From macro to micro-archaeology:
An Introduction to Geo-archaeology
and Soil Micromorphology

Guide 48
From macro to micro-archaeology: An Introduction to Geo-archaeology and Soil Micromorphology

Val Dufeu November 2017
Introduction

Any landscape is structured by spatial layout and the association of both ecosystems and soil occupation that are connected to it. Soil composing the basis of any archaeological sites retain their properties with human occupation and activities. Archaeological stratigraphy is the result of soil accumulation over various lapse times. Each stratigraphy is composed of a number of horizons and while some horizons can be identified as strictly anthropogenic, others can be the sum of different formation processes including biogenic, geogenic and anthropogenic activities. Soil micromorphology is the ideal tool for the geo-archaeologist, since it can help for the reconstruction of past landscapes and environments as well as the identification of spatial occupation areas by humans.

The aim of this short guide is to outline the importance of soils in archaeological sites and to provide the readers with a better understanding of how soils can help understand site formation process and provide a chronology for human occupation and activities in situ.
SECTION 1 : Science of sediments

Soils and sediments, some definition and characteristics

It is essential to understand the difference between soil and sediments for a better interpretation of any profile and landscape formation.

Soils

Soil is formed by soil-forming factors that are parent material, climate, biota, time, and human activity. Soil is living and its growth and development can be affected by any of the soil forming factors, there are three soil-formation process types:

- anthropogenic or transformed by human occupation and activity,
- biogenic or formed/transformed by living organisms,
- geogenic or formed/transformed by environmental factors such as climate, wind erosion, sand erosion, slope gradient, and hill-wash to name the most common agents.

Remember

1. Soil is affected by various processes and it is not rare to see all three formation processes described above on a same profile and of course archaeological site. Each process can affect soil horizontally and vertically with either an abrupt or diffuse boundary between each event.

2. Soil hydrology plays a key role in the soil structure and should always be noted during fieldwork.

3. Parent materials play a role on soil properties.

Paleosols and buried soils are of particular interest in geo-archaeology and archaeology. A paleosol is a soil which formed on a landscape at some point in the past. They can be buried or on the surface and have developed under various climatic conditions. It is important to identify paleosols in an archaeological profile since it shows landscape stabilization - geomorphic stability - with human occupation whether seasonal or permanent. (Plate 1) Paleosols can have been buried by rapid geogenic event like windblown sand or silt following flood plain, and these events tend to protect or seal the paleosols.
Sediments

It is important to describe the colour and texture of the sediments since this provide data on the nature of the environment at the time of sediment deposition and soil formation process though this does require training to become proficient. In the early 20th century, Professor Munsell described soils and sediments using a chart based on three colour dimensions being hue, chroma and value (Plate 2). When describing colours, one of the key factor is to note the natural light and level of dampness since these can considerably affect the perception of the
colours as seen below: same profile but on the left, photo taken after rain early morning while on the right, afternoon shoot after few dry days (Plate 3).

As soils, sediments can be translocated and redeposited by water, wind and glacier movement; on an archaeological site, also, human activity can move sediments. This can be verified especially on archaeological site; for instance, sediments might have been dug up and dumped following building construction or might have been added to building materials.

Sedimentary stones like sandstones and siltstones or igneous rocks (indeed any form of non-local geology) should also be recorded if not originating from the site but observed in archaeological profile. If translocated, these stones might be an indication of a nearby paleo-landscape still visible or buried.

**Auger survey**

Auger surveys provide a rapid answer regarding possible buried soils, agricultural practice remnants, anthropogenic presence, geogenic events like river path course. To be effective, a grid should be designed, and each bore hole thoroughly described (texture, colour, depth, size of soil particles graded from fine sand to stones). Though some results will appear *in situ*, mapping is essential to get the full picture of the surveyed area.

