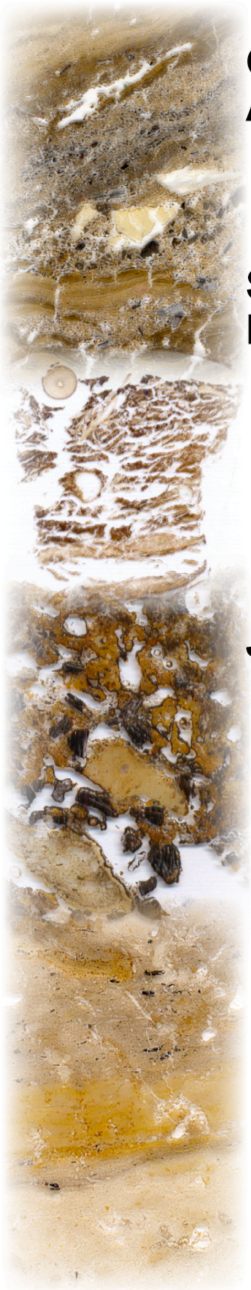

GABII
Area D

Soil Micromorphology Report

July 2015

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1. Introduction

The following report concerns the analysis of thin sections collected during the 2011 campaign at Gabii. The studied thin sections are listed in the following table.

Thin section	Area	section	SU	notes
13	D	100	3135, 3166, 3227	contact btw rubified surface and underlying sandy silt sediment
14	D	100	NA	bottom of the lower sandy silt sediment and top of mixed material (pottery, bones) surface
15	D	100	NA	sandy silt sediment on top burnt? red surface
16 TER	D	100	NA	red surface/ green layer and underlying silty clay
17	D	100	NA	bottom of the lower sandy silt sediment and top of mixed material (pottery, bones) surface. Pottery collected. Spillone special find 666
18	D	100	NA	sandy silt with charcoal under surface
19	D	100	NA	silty clay. Bottom of section
20 BIS	D	101	3136	yellow brown surface and bright yellow surface
21	D	101	3207	bright yellow surface and underlying sandy silt
27	D	104	3219	dark gray dump
28	D	104	3074	red over pottery, burnt wall layer (3086)
29	D	105	NA	probable floor under 3088
30	D	105	3214	probable floor under 3088 and underlying sandy silt with charcoal
32	D	106	NA	sandy silt with orangy round inclusions
34	D	106	NA	more compact sandy silt with some charcoal

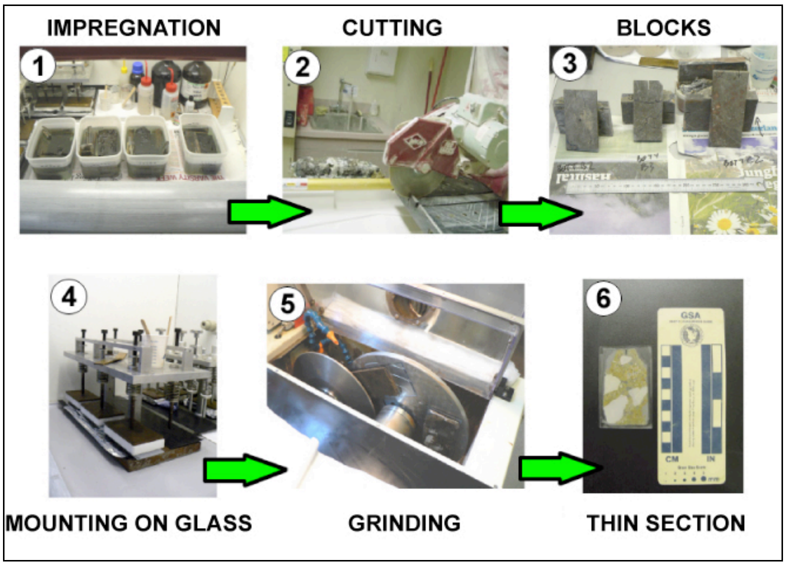
1.1 Soil micromorphology

Soil micromorphology consists in the study of undisturbed soil samples in thin section under the petrographic microscope. The technique was introduced by the German soil scientist Kubiena in the 1930s and was applied to archaeology by Cornwall in the 1950s (see Macphail, Goldberg & Courty, 1990).

Sample collection is performed on stratigraphic profiles and cross-sections. The sample must be undisturbed and oriented, in such a way that all soil components maintain their original position and arrangement. The block of sampled material is then left to dry naturally or in a ventilated oven at low temperatures. Polyester or epoxy resins are employed to embed the sample, normally under vacuum, in such a way that all pores are filled and all soil particles fixed. After resin hardening (which takes up to 5-8 weeks) the sample can be cut, ground and lapped without loss or deformation of the original soil material, similarly to rock samples (Fig. 1). Progressive thinning and polishing is achieved through the use of automatic grinding machines and finally with abrasive powder by hand, until the standard thickness of 30μm (μm = "micron" = 1 x10^{-3} millimetres) is reached.

Thin sections are studied under the petrographic or polarizing microscope, which mounts a set of two polarizing filters or *nichols*. Study of thin sections is performed under normal or plane polarized light (PPL), crossed polarized light (XPL), oblique incident light (OIL), fluorescent light, generally in the UV (UVL) or blue (BL) wavelengths. Additional analyses on uncovered thin section include microprobe (especially for elemental mapping), scanning electron microscopy and energy

dispersive spectrometer (SEM/EDS) or energy-dispersive X-ray analysis (EDXRA) and micro Fourier transform infrared spectrometry (micro-FTIR).
For thin section description the terminology of Stoops (2003) was employed.



The production process of soil/sediment thin sections.

2. Results

2.1 Section 100

At the time of sampling no stratigraphic unit (SU) number was yet assigned, hence the sequence was labeled with capital letters.

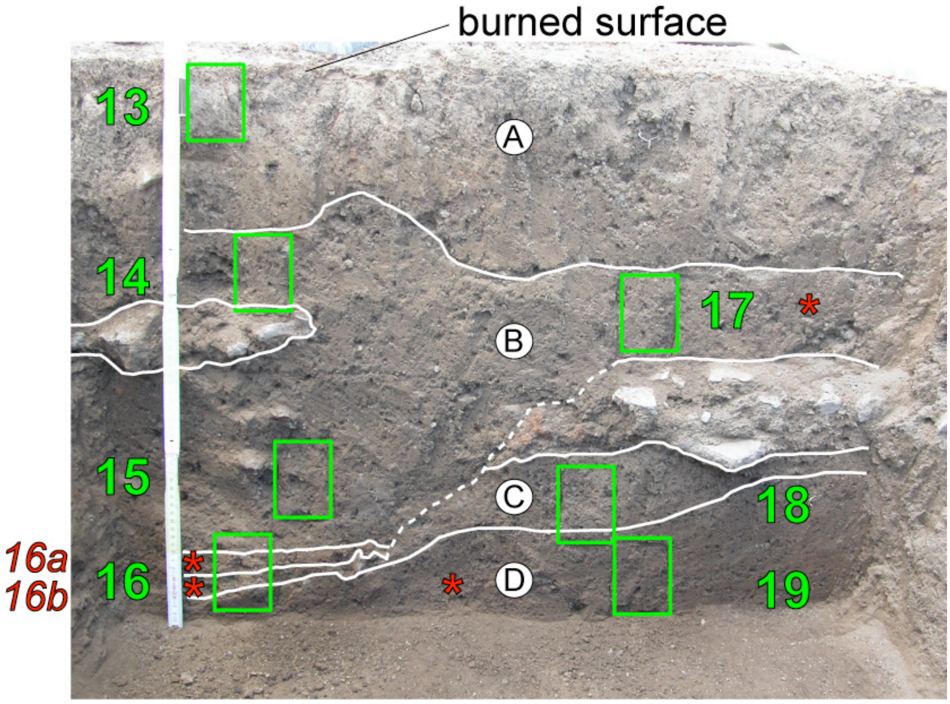


Figure 1 Gabii – Area D. Section 100. Position of thin section.

Unit "A" (Thin section 13): this unit is composed of anthropic backfill containing charcoal, pottery/burnt soil fragments, bone, and scarce fecal material. This backfill show signs of strong compression, most likely lined to the creation of a "beaten earth floor" (Fig. 2). On top of this, a thin layer of clayey sediments quarried from the local soils was spread as a form of lining for a floor. The latter shows sign of reddening, possibly connected to exposure to fire.

