



McDONALD INSTITUTE MONOGRAPHS

Temple landscapes

Fragility, change and resilience of Holocene environments in the Maltese Islands

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*

Temple landscapes



McDONALD INSTITUTE MONOGRAPHS

Temple landscapes

Fragility, change and resilience of Holocene environments in the Maltese Islands

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

With contributions by

Gianmarco Alberti, Jeremy Bennett, Maarten Blaauw, Petros Chatzimpaloglou,
Lisa Coyle McClung, Alan J. Cresswell, Nathaniel Cutajar, Michelle Farrell,
Katrin Fenech, Rory P. Flood, Timothy C. Kinnaird, Steve McCarron,
Rowan McLaughlin, John Meneely, Anthony Pace, Sean D.F. Pyne-O'Donnell,
Paula J. Reimer, Alastair Ruffell, George A. Said-Zammit, David C.W. Sanderson,
Patrick J. Schembri, Sean Taylor, David Trumpf, Jonathan Turner, Nicholas C. Vella
& Nathan Wright

Illustrations by

Gianmarco Alberti, Jeremy Bennett, Sara Boyle, Petros Chatzimpaloglou,
Lisa Coyle McClung, Rory P. Flood, Charles French, Chris O. Hunt, Michelle Farrell,
Katrin Fenech, Rowan McLaughlin, John Meneely, Anthony Pace, David Redhouse,
Alastair Ruffell, George A. Said-Zammit & Simon Stoddart



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



This project has received funding from the European Research Council (ERC) under the European Union's Seventh Framework Programme (FP7-2007-2013) (Grant agreement No. 323727).

Published by:

McDonald Institute for Archaeological Research
University of Cambridge
Downing Street
Cambridge, UK
CB2 3ER
(0)(1223) 339327
eaj31@cam.ac.uk
www.mcdonald.cam.ac.uk



McDonald Institute for Archaeological Research, 2020

© 2020 McDonald Institute for Archaeological Research.

Temple landscapes is made available under a
Creative Commons Attribution-NonCommercial-
NoDerivatives 4.0 (International) Licence:
<https://creativecommons.org/licenses/by-nc-nd/4.0/>

ISBN: 978-1-902937-99-1

Cover design by Dora Kemp and Ben Plumridge.
Typesetting and layout by Ben Plumridge.

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

Edited for the Institute by James Barrett (*Series Editor*).

CONTENTS

Contributors		xi
Figures		xiii
Tables		xvi
Preface and dedication		xix
Acknowledgements		xxi
Foreword		xxiii
<i>Introduction</i>	CAROLINE MALONE, SIMON STODDART, CHRIS O. HUNT, CHARLES FRENCH, ROWAN McLAUGHLIN & REUBEN GRIMA	1
0.1. Introduction		1
0.2. Background to <i>FRAGSUS</i> as an archaeological project		3
0.3. Environmental research in Malta and the Mediterranean		5
0.4. The development of the <i>FRAGSUS Project</i> and its questions		6
0.5. Archaeological concerns in Maltese prehistory and the <i>FRAGSUS Project</i>		8
0.6. The research programme: the sites and their selection		9
0.7. Investigating the palaeoenvironmental context		10
0.8. Archaeological investigations		11
Part I	The interaction between the natural and cultural landscape – insights into the fifth–second millennia BC	17
<i>Chapter 1</i>	The geology, soils and present-day environment of Gozo and Malta PETROS CHATZIMPALOGLOU, PATRICK J. SCHEMBRI, CHARLES FRENCH, ALASTAIR RUFFELL & SIMON STODDART	19
1.1. Previous work		19
1.2. Geography		19
1.3. Geology		21
1.4. Stratigraphy of the Maltese Islands		23
1.4.1. Lower Coralline Limestone Formation		23
1.4.2. Globigerina Limestone Formation		23
1.4.3. Chert outcrops		25
1.4.4. Blue Clay Formation		26
1.4.5. Greensand Formation		28
1.4.6. Upper Coralline Limestone Formation		28
1.4.7. Quaternary deposits		29
1.5. Structural and tectonic geology of the Maltese Islands		29
1.6. Geomorphology		29
1.7. Soils and landscape		31
1.8. Climate and vegetation		32
<i>Chapter 2</i>	Chronology and stratigraphy of the valley systems CHRIS O. HUNT, MICHELLE FARRELL, KATRIN FENECH, CHARLES FRENCH, ROWAN McLAUGHLIN, MAARTEN BLAAUW, JEREMY BENNETT, RORY P. FLOOD, SEAN D. F. PYNE-O'DONNELL, PAULA J. REIMER, ALASTAIR RUFFELL, ALAN J. CRESSWELL, TIMOTHY C. KINNAIRD, DAVID SANDERSON, SEAN TAYLOR, CAROLINE MALONE, SIMON STODDART & NICHOLAS C. VELLA	35
2.1. Methods for dating environmental and climate change in the Maltese Islands		35
2.1.1. Data sources for chronology building		35
2.1.2. Pottery finds		41

2.2. Basin infill ground penetrating radar surveys	41
ALASTAIR RUFFELL, CHRIS O. HUNT, JEREMY BENNETT, RORY P. FLOOD, SIMON STODDART & CAROLINE MALONE	
2.2.1. <i>Rationale</i>	41
2.2.2. <i>Geophysics for basin fill identification</i>	41
2.2.3. <i>Valley locations</i>	43
2.3. The sediment cores	43
CHRIS O. HUNT, MICHELLE FARRELL, RORY P. FLOOD, KATRIN FENECH, ROWAN McLAUGHLIN, NICHOLAS C. VELLA, SEAN TAYLOR & CHARLES FRENCH	
2.3.1. <i>Aims and methods</i>	43
2.3.2. <i>The core descriptions</i>	49
2.3.3. <i>Magnetic susceptibility and XRF analyses of the cores</i>	59
2.4. Age-depth models	64
MAARTEN BLAUW & ROWAN McLAUGHLIN	
2.4.1. <i>Accumulation rates</i>	64
2.5. A local marine reservoir offset for Malta	65
PAULA J. REIMER	
2.6. Major soil erosion phases	65
RORY P. FLOOD, ROWAN McLAUGHLIN & MICHELLE FARRELL	
2.6.1. <i>Introduction</i>	65
2.6.2. <i>Methods</i>	66
2.6.3. <i>Results</i>	67
2.6.4. <i>Discussion</i>	68
2.6.5. <i>Conclusions</i>	71
Chapter 3 The Holocene vegetation history of the Maltese Islands	73
MICHELLE FARRELL, CHRIS O. HUNT & LISA COYLE McCLUNG	
3.1. Introduction	73
CHRIS O. HUNT	
3.2. Palynological methods	74
LISA COYLE-McCLUNG, MICHELLE FARRELL & CHRIS O. HUNT	
3.3. Taxonomy and ecological classification	75
CHRIS O. HUNT	
3.4. Taphonomy	75
CHRIS O. HUNT & MICHELLE FARRELL	
3.5. The pollen results	87
MICHELLE FARRELL, LISA COYLE-McCLUNG & CHRIS O. HUNT	
3.5.1. <i>The Salina cores</i>	87
3.5.2. <i>Wied Żembaq</i>	87
3.5.3. <i>Xemxija</i>	87
3.5.4. <i>In-Nuffara</i>	87
3.5.5. <i>Santa Verna</i>	95
3.5.6. <i>Ġgantija</i>	105
3.6. Synthesis	107
3.6.1. <i>Pre-agricultural landscapes (pre-5900 cal. BC)</i>	107
3.6.2. <i>First agricultural colonization (5900–5400 cal. BC)</i>	108
3.6.3. <i>Early Neolithic (5400–3900 cal. BC)</i>	109
3.6.4. <i>The later Neolithic Temple period (3900–2350 cal. BC)</i>	110
3.6.5. <i>The late Neolithic–Early Bronze Age transition (2350–2000 cal. BC)</i>	111
3.6.6. <i>The Bronze Age (2000–1000 cal. BC)</i>	112
3.6.7. <i>Late Bronze Age, Punic and Classical periods (c. 1000 cal. BC to AD 1000)</i>	112
3.6.8. <i>Medieval to modern (post-AD 1000)</i>	113
3.7. Conclusions	113

Chapter 4	Molluscan remains from the valley cores	115
	KATRIN FENECH, CHRIS O. HUNT, NICHOLAS C. VELLA & PATRICK J. SCHEMBRI	
	4.1. Introduction	115
	4.2. Material	117
	4.3. Methods	117
	4.4. Radiocarbon dates and Bayesian age-depth models	117
	4.5. Results	117
	4.5.1. <i>Marsaxlokk (MX1)</i>	127
	4.5.2. <i>Wied Żembaq (WŻ)</i>	127
	4.5.3. <i>Mġarr ix-Xini (MĠX)</i>	128
	4.5.4. <i>Marsa 2</i>	128
	4.5.5. <i>Salina Deep Core</i>	133
	4.5.6. <i>Xemxija 1 and 2</i>	152
	4.6. Interpretative discussion	153
	4.6.1. <i>Erosion – evidence of major events from the cores</i>	153
	4.7. Environmental reconstruction based on non-marine molluscs	155
	4.7.1. <i>Early Holocene (c. 8000–6000 cal. BC)</i>	155
	4.7.2. <i>Mid-Holocene (c. 6000–3900 cal. BC)</i>	155
	4.7.3. <i>Temple Period (c. 3900–2400 cal. BC)</i>	155
	4.7.4. <i>Early to later Bronze Age (2400–c. 750 cal. BC)</i>	155
	4.7.5. <i>Latest Bronze Age/early Phoenician period to Late Roman/Byzantine period (c. 750 cal. BC–cal. AD 650)</i>	156
	4.8. Concluding remarks	156
	4.9. Notes on selected species	157
	4.9.1. <i>Extinct species</i>	157
	4.9.2. <i>Species with no previous fossil record</i>	158
	4.9.3. <i>Other indicator species</i>	158
Chapter 5	The geoarchaeology of past landscape sequences on Gozo and Malta	161
	CHARLES FRENCH & SEAN TAYLOR	
	5.1. Introduction	161
	5.2. Methodology and sample locations	164
	5.3. Results	165
	5.3.1. <i>Santa Verna and its environs</i>	165
	5.3.2. <i>Ġgantija temple and its environs</i>	174
	5.3.3. <i>Skorba and its immediate environs</i>	183
	5.3.4. <i>Taċ-Ċawla settlement site</i>	188
	5.3.5. <i>Xaġhra town</i>	190
	5.3.6. <i>Ta' Marżiena</i>	192
	5.3.7. <i>In-Nuffara</i>	192
	5.3.8. <i>The Ramla valley</i>	193
	5.3.9. <i>The Marsalforn valley</i>	195
	5.3.10. <i>Micromorphological analyses of possible soil materials in the Xemxija 1, Wied Żembaq 1, Marsaxlokk and Salina Deep (SDC) cores</i>	196
	5.4. The Holocene landscapes of Gozo and Malta	213
	5.5. A model of landscape development	217
	5.6. Conclusions	221
Chapter 6	Cultural landscapes in the changing environments from 6000 to 2000 BC	223
	REUBEN GRIMA, SIMON STODDART, CHRIS O. HUNT, CHARLES FRENCH, ROWAN McLAUGHLIN & CAROLINE MALONE	
	6.1. Introduction	223
	6.2. A short history of survey of a fragmented island landscape	223
	6.3. Fragmented landscapes	225

6.4. The Neolithic appropriation of the landscape	227
6.5. A world in flux (5800–4800 cal. BC)	227
6.6. The fifth millennium BC hiatus (4980/4690 to 4150/3640 cal. BC)	228
6.7. Reappropriating the landscape: the ‘Temple Culture’	230
6.8. Transition and decline	236
6.9. Conclusion	237
Part II The interaction between the natural and cultural landscape – insights from the second millennium BC to the present: continuing the story	239
<i>Chapter 7</i> Cultural landscapes from 2000 BC onwards	241
SIMON STODDART, ANTHONY PACE, NATHANIEL CUTAJAR, NICHOLAS C. VELLA, ROWAN McLAUGHLIN, CAROLINE MALONE, JOHN MENEELY & DAVID TRUMPT	
7.1. An historiographical introduction to the Neolithic–Bronze Age transition into the Middle Bronze Age	241
7.2. Bronze Age settlements in the landscape	243
7.3. The Bronze Age Phoenician transition and the Phoenician/Punic landscape	246
7.4. Entering the Roman world	250
7.5. Arab	250
7.6. Medieval	251
7.7. The Knights and the entry into the modern period	251
<i>Chapter 8</i> The intensification of the agricultural landscape of the Maltese Archipelago	253
JEREMY BENNETT	
8.1. Introduction	253
8.2. The <i>Annales</i> School and the Anthropocene	254
8.3. The Maltese Archipelago and the <i>longue durée</i> of the Anthropocene	255
8.4. Intensification	257
8.5. Population	258
8.5.1. <i>Sub-carrying capacity periods</i>	258
8.5.2. <i>Post-carrying capacity periods</i>	260
8.6. The agrarian archipelago	262
8.6.1. <i>The agricultural substrate</i>	262
8.6.2. <i>The development of agricultural technology</i>	262
8.7. Discussion: balancing fragility and sustainability	264
<i>Chapter 9</i> Locating potential pastoral foraging routes in Malta through the use of a Geographic Information System	267
GIANMARCO ALBERTI, REUBEN GRIMA & NICHOLAS C. VELLA	
9.1. Introduction	267
9.2. Methods	267
9.2.1. <i>Data sources</i>	267
9.2.2. <i>Foraging routes and least-cost paths calculation</i>	268
9.3. Results	271
9.3.1. <i>Garrigue to garrigue least-cost paths</i>	271
9.3.2. <i>Stables to garrigues least-cost paths</i>	273
9.4. Discussion	276
9.4. Conclusions	283
<i>Chapter 10</i> Settlement evolution in Malta from the Late Middle Ages to the early twentieth century and its impact on domestic space	285
GEORGE A. SAID-ZAMMIT	
10.1. The Medieval Period (AD 870–1530)	285
10.1.1. <i>Medieval houses</i>	288

