STUDY OF PAST AND PRESENT RECORDS IN SOILS FROM LORRAINE (FRANCE)

A geoarchaeological approach in the context of rescue archaeology

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ABSTRACT
This paper presents some aspects of past and present records gathered during the last two decades, examining soil profiles in rescue archaeological contexts in Lorraine. After a general presentation of the regional geomorphological context, the paper will report and discuss some results collected through both archaeological prospection and excavation phases. Finally, this report is an opportunity to make some conclusions on the possible geoarchaeological approach to rescue archaeology in Lorraine (France).

KEYWORDS
rescue archaeology, geoarchaeology, case studies, Lorraine, France

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Foreword

The French heritage code (section L510-1, 2016) defines archaeological heritage as all kinds of traces of past human existence, including the context in which they occur, amongst which the protection and study allows the understanding of the development of human history and its relation to the natural environment. So, as an integrated part of French rescue archaeology, the geomorphological approach is supposed to serve as a reference for the surrounding forthcoming operations and to contribute to the understanding of man/natural habitat interactions at the investigated site (Speller, 2008). Since 2017, the INRAP (Institut de Recherche en Archéologie Préventive) job description categorises all the earth science specialists (geomorphologists, geologists, soil scientists, micromorphologists) as 'geoarchaeologists', whose mission is to identify the different litho-pedo-sedimentological processes related to archaeological remains, implementing all the geoarchaeological tools (geology, geography, geomorphology, pedology, stratigraphy, micromorphology, petrography, pedochemical analysis, sedimentology, geophysical survey…). The geoarchaeologists help outline the scientific strategy (prospection/excavation) and the design process for data collection, necessary to contribute to the knowledge of links between human societies and their environment.

1. Introduction

This paper describes some aspects of past and present records, gathered during the last two decades, examining soils in rescue archaeological contexts in Lorraine. After a general presentation of the regional geomorphological context and the methodological approach of rescue archaeology in France, the results of four case studies are reported and discussed. The first ones are from two kinds of archaeological prospection types: (i) a rescue archaeological small surface prospection (Chamagne, 7 ha), (ii) a linear prospection (Cerville, 3 km of geomorphological observations along the landscape of a 13 ha prospected surface), (iii) Bulgnéville, 4,5 ha of archaeological excavation, (iv) an archaeological investigation at a structure scale (a *Grubenhaus* at Montigny-les-Metz, 350 m^2).

All these examples present different uses of the geoarchaeological approach as a help to understand human settlements, their evolution and interaction with the natural environment. The conclusion discusses how, in spite of time and administrative constraints, even scattered geoarchaeological data from rescue archaeology can be used in a research framework.

2. General contexts

The Lorraine area (Fig. 1), extends in the west from the eastern part of the Paris Basin to the Vosges mountain in the east. Mesozoic geology forms a characteristic landscape made of calcareous escarpments oriented north/south, which structure the main hydrographic network (Rivers Moselle, Meurthe and Sarre; Lexa-Chomard et Pautrot, 2006; Le Roux, 2007). The surface formations (Carcaud, 1992; Flageollet, 2002; Cordier et al., 2004) mainly result from Quaternary glaciations (valley alluvial deposits, alluvial terraces and loamy drift cover), but Tertiary and Quaternary slope deposits are also present. The superficial loamy cover, mostly of a regional origin, is of a mixed alluvial, aeolian and colluvial sediment (Caillier, 1977; Gury, 1990).

The climate is temperate to slightly continental. Precipitation ranges between 750 mm/year along the middle Moselle river valley to 2400 mm/year at the Ballon d'Alsace (Wahl, 2007). Except in mountainous areas, the quite uniform Lorraine climate does not have a sensitive influence on soil evolution, which is more strongly controlled by geological parent material and topography.

Therefore, brownification (brown soil evolution) and leaching seem to be the main pedological processes of the well-drained soils on the *Lorraine plateau*. *Brunisols* and *Luvisols* (Baize and Girard, 2008; *Cambisols* and *haplic Luvisols* from WRB, 2015) have a wide extension in Lorraine (Jamagne, 2011), even if clayey Tertiary and thick weathered rock layers strongly inhibit local drainage. The resulting set of processes can prevail over leaching and darkening. On the calcareous parts of this *Lorraine plateau* (upper and middle Trias), the lack of water rather dominates pedological processes. On thick loamy covers and ancient alluvial terraces, soils are more or less highly sensitive to leaching, clay translocation and weathering. Upper Mushelkalk, Keuper and Lias clayey formations generate heavy, compact, plastic, wet/sticky or dry/hard and fissured soils, which are very sensitive to meteorological and seasonal variations. These soils are difficult to plough and often strongly water saturated. Such hydromorphic soils are used as meadows and forest. Apart from the better drained slopes, excess water management is the most important challenge for agricultural development on clayey/marly substrate (Jacquin and Florentin, 1988; Jamagne, 2011). On the thick loamy cover (> 50 cm) overlying the Keuper clayey substrate, soils are *redoxic Neoluvisols* and *Luvisols* (Baize and Girard, 2008; *luvic Cambisols* and *haplic Luvisols*, WRB, 2015), affected by a low permeability of the Bt horizon; as such during the wet season temporary perched water tables are present (Jamagne, 2011). Those soils are characterized by a degraded glossic Bt horizon with large reddish iron oxide patches cut by vertical whitish tongues from the upper albic E horizon (Caillier, 1977; Gury, 1990; Florentin, 2005). Where there is a thinner (20 to 30cm) loamy cover overlying the clayey substrate the Bt horizon is thin; however the substrate's poor porosity still induces water saturation during the wet season. The rivers (Seille, Nied and tributaries) carry fine decarbonated clayey and loamy material, which accumulates in the valley, with colluvium. The soils, affected by temporary or permanent water tables are thicker, darkened, degraded Luvisols (Baize and Girard, 2008; *glossalbic Luvisol*, WRB, 2015). In the main valleys, the alluvial sediments of the rivers (Moselle, Meurthe, Sarre and tributaries) are coarse, and the soilscape is characterised by *Fluviosols* (Baize and Girard, 2008; *Fluviosols*, WRB, 2015). Bordering the valleys, from alluvial plains to up slope locations, terrace soils evolved from slightly leached *Neoluvisols* (*luvic Cambisols*, WRB, 2015) at younger sites, to thick leached argilic truncated paleosols on older landscape. On middle terraces there are *redoxic Luvisols* (Baize and Girard, 2008; *gleyic Luvisols*, WRB, 2015), sometimes compacted with glossic/fragic pedofeatures (Caillier, 1977; Gury, 1990).

3. Material and methods

In the studied region, geoarchaeologists are supposed to participate in both archaeological phases: investigation and excavation. Trial trenches, dug by a mechanical excavator having a 2 m wide smooth-edged bucket, are best aligned perpendicular to the valley. Trenches (25x2 m in size and 1 m deep) offset in a staggered pattern, represent 6% of the investigated landscape. For safety and time reasons, observations on deeper profiles (>1,20 m) are carried out from the top of the trench (photo and measurement of each unit's thickness) before immediate refilling of the hole. In the case of archaeological excavation, surface horizon stripping is done, until the archaeological features appear (often at the interface between dark organic and lighter coloured more minerogenic subsoil horizon). The geoarchaeologist is usually not present at this stage and only has access to profiles on rare central plots and on the edges of the excavation. This sometimes makes understanding of the general morpho-sedimentary context difficult.

In the field, each profile is described as a succession of units. Following pedo-sedimentary criteria, these units are interpreted and grouped into sequences corresponding to homogeneous sedimentary or pedogenetic phases. Sequence limits are boundaries resulting from changes in sedimentary or pedological processes. Soil horizons are described based upon classical macroscopic criteria (colour, texture, structure, etc.; Duchaufour, 1976; Baize and Jabiol, 1995).