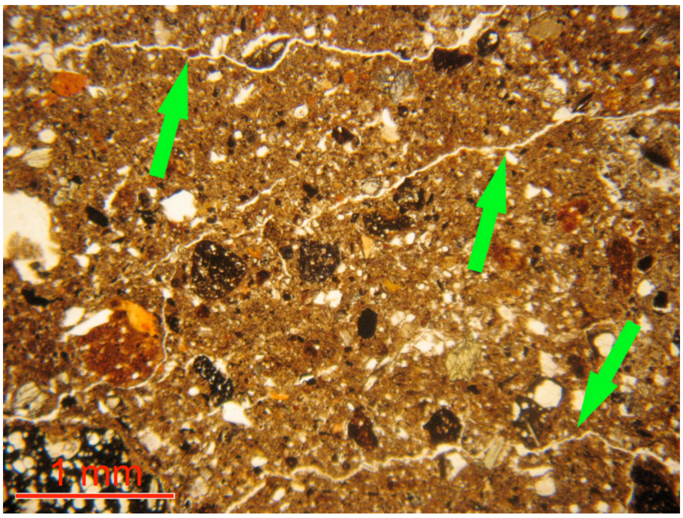


Figure 2 Unit "A", Thin section 13. Horizontal planar voids (arrows) delimiting platy aggregates. This microstructure can derive from strong compression of the sediments, as for the creation of a "beaten earth" floor. Parallel polarized light (PPL), 20x.

Unit "B" (Thin Sections 14 and 17). This unit rests on top of a discontinuous layer made up by in horizontally-lying pottery fragments, most likely corresponding to a surface (see Fig. 1). The sediments accumulating on top of this layer contain large quantities of silica phytoliths, mostly articulated. Some of these phytoliths can be identified as chaff (Fig. 3). Others, showing a dendriform morphology, can be linked more generally to cereals (Fig. 4). This unit contains also abundant fragments of clay-based construction materials (from floors, hearth linings, wall plasters, etc.), rare fragments of mud brick or daub characterized by the addition of vegetal temper, burnt soil/pottery fragments, bone, charcoal, and some rare charred cereal grains.

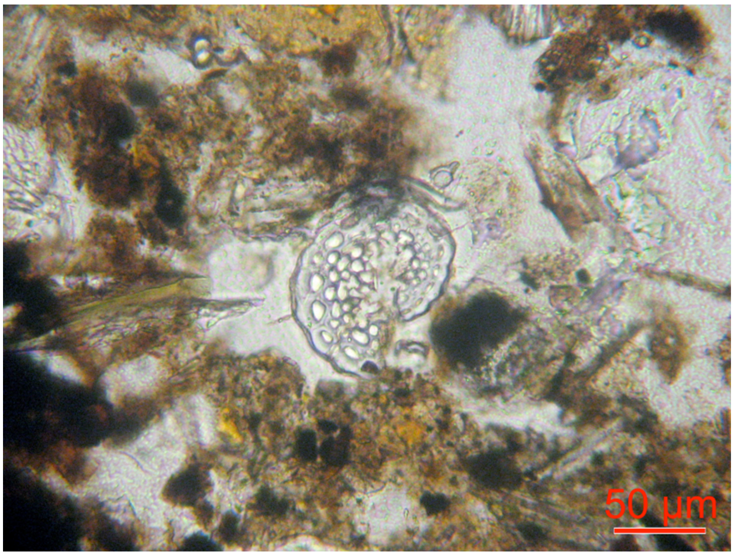


Figure 3 Unit "B", Thin section 15. Chaff (husk) silica residue. Parallel polarized light (PPL), 200x.

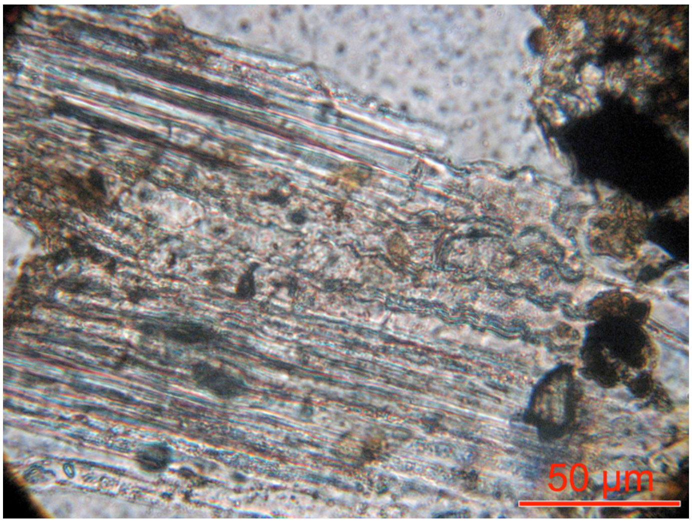


Figure 4 Unit "B", Thin section 15. Articulated silica phytoliths, showing a "dendriform" morphology, typical of cereals. Parallel polarized light (PPL), 400x.

In thin section 14 there are very well expressed "slacking crusts" (Fig. 4). These derive from the action of raindrop impact on a bare surface. They suggest a space not covered by a roof, with puddles forming at the surface, even for a very short time. These slacking crusts are – curiously – absent from thin section 17. This suggests a marked lateral variability in the deposit, which is probably disturbed by repeated phases of accumulation, destruction, and incision.

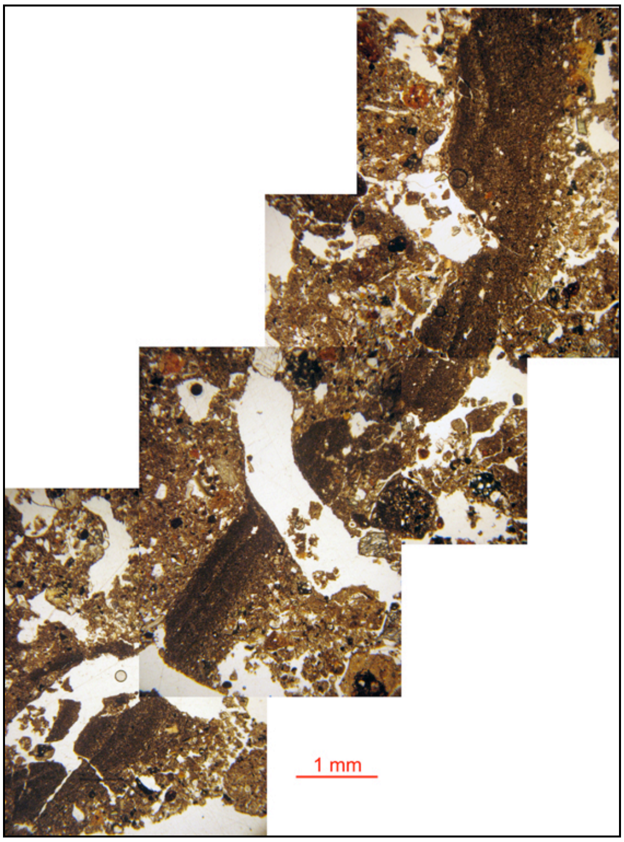


Figure 5 Unit "B", Thin section 14. Slacking crust, deriving from the impact of raindrops on a bare (unroofed) surface. These features form very quickly at a depth of a few centimeters from the exposed surface. Parallel polarized light (PPL), 20x.

A negative structure cuts through the pottery-rich discontinuous layer (see Fig. 1). Its upper fill (thin section 15) is composed of rubbish possibly used to seal the structure after it went out of use. This rubbish contains abundant charred grains (Fig. 6), charcoal, and fragments of earth-based construction materials (Fig. 7). These derive from the destruction and reworking of floors, linings for fireplaces and, possibly, wall plaster. Some fragments of reworked slaking crusts were also observed.

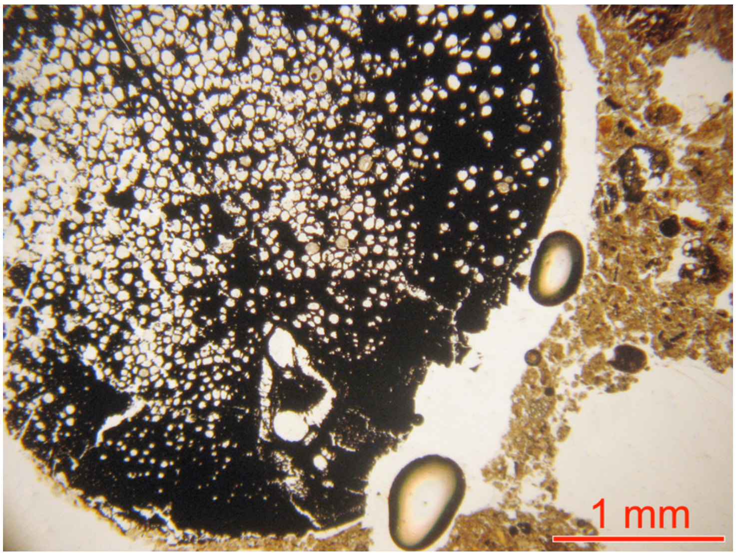


Figure 6 Unit "B", Thin section 15. Charred cereal grain. Parallel polarized light (PPL), 20x.