10.1.2. <i>Giren and hovels</i>	289
10.1.3. <i>Cave-dwellings</i>	292
10.1.4. <i>Architectural development</i>	292
10.2. The Knights' Period (AD 1530–1798)	293
10.2.1. <i>The phase AD 1530–1565</i>	293
10.2.2. <i>The phase AD 1565–1798</i>	293
10.2.3. <i>Early modern houses</i>	294
10.2.4. <i>Lower class dwellings</i>	297
10.2.5. <i>Cave-dwellings and hovels</i>	298
10.2.6. <i>The houses: a reflection of social and economic change</i>	298
10.3. The British Period (AD 1800–1900)	298
10.3.1. <i>The houses of the British Period</i>	299
10.3.2. <i>The effect of the Victorian Age</i>	300
10.3.3. <i>Urban lower class dwellings</i>	301
10.3.4. <i>Peasant houses, cave-dwellings and hovels</i>	301
10.4. Conclusions	302
<i>Chapter 11</i> Conclusions	303
CHARLES FRENCH, CHRIS O. HUNT, MICHELLE FARRELL, KATRIN FENECH, ROWAN McLAUGHLIN, REUBEN GRIMA, NICHOLAS C. VELLA, PATRICK J. SCHEMBRI, SIMON STODDART & CAROLINE MALONE	
11.1. The palynological record	303
CHRIS O. HUNT & MICHELLE FARRELL	
11.1.1. <i>Climate</i>	303
11.1.2. <i>Farming and anthropogenic impacts on vegetation</i>	307
11.2. The molluscan record	308
KATRIN FENECH, CHRIS O. HUNT, NICHOLAS C. VELLA & PATRICK J. SCHEMBRI	
11.3. The soil/sediment record	310
CHARLES FRENCH	
11.4. Discontinuities in Maltese prehistory and the influence of climate	313
CHRIS O. HUNT	
11.5. Environmental metastability and the <i>longue durée</i>	314
CHRIS O. HUNT	
11.6. Implications for the human story of the Maltese Islands	316
CHARLES FRENCH, CHRIS O. HUNT, CAROLINE MALONE, KATRIN FENECH, MICHELLE FARRELL, ROWAN McLAUGHLIN, REUBEN GRIMA, PATRICK J. SCHEMBRI & SIMON STODDART	
References	325
<i>Appendix 1</i> How ground penetrating radar (GPR) works	351
ALASTAIR RUFFELL	
<i>Appendix 2</i> Luminescence analysis and dating of sediments from archaeological sites and valley fill sequences	353
ALAN J. CRESSWELL, DAVID C.W. SANDERSON, TIMOTHY C. KINNAIRD & CHARLES FRENCH	
A2.1. Summary	353
A2.2. Introduction	354
A2.3. Methods	355
A2.3.1. <i>Sampling and field screening measurements</i>	355
A2.3.2. <i>Laboratory calibrated screening measurements</i>	355
A2.4. Quartz OSL SAR measurements	356
A2.4.1. <i>Sample preparation</i>	356
A2.4.2. <i>Measurements and determinations</i>	356

A2.5. Results	357
A2.5.1. Sampling and preliminary luminescence stratigraphies	357
A2.5.2. Gozo	357
A2.5.3. Skorba	363
A2.5.4. Tal-Istabal, Qormi	363
A2.6. Laboratory calibrated screening measurements	363
A2.6.1. Dose rates	367
A2.6.2. Quartz single aliquot equivalent dose determinations	367
A2.6.3. Age determinations	371
A2.7. Discussion	372
A2.7.1. Ġgantija Temple (SUTL2914 and 2915)	372
A2.7.2. Ramla and Marsalforn Valleys (SUTL2917–2923)	373
A2.7.3. Skorba Neolithic site (SUTL2925–2927)s	373
A2.7.4. Tal-Istabal, Qormi (SUTL2930)	376
A2.7. Conclusions	376
Appendix 2 – Supplements A–D	379
Appendix 3	401
Deep core borehole logs	
CHRIS O. HUNT, KATRIN FENECH, MICHELLE FARRELL & ROWAN McLAUGHLIN	
Appendix 4	421 (online edition only)
Granulometry of the deep cores	
KATRIN FENECH	
Appendix 5	441 (online edition only)
The molluscan counts for the deep cores	
KATRIN FENECH	
Appendix 6	535
The borehole and test excavation profile log descriptions	
CHARLES FRENCH & SEAN TAYLOR	
Appendix 7	549
The detailed soil micromorphological descriptions from the buried soils and Ramla and Marsalforn valleys	
CHARLES FRENCH	
A7.1. Santa Verna	549
A7.2. Ġgantija Test Pit 1	551
A7.3. Ġgantija WC Trench 1	552
A7.4. Ġgantija olive grove and environs	553
A7.5. Skorba	553
A7.6. Xagħra town	554
A7.7. Taċ-Ċawla	555
A7.8. In-Nuffara	555
A7.9. Marsalforn Valley Profile 626	556
A7.10. Ramla Valley Profile 627	556
A7.11. Dwerja	556
Appendix 8	557
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	
Appendix 9	563
The charcoal data	
NATHAN WRIGHT	
Index	565

CONTRIBUTORS

DR GIANMARCO ALBERTI

Department of Criminology, Faculty for Social
Wellbeing, University of Malta, Msida, Malta
Email: gianmarco.alberti@um.edu.mt

JEREMY BENNETT

Department of Archaeology, University of
Cambridge, Cambridge, UK
Email: jmb241@cam.ac.uk

DR MAARTEN BLAAUW

School of Natural and Built Environment, Queen's
University, University Road, Belfast, Northern
Ireland
Email: marten.blaauw@qub.ac.uk

DR PETROS CHATZIMPALOGLOU

Department of Archaeology, University of
Cambridge, Cambridge, UK
Email: pc529@cam.ac.uk

DR LISA COYLE MCCLUNG

School of Natural and Built Environment, Queen's
University, University Road, Belfast, Northern
Ireland
Email: l.coylemcclung@qub.ac.uk

DR ALAN J. CRESSWELL

SUERC, University of Glasgow, East Kilbride,
University of Glasgow, Glasgow, Scotland
Email: alan.cresswell@glasgow.ac.uk

NATHANIEL CUTAJAR

Deputy Superintendent of Cultural Heritage,
Heritage Malta, Valletta, Malta
Email: nathaniel.cutajar@gov.mt

DR MICHELLE FARRELL

Centre for Agroecology, Water and Resilience,
School of Energy, Construction and Environment,
Coventry University, Coventry, UK
Email: ac5086@coventry.ac.uk

DR KATRIN FENECH

Department of Classics & Archaeology, University
of Malta, Msida, Malta
Email: katrin.fenech@um.edu.mt

DR RORY P. FLOOD

School of Natural and Built Environment, Queen's
University, University Road, Belfast, Northern
Ireland
Email: r.flood@qub.ac.uk

PROF. CHARLES FRENCH

Department of Archaeology, University of
Cambridge, Cambridge, UK
Email: caif2@cam.ac.uk

DR REUBEN GRIMA

Department of Conservation and Built Heritage,
University of Malta, Msida, Malta
Email: reuben.grima@um.edu.mt

DR EVAN A. HILL

School of Natural and Built Environment, Queen's
University, University Road, Belfast, Northern
Ireland
Email: ehill08@qub.ac.uk

PROF. CHRIS O. HUNT

Faculty of Science, Liverpool John Moores
University, Liverpool, UK
Email: c.o.hunt@ljmu.ac.uk

DR TIMOTHY C. KINNAIRD

School of Earth and Environmental Sciences,
University of St Andrews, St. Andrews, Scotland
Email: tk17@st-andrews.ac.uk

PROF. CAROLINE MALONE

School of Natural and Built Environment, Queen's
University, University Road, Belfast, BT7 1NN,
Northern Ireland
Email: c.malone@qub.ac.uk

DR STEVE MCCARRON

Department of Geography, National University of
Ireland, Maynooth, Ireland
Email: stephen.mccarron@mu.ie

DR ROWAN McLAUGHLIN

School of Natural and Built Environment, Queen's
University, University Road, Belfast, Northern
Ireland
Email: r.mclaughlin@qub.ac.uk

JOHN MENEELY
School of Natural and Built Environment, Queen's
University, University Road, Belfast, Northern
Ireland
Email: j.meneely@qub.ac.uk

DR ANTHONY PACE
UNESCO Cultural Heritage, Valletta, Malta
Email: anthonypace@cantab.net

DR SEAN D.F. PYNE-O'DONNELL
Earth Observatory of Singapore, Nanyang
Technological University, Singapore
Email: sean.1000@hotmail.co.uk

PROF. PAULA J. REIMER
School of Natural and Built Environment, Queen's
University, University Road, Belfast, Northern
Ireland
Email: p.j.reimer@qub.ac.uk

DR ALASTAIR RUFFELL
School of Natural and Built Environment, Queen's
University, University Road, Belfast, Northern
Ireland
Email: a.ruffell@qub.ac.uk

GEORGE A. SAID-ZAMMIT
Department of Examinations, Ministry for
Education and Employment, Government of Malta,
Malta
Email: george.said-zammit@gov.mt

PROF. DAVID C.W. SANDERSON
SUERC, University of Glasgow, East Kilbride,
University of Glasgow, Glasgow, Scotland
Email: david.sanderson@glasgow.ac.uk

PROF. PATRICK J. SCHEMBRI
Department of Biology, University of Malta,
Msida, Malta
Email: patrick.j.schembri@um.edu.mt

DR SIMON STODDART
Department of Archaeology, University of
Cambridge, Cambridge, UK
Email: ss16@cam.ac.uk

DR SEAN TAYLOR
Department of Archaeology, University of
Cambridge, Cambridge, UK
Email: st435@cam.ac.uk

DR DAVID TRUMPT

DR JONATHAN TURNER
Department of Geography, National University
of Ireland, University College, Dublin, Ireland
Email: jonathan.turner@ucd.ie

PROF. NICHOLAS C. VELLA
Department of Classics and Archaeology, Faculty
of Arts, University of Malta, Msida, Malta
Email: nicholas.vella@um.edu.mt

DR NATHAN WRIGHT
School of Social Science, The University of
Queensland, Brisbane, Australia
Email: n.wright@uq.edu.au

Figures

0.1	<i>Location map of the Maltese Islands in the southern Mediterranean Sea.</i>	2
0.2	<i>Location of the main Neolithic archaeological and deep coring sites investigated on Malta and Gozo.</i>	11
0.3	<i>Some views of previous excavations on Malta and Gozo.</i>	12–13
0.4	<i>Some views of recent excavations.</i>	14
1.1	<i>The location of the Maltese Islands in the southern Mediterranean Sea with respect to Sicily and North Africa.</i>	20
1.2	<i>Stratigraphic column of the geological formations reported for the Maltese Islands.</i>	22
1.3	<i>Geological map of the Maltese Islands.</i>	22
1.4	<i>Typical coastal outcrops of Lower Coralline Limestone, forming sheer cliffs.</i>	23
1.5	<i>Characteristic geomorphological features developed on the Lower Coralline Limestone in western Gozo (Dwerja Point).</i>	24
1.6	<i>The Middle Globigerina Limestone at the Xwejni coastline.</i>	24
1.7	<i>An overview of the area investigated in western Malta.</i>	25
1.8	<i>The end of the major fault system of Malta (Victorian Lines) at Fomm Ir-Rih.</i>	26
1.9	<i>An overview of the western part of Gozo where the chert outcrops are located.</i>	27
1.10	<i>Chert outcrops: a) and c) bedded chert, and b) and d) nodular chert.</i>	27
1.11	<i>Four characteristic exposures of the Blue Clay formation on Gozo and Malta.</i>	28
1.12	<i>Map of the fault systems, arranged often as northwest–southeast oriented graben, and strike-slip structures.</i>	30
2.1	<i>Summary of new radiocarbon dating of Neolithic and Bronze Age sites on Gozo and Malta.</i>	36
2.2	<i>Summed radiocarbon ages for the main sediment cores.</i>	36
2.3	<i>The location of the Birżebbuġa Għar Dalam and Borġ in-Nadur basins and their GNSS-located GPR lines.</i>	42
2.4	<i>The core locations in Malta and Gozo.</i>	44
2.5	<i>Radiocarbon activity in settlement cores.</i>	48
2.6	<i>The Xemxija 2 core by depth.</i>	51
2.7	<i>The Wied Żembaq 1 and 2 cores by depth.</i>	52
2.8	<i>The Mġarr ix-Xini core by depth.</i>	54
2.9	<i>The Marsaxlokk 1 core and part of 2 by depth.</i>	55
2.10	<i>The resistivity and magnetic susceptibility graphs for Xemxija 1 core.</i>	60
2.11	<i>The resistivity and magnetic susceptibility graphs for Xemxija 2 core.</i>	60
2.12	<i>The multi-element data plots for Xemxija 1 core.</i>	61
2.13	<i>The multi-element data plots for Wied Żembaq 1 core.</i>	62
2.14	<i>The multi-element data plots for Marsaxlokk 1 core.</i>	63
2.15	<i>RUSLE models of soil erosion for the Maltese Islands in September and March.</i>	69
2.16	<i>R and C factors and their product.</i>	70
3.1	<i>Valley catchments and core locations in the Mistra area of Malta.</i>	79
3.2	<i>The modern pollen spectra.</i>	81
3.3	<i>Pollen zonation for the Salina Deep Core.</i>	82–3
3.4	<i>Pollen zonation for the Salina 4 core.</i>	88–9
3.5	<i>Pollen zonation for the Wied Żembaq 1 core.</i>	92–3
3.6	<i>Pollen zonation for the Xemxija 1 core.</i>	96–7
3.7	<i>Pollen zonation for the pit fills at In-Nuffara.</i>	101
3.8	<i>Pollen and palynofacies from the buried soils below the temple at Santa Verna.</i>	102
3.9	<i>Pollen and palynofacies from Test Pit 1 on the southwestern edge of the Ġgantija platform.</i>	104
3.10	<i>Photomicrographs (x800) of key components of the palynofacies at Santa Verna and Ġgantija.</i>	106
4.1	<i>Marsaxlokk 1 molluscan histogram.</i>	120
4.2	<i>Wied Żembaq 1 molluscan histogram.</i>	122
4.3	<i>Mġarr ix-Xini molluscan histogram.</i>	129
4.4	<i>Marsa 2 molluscan histogram.</i>	134
4.5	<i>Salina Deep Core molluscan histogram.</i>	138
4.6	<i>Marine molluscan histogram for the Salina Deep Core.</i>	139