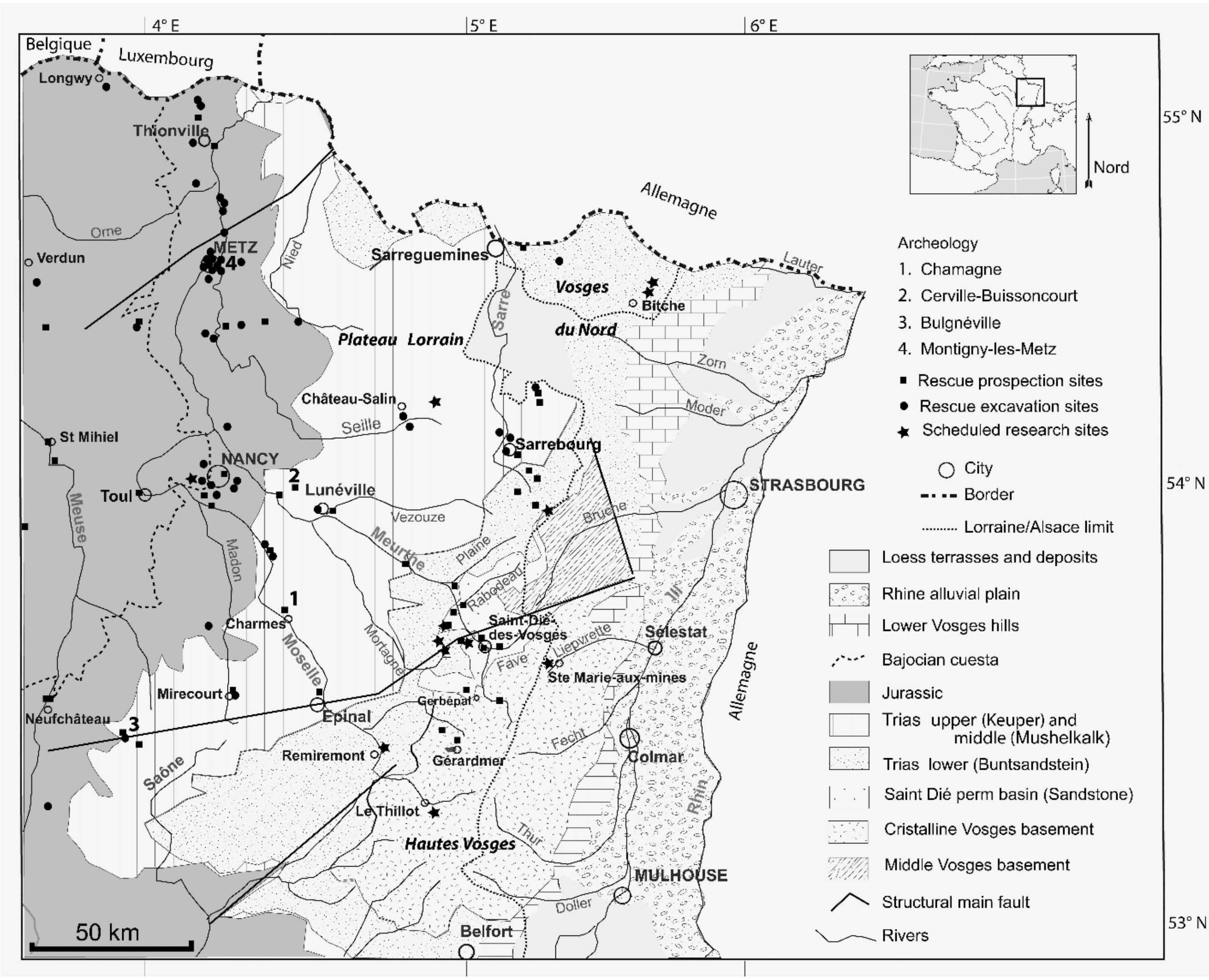

Figure 1. Location of all the studied sites on the geological map of the area (simplified from Lexa-Chomard and Pautrot, 2006; Sell et al. 1998), with special reference to the 4 examples detailed in this paper. The crystalline rocks of the Vosges correspond to the base, the 'sandstony Lorraine' to the Permian and lower Trias sandstones, the 'Plateau lorrain' to the middle and upper Trias, respectively.

The descriptions of the sites discussed here are reported in tables 1 to 5. Soil classification follows the French Soil Classification System (Baize and Girard, 2008) with the equivalences to the World Reference Base (WRB, 2015) being reported in this paper. On archaeological sites, observations are sometimes extended through micromorphological investigations of the soil. Thin sections are then described following international soil thin section description methods (Bullock et al., 1995; Stoops et al., 2010) and interpretation (Macphail and Goldberg, 2017; Nicosia and Stoops, 2017).

The distribution of the seemingly random pattern of the locations of the prospected and excavated sites researched by the author (Fig. 1), can be explained by the spatial and economic planning related to city expansion and valley urbanisation along the major routeway network (fast train, highways, etc.), and on the prescribing rate of the archaeological regional state service which also depend on the regional archaeological risk map. The main geoarchaeological studies are spatially recorded in the *Arkeogis* database, with references to associated reports and published papers (Bernard, 2012).

4. Case studies

In Lorraine, geoarchaeological studies sometimes feature approaches at different scales: the site scale (archaeological features), the middle scale (the site itself) and a larger scale, as a river basin in the frame of large prospection areas or the regional synthesis of several small investigated plots.

Pedo-sedimentary profiles include more or less eroded soils, fossilized under valley colluvio-alluvial accumulations or slope colluvial deposits. Valley infills often have inverted profiles, characterized by dark thick horizons covered by less dark loamy sediments derived from ancient mineral horizons eroded upslope. After abandonment, man-made excavations, like hollow ways, ponds, ditches, post-holes, etc. can locally trap microscopic eroded horizon fragments that provide true indications of past environments and their evolution, related or not to past human activities (Gebhardt, 1996). Furthermore, the study of man-made structures at the site scale gives information about ancient lifestyles or human artefact taphonomy (Gebhardt and Langohr, 1999).

4.1. GEOARCHAEOLOGY IN RESCUE ARCHEOLOGICAL PROSPECTIONS

4.1.1. Chamagne: a small surface investigation

This small investigated surface, covering around 7 ha, is located on an ancient terrace along the Moselle valley, (Bois de Genêt, Chamagne, Vosges; Fig. 11, Fig. 2a). After some unsuccessful attempts at corn growing, this ancient wood, cleared in the sixties, is now used for grazing (Rachet and Gebhardt, 2017). Around 20 m above the river, and on the right at a height of 285 m, this middle-Würmian alluvial terrace overlies the dolomitic Mushelkalk limestone which outcrops along the Moselle at Bout du Pont (Minoux et al.,1978). It is made up (Table 1) of roughly bedded sandy gravels including pebbly to sandy layers with clayey lenses (Fig. 2b, U3b). Locally, the sequence shows periglacial dumb-bell type involutions (Fig. 2c, U3a). A dark reddish manganese concretion layer (Fig. 2b, U3c) is observed at around 1,5 m depth, at the boundary with the lower sands (Fig. 2b, U3d). The coarse series (Fig. 2, U3), made of sand, gravels and pebbles, correspond with the highly dynamic stream of the Moselle river, alternating with clay sedimentation formed in oxbow lakes (Carcaud, 1992).

U3 formations are overlapped by an irregularly (0 to 2 m) thick moderately compact fine clay-loamy layer, U2 (Fig. 2c). From top to bottom, this loamy sequence shows a homogeneous loamy light grey level reworked in the 40cm thick ploughed horizon (U1). Downhill, this layer is thicker and probably related to historical agricultural colluviation. Beneath this colluvium a compact clear-brown-orange loamy-clay occurs, affected by the formation of deep and narrow whitish tongues (Fig. 2c). The horizontal section of this unit shows a small irregularly reticular polygonal network pattern (of around 5/10 cm diameter, Fig. 2d) becoming larger (up to 50 cm) with increasing depth (Fig. 2e). Modern drainage crosses those features (Fig. 2h), but a large ditch infill, less clayey and more bioturbated than the surrounding sediment, is slightly affected by those glossy features (Fig. 2f, 2g). The sherds found indicate that this ditch is linked to an ancient protohistoric occupation.

At the regional scale, it appears that this soil degradation mainly occurs along hillside deposits at the border of wetlands, or on the plateau on thick loam covers over clay substrate. The development of this glossic network has already been described as altered *Luvisols*, possibly associated with cracks in the ground (Caillier, 1977; Gury, 1990; Florentin, 2005). This feature may result from hydric stress on regularly water saturated loamy clay soils from Lorraine. Jacquin and Florentin (1988) noticed that those features are better developed under forest, with trees desiccating the soil by evapo-transpiration. In fact, giving a particular attention to this type of pedogenetic features, linked to other dated sites from the North Eastern part of France, we found that in long sedimentary sequences, those glosses/cracks features are mainly affecting Roman levels (from the beginning of the first millennium of our era), cross structures dated to the Iron-Age or older, and are cut by early medieval or later occupation. The good quality for agriculture of those hydromorphic degraded *Luvisols,* when ameliorated, has been known for a long

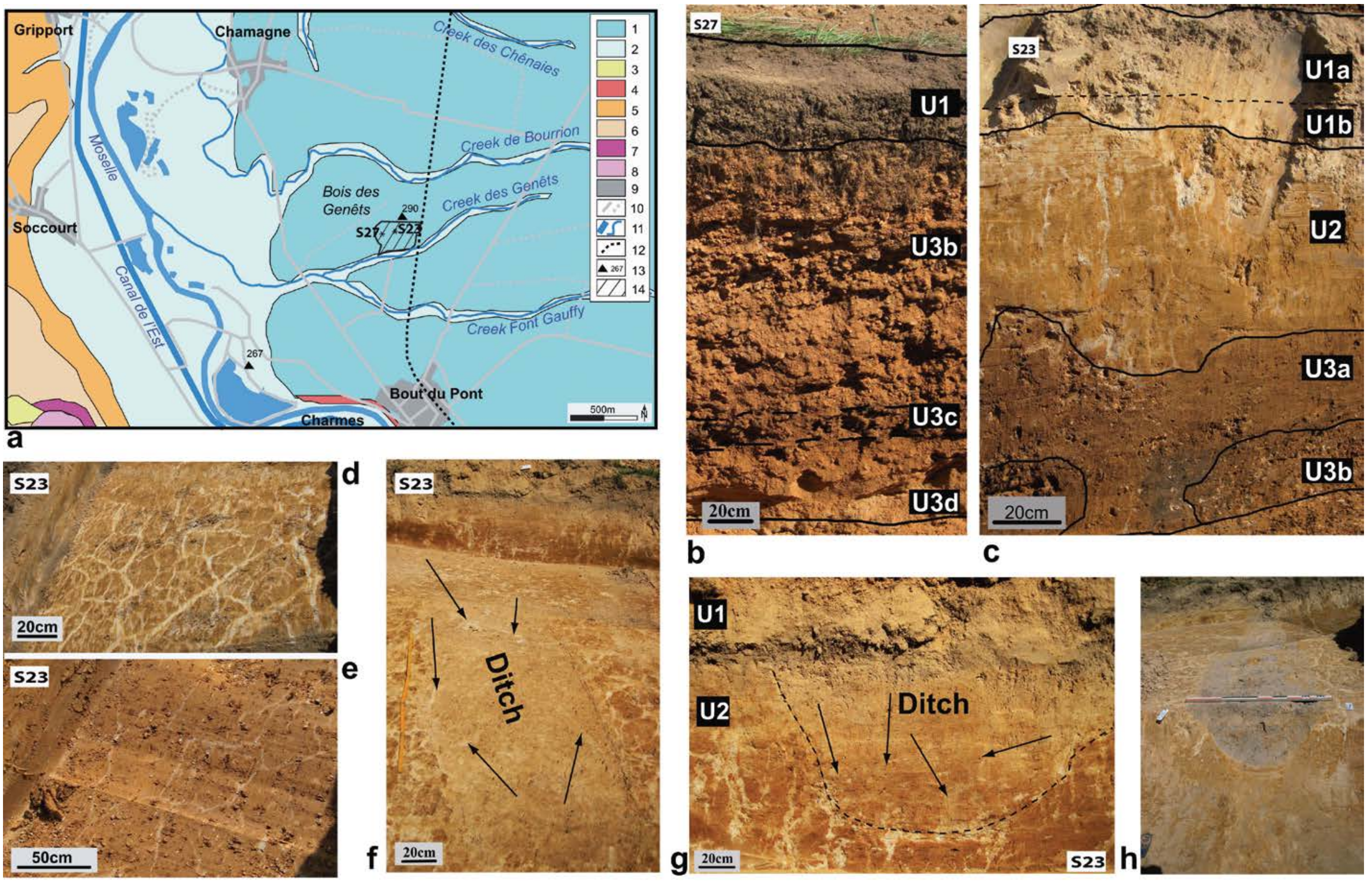

Figure 2. Chamagne (Vosges, France):