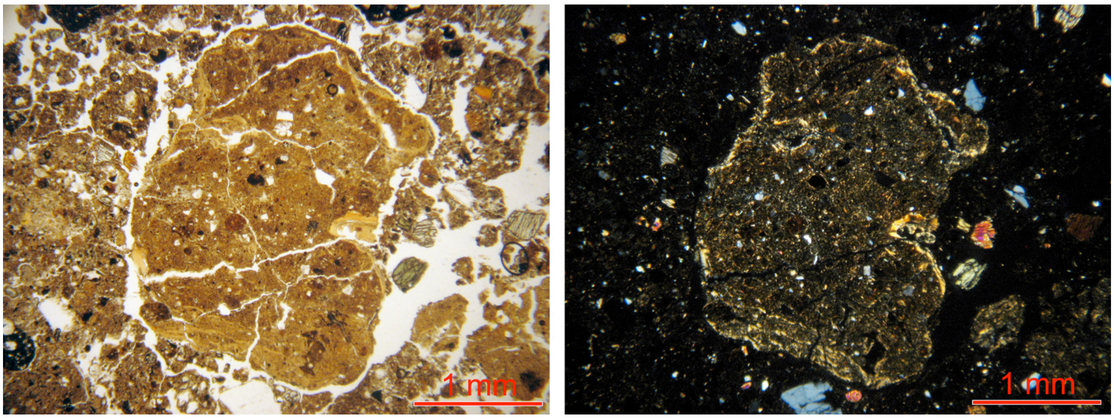


Figure 7 Unit "B", Thin section 15. Reworked fragment of earth-based construction material. These were quarried from local soils: note the presence of illuvial limpid clay coatings around the aggregate. Parallel polarized light (PPL) and crossed polarized light (XPL), 20x.

The base of the negative structure (thin section 16) shows an alternating sequence of clays from the local soils laid out as a basal lining. At the present state of research it is not possible to establish if these clays were exposed to heat. A thin layer of coarse sand- and gravel-sized tuff fragments overlies this material. Above it, one more coating of clay has been observed, suggesting multiple re-use of the structure. The presence of charred grains in thin section 16 and in the rubbish deposits within and around the structure (where also cereal phytoliths are abundant) suggest that this structure could have been used for cereal processing (parching ? toasting ? – see Harvey & Fuller 2005).

Units "C" and "D" (Thin sections 18 and 19). These units can be interpreted as backfill units, showing a much lower degree of anthropization with respect to the units described above. They are composed of silty clay-textured materials, also quarried from local soils. These display vertic properties, i.e. they are characterized by the repeated shrinking and swelling of clay-rich soil materials. Small fragments of pottery/burnt soil, rare charcoal fragments, and reworked fragments of clay-based construction material highlight an anthropic signature for these sediments.

2.2. General remarks

The studied sequence is the result of a superimposition of layers of backfill supporting floors or activity surfaces. Backfill was most likely spread out for leveling and ground-rising purposes during refurbishment or after destruction of buildings. Large quantities of earth-based construction materials (used in floors, walls, fireplaces etc.) were observed in all backfill units.

The sequence can be subdivided in three parts, from bottom to top:

1. At the base of the profile (Units C and D), backfill is made up by sediments quarried from soils with vertic properties (Vertisols), with minor (yet, important) inputs of fragments of earth-based construction material and charcoal.

2. A discontinuous layer of compressed and stacked pottery rests directly on backfill corresponding to units C and D. Its continuity is interrupted by a negative structure, the walls of which are lined with clay (quarried from local soils). Such a structure has undergone at least two cycles of plastering and re-use. The material filling it, and covering the layer of compacted pottery is very rich in cereal processing by-products

(Unit B). These encompass chaff phytoliths, generic "cereal" phytoliths in very large quantities (especially in thin section 14), and charred cereal grains.
This phase is also characterized by indicators suggesting an unroofed space (slacking). Bare conditions would have left traces in the soil even in case they persisted just for a very short period of time. The negative structure is possibly linked to cereal processing as well.

3. The top part of the sequence (Unit A) is a beaten-earth floor composed of anthropic backfill. This is significantly poorer in waste derived from cereal processing than Unit B. A thin lining of clay, quarried from the "Bt" or "argic" horizons[1] of local soils, overlies the beaten earth floor. Its composition recalls that of the very thin clay floors observed in Area D – Room 2 (section 105, between SU 3088 and 3214), and of many of the broken-up fragments of earth-based construction material observed throughout the sequence.

[1] "Bt" soil horizons (labeled "argic" in the USDA Soil Taxonomy – see Soil Survey Staff, 2003) are soil horizons that, by virtue of soil forming processes, get enriched in clay. The latter is transferred from the horizons above (termed "eluvial horizon") to the pores of the clay-enriched horizon below.

2.3 Section 105

Microstratigraphy revealed that this sequence comprises a series of superimposed thin clay floors (or “mud plaster floors” – see Moffa 2002), barely visible in the field, intercalated to the remains of domestic occupation waste, usually trampled and with traces of dislocation by raking.
The waste micro-layers contain phytoliths, burnt bone, charred grains, charcoal fragments, and burnt soil, suggesting the functioning and maintenance of domestic hearths and the dismantling of earth-based architecture (Figure 9, 10).
Periodically, new clays were laid out, possibly in the liquid or semi-liquid state, after waste and construction debris was leveled (Figure 11). The reddening of the upper portion of such clay-based floors might indicate that burning was employed in order to harden the surface. In thin section 29 we observed the presence of scarce vegetal temper (grasses ?) within one of the clay floors. The latter shows the strongest signs of reddening.

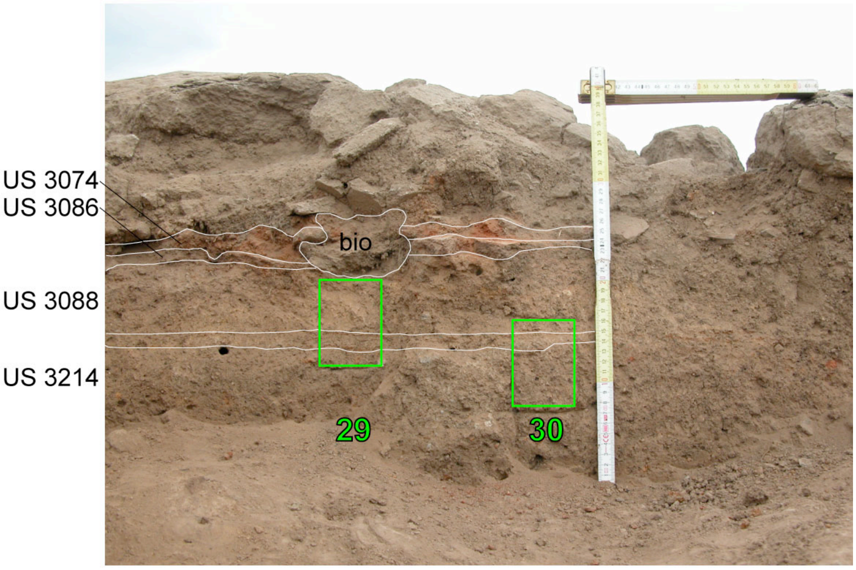


Figure 8 Section 105 with position of thin sections 29 and 30.

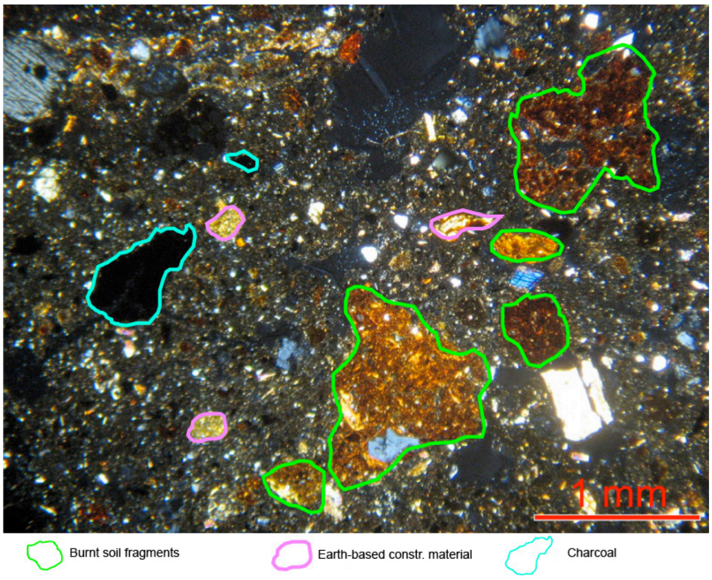


Figure 9 Thin section 29. Waste micro-layer intercalated between floors.

