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By Charles French, Chris O. Hunt, Reuben Grima, Rowan McLaughlin, Simon Stoddart & Caroline Malone

Volume 1 of Fragility and Sustainability – Studies on Early Malta, the ERC-funded *FRAGSUS Project*

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With contributions by
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On the cover: *View towards Nadur lighthouse and Għajnsielem church with the Gozo Channel to Malta beyond, from In-Nuffara (Caroline Malone).*

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Preface and dedication

Caroline Malone

The *FRAGSUS Project* emerged as the direct result of an invitation to undertake new archaeological fieldwork in Malta in 1985. Anthony Bonanno of the University of Malta organized a conference on 'The Mother Goddess of the Mediterranean' in which Colin Renfrew was a participant. The discussions that resulted prompted an invitation that made its way to David Trump (Tutor in Continuing Education, Cambridge University), Caroline Malone (then Curator of the Avebury Keiller Museum) and Simon Stoddart (then a post-graduate researcher in Cambridge). We eagerly took up the invitation to devise a new collaborative, scientifically based programme of research on prehistoric Malta.

What resulted was the original Cambridge Gozo Project (1987–94) and the excavations of the Xagħra Brochtorff Circle and the Għajnsielem Road Neolithic house. Both those sites had been found by local antiquarian, Joseph Attard-Tabone, a long-established figure in the island for his work on conservation and site identification.

As this and the two other volumes in this series report, the original Cambridge Gozo Project was the germ of a rich and fruitful academic collaboration that has had international impact, and has influenced successive generations of young archaeologists in Malta and beyond.

As the Principal Investigator of the *FRAGSUS Project*, on behalf of the very extensive *FRAGSUS* team I want to dedicate this the first volume of the series to the enlightened scholars who set up this now 35 year-long collaboration of prehistoric inquiry with our heartfelt thanks for their role in our studies.

We dedicate this volume to:

Joseph Attard Tabone
Professor Anthony Bonanno
Professor Lord Colin Renfrew

and offer our profound thanks for their continuing role in promoting the prehistory of Malta.

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For Chapter 2, we extend warm thanks to the staff of the ^{14}CHRONO centre at QUB, especially Stephen Hoper, Jim McDonald, Michelle Thompson and Ron Reimer, all of whom took a keen interest in the *FRAGSUS Project*. The success of the *FRAGSUS Project* in general and the radiocarbon dating exercise has depended on their work. We thank the Physical Geography Laboratory staff at the School of Geography, University College Dublin, for the use of their ITRAX XRF core scanner. In particular, we would like to thank Dr Steve McCarron, Department of Geography, National University of Ireland, Maynooth and Dr Jonathan Turner, Department of Geography, National University of Ireland, University College, Dublin. We thank Prof. Patrick Schembri for sourcing and collecting the *Acanthocardia* samples from the Natural Museum of Natural History. Sean Pyne O'Donnell thanks Dr Chris Hayward at the Tephrochronology Analytical Unit (TAU), University of Edinburgh, for help and advice during microprobe work. Dr Maxine Anastasi, Department of Classics and Archaeology, University of Malta, helped identify the pottery from the settlement cores. Dr Frank Carroll helped show us the way forward; but sadly is no longer with us. Chris Hunt, Rory Flood, Michell Farrell, Sean Pyne O'Donnell and Mevrick Spiteri were the coring team. They were helped by Vincent Van Walt, who provided technical assistance. Al Ruffell and John Meneely did geophysical evaluation and GRP location of the cores. During fieldwork, Tim Kinnaird and Charles French were assisted by Sean Taylor, Jeremy Bennett and Simon Stoddart. We are grateful to the Superintendence of Cultural Heritage, Malta and Heritage Malta for permission to undertake the analyses and much practical assistance.

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For Chapter 6, Reuben Grima wrote the first draft of this contribution, receiving comments and additions from the other authors.

For Chapter 7, Simon Stoddart wrote the first draft of this contribution, receiving comments and additions from the other authors.