a. locations of the site on the synthesised geological map: 1. middle-Würm lowest of the old terraces, 2. younger alluvial terrace 3. loamy deposits 4. dolomitic Muschelkalk 5. lower and middle keuper marls, 6. upper Keuper clay, dolomite and marl 7. rhetian sandstone and clays, 8. hettangian-sinemurian limestone 9. urbanized zones, 10. roads, 11. river, canal and lakes 12. railway 13. altitudes 14. investigated surface
b. profile S27 with sandy/gravel sequence (see description table1)
c. profile S23 with upper loamy sequence
d. S23, horizontal section with upper small size polygonal network; upper part of the profile
e. S23, horizontal section of the polygonal network; lower part of the profile
f. horizontal sections of the ditch with polygonal network traces (arrows)
g. idem in profile
h. modern drainage

Table 1 Field description of the prospected site Chamagne (Vosges, France)

Unit		Field description	Pedo-sed interpretation)
U1		40cm thick dark brown crumby sandy loam level, many fine + some big roots. Structure and color sharp limit with U2.	ploughed horizon (LA)
U2		40cm thick brown-orange sandy-clayey loam, scattered gravels, fine roots, vertical 'glosse' type digitations network with greyish to whitish infill crossing the protohistoric ditch infill, fragmented very small rounded charcoals at the top. Sharp texture and colour limit with U3.	Reworked superficial loamy blanket
U3	Sandy to gravely formation with pebbles and clayey lenses.		Ancient alluvial terrace sediments
	U3a	Compact orange-brown clay, green-grey with depth. Sharp textural limit with U3b.	
	U3b	Pebbles and gravels in sandy matrix.	
	U3c	Idem 3b but manganese black coloured. Colour sharp limit with U3d.	
	U3d	Sand with scattered gravel.	

time. In that way, the Seille valley, for example, is nowadays, still a good place for growing vegetables (Florentin, 2005) and has been occupied and drained since Roman times (OIivier, 2002; Riddiford, 2012).

The formation of these irregular polygonal network pattern was largely discussed in a recent paper (Gebhardt et al., 2018) and the origin of many of these well-marked regional degradations/desiccations of soils can now be interpreted as both anthropogenic and/or climatic. For each site, further research is required to investigate the local climate more precisely and to monitor the land use changes during this period. If these correlations are confirmed, this level of integrated investigations could be a useful milestone for rescue archaeological prospection in Lorraine.

4.1.2. Cerville-Buissoncourt: an example of linear prospection

The prospected site of Cerville-Buissoncourt (Meurthe-et-Moselle; Forelle et al., 2012; Fig. 12, Fig. 3a, Table 2) crosses, north/south, an undulating landscape culminating at 240 m high. 53 profiles, spread across 5 areas running from south towards north (Fig. 3b,c), allowed the observation (Table 2) of the local pedo-sedimentary sequence and human impacts. The creek l'*Etang Le Comte*, regulated/canalised for modern agronomical purposes, is cut in a 2 m thick yellow/beige light sandy loamy-clay cover derived from quaternary sedimentary processes affecting the greyish Domerian marl beneath. The origin of the loamy fraction (aeolian or weathered substrate) is still not clear (Haguenauer et al., 1978). In this location, pedogenesis is strongly influenced by the impermeable marl.

Transect **Tr.c** runs on the upper part of the line of prospection, along a north-east facing gentle slope above the valley of l'*Etang Le Comte* creek. On top of the hill (S307, Fig. 4a); the hardened Liasic sediments outcrop as a hard fractured fine grey calcareous sandstone bed, alternating with small clayey layers (U5). Above this substratum, the paleosol (U3/U4/U5) buried under a thin colluvial sequence (U2) is a *Brunisol* (Baize and Girard, 2008; *Cambisol*, WRB, 2015), with well-developed structural IIS and organic IIA horizons. In this buried sequence, abundant man-made structures (ditches, post-holes), bones, charcoal and unabraded pottery sherds from the Bronze Age were found. It would have been interesting to analyse this well-dated buried sequence in terms of environmental human impact (deforestation, cultivations, grazing, erosion), but during the prospection phase, it was impossible to proceed with further pedo-sedimentary analyses, like soil micromorphology, to describe the sequence in more detail.

The next transect, **Tr.d**, is in continuity with the previous one and S382 shows a last thin occurrence (U4) of the IIA buried horizon (Fig. 4b), rich in charcoal, and probably related to U3, observed in the previous transect (Tr.c, S307). The sequence is topped by a colluvial deposit (U2/3) and affected by strong gleying processes; these were described as *Reductisol* (Baize and Girard, 2008; *Gleysol*, WRB, 2015).

The transect **Tr.b** crosses the valley bottom and the wooded south facing slopes. In the middle of the slope, in profile S132 (Fig. 4c) the uppermost part of the marl (U5) is covered by oxidized sandy channel beds (U4); both are slightly disturbed by quaternary periglacial features. The profile is buried under colluvial deposits (U2) and affected by oxido-reduction at the base (U3). On the wooded top of the hill (S452, Fig. 4d), a typical *Reductisol* (Baize and Girard, 2008; *Gleysol*, WRB, 2015) developed on the calcareous marl (U4) and has no colluvial cover. In this area, there are several drainage ditches filled with an oxidized/oxido-reduction sediment containing scattered Bronze Age material. Abundant modern drains cut the clayey horizons (U2/3).

Tr.e continues facing north, from the wood downslope to pastures, separated by hedges. There, the profile S425 (Fig. 4e) reveals the development of redoximorphic horizons at the base (U3/4) (*Reductisol*, Baize and Girard, 2008; *Gleysol*, WRB, 2015) on the marly substrate (U5/4). Colluvial deposits (U1/U2) cover the marl, except on the very top of the hill. These accumulations appear thicker on the slope at the field limit, the sediment being retained by hedges (many large vertical root channels can be observed in U2).

The last transect **Tr.a** is localised offset on the north facing slope and crosses Le Bois-des-Moines forest. As is the case for S53, profiles reflect strong waterlogging effects with a well-structured subsurface horizon, which is locally strongly mottled with iron/manganese impregnations and concretions (U2, Fig. 3g), developed on greyish reduced horizons (U3/U4). In the U2 horizon, traces of undated cart wheel tracks (Ct, Fig. 4g,h) and a couple of horseshoes (Hs, Fig. 4i) have been found. Here, orange mottling indicates an old compacted traffic-induced soil pan (Gebhardt and Langohr, 2015; Rentzel et al., 2017; Macphail et al., 2016; Macphail and Goldberg, 2017).

This example of topotransect (or *catena*) gives an idea about the relationship between landscape, soil development and human activity. A remain of a paleosol reveals that in Bronze Age times, people settled on the well-drained top of the hill. Later, at an undefined period, the valley was drained for agriculture, which probably triggered erosion and colluviation at this site. Local intensive use of wheeled vehicles pressed the trackway sediment into a thick compacted layer, which developed into stagnic *Reductisol* (Baize and Girard, 2008; *Gleysol*, WRB, 2015).