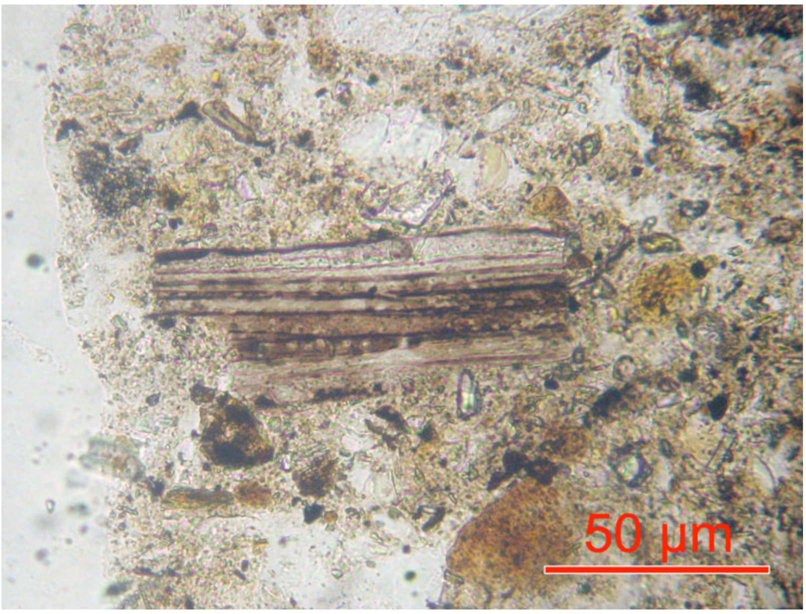


Figure 10 Thin section 29. Phytolith, suggesting possible crop processing residues (showing traces of charring) within a waste micro-layer intercalated between floors.

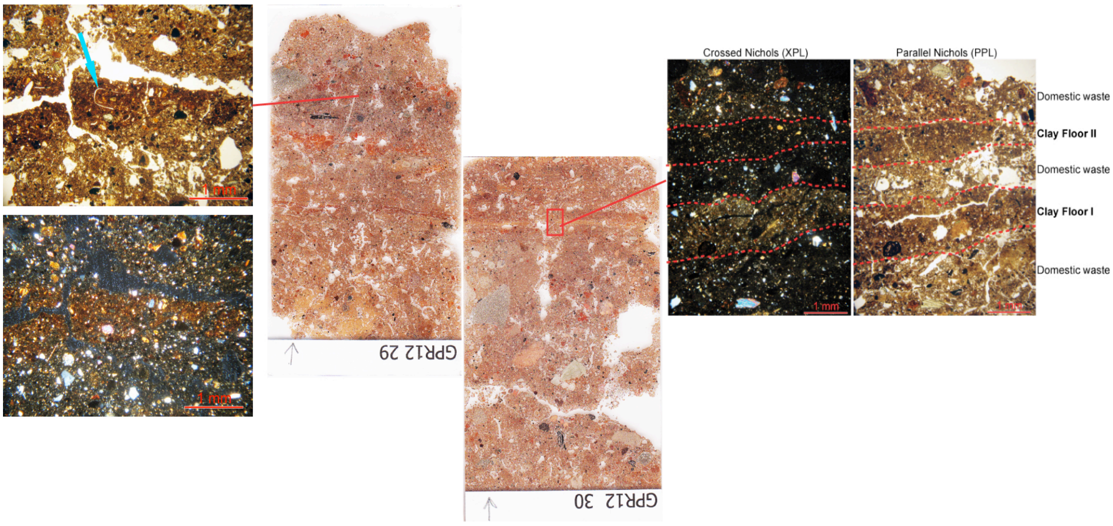


Figure 11 SU 3088 and SU 3214. Scanned thin section showing a sequence of two superimposed clay-based floors (mud plaster floors).

2.4 Section 101

This sequence is composed by a series of superimposed floor levels (SU 3092, 3136, SU 2/3 and SU 3/3 – see Figures 12, 13).

Figure 12 Stratigraphic unit 3092 (Ambiente Sud – photo by L. Motta)

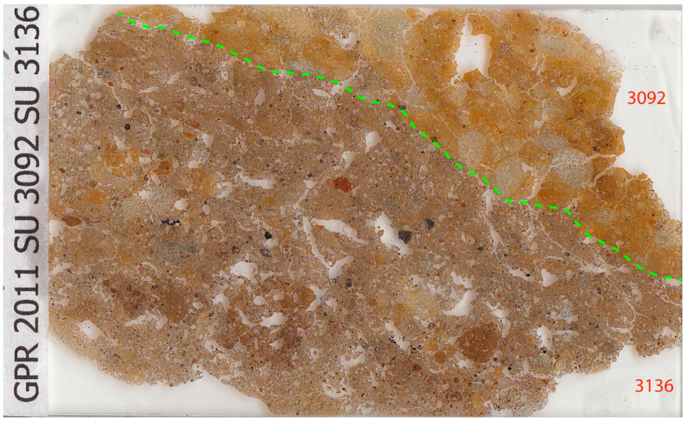


Figure 13 Stratigraphic units 3092 and 3136 in the scan of the thin section.

SU 3136

This unit is composed of construction rubble that underwent leveling and comprises several diverse types of earth-based architectural residues reworked in the deposit (see below, chapter 2.5).

SU 3092

The composition of such unit is peculiar, as it is composed of a material that was only observed in this very thin section. Such material is a mixture of volcanic scoria[2] which, upon weathering, released large quantities of clays. The material was therefore quarried from a substrate of weathered volcanic rock, and used to construct a floor. The plasticity and the consistency of the weathered volcanic scoria deposits were probably the desirable qualities sought. This material would have had hard consistency once dried The activities tat took place on such floor did not leave traces in the studied sample.

[2] Altered basic tuff, partly composed of vesicular basaltic (sometimes even tachylytic) material.

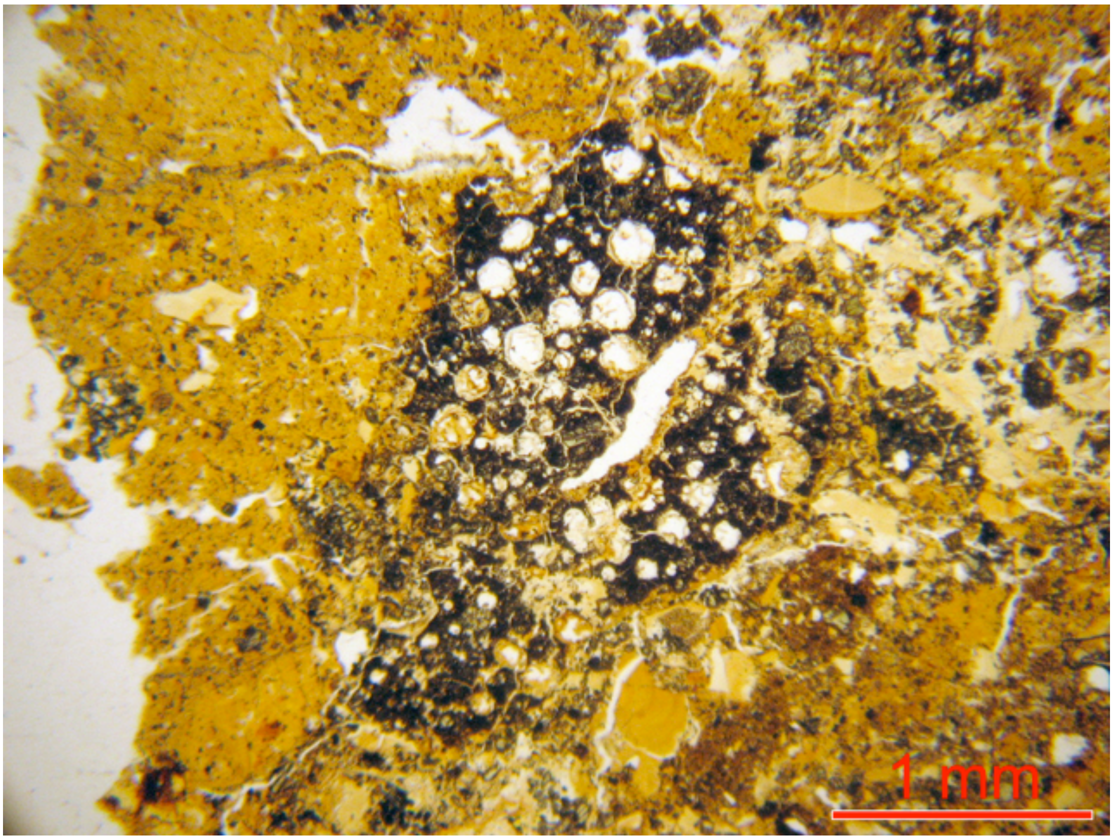


Figure 14 Stratigraphic unit 3092. Volcanic scoria (center) surrounded by yellowish clays deriving from its weathering. PPL.