For Chapter 9, we thank Sharlo Camilleri for providing us with a copy of the GIS data produced by the MALSIS (MALtese Soil Information System) project. We are grateful to Prof. Saviour Formosa and Prof. Timmy Gambin, both of the University of Malta, who facilitated the donation of LiDAR data, together with computer facilities, as part of the European project ERDF156 *Developing National Environmental Monitoring Infrastructure and Capacity*, from the former Malta

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Firstly, the FRAGSUS Project is the result of a very generous research grant from the European Research Council (Advanced Grant no' 323727), without which this and its two partner volumes and the research undertaken could not have taken place. We heartily thank the ERC for its award and the many administrators in Brussels who monitored our use of the grant. The research team also wants to record our indebtedness to the administrators of the grant within our own institutions, since this work required detailed and dedicated attention. In particular we thank Rory Jordan in the Research Support Office, Stephen Hoper and Jim McDonald – CHRONO lab, and Martin Stroud (Queen's University Belfast), Laura Cousens (Cambridge University), Glen Farrugia and Cora Magri (University of Malta), the Curatorial, Finance and Designs & Exhibitions Departments in Heritage Malta and Stephen Borg at the Superintendence of Cultural Heritage. Finally, we thank Fr. Joe Inguanez (Emeritus Head of Department, Department of Sociology, University of Malta) for offering us the *leitmotif* of this volume while a visiting scholar in Magdalene College, Cambridge: '*Mingħajr art u ħamrija, m'hemmx sinjorija*' translating as 'without land and soil, there is no wealth'.

Foreword

Anthony Pace

Sustainability, as applied in archaeological research and heritage management, provides a useful perspective for understanding the past as well as the modern conditions of archaeological sites themselves. As often happens in archaeological thought, the idea of sustainability was borrowed from other areas of concern, particularly from the modern construct of development and its bearing on the environment and resource exploitation. The term sustainability entered common usage as a result of the unstoppable surge in resource exploitation, economic development, demographic growth and the human impacts on the environment that has gripped the World since 1500. Irrespective of scale and technology, most human activity of an economic nature has not spared resources from impacts, transformations or loss irrespective of historical and geographic contexts. Theories of sustainability may provide new narratives on the archaeology of Malta and Gozo, but they are equally important and of central relevance to contemporary issues of cultural heritage conservation and care. Though the archaeological resources of the Maltese islands can throw light on the past, one has to recognize that such resources are limited, finite and non-renewable. The sense of urgency with which these resources have to be identified, listed, studied, archived and valued is akin to that same urgency with which objects of value and all fragile forms of natural and cultural resources require constant stewardship and protection. The idea of sustainability therefore, follows a common thread across millennia.

It is all the more reason why cultural resource management requires particular attention through research, valorization and protection. The *FRAGSUS Project* (Fragility and sustainability in small island environments: adaptation, cultural change and collapse in prehistory) was intended to further explore and enhance existing knowledge on the prehistory of Malta and Gozo. The objective of the project as designed by the participating institutional partners and scholars, was to explore untapped field resources and archived archaeological material from a number of sites and their landscape to answer questions that could be approached with new techniques and methods. The results of the *FRAGSUS Project* will serve to advance our knowledge of certain areas of Maltese prehistory and to better contextualize the archipelago's importance as a model for understanding island archaeology in the central Mediterranean. The work that has been invested in *FRAGSUS* lays the foundation for future research.

Malta and Gozo are among the Mediterranean islands whose prehistoric archaeology has been intensely studied over a number of decades. This factor is important, yet more needs to be done in the field of Maltese archaeology and its valorization. Research is not the preserve of academic specialists. It serves to enhance not only what we know about the Maltese islands, but more importantly, why the archipelago's cultural landscape and its contents deserve care and protection especially at a time of extensive construction development. Strict rules and guidelines established by the Superintendence of Cultural Heritage have meant that during the last two decades more archaeological sites and deposits have been protected in situ or rescue-excavated through a statutory watching regime. This supervision has been applied successfully in a wide range of sites located in urban areas, rural locations and the landscape, as well as at the World Heritage Sites of Valletta, Ġgantija, Ħaġar Qim and Mnajdra and Tarxien. This activity has been instrumental in understanding ancient and historical land use, and the making of the Maltese historic centres and landscape.

