

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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Applied Soils and Micromorphology in Archaeology

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Cambridge University Press & Assessment
978-1-107-64868-5 — Applied Soils and Micromorphology in Archaeology
Richard I. Macphail, Paul Goldberg
Frontmatter
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CAMBRIDGE
UNIVERSITY PRESS

Shaftesbury Road, Cambridge CB2 8EA, United Kingdom
One Liberty Plaza, 20th Floor, New York, NY 10006, USA
477 Williamstown Road, Port Melbourne, VIC 3207, Australia
314-321, 3rd Floor, Plot 3, Splendor Forum, Jasola District Centre, New Delhi – 110025, India
103 Penang Road, #05-06/07, Visioncrest Commercial, Singapore 238467

Cambridge University Press is part of Cambridge University Press & Assessment, a department of the University of Cambridge.

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www.cambridge.org
Information on this title: www.cambridge.org/9781107648685

DOI : 10.1017/ 9780511895562

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First published 2018

A catalogue record for this publication is available from the British Library

Library of Congress Cataloging-in-Publication data

Names: Macphail, Richard, author. | Goldberg, Paul, author.

Title: Applied soils and micromorphology in archaeology / Richard I. Macphail, University College London, Institute of Archaeology; Paul Goldberg, Department of Archaeology, Boston University.

Description: New York : Cambridge University Press, 2018. |

Series: Cambridge manuals in archaeology | Includes bibliographical references and index.

Identifiers: LCCN 2017004142 | ISBN 9781107011380 (hardback : alk. paper)

Subjects: LCSH: Soil science in archaeology. | Soil micromorphology.

Classification: LCC CC79.S6 M33 2017 | DDC 930.1028-dc23

LC record available at <https://lccn.loc.gov/2017004142>

ISBN 978-1-107-01138-0 Hardback

ISBN 978-1-107-64868-5 Paperback

Cambridge University Press & Assessment has no responsibility for the persistence or accuracy of URLs for external or third-party internet websites referred to in this publication and does not guarantee that any content on such websites is, or will remain, accurate or appropriate.

Color plates and additional figures found at www.cambridge.org/9781107648685

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

CONTENTS

<i>List of Figures</i>	<i>page xi</i>
<i>List of Tables</i>	<i>xvi</i>
<i>List of Boxes</i>	<i>xviii</i>
<i>Preface</i>	<i>xix</i>
<i>Acknowledgments</i>	<i>xxiv</i>
PART I BACKGROUND APPROACH AND METHODS	1
1 Applied Principles from Geology and Soil Science	3
1.1 Introduction	3
1.2 Sediment Types and Geological Processes	14
1.3 Facies and Microfacies	21
1.4 Examples of Sedimentary Geology	24
1.5 Coastal and Terrestrial Soil-Sediments Examples	27
1.6 Soils	27
1.7 Soils and Experiments, Including Archaeological Reconstructions and History of Research	28
1.8 Reference Materials and Their Study	30
1.9 Fieldwork, Sampling, and Laboratory Processing	31
1.10 Conclusions	38
2 Complementary Analyses	39
2.1 Introduction	39
2.2 Macro- and Microfossil Studies (Including <i>In Situ</i> Identifications)	43
2.3 Soil Micromorphology and <i>Associated</i> Chemical, Macro-, and Microfossil Studies	46
2.4 Use of Instrumental Methods	54
2.5 Conclusions	65
3 Systematic Soil Micromorphology Description	66
3.1 Introduction	66
3.2 Development of Soil Micromorphology Description	66
3.3 Sample Listing and Organization	69