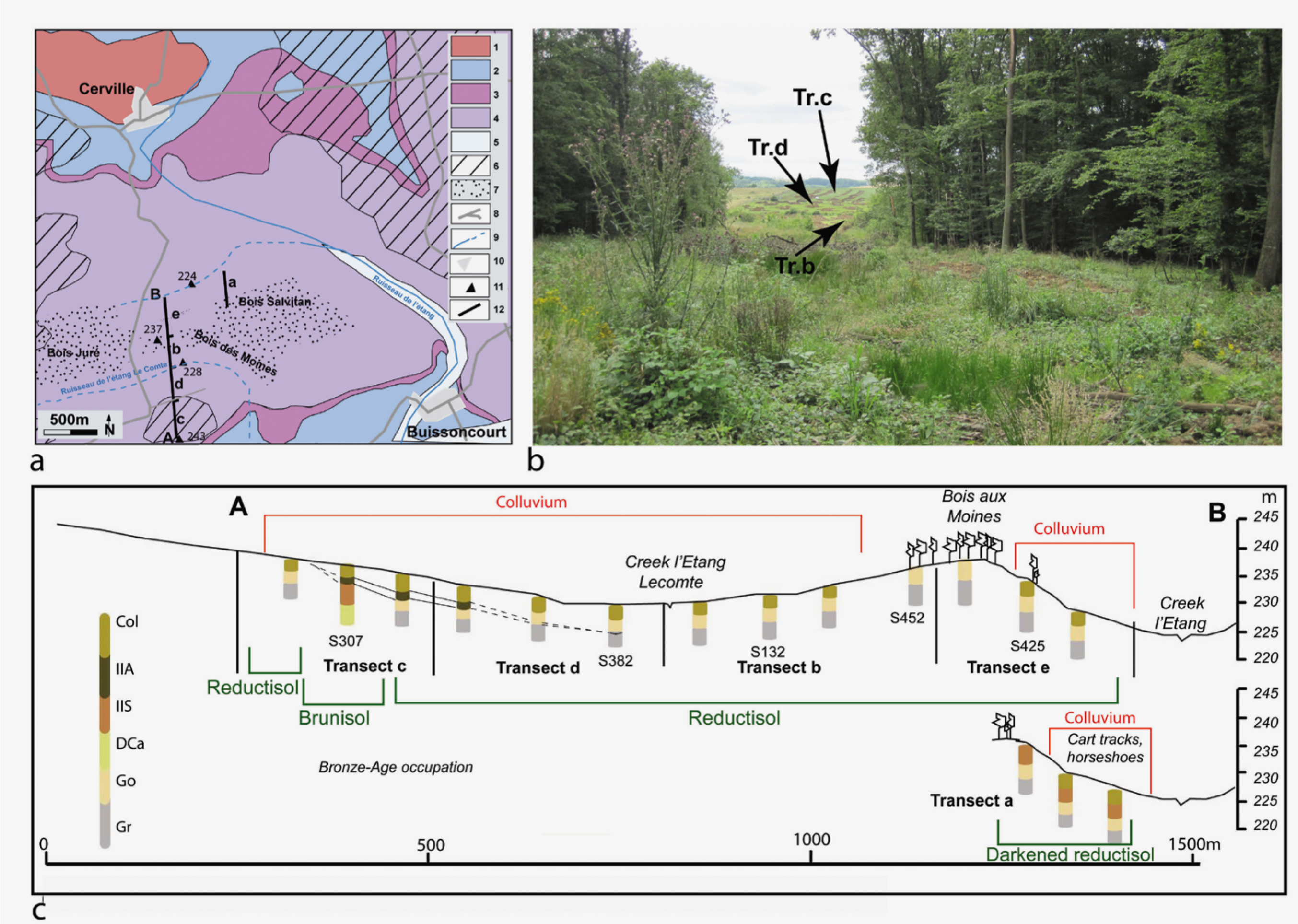

Figure 3. Cerville-Buissoncourt (Meurthe-et-Moselle, France):

a. locations of the site on the synthesised geological map: 1. hettangian-sinemurian limestone; 2. lotharingian clay; 3. carixian limestone; 4. domerian marls; 5. younger alluvial terrace; 6. loamy deposits; 7. woodland; 8.roads; 9. rivers; 10. urbanized zones; 11. altitudes; 12. transects

b. general view of the landscape

c. cross section of the landscape with location of the transects and soil profiles Col: colluvium, IIA: organic paleosoil horizon IIS: organo-mineral paleosoil horizon DCa: substrate Go: oxidized gley horizon Gr: reduced gley horizon

4.2. GEOARCHAEOLOGY IN A RESCUE ARCHAEOLOGICAL EXCAVATION

4.2.1 Les Longues Royes site

The polyphased archaeological site of Les Longues Royes (Boulanger et al., 2018) is situated in the Bulgnéville district (Vosges, Fig. 13, Fig. 5a). Three main cultural phases follow each other, represented by a La Tène culture enclosure (I^{st} c. BC) and two phases of Roman occupation from a farm (I^{st} c. AD) to a villa (II^{d}-III^{d} c. AD).

The geology of the area (Fig. 5a) is characterized by Keuper marl, topped with lower liasic moderately compacted dark paperschist layers covered with a homogeneous whitish dolomitic sandstone bed. The latter is a porous formation, and this type of geology can be strongly resistant to erosion, yielding a consistent groundwater supply (Minoux, 1967). The homogenous irrigated marl outcrops are often furrowed by gullies. Recent valley infillings are clayey-marly sands, with some pebbles (from the lower Trias). Irregular loamy slope deposits cover the Lias and Trias outcrops.

The site is divided into 3 sectors: the *pars urbana* with the villa on the top of a gently sloped west/north-west oriented plateau (Sector 1), the *pars rustica* on the slope below, with two farm buildings overlooking the creek des Fossés (Sector 2), and a third one (Sector 3) being an entrance building linking the two other sectors with less well-drained ground near a spring (Fig. 5b).

Although the excavations had to be accelerated because of financial and time constraints, thorough investigations were carried out thanks to a committed, perceptive and dedicated archaeologist who called for

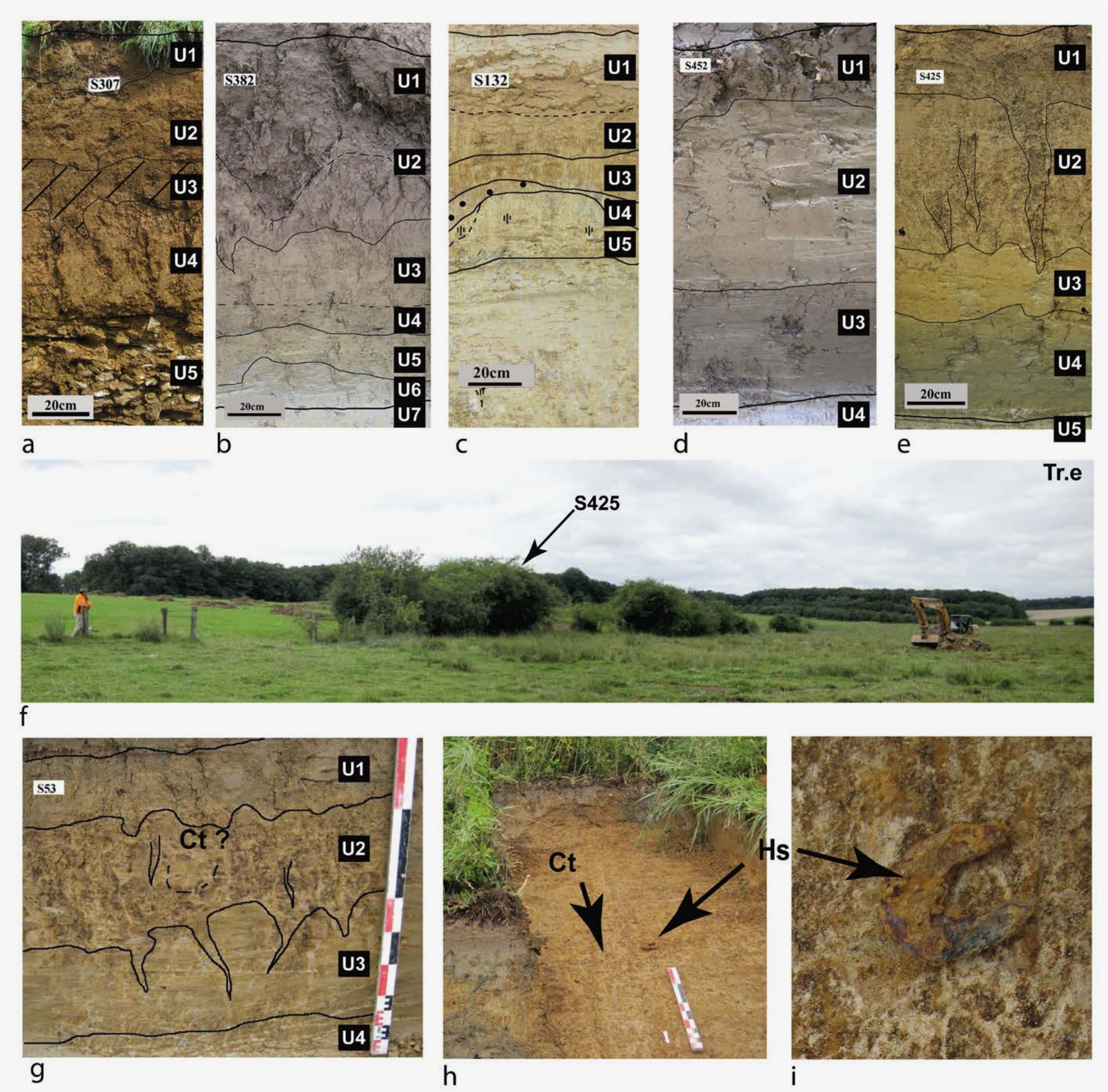

Figure 4. Cerville-Buissoncourt (Meurthe-et-Moselle, France):

a. transect c / profile 307, with the paleosol (U3/U4)
b. transect d / profile 382
c. transect b / profile S132
d. transect b / profile 452
e. transect e / profile 425
f. general view of transect e in the facing north slope with old hedges
g. transect a -profile S53 with cart track in profile (Ct)
h. transect a, horizontal section of the cart track (Ct) and horse shoe (Hs)
i. horse shoe (detail)

Table 2 Field description of the prospected site Cerville-Buissoncourt (Meurthe-et-Moselle, France)