4.7	<i>Xemxija 1 molluscan histogram.</i>	144
4.8	<i>Base of Xemxija 2 molluscan histogram.</i>	145
5.1	<i>Location map of the test excavation/sample sites and geoarchaeological survey areas on Gozo and Malta.</i>	164
5.2	<i>Plan of Santa Verna temple and the locations of the test trenches.</i>	166
5.3	<i>Santa Verna excavation trench profiles all with sample locations marked.</i>	167
5.4	<i>The red-brown buried soil profiles in Trench E, the Ashby and Trump Sondages within the Santa Verna temple site.</i>	170
5.5	<i>Santa Verna soil photomicrographs.</i>	172–3
5.6	<i>Plan of Ġgantija temple and locations of Test Pit 1 and the WC Trench excavations, with as-dug views of the WC Trench and TP1.</i>	175
5.7	<i>Section profiles of Ġgantija Test Pit 1 on the southwest side of Ġgantija temple and the east-west section of the Ġgantija WC Trench on the southeast side.</i>	176
5.8	<i>Ġgantija TP 1 photomicrographs.</i>	178
5.9	<i>Ġgantija WC Trench 1 photomicrographs.</i>	180
5.10	<i>Section profiles of Trench A at Skorba showing the locations of the micromorphological and OSL samples.</i>	183
5.11	<i>Skorba Trench A, section 1, photomicrographs.</i>	185
5.12	<i>Skorba Trench A, section 2, photomicrographs.</i>	186
5.13	<i>Taċ-Ċawla soil photomicrographs.</i>	189
5.14	<i>A typical terra rossa soil sequence in Xaghra town at construction site 2.</i>	191
5.15	<i>Xaghra soil photomicrographs.</i>	191
5.16	<i>In-Nuffara photomicrographs.</i>	193
5.17	<i>The Marsalforn (Pr 626) and Ramla (Pr 627) valley fill sequences, with the micromorphology samples and OSL profiling/dating loci marked.</i>	194
5.18	<i>Ramla and Marsalforn valley profiles soil photomicrographs.</i>	195
5.19	<i>Photomicrographs of the Blue Clay and Greensand geological substrates from the Ramla valley.</i>	199
5.20	<i>Xemxija 1 deep valley core photomicrographs.</i>	202
5.21	<i>Wied Żembaq 1 deep valley core photomicrographs.</i>	206
5.22	<i>Marsaxlokk and Salina Deep Core photomicrographs.</i>	210
5.23	<i>Scrub woodland on an abandoned terrace system and garrigue plateau land on the north coast of Gozo.</i>	213
5.24	<i>Terracing within land parcels (defined by modern sinuous lanes) on the Blue Clay slopes of the Ramla valley with Xaghra in the background.</i>	216
6.1	<i>The location of the Cambridge Gozo Project survey areas.</i>	224
6.2	<i>Fieldwalking survey data from around A. Ta Kuljat, B. Santa Verna, and C. Ghajnsielem on Gozo from the Cambridge Gozo survey and the FRAGSUS Project.</i>	227
6.3	<i>The first cycle of Neolithic occupation as recorded by the Cambridge Gozo survey using kernel density analysis for the Ghar Dalam, Red Skorba and Grey Skorba phases.</i>	229
6.4	<i>The first half of the second cycle of Neolithic occupation as recorded by the Cambridge Gozo survey using kernel density analysis implemented for the Żebbuġ and Mġarr phases.</i>	232
6.5	<i>The second half of the second cycle of Neolithic occupation as recorded by the Cambridge Gozo survey using kernel density analysis for the Ġgantija and Tarxien phases.</i>	233
7.1	<i>Kernel density analysis of the Tarxien Cemetery, Borġ in-Nadur and Bahrija periods for the areas covered by the Cambridge Gozo survey.</i>	244
7.2a	<i>The evidence for Bronze Age settlement in the Mdina area on Malta.</i>	245
7.2b	<i>The evidence for Bronze Age settlement in the Rabat (Gozo) area.</i>	245
7.3	<i>Distribution of Early Bronze Age dolmen on the Maltese Islands.</i>	246
7.4	<i>Distribution of presses discovered in the Mġarr ix-Xini valley during the survey.</i>	248
7.5	<i>The cultural heritage record of the Punic tower in Żurrieq through the centuries.</i>	249
7.6	<i>The changing patterns of social resilience, connectivity and population over the course of the centuries in the Maltese Islands.</i>	252
8.1	<i>An oblique aerial image of the northern slopes of the Maghtab land-fill site, depicting landscaping efforts including 'artificial' terracing.</i>	256
8.2	<i>RUSLE estimates of areas of low and moderate erosion for Gozo and Malta.</i>	259
9.1	<i>a) Sheep being led to their fold in Pwales down a track; b) Sheep grazing along a track on the Bajda Ridge in Xemxija, Malta.</i>	269

9.2	<i>Least-cost paths (LCPs), connecting garrigue areas, representing potential foraging routes across the Maltese landscape.</i>	271
9.3	<i>Density of LCPs connecting garrigue areas to random points within the garrigue areas themselves.</i>	272
9.4	<i>Location of 'public spaces', with size proportional to the distance to the nearest garrigue-to-garrigue LCP.</i>	273
9.5	<i>LCPs connecting farmhouses hosting animal pens to randomly generated points within garrigue areas in northwestern (A) and northeastern (B) Malta.</i>	274
9.6	<i>As for Figure 9.5, but representing west-central and east-central Malta.</i>	274
9.7	<i>As for Figure 9.5, but representing southern and southwestern Malta.</i>	275
9.8	<i>Location of 'public spaces', with size proportional to the distance to the nearest outbound journey.</i>	276
9.9	<i>a) Public space at Tal-Wei, between the modern town of Mosta and Naxxar; b) Tal-Wei public space as represented in 1940s survey sheets.</i>	277
9.10	<i>Approximate location of the (mostly disappeared) raħal toponyms.</i>	279
9.11	<i>Isochrones around farmhouse 4 representing the space that can be covered at 1-hour intervals considering animal walking speed.</i>	280
9.12	<i>Isochrones around farmhouse 2 representing the space that can be covered at 1-hour intervals considering animal walking speed (grazing while walking).</i>	281
9.13	<i>a) Isochrones around farmhouse 5 representing the space that can be covered at 1-hour intervals; b) Isochrones around farmhouse 6; c) Isochrones around farmhouse 7.</i>	282
10.1	<i>The likely distribution of built-up and cave-dwellings in the second half of the fourteenth century.</i>	286
10.2	<i>The lower frequency of settlement distribution by c. AD 1420.</i>	286
10.3	<i>The distribution of settlements just before AD 1530.</i>	288
10.4	<i>The late medieval Falson Palace in Mdina.</i>	289
10.5	<i>A girna integral with and surrounded by stone dry walling.</i>	290
10.6	<i>A hovel dwelling with a flight of rock-cut steps.</i>	291
10.7	<i>The hierarchical organisation of settlements continued, with the addition of Valletta, Floriana and the new towns around Birgu.</i>	295
10.8	<i>An example of a seventeenth century townhouse with open and closed timber balconies.</i>	296
10.9	<i>An example of a two-storey razzett belonging to a wealthier peasant family.</i>	297
10.10	<i>The distribution of built-up settlements in about AD 1900.</i>	299
10.11	<i>An example of a Neo-Classical house.</i>	301
11.1	<i>Summary of tree and shrub pollen frequencies at 10 sample sites.</i>	304
11.2	<i>Summary of cereal pollen frequencies at 14 sample sites.</i>	305
11.3	<i>Schematic profiles of possible trajectories of soil development in the major geological zones of Malta and Gozo.</i>	311
11.4	<i>The main elements of a new cultural-environmental story of the Maltese Islands throughout the last 10,000 years.</i>	317
A2.1	<i>Marsalforn valley, Gozo.</i>	360
A2.2	<i>Marsalforn valley, Gozo.</i>	361
A2.3	<i>Ramla valley, Gozo.</i>	361
A2.4	<i>Ġgantija Test Pit 1, Gozo.</i>	361
A2.5	<i>Skorba Neolithic site; trench A, East section; trench A, South section.</i>	362
A2.6	<i>Skorba, Trench A, South section.</i>	362
A2.7	<i>Tal-Istabal, Qormi, Malta.</i>	364
A2.8	<i>Tal-Istabal, Qormi, Malta.</i>	364
A2.9	<i>Photograph, showing locations of profile sample and OSL tubes, and luminescence-depth profile, for the sediment stratigraphy sampled in profile 1.</i>	365
A2.10	<i>Photograph, and luminescence-depth profile, for the sediment stratigraphy sampled in profile 3.</i>	365
A2.11	<i>Photograph, and luminescence-depth profile, for the sediment stratigraphy sampled in profile 2.</i>	366
A2.12	<i>Photograph, and luminescence-depth profile, for the sediment stratigraphy sampled in profiles 4 and 6.</i>	366
A2.13	<i>Photograph, and luminescence-depth profile, for the sediment stratigraphy sampled in profile 5.</i>	367
A2.14	<i>Apparent dose and sensitivity for laboratory OSL and IRSL profile measurements for SUTL2916 (P1).</i>	370
A2.15	<i>Apparent dose and sensitivity for laboratory OSL and IRSL profile measurements for SUTL2920 (P2).</i>	370
A2.16	<i>Apparent dose and sensitivity for laboratory OSL and IRSL profile measurements for SUTL2913 (P3).</i>	370
A2.17	<i>Apparent dose and sensitivity for laboratory OSL and IRSL profile measurements for SUTL2924 (P4).</i>	370

A2.18	<i>Apparent dose and sensitivity for laboratory OSL and IRSL profile measurements for SUTL2929 (P5).</i>	371
A2.19	<i>Apparent dose and sensitivity for laboratory OSL and IRSL profile measurements for SUTL2928 (P6).</i>	371
A2.20	<i>Apparent dose and sensitivity for laboratory OSL and IRSL profile measurements for SUTL2931 (P7).</i>	371
A2.21	<i>Probability Distribution Functions for the stored dose on samples SUTL2914 and 2915.</i>	374
A2.22	<i>Probability Distribution Functions for the stored dose on samples SUTL2917–2919.</i>	374
A2.23	<i>Probability Distribution Functions for the stored dose on samples SUTL2921–2923.</i>	375
A2.24	<i>Probability Distribution Functions for the stored dose on samples SUTL2925–2927.</i>	375
A2.25	<i>Probability Distribution Function for the stored dose on sample SUTL2930.</i>	376
SB.1	<i>Dose response curves for SUTL2914.</i>	385
SB.2	<i>Dose response curves for SUTL2915.</i>	385
SB.3	<i>Dose response curves for SUTL2917.</i>	386
SB.4	<i>Dose response curves for SUTL2918.</i>	386
SB.5	<i>Dose response curves for SUTL2919.</i>	387
SB.6	<i>Dose response curves for SUTL2921.</i>	387
SB.7	<i>Dose response curves for SUTL2922.</i>	388
SB.8	<i>Dose response curves for SUTL2923.</i>	388
SB.9	<i>Dose response curves for SUTL2925.</i>	389
SB.10	<i>Dose response curves for SUTL2926.</i>	389
SB.11	<i>Dose response curves for SUTL2927.</i>	390
SB.12	<i>Dose response curves for SUTL2930.</i>	390
SC.1	<i>Abanico plot for SUTL2914.</i>	391
SC.2	<i>Abanico plot for SUTL2915.</i>	391
SC.3	<i>Abanico plot for SUTL2917.</i>	392
SC.4	<i>Abanico plot for SUTL2918.</i>	392
SC.5	<i>Abanico plot for SUTL2919.</i>	392
SC.6	<i>Abanico plot for SUTL2921.</i>	393
SC.7	<i>Abanico plot for SUTL2922.</i>	393
SC.8	<i>Abanico plot for SUTL2923.</i>	393
SC.9	<i>Abanico plot for SUTL2925.</i>	394
SC.10	<i>Abanico plot for SUTL2926.</i>	394
SC.11	<i>Abanico plot for SUTL2927.</i>	394
SC.12	<i>Abanico plot for SUTL2930.</i>	395
SD.1	<i>Apparent ages for profile 1, with OSL ages.</i>	397
SD.2	<i>Apparent ages for profile 2, with OSL ages.</i>	397
SD.3	<i>Apparent ages for profile 3, with OSL ages.</i>	398
SD.4	<i>Apparent ages for profiles 4 and 6, with OSL ages.</i>	398
SD.5	<i>Apparent ages for profile 5, with OSL ages.</i>	399
SD.6	<i>Apparent ages for profile 7.</i>	399

Tables

1.1	<i>Description of the geological formations found on the Maltese Islands.</i>	21
2.1	<i>The cultural sequence of the Maltese Islands (with all dates calibrated).</i>	37
2.2	<i>Quartz OSL sediment ages from the Marsalforn (2917–2919) and Ramla (2921–2923) valleys, the Skorba temple/buried soil (2925–2927) and Tal-Istabal, Qormi, soil (2930).</i>	40
2.3	<i>Dating results for positions in the sediment cores.</i>	45
2.4	<i>Summary stratigraphic descriptions of the sequences in the deep core profiles.</i>	57
2.5	<i>Mean sediment accumulation rates per area versus time for the deep cores.</i>	64
2.6	<i>Radiocarbon measurements and ΔR values from early twentieth century marine shells from Malta.</i>	65
2.7	<i>Calibrated AMS ^{14}C dates of charred plant remains from Santa Verna palaeosol, Gozo.</i>	68
2.8	<i>Physical properties of the catchments.</i>	68
2.9	<i>Normalized Diffuse Vegetation Index (NDVI) for the catchments in 2014–15 and average rainfall data for the weather station at Balzan for the period 1985 to 2012.</i>	69
3.1	<i>Semi-natural plant communities in the Maltese Islands.</i>	76