viii	CONTENTS	
	3.4	Observational Steps 74
	3.5	Estimations and Numerical Data 93
	3.6	Recording Soil Micromorphology 95
	3.7	Conclusions 96
	PART II	SOILS AND SEDIMENTS 97
	4	Soils and Burial (Horizon Types and Effects of Burial in the Temperate and Boreal Regions) 99
	4.1	Introduction 99
	4.2	Mull Humus Horizons and Their Variants, and Effects of Burial 100
	4.3	Moder and Mor Humus Topsoils, and Effects of Burial 118
	4.4	Upper Subsoils 125
	4.5	Subsoils 128
	4.6	Conclusions 134
	5	Soil-Sediments 135
	5.1	Introduction 135
	5.2	Alluvium and Alluvial Soils 136
	5.3	Colluvium 166
	5.4	Colluvial Palaeosols – Examples from Last Late Glacial Windermere (~Allerød) Interstadial, UK 174
	5.5	Examples of Colluvia Resulting from Clearance and Agriculture (e.g., Hillwash) 179
	5.6	Ponds, Lakes, and Associated Wetland 183
	5.7	Conclusions 185
	6	Inundated Freshwater and Coastal Marine Sites 186
	6.1	Introduction 186
	6.2	Inundation by Freshwater (Upper Palaeolithic and Early Mesolithic Three Ways Wharf, Uxbridge, Middlesex as Example of an “Inland” Site; after Macphail et al., 2010) 187
	6.3	Inundation by Freshwater at Sites Later Affected by Marine Alluviation (Lower Thames Valley and the Fens, UK) 188
	6.4	Experimental Marine Inundation at Wallasea Island, Essex 190
	6.5	General Effects of Marine Inundation (Archaeological Sites on the River Blackwater and River Severn) 198
	6.6	Sediment Ripening and Freshwater Inundation at Boxgrove (Units 4b, 4c, and 5a) 201
	6.7	The Middle Pleistocene Kirkhill Quarry Palaeosol, Buchan, Scotland 207
	6.8	Conclusions 208
	PART III	ARCHAEOLOGICAL MATERIALS 209
	7	Archaeological Materials and Deposits 211
	7.1	Introduction 211
	7.2	Constructional Materials 212

7.3	Prepared Constructional Materials	229
7.4	Some Effects of Fire on Building Materials and Archaeological Deposits in General	234
7.5	Industrial, Material Processing, and Artisan Activity Traces	237
7.6	Fecal Waste (Coprolites, Dung, Excrement, and Cess)	247
7.7	Conclusions	268
PART IV FEATURES AND ACTIVITIES IN THE LANDSCAPE		269
8	First Records of Human Activity	271
8.1	Introduction	271
8.2	Sampling Strategies in Sites Where Natural Processes Predominate (the Pleistocene Examples of Chongokni, Korea and Boxgrove, UK)	277
8.3	The Freshwater Occupation Pond Sediments at Boxgrove, UK	279
8.4	Southfleet Elephant Site, Ebbsfleet, Kent	280
8.5	Open Air Sites (Camps and Middens)	282
8.6	Conclusions	289
9	Clearance and Cultivation	290
9.1	Introduction	290
9.2	Clearance	290
9.3	Cultivation	303
9.4	Experiments in Ancient Cultivation	308
9.5	Cultivation without (Evident) Manuring	312
9.6	Cultivation with Manuring, Including Horticulture	316
9.7	Worldwide Cultivation	330
9.8	Conclusions	340
10	Occupation Surfaces and Use of Space	342
10.1	Introduction	342
10.2	Ethnoarchaeological Studies and Experiments	346
10.3	Stabling and Semi-Intact Stabling/Byre Waste Deposits	354
10.4	Domestic Space Including Hearths	368
10.5	Industrial and Craft Activities	379
10.6	Conclusions and Recognizing Different Uses of Space	383
11	Settlement Morphology	386
11.1	Introduction	386
11.2	Constructions	394
11.3	Trackways and Roads	412
11.4	Animal Management	436
11.5	Waste Disposal I (Middening)	456
11.6	Waste Disposal II (Cess Pits and Latrines)	458
11.7	Water Management and Control (Wells, Reservoirs, Ditches, and Moats)	461
11.8	Specialist Domestic, Artisan, and Industrial Activity	466

