

ROUTLEDGE STUDIES IN ARCHAEOLOGY

Open-Air Rock-Art Conservation and Management

State of the Art and Future Perspectives

Edited by
Timothy Darvill and
António Pedro Batarda Fernandes



Open-Air Rock-Art Conservation and Management

While much has been achieved in understanding and managing weather effects and erosion phenomena affecting ancient imagery within the relatively protected environments of caves and rock-shelters, the same cannot be said of rock-art panels situated in the open-air. Despite the fact that the number of known sites has risen dramatically in recent decades, there are few examples in which the weathering and erosion dynamics are under investigation with a view to developing proposals to mitigate the impact of natural and cultural processes. Most of the work being done in different parts of the world appears to be ad hoc, with minimal communication on such matters among teams and with the wider archaeological community.

This richly illustrated book evaluates rock-art conservation in an holistic way, bringing together researchers from across the world to share experiences of work in progress or recently completed. The chapters focus on a series of key themes: documentation projects and resource assessments; the identification and impact assessment of weathering/erosion processes at work in open-air rock-art sites; the practicalities of potential or implemented conservation interventions; experimentation and monitoring programmes; and general management issues connected with public presentation and the demands of ongoing research investigations. Consideration is given to the conservation of open-air rock-art imagery from many periods and cultural traditions across the Old and New Worlds. This timely volume will be of interest to conservators, managers, and researchers dealing with aesthetic and ethical issues as well as technical and practical matters regarding the conservation of open-air rock-art sites.

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Contents

<i>List of Figures</i>	ix
<i>List of Tables</i>	xiii
<i>Abbreviations and Acronyms</i>	xv
<i>Preface and Acknowledgements</i>	xix
1 Open-Air Rock-Art Preservation and Conservation: A Current State of Affairs	1
TIMOTHY DARVILL AND ANTÓNIO PEDRO BATARDA FERNANDES	
2 Approaches to the Conservation and Management of Open-Air Rock-Art Panels in England, United Kingdom	17
TIMOTHY DARVILL	
3 The Preservation and Care of Rock-Art in Changing Environments: A View from Northeastern England, United Kingdom	38
MYRA J. GIESEN, ARON D. MAZEL, DAVID W. GRAHAM, AND PATRICIA A. WARKE	
4 Pride and Prejudice: The Challenges of Conserving and Managing Rock-Art in the Landscape of Northern England, United Kingdom, through Public Participation	53
KATE E. SHARPE	
5 Irish Open-Air Rock-Art: Issues of Erosion and Management	70
ELIZABETH SHEE TWOHIG AND KEN WILLIAMS	
6 The Open-Air Rock-Art Site at Leirfall, Central Norway, within the Context of Northern Scandinavian Rock-Art Conservation and Management Practices over the Past 50 Years	82
ELIZABETH E. PEACOCK, EVA LINDGAARD, KALLE SOGNNES, ROAR SÆTERHAUG, AND GORDON TURNER-WALKER	

7	Experiences Documenting Petroglyphs at Lake Onega, Russia, 1998–2012	98
	NADEZHDA V. LOBANOVA	
8	‘Preservation by Record’: The Case from Eastern Scandinavia	112
	LILIANA JANIK	
9	Aspect and Rock-Art Conservation: Preliminary Meteorological Data Regarding the Côa Valley, Portugal, Open-Air Rock-Art Complex	125
	ANTÓNIO PEDRO BATARDA FERNANDES	
10	Lonely Stones: Preservation of Megalithic Art in the Iberian Peninsula	142
	FERNANDO CARRERA RAMÍREZ	
11	The Conservation of Spanish Levantine Rock-Art in Aragón, Spain, Using 3-D Laser Scanning	159
	MANUEL BEA AND JORGE ANGÁS	
12	Conservation Programs in Chaco Cultural National Historical Park, USA: Outgrowths and Consequences of Rock-Art Recording Projects	167
	JANE KOLBER AND DONNA YODER	
13	Managing Chaos: Vandalism Rock-Art at the Okotoks Erratic, Alberta, Canada	174
	JACK W. BRINK	
14	The Conservation Diagnostic Process in Colombian Rock-Art Research	189
	GUILLERMO MUÑOZ AND JUDITH TRUJILLO	
15	Conservation of Rock-Art Sites in Northeastern Brazil	201
	MARIA CONCEIÇÃO SOARES MENESES LAGE AND WELINGTON LAGE	
16	Past and Present, Traditional and Scientific: The Conservation and Management of Rock-Art Sites in Australia	214
	MELISSA MARSHALL AND PAUL S.C. TACON	
17	Challenges of Conserving Rock-Art at the uKhahlamba Drakensberg Park, KwaZulu-Natal, South Africa	229
	NDUKUYAKHE NDLOVU	

18	Non-invasive Methods for <i>In-Situ</i> Assessing and Monitoring of the Vulnerability of Rock-Art	244
	ELIZABETH BEMAND, HAIDA LIANG, AND MARTIN BENCSIK	
19	Computer-Aided Simulation of Natural Erosion Processes on Rock-Art: A Mathematical Tool for Conservation Studies and Absolute Dating	259
	PAOLO EMILIO BAGNOLI	
20	Rock-Art: An Overview of Recent Developments and Initiatives by UNESCO and ICOMOS with Especial Reference to World Heritage Sites	272
	AMANDA CHADBURN	
	<i>Contributors</i>	283
	<i>Index</i>	293

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Figures

2.1	Comparison of motif plans.	28
2.2	Laser scanning rock-art.	29
2.3	English rock-art and the public.	32
3.1	Rock-art in the landscape.	44
3.2	Climate change models.	46
3.3	General guidance criteria for assignment of Staged Assessment for monuments.	49
4.1	Rock-art in woodland at Rivoek Edge, West Yorkshire.	54
4.2	The Carved Stones Investigations: Rombalds Moor.	60
4.3	Rock Art Mobile Project.	65
5.1	A moss-covered boulder at Forenaghts, Co. Kildare.	72
5.2	Irish open-air rock-art on public view.	75
5.3	The changing state of rock-art panels.	78
6.1	Map of Scandinavia showing the location of the Leirfall rock-art site in central Norway.	83
6.2	The Leirfall III panel.	84
6.3	Monitoring temperature at Leirfall III.	90
6.4	Leirfall III winter covering.	94
7.1	Location map showing the position of Lake Onega.	99
7.2	The 'Hermitage Rock'.	101
7.3	Recording Lake Onega open-air rock-art.	108
7.4	Recording Lake Onega underwater rock-art.	109
8.1	Map showing the White Sea region and the locations of rock-art sites.	113
8.2	Map of Zalavruga.	118
8.3	Recording rock-art in the White Sea region.	120
8.4	Zalavruga site, walking platforms.	123
9.1	Location and altitude of the Côa Valley rock-art outcrops.	126

