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Micromorphology and context

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ABSTRACT

Context is an important concept in archaeology, although the term tends to have a variety of meanings to different people. In this brief note we illustrate how context can be considered at a microstratigraphic scale using the technique of soil micromorphology. Examples are given from the sites of Geißenklösterle (Germany), Sibudu (South Africa), and Pech de l'Azé IV (France) to show that micromorphology is an indispensible and robust tool for not only documenting the contextual position of archaeological objects and features within the matrix of the site but also for making accurate interpretations of the archaeological record.

1. Introduction

The term context means different things to different people, depending on discipline and approach. From a regional viewpoint, one that might be held by a geographer, for example, context would be encompassed within the following, where archaeological sites fit into a geographic and ecological system:

> The goal of contextual archaeology should be the study of archaeological sites as part of a human ecosystem, within which past communities interacted spatially, economically, and socially with the environmental subsystem into which they were adaptively networked. (Butzer, 1980)

Similarly, we often consider archaeological sites within regional or local geological contexts and settings, such as "riverine" or "coastal" sites, or "upland" *vs.* "lowland" ones. Even within these broad categories there are subdivisions, including occupations on the levee rather than those on the floodplain or next to oxbows.

Moreover, as is typical of historical sciences such as geology and archaeology, temporal changes in geological contexts occur at both the site and regional level. At Boxgrove, UK, for example, a stratigraphic succession documents sea level regression associated with the change from interglacial to glacial conditions (Macphail, 1999). Similarly, at the site of Wilson–Leonard, near Austin, Texas, a shift from early Holocene channel gravels gave way to a succession of overbank silts that are increasingly enriched in colluvial silt and gravel. These changes take place over about 10,000 years through a vertical thickness of deposits of about 6 m as documented in Bousman et al. (2002).

At the more refined scale of individual sites and objects, the definition/conception of context takes on different meanings and here the focus is on a finer scale, even a particularistic one in which an individual object is placed within its space. The American Society for American Archaeology (SAA) sums it up this way:

> Context in archaeology refers to the relationship that artifacts have to each other and the situation in which they are found. Every artifact found on an archaeological site has a precisely defined location. The exact spot where an artifact is found is recorded before it is removed from that location…. Context is what allows archaeologists to understand the relationship between artifacts on the same site, a well as how different archaeological sites are related to each other. (http://www.saa.org/public/educators/03_whatis.html#06)

Similarly, at the artifact level Renfrew and Bahn (2007) note that:

> An artifact's context usually consists of its immediate *matrix* [authors' emphasis] (the material around it e.g., gravel, clay or sand), its provenience (horizontal and vertical position in the matrix), and its *association* [authors' emphasis] with other artifacts (with other archaeological remains, usually in the same matrix) (p. 290).

At the site and object-specific scale, context is normally first monitored and documented in the field and then later analyzed in the laboratory with different approaches. In the field, the first line

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Fig. 1. Stratigraphic profile at Geißenklösterle showing Middle Palaeolithic and Upper Palaeolithic deposits and plastered samples used in the micromorphological analysis; sample GK 48-259, which spans the MP/UP boundary is illustrated in Fig. 2a, b.

of contextual defense is the construction of a firm stratigraphic framework in which lithostratigraphic units are described using standard parameters, such as color, composition, texture, shape of clasts, and bedding; the vertical and horizontal extents of the stratigraphic units as well as their boundaries are also noted (Courty, 2001; Macphail and Cruise, 2001; Goldberg and Macphail, 2006). Such scrutiny of the stratigraphy is required if we are to establish the geometric (and thus temporal) relationships of deposits and features at a site.

Taking place at the same time in the field, archaeologists record objects in their proper spatial context using a Total Station. Such detailed recording not only enables us to judge the three-dimensional spatial relationships among objects and deposits, but also minimizes errors (McPherron et al., 2005), allowing for both high precision and accuracy.