Though the cumulative effect of archaeological research is being felt more strongly, new areas of interest still need to be addressed. Most pressing are those areas of landscape studies which often become peripheral to the attention that is garnered by prominent megalithic monuments. *FRAGSUS* has once again confirmed that there is a great deal of value in studying field systems, terraces and geological settings which, after all, were the material media in which modern Malta and Gozo ultimately developed. There is, therefore, an interplay in the use of the term sustainability, an interplay between what we can learn from the way ancient communities tested and used the very same island landscape which we occupy today, and the manner in which this landscape is treated in contested economic realities. If we are to seek factors of sustainability in the past, we must first protect its relics and study them using the best available methods in our times. On the other hand, the study of the past using the materiality of ancient peoples requires strong research agendas and thoughtful stewardship. The *FRAGSUS Project* has shown us how even small fragile deposits, nursed through protective legislation and guardianship, can yield significant information which the methods of pioneering scholars of Maltese archaeology would not have enabled access to. As already outlined by the Superintendence of Cultural Heritage, a national research agenda for cultural heritage and the humanities is a desideratum. Such a framework, reflected in the institutional partnership of the *FRAGSUS Project*, will bear valuable results that will only advance Malta's interests especially in today's world of instant e-knowledge that was not available on such a global scale a mere two decades ago.

FRAGSUS also underlines the relevance of studying the achievements and predicaments of past societies to understand certain, though not all, aspects of present environmental challenges. The twentieth century saw unprecedented environmental changes as a result of modern political-economic constructs. Admittedly, twentieth century developments cannot be equated with those of antiquity in terms of demography, technology, food production and consumption or the use of natural resources including the uptake of land. However, there are certain aspects, such as climate change, changing sea levels, significant environmental degradation, soil erosion, the exploitation and abandonment of land resources, the building and maintenance of field terraces, the rate and scale of human demographic growth, movement of peoples, access to scarce resources, which to a certain extent reflect impacts that seem to recur in time, irrespectively of scale and historic context.

Anthony Pace
Superintendent of Cultural Heritage (2003–18).

Appendix 8

The micromorphological descriptions for the Malta deep cores of Xemxija 1, Wied Żembaq 1, Marsaxlokk and the base of the Salina Deep Core (21B)

Charles French & Sean Taylor

Table A8.1. *Xemxija 1 core micromorphology sample descriptions.*

Sample no.	Depth (m)	Description
1	1.99–2.01	fine gravelly, calcitic sandy clay loam; *Structure*: massive to incipient, sub-angular small blocky, <1 cm, porphyric; *Porosity*: <5% vughs, <200 μm; <2% channels/planes, <100 μm wide, <1 cm long, weakly serrated, accommodated; *Mineral components*: 15% limestone gravel, <5 mm, sub-rounded to sub-angular; c/f ratio = 25/75; coarse fraction: 10% coarse sand & limestone fragments, sub-rounded; 5% medium & 10% fine quartz sand; fine fraction: 10–15% very fine quartz sand; 10–15% micro-sparite; few (<2%) coarse silt-sized glauconite grains, 25–50 μm; few (<2%) haematite crystals, 25–50 μm; 35% dusty clay, weak to non-birefringent, stipple-speckled; golden brown (CPL) to brown (PPL); *Organic components*: 10% organic/charcoal punctuations, <50 μm; *Amorphous*: common thin calcitic coatings of voids; weak to moderate amorphous sesquioxide staining of dusty clay and few zones of more strongly sesquioxide staining; few (5%) amorphous sesquioxide nodules, <100 μm, sub-rounded
2	2.20–2.23	sub-angular blocky, fine gravelly, calcitic sandy clay loam; as for sample 1, but well developed sub-angular blocky ped structure, <2 cm
3	2.50–2.53	mix of fine gravel, sand-size limestone and crumb structured minor micritic silty clay; *Structure*: massive to large crumb, <4 mm, sub-rounded; *Porosity*: 10% vughs, <200 um; 10% channels, <1 cm long, <200 μm wide, weakly serrated, accommodated; *Mineral components*: <40% limestone gravel, <6 mm, sub-rounded to sub-angular; c/f ratio = 60/40; coarse fraction: 30% coarse, 15% medium and 15% fine sand-sized limestone fragments, sub-rounded; fine fraction: 5% very fine quartz sand; 15% micro-sparite; few (2–5%) coarse silt/very fine sand-sized glauconite grains, 50–60 μm; 20% dusty clay, weak to moderate birefringence, stipple-speckled to striated; golden brown (CPL) to brown (PPL); *Organic components*: 20% organic/charcoal punctuations, <50 μm; few (<2%) charcoal fragments, <300 μm; *Amorphous*: weakly calcitic groundmass; weak to moderate amorphous sesquioxide staining of dusty clay; few (5%) amorphous sesquioxide nodules, <100 μm, sub-rounded
4	2.73–2.75	very fine sandy silty clay loam with 10% very fine limestone gravel; *Structure*: small aggregated to weakly pellety, <5 mm; *Porosity*: <1% channels, <2 cm long, <200 μm wide, weakly serrated, accommodated; <20% vughs, <400 μm; *Mineral components*: 10% limestone gravel, <6 mm, sub-rounded to sub-angular; c/f ratio = 5/95; coarse fraction: 5% fine sand and limestone, sub-rounded; fine fraction: 20% very fine quartz sand; few (2–5%) coarse silt/very fine sand-sized glauconite grains, 50–100 μm; <5% micro-sparite; up to 65% dusty clay, weak to moderate birefringence, stipple-speckled to striated; gold (CPL); reddish to brown (CPL/PPL); *Organic components*: general humic staining of groundmass; rare fine charcoal, 50–400 μm; *Amorphous*: 50% of groundmass with moderate to strong amorphous sesquioxide staining
5	3.02–3.04	mix of very fine sandy clay loam and 25–50% very fine limestone gravel; few (2–5%) coarse silt/very fine sand-sized glauconite, 50–100 μm; as for sample 6 below
6	3.35–3.39	finely aggregated very fine sandy clay loam with up to 50% amorphous sesquioxide staining; *Structure*: small aggregated to weakly pellety, <5 mm; porphyric; *Porosity*: <5% planar channels, <2 cm long, <200 μm wide, weakly serrated, accommodated; <5% vughs, <300 μm; *Mineral components*: <5% limestone gravel, <6 mm, sub-rounded to sub-angular; c/f ratio = 10/90; coarse fraction: 5% fine sand, sub-rounded; few (2–5%) very fine sand-sized glauconite grains, 50–60 μm; fine fraction: 25% very fine quartz sand; <5% micr-sparite; up to 65% dusty clay, weak to moderate birefringence, stipple-speckled to striated; gold (CPL); reddish to brown (CPL/PPL); *Amorphous*: 50% of groundmass with strong amorphous sesquioxide staining

