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A question of scales: studying Neolithic subsistence using micro CT scanning of midden deposits

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We tested whether micro CT scanning could be used to study phytoliths and bone fragments on samples from a Middle Neolithic midden deposit from Swifterbant (The Netherlands). We scanned an untreated block sample, and an impregnated sample that was used to make a thin section of. Ample small bones or bone fragments could be discerned and identified – most of them from fish – although sieving showed that many went undetected. It was possible, however, to identify several deposition events within a few cm of stratigraphy, and distinguish deposits with cleaning refuse from bones that were discarded during or after meals. Bone fragments embedded in coprolitic material represented the ingested and excreted bone fragments. Moreover, it proved to be possible to identify articulated bones or bone fragments that would become separated and unidentifiable during sieving and to recognize specific decay patterns. Silica phytoliths could be discerned, but the resolution was not enough to use it for species identification. Overall, the greatest advantage of microCT scanning of undisturbed samples form archaeological sites seem to lie in non-destructively providing context and taphonomical information on which further sample treatment and analyses – including microsampling and micromorphology – can be based.

1. Introduction

Neolithic sites on the banks of a former creek system in the Swifterbant area (the Netherlands) – ^{14}C dated between 4300 and 4000 cal. BC – commonly consist of deposits of dark, artefact- and refuse-rich material up to a metre thick (Lanting and van der Plicht, 1999/2000; Raemaekers, 1999; de Roever, 2004). Exceptionally good preservation of materials and the microstratigraphy made it possible to study sequences of human activities and natural events in detail. A microstratigraphical approach using high-density sampling micromorphology – similar to the approach by Shillito et al. (2011a) – on one of the sites (S4) showed evidence for many instances of refuse dumping and several phases of natural clay sedimentation, interspersed with phases of soil tillage (Huisman et al., 2009; Huisman and Raemaekers, in press). The dark deposits were found to consist mostly of phytoliths and carbonized materials, and to contain large amounts of charcoal, bone fragments and carnivore or omnivore coprolites. It is most likely that these deposits represent middens where refuse was dumped together with grass-like plant material (grass, reeds or straw; possibly bedding) and burned or left to decay *in situ* (Huisman et al., 2009; Huisman and Raemaekers, in press).

Despite the large amount of information that was derived from detailed micromorphological investigations in Swifterbant, the method is limited by its two-dimensional nature. Random cross-sections through phytoliths and bones prevent proper species identification. Normally such identification is done by sampling and fine-mesh sieving (for bones) or elaborate sample preparation (for phytoliths). This has several disadvantages that up till now could not be overcome. Firstly, spatial relations are lost in sieving and/or processing. This results in the mixing of multiple layers, and therefore multiple events, in finely layered deposits. Articulated or *in situ* fragmented material will become separated, which may hinder identification. Secondly, even if a small mesh size is chosen – e.g. 2 mm – some identifiable bone fragments will still be too small to be recovered. They are therefore systematically overlooked. Finally, linking results with micromorphological

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observations is not possible because the observations are done on separate samples. As a result, there is either a lack of species identification (in thin sections) or a lack of micro-context in other methods of analysis.

These problems can be overcome to some extent by combining micromorphology with microsampling (e.g. Madella and Lancelotti, 2010; Matthews, 2010; Shillito et al., 2011a) which entails taking small samples in the lab from micromorphology samples prior to impregnation and thin section production. This method, however, still has the disadvantage that sampling precedes the thin section study (which gives the microstratigraphic and taphonomic information). Moreover, micro samples are too small to be useful for the study of small bones or bone fragments.

The step from 2-D to 3-D analysis of soil samples requires some form of scanning technique. We tested whether CT scanning could be used for this purpose using two samples from the midden deposit at Swifterbant S4. The first test was with a medical ("normal") CT scanner. A few papers present studies that have used such scans to study 3-D properties of archaeological materials embedded in soils, e.g. the distribution of fragmented glass (Jansen et al., 2006), or the content of urns (Minozzi et al., 2010). However, we found that the resolution was not sufficient to study the fine layering and the small remains in the Swifterbant midden deposits. We therefore switched to a micro CT scanner. The advantage of micro CT scanners is that they have better resolution than normal CT scanners. Micro CT scanning has been used before to study natural sediments (Killfeather and van der Meer, 2008) and archaeological artefacts (McBride and Mercer, 2012; Haneca et al., 2012). In this paper, we present the results of our tests on the applicability of micro CT scans as part of a microstratigraphical strategy to study finely layered archaeological deposits like middens, and derive information on human activities and subsistence.