However, there is only so much one can do in the field regardless of how much one strives to document and control for context. In spite of increased awareness of the occurrence of microstratigraphic units and associated microfacies (Courty, 2001), and the care with which we document them in the field, it is simply very difficult to recognize stratigraphic units that are less than a few cm thick, even with a hand lens. Moreover, it is not yet clear how we can coordinate the recognition of microstratigraphic mm- to cm-thick units with the excavation of lithics or bones that are thicker than the layers we can delineate in the field; this last issue is considered below in greater detail.

The object of this brief note is to succinctly discuss the role of microstratigraphy and micromorphology in understanding and illuminating context, and how they can be used to better interpret the sediments and the objects that they enclose; it is not meant to be an exhaustive discussion of context in archaeology. Nevertheless, all of these objects and materials are intimately bound to form the archaeological record. Until recently, the role of sediments as "artifacts" in the archaeological record has been largely neglected.

2. Microstratigraphic context and examples

Below, we present some examples of the applications of soil micromorphology to archaeological sites to demonstrate the level of contextual resolution that is possible using the methodology.

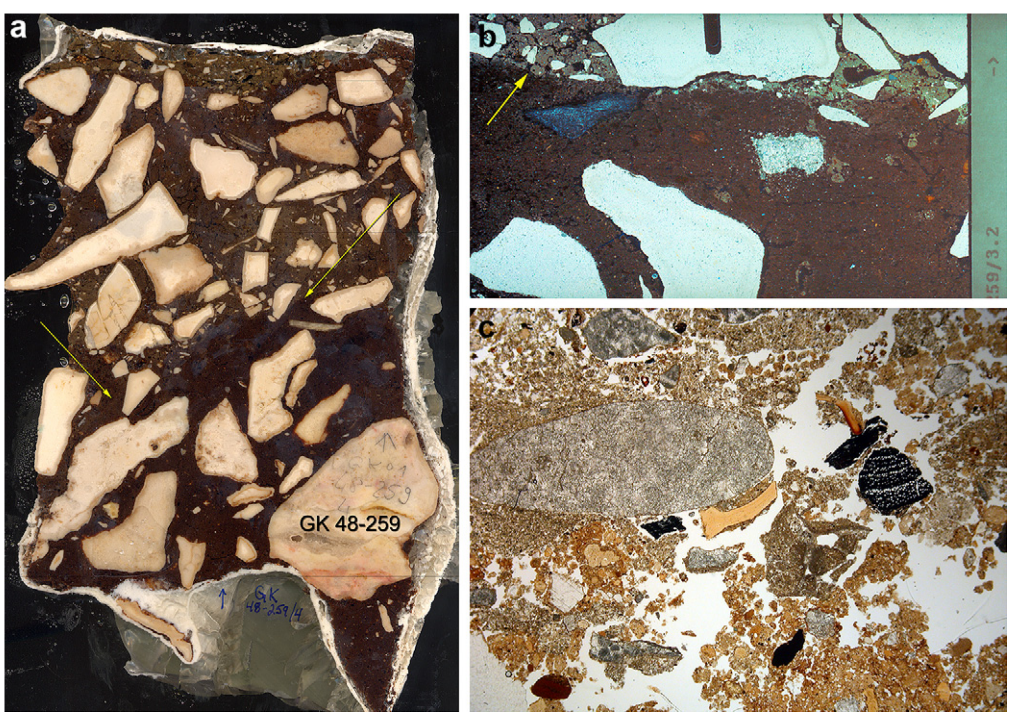

Fig. 2. (a) polished slab of sample GK 48-259 (see Fig. 1) showing sharp and eroded contact (arrows) between the Middle Palaeolithic and Upper Palaeolithic deposits. The matrix in the lower deposits is extensively phosphatized, hence the dark color, whereas the overlying sediments of the Upper Palaeolithic are lighter in color and calcareous. The length of the sample is 29 cm. (b) Macro scan of thin section that spans the Middle Palaeolithic/Upper Palaeolithic contact (arrow) in cross-polarized light (XPL). This is illustrated here by the bright, calcareous loessial silts overlying darker reddish brown phosphatic clays. Length of view is 45 mm. (c) Photomicrograph of GK 48-259 in which charcoal and yellow bone fragments occur at the contact between the yellow–brown, phosphatized Middle Palaeolithic sediment below and the lighter, calcareous sediment above it. The issue is the context of the charcoal fragments and to which layer do we ascribe them? Width of view is 6.4 mm. (For interpretation of the references to color in this figure legend, the reader is referred to the web version of this article.)

Fig. 3. (a) Sibudu profile showing bedded combustion features in the upper part (mostly Howiesons Poort, but some post-Howiesons Poort deposits at the very top) and the massive, mostly Still Bay deposits below; the knife is 13 cm long. (b) Scan of impregnated slab of sample SS-5 showing detail of combustion layers with inclusions of some roof fall. The arrows point to concentrations of secondary gypsum; red vertical scale in upper left is 1 cm. (For interpretation of the references to color in this figure legend, the reader is referred to the web version of this article.)