Table A8.1 *(cont.).*

Sample no.	Depth (m)	Description
7	4.03–4.05	micro-laminar very fine quartz and silt, strongly reddened with amorphous sesquioxides; *Structure*: single grain to finely laminar in places, <100 μm and <1 mm; *Mineral components*: <5% fine sand-sized limestone, 100–250 μm; 45% very fine quartz sand, 50–100 μm, sub-rounded; 50% silt; 1 zone, *c*. 10% of groundmass, with micro-laminar silt crusts; golden to reddish brown (CPL/PPL); *Amorphous*: <75% of groundmass strongly reddened with amorphous sesquioxides
	4.60–5.43	black organic silt mud to highly humified peat
8	4.95–4.97	heterogeneous mix of very fine quartz sand and silt with greater/lesser zones of amorphous sesquioxides and humic staining; Main fabric: >90% as for sample 7 (above), but stone-free and without laminae; few (2–5%) very fine/fine sand-sized glauconite grains, 50–250 μm; dark brown to dark reddish brown (CPL), golden to dark reddish brown (PPL); Minor fabric: <10% of soil fabric similar to sample 1;
9	5.15–5.17	very fine sand silt with strong amorphous sesquioxide staining; *Structure*: single grain to sub-angular blocky, <2 cm; porphyric; *Porosity*: 5% planar voids, <4 cm long, <200 μm wide, smooth, accommodated; *Mineral components*: 50% very fine quartz sand, 50–100 μm, sub-rounded; 5% micro-sparite; 40% silt; 5% dusty clay aggregates with rare to few dusty clay coatings with strong birefringence, 50–750 μm; golden to reddish brown (CPL/PPL); *Amorphous*: <60% of groundmass strongly reddened with amorphous sesquioxides
10	5.45–5.47	as for samples 9 and 11; very fine sand silt with strong sesquioxide staining throughout; few (2–5%) coarse silt/very fine sand-sized glauconite grains, 50–100 μm
	5.43–6.75	dark grey to black highly organic silt mud with common organic matter fragments; 10YR4/1; 10YR2/1
11	5.78–5.80	as for samples 9 and 10; very fine sand silt with moderate sesquioxide staining; few (2–5%) coarse silt/very fine sand-sized glauconite grains, 50–100 μm
12	6.10–6.12	heterogeneous mix of shell-rich, calcitic, very fine sand silt (as in samples 9–11) and 10% charred plant matter
13	6.45–6.47	calcitic, very fine sandy/silty clay loam; *Structure*: dense, massive to very weakly sub-angular blocky, <1 cm; *Porosity*: 20% vughs, <100 μm; 10% channels, <1.5 cm long, <1 mm wide, partly accommodated, weakly serrated; *Mineral components*: 15% very fine quartz sand, 50–100 μm; few (<2%) gypsum crystals, in clusters, <50 μm; 40% micro-sparite; 30% silt; 10% clay, weak birefringence, pale golden brown (CPL); yellowish brown to grey (CPL), reddish brown (PPL); *Organic components*: 10–15% charred organic punctuations, <50 μm; *Excremental*: few (<5%) calcitic aggregates as discontinuous infills in voids, <50 μm; *Amorphous*: >50% of groundmass strongly reddened with sesquioxide staining
14	6.85–6.87	as for sample 13; calcitic very fine sandy/silty clay loam with >50% strong amorphous sesquioxide staining; except for: 40% porosity; few (5%) humified plant tissue fragments, <50 μm; few (5%) shell fragments, <50 μm; and few (5%) amorphous sesquioxide nodules, <250 μm
15	7.25–7.27	as for samples 13 and 14; calcitic very fine to fine sandy/silty clay loam with *c*. 50% strong amorphous sesquioxide staining; few (<2%) gypsum crystals, in clusters, <50 μm; common shell fragments, <50 μm
16	7.72–7.74	as for samples 17, 18 and 20; reddish brown humic, calcitic silt with very strong amorphous sesquioxide staining and 5% shell fragments, <50 μm
