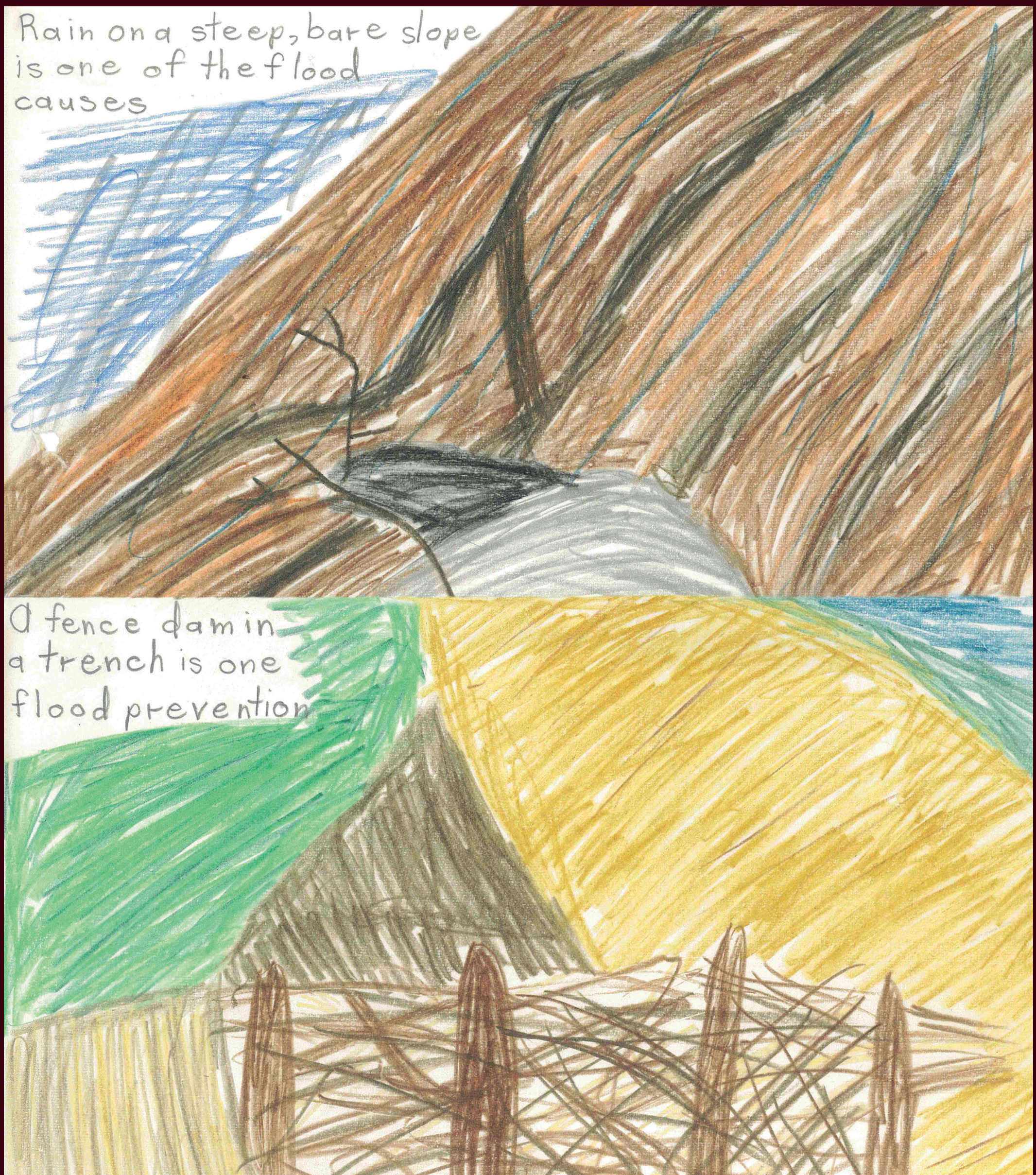
McDONALD INSTITUTE CONVERSATIONS

Inspired geoarchaeologies: past landscapes and social change

Essays in honour of Professor Charles A. I. French

Edited by Federica Sulas, Helen Lewis & Manuel Arroyo-Kalin



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Essays in honour of Professor Charles A. I. French

Edited by Federica Sulas, Helen Lewis & Manuel Arroyo-Kalin

with contributions from
Michael J. Allen, Andrea L. Balbo, Martin Bell, Nicole Boivin, Christopher Evans, David Friesem, Kasia Gdaniec, Lars Erik Gjerpe, Michael Gill, Martin Green, Ann-Maria Hart, Robyn Inglis, Martin Jones, Gabriella Kovács, Helen Lewis, Johan Linderholm, Roy Loveday, Richard I. Macphail, Caroline Malone, Wendy Matthews, Cristiano Nicosia, Bongumenzi Nxumalo, Innocent Pikirayi, Tonko Rajkovaca, Rob Scaife, Simon Stoddart, Fraser Stuart, Federica Sulas & Magdolna Vicze

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On the cover: *Hand drawn illustration by Charly French, aged around 10 years old.*
Courtesy of Kasia Gdaniec.

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Contributors

Michael J. Allen
Allen Environmental Archaeology, Redroof, Green Road, Codford, Wiltshire, BA12 0NW, UK
Email: aea.escargots@gmail.com
Mike's (BSc, PhD, MCIfA, FLS, FSA) research and geoarchaeological interest was originally based around the analysis of colluvium and land snails, including in the South Downs, Dorchester, Cranborne Chase, Stonehenge and Avebury in particular; these were the subject of both his undergraduate and PhD research. He has combined a career dominated by commercial archaeology with involvement in university research projects and as a staff lecturer at Sussex, Bournemouth and Oxford Universities. He was Environmental Manager at Wessex Archaeology for twenty years and for fifteen years has run his own geoarchaeological consultancy from a purpose-built bespoke lab, where he is involved in research designs and coordination of environmental archaeology from fieldwork to publication. Projects have been as diverse as intertidal zone research and Maltese prehistoric temples. His interests now lie principally in landscape archaeology and the development and creation of landscapes through prehistoric human intervention. He has worked with – and still is working with – Charly French in Cranborne Chase, the Stonehenge Riverside Project, and both recent Avebury landscape projects. He is vice-president of the Conchological Society, and as founding editor of the Prehistoric Society Research Papers has seen ten peer-reviewed volumes through to publication.

Manuel Arroyo-Kalin
Institute of Archaeology, University College London, 31–34 Gordon Sq., London WC1H 0PY, UK
Email: m.arroyo-kalin@ucl.ac.uk
Manuel is Associate Professor of Geoarchaeology at the Institute of Archaeology, UCL. He is interested in the Anthropocene, Human Niche Construction, and Historical Ecology and uses earth science methods, including soil micromophological analysis, to study past anthropic landscape modification and anthropogenic soil formation. His main research focus is the pre-Colonial human landscape history of tropical lowland South America, particularly the Amazon basin, where he is engaged in the long-term comparative study of Amazonian Dark Earths. He has also been involved in geoarchaeological studies in other world regions and published on the archaeology and palaeodemography of the Amazon basin. In recent years he has coordinated an intercultural and interdisciplinary research project focused on the northwest Amazon region.

Andrea L. Balbo.
Platform Anthropocene, 160 Riverside Blvd, 30E - 10069 New York, NY, USA
Email: andrea.balbo@planthro.org
Following his PhD at the University of Cambridge (2008), Andrea conducted geoarchaeological research at the Spanish Research Council (CSIC) and at the University of Hamburg. Since 2019 he has been employed at the ALIPH Foundation for the protection of heritage in conflict areas, based in Geneva, where his main focuses are the linkages between climate change, conflict and cultural heritage protection, and the role of documentation and ICT in cultural heritage protection. Co-founder and CEO of Platform Anthropocene Ltd., Andrea leads the development of a comprehensive interdisciplinary web repository on the Anthropocene. He also maintains university teaching in archaeology, heritage and human-environment interaction and acts regularly as a scientific evaluator, rapporteur, and monitor for the European Commission.

Martin Bell
Department of Archaeology, University of Reading, Whiteknights, PO Box 217, Reading, Berkshire, RG6 6AH, UK
Email: m.g.bell@reading.ac.uk
Martin is an emeritus professor of Archaeology at Reading University. His research interests are in geoarchaeology, environmental archaeology, coastal and maritime and experimental archaeology. He has been involved in several experimental archaeology projects, particularly the Experimental Earthwork Project. He has been excavating coastal sites in the Severn Estuary for forty years and has produced four monographs on the prehistory of the Severn Estuary. He believes that environmental archaeology has a key role in finding sustainable strategies for nature conservation. His most recent book *Making One's Way in the World: The Footprints and Trackways of Prehistoric People* (Oxbow 2020) explores the ways in which we can investigate prehistoric routeways and connectivity. He is a Fellow of the British Academy and the Society of Antiquaries of London.

Nicole Boivin
Max Planck Institute for the Science of Human History, Kahlaische Strasse 10, 07745 Jena, Germany
Email: boivin@shh.mpg.de
Nicole was a director at the Max Planck Institute for the Science of Human History in Jena, Germany. The author of *Material Cultures, Material Minds: The*

Role of Things in Human Thought, Society and Evolution (Cambridge University Press 2008), she has also been editor of several books, including *Globalisation and the 'People without History': Understanding Contact and Exchange in Prehistory* (Cambridge University Press 2018). She has been awarded research funding from many international bodies, including the European Research Council and the National Geographic Society, is a Fellow of the Society of Antiquaries of London, and holds an Honorary Professorship at the University of Queensland.

Christopher Evans
Department of Archaeology, University of Cambridge, Downing Street, Cambridge CB2 3DZ, UK
Email: cje30@cam.ac.uk
Christopher was the executive director/director of research of the Cambridge Archaeological Unit (CAU), University of Cambridge until 2021. Having worked in British archaeology for over forty years – with his initiation to Fenland archaeology coming at Fengate – following on from the Haddenham Project, he co-founded the CAU with Ian Hodder in 1990. He has directed a wide variety of major fieldwork projects, both abroad – Nepal, China and Cape Verde (the latter sometimes involving Charly) – and in the United Kingdom. A fellow of the Society of Antiquaries of London, in 2018 he was elected a fellow of the British Academy. He has published widely, including monographs arising from both his own landscape projects and those of earlier-era practitioners in the CAU's 'Historiography and Fieldwork' series (e.g. Mucking in 2016). Together with Tim Murray, he edited Oxford University's *Histories of Archaeology: A Reader in the History of Archaeology* (2008).

David Friesem
Department of Maritime Civilizations, School of Archaeology and Maritime Cultures, University of Haifa, 199 Aba Khoushy Ave, Mount Carmel, Haifa 3498838, Israel
Email: dfriesem@univ.haifa.ac.il
David is a senior lecturer of environmental archaeology at the Department of Maritime Civilizations, University of Haifa, and a research member of the Haifa Center for Mediterranean History. He combines field archaeology, geoarchaeology, ethnography, and social theory in order to study human ecology, technology, and social interactions, and reconstruct the often-missing small-scale perspective of human-environment interactions. His research interests include human adaptation during the Late Pleistocene, the emergence of complex societies, and hunter-gatherer anthropology.

Kasia Gdaniec
Higher Shippon, Bridge Reeve, Chulmleigh, Devon EX18 7BB, UK
Email: kasia.gdaniec@btinternet.com
Kasia works as an archaeological curator at Cambridgeshire County Council, advising local planning authorities on managing change to the historic environment, and scoping investigation programmes for developers and commercial archaeologists that promote both academic rigour and public engagement. Her particular interests lie in the technical difficulties of preservation *in situ* as a long-term archaeological management technique, the ceramic traditions of Neolithic and Bronze Age Britain, the evolution of the East Anglian fens and the adaptation of local communities to their changing environments, and the history and legacy of post-medieval fen draining schemes and how this shapes current competing land use and environmental pressures.

Michael Gill
48 Saunders Avenue, Salisbury, SP1 3PQ, UK
Email: mjg.gbr@gmail.com
Michael has an MA in Landscape Studies (archaeology and history) and an MSc in Geographical Information Systems, both from Leicester University. He works as a GIS consultant with Ordnance Survey, and is an active member of Avon Valley Archaeological Society, where he leads the geophysics survey team. He has a personal research interest in the Neolithic monuments on Cranborne Chase and in the Avon Valley, and has surveyed a number of long barrows and related sites in this region.