3.2	<i>Attribution of pollen taxa to plant communities in the Maltese Islands and more widely in the Central Mediterranean.</i>	77
3.3	<i>Characteristics of the taphonomic samples from on-shore and off-shore Mistra Valley, Malta.</i>	80
3.4	<i>The pollen zonation of the Salina Deep Core with modelled age-depths.</i>	84
3.5	<i>The pollen zonation of the Salina 4 core with modelled age-depths.</i>	90
3.6	<i>The pollen zonation of the Wied Żembaq 1 core with modelled age-depths.</i>	94
3.7	<i>The pollen zonation of the Xemxija 1 core with modelled age-depths.</i>	98
3.8	<i>The pollen zonation of the fill of a Bronze Age silo at In-Nuffara, Gozo.</i>	103
3.9	<i>Summary of the pollen analyses of the buried soil below the Santa Verna temple structure.</i>	103
3.10	<i>Summary of the pollen analyses from the buried soil in Ġgantija Test Pit 1.</i>	105
3.11	<i>Activity on Temple sites and high cereal pollen in adjacent cores.</i>	105
4.1	<i>List of freshwater molluscs and land snails found in the cores, habitat requirement, palaeontological record and current status and conservation in the Maltese Islands.</i>	118
4.2	<i>Molluscan zones for the Marsaxlokk 1 core (MX1).</i>	121
4.3	<i>Molluscan zones for the Wied Żembaq 1 core (WŻ1).</i>	123
4.4	<i>Molluscan zones for the Wied Żembaq 2 core (WŻ2).</i>	125
4.5	<i>Integration of molluscan zones from the Wied Żembaq 1 and 2 cores.</i>	128
4.6	<i>Molluscan zones for the Mgarr ix-Xini 1 core (MGX1).</i>	130
4.7	<i>Molluscan zones for the Marsa 2 core (MC2).</i>	135
4.8	<i>The non-marine molluscan zones for the Salina Deep Core (SDC).</i>	140
4.9	<i>Molluscan zones for the Salina Deep Core (SDC).</i>	142
4.10	<i>Molluscan zones for the Xemxija 1 core (XEM1).</i>	146
4.11	<i>Molluscan zones for the Xemxija 2 core (XEM2).</i>	148
4.12	<i>Correlation and integration of molluscan data from Xemxija 1 (XEM1) and Xemxija 2 (XEM2).</i>	151
5.1	<i>Micromorphology and small bulk sample sites and numbers.</i>	162
5.2	<i>Summary of available dating for the sites investigated in Gozo and Malta.</i>	163
5.3	<i>pH, magnetic susceptibility, loss-on-ignition, calcium carbonate and % sand/silt/clay particle size analysis results for the Ġgantija, Santa Verna and the Xaghra town profiles, Gozo.</i>	168
5.4	<i>Selected multi-element results for Ġgantija, Santa Verna and Xaghra town buried soils, and the Marsalforn and Ramla valley sequences, Gozo.</i>	169
5.5	<i>Summary of the main soil micromorphological observations for the Santa Verna, Ġgantija and the Xaghra town profiles, Gozo.</i>	181
5.6	<i>pH, magnetic susceptibility and selected multi-element results for the palaeosols in section 1, Trench A, Skorba.</i>	184
5.7	<i>Loss-on-ignition organic/carbon/calcium carbonate frequencies and particle size analysis results for the palaeosols in section 1, Trench A, Skorba.</i>	184
5.8	<i>Summary of the main soil micromorphological observations of the buried soils in sections 1 and 2, Trench A, Skorba.</i>	188
5.9	<i>Summary of the main soil micromorphological observations of the possible buried soils at Taċ-Ċawla.</i>	189
5.10	<i>Field descriptions and micromorphological observations for the quarry and construction site profiles in Xaghra town.</i>	190
5.11	<i>Sample contexts and micromorphological observations for two silo fills at In-Nuffara.</i>	192
5.12	<i>Summary of the main soil micromorphological observations from the Ramla and Marsalforn valley fill profiles.</i>	196
5.13	<i>Main characteristics of the Upper and Lower Coralline Limestone, Globigerina Limestone, Blue Clay and Greensand.</i>	197
5.14	<i>Summary micromorphological descriptions and suggested interpretations for the Xemxija 1 core.</i>	200
5.15	<i>Summary micromorphological descriptions and suggested interpretations for the Wied Żembaq 1 core.</i>	207
5.16	<i>Summary micromorphological descriptions and suggested interpretations for the Marsaxlokk 1 core.</i>	209
5.17	<i>Summary micromorphological descriptions and suggested interpretations for the base zone of the base of the Salina Deep Core.</i>	211
8.1	<i>Carrying capacity estimates for the Neolithic/Temple Period of the Maltese Archipelago.</i>	258
8.2	<i>Summary of population changes in the Maltese Archipelago.</i>	261
11.1	<i>Summary of the environmental and vegetation changes in the Maltese Islands over the longue durée.</i>	306

11.2	<i>Summary of events revealed by the molluscan data in the deep cores.</i>	309
11.3	<i>Major phases of soil, vegetation and landscape development and change during the Holocene.</i>	312
11.4	<i>Occurrence of gypsum in FRAGSUS cores and contemporary events.</i>	314
A2.1	<i>Sample descriptions, contexts and archaeological significance of the profiling samples used for initial screening and laboratory characterization.</i>	358
A2.2	<i>Sample descriptions, contexts and archaeological significance of sediment samples SUTL2914–2930.</i>	360
A2.3	<i>Activity and equivalent concentrations of K, U and Th determined by HRGS.</i>	368
A2.4	<i>Infinite matrix dose rates determined by HRGS and TSBC.</i>	368
A2.5	<i>Effective beta and gamma dose rates following water correction.</i>	369
A2.6	<i>SAR quality parameters.</i>	369
A2.7	<i>Comments on equivalent dose distributions of SUTL2914 to SUTL2930.</i>	372
A2.8	<i>Quartz OSL sediment ages.</i>	372
A2.9	<i>Locations, dates and archaeological significance of sediment samples SUTL2914–2930.</i>	373
SA.1	<i>Field profiling data, as obtained using portable OSL equipment, for the sediment stratigraphies examined on Gozo and Malta.</i>	379
SA.2	<i>OSL screening measurements on paired aliquots of 90–250 µm 40% HF-etched ‘quartz’.</i>	380
SA.3	<i>OSL screening measurements on three aliquots of 90–250 µm 40% HF-etched ‘quartz’ for SUTL2924.</i>	382
SA.4	<i>IRSL screening measurements on paired aliquots of 90–250 µm 15% HF-etched ‘polym mineral’.</i>	382
SA.5	<i>IRSL screening measurements on three aliquots of 90–250 µm 15% HF-etched ‘polym mineral’ for SUTL2924.</i>	383
A3.1	<i>Stratigraphy and interpretation of the Salina Deep Core.</i>	401
A3.2	<i>Stratigraphy and interpretation of the Salina 4 core.</i>	405
A3.3	<i>Stratigraphy and interpretation of the Salina 2 core.</i>	407
A3.4	<i>Stratigraphy and interpretation of the Xemxija 1 core.</i>	408
A3.5	<i>Stratigraphy and interpretation of the Xemxija 2 core.</i>	411
A3.6	<i>Stratigraphy and interpretation of the Wied Żembaq 1 core.</i>	413
A3.7	<i>Stratigraphy and interpretation of the Wied Żembaq 2 core.</i>	413
A3.8	<i>Stratigraphy and interpretation of the Mgarr ix-Xini core.</i>	414
A3.9	<i>Stratigraphy and interpretation of the Marsaxlokk core.</i>	416
A3.10	<i>Stratigraphy and interpretation of the Marsa 2 core.</i>	417
A3.11	<i>Stratigraphy and interpretation of the Mellieħa Bay core.</i>	418
A3.12	<i>Key to the scheme for the description of Quaternary sediments.</i>	419
A4.1	<i>Marsa 2.</i>	421 (online edition only)
A4.2	<i>Mgarr ix-Xini.</i>	424 (online edition only)
A4.3	<i>Salina Deep Core.</i>	427 (online edition only)
A4.4	<i>Wied Żembaq 2.</i>	429 (online edition only)
A4.5	<i>Wied Żembaq 1.</i>	430 (online edition only)
A4.6	<i>Xemxija 1.</i>	432 (online edition only)
A4.7	<i>Xemxija 2.</i>	435 (online edition only)
A4.8	<i>Marsaxlokk 1.</i>	438 (online edition only)
A5.1	<i>Marsa 2.</i>	442 (online edition only)
A5.2	<i>Mgarr ix-Xini.</i>	456 (online edition only)
A5.3	<i>Salina Deep Core non-marine.</i>	466 (online edition only)
A5.4	<i>Salina Deep Core marine.</i>	478 (online edition only)
A5.5	<i>Wied Żembaq 2.</i>	490 (online edition only)
A5.6	<i>Wied Żembaq 1.</i>	496 (online edition only)
A5.7	<i>Xemxija 1.</i>	502 (online edition only)
A5.8	<i>Xemxija 2.</i>	516 (online edition only)
A5.9	<i>Marsaxlokk 1.</i>	528 (online edition only)
A8.1	<i>Xemxija 1 core micromorphology sample descriptions.</i>	557
A8.2	<i>Wied Żembaq 1 core micromorphology sample descriptions.</i>	559
A8.3	<i>Marsaxlokk core micromorphology sample descriptions.</i>	560
A8.4	<i>Salina Deep Core micromorphology sample descriptions.</i>	561
A9.1	<i>The charcoal data from the Skorba, Kordin, In-Nuffara and Salina Deep Core.</i>	563

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 Ġhajnsielem 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.

Acknowledgements

This volume records research undertaken with funding from the European Research Council under the European Union's Seventh Framework Programme (FP/2007-2013)/ERC Grant Agreement n. 323727 (*FRAGSUS Project: Fragility and sustainability in small island environments: adaptation, cultural change and collapse in prehistory* – <http://www.qub.ac.uk/sites/FRAGSUS/>). All the authors of this volume are indebted to the ERC for its financial support, and to the Principal Investigator of the *FRAGSUS Project*, Prof. Caroline Malone (Queen's University, Belfast, UK), for her central role in devising the project and seeing this research through to publication.

For Chapter 2, we extend warm thanks to the staff of the ¹⁴CHRONO 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.

For Chapter 5, we would like to thank all at Heritage Malta, the Ġgantija visitor's centre and the University of Malta for their friendly and useful assistance throughout. In particular, we would like to thank George Azzopardi, Daphne Caruana, Josef Caruana, Nathaniel Cutajar, Chris Gemmell, Reuben Grima, Joanne Mallia, Christian Mifsud, Anthony Pace, Ella Samut-Tagliaferro, Mevrick Spiteri, Katya Stroud, Sharon Sultana and Nick Vella. We also thank Tonko Rajkovača of the McBurney Laboratory, Department of Archaeology, University of Cambridge, for making the thin section slides, the Physical Geography Laboratory, Department of Geography, University of Cambridge, and the ALS Global laboratory in Seville, Spain, for processing the multi-element analyses.

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

Environment and Planning Authority. A number of individuals were happy to share their recollections of shepherding practices in Malta and Gozo over the last sixty or seventy years; others facilitated the encounters. We are grateful to all of them: Charles Gauci, Grezzju Meilaq, Joseph Micallef, Louis Muscat, Ċettina and Anglu Vella, Ernest Vella and Renata Zerafa.

Simon Stoddart would like to thank Prof. Martin Jones and Rachel Ballantyne for their advice in constructing Figure 11.4. The editors would like to thank Emma Hannah for compiling the index.

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, Haġar 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 4

Granulometry of the deep cores

Katrin Fenech

Table A4.1. *Marsa 2.*

Depth (cm)	3	8	13	18	23	28	33	38	43
>8 mm	0	13	0	0	0	0	0	0	0
>500 μ	7	12	15	21	15	17	0	0	0
>63 μ	59	53	56	48	56	87	100	100	100
<63 μ	146	123	145	156	135	132	0	0	0
Munsell	10 YR 6/4	10 YR 6/4	10 YR 6/4	10 YR 6/4	10 YR 6/4	10 YR 6/4			

Depth (cm)	48	53	58	63	68	73	78	83	88
>8 mm	0	0	0	0	0	0	0	0	0
>500 μ	0	0	0	0	0	0	0	15	58
>63 μ	100	100	100	100	100	100	100	65	13
<63 μ	0	0	0	0	0	0	0	191	144
Munsell								10 YR 5/4	10 YR 5/4

Depth (cm)	93	98	103	107	113	118	123	128	133
>8 mm	0	0	0	0	12	132	100	100	100
>500 μ	17	15	14	22	25	24	0	0	0
>63 μ	58	65	77	72	90	30	0	0	0
<63 μ	103	127	127	126	81	48	0	0	0
Munsell	10 YR 5/4	2.5 YR 5/2	2.5 YR 5/2	2.5 YR 5/2	2.5 YR 5/2	2.5 YR 5/2			

Depth (cm)	138	143	148	153	158	163	168	173	178
>8 mm	100	100	100	100	100	100	100	49	38
>500 μ	0	0	0	0	0	0	0	38	26
>63 μ	0	0	0	0	0	0	0	90	43
<63 μ	0	0	0	0	0	0	0	116	24
Munsell								2.5 YR 6/1	2.5 YR 6/1

Depth (cm)	183	188	193	198	203	208	213	218	223
>8 mm	8	8	0	0	0	0	0	0	100
>500 μ	57	55	23	10	12	8	10	8	0
>63 μ	54	57	51	28	18	38	36	33	0
<63 μ	45	53	105	136	140	89	98	141	0
Munsell	2.5 YR 6/1	2.5 YR 6/1	2.5 YR 6/1	2.5 YR 5/1	2.5 YR 5/1	2.5 YR 5/1	2.5 YR 5/1	2.5 YR 5/1	

Appendix 4

Table A4.1 (cont.).