17	7.85–7.87	as for sample 20; dark reddish brown, calcitic, very fine sandy silt with strong amorphous sesquioxide staining throughout; few (2–5%) very fine/fine sand-sized glauconite grains, 50–250 μm; few (<2%) gypsum crystals, in clusters, <50 μm
18	8.23–8.26	as for sample 20; yellowish brown, calcitic, very fine sandy silt with strong amorphous sesquioxide replaced organic matter fragments, 10–15% organic punctuations and 5% shell fragments
19	8.33–8.35	as for sample 23; pale yellowish brown, calcitic, very fine sandy silt
20	8.68–8.70	yellowish brown/grey, calcitic, very fine sandy silt with small, very weakly developed sub-angular blocky peds; *Structure*: dense, massive to very weakly sub-angular blocky, <1 cm; *Porosity*: <1% vughs, <100 μm; <1% channels, <1.5 cm long, <200 μm wide, accommodated; *Mineral components*: 15% very fine quartz sand, 50–100 μm; few (<5%) gypsum crystals; few (2–5%) very fine sand-sized glauconite grains, 50–100 μm; 40% micro-sparite; 30% silt; 10% clay, weak birefringence, pale golden brown (CPL); yellowish brown to grey (CPL), reddish brown (PPL); *Organic components*: 5% shell fragments; 10% organic punctuations, <50 μm; *Amorphous*: weak to moderate sesquioxide staining of whole groundmass
21	9.13–9.15	as for sample 20

Table A8.1 *(cont.)*.

Sample no.	Depth (m)	Description
22	9.25–9.27	weak sub-angular blocky, pale brown, calcitic silty clay; *Structure*: dense, massive to very weakly sub-angular blocky, <5 mm; *Porosity*: <2% vughs, <100 μm; 5–8% channels, discontinuous, <1.5 cm long, <500 μm wide, accommodated; *Mineral components*: 10% very fine quartz sand, 50–100 μm; 40% micro-sparite; 40% dusty clay, weak birefringence, pale golden brown (CPL); pale golden brown (CPL/PPL); *Organic components*: 10% organic punctuations, <50 um; *Amorphous*: <20% of groundmass with weak sesquioxide staining
23	9.45–9.47	as above with minor charcoal and amorphous sesquioxide replaced organic matter; *Structure*: dense, massive to very weakly sub-angular blocky, <5 mm; porphyric; *Porosity*: 2% vughs, irregular, <2 mm; 5% channels, discontinuous, <1.5 cm long, <500 μm wide, accommodated; *Mineral components*: 5% very fine quartz sand, 50–10 μm; rare (<1%) gypsum crystals, <50 μm; 44% micro-sparite; 40% dusty clay, weak birefringence, pale golden brown (CPL); pale brown to pale yellowish brown (PPL); *Organic components*: rare (<1%) wood charcoal, <1 mm; 5% sesquioxide replaced plant tissue fragments; 10% organic punctuations, <50 μm; <5% shell fragments; common root holes infilled with same fabric; *Amorphous*: few channels with amorphous sesquioxide hypo-coatings; very weak sesquioxide staining of whole groundmass
24	9.65–9.67	as for sample 23, with 5–10% shell fragments
25	9.75–9.77	dense, homogeneous, pale golden brown, calcitic silty clay; *Structure*: dense, massive, apedal; *Porosity*: <1% vughs, <250 μm; <2% planar voids, <1 cm long, <500 μm wide, weakly serrated; *Mineral components*: 5–10% very fine quartz sand, 50–100 μm; 70% micro-sparite; 10% sparite, as dense infills in some voids; 10% dusty clay, weak birefringence, pale golden brown (CPL); pale brown to pale golden brown (CPL/PPL); *Organic components*: <2% organic punctuations, <50 μm; *Amorphous*: 20% of groundmass with weak, irregular staining with amorphous sesquioxides; <2% amorphous sesquioxide nodules, <10 μm