X CONTENTS

11.9	Funerary Features (Graves, Cremations, and Excarnation Features)	478
11.10	Conclusions	489
12	Site Transformation	490
12.1	Introduction	490
12.2	Decay, Destruction, and Razing Effects	490
12.3	European Dark Earth	494
12.4	Maya Dark Earth at Marco Gonzalez, Ambergris Caye, Belize	505
12.5	Conclusions	515
13	Final Remarks	517
<i>Color plates and additional figures are available at www.cambridge.org/9781107648685</i>		
	<i>Site Gazetteer</i>	519
	<i>References</i>	529
	<i>Index</i>	585

FIGURES

1.1	Pompeii, Italy, AD 79; volcanic ash road fill, plane - polarized light (PPL)	<i>page</i> 17
1.2	Oslo harbor, Norway; fourteenth-century B13 shipwreck remains	17
1.3	As Figure 1.2, harbor sediment and pyrite concentrations, flatbed scan (FS)	18
1.4	As Figure 1.2, harbor sediment and wood remains (FS)	18
1.5	As Figure 1.2, harbor sediment, pyrite, X-ray backscatter image (BSE)	19
1.6	As Figure 1.2, pyrite X-ray spectrum	19
1.7	As Figure 1.2, seaweed in harbor sediment (PPL)	20
1.8	Gokstad Ship Burial Mound, Vestfold, Norway; motor-coring	35
1.9	As Figure 1.8, location map of Norway, Gokstad and Heimdal (Heimdaljordet) sites	35
1.10	As Figure 1.8, coring map	36
2.1	Chongokni, Hantan River, Republic of Korea; XRD analysis of sediments	55
2.2	Åmot øvre, Lok 11 E18 road project, Vestfold, Norway; micro-FTIR analyses of burnt clay	56
2.3	As Figure 2.2, micro-XRF analyses of burnt clay	57
2.4	Stanford Wharf, River Thames, Essex, UK; Late Roman “green glaze” coated salt-working briquetage ceramic (FS)	58
2.5	As Figure 2.4, “green glaze” (BSE)	58
2.6	As Figure 2.4, Late Roman “green glaze” coated salt-working briquetage ceramic; micro-FTIR analyses	59
2.7	(A) Overton Down Experimental Earthwork, Wiltshire, UK; (B) comparison of manual counts with image analysis data	60
2.8	West Stow Anglo-Saxon Village, Suffolk, UK; amorphous phosphate in Saxon grubenhäuser (BSE)	64
2.9	As Figure 2.8, phosphate-stained charcoal	64
3.1	Soil micromorphology description guide	75
3.2	Stainton West (CNDR), Carlisle, Cumbria, UK; plant remains in palaeochannel (FS)	89

xii LIST OF FIGURES

4.1	Overton Down Experimental Earthwork, Wiltshire, UK, 1992; optical counts of chalk bank-buried soil	102
4.2	As Figure 4.1, field photo of chalk bank-buried soil	103
4.3	As Figure 4.1, control soil outside enclosure (FS)	103
4.4	As Figure 4.3, turf-buried soil (FS)	104
4.5	Wareham Experimental Earthwork, Dorset, UK; control profile	104
4.6	As Figure 4.5, subsoil Bh and Bhs horizon (FS)	105
4.7	As Figure 4.5, earthwork section drawing	105
4.8	As Figure 4.5, compilation of control soil example, bank-buried and turf-buried soils (FS)	106
4.9	As Figure 4.5, changes to thickness of buried Ao horizon through time	107
4.10	As Figure 4.5, bank colluvium (FS)	107
4.11	Butser Ancient Farm, Hampshire, UK; pasture soil (FS)	111
4.12	Easton Down, Wiltshire, UK; Neolithic buried soil (FS)	111
4.13	As Figure 4.12, chalk bank-buried soil	112
4.14	Gokstad Ship Burial Mound, Vestfold, Norway; vivianite concentration (BSE)	114
4.15	As Figure 4.14, vivianite X-ray spectrum	114
4.16	Short Dykes Project, Powys, Wales, UK; Short Ditch Dyke bank-buried soil (FS)	124
4.17	As Figure 4.16, Upper Short Ditch Dyke bank-buried soil (FS)	124
5.1	River Itchen paleochannel pollen diagram	141
5.2	As Figure 5.1, peat Contexts 1312 and 1313 (FS)	142
5.3	Map of Gubrandsdalen site locations, River Lågan, Norway	150
5.4	As Figure 5.3, field photo of Fryasletta alluvium containing charcoal layer	151
5.5	As Figure 5.3, Monolith P42 employed for thin sections M42A and M42B	151
5.6	As Figure 5.3, sample M63A, laminated mull horizon (PPL)	154
5.7	As Figure 5.3, iron-stained organic matter (BSE)	154
5.8	As Figure 5.3, X-ray SEM Spectrum	155
5.9	Huizui, Henan Province, China; site map	156
5.10	As Figure 5.9, Middle Neolithic (M239B) alluvium sediment sequence (FS)	157
5.11	Chongokni, Hantan River, Republic of Korea; site location	158
5.12	As Figure 5.11, alluvial soil sediments (FS)	160
5.13	As Figure 5.11, overbank flooding clayey channel fill (PPL)	160
5.14	As Figure 5.11, overbank flooding clayey channel fill (XPL)	161
5.15	As Figure 5.11, sampling below quartzite core	163
5.16	As Figure 5.11, core-buried soil sediments (FS)	163
5.17	Boxgrove, West Sussex, UK; sequence of marine and terrestrial sediments, including cool-climate path gravels	169
5.18	As Figure 5.17, example of cool-climate soil-sediment sampling	173
5.19	As Figure 5.17, horizontally fissured soil sediment (FS)	173
5.20	As Figure 5.17, horizontal clay coated fissures (PPL)	174