Depth (cm)	228	233	238	243	248	253	258	263	268
>8 mm	100	100	100	100	100	100	137	42	133
>500 μ	0	0	0	0	0	0	0	7	12
>63 μ	0	0	0	0	0	0	0	9	19
<63 μ	0	0	0	0	0	0	0	16	34
Munsell							2.5 YR 5/1	2.5 YR 5/1	2.5 YR 5/1

Depth (cm)	273	278	283	288	293	298	303	308	313
>8 mm	30	0	0	0	0	0	0	0	0
>500 μ	14	13	7	11	12	14	10	13	14
>63 μ	31	32	31	45	44	34	24	39	29
<63 μ	89	120	108	111	72	105	88	74	91
Munsell	2.5 YR 5/1	2.5 YR 5/1	2.5 YR 5/1	2.5 YR 5/1	2.5 YR 5/1	2.5 YR 5/1	2.5 YR 5/1	2.5 YR 5/1	2.5 YR 5/1

Depth (cm)	318	323	328	333	338	343	348	353	358
>8 mm	0	0	0	0	0	0	0	0	0
>500 μ	12	9	17	12	16	16	16	18	22
>63 μ	24	29	33	41	30	23	38	32	38
<63 μ	103	53	75	60	74	66	62	92	99
Munsell	2.5 YR 5/1	2.5 YR 5/1	2.5 YR 5/1	2.5 YR 5/1	2.5 YR 5/1	2.5 YR 5/1	2.5 YR 5/1	2.5 YR 5/1	2.5 YR 5/1

Depth (cm)	363	368	373	378	383	388	393	398	403
>8 mm	0	0	0	0	0	0	0	0	0
>500 μ	26	14	18	17	18	16	20	34	31
>63 μ	36	48	45	34	48	44	50	54	62
<63 μ	92	50	103	87	66	80	79	48	68
Munsell	2.5 YR 5/1	2.5 YR 5/1	2.5 YR 5/1	2.5 YR 5/1	2.5 YR 5/1	2.5 YR 4/1	2.5 YR 4/1	2.5 YR 4/1	2.5 YR 4/1

Depth (cm)	408	413	418	423	428	433	438	443	448
>8 mm	0	0	0	0	0	0	0	0	0
>500 μ	23	24	34	31	24	12	21	22	29
>63 μ	73	62	72	53	42	27	38	40	46
<63 μ	42	72	101	63	63	23	47	43	52
Munsell	2.5 YR 4/1	2.5 YR 4/1	2.5 YR 4/1	2.5 YR 4/1	2.5 YR 4/1	2.5 YR 4/1	2.5 YR 4/1	2.5 YR 4/1	2.5 YR 4/1

Depth (cm)	453	458	463	468	473	478	483	488	493
>8 mm	0	0	0	0	20	4	0	26	0
>500 μ	19	41	31	38	28	46	30	28	29
>63 μ	44	57	60	61	55	52	50	40	49
<63 μ	46	58	58	83	71	64	76	85	84
Munsell	2.5 YR 4/1	2.5 YR 4/1	2.5 YR 4/1	2.5 YR 4/1	2.5 YR 4/1	2.5 YR 4/1	2.5 YR 4/1	2.5 YR 4/1	2.5 YR 4/1

Depth (cm)	498	503	508	513	518	523	528	533	538
>8 mm	0	14	42	0	17	0	0	0	0
>500 μ	25	41	31	34	10	100	0	0	0
>63 μ	45	49	37	34	46	100	100	100	100
<63 μ	84	69	55	96	112	0	0	0	0
Munsell	2.5 YR 4/1	2.5 YR 4/1	2.5 YR 4/1	2.5 YR 4/1	2.5 YR 4/1				

Granulometry of the deep cores

Table A4.1 (cont.).

Depth (cm)	543	548	553	558	563	568	573	578	583
>8 mm	0	0	0	0	0	0	0	0	0
>500 μ	0	0	0	0	0	0	0	0	0
>63 μ	100	100	100	100	100	100	100	100	100
<63 μ	0	0	0	0	0	0	0	0	0
Munsell									

Depth (cm)	588	593	598	603	608	613	618	623	628
>8 mm	0	0	0	0	11	0	0	2	0
>500 μ	0	28	30	29	26	35	37	23	14
>63 μ	100	29	32	19	29	31	23	29	31
<63 μ	0	24	59	61	62	51	68	59	97
Munsell		2.5 YR 4/1	2.5 YR 4/1	2.5 YR 4/1	2.5 YR 4/1	2.5 YR 4/1	2.5 YR 4/1	2.5 YR 4/1	2.5 YR + 7.5 YR 3/2

Depth (cm)	633	638	643	648	653	658	663	668	673
>8 mm	0	0	8	12	36	16	73	46	55
>500 μ	30	13	22	42	50	45	33	62	65
>63 μ	42	52	30	47	24	29	29	21	16
<63 μ	82	110	106	99	136	91	85	106	85
Munsell	5 YR 3/2	5 YR 3/2	5 YR 3/2 + 10 YR 4/3	10 YR 4/3	10 YR 5/4	10 YR 5/4	10 YR 5/4	10 YR 5/4	10 YR 5/4

Depth (cm)	678	683	688	693	698	703	708	713	718
>8 mm	154	100	100	100	100	12	8	0	0
>500 μ	52	0	0	0	0	25	45	34	30
>63 μ	25	0	0	0	0	4	11	7	54
<63 μ	40	0	0	0	0	3	14	11	68
Munsell	10 YR 5/3					7.5 YR 6/8	7.5 YR 6/8	7.5 YR 6/8	7.5 YR 5/6

Depth (cm)	723	728	733	738	743	748	753	758	763
>8 mm	0	0	0	0	0	16	4	11	0
>500 μ	23	129	65	61	33	65	56	32	22
>63 μ	47	31	41	32	41	30	34	39	26
<63 μ	112	36	109	94	103	109	106	106	29
Munsell	7.5 YR 5/6	7.5 YR 5/6	7.5 YR 5/6	7.5 YR 5/6	7.5 YR 5/6	7.5 YR 5/6	7.5 YR 6/6	7.5 YR 6/6	7.5 YR 6/6

Depth (cm)	768	773	778	783	788	793	798	803	808
>8 mm	8	0	28	16	10	17	0	0	0
>500 μ	25	70	84	115	46	18	22	18	19
>63 μ	20	46	27	26	35	40	39	56	40
<63 μ	37	61	60	45	113	116	107	117	96
Munsell	7.5 YR 6/6	7.5 YR 6/6	7.5 YR 6/6	7.5 YR 6/6	7.5 YR 5/6	7.5 YR 5/6	7.5 YR 4/6	7.5 YR 4/6	5 YR 3/4

Depth (cm)	813	818	823	828	833	838	843	848	853
>8 mm	6	0	13	0	0	0	31	4	0
>500 μ	21	3	95	50	72	75	51	31	40
>63 μ	31	19	27	34	46	33	36	32	39
<63 μ	151	74	55	59	61	46	41	73	128
Munsell	5 YR 3/4	5 YR 3/4	7.5 YR 5/6	7.5 YR 5/6	7.5 YR 5/6	7.5 YR 5/6	7.5 YR 5/6	7.5 YR 5/6	7.5 YR 5/6

Appendix 4

Table A4.1 (*cont.*).

Depth (cm)	858	863	868	873	878	883	888	893	898
>8 mm	0	10	183	47	371	0	5	69	186
>500 μ	19	46	31	47	12	23	41	51	31
>63 μ	21	19	14	14	6	31	42	17	9
<63 μ	128	127	27	30	14	46	46	43	12
Munsell	5 YR 3/4	5 YR 3/4	5 YR 3/4	7.5 YR 5/6		7.5 YR 5/6	7.5 YR 5/6	7.5 YR 5/6	7.5 YR 5/6

Depth (cm)	903	908	913	918	923	928	933	938	
>8 mm	128	175	62	59	55	24	75	106	
>500 μ	81	40	63	64	61	22	42	58	
>63 μ	12	18	20	16	10	4	18	14	
<63 μ	24	27	33	31	21	9	23	29	
Munsell	7.5 YR 5/6	7.5 YR 5/6	7.5 YR 5/6	7.5 YR 5/6	7.5 YR 5/6	7.5 YR 5/6	7.5 YR 5/6	7.5 YR 5/6	

Table A4.2. *Mgarr ix-Xini.*

Depth (cm)	56	60	64	67	71	75	79	82	86
>8mm	1	0	2	3	0	4	4	6	0
>500 μ	5	5	6	2	7	8	3	5	8
>63 μ	7	8	8	4	8	4	4	6	7
<63 μ	33	26	33	20	33	13	13	24	25
Munsell	10YR 5/4	10YR 5/4	10YR 5/4	10YR 5/4	10YR 5/4	10YR 5/4	10YR 5/4	10YR 5/4	10YR 5/4

Depth (cm)	90	93	97	100	104	108	111	120	124
>8mm	10	4	8	0	7	2	9	4	15
>500 μ	6	6	5	13	12	13	18	25	10
>63 μ	7	8	8	9	8	14	7	9	6
<63 μ	23	19	19	10	1	10	1	0	1
Munsell	10YR 5/4	10YR 5/4	10YR 5/4	10YR 5/4 + 7/3	10YR 7/3	10YR 7/3	10YR 7/3	10YR 8/2	10YR 8/2

Depth (cm)	132	142	147	152	157	162	167	172	175
>8mm	16	45	16	0	2	0	2	0	0
>500 μ	5	7	11	30	20	13	17	11	5
>63 μ	7	10	7	9	11	7	8	8	2
<63 μ	2	1	1	1	2	1	0	0	0
Munsell	10YR 8/2	10YR 5/2	10YR 5/2	10YR 6/1	10YR 6/1	10YR 6/1	10YR 6/1	10YR 6/1	10YR 6/1

Depth (cm)	191	195	199	204	208	212	216	220	225
>8mm	0	9	5	10	3	3	0	0	0
>500 μ	13	14	25	8	10	5	2	2	2
>63 μ	10	11	10	3	5	6	5	4	5
<63 μ	1	3	4	3	6	30	35	20	40
Munsell	10YR 7/1	10YR 7/1	10YR 7/1	10YR 7/1	10YR 7/1	10YR 5/1	10YR 5/1	10YR 5/1	10YR 6/1

Granulometry of the deep cores

Table A4.2 (cont.).

Depth (cm)	229	233	237	246	251	256	261	266	271
>8mm	0	0	0	10	7	11	2	0	4
>500 μ	4	1	2	20	31	29	15	9	7
>63 μ	5	2	3	9	12	9	6	12	12
<63 μ	34	30	17	1	6	6	25	42	33
Munsell	10YR 6/1	10YR 6/1	10YR 6/1	10YR 5/2	10YR 5/2	10YR 5/2	10YR 5/2 + 6/1	10YR 6/1	10YR 6/1 + 4/1

Depth (cm)	276	281	286	291	296	300	309	314	319
>8mm	0	0	0	0	0	0	0	0	0
>500 μ	2	1	1	1	1	1	8	9	8
>63 μ	5	5	3	2	4	1	8	11	12
<63 μ	30	44	55	58	46	0	38	29	34
Munsell	10YR 4/1	10YR 4/1 + 5/1 + 6/1	10YR 6/1	10YR 6/1	10YR 6/1 + 4/1	10YR 6/1	10YR 6/1	10YR 6/1 + 6/6	10YR 6/1

Depth (cm)	324	329	334	339	344	352	359	364	383
>8mm	0	0	0	36	108	132	0	0	0
>500 μ	5	2	2	5	4	21	8	4	10
>63 μ	6	5	4	6	4	20	14	7	8
<63 μ	27	33	35	22	9	42	34	24	2
Munsell	10YR 6/1	10YR 6/1	10YR 6/1 + 3/1	10YR 6/1 + 3/1	10YR 6/1	10YR 3/1	10YR 3/1	10YR 3/1	10YR 7/2

Depth (cm)	387	391	395	399	403	407	411	415	419
>8mm	0	3	0	6	26	19	11	0	0
>500 μ	22	21	30	12	18	12	25	31	21
>63 μ	10	10	13	5	6	2	4	3	7
<63 μ	3	4	5	5	14	4	6	5	21
Munsell	10YR 7/2	10YR 7/2	10YR 7/2	10YR 7/2 + 3/1	10YR 7/2 + 3/1	10YR 7/2 + 3/1	10YR 7/2 + 3/1	10YR 7/2	10YR 7/2 + 3/1

Depth (cm)	423	427	434	439	444	449	454	459	464
>8mm	0	0	94	26	27	19	7	11	6
>500 μ	2	10	7	16	25	7	11	21	15
>63 μ	9	9	4	8	10	6	7	10	9
<63 μ	38	20	0	2	8	8	14	4	13
Munsell	10YR 4/1	10YR 4/1	10YR 7/2	10YR 7/2	10YR 7/2	10YR 6/1	10YR 6/1	110YR 6/2	10YR 4/1 + 6/2

Depth (cm)	469	474	479	484	489	499	502	506	510
>8mm	31	0	1	0	0	1	2	7	0
>500 μ	7	8	17	28	46	7	15	7	6
>63 μ	10	17	16	9	5	1	4	6	4
<63 μ	7	7	6	2		0	3	4	2
Munsell	10YR 4/1 + 6/2	10YR 4/1 + 6/2	10YR 6/2	10YR 6/2	10YR 6/2	10YR 7/1	10YR 7/1	10YR 7/1	10YR 7/1

Appendix 4

Table A4.2 (cont.).