Table A8.2. *Wied Żembaq 1 core micromorphology sample descriptions.*

Sample no.	Depth (m)	Description
26	0.07–0.09	reddish brown coarse-very fine sandy/silty clay with minor very fine charcoal; *Structure*: dense, massive; *Porosity*: <2% vughs, <250 μm; <2% channels, <500 μm long, <100 μm wide, vertical, accommodated, weakly serrated; *Mineral components*: c/f ratio: 22/78; coarse fraction: 2% coarse sand-size limestone; 10% fine quartz sand, 100–250 μm, sub-rounded; fine fraction: 20% very fine quartz sand, 50–100 μm, sub-rounded; 10% micro-sparite; 48% dusty clay, in groundmass, non-birefringent, with moderate to strong amorphous sesquioxide staining; reddish brown (CPL), brown (PPL); *Organic components*: 5% shell fragments, <1 mm; 5% very fine charcoal, <100 μm; 5% charred organic punctuations, <50 μm; *Amorphous*: few zones (<10% of groundmass) of very strong staining with amorphous sesquioxides
27	0.45–0.70	as for sample 26
28	0.80–0.82	golden brown, calcitic, coarse-very fine sandy/silty clay with illuvial silty clay infills; *Structure*: dense, massive; *Porosity*: <2% vughs, <250 μm; <2% channels, <500 μm long, <100 μm wide, vertical, accommodated, weakly serrated; *Mineral components*: c/f ratio: 25/75; coarse fraction: 5% coarse sand-size limestone; 10% medium and 10% fine quartz sand, 100–500 μm, sub-rounded; fine fraction: 10% very fine quartz sand, 50–100 μm, sub-rounded; 20% micro-sparite; 45% dusty clay, in groundmass and as void coatings/infills, weak birefringence; golden brown (CPL/PPL); *Organic components*: 5% very fine charcoal, <100 μm; 5% charred organic punctuations, <50 μm
29	2.15–2.17	as for sample 26, with 20% fine limestone gravel content
30	2.53–2.55	as for sample 28, with 10–15% fine limestone gravel content and up to 50% of groundmass strongly stained with amorphous sesquioxides
31	3.00–3.02	small blocky, golden/reddish brown, calcitic, very fine sandy/silty clay, with weakly laminar micro-structure; *Structure*: moderately well developed small sub-angular blocky, <2 cm; *Porosity*: <2% vughs, <250 μm; <5% channels, <2 cm long, <500 μm wide, vertical/horizontal, partly accommodated, weakly serrated; *Mineral components*: 30% very fine quartz sand, 50–100 μm, sub-rounded; 5–10% micro-sparite; 10% irregular zones of amorphous calcium carbonate; 50–55% dusty clay, in groundmass, non-birefringent, with strong amorphous sesquioxide staining; golden/reddish brown (CPL/PPL); *Organic components*: 2% very fine charcoal, <100 μm; 5% organic punctuations, <50 μm; part charred/part replaced with amorphous sesquioxides wood fragment; *Amorphous*: much of groundmass very strongly stained with amorphous sesquioxides

