the animals had passed through. The dwelling area, consisting of two adjacent rooms, could be identified by the sterol ratio (cholesterol/[stigmasterol + β-sitosterol + campesterol]). Lipids from an archaeological context have decayed further toward simpler compounds and become more difficult to identify. Some markers have however a better potential for survival. The results emphasize the importance of further studies on ethnoarchaeological material in order to recognize past activities by element analysis. Moreover, the combination of element and lipid analyses provided a tool that enabled all the separate areas to be identified and provided positive identification of the activities concerned in all areas except the smithy.

1. Introduction

The use of soil chemistry in archaeology, in the form of measurements of both inorganic and organic contents, has steadily increased since it was introduced in the early 20th century. From the time of the pioneering work by Olof Arrhenius, in which he showed the relationship between enhanced phosphate and archaeological remains (Arrhenius, 1935), most analyses have focused on bulk variables such as total organic content (TOC) and total phosphate. Since Lutz (1951) and Cook and Heizer (1962, 1965) noted that a number of elements were enriched in anthropogenic soils, element analysis has been repeatedly used, and is now a well-established technique in archaeology (see e.g. Davies et al., 1988; Entwistle et al., 2007; Holliday and Gartner, 2007; Linderholm, 2007; Middleton, 2004; Sterckeman et al., 2006; Wells, 2004; Wilson et al., 2008). Multi-element soil analysis has been used as a means of site prospecting (e.g. Aston et al., 1998; Bintliff et al., 1990; Schlezinger and Howes, 2000), and a number of studies have concentrated on determining which elements accumulate as a consequence of human activities (e.g. Davies et al., 1988; Entwistle, 2000; Konrad et al., 1983; Linderholm and Lundberg, 1994). Other studies have been intended for use as aids to interpret space use and activities within and around archaeological structures (e.g. Cook et al., 2006; Griffith, 1981; Hjulström and Isaksson, 2007; Knudson et al., 2004; Middleton and Price, 1996; Parnell et al., 2002; Sullivan and Kealhofer, 2004; Terry et al., 2004; Wells et al., 2000; Wells, 2004) or have tried to connect the element differentiation with specific uses and origins (e.g. Barba, 2007; Fernandez et al., 2002; Isaksson et al., 2000; Middleton and Price, 1996; Parnell et al., 2002). The relationships between specific activities and the elemental signals they produce are not fully understood and need to be better established although it has been possible to identify the activity concerned sometimes (Middleton, 2004). In contrast to these methods, lipid analysis is more time-consuming but has the potential to provide a higher diagnostic means of answering specific questions related to subtle differences in soil organic matter (SOM) engendered by various overlying vegetation changes or human activities (see van Bergen et al., 1997;

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Bull et al., 1999). A notable increase has taken place in the analysis of organic material, mainly the lipid content, in the last decade. Numerous studies have been made of vegetation, diagenesis and various diagnostic markers (e.g. Allard, 2006; Andersson and Nilsson, 2001; Ekschmitt et al., 2005; Feng and Simpson, 2007; Fernandez et al., 1997; Howard et al., 1998; Jandl et al., 2005; Jansen et al., 2006; Kiikkila et al., 2006; Kögel-Knabner, 2002; Muri et al., 2004; Naafs et al., 2004; Nierop et al., 2001; Otto et al., 2005; Poirier et al., 2005; Quenea et al., 2004; Rogge et al., 2006; Ruess et al., 2002; Wiesenberg et al., 2004). Several works have also focused on problems that are more applicable to archaeology (e.g. van Bergen et al., 1997; Bethell et al., 1994; Bull et al., 1999, 2002; Evershed et al., 1997; Hjulstrom et al., 2006; Isaksson, 1998; Simpson et al., 1998). Although the combination of element analysis and lipid analysis has proved fruitful (Isaksson et al., 2000), they are seldom applied to the same material. We set out here to combine these methods in order to evaluate which activities are identified by which method and when a combination of the two is to be preferred. The material was from a reconstructed Iron Age house and village at the Lejre Experimental Centre outside Roskilde, Denmark.

2. Material and sampling

2.1. The Lethra Iron Age village at the Lejre Experimental Centre

The aim at the Lejre Experimental Centre is that all work concerning the reconstructed Iron Age village of Lethra should be as authentic as possible with regard to both building techniques and the use of the houses. The houses are inhabited from late spring to early autumn each year. The samples used here were collected from one of the reconstructed multifunctional dwelling houses, a smithy and a clay pit. The degree of authenticity in the actual activities pursued is not of interest for the present purpose, but rather it is most important that the house has been inhabited and that no modern material or chemicals have been used when constructing or maintaining it, and also that the activities in the house have been documented.