x *Figures*

9.2	Two-headed horse motif in Fariseu Rock 1.	126
9.3	Aspect in the area of study.	127
9.4	Solar radiation in the area of study.	133
10.1	Current distribution of sites with megalithic art in the Iberian Peninsula.	143
10.2	Decorated stones at dolmens.	143
10.3	Average levels of risk, priority, and intensity in the whole group of studied sites.	151
10.4	Managing Iberian megaliths.	154
11.1	Main natural and human deterioration factors affecting Spanish Levantine art.	160
11.2	Steps for the geometric reconstruction of a rock-art panel.	164
12.1	Chaco in a barren area surrounded by the Navajo Nation.	168
12.2	Figures on the rock.	170
12.3	Presenting Chaco rock-art.	171
12.4	Monitoring Chaco rock-art.	172
13.1	The Okotoks Erratic.	175
13.2	Okotoks Erratic rock-art images.	177
13.3	Vandalism at Okotoks Erratic.	179
13.4	Vandalism paint and rock-art images.	182
14.1	Registration forms used in GIPRI's methodological approach.	193
14.2	GIPRI recording forms.	195
14.3	GIPRI digital laboratory.	197
15.1	Location of sites mentioned in the text.	202
15.2	Rock-art conservation in Northeastern Brazil.	205
15.3	Vale do Catimbau National Park rock-art panel.	212
16.1	Threats to rock-art sites in Australia.	218
16.2	Managing and recording rock-art panels in Australia.	220
16.3	Management of rock-art sites open to the public.	223
17.1	Sites discussed in Chapter 17.	230
17.2	The Kamberg Rock Art Centre.	235
17.3	Didima Rock Art Centre internal space.	238
18.1	Sample analysis.	250
18.2	Scans of stone surfaces.	251
18.3	Images of sandstone sample.	252
19.1	Theoretical models of rock-art characteristics and erosion parameters.	261

19.2	Dating methods applied to the Billhooks Step site, Mount Gabberi, Camaiore, Italy.	269
20.1	Stonehenge, Wiltshire, UK. Axe and dagger carvings on Stone 53 in 1953.	277
20.2	Stonehenge, Wiltshire, UK. Recent photograph of axe and dagger carvings.	277
20.3	New rock-art discovered in 2011 on Stone 53 at Stonehenge, Wiltshire, UK.	279

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Tables

2.1	Number of rock-art records and putative panels for sample transects.	20
2.2	List of rock-art recording techniques assessed by RAPP.	24
2.3	Summary matrix assessing field-recording technology.	26
3.1	Past destruction and current threats to Northumberland rock-art.	43
8.1	Dating of particular White Sea rock-art sites.	117
9.1	Average values for 2004–08 in PEN1 and 2011 total values for the remaining stations.	129
9.2	Temperature values recorded by CINF-B in 2011.	131
9.3	Temperature values recorded by PEN2-B in 2011.	131
9.4	Solar radiation values for CINF, PEN2, and VJE for 2011.	133
10.1	List of sites according to the results of the cultural heritage assessment.	146
10.2	Extent of alteration and levels of risk at Casa dos Mouros.	148
10.3	Priority and intensity of the actions suggested for Casa dos Mouros.	149
10.4	Level of alteration, risk, priority, and intensity in the studied Portuguese sites.	150
10.5	Cultural heritage assessment, cultural efficiency index, and action index.	152
10.6	Cultural heritage assessment, cultural efficiency index, and proposal of action.	153
11.1	Rock-art sites included in the study and a summary of their technical specifications.	162

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Abbreviations and Acronyms

AEMET	Agencia Estatal de Meteorología
AHRC	Arts and Humanities Research Council
AI	Action Index
AIATSIS	Australian Institute of Aboriginal and Torres Strait Islander Studies
AOTF	Acoustic-optical tunable filter
AURA	Australian Rock Art Association
BAP	Beckensall Archive Project
BAR	British Archaeological Reports
BP	Before Present (conventionally taken as 1950)
cal BC	calibrated radiocarbon determination in years Before Christ
CAR	ICOMOS International Committee on Rock Art
CARE	Condition assessment and Risk evaluation
CCD	Charge-coupled device
CD	Compact disk
CDEP	Community Development and Employment Program
CEI	Cultural Efficiency Index
CFC	Caring for Country
CHA	Cultural Heritage Assessment
CIMS	Cultural Information Management Systems
CMP	Conservation management plans
Co.	County
CSIRM	Carved Stone Investigations: Rombalds Moor
DEM	Digital Elevation Model
DNMI	Det Norske Meteorologiske Institutt
DTV	Diurnal temperature variation
DVD	Digital video disk
ECG	Electrocardiography
EKZNW	Ezemvelo KwaZulu-Natal Wildlife
EMBRAPA	Empresa Brasileira de Pesquisa Agropecuária
EPSRC	Engineering and Physical Sciences Research Council
EQ	Ever-Quest (square scanable graphic linked to an established website)

ERA	England's Rock Art
EU	European Union
FUMDHAM	Museum Foundation of the American Man
FWHM	Full width half maximum (waveband)
GIPRI	Grupo de Investigación de Arte Rupestre
GIS	Geographical information system
GNSS	Global navigation satellite system
GPS	Global positioning system
HER	Historic environment record
ICOMOS	International Council on Monuments and Sites
IFRAO	International Federation of Rock Art Organizations
IMP	Instituto de Meteorologia de Portugal
IMP	Integrated management plan
INORA	<i>International Newsletter on Rock Art</i>
IR	Infrared
ISCR	Istituto Superiore per la Conservazione ed il Restauro
KNP	Kakadu National Park
LiDAR	Light detection and ranging (laser-light surveying system)
	micro-CT micro computed tomography
MIP	Mercury intrusion porosimetry
MRI	Magnetic resonance imaging
NADRAP	Northumberland and Durham Rock Art Pilot Project
NHL	National Heritage List
NIEA	Northern Ireland Environmental Agency
NIR	Near infrared
NMC	National Monuments Council
NMI	National Museum of Ireland
NMS	National Monuments Service (in Ireland)
NMR	National Monuments Record (in UK)
NMR	Nuclear magnetic resonance
NRAP	Norwegian Rock-Art Project
NTNU	Norges teknisk-naturvitenskapelige universitet
OCT	Optical coherence tomography
OD	Ordnance datum
OUV	Outstanding universal value
PERAHU	Place, Evolution and Rock Art Heritage Unit
PDA	Personal digital assistant
PDF	Portable document format
PO	Post office
PRISMS	Portable remote imaging system for multispectral scanning
RANE	Rock-art in Northern Europe
RAMP	Rock Art Mobile Project (England, UK)
RAP	Rock Art Project (Norway)
RAPP	Rock Art Pilot Project (England, UK)

RAS	Russian Academy of Sciences
RCB	Rock Carvings in the Borderlands
RGB	Red-green-blue
RI	Refractive index
RMP	Record of Monuments and Places
SEWPAC	Department of Sustainability, Environment, Water, Population and Communities (Australia)
SMR	Sites and Monuments Record
UAV	Unmanned aerial vehicle
uDP	uKhahlamba Drakensberg Park (South Africa)
UFPI	Universidade Federal do Piauí (Brazil)
UISPP	Union Internationale des Sciences Préhistoriques et Protohistoriques
UK	United Kingdom
UNESCO	United Nations Education, Scientific and Cultural Organisation
USA	United States of America
UV	Ultraviolet
WHS	World Heritage Site
WMO	World Meteorological Organization
WOC	Working on country
2-D	Two-dimensional
3-D	Three-dimensional

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Preface and Acknowledgements

While much has been achieved in understanding, conserving, and managing ancient imagery within the relatively protected environments of caves and rock-shelters, the same cannot be said of rock-art panels situated in the open-air. Despite the fact that the number of known open-air sites has risen dramatically in recent decades, there are few examples in which the weathering and erosion dynamics have been investigated with a view to developing proposals to mitigate the impact of natural and cultural processes. Much of the work being done in different parts of the world appears to be ad hoc, with minimal communication on such matters among teams and with the wider archaeological community.

