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Module 2: Introduction to African Archaeology: Methods

Introduction into Micromorphology

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Goals and potential

Archaeological soil micromorphology studies the composition and structure of sediments at archaeological sites. It uses sediment thin sections and a petrographic microscope to unravel various features not visible to the naked eye.

The technique is used to identify types of mineral and organic constituents and their spatial organization. Clear understanding of sediment composition and fabric then allows to deduce processes of sediment accumulation and postdepositional alteration within or across archaeological layers. These in turn provide crucial hints on stratigraphy, taphonomy, palaeoenvironmental change and human activities at the site.

History of the method

Micromorphology is a technique widely used in soil science since the 1930ies for analyzing soil forming processes and soil functions on a microscale. It has been adopted to archaeology in the 1970ies and first textbooks have appeared shortly later (e.g., Courty et al., 1989). Nowadays, it is an indispensable technique for deciphering sediment contexts of rock shelters, caves or open air sites (e.g., Nicosia and Stoops, 2017, Macphail and Goldberg, 2018).

Sampling in the field

During excavation, sampling locations are selected considering the research question to be answered and the heterogeneity of the archaeological layers. Key to micromorphology is the extraction of undisturbed sediment blocks, i.e. the internal spatial structure of the sediment must be preserved. For this purpose, cuboid sediment blocks slightly larger than the thin section format and about three cm thick are exposed and, if unstable, covered with gypsum bandages. After drying of the gypsum, the blocks are carefully extracted and wrapped tightly for transport. Pure sandy, stony or shell-rich archaeological sediments are difficult to sample.

Preparation of thin sections

In the lab, the blocks are dried at 40°C for several days and impregnated with artificial resin under vacuum to ensure full saturation of pores with resin. After hardening, the blocks are cut using a rock saw and a one cm thick cuboid is mounted to a glass side, cut again, ground and polished to a thickness of ~25 µm. This thin section may be studied as is or protected by a permanently mounted cover class.

Equipment

A drying oven, a vacuum oven, a rock saw, a polishing machine, laboratory dishes and a lot of experience are needed for preparation of thin sections. Several labs offer thin section preparation on a commercial basis, which can be consulted if establishing an own preparation lab is not possible.

For inspection of the thin section at low magnification, a flatbed scanner equipped with transmitted light is very useful. Furthermore, a polarization microscope with camera is needed for the analyses under plane polarized light (PPL) or crossed polarizers (XPL). A torch can be used to apply oblique incident light (OIL). Polarization microscopy is a technique which uses polarized light for illumination of objects in thin sections or grain mounts and a second polarizer to use birefingence of crystals for identification of mineral grains. Further information on polarization microscopy and identification of minerals as based on optical features are available in textbooks of mineralogy (e.g., Raith et al.,) Thin section reference collections are helpful, but not mandatory. Access to atlases and textbooks on micromorphological features (e.g., Stoops et al., 2018), rocks and minerals as well as archaeological features (Nicosia and Stoops, 2017) should be ensured.

Workflow

The thin section is flatbed-scanned at 1200 dpi, and scans are investigated at the computer screen at magnifications of up to 25x. The thin sections may be subdivided into sublayers if internal boundaries can be discerned.

If uncovered thin sections are used, a few drops of immersion oil are spread on the surface. The polarization microscope is then used for inspection under PPL, XPL and OIL at magnifications of about 25x to 500x. The different illumination techniques and optical effects of light when passing through crystals or amorphous substances allow identification of rock fragments, minerals and organic matter, hence identification of mineral and organic constituents down to a grain size of about 5 µm in diameter.

The characteristics of the pore space, aggregates, groundmass and pedofeatures are then recorded using terminology of description manuals (e.g., Stoops, 2003). Finally, the observations are interpreted and discussed addressing the research questions.

Crucial Points

The thin section provides a two-dimensional view on three-dimensional features. The orientation of elongated particles or features in 3d cannot be discerned without information from excavation. The selection of sampling locations should be representative to layers, which in case of high heterogeneity is difficult to achieve.

Due to the thickness of the thin section, grains smaller than 10µm may superimpose each other and several technical problems such as wedging may occur. The true pore space is underestimated in thin section.

Micromorphological features may originate from different processes and identification of a specific process may be difficult. Sediments of archaeological sites are often heavily affected by postdepositional alteration or diachronic change in human impact. If possible, sediments should also be studied off-site in order to better understand palaeoenvironmental change without human impact.

Example: The rock shelter Ifri El Baroud (Potì et al., 2018)

Micromorphology shows, that the sediment sequence of Early Iberomaurusian (EIBM) time is weakly affected by bioturbation or other kind of disturbances, but heavily enriched in phosphate. The division into two subphases is supported by micromorphological evidence. Plant fragments and phytoliths occur in several microlayers, partly in context with ash.

The late Iberomaurusian layers (LIBM) are mainly composed of trampled or intact mollusk shell with large amounts of charcoal pieces. Postdepositional change is very limited.

Micromorphological features reflect the strong change in subsistence from EIBM to LIBM and confirm the excellent stratigraphic framework of the sequence.