Table A8.2 *(cont.).*

Sample no.	Depth (m)	Description
32	3.65–3.67	four thin fabric units: Upper fabric unit 1: as for sample 31; Fabric unit 2: mix of very fine quartz sand and micro-sparite; Fabric unit 3: as for sample 31; Lower fabric unit 4: very fine quartz sand
33	3.96–3.98	as for sample 28, except a few glauconite grains, 50–100 µm
34	4.10–4.12	humified and amorphous sesquioxide replaced organic matter with <5% shell fragments
35	4.33–4.35	small blocky, golden/reddish brown, coarse-very fine sandy/silty clay; *Structure*: weakly developed small sub-angular blocky, <2 cm; *Porosity*: <2% vughs, <250 µm; <5% channels, <2 cm long, <500 µm wide, vertical/horizontal, partly accommodated, weakly serrated; *Mineral components*: c/f ratio: 40/60; 2% coarse, 8% medium and 30% very fine quartz sand and limestone, 50–1000 µm, sub-rounded; few gypsum crystals, <50 µm, lenticular; 20% very fine quartz sand, 50–100 µm, sub-rounded; 40% dusty clay, in groundmass, non-birefringent, with strong amorphous sesquioxide staining; golden/reddish brown (CPL/PPL); *Organic components*: 5% charred organic punctuations, <50 µm; part charred/part replaced with amorphous sesquioxides wood fragment; *Amorphous*: *c*. 50% of groundmass strongly stained with amorphous sesquioxides
36	4.60–4.61	porous (15% irregular vughs), humified and amorphous sesquioxide replaced organic matter with 20% coarse-fine limestone/quartz, few gypsum crystals, <50 µm, and 2% shell fragments
37	4.96–4.98	fine gravelly, brown, calcitic, coarse-very fine sandy/silty clay with minor very fine charcoal; *Structure*: dense, massive; *Porosity*: <2% vughs, <250 µm; <2% channels, <500 µm long, <100 µm wide, vertical, accommodated, weakly serrated; *Mineral components*: c/f ratio: 40/60; coarse fraction: 5% coarse and 15%medium sand-size limestone, 500–1000 µm, sub-angular to sub-rounded; 10% fine quartz sand, 100–250 µm, sub-rounded; fine fraction: 20% very fine quartz sand, 50–100 µm, sub-rounded; 15% micro-sparite; 45% dusty clay, in groundmass, weak birefringence, golden brown (CPL); golden brown (CPL), brown (PPL); *Organic components*: 2% shell fragments, <1 mm; 5% very fine charcoal, <100 µm; 5% charred organic punctuations, <50 µm; 5–10% part charred/part humified plant tissue; *Amorphous*: few (<2%) amorphous sesquioxide nodules, <100 µm
38	5.28–5.30	as for sample 37, except fabric moderately to strongly reddened with amorphous sesquioxides, and few very fine sand-sized glauconite grains, 50–100 µm

Table A8.3. *Marsaxlokk core micromorphology sample descriptions.*

Sample	Depth (m)	Description
39	0.05–0.06	finely aggregated, vughy, pale brown calcitic silt; *Structure*: pellety to aggregated, <1 mm; *Porosity*: 10–20% interconnected vughy; *Mineral components*: 5% fine limestone gravel, <4 mm, sub-rounded; 10% fine and 5% very fine limestone, 50–250 µm, sub-rounded; 80% micro-sparite; pale brown (CPL), pale golden brown (PPL); *Organic components*: <2% amorphous sesquioxide replaced plant tissue
40	0.62–0.66	dense, pale grey weathered limestone and calcium carbonate; *Structure*: dense, aggregated, <5 mm; *Porosity*: <2% interconnected vughy; *Mineral components*: 15% fine limestone gravel, <4 mm, sub-rounded; 80% fine and 5% very fine limestone, 50–250 µm, sub-rounded;<5% dusty clay; pale grey brown (CPL/PPL); *Organic components*: <2% shell fragments; <2% charred organic punctuations, <50 µm
41	1.10–1.12	dense, pale grey weathered limestone and calcium carbonate and silt/micro-sparite; *Structure*: dense, homogeneous; *Porosity*: <1% interconnected vughy; *Mineral components*: < 5% very fine quart sand, 50–100 µm, sub-rounded; 95% micro-sparite; pale grey (CPL/PPL)
42	1.70–1.72	two units of micro-laminar humified and amorphous sesquioxide replaced plant remains; Upper fabric unit: finely laminar amorphous sesquioxide replaced plant tissue over weathered limestone (as in sample 40); over Fabric unit 2: dense humified/sesquioxide replaced plant tissue interleaved with 10–20% very fine quartz sand and 10% micro-sparite
43	2.15–2.17	reddish brown, coarse to very fine sandy/silty clay loam; *Structure*: weakly developed small sub-angular blocky, <1 cm; *Porosity*: <2% vughs, <250 µm; <5% short channels, <5 mm long, <100 µm wide, partly accommodated, weakly serrated; *Mineral components*: 5% limestone gravel, <1 cm, sub-rounded; c/f ratio: 25/75; coarse fraction: 10% coarse, 10% medium and 5% fine quartz sand, 100–1000 µm, sub-rounded; fine fraction: 10% very fine quartz sand, 50–100 µm, sub-rounded; 5–10% micro-sparite; 55–60% dusty clay, in groundmass, non-birefringent; dark reddish brown (CPL/PPL); *Organic components*: 5% charred organic punctuations, <50 µm