These sites have been and continue to be instrumental in our understanding of some important and complex issues related to human behavior, development, and evolution. They are all related to hunter-gatherer sites from the Old world, but it should be apparent how these concepts can be applied to any site in any location of any age.

2.1. *Geißenklösterle cave, Germany*

Geißenklösterle is a breached phreatic cave situated in the Swabian Jura above the Ach Valley. It has often played an important role within the debate about the Middle Palaeolithic–Upper Palaeolithic (MP/UP) transition and the arrival of anatomically modern humans into Europe (Zilhão and d'Errico, 1999; Zilhão and d'Errico, 2003; Conard et al., 2006; Conard and Bolus, 2008). Within this debate researchers have devoted considerable discussion to the stratigraphic record of not only Geißenklösterle but other key sites in which the MP/UP transition is debated. Typically, arguments center around refitting of piece-plotted finds and chronostratigraphy (both radiocarbon and thermoluminescence), and whether dates are in correct order. Interestingly, scant attention has been paid to the microstratigraphic context of the finds. Nevertheless, close scrutiny of the microstratigraphy at Geißenklösterle (and at the neighboring Hohle Fels site) provides possible windows into understanding the physical nature of the MP/UP boundary, and places finite constraints on what can be said about it. In turn, such observations ultimately can help to eliminate many unsubstantiated arguments in this debate.

In the field, the contact between the Middle Palaeolithic and the Upper Palaeolithic deposits was quite difficult to follow, since much of the deposits consist of coarse limestone *éboulis* within brown clay (Fig. 1). During excavation, it was possible to observe clear Middle Palaeolithic artifacts at the base of a profile and 'clean' Upper Palaeolithic assemblages at the top of the profile, yet the interface between them was not at readily apparent.

In order to document the contact and the context more clearly, micromorphological analyses were undertaken using blocks of undisturbed deposits (Fig. 1) (Goldberg and Conard, in press; Goldberg and Macphail, 2003). In the laboratory, these blocks were impregnated with polyester resin, slabbed with a rock saw, polished, and then examined at low magnifications (~6×) with a dissecting a microscope. In addition, many of these slices were processed into thin sections and analyzed with the petrographic microscope at somewhat higher magnifications (ca. 20×–200×) using soil micromorphological techniques (Courty et al., 1989; Arpin et al., 2002; Goldberg and Macphail, 2003).

The micromorphological analysis furnishes two important findings. For example, observations of the polished block plainly reveal a sharp erosional contact between the Middle Palaeolithic and Upper Palaeolithic deposits (Fig. 2a and b). Thus, arguments of "mixing" of Middle Palaeolithic and Upper Palaeolithic artifacts and bones, for example, cannot be maintained, at least from these samples, which are typical of the deposits elsewhere in the site.