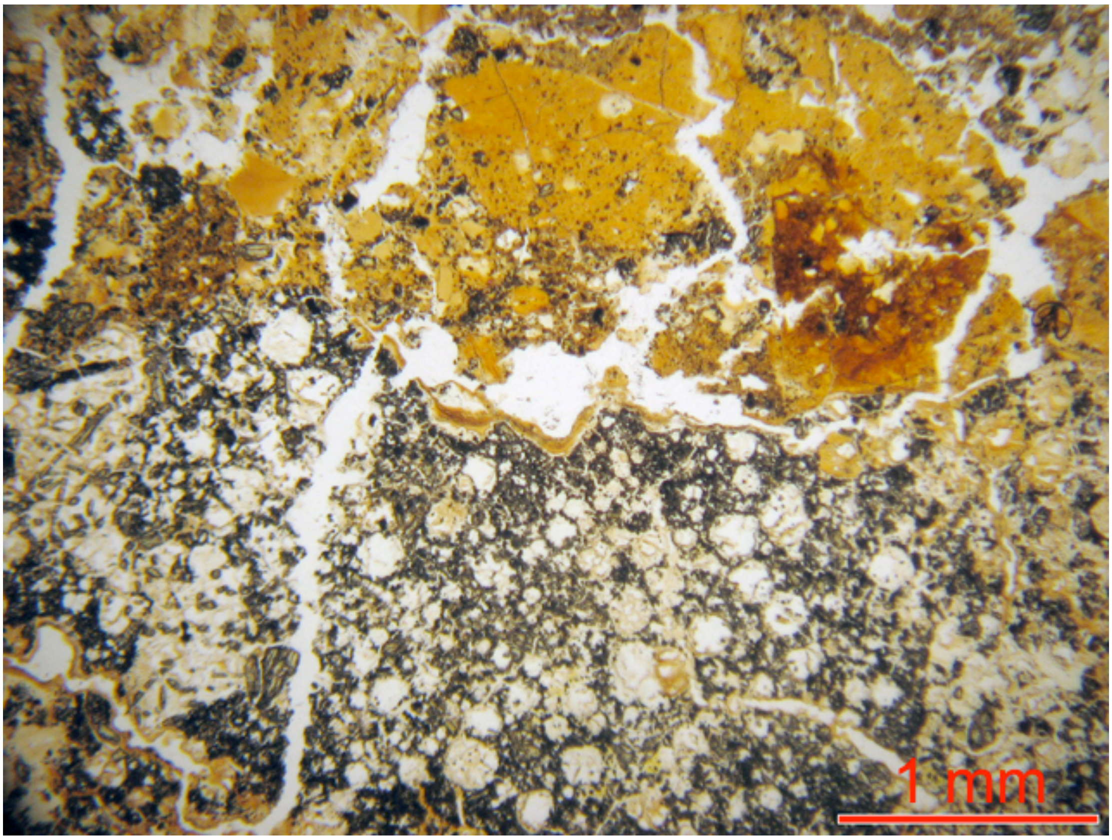


Figure 15 Stratigraphic unit 3092. Volcanic scoria (bottom) overlain by weathering clays. PPL.

SU 3136, SU 2/3, SU 3/3

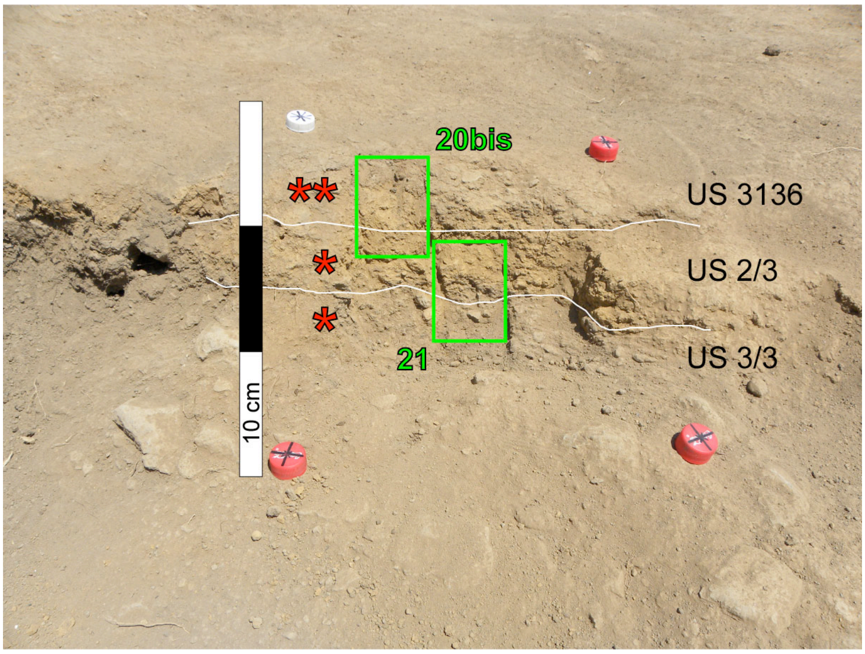


Figure 16. Position of samples 20bis and 21

This sequence is composed by a series of superimposed levels (SU 3092, 3136, SU 2/3 and SU 3/3) deriving from the destruction and leveling of earth-based architecture (floors, wall plaster, mud-based mortars, hearth preparations, etc). We observed the use of silty clays quarried possibly from the nearby volcanic lake shores. They are in fact fine-grained, and contain remains of freshwater algae that do not grow in terrestrial environments (Chrysophycean cysts – Figure 17). Such microfossils reveal the origin of the sediments used for construction. Such materials are found in large quantities in SU 3219 (see below), interpreted as a dump of hearth-derived waste. This suggests that such lacustrine sediments were possibly used in hearths.

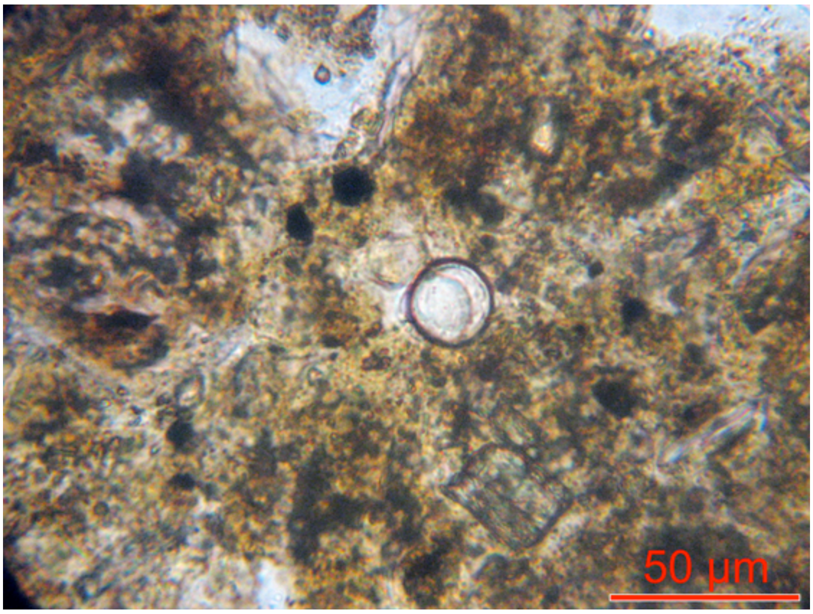


Figure 17 Thin section 20bis, SU 3136. Chrysophycean cysts. PPL.

In SU 3136 we observed traces of strong compression, which might suggest that this was in fact a beaten earth floor (platy microstructure – Figure 18). Anthropic materials are scarce throughout: few charcoal, and very few pottery and bone fragments.

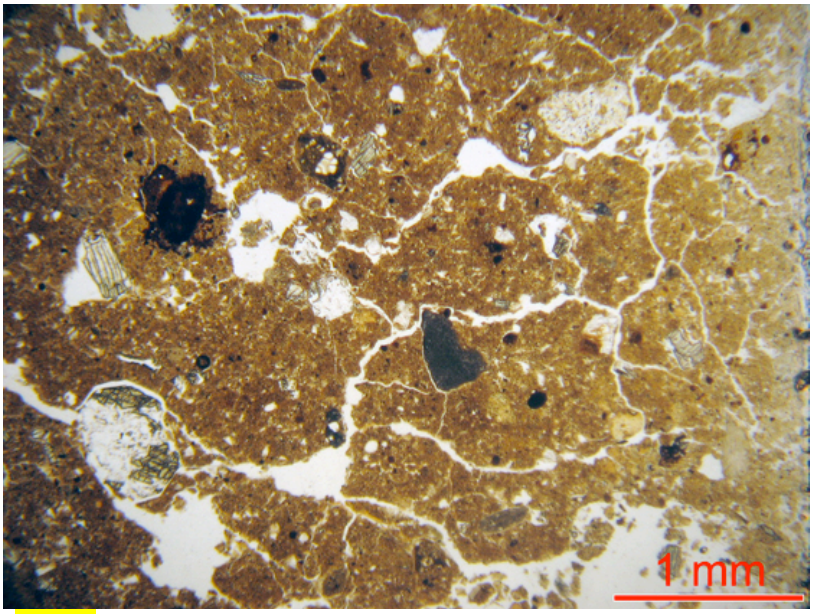


Figure 18 Thin section 20bis, SU 3136. Platy microstructure. PPL.

