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Signatures of degraded body tissues and environmental conditions in grave soils from a Roman and an Anglo-Scandinavian age burial from Hungate, York

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ABSTRACT

Despite the importance of human burials in archaeological investigations of past peoples and their lives, the soil matrix that accommodates the remains is rarely considered, attention being focused mainly on visible features. The decomposition of a buried corpse and associated organic matter influences both the organic composition and, directly or indirectly, the microstructure of the burial matrix, producing signatures that could be preserved over archaeological timescales. If preserved, such signatures have potential to reveal aspects of the individual's lifestyle and cultural practices as well as providing insights into taphonomic processes. Using organic chemical analysis and soil micromorphology we have identified organic signatures and physical characteristics relating to the presence of the body, and its decomposition in grave soils associated with two human skeletons (one Roman age and one Anglo-Scandinavian age) from Hungate, York, UK. The organic signatures, including contributions from body tissues, gut contents, bone degradation and input from microbiota, exhibit spatial variations with respect to anatomical location and features of the immediate burial environment. In the Roman grave broad changes in redox conditions associated with the decomposition of the corpse and disturbance from the excavation and use of an Anglo-Scandinavian age cess pit that partially cuts the grave were evident. Leachate from the cess pit was shown to exacerbate the degradation of the skeletal remains in the regions closest to it, also degrading and depleting spherulites in the soil, through decalcification of the bone and liberation of bone-derived cholesterol into the soil matrix. The findings from this work have implications for future archaeo- and contemporary forensic investigations of buried human remains.

1. Introduction

The study of human burials in the archaeological record provides a unique glimpse into the lives (and deaths) of our ancestors. Investigations typically focus on the recording, recovery and analysis of the visible human remains, grave goods and burial structures (Brothwell, 1981). Although some well-preserved burials have provided evidence of clothing (Barfield, 1994; Hadian et al., 2012), organic grave goods (Barfield, 1994) and body tissues (O'Connor et al., 2011; Stead et al., 1986), the survival of perishable materials in a condition that can be visually recognised is rare and generally limited to particular burial environments (e.g. waterlogged, arid, frozen) and modes of preparation of the corpse (e.g. embalming and mummification). While organic materials were undoubtedly significant, widespread and varied components of human burials, in the vast majority of burials the extent of decay is such that evidence of these components is invisible to traditional archaeological techniques.

Organic chemical analysis is now an established tool in the field of archaeology and has been applied to many different types of archaeological remains (Evershed, 2008), including human remains. Bone collagen can survive over archaeological timescales and is routinely isolated for stable isotope and radiocarbon analysis. Exceptional

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examples of soft tissue preservation have provided rare opportunities to study their protein and lipid compositions and thereby the extent and mechanisms of preservation (Evershed and Connolly, 1988; Gulaçar et al., 1990; Mayer et al., 1997; O'Connor et al., 2011). Likewise, chemical characterisation of organic residues associated with the wrappings of Egyptian mummies has provided information on the preparations used by ancient embalmers (Buckley and Evershed, 2001). By contrast, the potential for the soil in contact with buried human remains to retain molecular information relating to decayed organic components of the burials has received little attention. Such organic remains could relate to components from the body tissues of the interred, from the stomach and gut contents, from formulations used in preparing the body for burial and from substances associated with grave goods and burial structures, such as a coffin. Each of these sources has potential to inform the archaeological interpretation: components established to derive from the body tissues, whether or not the physical remains survive, could provide opportunities for isotopic analysis and hence consideration of differences in diet among past populations (Stott et al., 1999); stomach contents can reveal information regarding the balance of plant vs meat in the meals immediately prior to death (Pickering et al., 2014); formulations used in burial rituals could reveal commonalities and differences among individuals within localities and over time; signatures from grave goods could reveal the nature of now decayed materials that were placed within the graves and signatures of the burial structures (Burns et al., 2017) could also reveal commonalities and differences over time and with geographical location. In order for organic signatures to be meaningfully employed it is necessary to gain insights into the nature and extent of their alteration in the environments particular to graves. Whilst much variation can be expected according to burial practice, soil composition and chemistry, hydrology and age of burial, some generalities can be anticipated owing to the presence of a substantial amount of organic matter in a somewhat defined space.

Grave soils from contemporary human burials have been shown to contain chemical signatures of degraded adipose tissue (Bull et al., 2009; Forbes et al., 2002). Given that the recalcitrance of lipids allows their survival over geological timescales (Eigenbrode et al., 2008), informative chemical signatures from wide variety of sources have the potential to be preserved in archaeological grave soils. We present results of the chemical and micromorphological analysis of grave soils and sediments from two human burials from Hungate, York (UK), one of Roman age and the other of Anglo-Scandinavian age.