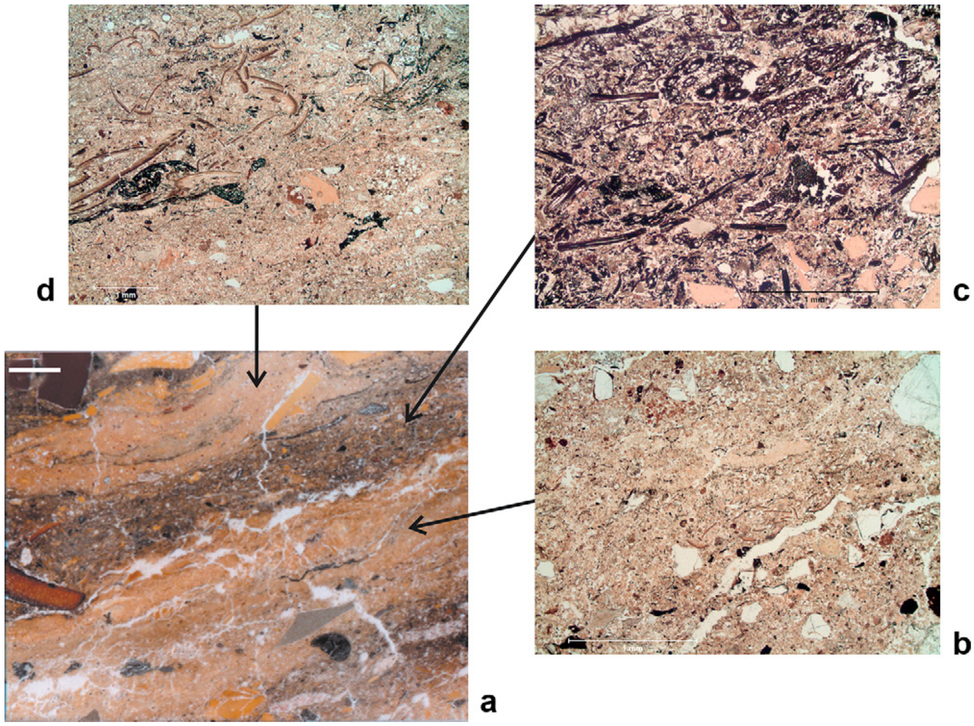

Fig. 4. Part of sample SS-5 shown in Fig. 3 illustrating different types of microfacies, which exhibit compositional variations over thickness of ~1–2 cm: (a) macro scan of thin section of sample SS-5C (Goldberg et al. 2009) showing a sequence of different microfacies, which are detailed with surrounding microphotographs; white bar scale = 1 mm; (b) massive mixture of calcareous and phosphatized ash that underlies (c). (c) irregular pieces of charcoal, mostly laminar, along with angular and crushed pieces of yellow bone shown in the lower right-hand quadrant; (d) predominantly phytoliths mixed with a piece of yellow bone in the center-right, and some black charred material. (For interpretation of the references to color in this figure legend, the reader is referred to the web version of this article.)

Which such a sharp boundary, it is not possible to think of younger archaeological or lithological material being worked into the substrate by trampling, as we would clearly see domains of the fresher calcareous silt within the older, phosphatic deposits.

A second and more subtle observation about context can be made at higher magnifications (Fig. 2c). In this case, a cm-size piece of charcoal can be seen to rest on the erosional contact between the two deposits. The issue illustrated in this figure relates to the stratigraphic attribution of this and other pieces of charcoal that rest on the contact. Do they constitute an erosional lag of charcoal derived from the lower, Middle Palaeolithic deposits, or do they represent in fact the first and oldest occurrences of Upper Palaeolithic charcoal at the site? Unfortunately, we cannot determine this within the section, nor can we do it in the field, so essentially, we cannot know which one of the above scenarios is the 'correct' one. In other words, when we collect charcoal in the field, not just at Geißenklösterle, how can we determine exactly from which stratigraphic unit it is derived? In many cases, unfortunately, we cannot. Our salvation would be to document the deposits first micromorphologically and then undertake the collection of charcoal, or at least try to do them at the same time.