6.1	Three Ways Wharf, Uxbridge, UK; Upper Paleolithic and early Mesolithic stratigraphy	188
6.2	Wallasea Island on the River Crouch, Essex, UK; site location map	191
6.3	As Figure 6.2, example of tidal mudflat foraminifera (PPL)	195
6.4	Goldcliff, Gwent, Wales, UK; marine sediment-sealed Mesolithic “soil” (FS)	200
6.5	Boxgrove, West Sussex, UK; borehole survey location map	206
7.1	Gokstad, Vestfold, Norway; Viking ship burial within mound	213
7.2	As Figure 7.1, robber trench disturbance and soil inwash (PPL)	213
7.3	Bordușani-Popină, Borcea River, Romania; Chalcolithic tell	214
7.4	As Figure 7.3, loess-based construction and occupation surfaces (FS)	214
7.5	Whittington Ave., City of London, UK; first-century AD Roman spade dug brickearth destruction levels (FS)	215
7.6	London Guildhall (GYE), London, UK; early medieval brickearth floors and trample (FS)	215
7.7	Dragon Hall, Norwich, UK; medieval mortar floor and occupation deposits (Composite FS and BSE images)	232
7.8	As Figure 7.7, siliceous plant stem remains and charcoal (PPL)	235
7.9	Åmot øvre, Vestfold, Norway; Iron Age burnt clay (FS)	236
7.10	Hol, Buskerud, Norway; medieval vesicular iron spherule (BSE)	243
7.11	Butser Ancient Farm, Hampshire, UK; reference sheep-goat dung (FS)	256
7.12	Bedfordshire, UK; reference badger excrement (PPL)	258
7.13	El Morro de Arica, Chile; Chinchorro mummy intestinal contents (PPL)	265
8.1	Boxgrove, West Sussex, UK; refitting flints within cool-climate sediments	273
8.2	As Figure 8.1, mammilated excremental soil (XPL)	274
8.3	As Figure 8.1, calcite root pseudomorph in pond deposits (PPL)	280
8.4	Southfleet (Pleistocene Elephant Site), Ebbsfleet, Kent, UK; lacustrine sediments (FS)	281
8.5	Unnerstvedt and Ragnhildrød, Vestfold, Norway; twig-lined cooking pit fill (FS)	286
8.6	As Figure 8.5, charred twigwood section (PPL)	286
8.7	Helganes, Haugesund airport, North Rogaland, Norway; prehistoric cooking pit char	287
8.8	La Cotte de St Brelade, Jersey, UK; Fe and Zn rich guano (BSE)	288
8.9	As Figure 8.8, X-ray spectrum	288
9.1	Bagböle Experimental Farm, Umeå, Västerbotten, Sweden; conifer woodland control topsoil (FS)	298
9.2	As Figure 9.1, slash-and-burn topsoil (FS)	298
9.3	As Figure 9.1, manured and cultivated: 0–80 mm (FS)	299
9.4	As Figure 9.1, 80–160 mm (FS)	299
9.5	Kilham, Yorkshire Wolds, North Yorkshire, UK; Neolithic long barrow-buried soil (PPL)	304
9.6	As Figure 9.5, XPL	304