Lars Erik Gjerpe
Cultural History Museum, University of Oslo, Frederiks gate 2, 0164 Oslo, Norway
Email: l.e.gjerpe@khm.uio.no
Lars has a Masters and PhD in archaeology from the University of Oslo, with a thesis on Iron Age settlement and property rights in southeastern Norway. He has directed several large-scale heritage management excavations for the Museum of Cultural History at the University of Oslo, mainly targeting Iron Age burials, settlements and agricultural remains, while including other periods and relics. As a result, he has been editor and main author of publications on cemeteries (*Gravfeltet på Gulli*, University of Oslo 2005) and Iron Age settlements. Interdisciplinary cooperation and environmental archaeology, including archaeometric analysis (e.g. seeds, charcoal and soil), have been an integrated part of these projects. He has also been editor for the journal *Primitive tider* and academic editor of Trond Løken's 2020 *Bronze Age and Early Iron*

Age House and Settlement Development at Forsandmoen, South-western Norway. Currently, he is a member of the steering committee for large-scale heritage management excavations at the NTNU (Norwegian University of Science and Technology).

Martin Green
Down Farm, Woodcutts, Salisbury SP5 5R, UK
Email: mgreendownfarm@gmail.com
Martin began a fieldwalking survey as a lad on Cranborne Chase in the latter 1960s. Following experience gained on a number of field projects, he began excavating independently in the region in 1976. He joined Richard Bradley's and John Barrett's Cranborne Chase Project the following year, contributing four site excavations to *Landscape, Monuments and Society* in 1991. He continued independent fieldwork in the early 1990s in collaboration with Mike Allen, in particular on the Fir Tree Field shaft which revealed a remarkable sequence of deposits dating from the late Mesolithic to the Beaker period, and worked with Charly French on the Upper Allen Valley Project 1998–2003, contributing four further site excavations to *Prehistoric Landscape Development and Human Impact in the Upper Allen Valley, Cranborne Chase, Dorset* (2007). Since that time, he has continued independent research, also in collaboration with Josh Pollard and Southampton University, on the Dorset Cursus, on Down Farm and in the Knowlton environs whilst continuing to increase the biodiversity on his small farm. He was made an FSA (Fellow of the Society of Antiquaries) in 2004 and received an honorary Doctor of Science degree from Reading University in 2006.

Ann-Maria Hart
Ann-Maria is currently working in contracts and commercial management within the Australian defence industry, but still maintains an interest in her former career as a geoarchaeologist.

Robyn Inglis
York Environmental Sustainability Institute (YESI), K/220, Department of Biology, Wentworth Way, University of York, Heslington, York YO10 5DD, UK
Email: robyn.inglis@york.ac.uk
Robyn is a geoarchaeologist interested in the formation of the archaeological record and its impact on our understanding of Palaeolithic dispersals. After receiving her BA in Archaeology and Anthropology from Cambridge, she gained her MSc in Geoarchaeology from Reading. Her PhD in the McBurney Laboratory focussed on the micromorphological reconstruction of sedimentation at the Haua Fteah, Libya, and its implications for understanding human/environment interactions. From 2011–8 she led geoarchaeological survey in Saudi Arabia to further understand the Palaeolithic occupation of the Red Sea littoral and its role in hominin dispersals, first as part of the DISPERSE project at the University of York, and later as a Marie Skłodowska-Curie Global Fellow (University of York and Macquarie University). She now works in research development at the York Environmental Sustainability Institute, University of York, and is an Honorary Research Associate in the university's Department of Archaeology.

Martin Jones
Department of Archaeology, University of Cambridge, Downing Street, Cambridge CB2 3DZ, UK
Email: mkj12@cam.ac.uk
Martin was the first George Pitt-Rivers Professor of Archaeological Science at the University of Cambridge. He works on archaeobotany and archaeogenetics, in the context of the broader archaeology of food. In his earlier career he explored the development of agriculture in later prehistoric and Roman Europe, after which he was very much involved in the development of biomolecular approaches within archaeology. These he applied to research into the spread of farming of both major and minor crops across Asia, most recently in the context of the Food Globalization in Prehistory Project. His latest project is exploring the co-evolution and Eurasian biogeography of crops and bees.

Gabriella Kovács
Matrica Museum and Archaeological Park, 2440 Százhalombatta, Gesztenyés út 1–3, Hungary
Email: antropologus@yahoo.com
Gabriella (PhD) is a museologist and soil micromorphologist at the Hungarian National Museum National Institute of Archaeology. Her main interest is the Middle Bronze Age tell settlement of Százhalombatta-Földvár, under the framework of the international SAX (Százhalombatta Archaeological Expedition) project. Besides this site, other Bronze Age settlements of Hungary are also part of her research interests, regarding the comparison of single and multi-layered settlements of the period, mainly the so-called Vatya Culture. She focuses on the use of space and building techniques via soil micromorphology to add details to traditional archaeological methods.

Helen Lewis
School of Archaeology, University College Dublin, Dublin 4, Ireland
Email: helen.lewis@ucd.ie
Helen is an associate professor at University College Dublin School of Archaeology. Her background is in archaeology and anthropology (BA University of

Toronto), environmental archaeology (MSc University of Sheffield) and archaeological soil micromorphology (PhD University of Cambridge). She mostly works today on cave sites in Southeast Asia, but she still loves northwest European Neolithic and Bronze Age monuments and landscapes, and ancient agricultural soils.

Johan Linderholm
Environmental Archaeology Laboratory (MAL),
University of Umeå, S-90187 Umeå, Sweden
Email: johan.linderholm@umu.se
Johan trained in archaeology and chemistry, specializing in soils and archaeology (BSc and MSc Umeå University). His PhD dealt with soil chemical aspects on settlement organization over time and general human impact on soils. He has been working with research and contract archaeology in several large projects over the last thirty years, mainly in Scandinavia but also in Gibraltar, Italy, France and the UK. Currently he holds a position as associate professor at Umeå University and is conducting research related to reflectance spectroscopy at the Environmental Archaeology Laboratory (MAL), University of Umeå.

Roy Loveday
School of Archaeology and Ancient History,
University of Leicester, University Road, Leicester
LE1 7RH, UK
Email: r.e.loveday@btinternet.com
Roy is an honorary research fellow in the School of Archaeology and Ancient History, University of Leicester. He completed a PhD surveying cursuses and related monuments of Great Britain in 1985. His particular interests are the societal mechanisms underlying monument plan transmission and construction.

Richard I. Macphail
Institute of Archaeology, University College
London, 31–34 Gordon Sq., London WC1H 0PY, UK
Email: r.macphail@ucl.ac.uk
Richard trained in geology and geography, specializing in soil science (BSc Swansea University). An MSc in pedology and soil survey (Reading University) prepared him for a soil science PhD on podzol development on heathlands (Kingston Polytechnic). An English Heritage-funded archaeological soil contract at the Institute of Archaeology (University College London) provided further training and international research opportunities were developed, including working with the Soil Survey of England and Wales and Macaulay Institute, UK, the CNRS, France, and the Soprintendenza, Italy. This led to the publication of *Soils and Micromorphology in Archaeology* (with Courty and Goldberg; Cambridge University Press 1989), the founding of the International Archaeological Soil Micromorphology Working Group, and training weeks at UCL. As a result, *Practical and Theoretical Geoarchaeology* (Blackwell 2006; Wiley 2022) and *Applied Soils and Micromorphology in Archaeology* (Cambridge University Press 2018), both with Goldberg, were written. Macphail is a recipient of the Geological Society of America's Rip Rapp Award for Archaeological Geology (2009), and is a fellow of the Geological Society of America. He is also the 2021 co-awardee (with P. Goldberg) of the International Union of Soil Sciences Tenth Kubiëna Medal for Soil Micromorphology. The paper included here also reflects more than two decades of research across Scandinavia.

Wendy Matthews
Department of Archaeology, University of Reading,
Whiteknights, PO Box 217, Reading, Berkshire, RG6
6AH, UK
Email: w.matthews@reading.ac.uk
Wendy is a specialist in Near Eastern Archaeology and geoarchaeology, focusing on micromorphology of the built environment and long-term perspectives on sustainability (MA Edinburgh 1984; PhD Cambridge 1992, 'Micromorphology of occupational sequences and use of space in a Sumerian city'). She was a research associate and fellow of the McDonald Institute (1993–2000) and is an associate professor in Archaeology at the University of Reading, following a semester as visiting lecturer at UC Berkeley. She was a member of the *Çatalhöyük* team and steering committee, Turkey (1993–2017). She co-directs the *Central Zagros Archaeological Project* investigating the Neolithic of the Eastern Fertile Crescent, Iraq, Iran (2007–), and has conducted research in Syria and Bahrain. She has co-supervised twenty-two PhD students and teaches modules on past, present and future sustainability; micromorphology; and Mesopotamia. She co-designed a new prehistory gallery at the Slemani Museum with Iraqi and Reading colleagues, with sustainability as a central theme.

Cristiano Nicosia
Dipartimento di Geoscienze, Università di Padova,
Via Gradenigo 6, 35131 Padova, Italy
Email: cristiano.nicosia@unipd.it
Cristiano is a geoarchaeologist working as full professor at the Department of Geosciences of the University of Padova, Italy. His research focuses on the study of anthropic deposits, on alluvial geoarchaeology, and on the human impact on soils and landscapes. He is currently the principal investigator of the ERC-funded GEODAP project (GEOarchaeology of DAily Practices: extracting Bronze Age lifeways from the

domestic stratigraphic record). He is involved as chief geoarchaeologist in several Italian archaeological projects and directs the excavations of the Bronze Age site of La Muraiola di Povegliano (Verona) and of the mid-Neolithic site of Molino Casarotto (Vicenza). He collaborates as field geoarchaeologist and micromorphologist in research projects at Olduvai Gorge (Tanzania), Petra (Jordan), Pompeii (Italy), Damyanitsa (Bulgaria), and the Jiroft plain (Iran). In 2017 he coedited with G. Stoops the volume *Archaeological Soil and Sediment Micromorphology*, published by Wiley.

Bongumenzi Nxumalo
Department of Anthropology and Archaeology, Faculty of Humanities, Hatfield Campus, University of Pretoria, Private Bag X20, Hatfield 0028, South Africa
Email: u12378624@tuks.co.za
Bongumenzi (PhD 2020, Cantab.) is lecturer in archaeology at the Department of Anthropology and Archaeology, University of Pretoria. His research interests include hydrological modelling, geoarchaeology, the evolution of early state-societies, historical and modern climatic records.

Innocent Pikirayi
Department of Anthropology and Archaeology, Faculty of Humanities, Hatfield Campus, University of Pretoria, Private Bag X20, Hatfield 0028, South Africa
Email: innocent.pikirayi@up.ac.za
Innocent (PhD 1993, Uppsala) is professor in archaeology at the University of Pretoria. His research interests include geoarchaeology, development of ancient complex societies, water and social formation, and climate change.

Francis Pryor
Inley Drove Farm, Sutton St James, Spalding PE12 0LX, UK
Email: pryorfrancis@gmail.com
Francis has studied the archaeology of the Fens since 1971. His major excavations in the region took place near Peterborough at Fengate, Maxey and Etton. In 1982 his team's survey of fenland drainage dykes revealed the timbers of a waterlogged Bronze Age timber platform and causeway at Flag Fen, which was opened to the public in 1989. He was a member of Channel 4's long-running series *Time Team*. He has written many popular books including *Seahenge* (2001), *Britain BC* (2003), *Britain AD* (2004), *The Making of the British Landscape* (2010), *Home* (2014), *Stonehenge* (2016) and *The Fens* (2019). His most recent book is *Scenes from Prehistoric Life* (Head of Zeus 2021).