The aim of this book, based on papers presented at a session organized by the editors at the 16th Annual Meeting of the European Association of Archaeologists held in The Hague, Netherlands, in September 2010 is to discuss rock-art conservation in an holistic way in an attempt to bring researchers together and to share experiences of work in progress or recently completed. The papers focus on documentation projects and resource assessments; on the identification and impact of weathering/erosion processes at work in open-air rock-art sites; on the practicalities of potential or implemented conservation interventions; on experimentation and monitoring work; and on management issues connected with public presentation and ongoing research. Consideration is given to the conservation of open-air rock-art imagery from many periods and cultural traditions across the Old and New Worlds.

Rock-art is notoriously difficult to date, but the ages cited in this volume are given in calibrated years before Christ as ‘cal BC’ based on relevant local calibration curves as cited by authors in their respective chapters.

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1 Open-Air Rock-Art Preservation and Conservation

A Current State of Affairs

*Timothy Darvill and
António Pedro Batarda Fernandes*

INTRODUCTION

One of the great achievements of archaeological investigation across the world over the past half century has been the recognition and recording of rock-art covering the whole span of human existence from the Pleistocene through to modern times (Bahn 1998; Clottes 2002). But this success also presents a challenge for the future, as protecting, conserving, and managing these remains is neither simple nor straightforward. It is extraordinary that so much open-air rock-art has survived at all given the abrasive environmental conditions that many sites face (Bahn 2010a, 170–97; Carrera Ramírez 2002; Dorn *et al.* 2008; Hall *et al.* 2007; Herráez 1996; Hygen 2006; Lucas Pellicer 1977; Manning 2003; Soleilhavoup 1993; Swantesson 2005; Tratebas *et al.* 2004; Walderhaug and Walderhaug 1998), the impact of human actions ranging in severity from destructive property development to vandalism and theft (Anon. 2011; Bahn 2010a, 170–97; Bauman 2005; Harry *et al.* 2001; Keenan 2000; Searight-Martinet 2006; Sims 2006; Soler i Subils and Brooks 2007; Taruvinga and Ndoro 2003), and the abrasive effects of environmental change affecting many of the landscapes where rock-art sites commonly occur (Aberg *et al.* 1999; Christensen 2005; Fitzner *et al.* 2004). Conserving and managing these open-air sites is a field of study that has received relatively little attention, a situation that contrasts with the conservation of motifs found in caves which has benefited from extensive research (see, for instance, Brunet *et al.* 1987; Brunet *et al.* 1995). Similarly, although methods to monitor environmental conditions and weathering dynamics within caves are well developed (Brunet and Vidal 1993; Malaurent *et al.* 2007; Vouvé *et al.* 1983), few comparative data are available from open-air rock-art sites, and what there are tend to warn of the dangers of ill-considered and hastily prepared conservation works (see, for instance, Bakkevig 2004; Devlet and Devlet 2002).

To an extent, this state of affairs is understandable given that painted caves were the first evidence of prehistoric art to be discovered and recognized, a triumph coinciding with the moment when archaeology came of age in Europe in the mid 1800s (Bahn 1998, 1–69). And it was the antiquarian

focus on the study of these painted caves and the quality of the early records that has led to modern realization of just how fragile the decorated panels are and how much conservation work is needed. Lascaux in France and Altamira in Spain especially must be seen as paradigmatic in terms of the step-changes prompted by the careful conservation and management of the Ice Age cave-based rock-art they contain. Both sites, and others besides, display the complexity and difficulties in designing and implementing preservation and conservation measures (Bahn 2010b).

ROCK-ART IN CONTEXT

According to the International Federation of Rock Art Organizations, rock-art is everything inscribed or painted on rock surfaces possessing no utilitarian use (IFRAO 2008, 130). This wide definition embraces motifs and symbols made by pecking, engraving, or painting, whether of prehistoric or historic date, located in caves, natural shelters, or the open-air, and from cup-marks and 'plain' drawings and paintings to the exquisite works present in the well-known caves of western France and northern Spain already referred to. Although there may be scope for further discussion about the precise wording of the IFRAO definition and the increasing range of evidence observed in the field that can be considered as rock-art, this fairly inclusive definition is widely accepted by rock-art researchers (but see also Bahn 1998; Clottes 2002).

OPEN-AIR ROCK-ART

Open-air rock-art is found throughout the world in a wide range of environments, and its investigation, conservation, and management are international problems. Its date, site characteristics, geological underpinning, and original cultural context are very diverse. Some of it is still in use and fully part of living traditions by indigenous communities. In Europe, rock-art imagery has survived in a few places at least since the Upper Palaeolithic (the Côa Valley of Portugal, for example, and see Bahn 1992, 1995), the Neolithic (in many parts of Atlantic northwest Europe and the British Isles, for example: Sharpe *et al.* 2008), and the Bronze Age (for instance in Scandinavia: Tansem and Johansen 2008) as well as from more recent historic times. Elsewhere, there is much discussion as to whether open-air rock-art panels, which are inherently difficult to precisely date, are prehistoric or not. Much of the best-known imagery was made by indigenous, aboriginal, or First Nation communities in Australia (for instance, in Kakadu National Park: Sullivan 1991), North America (the Coso Range, California: Whitley and Dorn 1987), South America (Serra da Capivara National Park, Brazil: Nash 2009), Asia (Altai, Russia: Kubarev *et al.* 2004), and Africa (Tassili n'Ajjer,

Algeria: Coulson and Campbell 2010). But more recent images by settlers, migrants, invaders, and colonists with all sorts of cultural backgrounds are also present in many of these areas. Because individuals painted or engraved rock-faces within their landscape, open-air rock-art can be found on almost every kind of rock type known (schists, granites, sandstones, etc.). Preferences for particular kinds of rock can certainly be detected in many areas, although some care is needed to ensure that patterns are not the result of differential preservation rather than cultural selectivity.

By definition, open-air sites comprise all rock-art that exists outside of caves or the enclosed spaces within constructed monuments, which possess very specific conservation and management issues related mainly to the disruption of the delicate environmental equilibrium associated with opening sites to the public. In general, open-air rock-art sites comprise panels that exist on exposed rock surfaces that are open to the sky, including natural cliff faces, exposed rock outcrops, earthfast boulders, and glacial erratics. A case can also be made for including decorated rocks incorporated into built structures where these were originally or have become exposed to the sky such as with the rock-art panels found on some of Europe's well-known megalithic tombs or the carved faces of stelae and standing stones. Not included in this book or elsewhere in the literature on open-air rock-art is a discussion of the wealth of inscriptions, dedications, and ornamentation cut into the walls of monumental structures associated with classical civilizations the world over, although it is recognized that these do share some conservation and management issues with what is traditionally defined as rock-art.

