Applied Soils and Micromorphology in Archaeology

Applied Soils and Micromorphology in Archaeology provides the most up-to-date information on soil science and its applications in archaeology. Based on more than three decades of investigations and experiments, the volume demonstrates how description protocols and complementary methods (SEM/EDS, microprobe, micro-FTIR, bulk soil chemistry, micro-, and macrofossils) are used in interpretations. It also focuses on key topics, such as palaeosols, cultivation, and occupation surfaces, and introduces a range of current issues, such as site inundation, climate change, settlement morphology, herding, trackways, industrial processes, funerary features, and site transformation. Structured around important case studies, *Applied Soils and Micromorphology in Archaeology* is thoroughly illustrated, with color plates and additional figures available at www.cambridge.org/9781107648685. Chapter appendices can be accessed separately by visiting www.geoarchaeology.info/asma. This book will serve as an essential volume for all archaeological inquiry about soil.

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The book is dedicated to our previous coauthor Marie-Agnès Courty and the late Nick Fedoroff with whom we worked for so many years.

From RIM: to Jill, Flora, Pete and Sue, Steve and Marilyn, and NHS Luton and Dunstable University Hospital.

From PG: to my folks

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PREFACE

Soils and Micromorphology in Archaeology written by Marie-Agnès Courty, Paul Goldberg, and Richard Macphail during the 1980s and published in 1989 by Cambridge University Press (Courty et al., 1989), summarized the state of the discipline at that time. To some extent this book was made possible and user-friendly because of the standardization of soil micromorphological descriptive terms and personal collaborations with Peter Bullock and Nicholas Fedoroff, for example (Bullock et al., 1985). While it owed a great deal to earlier works, especially by Ian Cornwall, and Romans and Robertson (Cornwall, 1953; Limbrey, 1975; Romans and Robertson, 1975a, 1983c), it can be suggested that this 1989 book was largely responsible for the expansion of the technique as a requisite method in geoarchaeology, especially in Europe. From being a minor player in mainstream soil micromorphology in the early 1980s (Bullock and Murphy, 1983), it slowly began to compete with traditional agronomy and palaeosol studies in the numbers of papers submitted (Douglas, 1990; Fedoroff et al., 1987). In 1990 a specialist working group (Archaeological Soil Micromorphology) was formed, and instead of a working-meeting every four years, participants met and continue to meet once or twice a year, usually in the UK or Europe (Arpin et al., 1998; Macphail, 2014a). The most recent (fourteenth) meeting of the International Working Meeting on Soil Micromorphology led to the publication of thirteen papers from Session 5 “Site Formation Processes in Archaeology” held at Lleida, Spain July 2012 (Macphail, 2013).

There are of course other books on geoarchaeology where there has been a focus on the application of archaeological soil micromorphology (French, 2003, 2015; Goldberg and Macphail, 2006b; Lewis, 2012), and the most recent volume on the interpretation of micromorphology features includes sections on anthropogenic materials and features (Stoops et al., 2010). In addition, the Archaeological Soil Micromorphology working group is currently producing their own guide to archaeological materials and features (Nicosia and Stoops, In press 2017).

It is now more than twenty-five years since *Soils and Micromorphology in Archaeology* was published, and many more archaeological sites, materials, experiments, and processes have been studied by soil micromorphologists. The need of students and workers to improve and widen their knowledge first led to the establishment of a working group, as noted earlier. The many site studies and experiments also produced an extensive reference collection which, although used in part at workshops, was not employed systematically for training. It was therefore decided to utilize this asset for an Intensive Training Course in Archaeological Soil Micromorphology at the Institute of Archaeology, University College London, and this has been delivered annually for the last ten years. The course comprised nine thematic sessions and one test session utilizing hundreds of reference thin sections from around the world. In addition, this book *Applied Soils and Micromorphology in Archaeology* was written to accompany this course and use of the thin section collection. The book is not, however, intended to be a review of the state of the science, because it would be impossibly long and unpublishable, and other reviews have already been published (Goldberg and Macphail, 2006b; Macphail and Goldberg, 2010). Nevertheless, discussions are fulsomely supported by literature citations, including some suggested by a series of reviewers in 2015. In order to make the bibliography a manageable size for publication, a fuller bibliography that includes numerous unpublished reports and other gray literature is available online, along with chapter appendices and other supportive material, including color plates and color images supporting the black and white figures in the printed book (www.geoarchaeology.info/asma).

The book is composed of twelve chapters in four main sections. In Part I, applied soil micromorphology in archaeology is introduced alongside its fundamental soil, geological, and experimental background in Chapter 1 (Applied Principles from Geology and Soil Science). As many of the developments within archaeological soil micromorphological reconstruction of past site formation processes have been aided by complementary analyses, a selection of these are presented in Chapter 2. These methods, which provide a holistic basis to soil micromorphological endeavors, contribute to the characterization of microfacies, and include correlated background bulk analysis for chemistry and microfossil remains for example, as already introduced in Chapter 1. These complementary data also involve the gathering of information from thin section (e.g., SEM/EDS, microprobe, micro-FTIR and occasional identifications of biological remains within the thin section). Descriptions are carried out using a petrological microscope employing standard lighting techniques and methods: plane-polarized light (PPL), crossed-polarized light (XPL), oblique incident light (OIL) and fluorescence microscopy (in our case, mainly blue light – BL). Also, as detailed in Chapter 3 (Systematic Soil Micromorphology Description), the observational sequence from field to impregnated block and to thin section digital scanning are recommended. In reality, thin section description and photographic recording are carried out ahead of any instrumental studies for practical reasons and in order to be scientifically objective. It is emphasized that systematic and accurate thin section description always leads the study, and no amount of complementary analyses and/or "blue sky thinking" can achieve a well-founded data-based interpretation without it.