Tonko Rajkovaca
Charles McBurney Laboratory for Geoarchaeology, Department of Archaeology, University of Cambridge, Downing Street, Cambridge CB2 3DZ, UK
Email: tr251@cam.ac.uk
Tonko is chief research laboratory technician in geoarchaeology at the University of Cambridge. Involved in archaeology since his childhood, he held posts of archaeological site director and museum curator in Serbia (pre-1994) before moving to the UK to specialize in the late Upper Palaeolithic archaeology of ex-Yugoslavia via an MPhil (2004) at the University of Cambridge, and a PhD at the University of Ljubljana (2017). After four years at the Cambridge Archaeological Unit, he took up the post of geoarchaeology technician at the Department of Archaeology in 2008, and since then he has been working at the McBurney Laboratory of Geoarchaeology. He has directed and managed several archaeological projects, field and laboratory training in the UK and eastern Europe. He has authored several volumes and articles, including a monograph on preventive archaeology in ex-Yugoslavia published by Belgrade's Institute of Archaeology (2019) and a manual of archaeological excavation (co-authored with J. Appleby, 2015).

Rob Scaife
Palaeoecology, University of Southampton, University of Southampton University Road, Southampton SO17 1BJ, UK
Email: r.scaife@soton.ac.uk
Rob is a visiting professor of palaeoecology and environmental archaeology at the University of Southampton, and an honorary research associate of the McDonald Institute for Archaeological Research at the University of Cambridge. His first degree was in geography with geology, and an interest in the Pleistocene led him into palynology. He investigated the Late and Post-glacial vegetation changes of the Isle of Wight for his PhD (King's College London). Subsequently, he worked at the Institute of Archaeology, London, and the Ancient Monuments Laboratory at English Heritage. As a freelance palaeoecologist, he has continued to work across southern and eastern England, along with international studies in Italy, Turkey, Peru and Chile.

Simon Stoddart
Magdalene College, Cambridge, CB3 0EU, UK
Email: ss16@cam.ac.uk
Caroline Malone
8 Lansdowne Road, Cambridge, CB3 0EU, UK
Email: c.malone@qub.ac.uk
Simon and Caroline have been engaged in the research of ancient landscapes for nearly forty years, with a

focus on the central Mediterranean. They both attended lectures by Keith St. Joseph, Richard West, Nick Shackleton and John Coles on the outlines of environmental archaeology. Simon Stoddart went on to study with Bill Farrand and Donald Eschmann at the University of Michigan. Caroline Malone worked at Fengate under the inspired guidance of Francis Pryor, where Charly French also undertook his early geoarchaeological work. They both collaborated in their first major project in the 1980s with Edoardo Biondi, Graeme Barker, Mauro Coltorti, Rupert Housley, Chris Hunt, Jan Sevink (and his pupils Peter Finke and Rene Fewuster) in the regional study of Gubbio. It was, though, the later study of the uplands of Troina at the turn of the millennium in Sicily with Charly French and Gianna Ayala that opened their eyes to new ways of understanding geoarchaeology. This led to the in-depth collaboration with Charly on the island of Malta, entitled FRAGSUS (PI Caroline Malone), which substantially interrogated the rationale for the stability and fragility of the ecology of the Maltese temples. The collaboration lives on through the prospect of continuing work with Charly's pupils, notably Federica Sulas, Gianbattista Marras, Petros Chatzimpaloglou, and Sean Taylor. Caroline Malone is a professor emerita of prehistory at Queen's University Belfast and Simon Stoddart is professor of prehistory at the University of Cambridge.

Fraser Sturt
Southampton Marine and Maritime Institute,
University of Southampton, Avenue Campus,
Southampton SO17 1BF, UK
Email: F.Sturt@soton.ac.uk
Fraser is a prehistorian and marine geoarchaeologist who focuses on the Mesolithic/Neolithic transition in submerged, coastal and island contexts.

Federica Sulas
Charles McBurney Laboratory for Geoarchaeology,
Department of Archaeology, Downing Street,
Cambridge CB2 3DZ, UK
Email: fs286@cam.ac.uk
Federica (PhD 2010, Cantab.) is a senior research associate at the McDonald Institute for Archaeological Research, University of Cambridge. Her research interests include geoarchaeology and landscape historical ecology.

Magdolna Vicze
Matrica Museum and Archaeological Park, 2440
Százhalombatta, Gesztenyés út 1–3, Hungary
Email: vicze@matricamuzeum.hu
Magdolna (PhD) is an archaeologist with primary interests in household archaeology. She is working in the National Institute of Archaeology of the Hungarian National Museum as a Bronze Age researcher and is the leader of the SAX Project (Százhalombatta Archaeological Expedition). The archaeological expedition at Százhalombatta is a long-term international research program with the aim of studying the life and daily activities of prehistoric people at a Bronze Age tell settlement. Her other interest is in mortuary practices.

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Chapter 11

Landscape sequences and Iron Age settlement in southern Africa: managing soils and water in the Greater Mapungubwe landscape

Federica Sulas, Bongumenzi Nxumalo & Innocent Pikirayi

Once home to one of southern Africa's earliest state societies, the Mapungubwe culture (eleventh–fifteenth centuries AD*), the middle Limpopo basin has long been considered a chronically poor and unproductive dryland, becoming a focus for developing mining and commercial farming since the early twentieth century. The rise and then decline of the Mapungubwe culture has been linked to changing rainfall patterns, ultimately driving human action in the making of a marginal dryland. Yet, recent geoarchaeological survey, soil micromorphology and multi-element chemical analyses reveal a different scenario. Buried soil sequences capture the rhythm and space of slow, overbank flooding along the middle Limpopo River, and alluvial-colluvial feeding of small valleys supporting ancient settlement. Within a trend of prolonged landscape stability and incipient soil formation, there is also evidence for pulses of localized disruption. These sequences chronicle the history of a diverse landscape, where ecological niches supported and responded to changing climate and land uses over time. Seen over the long term, the new Mapungubwe record shows how an ancient society was able to adopt and adapt to an evolving dryland by exploiting and creating diversity.*

> '...people show remarkable powers of adaptation, and many landscapes perceived as marginal regularly exhibit long-term resilience…'
> (French 2019, 263)

Occupied by human societies for millennia, drylands preserve some of the longest records of plant and animal domestication, social complexity, trade, urban and mobile lifeways in human history (Barker & Gilbertson 2000). Embracing a variety of ecosystems, including savannas, grasslands, semi-deserts and forests, drylands support several habitats for a great diversity of biomes and human lifeways even today (Chakrabarti 2016). Dryland soil organic and inorganic carbon reserves have played a vital role in supporting food production and environmental health through time (Laban *et al.* 2018; Hanan *et al.* 2021), a function today recognized as important for climate regulation (Van de Broek *et al.* 2019). These benefits are linked to equally significant factors that today are perceived as challenges to human livelihoods and environmental health: aridification, and low, often concentrated rainfall interacting with high temperatures to enhance albedo effect and evapotranspiration rates (Prăvălie 2016).

Archaeologists have long been drawn to the study of drylands as environments where significant ancient civilizations developed – and where their remains are well preserved – such as the Mesopotamian empires and some Maya city-states (Barker & Gilbertson 2000). From a focus on settlements, monumental architecture, and material culture, regional and landscape studies have gradually grown to unveil long-term, spatio-temporal dynamics and interdependencies between societies and drylands (e.g. Balbo *et al.* 2016; Bao *et al.* 2018; Nyamushosho *et al.* 2018; Scarborough & Isendahl 2020). Geoarchaeological approaches have played a pivotal role in placing the human record into its dryland context by revealing the pace and space of landscape evolution, resource uses and their impact over time. Moving across and beyond ancient sites and landscapes, geoarchaeology, with the formidable lens of soil micromorphology, has multiplied the scales of view into the past and its legacies by reconciling the contingencies of human practices and landscape processes with longer-term cultural and environmental developments. Work by Charly French has been uniquely instrumental in developing theoretical frameworks and practices to address human-environment interactions in dryland landscapes (French 2010a,b). In the Rio Puerco valley of New Mexico, for example, French's intuition about aggradation of fine sands and cumulic organic soil development first revealed the fundamental nexus between fire occurrences, pre-Puebloan and Puebloan occupation, and later channel incision – ultimately resolving a 6000 year-long sequence of socioecological interaction in a dryland (French *et al.* 2009; French 2015, 50–4). French's extraordinary ability to see pedofeatures in the field and landscapes in thin section extended the frames for understanding cultural and environmental developments in the Dhamar highlands of Yemen, too (French 2003, 224–34; 2010b). Here, organic-rich soils occurring over argillic (Bt) horizons showed that thick organic, moist and well-structured soils were available by the mid-Holocene, pushing a few thousand years earlier the potential for human exploitation ahead of the emergence of polities and kingdoms in the Bronze Age. Amongst the key lessons from French's diverse works is the potential of landscape-scale approaches to chart human-environment interactions over time and across space, reaching into the present-day. And it is perhaps regarding settlements that such a landscape-scale approach has made a transformative impact. By looking at settlements in their landscape over the long term, geoarchaeology has taken down that artificial (if not abstract) rural-urban divide to reach into interdependencies and nexus relations and began to ask questions about food and water security, urban resilience, and so much more (French 2019; French *et al.* 2017; 2020).

Sub-Saharan Africa remains somewhat peripheral to geoarchaeological research on dryland environments. Inspired by learning from, and working with Charly French, we initiated geoarchaeological research into the landscape history of Iron Age societies emerging in the drylands of southern Africa. Combining borehole surveys, soil micromorphology, and multi-element chemical analyses, this chapter examines the long-term landscape history of the Mapungubwe culture in the middle Limpopo basin, South Africa.

Southern African drylands and empires

Today, drylands – regions with an Aridity Index of 0.65 or less, following the Nations Convention to Combat Desertification and the United Nations Food and Agriculture Organization (UN Environment Management Group 2011) – account for over seventy per cent of African environments and are projected to expand (Cervigni & Morris 2016; Prăvălie 2016). Southern Africa is home to a special type of dryland: the miombo woodland biome, which today covers sparsely populated regions that are largely considered degraded, and not particularly hospitable for human settlement. Yet, archaeological evidence shows miombo regions have long been settled by human societies, with subsistence practices and state systems emerging as early as the ninth century BC in the Shashe-Limpopo basin of northern South Africa (Fig. 11.1; Huffman 2000; Huffman & Woodborne 2016). Over 1750 km,

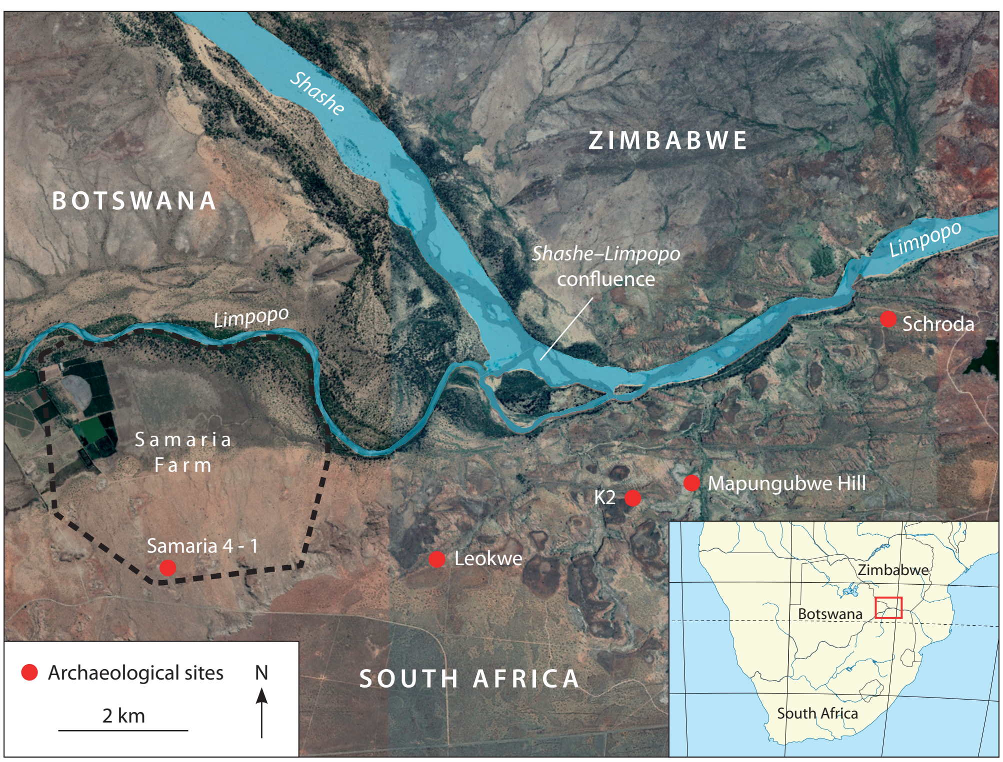

Figure 11.1. *Map of southern Africa, showing the distribution of major archaeological sites in the middle Limpopo valley and Samaria farm (black dotted polygon). Satellite imagery: © CNES/ Airbus, imagery date 12 November 2022 (accessed through Google Earth v9.175). Image: Federica Sulas.*

the Limpopo River straddles the modern national boundaries of South Africa, Botswana, Zimbabwe, and Mozambique. Long before reaching the Indian Ocean, the Shashe-Limpopo confluence feeds an extensive floodplain, which is home today to national and transnational parks, and nature reserves. Among these, the Mapungubwe National Park and UNESCO Cultural Landscape combines significant faunal and floral diversity with equally diverse archaeological and heritage sites, spanning the later prehistory and the Iron Ages (SANParks 2019). All around it, extensive and intensive mining for precious stones and coal, game farming, and agribusinesses have grown out of government-led policies and international investments to develop South Africa's northernmost province. Despite such rich natural and heritage resources, the Limpopo Province remains amongst the poorest regions in southern Africa.