Because of their recognized outstanding universal value, a number of rock-art sites have been inscribed on the World Heritage List (WHL) established by UNESCO (see Chapter 20). In 2013 the WHL included 33 rock-art sites (a small minority consisting of caves), and a further 43 were listed on the so-called Tentative List (Sanz 2008).¹ But it is a small and highly selective sample. A preliminary review suggests that worldwide there are more than 70,000 rock-art sites comprising some 45 million images (Anati 2004), although some commentators believe this estimate to be far too conservative (Malotki 2007, 6). Certainly there are many parts of the world where the search for open-air rock art has hardly begun, if at all, and, as several chapters in this book illustrate, even well-researched landscapes can still reveal big surprises because of the number and quality of sites and panels awaiting discovery.

On a world-wide scale, open-air sites are extremely significant. They vastly outnumber rock-art panels located in caves, not least because of the simplicity and widespread availability of natural rock surfaces as the main prerequisite for the creation of an open-air rock-art panel. Progress with the investigation of open-air rock-art and the recognition of its proper place within studies of material culture more generally was perhaps held back slightly through the later twentieth century by Euro-centric approaches. For a several decades, the study of open-air rock-art was perceived as being 'less spectacular' than other kinds of field archaeology, a view no doubt supported by the difficulties of

finding sites, the heavily weathered nature of the motifs and symbols, and the self-inflicted difficulties of interpretation brought about by trying to apply prevailing positivist models. This has now changed, and the interest in recognizing and understanding the symbolic meanings embedded within material culture that is central to post-processual archaeology has given rock-art studies a new lease of life, and new research agendas are starting to emerge (Bradley 1997, 2009; Fredell *et al.* 2010; Jones *et al.* 2011; Nash and Chippindale 2002). Behind these changes lies a fairly straightforward, recurrent, almost universal pattern of developing appreciation and investigation: discovery; mapping; description and documentation; interpretation; protection from human impacts; protection from natural decay; integrated conservation and management; and monitoring and critical reflection. All these stages require the investment of time and resources, and as several chapters in this book emphasize, obtaining and targeting such resources for best effect is often far from easy. Increasingly important, therefore, is making rock-art contribute to present-day society in a way that allows it to be valued and understood for what it is and for what it stands for. As several authors here show, there is much to be done in this field, but already a number of major themes are emerging, including questions of identity and tourism.

Across the world, rock-art (and the remains of the past more generally) has found an important role in providing social cohesion and new senses of identity for communities, particular ethnic groups, regions, and whole countries and nation states. Rock-art has found a place within the rising tide of interest in signalling the importance of non-Western pasts and political desires to provide time-depth to life in the modern age. Chapters 10, 12, 14, 15, 16, and 17 touch on aspects of these issues with respect to rock-art in Iberia, the southwestern US, Columbia, Brazil, Australia, and South Africa, respectively.

The tourism industry is a major consumer of knowledge about rock-art and exploits sites and landscapes where rock-art can be seen for visits, tours, and expeditions. Together with the interesting revenues that tourism generates in sometimes rather underdeveloped areas where rock-art sites can be seen, it also forces attention on issues of conservation and management (Anati 1983; Anati *et al.* 1984; Deacon 2006; McManamon and Hatton 2000; Soleilhavoup 1991–1992, 1998). People will not spend time and money looking at sites that are heavily damaged or in an advanced state of decay. Moreover, since tourists are often the people that quickly and independently make critical comparisons between what they see and experience in different places, they can be very demanding with high expectations. Tourism is considered in many of the chapters in this book, and in closing the volume, Chapter 20 offers an account of recent actions regarding management and conservation of rock-art undertaken by UNESCO and ICOMOS in the international arena.

One outcome of these changing interests is the investigation of open-air rock-art sites that are subject to human impact issues. There are plenty of cases from all over the world in which such issues relate to heritage management in general (Hall and McArthur 1996 and 1998, for instance, provide

an overview of the most relevant current heritage management trends), but this is the first attempt to draw together experiences with specific reference to open-air rock-art sites. It is clear from the contributions here that current approaches to managing rock-art sites try to balance the need to preserve the art with the pressure arising from tourism and economic development. Chapter 17 presents an especially revealing case study of tourism management in a rock-art—rich region of South Africa. Among the most well-used strategies are management planning for impact reduction, access restrictions, seasonal closure, access only on guided tours, and the construction of pathways, fences, and interpretation facilities (Jacobs and Gale 1994; Lambert 1989; Ward and Ward 1995).

Of course, human factors are only part of the problem so far as management and conservation are concerned; natural processes represent an equally important field for consideration, not least as their impact is medium and long term. Natural processes play a critically important and rather understudied role in the long-term security of rock-art and yet are not well covered by archaeological research. Even among related disciplines such as geomorphology and geology, the study of weathering and the erosional dynamics of stone in its natural context are dominated by issue-based approaches such as physical, chemical, or biological decay under the very specific conditions of a particular site or landscape. These have undoubtedly made useful contributions to the wider understanding of such dynamics and informed conservation work beyond the individual case, but there is much more to do, and especially so in relation to the combined impacts of these interrelated processes such as we see discussed in Chapters 14 and 15. Trying holistically to understand and address degradation dynamics is not an issue unique to any one open-air rock-art site. Although each case has its own specific overall context, the case studies reported here have significant implications for other sites. The methodologies used, the research issues addressed, and the results obtained will be of use to rock-art managers and conservators worldwide. Importantly, the work presented in the studies included in this volume contributes to wider understandings of natural degradation processes and will help develop and implement sound and informed conservation actions at open-air rock-art sites.

OPEN-AIR ROCK-ART PRESERVATION AND CONSERVATION

A major focus of the present volume is the preservation and conservation of open-air rock-art. Critical here is a distinction between the terms ‘preservation’ and ‘conservation’, as they are used throughout this Introduction. Although the two terms are often seen as having an intertwined meaning (see, for instance, Bednarik 1996 or Herráez 1996), the authors consider there to be an important distinction between these two concepts (see Fernandes 2007, 72–3). The term ‘preservation’ is here applied to all actions that indirectly aim to address menaces to the perpetuation of a heritage asset (in this case,

rock-art). By 'indirect' we mean things such as protective legislation, land-use planning, and the creation of positive attitudes and education programmes that serve to provide the context for management activities and deflect or avert the impact of widespread menaces. Most of the menaces that can be dealt with in this way are anthropogenic, or at least greatly enhanced by human intervention in the landscape from the micro-scale (e.g. overvisiting at a heritage site that subsists in a delicate and interdependent natural equilibrium) to the mega-scale (e.g. climate change). Thus, heritage management strategies are created and implemented to try to inhibit human impacts from accelerating natural weathering or natural decay processes at work at a given site besides preventing the destruction of heritage assets due to vandalism or economic growth (farming, infrastructure building, or urban development).

On the other hand, the term 'conservation' is proposed to include all the 'hard' interventions brought to bear on heritage assets with the aim of prolonging their 'natural' physical lifetime. Therefore, actions such as stabilization, consolidation, and cleaning (either built, ruins, or rock-art) represent conservation actions. It is more than a matter of linguistics. Although different words might be used, it is suggested that such a distinction is made not only for clarification and systematization questions but also in relation to the theory, methodologies, and techniques behind each concept which are quite different and ultimately rest in different spheres of academic discourse and which anticipate a range of distinct approaches.