Unit		Field description	Pedo-sed interpretation	
Tr.c	**U1**	40cm thick black-brown loamy-clay, crumby/fluffy structure, many roots and mouse galleries, big recent pottery fragments and tiles fragments, HCl<0. Organic horizon probably ploughed. Sharp strait structural limit.	ploughed horizon (LA)	
S307	**U2**	20cm compacted homogeneous brown loamy-clayey, some small pinkish quarzitic (ancient vosgian terrace?) and calcareous gravels. Abundant reddish tile/brick millimetric fragments. HCl<0. Sharp color/structure limit.	colluvial horizon	
	U3	20cm of dark brown-grey loamy-clayey, well marked angular polyhedral structure. Some gravel rounded Abundant Bronze-Age pottery fragments. Undulated gradual limit with the next level. HCl<0. Sharp textural limit.	organic paleo-horizon (IIA)	
	U4	40cm light polyhedral pale brown-grey loamy-clay, local biogalleries, HCl<0.	mineral paleo-horizon (IIS)	Cambisol
	U5	Fractured mesoliasic domerian calcareous sandstone substrate (HCl>0) with fine clay levels between blocks.	domerian calcareous sandstone	
Tr.d	**U1**	40cm thick dark brown-grey crumby sandy loam level, many fine roots, some bigger, organic plough horizon. Structure/colour sharp limit with the next level.	ploughed horizon LA)	
S382	**U2**	20cm homogeneous brown-grey loamy-clayey, light polyhedral structure, small pinkish quarzitic (old vosgian terrace) and calcareous gravels. Abundant reddish tile/bricks millimetric fragments. HCl<0. Gradual and waved colour limit.	upper colluvial horizon	
	U3	20cm light grey-brown loamy-clayey homogeneous level, quite compacted structure, small pinkish quartzite and calcareous gravels, reddish tile/bricks millimetric fragments. HCl<0. Gradual colour/structure limit.	deep colluvial horizon	
	U4	20cm light angular polyedral darker brown-greyish loamy-clay. Some rounded gravels, abundant very small charcoals fragments. Undulated gradual limit with U5.	organic paleo-horizon (IIA) with hydric level variation	
	U5	15cm homogeneous brown reddish clay, iron/manganese concretions and impregnations. HCL<0. Gradual colour limit.	hydric variation (Go)	
	U6	15cm homogeneous compact reduced grey-whitish clay, oxidised sand lenses. HCl<0.	permanent watertable (Gr)	Gleysol
	U7	Compact calcareous clay + some small calcareous nodules.	domerian marly substrate.	
Tr.b	**U1**	30cm thick dark brown-grey crumby sandy loam level, many fine roots, some bigger. Sharp structure/colour limit.	ploughed horizon (LA)	
S132	**U2**	20cm quite compacted homogeneous light brown loamy-clay, small pinkish quartzite and calcareous gravels, millimetre reddish tile/brick. HCl<0. Gradual colour/structure limit.	colluvial horizon	
	U3	Same as U2 with localised iron/manganese concretions and impregnations. HCl<0. Gradual colour/structure limit.	hydric variations in colluvial horizon	Gleysol
	U4	10/5cm brown-reddish oxidised layered sands, ± channelized. Periglacial deformations.	domerian marly substrate.(Go)	
	U5	Compact calcareous clay + some small calcareous nodules. Periglacial deformation.	domerian marly substrate. (Gr)	
Tr.b	**U1**	20cm dark dark-grey well structured clayey-loam, big roots, dominant. HCl<0. Sharp structure/colour limit with U2.	upper organic horizon (A)	
S452	**U2**	50cm homogeneous light grey loamy-clay, quite compacted, localised iron/manganese concretions and impregnations. HCl<0. Gradual color and structure limit with U3.	hydric variation (Go)	
	U3	15cm homogeneous compact reduced grey-whitish clay, oxidised around sandy lenses. HCl<0	permanent watertable level (Gr)	Gleysol
	U4	Domerian marly substrate. Compact calcareous clay + some small calcareous nodules.	Mm: domerian marly substrate.	
Tr.e	**U1**	30cm thick dark brown crumby sandy loam, fine roots, filled roots galleries. HCl<0. Sharp structure/colour limit with U2.	organic plough horizon (LA).	
S425	**U2**	40cm of brown homogeneous compacted loamy-clay, Abundant reddish tile/bricks millimetric fragments. HCl<0. Quite sharp color/structure limit with U3.	colluvial horizon	
	U3	20cm of light yellowish homogeneous clayey-loam, quite compact, very localised iron/manganese concretions and impregnations. HCl<0. Sharp colour limit with U4.	hydric variation (Go)	
	U4	Unoxidized grey homogeneous compact clay. HCl<0	permanent watertable level (Gr)	Gleysol
	U5	Domerian marl substrate. Compact calcareous clay with small calcareous nodules fissured and recalcified (septarias?), grypheus, belemnite rostrum.	domerian marly substrate.	
Tr.a	**U1**	25/30cm thick grey-brown crumby sandy loam, many fine roots. HCl<0. Sharp structure/color limit with U2l.	ploughed horizon (LA)	
S53	**U2**	40cm light polyhedral thick brown loamy clay, strong iron mottling impregnation/concretions, biogalleries. HCl<0. Sharp oxidation limit.	Sg	
	U3	20cm compact light brown homogeneous clayey-loam, iron/manganese concretions/impregnations. HCl<0. Sharp colour limit.	hydric variation (Go)	Gleysol
	U4	Unoxidized grey homogeneous compact clay. HCl<0.	permanent watertable level (Gr)	

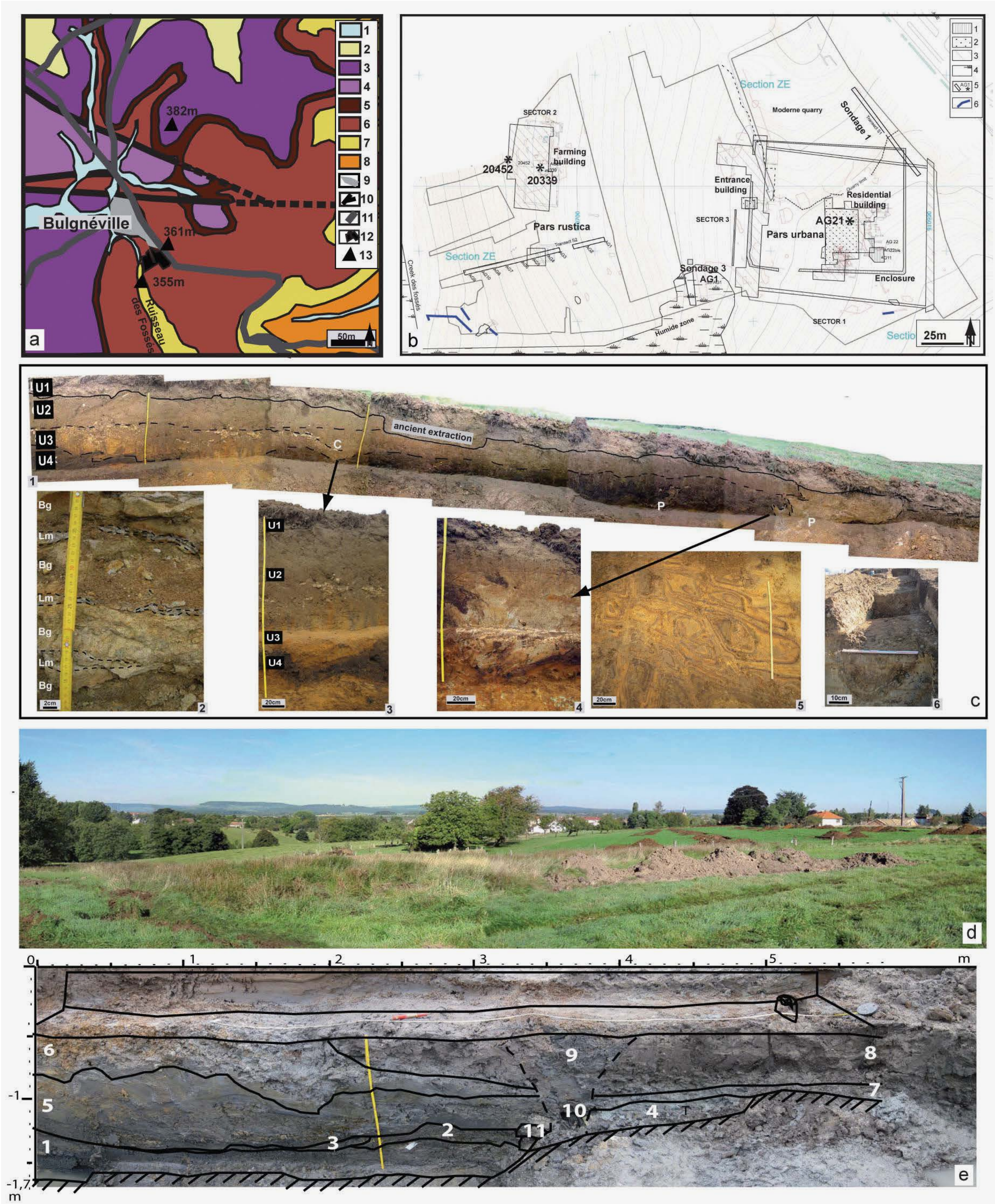
a
Bulgnéville
382m
361m
355m
Ruisseau des Fossés
50m
1
2
3
4
5
6
7
8
9
10
11
12
13
b
Section ZE
Moderne quarry
Sondage 1
SECTOR 2
Farming building
20452
20339
Entrance building
Residential building
SECTOR 3
AG21
Pars urbana
Pars rustica
Sondage 3
AG1
Enclosure
Humide zone
Creek des fossés
SECTOR 1
25m
N
c
U1
U2
U3
U4
ancient extraction
C
P
Bg
Lm
2cm
20cm
10cm
d
e
6
5
1
3
2
11
10
9
4
8
7
m
-1
-1,7
m

Figure 5. Bulgnéville (Vosges, France), a La Tène culture enclosure (Istc. BC) with two phases of Roman occupation from a farm (Istc. AD) to a villa (II^{d}-III^{d} c. AD):

a. locations of the site on the synthesised geological map: 1. younger alluvial terrace 2. loamy deposits 3. sinemurian-hettangian limestone 4. upper sinemurain limestone 5. rhetian clays 6. infralias sandstone 7. upper keuper marls 8. lower keuper marls 9. urbanized zones 10. faults 11. roads 12. investigated surface 13. altitudes

b. 1. La Tène enclosure (Istc. BC), 2. first roman farm (Istc. AD), 3. Roman villa (II^{d}-III^{d}c. AD) 4. humid zone 5. investigated trenches and profiles 6. drains

c. transect1 1. general profile 2. infraliasic sandstone substrate made of irregular and brittle sandstone beds (Bg) alternating with fine marly beds (Lm) 3. windthrown tree depressions 4. residual patches of vivid brown whitish heterogeneous marly-sand, with periglacial injections (P) 5. geometrical alteration probably due to ante-pleistocene tropical humid conditions 6. gullies

d. general view of the humid zone at the slope failure

e. succession of natural and anthropogenic materials, accumulated in a small natural depression 1. residual black schists 2/3. alternating fine and coarse clayey dark discontinuous late-glacial surface flushed material 4/5. protohistoric colluvium 6/7/8. dumped earth 10. Roman wooden water extraction pipe 9. trench of the wooden pipe dug through the anthropogenic sediments 11. stones fixing the pipe

geoarchaeological collaboration from the very onset of the excavation. As soon as the top soil was removed, the locations for the profiles/trenches were strategically chosen and observations were carried out (Table 3). As a result, the geoarchaeological approach was comprehensive in that it extended from investigating the paleo-environmental context to studying specific archaeological structures.