The flourishing of complex Iron Age societies in what is today considered a dry, harsh environment has long been linked to higher rainfall recorded by regional paleoclimatic studies between *c.* AD 900 and 1300, favouring the rise of the Mapungubwe culture (Huffman 2000; Manyanga 2007; Smith *et al*. 2007; Huffman & Woodborne 2021). Subsequent climate deterioration and water shortages might have contributed to the 'collapse' of Mapungubwe, setting the region onto a pathway of aridification and degradation (Tyson & Lindesay 1992; Tyson *et al.* 2000; 2002; Huffman 2000; 2010). While reconciling eastern and southern African climate records and cultural sequences (e.g. Holmgren & Öberg 2006), this narrative of socioecological rise-and-fall lacks site-specific information from the Mapungubwe landscape itself. Macroregional climate sequences and site-specific archaeological studies provide detail on rainfall patterns and settlement dynamics in the Shashe-Limpopo basin (e.g. Huffman & Woodborne 2016; 2021), but how past societies accessed, used, and managed land and water, and how they negotiated changes to these resources, remains contested. Debates have focused on rainfall and the Limpopo River as the only sources of water for the subsistence of people and animals, crop growing, and spiritual services supporting Iron Age developments at Mapungubwe. Floodplain irrigation would have supported small-scale farming, with cattle herding and trade providing the bulk of the Iron Age economy (Huffman 2008). Rainmaking rituals have long been seen as a strategy deployed by ancient Mapungubwe societies to react and respond to droughts. Water pits (or cupules) carved into hard rock outcrops across the middle Limpopo valley have been linked to water storing practices in response to water stress (Schoeman 2009; Huffman 2000; 2010).

Mapungubwe landscapes, ecologies, and cultures

The lowland topography of the Mapungubwe landscape is shaped by the interaction between the Limpopo River and its tributaries, and the discontinuous, underground geologies that have shaped a wide floodplain, sandstone ridges, kopjes (small hills), and small valleys in between. At about 600–620 m above sea level, the Mapungubwe landscape lies over the geological substratum of the Limpopo Mobile Belt – an extensive belt of high-grade metamorphic tectonites trending east-northeast (Mason 1973) and shaping a granite-greenstone terrain with common metamorphic rocks along with aeolian and fluvial sediments (Van Reenen *et al.* 1992; Smit & Van Reenen 1997; Holland & Witthüser 2011). These geological substrata and related geomorphological processes influence hydrologic and groundwater systems. Along the lower regions of the Shashe-Limpopo Rivers, floodplains are intersected by narrow channels where surface and underground aquifer systems drain north of Pafuri eastwards, toward Mozambique (FAO 2004; Busari 2008). Major soil types reported in for this region are Luvisols and Cambisols along the Limpopo River, and Arenosols and Regosols found in the inland parts of the Mapungubwe landscape (Gandiwa *et al.* 2016).

In the Shashe-Limpopo basin, local and regional climatic conditions are influenced by warm advection from the Indian Ocean and cool air from the South Atlantic Ocean, dominant atmospheric high- and low-pressure systems, including the migration of the Inter-Tropical Convergence Zone (ITCZ) (Woodborne *et al.* 2016; Pomposi *et al.* 2018). Oceanic and atmospheric pressure systems are also influenced by the near-decadal appearance of the El Niño–Southern Oscillation (ENSO) (Smith *et al.* 2010; Pomposi et *al.* 2018). Rainfall is highly seasonal and follows a north-south gradient, concentrating during summer season (October–March), while cooler and clear weather conditions appear in winter months (June–August). The regional annual average rainfall of 400-600 mm is characterized by episodic increases and decreases (Ekblom *et al.* 2012; Nxumalo 2020). Annual rainfall in the Mapungubwe landscape ranges between 350–400 mm between November and April (SANParks 2019, 21). According to regional climatic records, the region experiences a mean annual temperature of 20–45 degrees C, with hot summers and mild winters (Tyson & Preston-Whyte 2000; Smith *et al.* 2007; Pomposi *et al*. 2018). Under these semi-arid conditions, a savanna bushveld vegetation is displaced on uneven terrain towards low-lying valleys and changes from dense, undersized bushveld and moderately open tree savannah covering across most of Limpopo and the North

West provinces of South Africa (Ekblom *et al.* 2012; Woodborne *et al.* 2016; Fitchett & Bamford 2017). The vegetation cover is characterized by medium to dense mopani (*Colophospermum mopani*), acacias (*Acacia tortilis*) and other trees (e.g. *Terminalia sericea*). Recent mapping of tree densities has revealed positive correlations between major soil types and tree height, with the tallest trees occurring over Cambisols in the floodplain, whereas short woody plants are common over the Arenosols and Regosols of the inland Mapungubwe landscape (Gandiwa *et al.* 2016).

Regional paleoclimatic data and isotopic studies on archaeological fauna suggest higher rainfall between AD 800–1200, which would have favoured cattle herding, floodplain agriculture and trade expansion supporting early state systems in southern Africa. These emerged in the Mapungubwe landscape from around AD 900. Archaeological studies suggest that the occurrence of 400–500 mm rainfall would have supported farming practices between *c.* AD 1000–1300 (Huffman 2000; Tyson *et al.* 2000; Holmgren *et al.* 2003). Pulses of drier conditions at around AD 1000 and 1100–1200 would have led to the shifting of political centres (or capital sites) over small distances: a first capital settlement at Schroda (AD 900–1000), followed by a second one at K2 (AD 1000–1220), and culminating in the settlement on Mapugubwe Hill (Fig. 11.1; Huffman 2000; Smith *et al.* 2007; 2010).

Further climate deterioration associated with increasing drier conditions and consequent water shortages would have led to the 'collapse' of Mapungubwe in the late thirteenth century AD. New radiocarbon dates and revised ceramic typologies suggest Mapungubwe was abandoned around AD 1320 (Huffman & Woodborne 2021).

Geoarchaeological work

In 2013–5, geoarchaeological field investigations explored the buried landscape sequences within the perimeter of the Mapungubwe National Park and Cultural Landscape (Fig. 11.1). The aim was to begin building a local record of past environmental conditions and land use, and how these related to existing archaeological evidence with a view of revisiting long-held narratives concerning the role of water in the growth and 'collapse' of the Mapungubwe culture. Geoarchaeological research pursued three fundamental questions: What is the nature of local soil and water resources? How did these change over time? How do local landscape sequences relate to the settlement record?

Research combined opportunistic and systematic surveys, test pitting, and sampling for soil chemical and micromorphological analyses to capture different landscape units and repository areas in the middle Limpopo floodplain and valleys within the core ancient Mapungubwe area (Figs 11.2 and 11.3). The selection of survey areas was determined by the presence and nature of archaeological evidence, current environmental settings, and management strategies.

The environmental settings are generally consistent throughout the study area, with gently sloping to flat lands, punctuated by (Karoo) sandstone hills and ridges. In the Limpopo floodplain, the Samaria-Den Staat area was farmed until the late 2000s and has since been managed by South African National Parks but remains inaccessible to the public. Surface archaeological records from this area and, more generally, the eastern sector of the park have been dated to the K2/Mapugubwe period (*c.* AD 1000–1220; Huffman & Hanisch 1987; Huffman 2000; Meyer 2000; 2003; Huffman & Woodborne 2021). In 2012, our first reconnaissance survey recorded a chain of kraal and settlement complexes in this area, distributed along a north–south axis from the higher grounds south of the Samaria Citrus Farm to the Limpopo River. Surface artefact scatters spanning the early K2 period and post-Mapungubwe times (*c.* AD 1000–1400) were found (Sulas *et al.* 2012). Based on these findings, we then conducted a systematic borehole survey and soil sampling over a north-south transect across the Samaria floodplain area (Sulas *et al.* 2013).

In the core Mapungubwe area, small valleys are shaped by sandstone kopjes and a network of seasonal streams and water courses feeding into the Limpopo River (Fig. 11.3). Here, multiple seasons of archaeological excavations have uncovered the settlement history of the ancient Mapungubwe culture, exposing deep stratigraphies of occupation on hilltop locations. These include the main capital centres of Schroda, K2 on Bambandyanalo Hill, and Mapungubwe Hill (Meyer

Table 11.1. *Sites, contexts and samples.*

Area		Profiles	ICPAES	Thin sections
Samaria floodplain	Limpopo River	1 section DS/1	2	3
	Floodplain	11 boreholes GA1–GA11	30	/
Core Mapungubwe Area	Leokwe valley	2 sections LK1 and LK2	5	5
	K2-Bambandyanalo valley	2 section K2/1 and K2/2	5	5

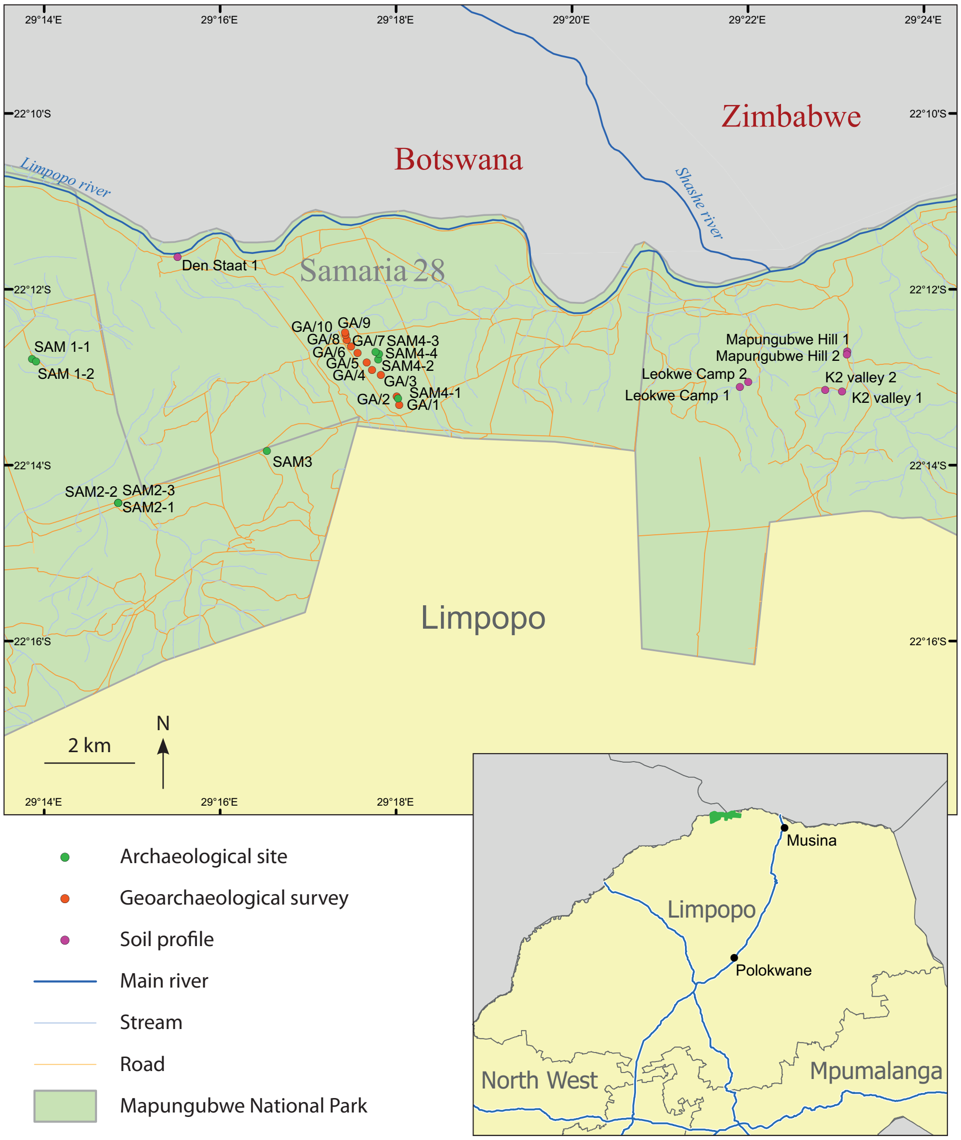

Figure 11.2. *Map of the Shashe-Limpopo basin showing the location of geoarchaeological survey transect and soil profiles discussed in the text. Image: Bongumenzi Nxumalo.*

1998; Huffman 2005). Geoarchaeological fieldwork recorded six soil profiles in the valley bottoms and along the K2 and Leokwe watercourses.