In SU 2/3 there are several floor fragments with rounded edges showing traces of low-temperature combustion, possibly deriving from the functioning and maintenance of hearths (Figure 19). Such fragments are reworked in the stratigraphic unit, suggesting that floors, walls, and hearths were disrupted, leveled, and rebuilt several times.

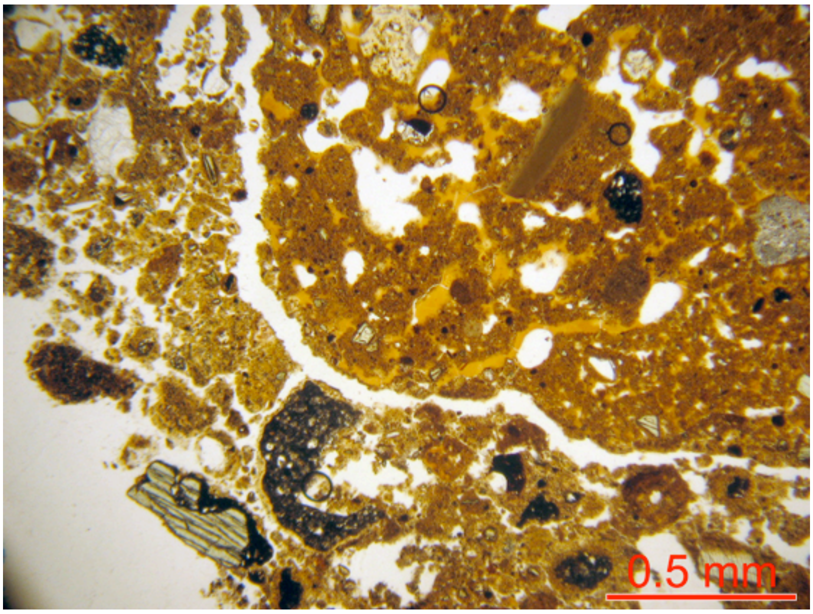


Figure 19 Thin section 21, SU 2/3. Reworked floor (?) material built with Bt horizon fragments. PPL.

Interestingly, at the very bottom of thin section 21, a remnant of an occupation surface was found. This sub-millimetric layer is composed of several horizontally-layered phytoliths, often partially charred (Figure 20, 21). These phytoliths suggest that grasses, possibly even cereal remains (some awn and ask residues can be identified), accumulated on the floor and were trampled. As there are no trace of animal fecal material, we can suggest that the use of the floor was for domestic activities

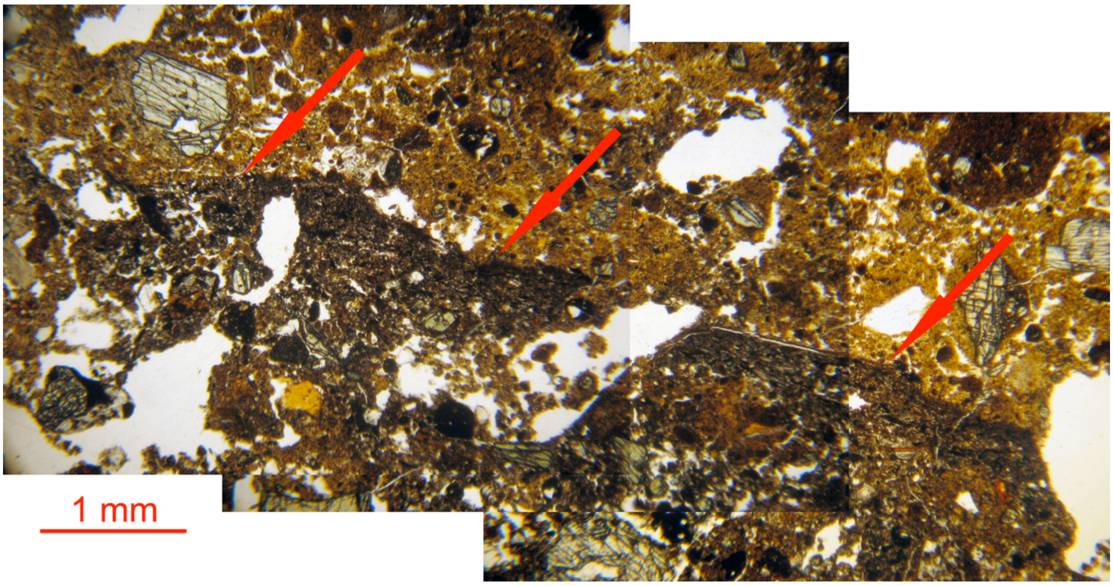


Figure 20 Thin section 21, SU 3/3. Remnant of a dwelling surface (arrows). PPL.

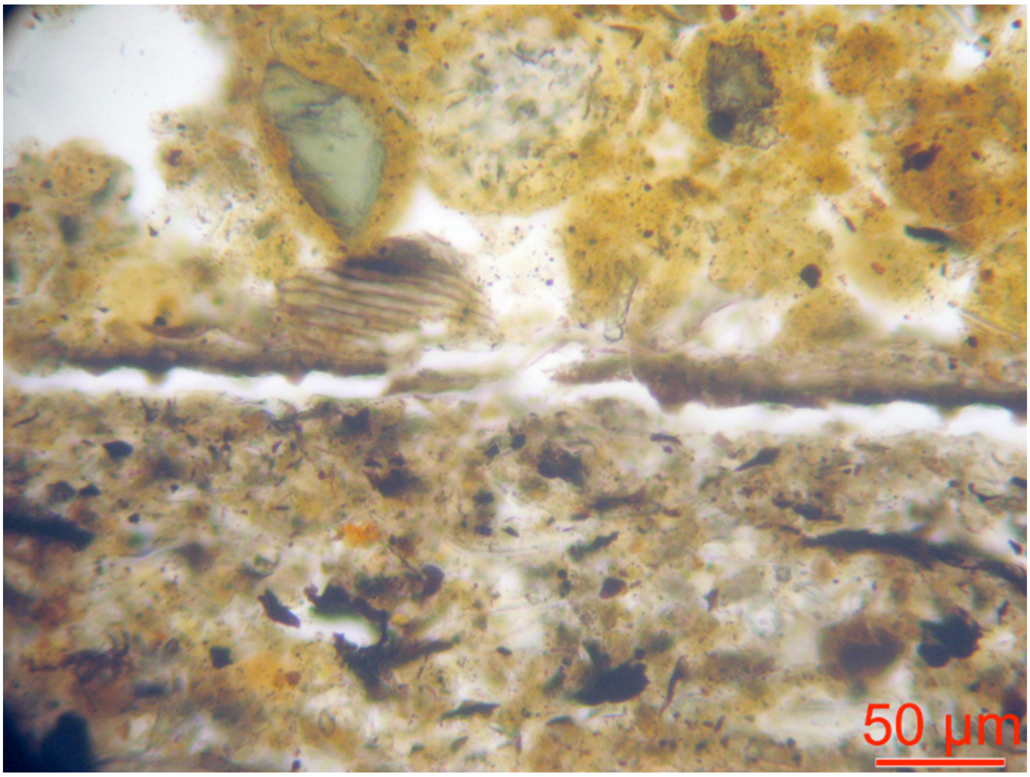


Figure 21 Thin section 21, SU 3/3. Detail of the dwelling surface, with phytoliths and charred vegetal remains. Some phytoliths are identifiable as cereal waste (chaff). PPL.

2.5 Section 104

Figure 22 Position of samples 27 and 28

Thin section 28

SU 3074.
This unit is composed of earth-based constructional materials of different sorts. We could identify clay aggregates (similar to those observed in Section 101) and silty clay aggregates. All these materials pertain to different usages (floors, wall plastering, hearth construction) and appear to have been exposed to temperatures between 400-600 °C. These are compatible with temperatures reached during the burning of a structure. The state of fragmentation of all these materials suggests that they are in secondary depositional setting. This unit can be interpreted as rubble deriving from the burning of a structure employing earth-based constructional materials.

SU 3086
The interpretation of such unit is similar to SU 3074, although the quantities of burnt construction material are lower. Large quantities of lake-derived sediments, employed as construction material, have been identified in this unit (Figure 23).