xiv LIST OF FIGURES

9.7	Ashcombe bottom, near Lewes, East Sussex, UK; Beaker ard-ploughed colluvium (PPL)	315
9.8	Hørdalsåsen, Vestfold, Norway; Iron Age to Migration Period cultivation soil accumulation	323
9.9	As Figure 9.8, dung-enriched fine soil (PPL)	323
9.10	Avaldsnes Royal Manor (near Haugesund), Rogaland, Norway; dung fragment in plough soil colluvium	324
9.11	Hesby, Vestfold, Norway; footslope colluvium	331
9.12	As Figure 9.11, layered cultivation colluvium (FS)	331
10.1	Bedouin camp, Beer Sheva, Israel; tented floor surface (PPL)	348
10.2	Ha Roa, Negev Highlands, Israel; recent bedouin stabling surface	349
10.3	Ramon Crater, Mizpe Ramon, Negev Desert, Israel	359
10.4	Winchester, Hampshire, UK; medieval organic refuse in cathedral precincts (FS)	367
10.5	As Figure 10.4, layered stabling waste (PPL)	367
10.6	Tønsberg, Vestfold, Norway; medieval “silting” below plank floor (PPL)	374
11.1	Bordușani-Popină, Borcea River, Romania (near River Danube); site location	390
11.2	Stanford Wharf, River Thames estuary, Essex, UK; charred remains in plant-tempered clay oven (PPL)	401
11.3	Jarlsberg, Vestfold, Norway; contour map of Migration Period longhouse	402
11.4	Grytting, Gudbrandsdalen, Oppland, Norway; Iron Age clay hearth (FS)	403
11.5	White Horse Stone, Kent, UK; Early Neolithic long house posthole fill (PPL)	404
11.6	As Figure 11.5, bone inclusion – Blue Light (BL)	404
11.7	Lyminge, Thanet, Kent, UK; Saxon grubenhaus	409
11.8	As Figure 11.7, iron (plough) coulter	409
11.9	As Figure 11.7, iron-stained remains of grubenhaus plank floor (BSE)	412
11.10	Brougham Castle, Penrith, Cumbria, UK; Iron Age trackway silts (PPL)	413
11.11	Ware, Essex, UK; pre-Roman road trackway sediments	414
11.12	As Figure 11.11, Roman road surface	414
11.13	E18, road project map, Vestfold, Norway	428
11.14	Whitefriars, Canterbury, UK; diagrammatic Roman and Saxon bulk data profiles	433
11.15	As Figure 11.14, elemental microprobe maps of road deposits	434
11.16	Cevennes mountains, southern France; troupeau transhumance	444
11.17	As Figure 11.16, dung concentration	445
11.18	Niederhummel, Bavaria, Germany; Early LBK feature fill – (a) plots of P_2O_5 vs MnO ; (b) plots of P_2O_5 vs FeO	445
11.19	Arene Candide, Liguria, Italy; Middle Middle Neolithic stabling layers	446