Samples were collected for soil chemical and micromorphological analyses (Table 11.1). Sub-samples (particles of <250 μm; 10-11.5 g) were analysed by ALS Global Minerals for Inductively Coupled Plasma-Atomic Emission Spectrometry (ICPAES) to determine thirty-three elements using four acid digestion (ME-ICP61; see ASL Minerals 2009; 2010). Following low temperature drying (< 60 degrees C) and dry sieving using a 180 μm (Tyler 80) mesh, 0.25 g of material were digested with perchloric, nitric, hydrofluoric and hydrochloric acids. The residues were then topped up with dilute hydrochloric acid and analysed by ICPAES. The results are corrected for spectral interferences. Micromorphological thin sections were manufactured at the McBurney Laboratory for Geoarchaeology, Cambridge (French & Rajkovaca 2015; Rajkovaca in this volume). Thin sections were analysed using petrographic microscopes at different magnifications under plane-polarized light (PPL), cross-polarized light (XPL), and oblique incident light (OIL), and described following international standards for terminology (Bullock *et al.* 1985; Stoops 2003). The identification and interpretation of features in thin section followed guidelines from Stoops *et al.* (2010), Macphail & Goldberg (2018a), Nicosia & Stoops (2017), and relevant literature. In the absence of stratified organic macroremains, we submitted bulk soil samples (n=6) for AMS dating at the Poznán Radiocarbon Laboratory, which yielded either no or modern charcoal. Full geochemical and soil micromorphological data are given in the Appendix to this chapter (Tables A11.1 and A11.2, respectively).

Figure 11.3. *Mapungubwe landscapes. Top: the Limpopo River near the Shashe-Limpopo confluence; bottom: valley between Mapungubwe Hill and Leokwe Camp site. Images: Federica Sulas.*

Characterizing the Mapungubwe landscapes through time

Field investigations detected the presence of two main soil types in the wider study area. A reddish-brown (5YR 4/3–5/3) fine to very find sandy loam, likely a Cambisol originating from the weathering of red (Karoo) sandstone and wind-blown (Kalahari) sands, is present across different landscape units under open vegetation cover on sandstone ridges and sloping terraces in the Samaria floodplain area and the core ancient Mapungubwe area. Under relatively stable conditions, these sands begin to aggrade and undergo incipient soil development, as observed in the profiles discussed below. The second soil type is a dark brown (10YR 3/3) fine sand silty loam, with Fluvisol-like properties, and is found primarily on valley bottoms in the core ancient Mapungubwe area (e.g. Leokwe Camp, LKC2; see below). ICPAES measurements of topsoil samples from both soil types yielded similar concentrations of calcium (Ca 1.8 per cent), copper (Cu 30–37 ppm), iron (Fe 3.3–3.9 per cent), lead (Pb 4–5 ppm), strontium (Sr 251–281 ppm), and zinc (Zn 35–46 ppm) (see Appendix, Table A11.1). Topsoil samples of the reddish-brown sandy loam returned slightly enriched levels of aluminium (Al > 2 per cent), barium (Ba > 400 ppm), chromium (Cr > 400 ppm), potassium (K > 1 per cent), manganese (Mn > 500 ppm), and phosphorus (P > 1000 ppm) than those detected in the dark brown sand silty loam topsoil. The latter yielded slightly enhanced contents of cobalt (Co > 20 per cent), magnesium (Mg > 4 per cent), and nickel (Ni > 200 ppm).

Samaria floodplain soil sequences

Shaped by sandstone ridges and broad, gently sloping terraces leading onto the Limpopo River, the Samaria floodplain offers differential preservation conditions of palaeoenvironmental and archaeological records. This is reflected in the thirteen soil profiles investigated (Table 11.2; Fig. 11.4). By and large, the southern, upslope part of the floodplain displays a thin soil cover of reddish fine to medium sands, resting on bedrock. Profile development appears further downslope and nearby sandstone ridges, where anthropogenic inclusions are sometime observed in subsoil deposits. Along the northern edge of the floodplain, towards the Limpopo River, there is evidence of profile development over aggrading alluvium with a buried, light brown fine sand silty loam that shows incipient soil formation and is characterized by abundant organic matter, microcharcoal and anthropogenic inclusions. In thin section, fragments of limpid clay and iron nodules found in this buried soil point to a stable vegetation cover and well-watered environment with (seasonal) alternation of soil moisture content.

The river channel displays a much deeper history of landscape processes, capturing the pace of occupation, change of the floodplain, and water flow dynamics. At the Samaria Citrus Farm, the Limpopo River incises deeper sections, reaching over 4 m above the current water level. The section investigated (DS/1) shows the overlay of recent, very fine sandy silt alluvium over a deep Ah horizon of a brown sand silty loam. ICPAES data show no significant variation between the alluvium

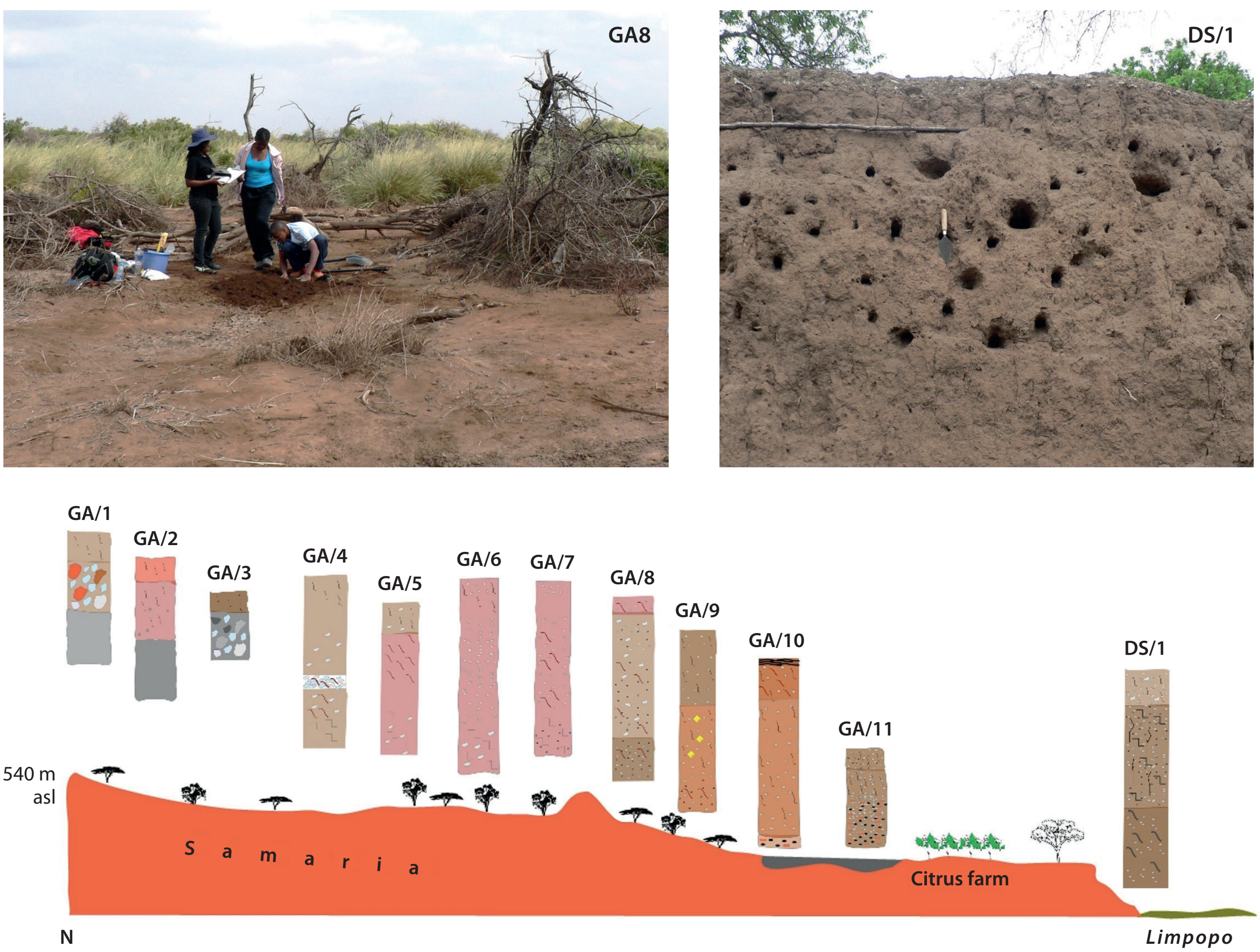

Figure 11.4. *Floodplain profiles. View of testing profile GA8 in the lower part of the floodplain and the Limpopo River section investigated at DS/1. Bottom sketch of soil catena across the geoarchaeological transect, profile logs not to scale. Images: Federica Sulas.*

Table 11.2. *Floodplain profiles: field records and selected ICPAES trends. Full ICPAES results are provided in Table A11.1 in the Appendix to this chapter.*