2. Experimental

2.1. Excavation

The Roman age grave (C51364, 1st – 4th C CE) and Anglo-Scandinavian age grave (C53700, ^{14}C date 870–980 CE) were sampled for the InterArChive project in 2010 and 2011 during excavation of the Hungate site. Both were undisturbed burials, containing articulated skeletons (Fig. 1). The graves presented differences in the levels of preservation, both in terms of completeness of the skeletal remains and in the physical condition of the bones. Whereas the bone in the Anglo-Scandinavian burial was very well preserved, that in the Roman burial had lost much structural integrity and was incomplete, particularly the upper left side of the remains (Fig. 1).

2.2. Sampling

Controls were collected from non-grave soil from the site (C1) and from grave fill above the level of the skeletal remains, C2 and C3, as essential comparators of grave fill that has not been in contact with the buried remains (Fig. 2).

Samples of the burial matrix were collected in line with the InterArChive sampling strategy (Usai et al., 2014) from key anatomical locations on the skeleton (Table 1). The maximum number of prescribed points around the skeletal remains were targeted for chemical analysis and 4 key areas; head (1), pelvis (2) and feet (3/4) were targeted for micromorphological analysis (Table 1). Additional samples (prefixed by the letter 'A') were collected in response to specific features of the individual graves and from a cess pit adjacent to the Roman burial. Samples for micromorphology were collected from undisturbed archaeological sediment or grave fills using Kubiena tins (83 × 50 × 32 mm, 83 × 55 × 42 mm, and 65 × 38 × 28 mm). On return to the laboratory, samples were refrigerated prior to thin section preparation. Samples for chemical analysis were collected proximal to the skeletal remains or feature using a spatula, wrapped in pre-cleaned foil, placed in geochemical sample bags and stored cold. On return to the laboratory, samples were stored frozen until required for analysis.

2.3. Manufacture of thin sections

The samples were dried in the tins through acetone vapour exchange (Miedema et al., 1974) and impregnated under vacuum with a slow curing polyester resin (Polylite 32320-00). The resulting consolidated soil blocks were cut to produce the thin sections. The cut sections were back-polished, mounted, cut and ground to 30 μm thickness, with final 3 μm and 1 μm polishes.

2.4. Optical microscopy

Micromorphological observations were performed using a petrographic microscope (Zeiss AxioLab A1) equipped with a Zeiss AxioCamERc5s camera and AxioVision imaging software. The standard terminologies proposed by Bullock et al. and by Stoops (Bullock et al., 1985; Stoops, 2003) were adopted for the descriptions of the slides and semi-quantitative estimation of the features.

2.5. Scanning electron microscopy-energy dispersive X-ray analysis (SEM-EDS)

SEM-EDS analyses were conducted at the University of Stirling employing an EVO MA 15 Zeiss scanning electron microscope with workflow automation and an Oxford Instruments INCA X-Max EDS to provide micro-chemical data of fine material and inorganic pedofeatures of uncertain interpretation (Courty et al., 1989; Fitzpatrick, 1993; Goldberg and Macphail, 2003). Standard operating conditions were 8.5 mm working distance and 20 kV accelerating voltage. Calibration was achieved through the analysis of standard cobalt every 2 h and standard dolomite at the beginning of each session. A minimum of seven individual point analyses were carried out for each measured region. The measurements of O and C were excluded owing to the presence of the resin in which the samples were consolidated and weight percent data were normalised to 100%.

2.6. Preparation of materials and extracts for chemical analysis

All solvents used were analytical grade or higher. All glassware was baked (450 °C, 6 h) prior to use using a Pyroclean Trace oven (Barnstead International, USA) to remove organic contaminants. Frozen soil samples were freeze dried using a HETO PowerDry PL3000 (Thermo, Hemel Hempstead, UK). Dry soils were disaggregated with a pestle and mortar, and sieved using 1 mm, 400 μm and 200 μm sieves. All subsequent work was performed on the sub 200 μm fraction. Extraction was performed using an accelerated solvent extraction system (ASE 350, Dionex, Hemel Hempstead, UK). Prior to loading soil samples, the empty extraction cells were subjected to extraction using the same solvents and conditions as for the samples. Soil (3–6 g) was loaded into 5 ml stainless steel cells and extracted three times with dichloromethane:methanol (9:1 v/v; 5 min at 100 °C and 1500 psi). A blank extraction was also performed to assess whether any