Transdisciplinary Approaches

From the many calls for conservation of rock-art coming from very different parts of the world (see, for instance, Anati 1983; Anati *et al.* 1984; Crotty 1989; Pearson 1978; Seglie 2006; Silver 1989; Vidal 2001), it becomes apparent that there are many threats to the perpetuation of this significant heritage. Nevertheless, while some authors reference physical weathering as the most pressing risk (see for instance Fitzner *et al.* 2004; Meiklejohn *et al.* 2009; Pope *et al.* 2002; Walderhaug and Walderhaug 1998), others invoke the negative effects of biodegradation, especially when lichen colonization is concerned (Dandridge 1999; Florian 1978; Knight *et al.* 2004; Tratebas 2004), or human factors (for instance, Cittadini 1993; Deacon 2006; Dragovich 1995; Fossati 2003; Haskovec 1991). In the present volume, Chapter 13 presents a relevant case study regarding vandalism at rock-art sites. It is suggested that the way emphasis is placed on the different forms of risk has much to do with the specific area of expertise of each researcher, and, more importantly, with the different environments where rock-art exists. Hence, different settings will determine which weathering patterns are more active and pose more urgent risks to be dealt with by rock-art managers and conservators.

The worldwide paucity of experienced rock-art professionals signals that open-air rock-art conservation has not received the attention (Silver 1989) that other archaeological remains have attracted (as, for instance, the

conservation of Roman sites). The panorama is slowly changing as touristic development is raising awareness, transforming selected sites into tourism attractions (for instance, Deacon 2006), and creating a demand for resource managers and conservators.

To understand and tackle, in the most complete way possible, the interconnections between all the various impacts on rock-art panels ideally requires an interdisciplinary approach whether through team building or the development of a wide experience base. But there are dangers, as the following words intended to portray the general situation amongst stone conservators imply:

I am a bit worried to notice that you are carrying out your research without organized dialogue, each person working in his or her own corner, the exchange of information remaining very limited (. . .) I also have the feeling that the general tendency among researchers is to remain confined to one's own speciality (. . .) Don't fail to see the wood for the trees! Before going into detail, an assessment of the whole is necessary.

(Chamay, quoted in Doehne and Price 2010, 69)

Much the same could be said about open-air rock-art conservation and management. To precisely see the wood as well as the trees requires an interdisciplinary approach that is fundamental and one that can be applied at different scales at once. Unfortunately, rock-art conservation experts often work in a 'closed circuit'. As Cervený notes, "the application of stabilizing agents on rock art panels is not widely discussed in refereed publications, (although) proponents discuss active intervention on the stage of newsletters and similar forums" (2005, 8). She also "urge(s) treatment advocates to come out of the newsletters and short courses (and to) publish suggested treatments" (Cervený 2005, 38). Even though her remarks refer only to proponents of the use of stabilizing agents on rock-art panels, it suggested that her criticism depicts quite accurately the global situation within (open-air) rock-art conservation research as a whole. Indeed, studies and contributions are rarely published in peer-reviewed journals but abound in the so-called 'grey literature'. Hence, the present volume also aims to foster a transdisciplinary approach to rock-art conservation and presentation in mainstream media of worldwide original contributions to this field of study. For instance, Chapters 5, 6, 9, 10, 13, 14, and 15 present diverse but transdisciplinary approaches to understanding and tackling the different threats faced by rock-art conservators in several parts of the world.

The Importance of Documenting Rock-Art

Since rock weathering processes are complex, dynamic, and not yet fully understood (Bland and Rolls 1998; Doehne and Price 2010), many authors suggest that compiling competent documentation is of paramount importance

to ongoing management of ancient rock-art imagery. The argument goes that since it is unrealistic to tackle weathering dynamics on the total corpus of the planet's rock-art resource (at least at the same time and in the foreseeable future), some panels and outcrops that now host ancient imagery will inevitably break up, and their motifs and symbols will be lost forever. Documenting panels now will assure that at least accurate copies of motifs will be available to future generations, a philosophy generally known as 'preservation by record' (see, for instance, Anati *et al.* 1984; Doehne and Price 2010; Letellier 2007, 15; Sharpe *et al.* 2008, 12; and see Chapter 8). Furthermore, documentation work (including motifs, symbols, and the rock massif where they are located) can be an essential tool to record, describe, and precisely locate weathering patterns active at a given rock-art panel or outcrop (Brink 2007; Fitzner 2004; Lewis 2007; Loubser *et al.* 2000; Vogt 2007). Multiple successive documentation events over decades and centuries will provide secure information on diachronic change and the dynamics of weathering.

In the last few years, quite a few methods have been developed for recording rock-art and associated natural weathering patterns. Most have taken advantage of the possibilities offered by combining new photographic and computer technologies (Clogg *et al.* 2000; and see Chapter 14). The rapid introduction and adoption of these new methods has almost entirely replaced the 'old-fashioned' intrusive and sometimes damaging methods of recording rock-art (Sundstrom and Hays-Gilpin 2011, 354).

Careful documentation is fundamental for the dissemination and depiction of rock-art. It also provides a valuable resource to draw upon when attempting to raise awareness of rock-art and its value amongst members of the public, local communities, and, especially, future generations. Promoting the message that rock-art deserves to be preserved within an ethical framework that also covers topics such as visiting rock-art sites and what can be done while viewing them is also important (Fossati 2003; Pilles 1989; Seglie 2006; Soleilhavoup 1991–1992). Several chapters in this volume deal with documentation and public education, especially Chapters 2, 7, 8, 11, and 12. It should be noted that Chapter 11 presents a methodology (and its results) to document rock-art in a non-invasive fashion using 3-D laser scanning.

Many techniques for the documentation of rock-art have been developed, sometimes with general application and sometimes with a specific type of rock-art in mind. Chapter 2 includes a review of a range of methods applied to the documentation of rock-art in England, and it is noted that, at a rather general level, the methods can be subdivided into contact and noncontact techniques. One of the contact methods is based on making 'rubblings' of the rock surface and has been widely used with some success in the past (see also Chapter 8). However, in recent years this has become a controversial method, as intrusive documentation methods are increasingly frowned upon by the wide rock-art community. Certainly at panels made in soft rock and carrying fine engravings, the scope for damage by rubbing is considerable, especially when the practice is repeated many times over and

by inexperienced operators (see Historic Scotland 2005, 27, for useful summary of the issues and a set of guidelines published by a national heritage agency). The editors wish to state that, in principle, they do not support the use of rubbing because of the impact that it can have upon rock-art surfaces and motifs. Nevertheless, it is accepted that it makes sense to report documentation work undertaken with rubbing as one of the recording methods used because in some parts of the world the technique is still valued; there is also a large corpus of documentation that includes rubbings that has built up from research dating back several decades. We believe that it is best not to sweep such situations under the carpet but rather to make them known and subject to open discussion by those interested in rock-art recording, management, and conservation and to enjoin researchers to consider rather carefully the most appropriate techniques to use within the framework of their research and the nature of the panels under scrutiny.

UNDERSTANDING NATURAL DEGRADATION OF OPEN-AIR ROCK-ART

Complementing the documentation work detailed previously, identifying and understanding the natural degradation patterns at open-air panels is another facet of the worldwide effort to save the planet's rock-art. In fact, it can be said that in every country with rock-art, some sort of study dedicated to the conservation and preservation of rock-art sites has been published. Unfortunately, standards vary greatly, and many studies are incomplete. Few try to offer a comprehensive characterization of each site's specific condition. Typically, one or two examples of weathering patterns at work are examined, while other erosive forces are either poorly addressed or not considered at all.