Profile	cm	Area	Field description	Selected ICPAES
DS/1	400+	South section of the Limpopo River near the Samaria Citrus Farm.	Topsoil: 40 cm-thick, light brown (7YR 3/3) fine to very fine sandy loam. Buried soil: Ah horizon of darker brown, fine sand silty loam with subangular blocky structure at *c*. 150–255 cm depth.	▲ Al, Ba, Ca, Cu, Fe, K, Mn, Na, Zn
GA1	37+	Gently sloping land of an E–W-running sandstone ridge covered by sparse mopane and acacia trees, low shrubs, bushes, short grasses; Iron Age kraal site *c*. 20 m East.	Topsoil: light brown (7YR 2.5/3–7.5YR 4/4) fine sandy loam, rare silt and coarse sand; fresh fine rootlets. Buried deposit: 15 cm-thick gravelly bed of pebbles (90%), few rock fragments (10–15 cm) mixed with topsoil material.	n/a
GA2	50+	Footslope of the same ridge (GA1, common mopane and acacia trees, low shrubs, bushes, and stone-free.	Topsoil: reddish brown (5YR 3/4–4/6) fine sandy loam, coarse sand and rare silt; occasional fine rootlets; granular and loose, and resting on weathering bedrock (slate?).	▼ Ca, Co, Cr, Cu, Fe, K, Mg, Mn, Na, Ni, Sr, Zn
GA3	28+	Same as GA2	Topsoil: light to dark brown (7.5YR 3/4–10YR 5/4), ashy fine sandy loam, common coarse sand, rare silt and few pebbles; occasional fine rootlets; granular and loose, and resting on conglomerate bedrock.	n/a
GA4	54+	Test pit on open, stone-free flatland; sparse mopane and acacia trees, very short grasses. Low density pottery scatter on an area of *c*. 10 m radius from the test pit.	Topsoil: light brown (7.5YR 3/3–5/4) medium to fine sandy loam, common coarse sand and rare quartz grains; granular and loose; covering a *c*. 7 cm-thick gravelly bed of whitish, rounded pebbles (2–5 cm). At *c*. 35 cm depth, the light brown medium to fine sandy loam exhibits poorly developed subangular structure, mineralized root-channels; compact and dry.	▲ Ba, Ca, K, Pb, Sr - ▼ Al
GA5	57+	Test pit on open, stone-free flatland; common mopane and acacia trees, rare short grasses.	Topsoil: as GA4. At *c*. 10 cm depth, a reddish brown (5YR 3/3–4/4) medium to fine sandy loam, common coarse sand, rare silt and fine quartz grains; common very fine rootlets, amorphous organics; loose to granular; crumb to poorly developed subangular blocky over depth.	▲ Ba
GA6	42+	As GA5.	As GA5.	▼ Ca, Co, Cu, Fe, K, Mg, Mn, Na, Ni, Pb, Sr, Zn
GA7	55+	As GA5–6.	As GA5.	▼ Ca, Co, Cu, Fe, Mg, Mn, Na, Ni, Pb, Sr, Zn
GA8	60+	Test pit on gently N-sloping land at the foot of a sandstone ridge; open grassland with mopane and acacia trees at the edge of the dry floodplain (*c*. 10 m away from an artificial pond of the Samaria Citrus Farm).	Topsoil: as GA5–6. At *c*. 5 cm depth, *c*. 40 cm-thick ashy, light brown (7.5YR 3/3–5/3) very fine sand silty loam, rare coarse sand and pebbles, rare microcharcoal; loose; diffuse boundary. This covers an ashy brown (7.5YR 3/2–5/4) very fine sandy loam similar to the one recorded at *c*. 5 cm depth.	▲ P - ▼ Al, Ba, Ca, Co, Cr, Cu, Fe, Mg, Mn, Na, Ni, Sr, Zn
GA9	54+	Test pit on gently N-sloping land with high grasses, sparse acacia trees, shrubs, bushes and common *Tribulus* sp. at the margin of the Citrus Farm's pond and next to Samaria Road bridge.	Topsoil: darkish brown (7.5YR 3/2–4/4) fine to medium sandy loam, some silt and clay, rare coarse sand and pebbles; rare amorphous organics, fine fresh roots, microcharcoal, potsherds (Iron Age?); loose and granular; diffuse boundary. At *c*. 20 cm depth, dark to reddish brown (7.5YR 2.5/3–5YR 4/4) very fine sand silty loam, rare coarse sand; fine fresh rootlets, microcharcoal and rare potsherds (Iron Age?); crumb to poorly developed subangular blocky structure.	▲ Pb - ▼ Ba, Ca, Co, Cr, Cu, Fe, Mg, Mn, Na, Ni, P, Sr, Zn
GA10	55+	Test pit in the dry bottom of the Samaria pond, next to Samaria road bridge. Flatland with common high reeds and dead tree trunks.	Topsoil: darkish brown (7.5YR 3/2–4/4) very fine sand clayey loam, rare coarse sand and silt; common plant residues; crumb structure, sharp boundary. At *c*. 7 cm depth, over 40 cm-thick dark reddish brown (7.5YR 3/3–5YR 3/3) very fine sand silty loam, rare medium sand and clay; fine fresh rootlets; moist and crumb structure; black and orange mottling at the bottom.	▼ Ca, Co, Cr, Cu, Fe, Mg, Mn, Na, Ni, P, Sr, Zn
GA11	34+	Test pit in margin area between acacia tree cover and the Citrus Farm's pond (dry) with high reeds.	Topsoil: dark brown (10YR 3/2–7.5YR 2.5/2) clayey loam, very fine sand and rare silt; common plant material, amorphous organics, waterlogged and increasing with depth; moist and crumb structure; black and orange mottling at the bottom.	▲ Al - ▼ Co, Cr, Mg, Ni, Sr

and the buried soil; both yielded distinctive enrichment in nutrients, salts, and metal elements (e.g. Al, Ba, Ca, Cu, K, Mn, P, S, Sr, Zn) against the entire sample set.

At about 40 cm below the ground surface, an aggrading buried soil consists of a light brown, medium to fine sand silty loam. The upper horizon bears signs of incipient soil development and rests over a moderately developed Ah horizon with a subangular, blocky structure (150–255 cm below the surface). In thin section, this horizon shows very fine sand material and weak iron-impregnation. The vughy porosity and common channel voids reflect a high degree of bioturbation. Organic and biogenic components include microcharcoal, shell and bone fragments, pollen grains, phytoliths, and calcite features. Amongst the pedofeatures observed, wood ash is seen in channels and vughs, and iron-rich clay coatings, dusty clay coatings, and rare crust fragments are present in the groundmass (Fig. 11.5a,b). The crust fragments show microlaminations with very dense, homogenized, and strongly iron-impregnated internal micromass of amorphous organic matter, occasional laminated clay, grass (elongate) phytoliths and microcharcoal.

At the top of the sequence, the *c.* 40 cm thick topsoil (and subsoil) is associated with modern land uses. The studied thin section exhibits a moderately sorted, very fine sand silty loam with some clay, strong iron-impregnation, amorphous iron, plant pseudomorphs, and rare charcoal. Porosity is vughy with rare channels. Distinctive pedofeatures include very common yellow dusty clay coatings, red iron-rich clay (Fig. 11.5c), and very rare crust fragments. The latter exhibit a very dense micromass of amorphous organic matter and iron, clay, and little silt with common microcharcoal, organic punctuations, and grass (non-smooth elongate and bulliform) phytoliths (Fig. 11.5d).

In the Samaria floodplain, boreholes revealed a complex stratigraphic sequence (Fig. 11.4). The southern, higher sector shows very thin topsoils of reddish-brown (5YR 3/3–4/4), fine-textured sandy material, which rests either on gravelly beds or bedrock (e.g. profiles GA1–3). Further into the floodplain and towards the Limpopo River, the topsoil thickens and aggrades over depth (e.g. profiles GA4–7). A different soil cover is found on the floodplain edge where a darkish brown (7.5YR 3/2–4/4) fine sand silty loam (e.g. profiles GA9–11) exhibits horizon development with profiles reaching up to 60 cm deep. The transition between the reddish brown fine sandy loam and the darkish brown fine sand silty loam is illustrated in profile GA8, where the reddish and sandy topsoil is resting on a buried dark brown fine sand silty loam. Whilst micromorphological data from these profiles has not been produced yet, ICPAES analysis shows alternating sequences of high and low element concentrations (Table 11.2). For example, phosphorus, manganese, chromium, and iron contents appear to decrease following topography: from higher grounds (profiles GA1–3) to the central regions (profiles GA 4–7); those situated further towards the Limpopo River (profiles GA 9–11), samples are characterized by a less coherent chemical distribution (see Nxumalo 2019, 72–3).

Valley soil sequences

In the core Mapungubwe area, four soil profiles were recorded and sampled along small watercourses draining the valleys of Leokwe and K2-Bambandyanalo. (Table 11.3; Fig. 11.6).

At Leokwe, two sections (LKC1 and LKC2) were investigated along a watercourse that drains the northeastern margin of a sizable valley delimited by sandstone ridges and hills with steep sides, and almost entirely denuded of soil cover. The sections capture a sequence of soil development, separated by an episode of truncation. ICPAES results yielded elemental concentrations generally in range with those detected in reference topsoil samples but for a peak in iron detected in the buried soil found at *c.* 30 cm below the surface. This buried dark brown (10YR 3/3) fine sand silty loam shows relatively high clay content, moderately developed subangular blocky structure, and high degree of bioturbation. The organic fraction contains abundant amorphous matter, excremental matter (including pellets), microcharcoal, rare shell fragments, and fungal sclerotia. In thin section, distinctive pedofeatures include limpid clay coatings and fragments, and rare rounded, coarse aggregates characterized by denser fine groundmass, few quartz grains, and a high degree of amorphous organic/iron impregnation, possibly including charcoal. These aggregates occasionally incorporate fragments of microlaminated, limpid clay coatings.

The lower topsoil (10–20cm below the surface) shows light brown (7.5YR 4/3), poorly sorted material, with rare angular coarse sands and pebbles, and subrounded medium to fine sands. In thin section, the groundmass is calcitic with moderate vughy porosity. Organic matter is mostly amorphous, but for a few fresh rootlets, very fine charcoal, microcharcoal and rare phytoliths. Pedofeatures include a few fine typic iron nodules, weak to moderate iron-manganese impregnation, yellow to light reddish, iron-rich (dusty) clay coatings, bright red iron-rich, dusty clay coatings and fragments, and possibly wood ash domains (calcium carbonate crystals mixed with amorphous organic matter and iron, and phytoliths). Yellowish, subrounded aggregates of organic-rich material are likely of excremental origin.

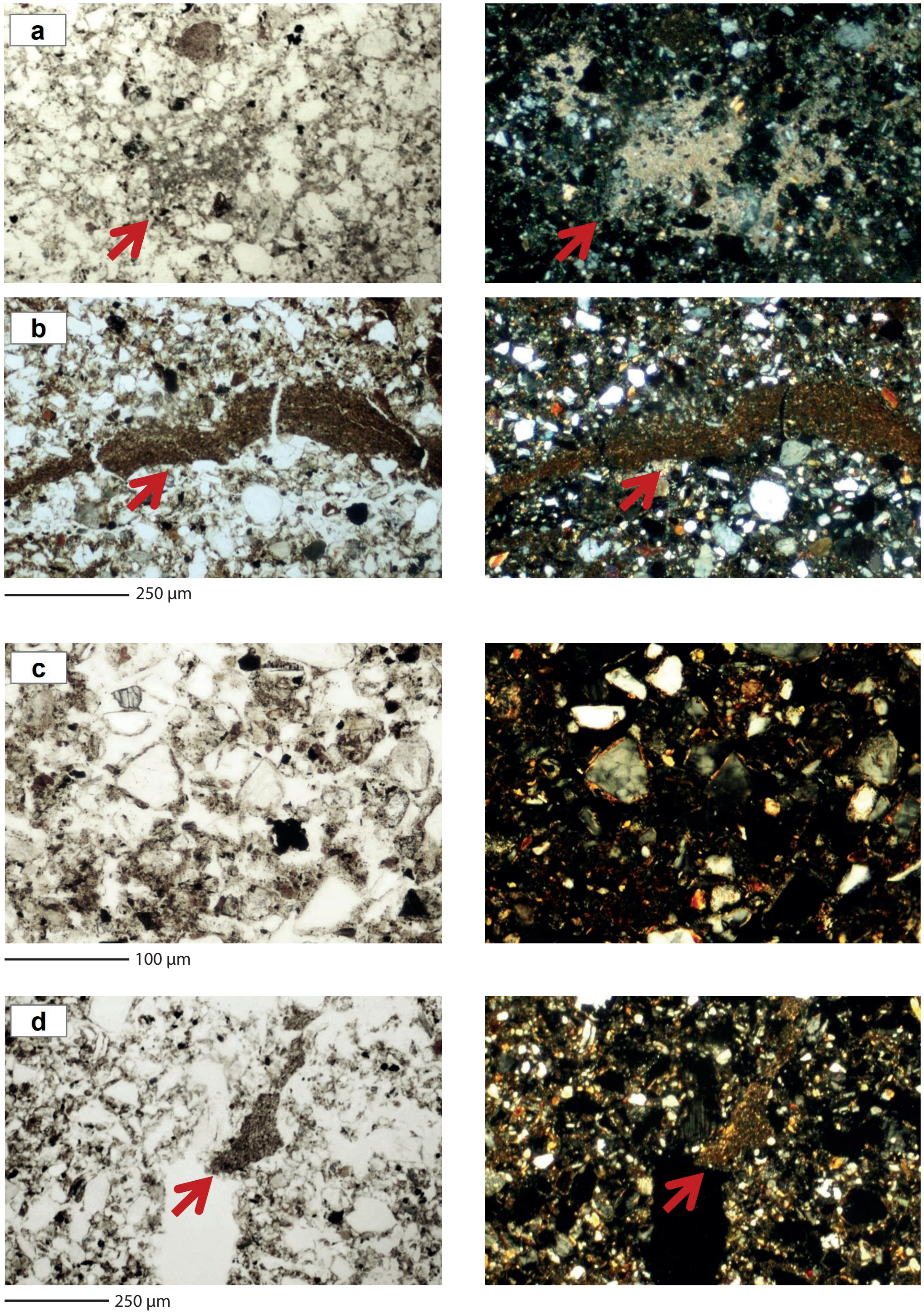

Figure 11.5. *Micromorphology of floodplain soils. Microphotographs in PPL (left) and XPL (right): (a) a calcium carbonate infilling (wood ash) and microcharcoal (red arrow), and (b) crust fragment (red arrow) at 152–160 cm below surface; (c) dusty clay, and (d) crust fragment (red arrow) at 30–40 cm below surface. All from the Limpopo River section, DS/1; micromorphological descriptions are provided in Table A11.2 in this Appendix to this chapter. Images: Federica Sulas.*