11.20	West Stow Anglo-Saxon Village, Suffolk, UK; pig pasture and pig pen areas	451
11.21	As Figure 11.20, pigs and pig trample	451
11.22	Heimdaljordet (Heimdal), Vestfold, Norway; Viking coastal settlement map	460
11.23	As Figure 11.22, fishbone in cess-rich parcel ditch fill (BSE)	460
11.24	Hesby, Vestfold, Norway; base of Viking well fill (FS)	462
11.25	Stanford Wharf, Thames Estuary, Essex, UK; site location	470
11.26	As Figure 11.25, Romano-British salt working – siliceous plant residue (PPL)	471
11.27	As Figure 11.25, lead stained Late Roman floor (BSE)	472
11.28	Marco Gonzalez, Ambergris Caye, Belize; regional location map	473
11.29	As Figure 11.28, Maya settlement map	474
11.30	As Figure 11.28, Maya salt-working levels with lime floor and debris including pot fragments	475
11.31	As Figure 11.28, burnt intertidal marine sediment (PPL)	476
11.32	As Figure 11.28, Coconut Walk ware pottery coating (BSE)	477
11.33	Bjørnstad sondre, Sarpsborg, Østfold, Norway; Iron Age inhumation	481
11.34	As Figure 11.33, coffin remains	481
11.35	As Figure 11.33, wood residues and vivianite (PPL)	482
11.36	Heimdaljordet, Vestfold, Norway; Viking boat grave – mineralized gut remains (BSE)	485
11.37	Hørdalen, Vestfold, Norway; Iron Age grave mound – cremated bone (PPL)	488
11.38	As Figure 11.37, OIL	488
12.1	Courages Brewery site, Southwark, London, UK; collapsed Roman brickearth structure and sealed floor deposits	492
12.2	Butser Ancient Farm, Hampshire, UK; reconstructed villa interior	493
12.3	Prosper-Mérimée Square, Tours, France; fourth- to sixth-century AD occupation surface (FS)	501
12.4	As Figure 12.3, twelfth-century AD dark earth (FS)	502
12.5	As Figure 12.3, earthworm granules in dark earth (PPL)	503
12.6	Tarquimpol, La Moselle, France; section through Late Antique rampart and dark earth	504
12.7	Marco Gonzalez, Ambergris Caye, Belize; Maya dark earth	506
12.8	As Figure 12.7, lime floor fragment in dark earth (PPL)	512
12.9	As Figure 12.7, OIL	512
12.10	As Figure 12.7, modern woodland surface soil formed over dark earth (FS)	513

TABLES

1.1	Common sedimentary environments and their subdivisions – site examples	<i>page 5</i>
1.2	Calcium carbonate (CaCO ₃) formations, features, and inclusions	6
1.3	Coastal environments	8
1.4	Soil horizons, soil types, and studied examples	10
2.1	Examples of selected (and sometimes generalized) particle size data and texture class (<2 mm)	41
2.2	Examples of shared sampling of the same cores for soil micromorphology and complementary studies	50
2.3	Examples of SEM/EDS data	62
3.1	Suggested outline for presenting soil micromorphological information	68
3.2a	Description Protocol 2: Examples of count sheet – Neolithic soil	70
3.2b	Description Protocol 2: Examples of count sheet – complex society site	71
3.3	Description Protocol 1: Fine fraction	77
3.4	The most commonly occurring single and compound mineral grains	79
3.5	Frequency and abundance semi-quantitative estimates as employed on count sheets	93
4.1	Wareham – changes in the buried soil	108
4.2	Gokstad Mound soil micromorphology	116
4.3	Particle size analysis of Roman truncated and sealed <i>in situ</i> Argillic Brown Earth soils (Luvisols) and “Brickearth clay” used in Roman constructions	130
5.1	Sediment types at Lower Paleolithic and Middle Pleistocene Boxgrove	147
5.2	White Horse Stone, Kent: summary of late glacial stratigraphic history based upon soil micromorphology	148
5.3a	Gudbrandsdalen, Oppland, Norway; particle size analysis	152
5.3b	Gudbrandsdalen, Oppland, Norway; five parameter analysis	152
5.3c	Fryasletta, River Lågan alluvium Gudbrandsdalen, Oppland, Norway; palynological study of Bronze Age charcoal-rich Context 1150	153
6.1	Wallasea Island; basic soil characterization and magnetic susceptibility data	193
6.2	Wallasea Island; particle size analysis	196