More ambitious works are available, some aiming at the full characterization of the conservation, management, and documentation issues related to a country's rock-art. Darvill and colleagues (2000) coordinated a detailed study (the Rock Art Pilot Project—RAPP) that describes the situation in England and offered proposals to address some of the problems faced by rock-art in that country (see Chapter 2). The results of RAPP enabled English Heritage to create a Rock Art Management, Access, Study and Education Strategy aimed at the amelioration of the situation regarding the management and divulgation of England's rock-art (Sharpe *et al.* 2008, and see Chapters 3 and 4). For a perspective regarding the situation in Ireland, see Chapter 5. Other countries have also developed their own systematic studies on these matters, such as the projects coordinated by Hygen (2006) and by Bjelland and Helberg (2007) devoted to Norwegian rock-art. For a wider discussion of Scandinavian rock-art management and conservation studies, the Leirfall case study presented in Chapter 6 provides a valuable example. Chapters 18 and 19 introduce novel methodologies to assess and monitor the condition of rock-art.

CONSERVATION INTERVENTIONS ON OPEN-AIR ROCK-ART

In the last few decades, crack filling, reattachment, massif consolidation, and the impregnation of rock surfaces have been approached with increasing caution, especially given the scale of unintentional damage that resulted from past interventions of this kind (Andersson 1986; Finn and Hall 1996; Walderhaug and Walderhaug 1998). Against a background where conservation actions are of a complex and delicate nature, there is often little information on the long-term implications of using new materials (Dean 1999), especially in largely uncontrollable environments.

Avery (1978) offers an enlightening account of how laboratory testing might prove helpful in avoiding ill-prepared interventions at rock-art outcrops. He notes how in one case, “a preservative with penetration of over one centimetre was introduced into a rock sample” (Avery 1978, 68). Subsequent weathering tests suggested that the consolidation was satisfactory and that the rock surface had been suitably strengthened. However, after a short time, the ‘protected’ outer surfaces tidily broke off from the parent body precisely “at the point of deepest penetration” (Avery 1978, 68). Not the intended consequence at all! Avery also offers a word of warning about prior laboratory testing where the results are going to be used for the conservation of particular rock-art panels: “success in simulated laboratory experiments may not necessarily indicate results which might be obtained over long periods of time under natural conditions in the field” (1978, 68).

ETHICAL AND AESTHETICAL ISSUES REGARDING CONSERVATION WORK

Finally, attention may be directed towards ethical and aesthetical issues, particularly in the case of the Côa Valley, where one of the authors (APBF) has attempted to demonstrate that it is the whole outcrop that should be considered when planning and carrying out conservation works (Fernandes 2008). It would be pointless to try only to tackle the weathering patterns active on individual panels of rock-art without endeavouring to stabilize and consolidate the whole outcrop. On the other hand, the *entirety* of the outcrop should be regarded as the ‘total’ art object because it has been singled out for attention by those executing the rock-art in the first place. Hence, our conservation efforts should be aimed at promoting the long-term endurance of the total art object: outcrop + panel + existing ancient rock-art (and its milieu). The goal would thus be to intervene only when strictly necessary (and in the least intrusive fashion possible) to ensure the endurance of a rock-art site if and when it is agreed that the panels should not be allowed to completely decay because of weathering or other natural processes.

CONCLUSION

In setting the scene for the chapters which follow, two important general points can be identified. First, a transdisciplinary approach will significantly increase the likelihood of attaining the fullest possible comprehension of weathering dynamics and their impacts on the rock-art panels at any given site. Second, a case-by-case approach is fundamental to conceptualize, plan, and implement *in situ* interventions since each site is unique and presents different technical, ethical, and aesthetical challenges. What might be justifiable in one case might be entirely indefensible in another.

The 19 chapters that follow provide a unique global review of the state of open-air rock-art conservation and management and consider future perspectives. In Chapters 2 to 5, attention is directed to work in Britain and Ireland, where a wide range of projects is not only exploring the rock-art itself but taking the findings and the excitement of discovery out into the community. Chapters 6 to 8 turn the spotlight on research in Scandinavia, where figurative engraved rock-art provides particular challenges of documentation and conservation. Chapters 9 and 10 look at recent and current work in Iberia, where some of the oldest open-air rock-art in Europe was discovered as recently as the 1980s and now stands proudly alongside the painted rock-art found on the walls of chambered tombs. In both cases, the panels are extremely fragile and sensitive to contact-based recording; Chapter 11 illustrates what can be achieved by 3-D laser scanning to overcome these problems. North America is the focus of Chapters 12 and 13, where the important contribution from Indigenous peoples is discussed. Chapters 14 and 15 consider approaches used in South America, highlighting some of problems associated with tourism and the technical demands of documenting rock-art in these areas. Community involvement in rock-art conservation and management is a theme picked up in Chapters 16 and 17, looking at work in Australia and South Africa, respectively. Novel technical developments in noninvasive assessment and monitoring and in mathematical modelling of rock-decay processes are discussed in Chapters 18 and 19. Fittingly, the volume concludes with Chapter 20, which looks at the role of UNESCO and ICOMOS in creating international legislative frameworks for promoting the preservation, conservation, and management of the very best of the world's open-air rock-art sites.

NOTE

1. A detailed examination of the inventory provided by Sanz (2008, 59–62) reveals that in some of the listed sites, the principal criterion for inclusion in the WHL was not the existing rock-art but rather combined cultural and natural features. Nevertheless, even if rock-art was not the main reason for inscription, it is now a major contributor to the overall significance of these properties. In other cases (such as Rapa Nui Island, Chile, or Petra, Jordan), the property is not listed in the inventory as a rock-art site but contains elements that could easily be classified as rock-art as defined by the IFRAO.

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2 Approaches to the Conservation and Management of Open-Air Rock-Art Panels in England, United Kingdom

Timothy Darvill

INTRODUCTION

Prehistoric rock-art has been recognized in Britain since the early days of antiquarian inquiry. One of the first known drawings of British petroglyphs was made in 1785 by Colonel Montgomery and showed a cist cover from Coilsfield in Ayrshire, Scotland, with a spiral and cup-and-ring marks (Wilson 1863, I, 480). Forty years later, John Langlands recognized two decorated boulders at Old Berwick in Northumberland, England (Beckensall 2001, 14), a discovery that signalled the start of searches for decorated stones across the country. Publications including those by G. Tate (1865) and J. Y. Simpson (1865) with delightful and detailed illustrations brought rock-art to the attention of the academic community and the general public. Surveys and interpretative reviews continued to appear through the later nineteenth, twentieth, and early twenty-first centuries, creating a very considerable literature variously covering Britain and its main constituent parts (Beckensall 1999; Bradley 1995; Darvill and O'Connor 2005; Darvill and Wainwright 2003; Morris 1989; Waddington 2007) as well as rock-art-rich subregions (Beckensall 1983; 2001; 2002; Beckensall and Laurie 1998; Boughey and Vickerman 2003; Brown and Brown 2008; Brown and Chappell 2005; Ilkley Archaeology Group 1986; Van Hoek 1997). More than 2,500 sites with rock-art are known across Britain, about 1,600 of them in England, but it is widely recognized that many more still await discovery.