The infra-liasic sandstone substrate was observed in the long lateral eastern trench 1 (Sondage 1, Fig. 5b, Fig. 5c-1). It is composed of irregular and brittle sandstone beds (Bg, Fig. 5c-2) alternating with fine marly beds (Lm, Fig. 5c-2). The weathering of the upper parts of these formations can produce approximately 1 m thick of mottled red-black (U4) to yellowish-orange (U3) sands, which show clear geometrical alteration probably due to pre-Pleistocene tropical humid conditions (Fig. 5c-5). This sand seems to have been used by the small modern quarry industry near the site (Fig. 5b). Residual patches of light brown/whitish heterogeneous marly-sand (Fig. 5c-4) can be seen in these formations. This substrate is strongly affected by quaternary periglacial processes (Fig. 5c-1, P; Fig. 5c-4). Erosion-inducing, late-glacial/early Holocene climate-related events led to solifluction and gullying on the slopes (Fig. 5c-6). Windthrow tree depressions were observed (Fig. 5c-1, C; Fig. 5c-3) in the marly outcrop. Lastly, a mixture of colluvial rhetian fine sands and periglacial loams, which include some protohistoric sherds, locally covers the slopes (U2/U1, Fig. 5c-1). This last

Table 3 Bulgnéville (Vosges, France), field description of trenches S1 and S3

Units		Field description	Pedo-sed interpretation
S1	U1	40cm of dark well- structured grey loamy sands.	plough layer (LA)
	U2	60cm of beige sandy loams including protohistoric sherds.	Colluvium
	U3	20/40cm heterogeneous residual brown-whitish marly sand patches, periglacial deformation.	Ante-pleistocene alteration of infraliasic sandstone and marly sands
	U4	10/20cm irregular red-black/yellowish-orange strongly oxidized sand, plane geometrical concentric alterations.	
	Bg	Irregular and brittle 10/15cm thick sandstone beds.	Infraliasic substrate levels
	Lm	Thin 1/2cm marly beds.	
S3	11	Dolomite stones used to stall the pipe.	Trench for roman water adduction pipe
	10	Wooden pipe still driving water.	
	9	Mixture of sands and yellowish clays.	
	8	Grey-brown clayey sand.	Man perturbated
	7	Grey clayey matrix with many stones (equivalent to 6?).	
	6	Stones + grey less clayey matrix. Sharp wavy limit with U5	
	5	Homogeneous grey-orange clay rich in organic matter fragments and oxidation spots (equivalent to 4?).	Colluvium?
	4	Grey clayey sand (with sherds).	
	3	Stony lens with yellow-brown clay matrix.	Periglacial erosion
	2	Homogeneous black clay lenses.	
	1	Compact black brittle clay hard schists.	Paperschists Keuper

occurrence can be related to the Iron Age climatic degradation combined with strong agricultural pressure, as can also be observed elsewhere in western Europe (Fechner et al., 2014, Gebhardt et al., 2014).

Investigation of the humid zone of the sector 3, at the junction between the slope (sector 2) and the flatter sector 1 (Fig. 5d), showed a succession of natural and anthropogenic materials, accumulated in a small natural depression (Fig. 5e). The rhetian sandstone, here is totally eroded and only represented by relict black schists (1), and is covered by alternating fine and coarse clayey dark discontinuous layers interpreted as water-laid late-glacial surface material (2, 3). The depression was then filled with protohistoric colluvium (4, 5) and dumped soil (6, 7, 8). A wooden water extraction pipe dating from Roman times (10), which still carries water, was discovered at the interface between the clay and the sand, in a trench (9) dug through the anthropogenic sediments.

Soil micromorphological expertise was used to find an answer to several questions concerning selected periods: What was the pre-Roman landscape like, and are there any clues for differentiating specific activities areas in the farm building?

The soil before Roman occupation

An important characteristic of the multiphase occupation at Bulgnéville is the fossilization of older soil plots found under the Roman buildings. First, a *terrazzo* from the first residential villa (I[st] c. AD), sealed the ancient Iron Age enclosure's soil sequence. From top to bottom, this AG21 plot (Fig. 6a-1) shows, under the lime concrete and stone cover (U0), a succession of compact brown weakly bioturbated sands (U1, U2), which become brown reddish downwards (U3). The limit between U2 and U3 is not very well marked. At the base of U1, a fine blackish spotted transition horizon of iron/manganese impregnation soil was observed. Thin section studies reveal that the top of the sediment includes many abraded artefacts: charcoal, ashes, lime mortar (Fig. 6a-3), and other calcareous fragments associated with the *terrazzo* construction.

The ferro-manganese staining of lime and micrite precipitations (Fig. 6a-4) probably indicate wetting and drying phases associated with lime concrete floor manufacture. Abundant small charcoal fragments (mainly from deciduous trees, Fig. 6a-2) scattered in U2/U3 indicate clearance cultivation practices (Deak et al., 2017; Macphail and Goldberg, 2017), although the abundant dusty coatings

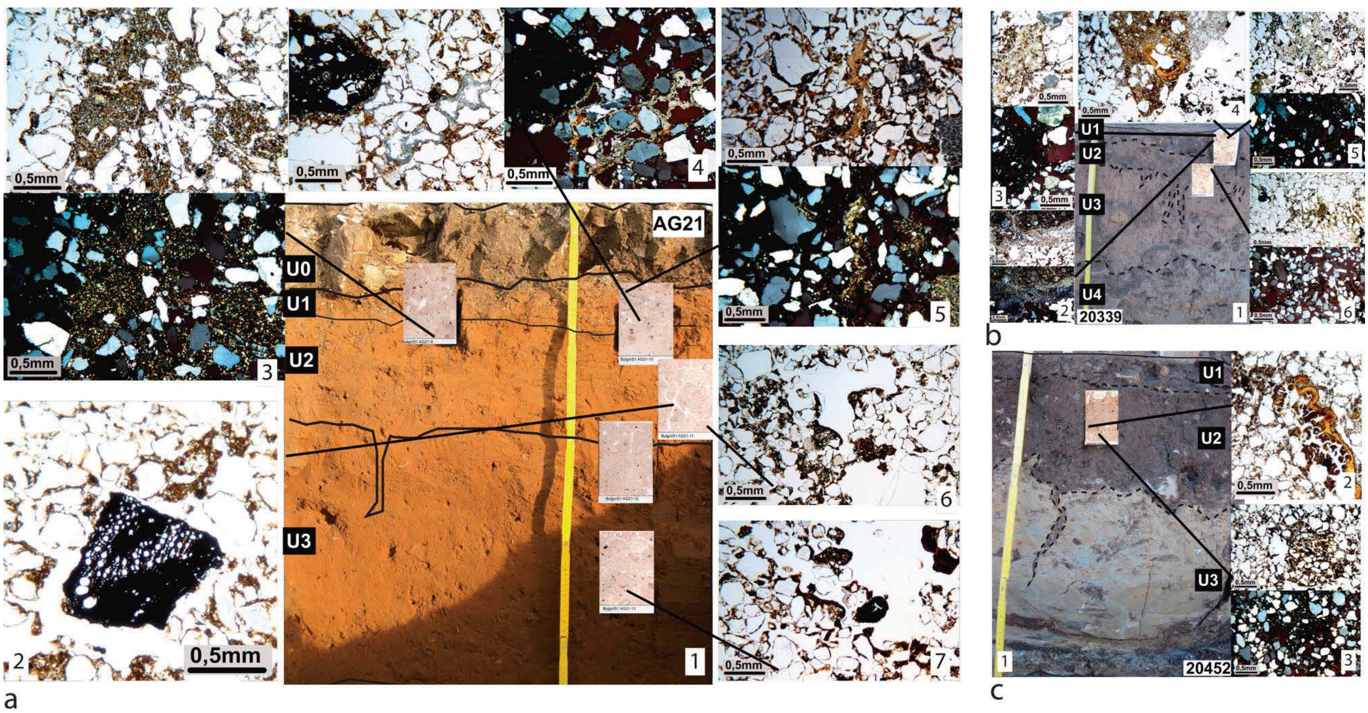

Figure 6. Bulgnéville (Vosges, France), main soil micromorphological features:

a. AG21, profile in the early iron age enclosure soil sequence under the terrazzo from the first residential villa (I[st] c. AD) 1. lime concrete (terrazzo) and stones cover (U0), successions of compact brown weakly bioturbated sand (U1, U2) to brown reddish downwards (U3) 2. charcoal from deciduous trees 3. Lime mortar 4. micrite precipitation, 5/6/7 dusty coatings;

b. 1. farm building man-made floor profile (20339) 2. limestone mortar 3. bone 4. rounded soil fragment 5. omnivore dejection 6. organic non birefringent coating;

c. western gallery (20452) 1. soil profile 2. crystallisation of goethite 3. organic coatings.

(Fig. 6a-5/6/7) could attest to rainsplash effects on bare soil within the Latenian Iron Age enclosure. The 20 cm thick colluvium between the Gaul farm basement and the first Roman construction phases associated with the observation of microscopic disturbed horizon fragments, can be related to erosion/colluviation processes resulting from cultivation (Gebhardt, 2014).