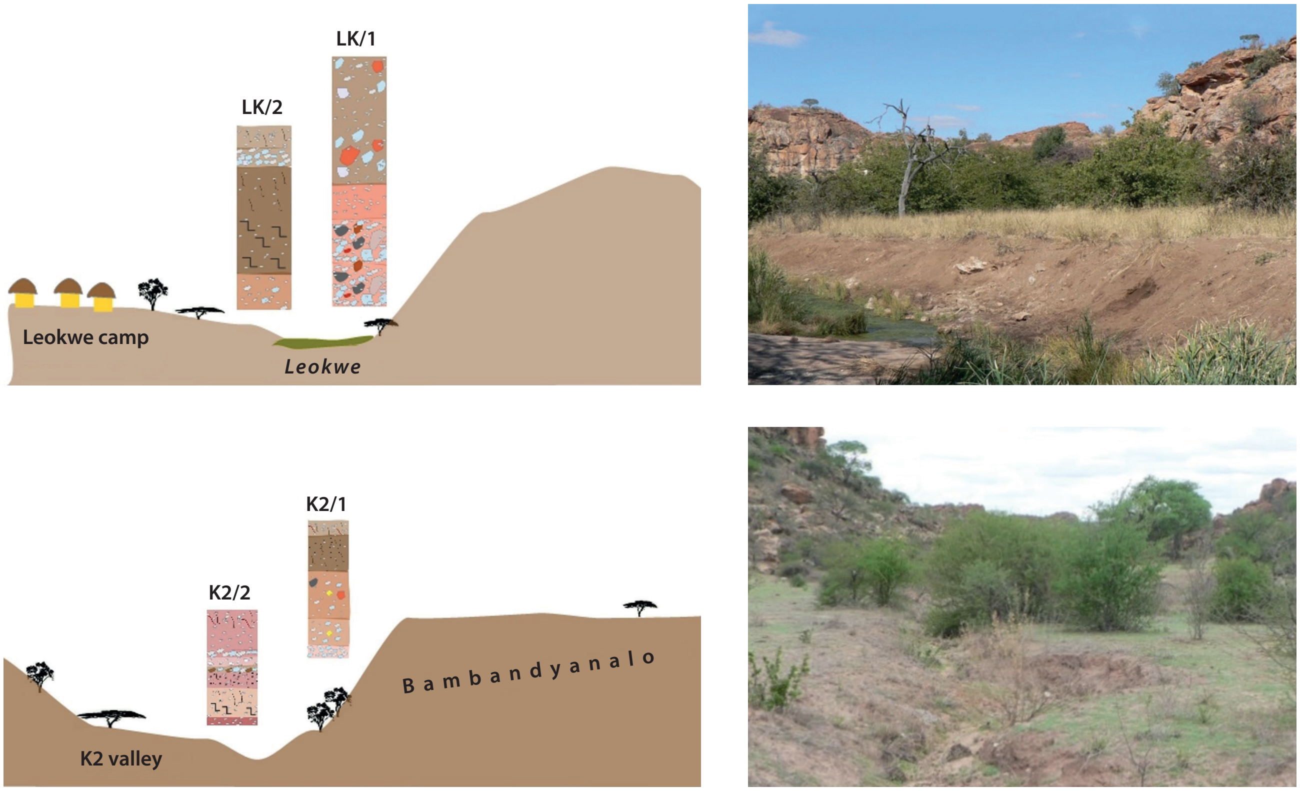

Figure 11.6. *Valley profiles. Top: sketch of soil catena across the Leokwe valley and view of Leokwe streambed; bottom: sketch of soil catena across K2 valley and view of streambed; profile logs not to scale. Images: Federica Sulas.*

Table 11.3. *Valley profiles: field records and selected ICPAES trends. Full ICPAES results are provided in Table A11.1 in the Appendix to this chapter.*

Profile	cm	Area	Field description	Selected ICPAES
LK/1	140+	NE section of Leokwe stream draining a narrow valley running NE–SW and delimited by steep-sided sandstone hills	Topsoil: reddish brown (7.5YR 6/6) fine sand silty loam, common sandstone and granitic (?) tabular rocks on surface; common amorphous organics; loose and dry. At *c.* 35 cm depth, increased content of pebbles (2–5 cm), possibly indicating a standstill horizon. At *c.* 60 cm depth, a reddish brown (5YR 4/4) fine to medium sand is found. At *c.* 80 cm, poorly sorted, gravelly bed with rounded pebbles resting over streambed.	▲ Fe
LK/2	114+	S section of Leokwe stream along the NE sector of a valley delimited to the NE by a steep-sided, exposed sandstone hill and to the SW by gently sloping land with mopane trees and shrubs.	Topsoil: light brown (7.5YR 4/3) fine sand silty loam, common rooting and coarse sand. At *c.* 15 cm depth, gravel bed. Buried soil: at *c.* 30 cm depth, over 40 cm-thick dark brown (10YR 3/3) fine sand silty loam, rare coarse sand; common very fine rootlets; moist and crumbly, with increasing clay and poorly developed subangular blocky structure over depth; moist and compact.	not available
K2/1	110+	S section of dry, EW-running stream/gully on the narrow valley between Bambandyanalo Hill and a sandstone hill, leading onto K2 valley; acacias, low shrubs and grasses.	Topsoil: light brown (7.5YR 5/4) very fine sandy loam, common medium and fine rootlets; loose and dry. Buried soil: at *c.* 40 cm depth, pink-light brown (7.5YR 6/3) fine sandy loam, rare tabular rocks (2–5 cm), potsherds and bone fragments. At *c.* 80 cm depth, rubble deposit with potsherds. At *c.* 100 cm depth, gravelly bed resting on streambed.	▼ Co, Cr, Cu, Fe, Mg. Mn, Ni, P, S, Zn
K2/2	28+	As K2/1, section recorded further upstream adjacent to the ancient (Iron Age) settlement mound of K1.	Topsoil: reddish light brown (5YR 5/3) fine sandy loam, common coarse and medium sand; loose and dry. At *c.* 20 cm depth, fine gravelly bed. Buried soil: at *c.* 23 cm depth, a *c.* 40 cm-thick reddish brown (5YR 6/1) fine sand silty loam; slightly ashy, microcharcoal, increasing clay and subangular blocky structure over depth; interrupted by a 2 cm-thick standstill horizon at *c.* 28 cm depth. At *c.* 75 cm depth, dark pinkish brown (5YR 4/4) fine sandy loam, coarse sand; moist and compact.	▲ Al, K, Pb - ▼ Ca, Co, Cr, Cu, Fe, Mg, Mn, Ni, Sr, Zn

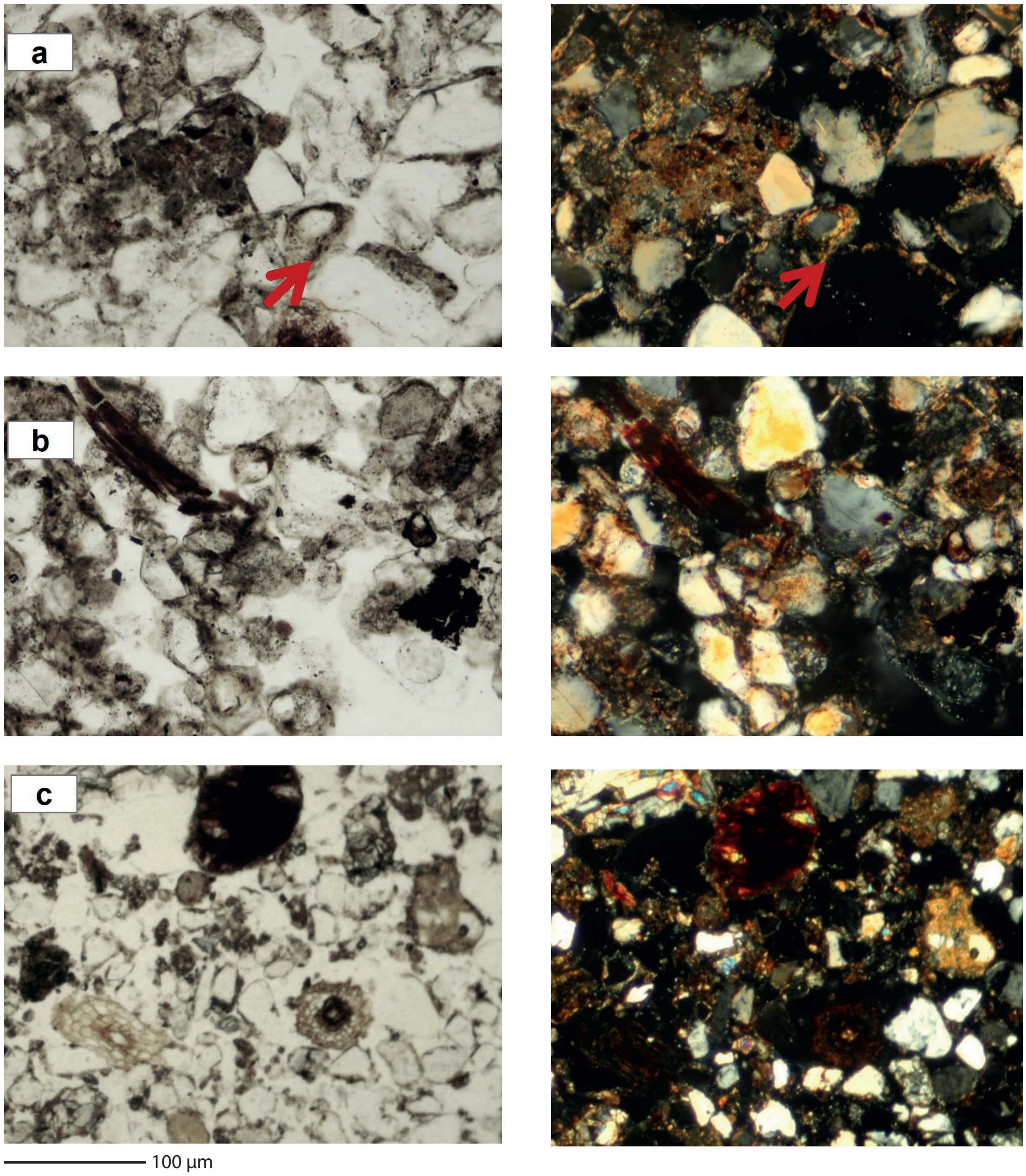

Figure 11.7. *Micromorphology of valley soils. Microphotographs in PPL (left) and XPL (right): (a) wood ash and clay coating (red arrow), and (b) charcoal-rich domain at K2/2, 74–86 cm below surface; (c) plant (root) residues and iron nodule from Leokwe, LK/2 30–40 cm. Micromorphological descriptions are provided in Table A11.2 in the Appendix to this chapter. Images: Federica Sulas.*

In summary, the sequence from Leokwe shows a 20 cm-thick topsoil of light brown fine sandy loam, primarily deriving from alluvial material. This is sitting on about a 5 cm-thick coarse gravelly bed that covers a buried dark brown very fine sandy silty loam (30–100 cm) with possibly two distinct horizons. The upper deposit (30–40 cm thick) is rich in organics and truncated, likely reflecting a lower Ah horizon. The lower one (40–100cm) shows a distinctively clay and iron-rich (Bt/Bs) horizon.