Auger survey can be done ahead of excavations or as complementary of archaeological research to define human occupation areas and paleo-landscape.
Soil micromorphology: soil and sediments analyses

Since the 1980s, micromorphology analysis has become a research tool in archaeology and geo-archaeology, for the study of soils plays an important role in:

➢ Archaeology
➢ Quaternary geology
➢ Paleo-pedology
➢ Soil management
➢ Forensic

In archaeological research, the understanding of site formation through the research of human waste, occupation debris, fuel residues and animal waste, enables the reconstruction of human occupation, economic activities and dietary habits.

Several environmental factors can affect the soil structure and they must be considered in micromorphological analysis. For instance, soil fauna activities such as feeding, reproduction and protection (burrowing), affect both soil components and therefore soil structure arrangement. It is important to identify and describe the soil structure observed during micromorphological analysis since as to be faunal induced or geogenically formed.

Plate 4. Faunal activity exhibiting a vermicular structure (left). Lenticular structure, (right) with a strongly expressed parallel oriented coarse organic matter. The channels and chambers are all due to faunal activity. (©Dufeu).

The presence of faunal activity can also be an indicator of anthropogenic waste and differentiating between fauna living and feeding from human waste to other species is key in archaeological site interpretation (Plate 4). For instance, presence of biogenic opal-phytoliths and diatoms amongst others (Plates 5 & 6) - in the groundmass and infillings (Shack-Gross et al., 2008) is indicative of soil amendment through animal manure and therefore animal
husbandry, as well as crops cultivation. Yet, if only diatoms are present, it can be safe to conclude that the soil observed has no anthropogenic feature since diatoms are single-celled algae formed in soils, lakes, rivers and marine environments.

As noted above, climatic conditions such as freezing and flooding also alter the microstructure of the soils (Plate 7).
SECTION 2: In the Field

Fieldwork and sampling profile for soil micromorphology analysis

Fieldwork is essential for the understanding and interpretation of the sampled soils. Observe the landscape and characterize it as much as possible. Take note of the shape of the hills, presence of terraces, raised beach, slopes’ gradient and length, type of vegetation and level of coverage, boulders, stones.

A pH kit will help you measure soil acidity which in turn will help you for human, mammal and fish bones preservation, seeds, and various artefacts.

The quality of micromorphological samples for site interpretation depends largely on the field strategy.

Choosing the profile or area to be sampled is key in the geo-archaeology of any site. The sampling strategy must be discussed ahead of sampling with site’s directors or PI. A survey of the site should allow you to identify the best place to sample. The technique consists of sampling undisturbed soils from archaeological profiles with metal containers known as Kubiena tins or if not available, an ‘electrical socket metal back box’. [Should you opt for the electrical box, do not forget to put a thin aluminium sheet on the bottom of (to cover the holes) as well as on the top to perfectly seal the sample]. Bearing in mind that one wants to capture as much data as possible, one of the best way to do that is by overlapping sampling tins as shown in the photo below (Plate 8). This prevents to miss horizon even if not clearly visible in the field. It also provides more data per horizons overlapped. If time and money allow, it is a good idea to double the most important samples (Plate 9).
Sampling an archaeological profile

First the profile must be cleaned so all the horizons are clearly visible. Then the tin is pushed into the profile gently by using the trowel to remove soil around the tin as it is pushed in. The profile should never be cut prior to the thin is pushed into it. Some soils can be extremely compact and it is tempting to ‘hammer’ the tin into it; as this can break the soils this is not recommended.

*In situ*, a stratigraphic profile section is drawn, and each layer is noted and described - the texture and colour of the soil are recorded with a Munsell Chart. You must take note of the fauna activity and the type of animals encountered. The presence of worms indicate that the profile is still alive and might have been through several phases with constant rework of the matrix. Worm activity can also result in translocation of small artefacts.