2.2. Sibudu shelter, KwaZulu-Natal, South Africa

An important example that illustrates the importance of context comes from the rockshelter of Sibudu in KwaZulu-Natal, South Africa (Wadley, 2006; Wadley and Jacobs, 2006). This site has a rich sequence of anthropogenic deposits whose post-Howiesons Poort and late Middle Stone deposits date to about 58.5 ± 1.4 ka, 47.7 ± 1.4 ka, respectively (Jacobs et al., 2008). Here, painstaking excavation has resulted in a finely delineated stratigraphic record of many ashy and charcoal-rich lenses, which represent combustion features, many of which were difficult to trace horizontally for more than a few decimeters; some of these features are shown in Fig. 3a and b. Micromorphological analysis of the deposits (Goldberg et al., 2009) resulted in the recognition of a number of microfacies as defined by Flügel (2004): "the total of sedimentological and paleontological data which can be described and classified from thin sections, peels, polished slabs or rock samples." (p. 1).

Several types of microfacies can be recognized in the Sibudu deposits [see (Goldberg et al., 2009; Schiegl and Conard, 2006) for details], of which we illustrate only a few here (Fig. 4). Fig. 4a, a scan of a thin section from roughly the central part of the scanned block in Fig. 3b, shows a great deal of variation in the types of microfacies whose thicknesses vary from ca. 1–2 cm. The microfacies illustrated in Fig. 4b is thicker and more complex than the others shown here, and exhibits some differences from bottom to top: the lowermost part is comprised of largely phosphatized ashes (Schiegl and Conard, 2006), whereas the uppermost part exhibits unweathered calcareous ashes (with calcitic ash rhombs that are not shown here). The composition and structure of these phosphatic and calcareous ashes are most readily interpreted as rake out of ash from adjacent combustion features (Goldberg et al., 2009).

The dark material exhibited in Fig. 4c, on the other hand, is comprised of finely laminated fibrous organic matter and phytoliths, together with stringers of crushed burned bone that has been heated to varying degrees. This layer grades upward into a layer of laminated phytoliths (Fig. 4d), which likely represents grass matting that was trampled and later burned, thus leaving a residue of predominantly phytoliths.

The Sibudu example is instructive for many reasons. First, it shows that at the microstratigraphic/microfacies scale, many anthropogenic activities are taking place. Whereas in the field it is