Some indications of anthropic activities in the Roman era

Micromorphological investigations of the farm building's constructed floor (20339, Fig 6b-1, Table 4) revealed many anthropogenic artefacts like lime mortar (Fig. 6b-2), adobe/cob fragments, bones (Fig. 6b-3), abraded pottery fragments trapped in the soil material. The latter was shown by the presence of rounded soil fragments (Fig. 6b-4). Several phytoliths could suggest the use of straw, while the omnivore coprolites (Fig. 6b-5) indicate the passage of pigs, dogs (or rats). Organic non-birefringent «coatings» and voids infills (Fig. 6b-6) are probably issued from the abundant decayed organic material strewn on the floor (Macphail and Goldberg, 2017). These observations fit well with the archaeological results and we can interpret the place as a domestic cooking area used by farm workers.

In the western gallery (20452, Fig. 6c-1,) the sharp boundary between the dark occupation level and the fissured marly substrate is remarkable, and suggests that the natural top soil horizons were cleared. Crystallisation of goethite (Fig. 6c-2) reveals strong humidity (Gebhardt and Langohr, 1999) probably due to liquid animal waste and decaying organic matter. Amorphous organic coatings are abundant (Fig. 6c-3). The absence of dusty clay coatings, of trampling and of compacted soil structures could suggest that this gallery was a well-drained cattle stalling area, probably with a wooden floor and protected by a roof to avoid mud formation.

In conclusion, we see that the early farmers knew how to deal with the natural geological conditions of the area. The first Gaul farm was conveniently established on the very top of the hill, in order to take advantage of well-drained sandy soils suitable for cultivation, and of the proximity of spring water. Also, it is not surprising to see that during Roman times, this first farm expanded into a villa on the same dry location, while wetter slopes were better suited as meadows and as a location to build barns and stables.

4.2.2. Geoarchaeology at settlement scale

In most cases, the geoarchaeologist is only called in to help provide a clearer understanding of specific anthropogenic accumulations or archaeological structures. This may concern the formation and use of undefined subsoil hollow structures (windthrowns, dumping pits, ponds, workshops, *Schlitzgruben*, ditches, hollow-ways, *Grubenhäuser,* cattle

Table 4 Bulgnéville (Vosges, France), field and microscopic description of AG21, S20339 and S20452

Units		**Field description**	**Soil micromorphological description**	**Pedo-sed interpretation**
AG21	**U0**	Compacted Dolomite stones and lime concrete		Terrazzo
	U1	Dark-brown compacted sands with abundant calcareous fragments, underlined by a black iron/manganese oxidation line.	Compact microstructure, low pedality, intergrain low porosity (40%). Quarzitic angular sand (250µm, 40% to 500µm, 5%), rock fragments (0,5 to1cm, 5%): dolomite, sandstone, fossil shells fragments, prophyric low birefringent dusty silty groundmass, limestone, bones, limpid clay coatings fragments, ashes? Sparite precipitations, iron concretions.	Fossilized La Tène enclosure soil
	U2	Brown (10YR 4/6) compact sand, some biogalleries, diffuse unsharp limit of structure with U3.	Better microstructure and pedality, inter aggregates fissure porosity. Same mineral compound as U1, gefuric middle birefringent dusty silty groundmass, some charcoals. Seldom dusty clay coatings. Rounded iron concretions.	
	U3	Homogeneous brown-reddish (2,5YR3/4) sand with some blunt sandstone fragment, fine roots, rare biogalleries.	Same microstructure, mineral compound and groundmass as U2, calcite bionodules, very fine micro-charcoals, unlayered compact thin dusty clay coatings. Iron concretions.	
S 20339	**U1**	Dark brown (10YR 3/4) clayey sand, abundant calcareous stones level at the top with limestone fragments, charcoals and sherds.	Granular microstructure, good pedality, good intergrain porosity (40%). Quarzitic angular sands (250µm, 40% to 500µm, 5%), sandstone, dolomite fragments (0,5 to 1cm, 40%) gefuric dusty silty groundmass, low to no birefringence. Clay fragments, limpid clay coatings? BT reworked fragment?	Domestic cooking area
	U2	Yellowish-brown (10YR 6/8) clayey sand, big blunt stones. Diffuse colour limit with 3.	Same microstructure and mineral compounds, non-birefringent chitonic/gefuric dusty silty groundmass.	
	U3	Light grey (10YR 7/2) marly sand slightly bedded, big stones, redox traces at the bottom.		
	44	Yellowish (10yr 7/8) sandy marl substrate.		
S 20452	**U1**	Aboundant stones level.		Stalling area probably on wooden floor
	U2	Yellowish-brown (10YR 3/4) clayey sand, some calcareous stones, limestone fragments, charcoals and sherds	Granular microstructure, low pedality, good intergrain porosity (40%). Angular quartz sands (250µm, 40% to 500µm, 5%), sandstone+dolomite fragments (0,5 to 1cm, 40%), non-birefringent chitonic dusty silty groundmass, fresh roots, calcite bionodules, omnivore dungs, limestone fragments, pots sherds, some small micro-charcoals. Goethite nodules.	
	U3	Light grey (10YR 7/2) marly sand slightly bedded, big stones.		

path, etc.) or accumulation layers (dark earth, gardens, raised cultivation beds, terraces, fire installations and all kinds of Anthrosols, etc.; Gebhardt, 2005, 2008; Macphail and Goldberg, 2017). Even if some microscopic environmental data can be gathered from these structures (about soil erosion, landscape, etc.; Gebhardt, 2000) the main expectation of archaeologists is often to add information to their comprehension of the site (are sediments *in situ* or not? are there indications of cultivation, stabling, housing, workshop, ritual activities, tracks, etc.?).

The Montigny-les-Metz (Moselle, Fig. 14) site is located on Seille river alluvium composed of fine sands and loams. The first Merovingian occupation is followed by the construction of three *Grubenhäuser,* partly dug into the soil without walls (Fig. 7-1/3). The infill of the best preserved one, dated from 944-1020 BC, contains numerous pottery fragments and many domestic faunal remains (Carron et al., 2008). Here, the fill sediments seem to be *in situ* (Fig. 7-3), and not reworked, as would be the case in the relict shell of an abandoned house that has been filled with sediments from another house. As a consequence, all the micromorphological features observed can be clues to document the house's occupation. It is then possible to tell an interesting story by studying this infill left after abandonment.

Micro-investigations (Table 5) detected occupation debris such as compacted adobe fragments (Fig. 7-4), small abraded pottery sherds, bones remains, eggshell (Fig. 7-5), numerous small charcoal, dung (Fig. 7-6) and abundant phytoliths (Fig. 7-7).

Researchers cannot yet link avian eggshells to specific birds (Canti, 2017) but the diet of the rural society was probably mostly based on hen's eggs, along with goat or sheep milk. In the dung fragments, the presence of sometimes articulated phytoliths suggest the presence of herbivore dung (Brönnimann et al., 2017), probably from goats or sheep. Phytoliths occurring in the sediment may originate from straw roofing or mottle walls (Fig. 7-1), floor bedding, and fuel materials (Vrydaghs et al., 2017).

If sediment looks homogeneous and is left in situ after abandonment, as in some dark earth deposits (Nicosia et al., 2017), organic material can be strongly reworked by bioturbation. These features can also be related to cattle herding, associated with increased soil fertility. Earthworms, which activates soil bioturbation, can move anthropogenic artefacts down-profile (Schwartz and Gebhardt, 2011). The numerous organic materials present (mainly small roots) attest to the nutritive availability of this plot.

Nevertheless, herbivore dung in the sediment is consistent with keeping of stock (Shahack-Gross, 2017) and so the house could be interpreted as a small cattle stable (sheep, goats) with possible hen nesting. But it is also possible that dry dung was used as fuel for domestic heating (Canti and Brochier, 2017). With the many food residues present this *Grubenhaus* can also be interpreted as a living house or a cool larder as in Poland (Fig. 7-2). However, in absence of loom weights (Zimmerman, 1982) the simple observation of a small post hole does not indicate weaving practices. Generally, the *Grubenhaüser* infill reflects mixed practices from rural life (Macphail et al., 2006; Macphail, 2017) and many uses and phases can be considered, surely following each other as the same house was used for domestic purposes before sheltering stock, after which a new one was constructed for human use.

5. Conclusions

Twenty years of geoarchaeological experience in Lorraine allows us to give a detailed geoarchaeological overview of the region. The multi-scale approach permitted us to gather a huge amount of very diverse data collected from varied geomorphological contexts. The diversity of the collected data, the themes and the chronology make it difficult to find a common thread among the nearly hundred sites investigated, with sites spanning the last 10,000 years. Nevertheless, finding correlations between the scattered proxies is still feasible. Also, after a literature review, it is possible to make general considerations on soil genesis, erosion and anthropisation phases dating from the second half of the Holocene (Gebhardt et al. 2014; Fechner et al., 2014) and on soil desiccation and degradation features during the Subatlantic (Gebhardt et al., 2018).

As the spatial distribution of prospected and excavated rescue archaeological sites is the result of local economic parameters, the additional opportunity to follow scheduled archaeological research projects helps provide a more complete geoarchaeological database. This permits access to non-threatened sites, for example in forested areas, and to gather information on past human impact on forested mountain landscapes (Gebhardt 2007a, 2007b, 2017; Gebhardt et al., 2009; Gebhardt et al. 2015; Gebhardt et al., 2018).

At the settlement scale, the challenge is to solve several individual archaeological questions. For example, determining pedo-sedimentary features in order to interpret levels of occupation (Gebhardt, 2005) or our understanding of agricultural structures (Gebhardt, 2008; Georges-Leroy et al., 2009). One interesting challenge was to find micromorphological characteristics differentiating rolling and ploughing traces (Gebhardt and Langohr, 2015; Rentzel et al., 2017). As soil micromorphology is based on specific feature observations, it is necessary to complete the observations with the study of ethnological/reconstructed analogues or to make comparisons with a wider range of similar archaeological situations (Gebhardt, 1999; Gebhardt A., 2007a; Deak et al., 2017; Macphail et al., 2004). As contract archaeology is restricted to investigating threatened sites, there are constraints on soil micromorphological reference material acquisition. This unfortunately negatively impacts on improving our research base.