6.3	Summary of some taphonomic effects noted in sites influenced by rising groundwater, freshwater inundation, rising saline groundwater, and estuarine mudflat inundation and sedimentation	199
7.1	Archaeological materials associated with construction	217
7.2	“Clay floors”	227
7.3	Experiments on ovens, furnaces, and heated bone	238
7.4	EDS and microprobe analysis of some metal working traces and associated materials	242
7.5	Dung, coprolites, and cess	248
8.1	Boxgrove archaeology and associated depositional environments	275
8.2	Bronze Age/Pre-Roman Iron Age pit fill (Helganes, Norway); selected EDS data	288
9.1	Sites with soil micromorphological evidence of tree-throw and clearance	291
9.2	Changes to microfibrils when soils previously under natural vegetation were cultivated employing modern methods	306
9.3	Sites of experiments in “ancient agriculture”	309
9.4	Some ancient cultivated soils	318
9.5	Comments on the identification of cultivation microfeatures and recognition of agriculture	341
10.1	General characteristics and basic interpretations of the three distinct units identified in activity surfaces	343
10.2a–c	Key microstratigraphic features in the Moel-y-gar stable 1990, and after burial (1995), and in the Pimperne domestic roundhouse Butser Ancient Farm	350
10.3	Seasonal cycle residues from over-wintering of stock in Mediterranean caves – stabling deposits	356
10.4	Roman and Medieval stabling floors and deposits UK	363
10.5	Mediterranean cave site; typical domestic occupation deposits	369
10.6	Common difference between stable/byre and domestic floors, and indications of industrial and artisan activities	384
11.1	A model of settlement composition as selectively studied and identified through soil micromorphology	387
11.2	Summary of site formation processes and events in the history of the Gokstad Mound according to soil micromorphology	396
11.3	Iron Age road sequence; Sharpstone Hill, near Shrewsbury, Shropshire, UK	416
11.4	Iron Age rutted trackway, Södra Sallerup, Sweden	422
11.5	Raunds, Northamptonshire, UK. Landscape and land use stages, based on soil data	425
11.6	West Stow pig husbandry bulk chemical studies	453
12.1	Examples of dark earth development trajectories from England, and Tarquimpol (La Moselle) and Square Prosper-Mérimée, Tours (France)	499
12.2	Marco Gonzalez; summary of soil micromorphology and bulk soil findings – both generalized and context specific	507

BOXES

1.1	Marine harbor sedimentation in Oslo Fjord, Norway; the fourteenth-century “B13” wreck excavation; Figures 1.2–1.7	<i>page 15</i>
4.1	Experimental Earthwork Studies at Overton Down and Wareham, UK (1980–1996 results)	101
5.1	Late glacial and Holocene alluviation in England	139
5.2	Gudbrandsdalen Valley sediments	149
5.3	Sequence of Late Pleistocene lacustrine and alluvial sediments along the Imjin and Hantan Rivers, Korea, with Special Reference to the Chongokni Site	159
11.1	The Chalcolithic tell site of Bordușani-Popină, Borcea River, Romania	392
11.2	Whitefriars, Canterbury	432
11.3	An example of early animal husbandry: Raunds (Northamptonshire, UK)	438
11.4	Experimental pig husbandry at West Stow, Suffolk, 2008	452
11.5	Salt working at (1) the Romano-British and Late Roman Thames coastal site of Stanford Le Hope, UK and (2) Maya Marco Gonzalez Island, Belize	469

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).

XX PREFACE

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 χ_{LF} (low frequency) units ($10^{-8} \text{ m}^3 \text{ kg}^{-1}$). 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 $\text{mg P} (\text{P}_2\text{O}_5)/100 \text{ g}$. 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 ($\mu\text{g g}^{-1}$; 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:

$100.0 \text{ mg g}^{-1} = 1.0\% \text{ or } 10,000 \text{ ppm (e.g., P)}$

$100.0 \text{ mg}/100 \text{ g} = 0.1.0\% \text{ or } 1,000 \text{ ppm (e.g., P)}$

$100.0 \mu\text{g g}^{-1} = 0.100\% \text{ or } 100 \text{ ppm (e.g., for Cu, Pb and Zn)}$

$100.0 \text{ ng g}^{-1} = 0.0001\% \text{ or } 0.100 \text{ p pm (e.g., Hg)}$.