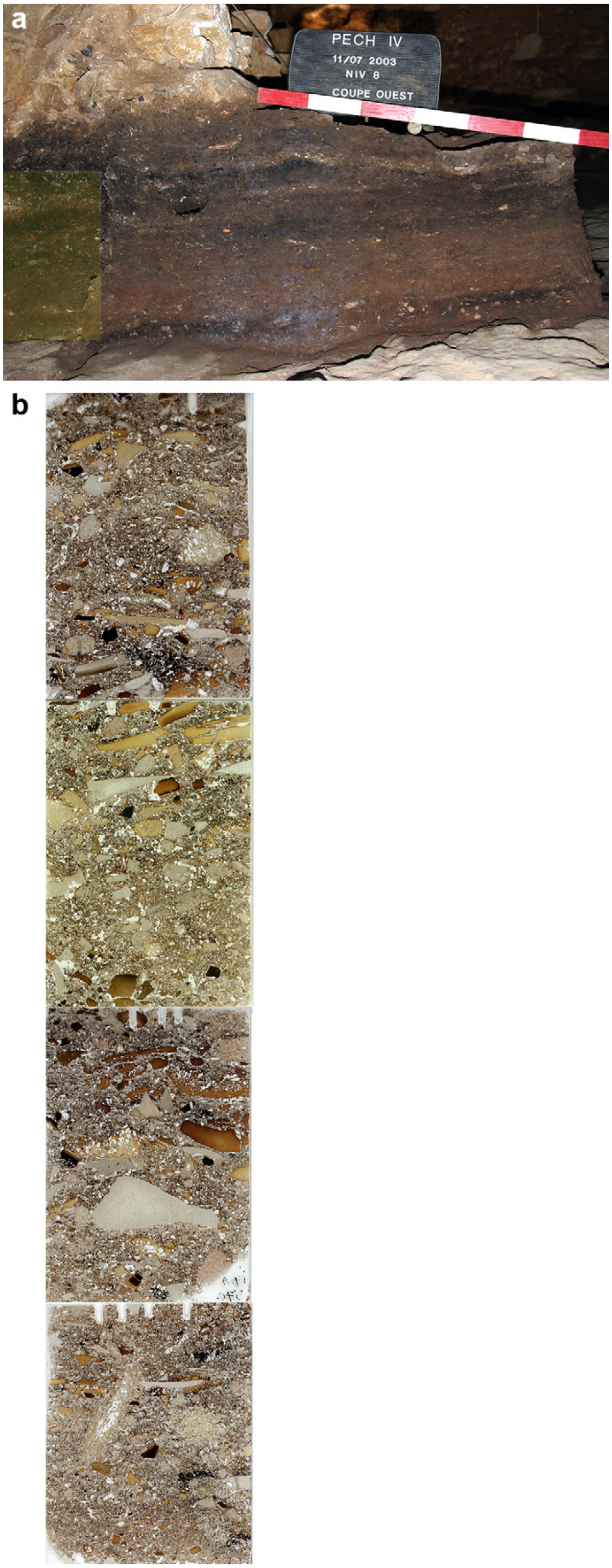

Fig. 5. (a) Layer 8 at Pech de l'Azé IV showing interbedded sandy layers and lenses of ashes and darker brown and back organic matter. The yellow rectangle at left delineates location of micromorphology column shown in Fig. 5b. (b) Superposition of four thin section scans made from block removed from a column shown in Fig. 5a. Note the abundance of burned bone fragments which vary in color from lighter to darker brown. In addition, two pronounced dark layers are visible which contain greater amounts of charcoal, organic fats derived from the bone and burned bone. FTIR results from the second thin section below the top is shown in Fig. 6. Each thin section is 75 mm long (total length of four sections = 30 cm). (For interpretation of the references to color in this figure legend, the reader is referred to the web version of this article.)

clear that burning is happening, we see at higher magnifications and degrees of resolution that different types of burning activities took place that are not visible to the naked eye at the field scale end. Thus, the micromorphology provides for a more detailed interpretation of individual anthropogenic events, which include the construction of hearths, the combustion of materials, the maintenance and alteration of the hearths, and their modification by diagenesis (phosphatization) and human activities, such as rake out and trampling. We also are able to observe differences in what was burned during individual combustion events: certain layers are composed of phytoliths (Fig. 4d) produced by the burning of grasses, while others represent the combustion of more woody plants (Fig. 4c). Thus, we have windows into looking essentially at the paleoanthropological context of these features and associated artifacts/ecofacts.

Finally, the Sibudu case, demonstrates that the remains of individual human activities (burning, hearth maintenance) are preserved at the centimetric scale. Such a situation raises issues relating to the context of other parts of the archaeological record. For example, in many sites – particularly prehistoric hunter and gatherer sites, including Sibudu – remains of lithics and bones are thicker or larger than the microstratigraphic unit which here is a record of individual 'anthropological events'. In other words, for most bones and stones collected from sites and contextualized with a Total Station, we do not (and so far cannot) ascribe them to the microstratigraphic anthropological event that is observable using micromorphology. [Sibudu is perhaps an exceptional example of well-preserved deposits and thus at other sites with less microstratigraphic differentiation it might be difficult to observe the degree of anthropological complexity registered at Sibudu.] We thus have to develop ways of integrating the level of analysis of deposits and stratigraphy observable at the microstratigraphic scale with that used in studies of the lithics, fauna, and plant remains. We have no solution for melding these two scales but we must be made aware of the issue if we are going to examine the archaeological record at a higher level of resolution than what is being done at present.