2. Methods

X-ray micro-computed tomography uses the principle of attenuation of X-ray by matter. X-ray attenuation is mainly a function of the thickness and density of the matter as well as the energy of the X-ray beam and the atomic number of the matter. The dependency between attenuation and density renders possible the visualisation of structures within objects made of materials of various densities. In a micro CT scanner, a source of X-ray illuminates the object and a planar X-ray detector records the X-ray transmitted by the object. The distances of the source to the object

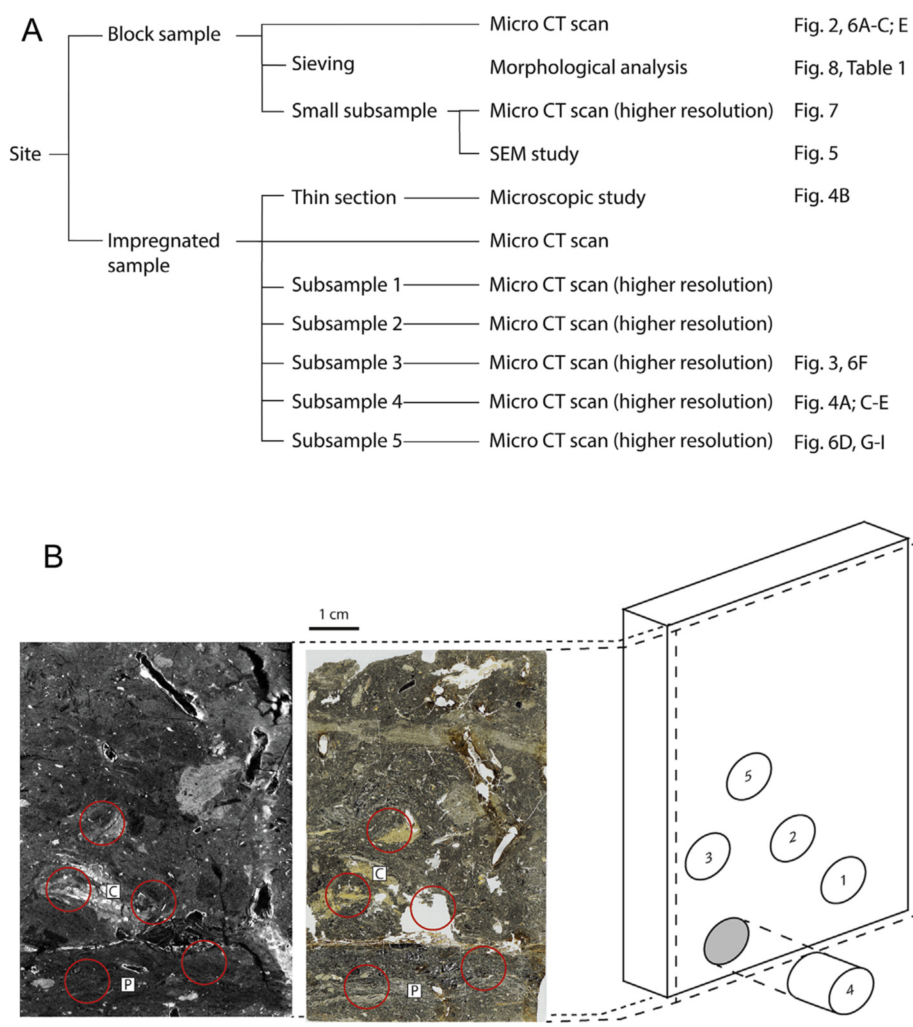

Fig. 1. Overview of samples and sample treatments. A: Samples, subsamples, treatments and analyses. The right column indicates the origin of the images and table in this publication for reference purposes. B: Visualisation of sampling and subsampling procedure of the impregnated sample. The scan of the thin section and a CT scan cross-section are shown next to each other. Because the thin section was cut off the block first, there is no direct overlap with the scans. However, there is enough similarity to identify e.g. deposits of thinly laminated phytoliths and carbonized materials (P) and bone-rich coprolites (C) in both the thin section scan and the CT scan. The locations of the subsamples are indicated in the block, and projected in the thin section and the CT scan.

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