As seen in Fig. 1, the house is divided into a dwelling area, a dwelling/cooking area with a hearth, an entrance area and a stable. The only separating wall is between the entrance and the stable. The floor consists of clay tempered with grass and hay. The stable has generally been used to store personal belongings rather than to accommodate animals, but 2 goats, 2 oxen and 2 horses were stabled there in the winters of 1998 and 1999 during an experiment concerned with indoor temperatures (Severine Beck et al., 2007). Three reference samples for studying the clay floor were collected from a clay pit near the house, and an additional six samples were collected from a smithy located some 100 m further away. The clay pits that were used when the house was built have been refilled, but the clay pit that was actually sampled is located nearby. The clay mined from the clay pit had been used for various purposes, such as ceramics and for repairing of the floors. The smithy had been built quite recently and had only been used a couple of times when the samples were collected. The smithy can be divided into two areas, as seen in Fig. 1. Most of the smiths' work has taken place in the inner room on the left, where the anvil and bellows are located.

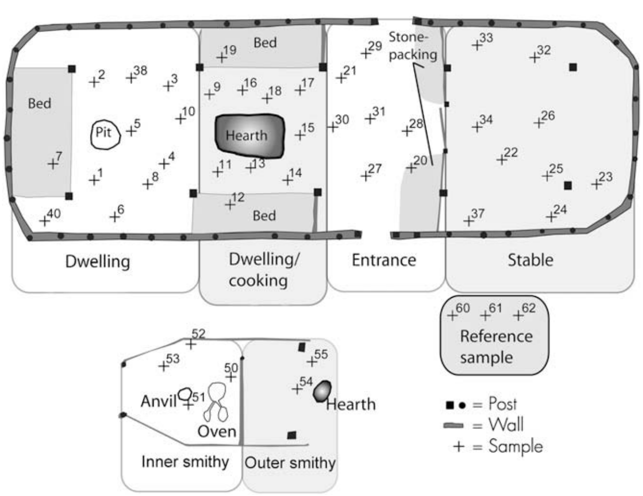

Fig. 1. Plans of the three-aisled multifunctional house and the smithy, with activity areas and sampling points. The smithy is located some 100 m from the house, and the reference samples were collected at a clay pit about 30 m from the house. The size of the multifunctional house is about 14 × 5 m.

2.2. Collection and preparation of samples

When sampling with a probe it is difficult to recognize differences in soil composition and to distinguish subtle layers and natural differences from pedogenic differences. Hence it is of great importance to identify the layer that is to be analysed during an excavation and to observe and document such differences when they appear. The present samples were collected from the top part of the floor down to a depth of ca. 2 cm, and only loose soil on the surface was removed before sampling. The characteristics of the soils from the different areas are shown in Table 1. The reference samples from the clay pit were taken from clean surfaces on the side of the pit. Although the samples were collected from the clay floor, there were considerable intrusions of hay in the samples from the stable. The soil from the smithy was somewhat darker, with a higher proportion of silt and sand. All the samples were air-dried, ground in a mortar and sieved through a 1.8 mm analytical sieve. Visible organic material such as roots cannot be assumed to be of relevance in an archaeological material and the signature of charcoal would obscure the soil composition. The frequency of charcoal is however of interest since the retention of certain elements has shown to be linked with the presence of charcoal (e.g. Davidson et al., 2007). Visible organic materials were hence documented and removed.

3. Methodology

The complex nature of the soil chemistry is nicely encapsulated by McBride (1994): "Much of soil science is empirical rather than theoretical in practice. This fact is a result of the extreme complexity and heterogeneity of soils, which are impossible to fully describe or quantify by simple chemical or physical models". Regarding the interpretation of archaeologically interesting soils

Table 1
Soil characteristics

Area	Soil	Color	Munsell
Dwelling	Gravelly clay	Brownish yellow	10YR6/6
Dwelling/cooking	Gravelly clay	Brownish yellow	10YR6/6
Entrance	Gravelly clay	Brownish yellow	10YR6/6
Stable	Coarse gravelly clay with intrusion of organic material	Brown	10YR5/3
Inner smithy	Coarse gravelly sand mixed with coarse gravelly clay	Dark gray & Brownish yellow	10YR4/1 & 10YR6/6
Outer smithy	Coarse gravelly clay I	Dark grayish brown	10YR4/2
Reference sample	Gravelly clay	Brownish yellow	10YR6/6