2.3. Pech de l'Azé IV, France

Pech de l'Azé IV (Bordes, 1975) is one of several Palaeolithic sites located in the Perigord region of southwest France within an abandoned phreatic cave system. The base of the sequence (Layer 8 of recent excavations (Dibble et al., in press) and equivalent to Bordes' layers X, Y, and Z) rests on bedrock and consists of ~50 cm thick layer of dark, predominantly anthropogenic sediments in the form of greasy cm thick sandy lenses of ash, charcoal/organic matter, and burned bone (Fig. 5). These layers represent several discrete intact and slightly mobilized combustion features that were not reworked by running water or cryoturbation [see Dibble et al., in press for details].

A ~30 cm long column was collected in these deposits (Fig. 5). In addition to standard micromorphological techniques, we employed FTIR microscopy (Fourier Transform Infrared Spectrometry), which has been quite successful in determining mineralogy within the context of the thin section and revealing temperature estimates of combustion based on calibrations of heated bone and

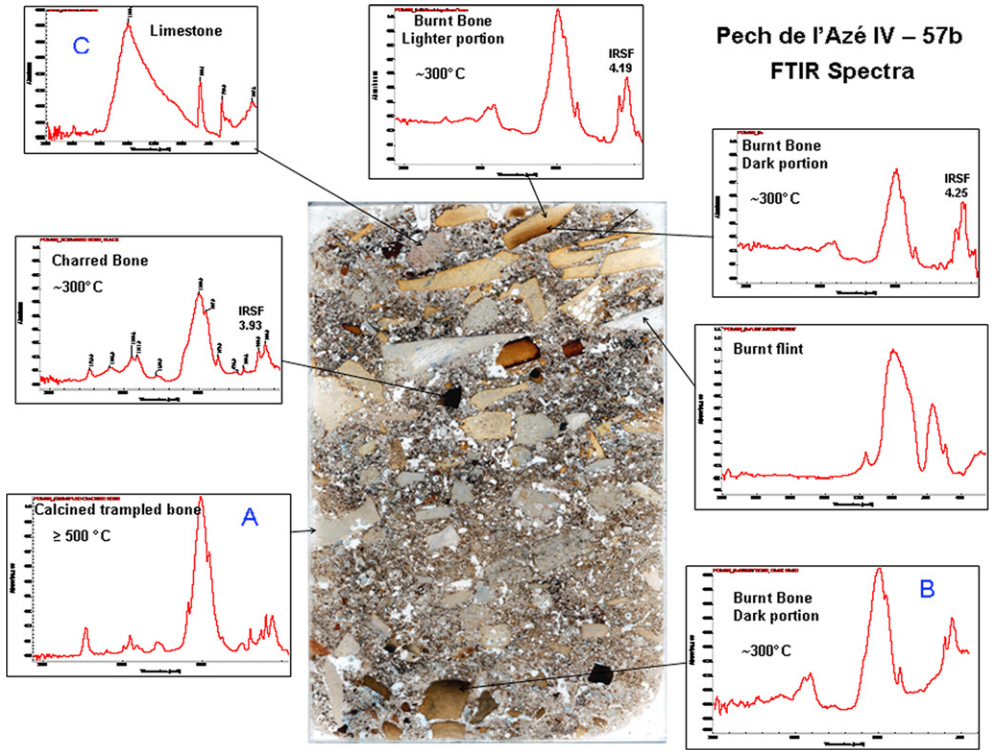

Fig. 6. Microscope FTIR spectra of in situ fragments of bone flint and limestone from Sample 57b from Pech de l'Azé IV (cf. Fig. 5).

clays within laboratory experiments (Berna and Goldberg, 2007; Berna et al., 2007).