Depth (cm)	513	517	520	524	528	531	535	538	542
>8mm	0	0	0	0	15	0	0	0	0
>500μ	3	2	2	3	8	11	23	22	12
>63μ	3	2	2	3	5	5	12	13	10
<63μ	2	2	2	1	4	6	7	9	8
Munsell	10YR 6/1	10YR 6/1	10YR 6/1	10YR 4/1	10YR 4/1	10YR 4/1	10YR 4/1 + 6/4	10YR 4/1 + 6/4	10YR 4/1 + 6/4

Depth (cm)	546	549	553	561	566	571	576	581	586
>8mm	0	0	0	10	24	8	3	1	1
>500μ	6	2	1	24	32	19	8	7	5
>63μ	11	12	8	14	12	8	15	16	14
<63μ	13	22	16	6	8	5	8	12	11
Munsell	10YR 4/1 + 6/4	10YR 5/2	10YR 5/2	10YR 7/2	10YR 7/3	10YR 7/3 + 6/1	10YR 6/1	10YR 6/1	10YR 6/1

Depth (cm)	591	596	601	606	611	615	641	644	648
>8mm	0	0	0	0	0	0	0	1	0
>500μ	2	4	3	2	1	1	7	7	8
>63μ	13	11	11	8	5	7	4	5	5
<63μ	11	16	31	26	25	24	1	0	2
Munsell	10YR 6/1	10YR 6/1	10YR 5/1	10YR 5/1	10YR 5/1	10YR 4/1	10YR 5/1	10YR 5/1	10YR 5/1

Depth (cm)	651	655	658	661	665	668	671	675	678
>8mm	0	0	6	2	7	3	5	7	10
>500μ	13	11	4	5	4	5	8	15	17
>63μ	8	8	7	8	6	4	4	5	6
<63μ	4	4	2	4	1	3	3	5	2
Munsell	10YR 5/1	10YR 5/2	10YR 5/2	10YR 5/2	10YR 5/2	10YR 5/2	10YR 5/2	10YR 7/2	10YR 7/2

Depth (cm)	687	692	697	702	707	712	717	722	727
>8mm	21	16	0	1	1	7	5	34	8
>500μ	15	8	2	7	6	14	14	15	28
>63μ	9	10	6	11	10	8	15	14	9
<63μ	11	10	20	21	24	12	10	13	9
Munsell	10YR 4/1 + 7/2	10YR 4/1	10YR 4/1	10YR 4/1	10YR 4/1	10YR 4/1 + 5/3	10YR 4/1 + 5/3	10YR 5/3	10YR 5/3

Depth (cm)	732	737	741
>8mm	62	40	85
>500μ	17	18	14
>63μ	6	7	10
<63μ	7	5	9
Munsell	10YR 5/3 + 8/2	10YR 5/3 + 8/2	10YR 8/2

Granulometry of the deep cores

Table A4.3. *Salina Deep Core.*

Depth (cm)	1113	1121	1131	1140	1150	1160	1191	1201	1211
>8mm	0	0	0	0	3	0	0	0	0
>500μ	8	26	48	40	70	47	11	62	36
>63μ	112	227	263	156	203	140	128	204	138
<63μ	274	365	384	325	447	374	599	554	589
Depth (cm)	1216	1221	1231	1241	1247	1257	1267	1277	1290
>8mm	0	0	5	3	0	0	0	0	0
>500μ	24	20	43	23	16	36	32	38	48
>63μ	165	127	377	180	135	302	320	305	150
<63μ	183	189	366	435	180	412	454	311	431
Depth (cm)	1300	1310	1384	1394	1404	1414	1425	1434	1444
>8mm	0	12	0	0	0	0	0	0	0
>500μ	121	48	15	9	9	9	6	11	13
>63μ	194	262	86	129	94	121	87	128	178
<63μ	370	435	350	646	466	537	655	507	641
Depth (cm)	1450	1459	1470	1479	1489	1630	1640	1650	1682
>8mm	0	0	0	0	0	0	0	4	0
>500μ	15	47	52	90	69	4	2	28	2
>63μ	70	185	191	257	223	103	87	144	75
<63μ	250	451	439	455	516	438	397	475	521
Depth (cm)	1692	1702	1710	1720	1730	1740	1745	1755	1765
>8mm	0	0	0	0	0	0	0	0	0
>500μ	1	1	1	1	1	1	3	2	1
>63μ	62	57	11	24	47	29	35	18	23
<63μ	391	536	387	701	551	515	193	579	449
Depth (cm)	1770	1780	1790	1841	1851	1861	1869	1879	1889
>8mm	0	0	1	0	0	0	0	0	0
>500μ	3	5	4	2	1	1	1	1	1
>63μ	54	42	62	45	12	15	8	12	6
<63μ	205	519	669	326	523	509	328	575	544
Depth (cm)	1890	1900	1910	1920	1930	1940	1971	1981	1991
>8mm	0	0	0	10	2	0	0	0	0
>500μ	1	1	1	5	4	4	2	2	2
>63μ	8	17	23	30	180	102	17	34	16
<63μ	657	593	669	553	489	529	377	564	462
Depth (cm)	1994	2004	2014	2023	2033	2043	2046	2056	2066
>8mm	0	0	0	0	0	13	0	0	0
>500μ	1	2	3	3	4	3	1	2	2
>63μ	1	13	8	13	17	16	6	6	22
<63μ	221	586	551	514	635	558	275	583	438

Appendix 4

Table A4.3 (cont.).

Depth (cm)	2070	2080	2100	2101	2103	2105	2106	2113	2123
>8mm	13	0	0	0	0	0	0	1	0
>500μ	6	13	4	1	1	1	1	1	4
>63μ	4	13	12	2	4	7	2	50	12
<63μ	259	581	469	358	653	662	530	388	628

Depth (cm)	2133	2143	2153	2163	2183	2192	2202	2222	2240
>8mm	0	0	0	0	0	0	0	0	0
>500μ	7	1	1	1	1	1	1	1	2
>63μ	34	8	31	4	26	17	20	13	28
<63μ	523	456	411	337	576	487	502	430	554

Depth (cm)	2260	2285	2295	2305	2308	2318	2328	2338	2348
>8mm	0	0	0	0	0	0	0	0	0
>500μ	2	3	5	4	20	21	37	38	2
>63μ	7	8	19	9	70	88	171	164	2
<63μ	511	513	393	553	263	578	393	483	644

Depth (cm)	2358	2363	2368	2380	2390	2398	2408	2418	2428
>8mm	0	0	0	0	0	0	0	0	0
>500μ	2	5	10	2	1	229	130	160	226
>63μ	20	37	38	18	8	88	61	125	110
<63μ	646	378	244	598	674	238	492	506	298

Depth (cm)	2458	2468	2508	2528	2550	2570	2580	2590	2600
>8mm	0	0	0	0	0	0	0	0	0
>500μ	72	316	74	14	28	235	298	528	479
>63μ	140	178	207	54	106	54	89	147	91
<63μ	499	428	403	511	635	90	169	270	267

Depth (cm)	2613	2625	2638	2646	2656	2665	2670	2687	2693
>8mm	0	9	2	42	0	0	0	0	0
>500μ	399	134	336	288	314	305	159	712	316
>63μ	158	49	70	117	139	141	58	144	45
<63μ	333	132	197	293	317	447	186	434	163

Depth (cm)	2696	2700	2782	2786	2792	2797	2804	2807	2812
>8mm	0	0	0	0	0	6	16	0	0
>500μ	188	174	29	4	7	4	98	10	4
>63μ	37	47	30	13	50	21	26	19	22
<63μ	56	142	282	66	389	198	199	183	223

Depth (cm)	2820	2825	2832	2850
>8mm	393	230	209	1142
>500μ	209	74	171	310
>63μ	44	13	42	164
<63μ	171	44	123	505

Granulometry of the deep cores

Table A4.4. Wied Żembaq 2.

Depth (cm)	117	121	125	129	133	137	141	145	149
>8mm	0	0	1	81	10	12	24	11	0
>500μ	5	4	5	1	8	8	10	16	12
>63μ	8	8	8	2	6	6	7	7	11
<63μ	32	33	31	15	26	26	24	25	25
Munsell	10YR 4/6	10YR 4/6	10YR 4/6	10YR 4/6	10YR 4/6 + 10YR 3/3	10YR 4/4	10YR 4/4	10YR 4/4	10YR 4/4

Depth (cm)	153	157	161	165	169	173	177	181	185
>8mm	13	0	77	4	11	5	0	3	6
>500μ	9	9	5	12	12	13	10	9	8
>63μ	8	7	4	6	5	7	6	7	7
<63μ	25	25	19	24	31	36	36	42	42
Munsell	10YR 4/4	10YR 4/4	10YR 4/4	10YR 4/4	10YR 4/4	10YR 4/4	10YR 4/4	10YR 4/4	10YR 4/4

Depth (cm)	189	193	227	230	234	237	240	244	248
>8mm	0	6	0	0	0	1	0	0	0
>500μ	10	6	3	8	7	7	7	5	7
>63μ	9	7	6	8	8	7	7	5	5
<63μ	44	48	38	26	29	28	28	33	33
Munsell	10YR 4/4	10YR 4/4	10YR 5/8	10YR 5/8	10YR 5/8	10YR 5/8	10YR 5/8	10YR 5/8	10YR 5/6

Depth (cm)	251	254	258	262	265	269	272	276	279
>8mm	0	0	1	0	70	14	0	7	10
>500μ	5	3	6	3	2	8	4	3	7
>63μ	5	5	4	3	1	4	2	2	3
<63μ	39	36	33	21	12	23	18	10	16
Munsell	10YR 5/6	10YR 5/6	10YR 5/6	10YR 5/6	10YR 5/6	10YR 5/6	10YR 5/6	10YR 5/6	10YR 5/6

Depth (cm)	283	286	290	293	297	302	307	312	317
>8mm	32	19	22	0	40	5	9	2	2
>500μ	6	10	7	8	3	1	1	2	2
>63μ	2	3	5	8	6	5	6	4	6
<63μ	15	14	29	35	30	53	49	49	62
Munsell	10YR 5/6	10YR 4/2	10YR 4/2	10YR 4/2	10YR 4/2	10YR 4/2	10YR 4/2	10YR 4/2	10YR 4/2

Depth (cm)	322	327	332	337	342	347	352	357	362
>8mm	0	34	5	0	0	3	0	0	0
>500μ	2	1	1	1	2	2	2	2	2
>63μ	5	4	7	7	8	8	9	8	6
<63μ	59	42	56	50	49	61	55	53	56
Munsell	10YR 4/2	10YR 4/2	10YR 4/2	10YR 4/2	10YR 4/2	10YR 4/2	10YR 4/2	10YR 3/3	10YR 3/3

Depth (cm)	367	372	377	382	387	392	461	463	464
>8mm	0	0	0	0	0	0	0	0	2
>500μ	2	2	1	2	1	1	8	7	7
>63μ	6	5	7	8	5	5	4	2	2
<63μ	47	47	44	56	57	63	9	9	6
Munsell	10YR 3/3	10YR 3/3	10YR 3/3	10YR 3/3	10YR 3/2	10YR 3/2	10YR 5/4	10YR 5/4	10YR 5/4

Appendix 4

Table A4.4 (*cont.*).

Depth (cm)	466	468	470	471	473	475	477	479	480
>8mm	0	3	0	0	0	0	0	0	0
>500 μ	8	3	2	1	1	1	1	1	1
>63 μ	3	2	2	3	3	3	3	3	3
<63 μ	8	13	12	13	13	13	12	12	16
Munsell	10YR 5/4	10YR 5/4	10YR 5/4 + 1.7/1	10YR 5/4 + 1.7/1	7.5YR 4/2 + 1/71	7.5YR 4/2 + 1/71	7.5YR 4/2 + 1/71	7.5YR 4/2 + 1/71	7.5YR 4/2 + 1/71

Depth (cm)	481	483	485	487	489	490	492	494	503
>8mm	0	0	0	0	0	0	0	0	0
>500 μ	2	4	2	1	1	1	1	1	2
>63 μ	4	3	3	4	3	3	4	3	6
<63 μ	14	12	15	13	14	14	16	17	37
Munsell	7.5YR 4/2 + 2/1	7.5YR 4/2 + 2/1	7.5YR 4/2 + 2/1	7.5YR 4/2 + 2/1	7.5YR 4/2 + 2/1	7.5YR 4/2 + 2/1	7.5YR 4/2 + 2/1	7.5YR 4/2 + 2/1	7.5YR 2/1 + 5/4

Depth (cm)	507	511	515	519	523
>8mm	0	5	0	0	0
>500 μ	2	1	2	1	2
>63 μ	6	5	5	3	3
<63 μ	35	31	40	18	32
Munsell	7.5 YR 2/1 + 4/3	7.5 YR 2/1	7.5YR 1.7/1 + 4/3	7.5YR 1.7/1 + 4/3	7.5 YR 1.7/1

Table A4.5. *Wied Żembaq 1.*

Depth (cm)	126	131	136	141	145	150	154	159	163
>8mm	7	15	0	0	2	0	0	2	0
>500 μ	7	6	14	11	6	11	8	6	11
>63 μ	6	7	7	8	6	6	4	4	3
<63 μ	22	18	20	19	17	23	13	12	2
Munsell	10YR 3/3	10YR 4/3	10YR 4/3	10YR 4/4	10YR 4/4	10YR 4/3	10YR 4/3	10YR 4/3	10YR 7/6

Depth (cm)	168	173	178	182	187	191	195	199	204
>8mm	8	4	0	2	0	11	0	0	0
>500 μ	12	9	6	5	5	7	7	4	8
>63 μ	5	6	5	6	5	4	5	5	9
<63 μ	30	31	28	30	18	17	32	31	51
Munsell	10YR 4/3	10YR 4/3	10YR 4/3	10YR 4/3	10YR 2/3	10YR 2/3	10YR 2/3	10YR 2/3	10YR 3/2

Depth (cm)	208	213	227	232	237	242	247	253	258
>8mm	0	3	0	6	11	12	7	5	0
>500 μ	6	9	8	10	8	8	8	6	4
>63 μ	8	9	7	5	4	5	3	7	6
<63 μ	44	49	19	9	4	5	2	40	24
Munsell	10YR 3/2	10YR 3/2	10YR 4/3	10YR 6/4	10YR 4/3 + 6/4	10YR 7/4	10YR 7/4	10YR 4/2	10YR 4/2

Granulometry of the deep cores

Table A4.5 (cont.).