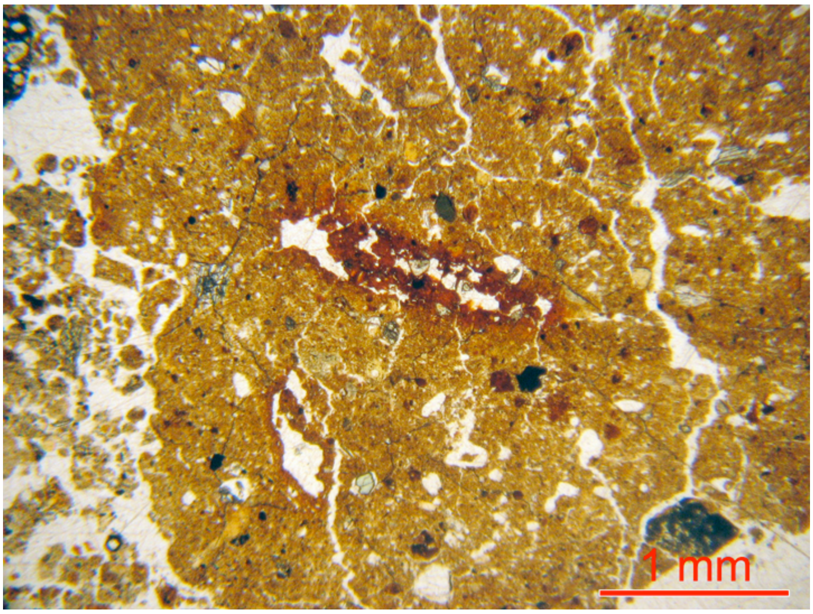


Figure 23 Thin section 28, SU 3086. Fragment of lake-derived construction material. We note the presence of iron mottles (hypo-coatings) that formed in the wet lake environment prior to quarrying. PPL.

SU 3219

The fill of this negative structure was sampled with one thin section in the lower part (Thin section 27). The studied portion of the fill can be subdivided in two parts.

(a) lower part: composed largely of charred cereal grains (Figure 24), very abundant chaff residues (phytoliths – Figure 25), charred legume testa (identification based on Macphail, Goldberg 2010, p. 607 – Figure 26), fragments of clay-textured (lakeshore-derived) construction material. Less frequent are burnt bone fragments, wood charcoal fragments, and burnt soil fragments richer in silt. Sometimes their color indicates burning in reducing conditions.

(b) top part: predominantly mineral sub-unit, silty clay textured. In it we observe reworked aggregates composed of chaff, several charred cereal grains, wood charcoal, fragments of burnt soil, and pottery fragments.

In both parts there are weak traces of formation of secondary carbonates. As these do not derive from the natural substrate, and the soil conditions are not favorable for their formation, we can suppose that the SU 3219 originally contained large quantities of carbonates. Given that most of the components of the unit show traces of charring or burning, these carbonates were probably originally ashes. These underwent weathering and leaching, and only feeble traces of their presence are now preserved.
The interpretation of SU 3219 must therefore take into account that a large quantity of ash was originally present in it. Ash, chaff, charred grains and burnt soil fragments point to the by-products of cereal processing by means of fire, possibly cereal toasting (?). Other components, such as burnt bone and charred legume testa suggest the presence of food preparation residues.

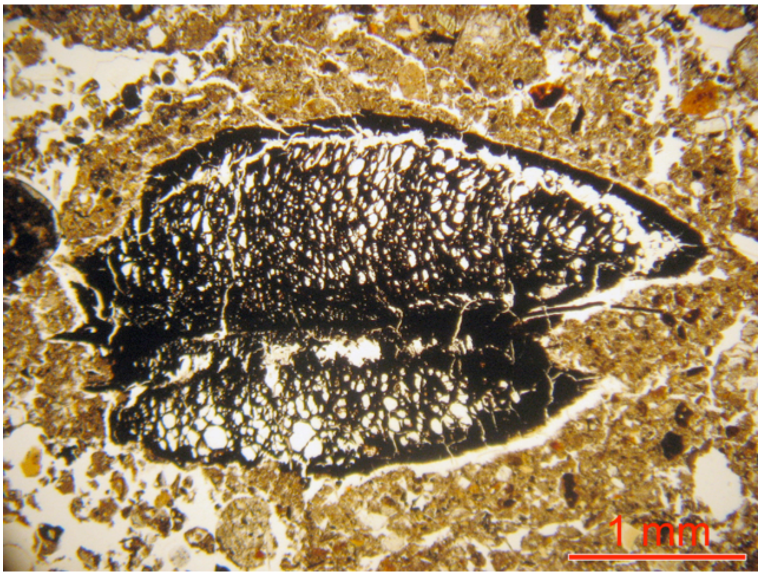


Figure 24 Thin section 27, SU 3219. Charred cereal grain. PPL.

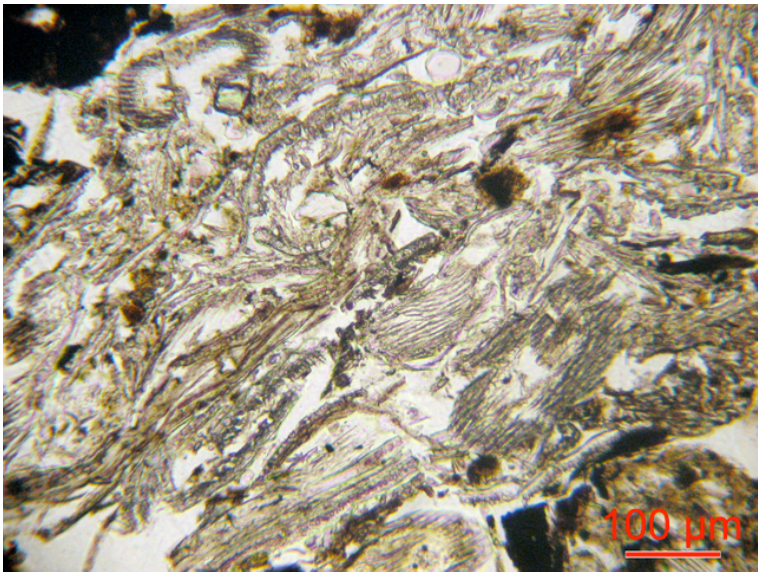


Figure 25 Thin section 27, SU 3219. Phytoliths of chaff (mainly husk fragments). PPL.

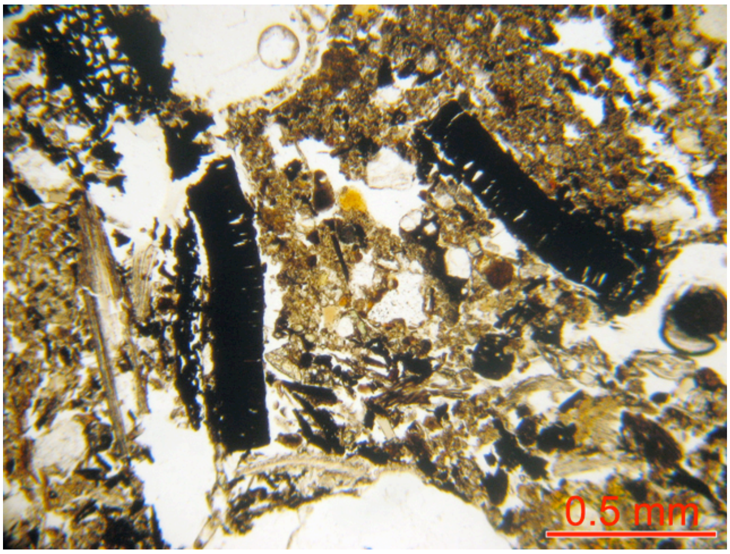


Figure 26 Thin section 27, SU 3219. Charred legume testa (?). PPL.

2.6 Section 106

Thin section 32

This samples contains mostly waste from hearths or fireplaces. The “orange rounded inclusions” that were observed in the field are in fact rounded (thus transported and reworked) aggregates of burnt soil. The latter, with a clay or silty clay texture, were employed in hearth preparations. We moreover observed the presence of fragments of bone, pottery, phytoliths, and of abundant charcoal. These components are scattered randomly through the sample. This evidence, together with the loose and disaggregated nature of the deposit, suggests that this unit is the outcome of dumping of domestic and hearth-derived waste.