To the east of Leokwe, the K2-Bambandyanalo valley was home to the earliest permanent settlement emerging in the Mapungubwe landscape, as indicated above. Here, geoarchaeological work investigated two sections from a dry watercourse draining the southern foothill of Bambandyanalo Hill: one section was recorded at the foot of the hill (K2/1), and a second one (K2/2) about 50 m further downstream immediately south of the eastern midden (or K1).

ICPAES results show no distinctive variability over depth either across sections, but generally depleted concentrations of metallic elements, plant nutrients, and some salts (Co, Cr, Cu, Fe, Mg. Mn, Ni, P, S, Zn). Enriched levels of aluminium, potassium and lead were found only in section K2/2.

The two sections, about a metre high, present a more complicated stratigraphy than the ones encountered so far. By and large, the sequence consists of a reddish-brown (5YR 5.3), fine sand silty loam aggrading over depth, interspersed with two fine gravelly beds. At about 40 cm depth, there is evidence of incipient subangular blocky structure development.

Toward the base of the sequence, a reddish-brown, very fine sand clayey loam lies on the weathering bedrock (80–100 cm). The upper 10 cm exhibit a poorly developed structure with amorphous organic and excremental matter, and common micro-charcoal (Fig. 11.7a,b). Occasionally, fungal spores and grass phytoliths (trichome, elongate, bulliform), burnt bone fragments, and potsherds are also seen. The pedofeatures include common iron typic nodules.

At 32–44 cm depth, the same reddish brown fine sandy silt loam shows little clay and abundant organic matter, and a high degree of bioturbation with dominant complex packing voids and channels (Fig. 11.7c). Organic matter is mainly amorphous, including common excremental matter, rare fresh roots, tabular, fine charcoal. The aggradation of this light brown sandy silt loam is interrupted by two short-period standstills, indicated by two bands (2 cm thick) of fine gravels cemented by coarse sand and silt at 20 cm and 28 cm depth.

The material from 10–20 cm below the ground surface is consistent with one observed at the top of the Leokwe sequence: a moderately sorted, light brown (5YR 5/3) medium to fine sandy silt loam with a crumb biostructure. The high degree of bioturbation is responsible for wide channels and coarse to fine vughs. The b-fabric is crystallitic to stipple speckled around grains. The organic content is dominated by amorphous and iron-replaced matter, with common very fine, tabular charcoal and some grass phytoliths. Rare (fresh?) bone fragments are also seen. Distinctive pedofeatures include dusty clay coatings, and medium-fine size round aggregates of red clay, very fine sand and amorphous organics; iron typic nodules, rare calcite nodules and microsparitic intergrowth within voids.

In summary, the sequence from K2 shows two standstill levels in the thin gravelly beds just beneath the topsoil. These are separated by a 5 cm-thick deposit of reddish-brown fine sand and silt, possibly related to aggrading alluvial material. Next, there are about 40 cm of largely the same fine alluvial material with increasing clay content and structuring down the profile, resembling a lower Ah horizon. Significantly, calcite features are only observed in the upper level, whereas the lower deposits exhibit higher organic matter contents and anthropogenic inclusions, as well as the clay features seen in the samples from Leokwe.

Building local landscape sequences for Mapungubwe

Geoarchaeological investigations revealed the presence of two main soil/sediment types in the greater Mapungubwe landscape. A reddish-brown fine to very fine sandy loam and a dark brown fine sand silty loam. The most common type is a reddish-brown, fine to very fine sandy loam that originated from the weathering of red (Karoo) sandstone and incorporates wind-blown (Kalahari) sands. Under relatively stable conditions, these sands began to aggrade and undergo incipient structure development, as observed for example in the K2-Bambandyanalo sections. The second type of soil is a dark brown fine sand silty loam that is found in the valley bottoms such as at Leokwe and the Samaria floodplain area. The silt and clay content and the darker colour point to organic-rich material, intense biological activity and continuous reworking leading to profile development.

At the edge of the floodplain, the Limpopo River section consists essentially of fine and nutrient-rich alluvial material, which from about 30 cm below the ground begins aggrading with the reworking of organic (oxidized) and soil material. Further down the profile, at about 150 cm, a moderately developed, fine-textured silty clay loam seems also a result of slow aggradation of fine alluvia. Rich in organic matter – some not yet fully oxidized – this buried soil displays a high degree of bioturbation, calcium carbonate features, and relict fragments of other horizons. The porosity points to wet and dry cycles (seasonal waterlogging) and bioturbation, but iron-manganese features do not seem to reflect abrupt changes in soil moisture. Significantly, there are two key pedofeatures that recur throughout the profile: organic and iron-rich crust fragments and iron-rich dusty clay. The river section illustrates a prolonged period of profile development on the riverbank over secondary, alluvial material. The fine textured and well sorted alluvium from 40 cm below the surface reflects low-energy depositional processes and – considering the essentially flat nature of the surrounding landscape – is likely the result of slow, overbank flooding into the wider Limpopo plain under mild climatic conditions. Over time, this nutrient-rich alluvium would favour vegetation growth and biological activity, in turn sustaining soil structure and profile development, which in this river section reaches well over 250 cm below the surface. Perhaps the crust fragments seen in the thin section might have originated from a surface not too dissimilar from the one we find today in the floodplain: developed on a gently sloping to flat land with open miombo vegetation and dotted by sandstone outcrops and ashy circular patches from (Iron Age) kraal sites.

Further away from the river, small valleys are protected by sandstone ridges and kopjes, and watered by a network of (now) seasonal watercourses, feeding into the Limpopo. At Leokwe, the buried (and truncated) dark brown fine sand silty soil reflects a vegetated and stable landscape, rather different from the almost denuded one that we see today. These small valley bottoms might well have provided ecological niches for farming on land enriched by colluvial input from the sandstone hillsides and alluvium from the small streams. The sequences recorded in the K2 area are indicative of a rather active landscape with alternating periods of profile development and localized disruption.

Key questions remain about the timing and triggers of landscape disruption, as captured in the valley sequences. As mentioned earlier, the climate sequence, built using (macro-)regional palaeorainfall data and local isotopic signatures (Smith *et al*. 2010; Woodborne *et al.* 2016), starts with dryland conditions – rainfall below 500 mm, similar to the present-day – around the mid-tenth to the mid-eleventh centuries AD, that are followed by a period of increased rainfall sustaining the emergence of the first capital at K2 and associated floodplain agriculture until about the early thirteenth century AD. A few decades later, dryland conditions would appear to resume, arguably playing a role in the abandonment of K2 and the establishment of a new capital on Mapungubwe Hill by the mid-thirteenth century AD. The latter would have thrived and expanded under wetter conditions and higher temperatures until about the mid-fifteenth century AD, when Mapungubwe was abandoned.

The geoarchaeological survey records indicate alternating sequences of profile development and regional disturbances, but some soil horizons maintain their original structure. By and large, the general sequence changes from compact towards very fine alluvial soil deposits across the upper and lower middle Limpopo valley, a trend that can be associated with clastic sedimentation and channel infilling as a result of past hydrological inundation (Nxumalo 2020). Enhanced phosphorus levels in buried soils might be linked to the Iron Age and post-Iron Age occupation in Mapungubwe (Nxumalo 2019; 2020; see also Thabeng *et al.* 2019; 2020). Enhanced levels of phosphorus (e.g. 300–1900 ppm) in archaeological sites have been linked past human habitation and activities (e.g. Courty *et al.* 1994; Gahoonia *et al*. 1994; Holliday & Gartner 2007). Phosphorus intakes by biotic components serve as useful indicators of soil moisture (French 2017a). The soil elemental signatures suggest that the Shashe-Limpopo basin might well have offered favourable plant growing conditions and pan sediments as sources of moisture by which humans exploited landscapes for shelter, water and socio-economic development. These conditions would have also been influenced by the role played by regional climatic conditions.

Discussion and conclusions

Although geoarchaeological work has just started to investigate local landscape histories across the Shashe-Limpopo basin, the first local soil sequences presented here seem to support prolonged human settlement and bear no evidence of major changes in the vegetation structure. Within this general trend, there is evidence of localized erosion and profile truncation in the valley sequences. In the lower sector of the floodplain, thick buried soil deposits are consistent with prolonged aggrading of rich alluvial sediments, human settlement, and an open grassland vegetation cover. At a regional scale, this scenario resonates with evidence for prolonged settlement where 'abandonment' was previously modelled, for example, in contemporary settlement areas of eastern Botswana (Denbow *et al*. 2008; Forssman 2020). A persistence of open grassland vegetation has also been recorded in the southern Limpopo basin (Ekblom *et al.* 2012). At a local scale, the new geoarchaeological records capture important facets of landscape evolution and land-water-settlement nexus relations over time. These have implications for debates around reconstructing a cultural and environmental sequence for the southern African Iron Age. Mindful of the new geoarchaeological record, we need to carefully focus on the role played by people on local landscape and regional environmental processes. The limited availability of experimental and comparative datasets in geoarchaeological inquiries across the southern African Iron Age remains a major challenge. For example, soil surfaces that are no longer in their original position are difficult to examine because they might well have similar macro- and micro-structural features, not necessarily derived from the same processes (French 2003; 2009; Macphail & Goldberg 2018a). This is likely to result in stratigraphic inconsistencies.

Inspired by Charly French's research, landscape-scale geoarchaeological approaches are best suited to chart human–environment interactions at multiple spatiotemporal scales, tracing legacies into the present-day. And it is with concern to settlement areas that such a landscape-scale approach can have a transformative impact. By looking at settlements and cities in their long-term landscapes, geoarchaeological research, as also shown by French (2003; 2010a), has unique potential to expose the strengths and fragilities of drylands, capturing the space and pace of multiscale processes, and disentangling the web of interactions between regional and local factors. In the Mapungubwe landscape, the humble soil bears new evidence of a prolonged dryland-settlement relationship that has weathered changing climate and political organizations for over a thousand of years.

Acknowledgements

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Inspired geoarchaeologies

Geoarchaeological research captures dimensions of the past at an unprecedented level of detail and multiple spatial and temporal scales. The record of the past held by soils and sediments is an archive for past environments, climate change, resource use, settlement lifeways, and societal development and resilience over time. When the McDonald Institute was established at Cambridge, geoarchaeology was one of the priority fields for a new research and teaching environment. An opportunity to develop the legacy of Charles McBurney was bestowed upon Charles French, whose 'geoarchaeology in action' approach has had an enormous impact in advancing knowledge, principles and practices across academic, teaching and professional sectors. Many journeys that began at Cambridge have since proliferated into dozens of inspired geoarchaeologies worldwide. This volume presents research and reflection from across the globe by colleagues in tribute to Charly, under whose leadership the Charles McBurney Laboratory became a beacon of geoarchaeology.

Editors:
Federica Sulas is a senior research associate at the McDonald Institute for Archaeological Research, University of Cambridge. Her background is in oriental studies and African archaeology (BA Hons, Naples) and geoarchaeology (MPhil & PhD, University of Cambridge). Her main research interests are in landscape historical ecologies and water–food security.
Helen Lewis is an associate professor at University College Dublin School of Archaeology. Her background is in archaeology and anthropology (BA, University of Toronto), environmental archaeology (MSc, University of Sheffield) and archaeological soil micromorphology (PhD, University of Cambridge). She mostly works today on cave sites in Southeast Asia, but she still loves northwest European Neolithic and Bronze Age monuments and landscapes, and ancient agricultural soils.
Manuel Arroyo-Kalin is Associate Professor of Geoarchaeology at the Institute of Archaeology, UCL. He is interested in the Anthropocene, human niche construction and historical ecology, and uses earth science methods, including soil micromorphological analysis, to study past anthropic landscape modification and anthropogenic soil formation. His main research focus is the pre-Colonial human landscape history of tropical lowland South America, particularly the Amazon basin, where he is engaged in the long-term comparative study of Amazonian dark earths.

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