Depth (cm)	263	268	273	278	283	288	293	298	303
>8mm	0	0	0	2	6	6	1	7	2
>500μ	6	7	7	6	10	6	3	5	5
>63μ	5	7	8	6	5	5	5	3	4
<63μ	30	33	42	47	27	39	47	42	45
Munsell	10YR 4/2	10YR 4/2	10YR 4/2	10YR 4/2	10YR 4/2	10YR 4/2	10YR 4/2	10YR 4/2	10YR 4/2

Depth (cm)	308	313	318	323	328	333	338	343	348
>8mm	4	7	9	0	0	0	0	0	0
>500μ	5	4	3	2	1	2	3	2	3
>63μ	5	6	4	4	4	6	7	6	5
<63μ	45	44	36	51	42	50	49	37	40
Munsell	10YR 4/2	10YR 3/2	10YR 3/2	10YR 3/2	10YR 3/2	10YR 3/2	10YR 3/2	10YR 3/2	10YR 3/1

Depth (cm)	353	358	363	368	373	378	383	388	393
>8mm	0	3	7	0	0	0	0	0	0
>500μ	6	8	2	1	1	1	1	1	2
>63μ	5	4	5	6	5	5	4	4	5
<63μ	16	21	45	44	50	58	51	48	38
Munsell	10YR 4/3	10YR 4/3	10YR 3/2	10YR 3/2	10YR 3/2	10YR 3/2	10YR 3/1	10YR 4/1 + 4/3	10YR 4/1 + 4/3

Depth (cm)	398	403	408	413	418	423	428	433	438
>8mm	0	0	0	0	0	0	0	0	0
>500μ	1	1	2	2	2	4	5	3	2
>63μ	5	4	5	9	5	7	8	6	6
<63μ	47	37	40	41	41	39	50	43	44
Munsell	10YR 2/1	10YR 2/1	10YR 2/1	10YR 2/1	10YR 2/1	10YR 4/1	10YR 4/1	10YR 4/1	10YR 4/1

Depth (cm)	443	448	456	468	480	492	504	516	528
>8mm	0	0	0	7	9	1	0	0	0
>500μ	3	2	11	26	6	6	3	3	2
>63μ	6	4	12	11	11	14	15	14	12
<63μ	33	25	90	72	109	111	124	104	79
Munsell	10YR 4/1	10YR 4/1	10YR 3/2	10YR 3/2	10YR 4/1	10YR 4/1	10YR 3/1	10YR 3/1	10YR 3/1

Depth (cm)	540
>8mm	7
>500μ	5
>63μ	12
<63μ	84
Munsell	10YR 3/1

Appendix 4

Table A4.6. *Xemxija 1.*

Depth (cm)	49	54	59	64	69	72	76	81	86
>8mm	0	0	0	0	0	1	3	0	0
>500μ	1	1	1	1	3	9	7	6	6
>63μ	1	2	2	1	4	4	9	8	5
<63μ	44	41	37	51	54	8	36	47	51
Munsell	10YR 6/4 +4/3	10YR 7/4	10YR 7/3	10YR 7/3	10YR 6/4	10YR 7/3	10YR 7/3	10YR 7/4	10YR 7/4

Depth (cm)	91	96	101	106	111	116	121	126	131
>8mm	7	3	1	18	3	0	5	13	14
>500μ	10	19	17	14	25	18	17	9	10
>63μ	7	9	7	8	12	8	8	3	5
<63μ	32	18	13	20	27	17	23	25	46
Munsell	10YR 8/4	10YR 7/4	10YR 7/4	10YR 7/4	10YR 7/4	10YR 7/4	10YR 7/4	10YR 5/6	10YR 6/4

Depth (cm)	136	141	145	149	154	158	163	168	173
>8mm	6	0	0	0	0	0	0	0	0
>500μ	4	2	0	1	1	1	1	1	1
>63μ	4	3	3	3	2	3	2	2	3
<63μ	55	61	52	51	43	51	54	55	56
Munsell	10YR 6/4 + 7/4	10YR 6/4	10YR 5/4	10YR 5/4	7.5YR 5/3	10YR 5/4	10YR 5/4	10YR 5/3	10YR 5/3

Depth (cm)	178	183	188	193	198	203	208	213	218
>8mm	0	0	0	0	0	0	0	0	0
>500μ	1	1	1	1	1	1	1	1	1
>63μ	1	1	1	1	1	3	3	6	4
<63μ	53	52	53	52	60	49	51	48	53
Munsell	10YR 5/4	10YR 5/4	7.5YR 5/4	7.5YR 6/3	7.5 YR 7/3 + 6/4	7.5 YR 7/3 + 6/4	10YR 5/2	10YR 5/2	10YR 4/1

Depth (cm)	223	238	233	238	243	248	267	271	275
>8mm	0	0	0	0	0	0	0	0	0
>500μ	1	1	1	1	1	1	1	1	1
>63μ	7	4	7	10	11	11	2	2	3
<63μ	51	56	52	56	55	23	50	53	51
Munsell	10YR 4/1	10YR 4/1	7.5 YR 5/1	7.5YR 6/1	10YR 6/2	10YR 5/2	10YR 5/3 +5/2	10YR 6/2	10YR 5/3 +5/2

Depth (cm)	280	284	288	293	297	301	306	310	314
>8mm	0	0	0	2	0	0	0	4	6
>500μ	1	3	5	2	2	2	3	7	9
>63μ	2	2	2	2	3	2	2	1	1
<63μ	52	49	48	50	46	46	49	42	39
Munsell	10YR 6/3	10YR 5/3	10YR 5/3	10YR 5/2	10YR 5/2	10YR 5/2	10YR 6/2 +5/1	10YR 6/2 +5/1	10YR 5/2

Granulometry of the deep cores

Table A4.6 (cont.).

Depth (cm)	318	323	327	331	336	340	344	349	353
>8mm	1	1	1	0	0	0	0	0	0
>500μ	5	3	2	1	2	1	1	1	1
>63μ	2	1	2	2	2	2	2	1	2
<63μ	43	45	49	47	48	49	53	47	52
Munsell	10YR 4/1	10YR 5/2	10YR 6/2 +4/1	7.5YR 3/1 +10YR 6/2	10YR 4/1	10YR 5/1	10YR 5/1	10YR 5/1	10YR 6/1

Depth (cm)	366	370	375	380	384	389	393	398	403
>8mm	0	4	5	7	0	4	4	0	0
>500μ	3	6	9	6	4	5	4	2	2
>63μ	2	1	1	1	3	2	1	2	1
<63μ	51	50	46	44	47	47	48	51	49
Munsell	10YR 6/1	10YR 6/1	10YR 6/1	10YR 6/1	10YR 6/1	10YR 5/2	10YR 5/2	10YR 5/2	10YR 5/2

Depth (cm)	407	412	416	421	426	430	435	439	440
>8mm	0	2	0	0	0	0	0	0	0
>500μ	4	3	3	6	3	2	1	1	1
>63μ	2	2	1	2	3	2	2	2	2
<63μ	52	54	49	50	48	51	54	49	51
Munsell	10YR 5/2	10YR 5/2 +7/2	10YR 5/2	10YR 5/2	10YR 5/1	10YR 6/1	10YR 5/1	10YR 5/1	10YR 5/1

Depth (cm)	449	453	458	483	487	491	495	499	503
>8mm	0	0	0	0	0	0	0	0	0
>500μ	1	1	1	2	1	2	2	0.8	1
>63μ	2	2	2	5	3	6	5	3	3
<63μ	52	52	50	33	37	26	30	36.2	32
Munsell	10YR 5/1	10YR 5/1	10YR 5/1	10YR 1.7/1	10YR 1.7/1	10YR 1.7/1	10YR 1.7/1	10YR 2/2	10YR 1.7/1

Depth (cm)	507	511	515	519	523	527	531	535	539
>8mm	0	0	0	0	0	1	0	1	0
>500μ	1	3	2	0.8	2	4	0.8	2	0.8
>63μ	4	3	4	3	3	2	3	2	2
<63μ	32	28	30	36.2	36	34	34.2	36	39.2
Munsell	10YR 1.7/1	10YR 1.7/1	10YR 1.7/1 +2/1 +7/1	10YR 3/1 +4/1	10YR 2/1 + 5/2	10YR 2/1 +4/1 +5/2	10YR 1.7/1	10YR 2/2 +4/1	10YR 1.7/1

Depth (cm)	543	547	551	555	559	563	582	586	590
>8mm	0	0	0	0	0	0	0	0	0
>500μ	1	1	1	1	0.8	0.8	1	1	1
>63μ	3	2	2	1	2	1	2	4	5
<63μ	37	41	43	40	39.2	38.2	50	46	44
Munsell	10YR 2/1 +4/1	10YR 3/1 +4/1	10YR 3/1	10YR 3/1 +4/1	10YR 3/1	10YR 3/1 +2/1	10YR 2/1	10YR 1.7/1	10YR 1.7/1

Appendix 4

Table A4.6 (cont.).

Depth (cm)	595	599	603	607	612	616	621	625	629
>8mm	0	0	0	0	0	0	0	0	0
>500μ	1	1	1	1	1	1	2	1	1
>63μ	4	4	6	6	4	5	5	3	3
<63μ	46	45	42	40	45	42	40	48	48
Munsell	10YR 1.7/1 +3/1	10YR 1.7/1	10YR 1.7/1	10YR 1.7/1	10YR 2/1	10YR 1.7/1	10YR 1.7/1	10YR 1.7/1 +2/2	10YR 2/2

Depth (cm)	633	638	642	646	651	655	659	634	668
>8mm	0	0	0	0	0	0	0	0	0
>500μ	1	2	5	2	2	3	3	6	1
>63μ	3	3	3	4	2	4	3	4	2
<63μ	48	51	39	49	46	42	45	40	36
Munsell	10YR 4/1	10YR 4/1	10YR 4/1	10YR 2/1	10YR 1.7/1 +2/2	10YR 2/2	10YR 1.7/1 +2/2	10YR 2/3	10YR 1.7/1

Depth (cm)	672	682	686	691	696	701	706	710	715
>8mm	0	0	0	0	0	0	0	0	0
>500μ	1	0	1	1	2	2	5	5	4
>63μ	4	1	5	7	8	10	6	6	6
<63μ	53	60	54	52	50	51	57	49	55
Munsell	10YR 2/3	10YR 3/2	10YR 2/3	10YR 3/1	10YR 4/2	10YR 4/2	10YR 4/2	10YR 3/2	10YR 4/2

Depth (cm)	720	725	730	734	739	744	749	754	758
>8mm	0	0	0	0	0	0	0	0	0
>500μ	4	8	6	5	9	8	15	19	19
>63μ	6	7	7	6	7	7	8	5	6
<63μ	51	49	57	49	54	48	57	48	46
Munsell	10YR 2/3	10YR 2/3	10YR 2/3	10YR 3/2	10YR 3/3	10YR 3/2	10YR 4/2	10YR 4/2	10YR 4/2

Depth (cm)	763	768	773	778	802	806	810	814	818
>8mm	0	0	0	0	0	0	0	0	0
>500μ	12	15	9	3	1	2	1	1	1
>63μ	8	8	8	8	10	9	9	10	10
<63μ	54	54	51	68	54	46	47	49	45
Munsell	10YR 4/2	10YR 3/3	10YR 4/2 +5/6	10YR 4/2 +5/6	10YR 4/2	10YR 2/3	10YR 2/3	10YR 2/3	10YR 2/3

Depth (cm)	822	826	831	835	839	843	847	851	855
>8mm	0	0	0	0	0	0	0	0	0
>500μ	1	1	1	2	1	1	1	1	1
>63μ	7	9	12	12	10	12	11	4	10
<63μ	50	43	45	45	44	44	45	51	44
Munsell	10YR 2/3	10YR 2/3	10YR 2/3	10YR 2/3	10YR 2/3	10YR 2/3	10YR 2/3	10YR 2/3	10YR 2/3

Granulometry of the deep cores

Table A4.6 (cont.).

Depth (cm)	859	863	867	871	876	880	884	887	888
>8mm	0	0	0	0	0	0	0	0	0
>500 μ	5	8	7	5	6	2	1	1	3
>63 μ	13	16	10	9	13	10	8	5	7
<63 μ	40	37	37	42	42	48	46	49	61
Munsell	10YR 2/3 +6/8 +5/8	10YR 2/3	10YR 2/3	10YR 2/3	10YR 2/3	10YR 3/2	10YR 2/3	10YR 2/2	10YR 2/2

Depth (cm)	889	894	899	905	910	916	921	927	932
>8mm	0	0	0	0	0	0	0	0	0
>500 μ	1	1	1	1	2	1	1	1	2
>63 μ	5	4	7	5	8	8	5	7	8
<63 μ	69	67	67	69	64	62	72	66	64
Munsell	10YR 2/3	10YR 3/2	10YR 2/3	10YR 3/2	10YR 3/3	10YR 2/3	10YR 2/3	10YR 2/2	10YR 2/2

Depth (cm)	938	943	949	954	960	965	971	976	982
>8mm	2	0	0	11	5	0	0	4	4
>500 μ	5	16	18	16	12	11	7	8	7
>63 μ	7	8	10	5	7	10	11	8	6
<63 μ	51	49	49	21	29	57	47	55	45
Munsell	10YR 3/2	10YR 5/4 +3/2	10YR 5/3 +4/2	10YR 4/2	10YR 4/3	10YR 4/2	10YR 4/3	10YR 4/2	10YR 4/3

Depth (cm)	987
>8mm	0
>500 μ	7
>63 μ	9
<63 μ	51
Munsell	10YR 4/3

Table A4.7. *Xemxija 2.*

Depth (cm)	120	124	129	133	137	141	146	150	154
>8mm	24	0	5	1	28	1	0	4	1
>500 μ	6	10	12	6	5	5	2	2	1
>63 μ	3	7	5	2	2	3	3	3	3
<63 μ	7	34	22	17	18	48	49	48	57
Munsell	10YR 8/4	10YR 6/4	10YR 7/4	10YR 7/4 + 10YR 4/3	10YR 5/6	10YR 5/3	10YR 5/6	10YR 6/3	10YR 6/4

Depth (cm)	158	163	167	171	175	180	184	188	192
>8mm	0	0	0	0	0	0	0	0	0
>500 μ	2	1	1	1	1	1	1	1	1
>63 μ	3	3	3	3	2	2	2	2	2
<63 μ	47	54	54	57	56	56	50	55	46
Munsell	10YR 5/3	10YR 4/3	10YR 4/3	10YR 4/2	10YR 4/3	10YR 4/3	10YR 4/2	10YR 4/3	10YR 4/4

Appendix 4

Table A4.7 (cont.).