Despite the long history of interest in British rock-art, little attention was given to its conservation and management until the late 1990s, when English Heritage funded the Rock Art Pilot Project (RAPP) to assess the state of England's open-air rock-art and suggest strategies to secure the future of the resource. This chapter briefly summarizes the results and implications of RAPP, a full report on which is available elsewhere (Darvill et al. 2000). Three themes are considered: the nature of England's rock-art assets, approaches to surveying and recording, and management through protective measures and public engagement.

THE ROCK ART PILOT PROJECT

RAPP was undertaken as a partnership between the Archaeology Group in the School of Conservation Sciences at Bournemouth University and the Institute of Archaeology, University College London. It was commissioned by English Heritage and carried out between February and December 1999 with a high-profile formal public launch on 4 June 1999 amid considerable media coverage.

The work involved the desk-based investigation of the state of rock-art studies in England in particular and the United Kingdom in general within the context of rock-art research in Europe and the rest of the world. RAPP had two main aims:

- To carry out and report a series of thorough reviews, tests, and experiments in order to establish the current state of rock-art studies, data availability and quality, relevant study methods, and the intellectual, academic, practical, and methodological basis for a wider study of rock-art
- To provide a draft project design and associated documentation for a larger programme of work, the main project of which would be United Kingdom based and which would aim to create a full record and analysis of British rock-art.

Archaeological records relating to rock-art in England were gathered, analyzed, and evaluated. Desk-based research was complemented by experimental fieldwork, project-specific IT development, project management studies, and communication and feedback to the archaeological community through newsletters, media contact, publicity, seminars, and advisory group meetings. Two sample transects were identified as being suitable for testing methods and procedures, and periods of intensive field survey were carried out in Northumberland and West Yorkshire.

ENGLAND'S ROCK-ART RESOURCE

British rock-art is either cut, engraved, incised, etched, gouged, ground, or pecked into rock surfaces, and, as such, the motifs may be referred to as *petroglyphs*. No widely accepted set of terminology exists to describe the main kinds of rock-art found in Britain, although 'cup-and-ring marked stones' is the most widely applied term and finds expression in the Monument Class Descriptions developed by English Heritage to assist in the assessment of sites being considered for formal legal protection (English Heritage 1990; and see Oswald 2011). In the light of research undertaken as part of RAPP, and recognizing the difficulties of combining broad terms such as 'art' and 'rock', a broad working definition of rock-art relevant to the situation in England was developed: "any artificially created mark that is cut, engraved, incised, etched, gouged, ground or pecked into, or applied with paint, wax or other substances onto, the surface of rock" (Darvill et al. 2000, 29).

Four terms relating to different spatial scales appropriate to recording English rock-art were developed:

Site as simply meaning a place where rock-art occurs without prejudice to physical size or extent

Panel to refer to any spatially discrete group of symbols or designs (there may be several panels within a site); provides the main unit of record for the purposes of identification and analysis

Motif to refer to a composite design within a panel (e.g. spiral, cup-and-ring), such that an individual panel may comprise one or more motifs

Symbol to denote the constituent parts of a motif where several are used to create the composite design

Research revealed three main situational contexts in which rock-art appeared in England:

Open-air rock-art where motifs and symbols occur on outcrops, earthfast boulders, or natural rock faces, some of which were later broken up or pieces detached so that panels or parts thereof could be incorporated into nearby ritual or ceremonial monuments or circulated as mobiliary rock-art.

Monument-based rock-art where the motifs and symbols occur on the faces of stones incorporated into the fabric or structure of a deliberately constructed monument. Some of these pieces may have been open-air rock-art before being incorporated into a monument, while others were created during monument building.

Mobiliary rock-art where motifs and symbols occur on the surface of stones that have been relocated from their source one or more times. These are essentially portable pieces of rock-art. The date of their relocation is rarely known but is not necessarily ancient.

These groups are not mutually exclusive, and indeed, a given piece of rock-art may, at different times in its life-history, belong to all three categories.

The classification of motifs and symbols is far more difficult and subjective and beyond the scope of RAPP. A number of schemes have been developed, including those by Breuil (1934), Morris (1989), Beckensall (1999), Shee Twohig (1981), Hewitt (1991), and Van Hoek (1993).

Most British rock-art dates to the fourth, third, and second millennial BC, within which three main traditions or styles have been recognized (Bradley 1995; Darvill 2010, figs. 45, 63 and 78; Waddington 2007): cup-marked and cup-and-ring-dominated panels, also known as the Glacial style (Bradley 1997); passage-grave art, also known as megalithic art because of its prominence at Neolithic tombs (Shee Twohig 1981); and cist-grave art, which is the latest of the three styles, mainly found on the cover-slabs of early Bronze Age cist graves and at Stonehenge (Simpson and Thawley 1972).

At the time that RAPP was carried out, there was no single consolidated record of rock-art sites in England, although three parallel sources were recognized as relevant. First, a search of the National Archaeological Record for England revealed about 800 records containing key words relating to rock-art taken from the monument thesaurus. Second, a survey was carried out of the network of 58 local-authority-based Sites and Monuments Records operating in England in 1989, producing 52 (90%) replies of which 15 (29%) confirmed the presence of records relating to ‘rock-art sites’. Consolidated, this gave a total of 655 specific entries on rock-art across England. Third, private archives compiled by four researchers (Stan Beckensall, Ian Hewitt, the Ilkley Archaeological Group, and Ronald Morris) were consulted and other private archives identified. The maximum number of records held in a single private archive was 630, but the various archives could not simply be consolidated as they involved various degrees of overlap and duplication. Comparing all three main sources and consolidating the results was not easy. Table 2.1 summarizes the records for the two sample transects examined in detail as part of the RAPP. Based on these figures, it was estimated that a total of about 1,600 rock-art panels had been recorded in England at the time of the project (Darvill *et al.* 2000, 57).

Most known British rock-art sites are situated in northern England, often in upland regions or their fringes. However, there are some sites in southern Britain, for example in Cornwall and Devon, and it is possible that the original distribution pattern of rock-art sites in Britain differed from the pattern seen today. In some areas, the destruction of rock-art sites because of quarrying, building activities, or farming is believed to have had a larger impact than in others (Bradley *et al.* 1993; Hewitt 1991). Also, rock-art research is focused on areas where rock-art is easily detected or where local researchers have been active. Other regions with reported rock-art sites, such as Cornwall and Derbyshire, have not been investigated to the same extent as

Table 2.1 Number of rock-art records and putative panels held by the National Monuments Record (NMR), local Sites and Monuments Records (SMR), and private archives for sample transects examined during the RAPP in 1999. (Source: Darvill *et al.* 2000, tab. 5.5)

Transect	NMR Records	NMR Panels	SMR Records	SMR Panels	SMR records not giving	Private archive Records	Private archive Panels	Panels surveyed by RAPP
					panel numbers			
Northumberland	7	15	14	21	3	47	65	20*
West Yorkshire	11	15	24	27	0	33	33	14
TOTALS	18	30	38	48	3	80	98	34*

* Plus 3 outside transect

many areas in northern England such as Northumberland, Durham, and West Yorkshire.