Micromorphology analysis: from macro to micro

In the lab, soil samples are dried and impregnated with resin. Then cut to 30μm thin section for petrographic microscope analysis whereas scanning electron microscope (SEM) needs the slide to remain uncovered. Thin sections are then described per units as a stratigraphy profile as seen below: the thin section has been cut from sample 4 on the stratigraphy drawing (Figure 1). While some soils have been removed during processing the tin, the strata are clearly visible.
SECTION 3: Geo-archaeology applications in archaeology

Archaeological sites can be situated in a complex soil matrix;

Before any interpretation bear in mind that several factors can affect the soil structure and that soils ‘alteration and loss of micromorphological features can happen between forty to two hundred years. Any good interpretation cannot be done without the fieldwork notes and the stratigraphy drawing that can be used as a depositional chronology. This is particularly helpful when samples from waterlogged profiles are analysed. A typical feature of these soils is the potential vertical and horizontal translocation of small artefacts, bones and plant remains. (Plate 11 and Figure 2)

For instance, a midden consists of several layers or strata of human waste - cultural deposits - accumulated through the ages. These layers are usually composed of bones and other food residues, occupation debris, fuel residues and manure (Plate 12).

The bulk of waste constituting farm midden will be, over time, transformed and altered by micro fauna and climatic conditions.

The analysis of such materials has as its main objective the identification of the different constituents of the midden and to semi-quantify these features. Interpretation is the next stage; differentiation between cultural - anthropogenic features as mentioned above - and natural features are essential in the understanding of midden formation process.
An introduction to geo-archaeology and soil micromorphology

BAJR Guide 48

Plate 11. Sampling of midden (©Dufeu)

Fig. 2. Profile drawn for soil micromorphology analysis (©Dufeu)

Plate 12. (A) Fish bone within a sand matrix. Note the clear boundary between sand and the organic matter strata. (B) Charred animal bone, fragments of charcoal and coal. (©Dufeu)
An introduction to geo-archaeology and soil micromorphology
BAJR Guide 48

Plate 13. Profile from an eroded and abandon fishing station and its section drawing for soil micromorphology analysis (©Dufeu)

Plate 14. (A) Vughy microstructure an irregularly shaped void or pore within a soil aggregate. A soil whose pore space consists mostly of vughs is said to have a vughy microstructure. (B) Re-worked soil organic matter by soil animals exhibiting vughs and hypocoating of the grain mineral (partially XPL). (Photo Dufeu)

Soils have their own properties and human activity affects those properties. Soils can be disturbed and transformed as much as the land can be affected by human presence.
An introduction to geo-archaeology and soil micromorphology

BAJR Guide 48

Geo-archaeology Environmental Services

The present guide highlights the foundation of soil micromorphology analysis and the use of geo-archaeology for archaeological research or projects whether academic or commercial. It is intended for beginners and curious.

As a professional geo-archaeologist, I have experience in auger survey, characterizing the landscape and soilscape, soil sampling for soil and sediments micromorphology analyses. As an archaeologist and environmental historian, I have experience in complex and single competent archaeological sites dating from the Mesolithic to the modern periods in contract, community, and academic settings.

My background involves multi-disciplinary research and development of environmental humanities and this equips me with technical expertise in all aspects of landscape reconstruction and analysis using geo-archaeological techniques, as well as economic modelling as used in historical reconstructions. I am interested in research collaborations including drafting proposals and grant, co-developing projects, fieldwork working in a geo-archaeological capacity, and teaching. I am especially interested in program development projects with government and non-governmental offices, and, community outreach figures significantly in my professional development plan.

Find me on Facebook https://www.facebook.com/micromorphology
Or on the website www.scottish-geo-archaeology.co.uk

Val Dufeu November 2017
Bibliography


Dufeu, V and Guðmundsson, G., Midden Investigations at GIÖGUR AND AKURVÍK, ÁRNESHEPPUR, STRANDASÝSLA, NORTH WEST ICELAND, INSTITUTE OF ARCHAEOLOGY, REYKJAVIK (2011)