Table A8.3 *(cont.)*.

Sample	Depth (m)	Description
44	2.55–2.57	as for sample 43, except 20% micro-sparite content
45	2.96–2.99	as for sample 44, with well developed, small sub-angular blocky structure
46	3.20–3.22	as above
47	3.65–3.67	very dense, massive, amorphous calcium carbonate

Table A8.4. *Salina Deep Core (21B; base of) micromorphology sample descriptions.*

Sample	Depth (m)	Description
Spot 1	27.83–27.88	well developed, small, sub-angular blocky, calcitic fine sandy clay loam over basal lens of fine limestone gravel; *Structure*: well developed small sub-angular blocky, <2.5 cm; *Porosity*: <2% vughs, <500 μm, sub-rounded; 10% channels, <3 cm long, <500 μm wide, accommodated, smooth to weakly serrated; *Mineral components*: in base of slide, 20–25% limestone gravel, <1 cm, sub-rounded to sub-angular; c/f ratio: 50/50; coarse fraction: 20% medium and 30% fine quartz sand, 100–500 μm, sub-rounded; fine fraction: 10% very fine quartz sand, 50–100 μm, sub-rounded; 10–20% micro-sparite; 20–30% dusty clay, in groundmass, weak birefringence; golden brown (CPL), brown (PPL); *Organic components*: rare (<1%) humified plant tissue; rare (<1%) shell fragments; *Amorphous*: few vughs with up to 50% micro-sparitic/amorphous calcium carbonate infillings; rare (<1%) amorphous sesquioxide nodule, <250 μm
Spot 2	27.91–27.96	as for spot sample 1, except no limestone gravel, fabric all weakly developed sub-angular blocky to massive, all voids filled with micro-sparite/amorphous calcium carbonate, and 30% amorphous humic/sesquioxide staining of groundmass
Spot 3	28.08–28.12	as for spot sample 1, except well developed, small, sub-angular blocky, minor limestone gravel, a few very fine sand-sized glauconite grains, 50–100 μm, and with micro-sparitic/amorphous calcium carbonate linings of all channels

Temple landscapes

The ERC-funded *FRAGSUS Project* (*Fragility and sustainability in small island environments: adaptation, cultural change and collapse in prehistory, 2013–18*), led by Caroline Malone (Queens University Belfast) has explored issues of environmental fragility and Neolithic social resilience and sustainability during the Holocene period in the Maltese Islands. This, the first volume of three, presents the palaeo-environmental story of early Maltese landscapes.

The project employed a programme of high-resolution chronological and stratigraphic investigations of the valley systems on Malta and Gozo. Buried deposits extracted through coring and geoarchaeological study yielded rich and chronologically controlled data that allow an important new understanding of environmental change in the islands. The study combined AMS radiocarbon and OSL chronologies with detailed palynological, molluscan and geoarchaeological analyses. These enable environmental reconstruction of prehistoric landscapes and the changing resources exploited by the islanders between the seventh and second millennia BC. The interdisciplinary studies combined with excavated economic and environmental materials from archaeological sites allows Temple landscapes to examine the dramatic and damaging impacts made by the first farming communities on the islands' soil and resources. The project reveals the remarkable resilience of the soil-vegetational system of the island landscapes, as well as the adaptations made by Neolithic communities to harness their productivity, in the face of climatic change and inexorable soil erosion. Neolithic people evidently understood how to maintain soil fertility and cope with the inherently unstable changing landscapes of Malta. In contrast, second millennium BC Bronze Age societies failed to adapt effectively to the long-term aridifying trend so clearly highlighted in the soil and vegetation record. This failure led to severe and irreversible erosion and very different and short-lived socio-economic systems across the Maltese islands.

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