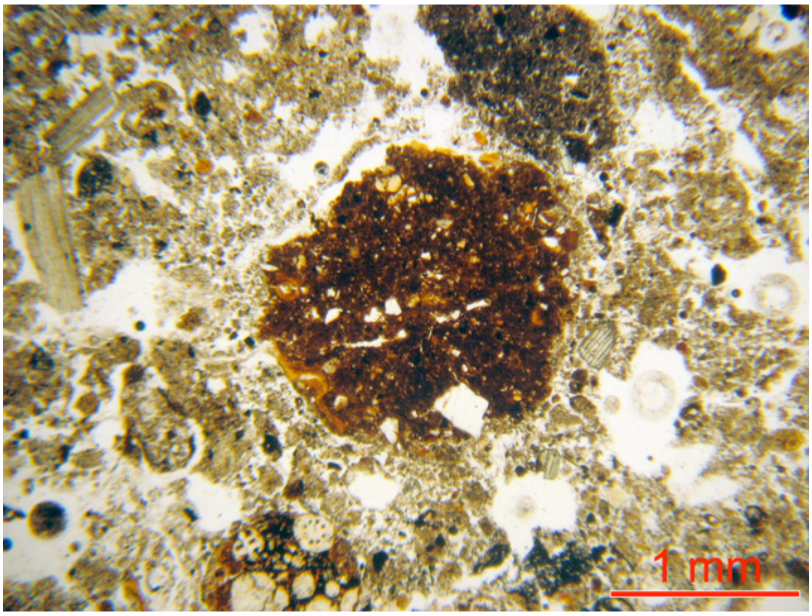


Figure 27 Thin section 32, fragment of burnt soil, deriving from hearth preparation. PPL.

Thin section 34

This material can be interpreted as a layer of fill containing large quantities of earth-based construction material (fragments of floors, mud plaster) and fragments of hearth preparation. One fragment has a composition similar to the floors material observed in SU 3092. It is in fact composed of a mixture of weathered volcanic scoria and soil material, and shows a gradient towards strong reddening. The latter indicates strong exposure to fire (burning of a structure?). Other anthropic components include bone fragments, small pottery fragments, phytoliths, and charcoal.

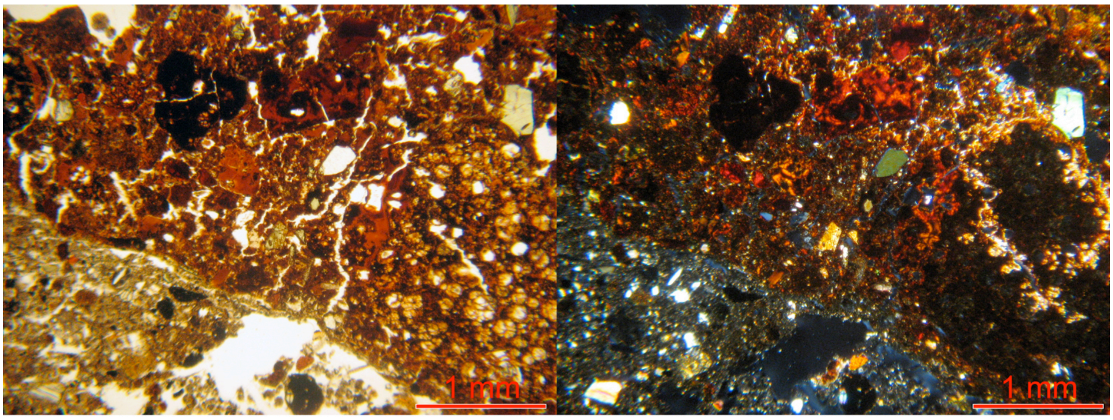


Figure 28 Thin section 34, fragment of hearth preparation with strong reddening. PPL.

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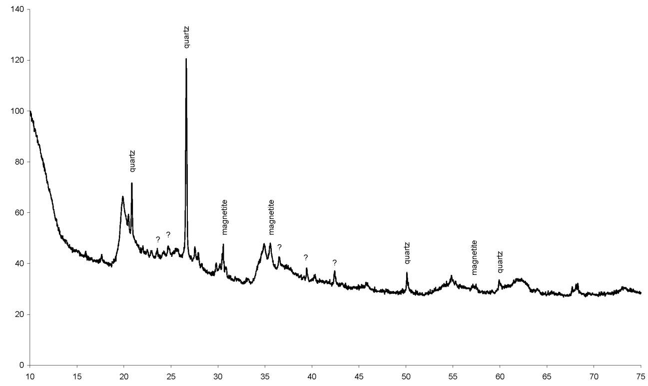
APPENDIX

Experimental burning of sediments[3]

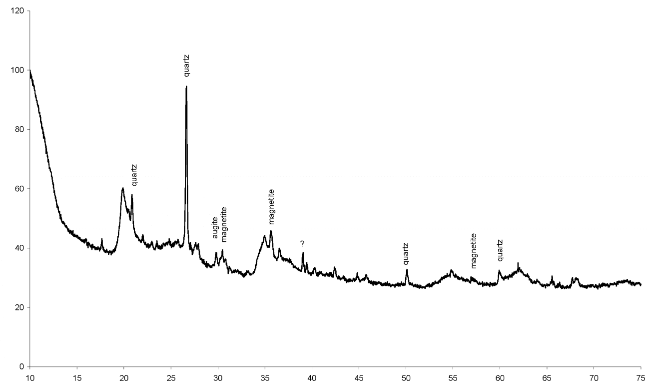
Sediments extracted from the "natural" substrate in profile 100 (slightly silty clays with Vertic properties at the base of the profile) were experimentally heated in the laboratory in order to determine the changes in optical qualities (by thin section analysis) and in mineralogy (detected by X-ray powder diffraction - XRD).
The same natural soil sample was heated for 60 minutes at different temperatures: 400 °C; 600 °C; 800 °C; 1000 °C. Part of the soil was resin impregnated for thin section mounting. Another (sieved to < 1 mm) fraction was used for XRD.
The gradient in reddening observed (Figure 29) was used to ascertain if certain materials in thin section had or had not been exposed to heat.
Results from X-ray powder diffraction show that indeed mineralogical changes occur upon heating, with low temperature samples containing magnetite, while the highly fired samples have hematite (see spectra in the following page).

Figure 29 Left: Thin section with the soil unburnt (top right quadrant) and burnt at different temperatures. Right: the raw samples. In both cases we not the gradient in reddening.

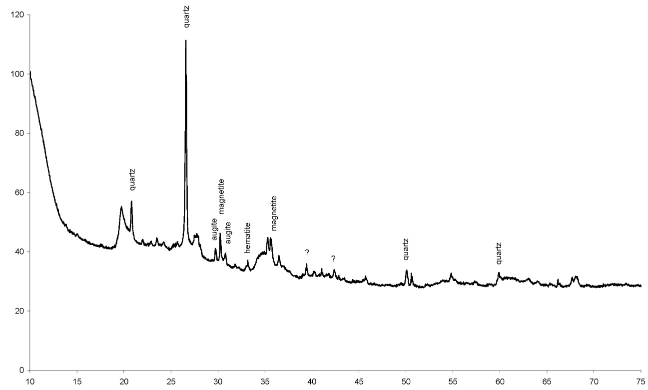
[3] These experiments were carried out with the help of M. Canti and D. Dungworth of Historic England (Portsmouth, UK).



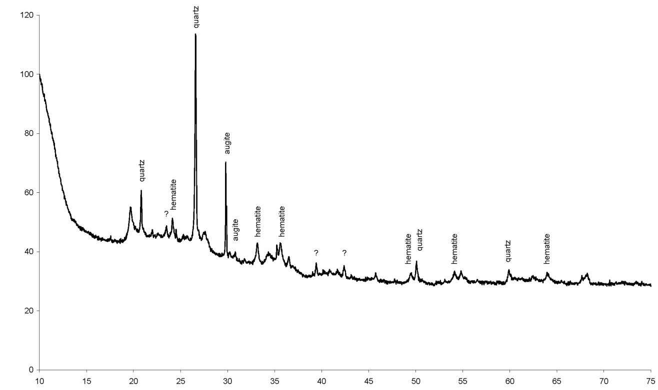
XRD spectrum – Unburnt sample



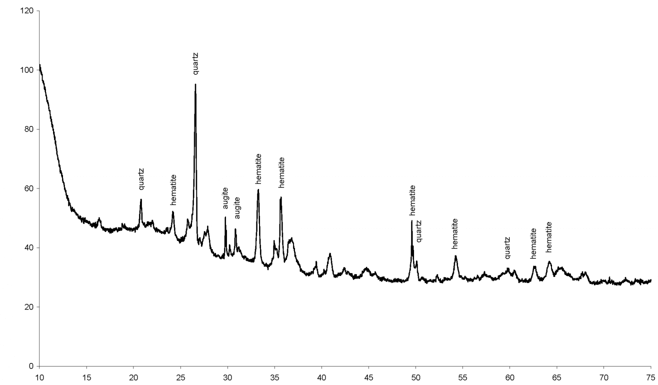
XRD spectrum – Sample burnt at 400 °C



XRD spectrum – Sample burnt at 600 °C



XRD spectrum – Sample burnt at 800 °C



XRD spectrum – Sample burnt at 1000 °C