Parts II–IV give thematic-based case studies on the number of ways that soil micromorphology contributes to archaeological investigations; sites are listed alphabetically in the Site Gazetteer. In the first instance (Part II, Chapter 4 – Buried Soils) the pedological and/or geogenic effects of burial on soils is described so that the accurate analysis of different buried soil types can be utilized in order to aid the reconstruction of past landscapes. There is also a focus here on earth-based constructions and many kinds of soil formation processes are detailed. In depositional environments, sedimentation is the chief process. Chapters 5 and 6 concentrate on sediments and sedimentary processes in environments where exposure to subaerial weathering of the regolith is often ephemeral, and pedological development is likely to be very weak. Part II, Chapter 5 (Soil-Sediments) thus examines different kinds of sediment – alluvium, colluvium, and mass-movement deposits – in relationship to human activity. In the case of clearances and cultivation (see Chapter 9), human-induced colluviation is a primary mechanism. On the other hand, sometimes human impact is negligible and natural formation processes are totally dominant. Nevertheless, the place of humans in such environments still needs to be understood. When sediment-buried old land surfaces are studied, the transformation of these has to be considered. Barrow-buried soils are described in Chapter 4, but when a river floods or the sea inundates coastal areas as in the early Holocene of western Europe, a different kind of effect is recognized. Thus, the last chapter in Part II (Chapter 6 – Inundated Sites) discusses how we can interpret microfeatures accurately that are present in flooded terrestrial sites (freshwater alluvium) and in the present-day intertidal zone (marine alluvium). Just to note: both the examples of Early Paleolithic Boxgrove (West Sussex, UK) and the Romano-British Stanford Wharf salt-working site (Essex, UK) can only be understood according to our knowledge of how marine inundation affects sites.

In Parts III–IV the emphasis of the book shifts to anthropogenic features and artifacts produced by humans, both as hunters and gatherers and as formed by complex societies. This also includes the pattern of archaeological deposit formation at both types of sites. The second half of the book therefore commences with the study of

Archaeological Materials in Part III, Chapter 7, and is aimed to be as comprehensive as possible within the constraints of a printed book chapter. Chapter 7 thus embraces everything from constructional to industrial materials, and human latrine waste to animal coprolites, and includes many examples gathered from our reference collections and well-studied site examples. Part IV considers human occupation and the effects of this, commencing with Chapter 8 (First Records of Human Activity). In addition to noting some hunter and gatherer culture sites, features that can be associated with activities peripheral to complex society settlements are also noted. Some aspects of Paleolithic human activity are described in Chapters 5 and 6. Part IV continues with Chapter 9 on how to recognize and differentiate major human impacts on the landscape, in the form of clearance and cultivation. Closer analysis of complex societies, however, also warrants a clear idea of how occupation surfaces (Chapter 10) reflect use of space by humans and stock, by the way trampled surface deposits can be characterized. Such analyses and identifications are fundamental building blocks to the spatial study of both rural and urban space. In Chapter 11 the various components that contribute our comprehension of settlement morphology are elucidated. Chapter 11 also includes many feature types, such as ditches, water holes and wells, graveyards, and middening areas. Lastly, Chapter 12 deals with site transformation studies on how once recognizable occupation layers and farmed soils, for instance, became reworked after abandonment or through a land use change; structures can collapse or be razed by fire. This is a key aspect of investigation on any archaeological site, and Courty et al. (1989) coined the term, "post-depositional processes" for this very reason. In fact, there has been a major focus on these kinds of studies on some of the most challenging archaeological deposits worldwide, such as European dark earth and Amazonian and "Maya" dark earths of the New World.

Please note that soil micromorphology is often carried out alongside chemical and magnetic susceptibility analyses on complementary and often exactly correlated bulk samples (Goldberg and Macphail, 2006b, chapter 16). Magnetic susceptibility is reported in the standard way as χLF (low frequency) units (10^{-8} m^3 kg^{-1}). Organic matter data is presented as %Organic C (carbon) or %LOI (Loss-On-Ignition) according to the methods employed; the former by wet chemistry, the latter by ignition in a furnace, although different temperatures are employed (e.g., 375°C for 16 hours or 550°C for 2 hours). Phosphate analysis also employs different methods and is reported by chemists either as P or as the oxide (P_2O_5) as mg g^{-1} or mg P (P_2O_5)/100 g. Chapter reviewers have suggested that all data should be given as % or ppm (parts per million). Often this has been done, but it can be seen why chemists use their own recording methods when small amounts of phosphorus (element)/

phosphate (oxide) and very small quantities of heavy metals (μg g^{-1}; micrograms of substance per gram of dry mass of sample) and trace elements (ng g^{-1}; nanogram of substance per gram of dry mass of substance = parts per billion) have been measured. Data from SEM/EDS (Scanning Electron Microscopy and Energy Dispersive X-ray Spectrometry) and X-ray microprobe studies on thin sections are given as %Element or %Oxide (e.g., Al or Al_2O_3). Some conversions are given below:
100.0 mg g^{-1} = 1.0% or 10,000 ppm (e.g., P)
100.0 mg/100 g = 0.1.0% or 1,000 ppm (e.g., P)
100.0 μg g^{-1} = 0.100% or 100 ppm (e.g., for Cu, Pb and Zn)
100.0 ng g^{-1} = 0.0001% or 0.100 p pm (e.g., Hg).