Nevertheless, because of its extensive field database collection, the French National Institute for Preventive Archaeological Research INRAP should now be able to reach the status of a true research institute. But in order not to remain at a simple 'stamp collections' level, an integrated multidisciplinary approach is required and written resources should be taken into account (Macphail et al., 2016). This aim is more and more difficult to achieve, because attaining substantial interpretations is time consuming as reading, synthesising and publishing takes up a great deal of time. Furthermore, the current necessity of carrying out administrative duties has to be taken into account. In spite of a warmly encouraged collaboration between INRAP agents and University/CNRS research teams, and the integration of a wide range of research themes (for instance human/environment interactions or landscape dynamics) in the huge geoarchaeological database, the internal frugality and pyramidal management of working time strongly complicates and hinders the research part of the job, which currently depends solely on the geoarchaeologist's obstinacy, perseverance and willingness to work more than 'nine to five'.

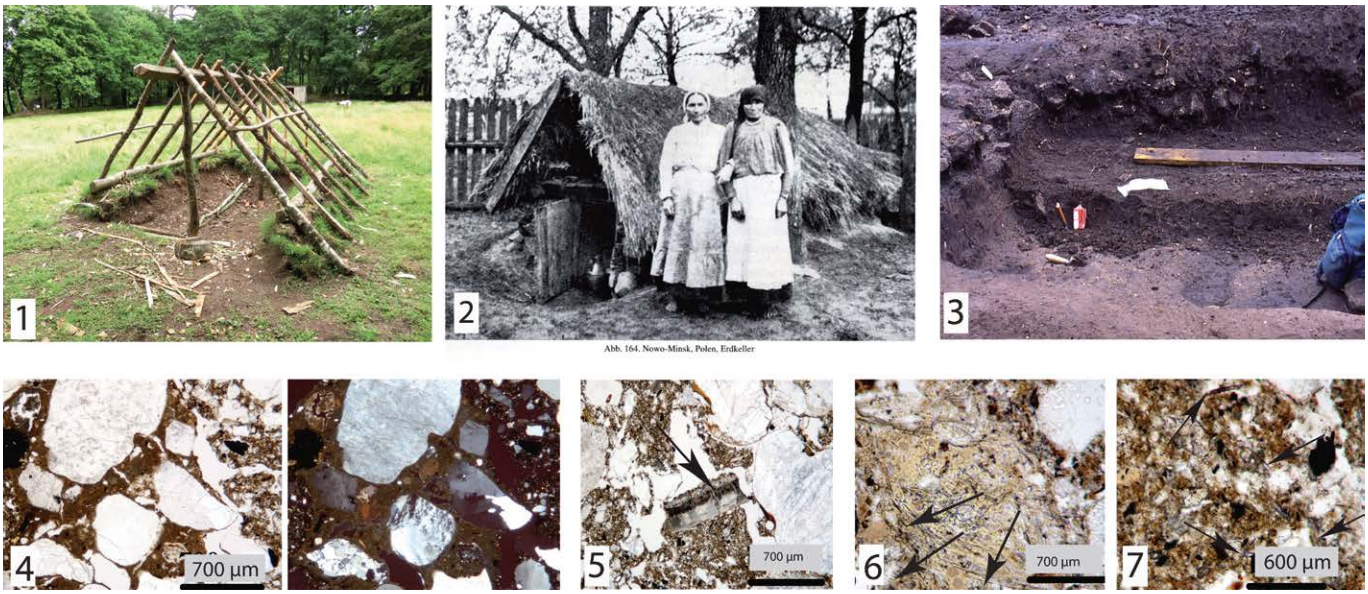

Figure 7. Grubenhaus and thin section studies:

1. partially reconstructed early medieval Grubenhaus (Melrand, Morbihan, France; courtesy: J.-M. Blaising)
2. cool larder (Poland; ancient postcard, courtesy: J.-M. Blaising)
3. archaeological grubenhaus sediment infilling at Montigny-les-Metz (Moselle, France)
4. compacted adobe fragments (a. plainlight, b. crosspolarised light)
5. eggshell
6. dung with abundant phytoliths (arrows)
7. phytoliths (arrows)

Table 5 Field and microscopic description of a grubenhaus infill at Montigny-les-Metz (rue Franiate, Moselle, France)

Field description	Soil micromorphological description	Pedo-sed interpretation
alluvial deposits of the Seille river: sandy-clay infill: 20cm of dark black-brown fine and homogeneous sandy loam, some roots.	Well-developed microstructure; good porosity: well-connected biogalleries, chambers, and fissures, good pedality: several millimetre sized aggregates. Rounded quartz/quartzite sands (250µm to 1mm, 50%), angular fine quartz (25µm to 200µm, 10%), some heterometric calcitic fragments (fossils, calcitic sand, 5%), dusty porphyric speckled groundmass, low birefringence; numerous small fresh organic residues, phosphate nodules, a lot of anthropogenic artefacts: microcharcoals, sandy adobe, herbivore dungs, eggshell, bones, pottery sherds, very numerous phytoliths (5%). No specific pedofeatures.	Infill of a *Grubenhaus* dug in the alluvial deposits of the Seille river

Final note

A career is built on numerous and diverse experiences and human encounters. Some are more powerful than others. In 1993, my time in the *Corridor* as a French 'postdoc', working on the 'Study of active and relict anthroposoils in Belgium, in comparison with other sites in Western Europe' (European Community fund 'Human capital and Mobility'), was of great significance. With my limited soil micromorphology background, experienced mainly on some archaeological sites in Brittany (France), I had the major opportunity to be initiated into *The Book* of archaeopedology. But that is not all... Besides the joy of being a team player and the amazing thrill of being recognized as a research peer, I met colleagues and friends from all over the world and discovered Ghent. Now, the *Ketje*, the *beguinages*, the *frietkots*, the *pralines*, the *moules-frites*, the *spare-ribs*, the *jenever* (sorry, I don't like beer), ... belong to my heritage.
Sincere warm thanks to you, Roger.

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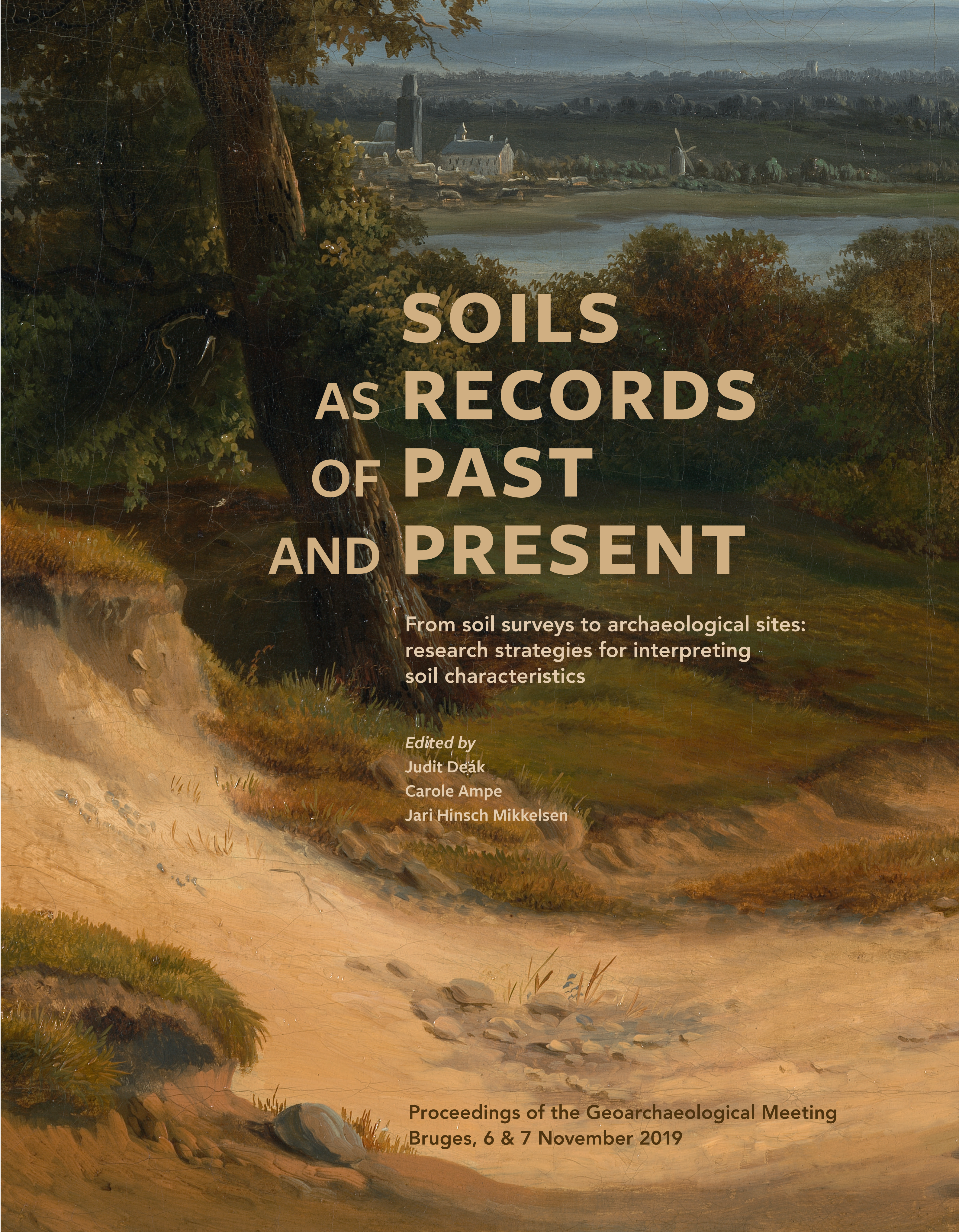

SOILS AS RECORDS OF PAST AND PRESENT

From soil surveys to archaeological sites: research strategies for interpreting soil characteristics

Edited by
Judit Deák
Carole Ampe
Jari Hinsch Mikkelsen

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