Burned bone is visible in most thin sections as evidenced by yellow, brown, and black colors; white bone produced by calcination is relatively rare as is charcoal. Organic burned residues of plant and animal matter also contributed to the dark organic color and 'greasy' feel of Layer 8. Locally calcareous ash rhombs occur as individual crystals or as cappings on bones and chert. Ash is also locally mixed into the groundmass or occurs as cemented masses, which became indurated soon after combustion (Dibble et al., in press) as trampled and broken cemented clasts of ash can be seen in thin section. Trampling is also indicated by the crushing of spongy bone and by scissor-like fractures of more massive bone fragments (Miller et al., in press).

In addition to trampling, combustion products (e.g., ash, bone, and charcoal) were mobilized by other human activities such as cleaning, which resulted in lateral redistribution of these components. Both trampling and rake out may have resulted in the breakdown in charcoal, as most pieces are quite small (mm size and smaller).

Components within the thin sections were analyzed using FTIR microscopy, whereby the contextual integrity of the objects within the slide and thus site space is conserved. Using the FTIR microscope we analyzed in situ burned, charred, and calcined bone, as well as flint and limestone within thin section PDA-IV-57b (Figs. 5 and 6). As stated above the overall lack of structured combustion visible in an in situ fireplace (typically a reddened substrate overlain by charred material and whitish ash, respectively) suggests that these materials are not in place but have been redistributed by hearth-cleaning and trampling; they have not been redistributed by water as no traces of lamination or sorting have been observed. This micromorphological observation is supported by the FTIR analyses which reveal important compositional properties of the bone fragments and soil particles analyzed. In the center left of Fig. 6, for example, a piece of trampled calcined bone (A) shows the characteristic recrystallization of bone carbonate hydroxyl apatite in the calcination process at above 550 °C. In the lowermost part of the slide, on the other hand, darkened parts of charred bone (B) yielded temperature estimates of ~300 °C but below 550 °C, since charred collagen is still present in the bones and only a slight amount of bone mineral recrystallization was detected. Estimated temperatures (250–500 °C) of bone heating are more homogeneous in the upper part of the slide. Overall, the very low incidence of calcined bone suggests that bone was not used exclusively as fuel, at least locally. These results along with those of faunal and anthracological analyses suggest that bone was used as a likely supplement to wood as fuel.

In sum, both the micromorphological and FTIR analyses exploit the undisturbed nature of the deposits preserved within the space of the thin section and allow us to ascertain that the of the intact deposits of Layer 8 exhibit evidence of multiple burning, trampling, and hearth-cleaning events. Furthermore, most the bone fragments, which were burned at various temperatures estimated to be between 300 °C and 550 °C are scattered over the space of the thin section, and thus support the inference that the combusted products have been remobilized by syn-depositional activities associated with occupation, such as trampling and hearth rake out.

3. Concluding remarks

We hope we have been able to demonstrate the value of paying attention to and analyzing the microstratigraphic and micromorphological aspects of archaeological deposits. These detailed approaches very clearly display the context of the all the material in its true space. In addition, the analysis and exhibition of objects within the thin section or impregnated block provides information about the integrity of these objects, how they got there and what were the human activities associated with their initial production (i.e., burning) but also human activity associated with their modification (e.g., displacement by trampling), or activities associated with hearth management (e.g., trampling, rake out). Although we have emphasized anthropogenic deposits here, it should not be a difficult task to envision the implications for studying the depositional and post-depositional aspects of geogenic deposits at the same scale. Finally, we note that our ability to examine and interpret the context of objects and deposits at the microscale behooves us to make strides to incorporate this micro-contextual approach with that used in the study of larger objects and features that typify the archaeological record from many archaeological sites.

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