Depth (cm)	197	200	201	206	211	216	223	227	232
>8mm	0	0	0	0	0	0	0	0	0
>500μ	1	1	1	1	1	1	1	1	1
>63μ	2	2	5	2	2	1	2	2	4
<63μ	49	48	41	57	51	53	59	59	63
Munsell	10YR 4/3	10YR 4/2	10YR 6/3	10YR 5/3	10YR 5/2	10YR 5/2	10YR 6/2	10YR 5/1	10YR 5/1

Depth (cm)	237	242	248	253	258	264	269	274	279
>8mm	0	0	0	0	0	0	0	0	0
>500μ	1	2	1	1	1	1	1	1	3
>63μ	4	18	11	4	3	2	1	3	1
<63μ	61	43	52	58	63	60	65	57	61
Munsell	10YR 5/3	10YR 5/3	10YR 5/2	10YR 5/3	10YR 5/2	10YR 4/1	10YR 5/2	10YR 5/3	10YR 5/2

Depth (cm)	285	290	295	300	319	323	328	332	336
>8mm	0	0	0	0	2	0	0	0	0
>500μ	1	1	1	1	2	5	1	1	1
>63μ	1	1	1	2	1	1	1	1	1
<63μ	38	42	35	40	35	41	48	52	49
Munsell	10YR 5/3	10YR 5/2	10YR 5/1	10YR 5/1 + 10YR 5/3	10YR 6/1 + 10YR 4/1	10YR 5/1 + 10YR 4/1	10YR 4/1	10YR 2/1	10YR 4/1

Depth (cm)	340	345	349	353	358	362	366	371	375
>8mm	0	0	0	0	0	0	0	0	4
>500μ	1	1	2	1	2	1	3	4	6
>63μ	1	1	1	1	1	1	1	1	1
<63μ	48	44	45	45	44	47	49	44	44
Munsell	10YR 5/1	10YR 5/1	10YR 6/1	10YR 6/1	10YR 6/1	10YR 6/1 + 10YR 5/1	10YR 6/1 + 10YR 5/1	10YR 6/1	10YR 6/1

Depth (cm)	379	384	388	392	397	401	415	420	424
>8mm	9	0	0	0	0	0	0	0	0
>500μ	9	3	2	2	2	3	5	1	1
>63μ	1	1	1	1	1	1	2	3	3
<63μ	36	44	46	45	40	46	20	43	42
Munsell	10YR 6/1	10YR 6/1	10YR 6/1	10YR 6/1	10YR 5/1	10YR 5/1	10YR 5/2 + 10YR 2/1	10YR 4/1	10YR 4/1 + 10YR 2/1

Depth (cm)	429	433	438	442	447	451	456	460	465
>8mm	0	3	13	0	0	0	0	0	0
>500μ	1	1	1	2	3	1	3	1	2
>63μ	2	1	1	2	1	1	1	2	2
<63μ	35	29	23	37	34	26	15	40	44
Munsell	10YR 4/1	10YR 4/1	10YR 4/1	10YR 4/1	10YR 4/1	10YR 4/1	10YR 4/1	10YR 4/1	10YR 4/1

Granulometry of the deep cores

Table A4.7 (cont.).

Depth (cm)	470	474	478	483	488	492	496	501	526
>8mm	0	0	0	0	0	0	0	0	0
>500μ	1	1	1	1	1	1	1	1	2
>63μ	2	3	2	1	2	1	1	1	2
<63μ	41	46	45	45	43	44	47	47	32
Munsell	10YR 4/1	10YR 4/1	10YR 4/1	10YR 4/1	10YR 4/1	10YR 4/1	10YR 4/1	10YR 4/1	10YR 2/1 + 10YR 5/2

Depth (cm)	530	534	539	543	547	551	556	560	564
>8mm	0	0	0	0	0	0	0	0	0
>500μ	1	1	1	2	2	2	2	1	1
>63μ	3	2	2	2	2	2	2	1	1
<63μ	38	41	42	40	39	40	42	45	42
Munsell	10YR 5/2+ 10YR 2/1	10YR 4/2 + 10YR 2/1	10YR 4/2 + 10YR 2/1	10YR 3/1	10YR 4/1	10YR 4/1	10YR 4/1	10YR 4/1	10YR 4/1 + 10YR 5/1

Depth (cm)	568	573	577	581	585	590	594	598	602
>8mm	0	0	0	0	0	0	0	0	0
>500μ	1	1	1	1	2	1	1	1	1
>63μ	2	2	3	2	2	1	1	2	1
<63μ	42	37	44	44	40	41	47	46	42
Munsell	10YR 4/1	10YR 4/1	10YR 4/1	10YR 4/1	10YR 4/1	10YR 4/1	10YR 4/1	10YR 4/1	10YR 4/1

Depth (cm)	606	611	626	630	635	639	644	648	653
>8mm	0	0	0	0	0	0	0	0	0
>500μ	2	4	2	1	1	1	2	2	2
>63μ	2	3	3	4	4	4	5	5	4
<63μ	40	36	49	48	40	42	41	38	40
Munsell	10YR 4/1	10YR 4/3 + 1.7/1	10YR 1.7/1	10YR 1.7/1	10YR 1.7/1	10YR 1.7/1	10YR 1.7/1	10YR 1.7/1	10YR 1.7/1

Depth (cm)	657	662	666	671	675	680	684	689	693
>8mm	0	0	0	0	0	0	0	0	0
>500μ	1	1	1	1	1	1	1	1	2
>63μ	5	4	4	2	2	3	2	3	4
<63μ	40	41	43	52	51	51	49	55	50
Munsell	10YR 1.7/1	10YR 1.7/1	10YR 1.7/1	10YR 3/1	10YR 4/1	25YR 2/1	25YR 2/1	25YR 4/2	25YR 3/2

Depth (cm)	698	702	707	711	716	738	742	746	750
>8mm	0	0	0	0	0	5	1	0	0
>500μ	1	2	2	4	3	9	8	9	9
>63μ	3	4	5	5	4	8	5	4	6
<63μ	53	50	52	54	52	71	43	40	39
Munsell	25YR 4/2	10YR 3/1 + 10YR 4/2	10YR 3/1	10YR 4/2	10YR 4/2	10YR 4/2	10YR 4/2	10YR 4/2	10YR 4/2

Appendix 4

Table A4.7 (cont.).

Depth (cm)	754	758	763	767	771	775	779	783	788
>8mm	7	4	0	10	1	0	0	0	0
>500µ	7	8	9	6	8	6	4	2	3
>63µ	4	5	5	5	8	8	8	7	7
<63µ	37	39	39	41	45	46	47	49	49
Munsell	10YR 4/2	10YR 4/2	10YR 5/3	10YR 5/3	10YR 5/3 + 10YR 4/2	10YR 5/3	10YR 5/3	10YR 5/3	10YR 4/3

Depth (cm)	792	796	800	804	808	813	817	821	858
>8mm	0	0	0	0	0	0	0	0	0
>500µ	2	2	1	1	1	3	1	1	1
>63µ	8	8	8	6	5	7	5	6	1
<63µ	49	49	52	53	52	49	52	53	23
Munsell	10YR 4/2 + 10YR 4/3	10YR 4/3	10YR 4/3	10YR 3/3	10YR 4/3	10YR 4/3	10YR 4/2 + 10YR 7/8	10YR 4/2	10YR 3/1 + 10YR 4/2

Depth (cm)	861	865	868	872	875	879	882	886	889
>8mm	0	0	0	0	0	0	0	0	0
>500µ	1	1	2	1	2	1	2	2	4
>63µ	2	2	2	2	2	2	2	2	2
<63µ	25	24	24	25	26	29	35	36	37
Munsell	10YR 5/2 + 10YR 3/1	10YR 5/2	10YR 1.7/1 + 10YR 4/1	10YR 1.7/1	10YR 1.7/1 + 10YR 4/2	10YR 4/1	10YR 4/1	10YR 4/1	10YR 4/1

Depth (cm)	893	896	900	903	907	910	914	917	921
>8mm	0	0	0	0	0	0	0	0	0
>500µ	1	1	1	1	1	1	1	1	1
>63µ	1	2	4	6	5	4	7	3	4
<63µ	33	29	35	37	34	33	35	35	38
Munsell	10YR 4/1	10YR 5/2	10YR 4/2 + 10YR 6/2	10YR 5/3 + 10YR 5/2	10YR 4/3	10YR 4/2	10YR 4/2 + 10YR 4/3	10YR 4/2	10YR 4/2

Depth (cm)	924	928	931
>8mm	0	0	0
>500µ	1	1	1
>63µ	4	4	4
<63µ	37	35	35
Munsell	10YR 4/2	10YR 4/3	10YR 4/2

Table A4.8. Marsaxlokk 1.

Depth (cm)	15	19	24	28	32	36	41	45	49
>8mm	3	0	1	0	3	0	5	11	12
>500µ	4	4	4	5	7	8	4	5	7
>63µ	9	9	10	10	11	8	8	8	9
<63µ	20	17	22	22	26	31	22	16	32
Munsell	10YR 5/4	10YR 5/4	10YR 5/4	10YR 5/4	10YR 5/4	10YR 5/4	10YR 5/4	10YR 5/4	10YR 5/4

Granulometry of the deep cores

Table A4.8 (cont.).

Depth (cm)	54	58	62	67	71	75	80	84	89
>8mm	0	0	0	0	0	0	0	2	0
>500μ	11	17	10	12	11	8	5	4	2
>63μ	12	9	12	13	12	12	12	11	10
<63μ	44	28	37	22	32	31	48	40	58
Munsell	10YR 5/6	10YR 5/6	10YR 5/6	10YR 5/6	10YR 5/6	10YR 6/4	10YR 6/4 + 10YR 4/3	10YR 4/3 + 10YR 6/4	10YR 6/3 + 10YR 6/2

Depth (cm)	94	99	104	109	114	119	124	129	134
>8mm	0	0	0	0	0	0	0	0	0
>500μ	1	1	1	1	1	1	2	2	1
>63μ	4	3	6	9	8	2	10	16	17
<63μ	60	61	63	55	59	67	56	44	52
Munsell	10YR 6/3 + 10YR 6/2	10YR 6/3	10YR 6/2 + 10YR 7/1	10YR 7/1	10YR 7/1	10YR 7/2	10YR 7/2	10YR 7/2	10YR 7/2

Depth (cm)	139	144	149	154	159	164	169	174	179
>8mm	2	1	0	0	3	1	0	0	0
>500μ	3	3	2	3	27	19	2	3	1
>63μ	16	18	15	14	14	8	6	8	6
<63μ	43	37	42	42	15	22	50	49	64
Munsell	10YR 7/2	10YR 7/2	10YR 7/2	10YR 7/2	10YR 7/2 + 10YR 6/4	10YR 6/4	10YR 3/1 + 10YR 7/2	10YR 7/1	10YR 7/2

Depth (cm)	184	189	194	199	204	209	214	219	224
>8mm	0	12	1	0	0	6	3	0	0
>500μ	3	19	17	8	10	9	9	12	13
>63μ	13	7	10	10	11	7	7	5	6
<63μ	63	7	31	39	38	34	34	40	42
Munsell	10YR 7/2	10YR 6/3	10YR 6/3 + 10YR 4/3	10YR 4/6	10YR 4/6	10YR 4/6	10YR 4/6	10YR 4/6	10YR 5/8

Depth (cm)	229	234	239	244	249	254	259	264	269
>8mm	11	3	6	0	7	0	6	3	2
>500μ	12	9	8	5	5	7	4	4	3
>63μ	2	4	5	5	4	5	3	3	3
<63μ	26	36	33	52	48	40	42	44	44
Munsell	10YR 5/3	10YR 5/8	10YR 4/6	10YR 5/8	10YR 4/4	10YR 4/6	10YR 4/6	10YR 3/4	10YR 3/4

Depth (cm)	274	279	284	289	294	299	304	309	314
>8mm	2	0	0	1	1	3	6	2	1
>500μ	2	3	2	10	19	11	3	5	5
>63μ	3	3	3	2	3	6	6	3	6
<63μ	36	40	53	1	12	34	43	42	50
Munsell	10YR 3/3	10YR 4/4	10YR 4/3	10YR 4/2	10YR 4/4	10YR 3/4	10YR 3/4	10YR 4/6	10YR 3/3

Appendix 4

Table A4.8 (*cont.*).

Depth (cm)	419	324	329	334	339	344	349	354	359
>8mm	5	0	6	3	7	0	0	9	0
>500μ	3	1	4	30	24	31	3	18	6
>63μ	4	2	5	9	6	5	4	8	6
<63μ	49	50	44	35	19	14	61	23	54
Munsell	10YR 3/3	10YR 4/6	10YR 3/3	10YR 8/3 + 10YR 8/4	10YR 8/4 + 10YR 6/6	10YR 5/8	10YR 5/8 + 10YR 8/3	10YR 8/2	10YR 8/3

Depth (cm)	364	369	374	379	384
>8mm	0	1	0	7	0
>500μ	7	1	8	1	2
>63μ	8	2	2	6	10
<63μ	31	34	47	37	47
Munsell	10YR 8/3	10YR 8/3	10YR 8/3	10YR 8/3	10YR 8/3 + 10YR 7/6

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.

Editors:

Charles French is Professor of Geoarchaeology in the Department of Archaeology, University of Cambridge. *Chris O. Hunt* is a Professor in the School of Biological and Environmental Sciences, Liverpool John Moores University, Liverpool.

Reuben Grima is a Senior Lecturer in the Department of Conservation and Built Heritage, University of Malta.

Rowan McLaughlin is Senior Researcher in the Department of Scientific Research at the British Museum and honorary research scholar at Queen's University Belfast.

Caroline Malone is a Professor in the School of Natural and Built Environment, Queen's University Belfast.

Simon Stoddart is Reader in Prehistory in the Department of Archaeology, University of Cambridge.

*Published by the McDonald Institute for Archaeological Research,
University of Cambridge, Downing Street, Cambridge, CB2 3ER, UK.*

Cover design by Dora Kemp and Ben Plumridge.

ISBN: 978-1-902937-99-1