Much research endeavour on British open-air rock-art has focused on the discovery and identification of new sites and panels, a process that has benefited enormously from the involvement of successive generations of amateur archaeologists working individually or in groups. Local knowledge of a landscape is highly valuable, but an experienced eye is essential. A recent case at Chapel Stile or Copt Howe, in Cumbria, right beside the pathway to the well-known Neolithic axe quarries at Great Langdale, highlights the point. Here, literally scores of archaeologists walked straight past a panel in plain sight until it was spotted by independent rock-art researchers Barbara and Paul Brown (Brown and Brown 1999; Sharpe and Watson 2010). In many areas, discovering previously unrecognized panels is made difficult because the majority are found at low level or ground level and are often obscured by vegetation cover. When wildfires strip upland landscapes bare, it is not unusual for an abundance of rock-art to be discovered as at Fylingdales Fir, Co. Durham (Lee 2010). One snag is that with many researchers working in overlapping areas, there is also the question of whether a panel has already been identified and recorded.

Very little investigation by way of geophysical surveys, excavations, or environmental reconstruction has been carried out at or around rock-art sites. Most of the documented excavations related to monument-based rock-art where the discovery of the panels was incidental to the main aims of the work. But there are exceptions, and important progress has been made through work at Gardom's Edge, Derbyshire, where three boulders featuring various motifs including multiple cup-and-ring marks and spirals were found during an early excavation of a large cairn. In 1996, the area surrounding the boulder featuring the most complex motifs was excavated in order to investigate whether activities which were contemporaneous with the rock-art could be identified. The excavation revealed two stake holes, a polished shale ring, and some chert and flint flakes (Barnatt et al. 1995). Farther north at Blackstone Beck, Ilkley Moor, West Yorkshire, an open-air panel situated within an enclosure was investigated (Edwards 1988). The aim was to investigate the relationship of three visible carved panels with artefact scatters. A fourth panel was found during the excavations. Two distributions of Grooved Ware and worked flint were found in close proximity to the boulders, as were areas of heat-affected soil. Charcoal yielding a radiocarbon date of 2923–2613 cal BC was found underneath one of the boulders in the enclosure, but in this case no rock-art was visible (Edwards 1988; Edwards and Bradley 1999). And north again, several open-air panels (some visible prior to excavation) and small mobiliary stones were found within and around Fowberry cairn, near Weetwood Moor, Northumberland, during an excavation investigating the relationship between the cairn and the outcrop panels (Beckensall 1999, 142–44). The only other artefactual evidence recovered was a flint scraper found in the deposit between the

cairn and the outcrop rock. The results from these investigations are now complemented by three recent excavations at decorated rock exposures near Kilmartin in southwestern Scotland (Jones et al. 2011).

SURVEYING AND RECORDING

Open-air rock-art in England is found on a wide range of lithologies of varying degrees of hardness. Each presents particular issues for surveying and recording as well as for conservation and management. Recording them is an issue with both practical and ethical dimensions. A major element of RAPP was to establish which surveying and recording techniques best suit rock-art in England. Accordingly, a number of carved panels in different situations within the study transects in Northumberland and West Yorkshire were selected for experimental recording.

Three key dimensions to surveying and recording English rock-art were identified, each reflecting a different problem or scale of analysis. First, as a primary process, identification requires both the recognition of panels that have already been recorded in some way and need to be relocated in the field and subject to further study and the discovery of hitherto unknown panels. Second, once recognized on the ground, panels need to be georeferenced and mapped. And third, the content and structure of a panel in terms of physical attributes and the motifs and symbols represented need to be recorded. In doing this last stage, there are ethical issues surrounding the use of methods involving direct contact with the panel surface and a stated and widely accepted preference for non-contact methods of recording and documentation. Issues connected with the last two of these three dimensions are considered in the following subsections.

Recording Panel Context and Structure

At the broadest scale, the detail of motif and panel designs needs to be accurately georeferenced so that individual panels can be related to one another and to other attributes of the landscape in which they lie. The key elements of this level of survey must be georeferenced first to provide an accurate location and second to situate the detailed record of a panel with reference to its context on the rock into which the motifs were cut and the landscape in which it is set.

Experiments georeferencing panels focused on three different grades of global positioning systems (GPSs), each of which uses a constellation of satellites to obtain location co-ordinates via a receiver. This allowed the field team to explore the possible applications of a range of GPSs varying in accuracy and cost. The equipment included a survey-grade System 500 GPS supplied by Leica Geosystems, a Fastmap GPS with limited GIS capability from Survey Supplies of York, and a Garmin 12 Personal Navigator handheld device. These units were capable of achieving accuracy levels of subcentimetre, submetre, and, through averaging, sub-10 m, respectively.

Prices ranged from £200 per day hire for the survey-grade GPS to £200 per week for the Fastmap to £116 to purchase the Garmin.

Each of the three GPSs had different limitations, accuracy levels, and optimum applications. The high-end Leica equipment was best suited for high-accuracy recording but required a higher degree of user input to process data than did the lower-grade Fastmap equipment. The Leica equipment was also more successful in poor survey conditions (such as poor satellite visibility and light woodland canopy cover). The Fastmap equipment was found to be best suited to wide-area recording such as picking up individual sites. This was less accurate but far simpler to use, and data collection was displayed as a developing map in real time. Lastly, the handheld Garmin receiver was easily operated, and its pocket size made it ideal for simple position-point data collection. All three systems were capable of working in the field with OSGB36 (the National Grid co-ordinate system) and displayed real-time map co-ordinates. All three could be used to navigate with, although the handheld Garmin unit was far easier to handle, and a point position could be fixed within a couple of minutes. This receiver was, however, far less accurate (at best claimed to be within 15 m). Selective availability of satellites affected all three systems, but both the Leica and Fastmap receivers got around the problem by using a second receiver to counteract the random errors. In the case of the Leica equipment, this came in the form of a second reference receiver, and in the case of the Fastmap, a second satellite signal was picked up from a network of stations around the coastline of Britain.

As a result of the recent expansion of rock-art research internationally, much discussion has taken place regarding the standardisation of methods and the establishment of minimum standards for recording and documentation (Clegg 1991; Gunn 1996; Loendorf et al. 1998; Swartz and Zancanella 1991; Walt et al. 1997). An interesting feature of each of these articles, however, is acknowledgement that in practice, such a task is rarely possible. Many variables apply to every field visit, including the purpose of the research, the uniqueness of each site, the experience and skill of the recorder, the field conditions encountered, and the resources of time, equipment, materials, and funding (Clegg 1991). Additionally, no single recording method provides a complete and purely objective record, as all fall victim to the subjectivity of the recorder, the effects of the environmental conditions, and the limitations of the materials or equipment used. The condition of a site and its context may also mean that some details cannot be recorded.

Successful rock-art documentation consists of two elements: non-image documentation comprising maps and field-notes containing information regarding the location, description, and any observations of the site and image documentation of the actual motifs and panel structure. To achieve the first, a series of existing databases for recording rock-art was reviewed (Darvill et al. 2000, 105–6) to provide ideas on the range and types of information that were typically recorded as standard practice for petroglyph sites across the world. This work highlighted the need for a recording system to integrate text, graphics, and georeferencing in order to allow an holistic

approach to rock-art interpretation. An experimental RAPP database linked to a GIS was designed with the potential for use in a much larger programme across the United Kingdom. Paradox for Windows was selected to create a relational database of 18 data tables and 38 lookup tables (see Darvill et al. 2000, Appendix E, for a full list of fields and tables) that covered a wide range of attributes covering the nature of the panels and motifs, location and measurement, situation and land use, palaeoenvironment, condition and weathering, view-shed data, digitized graphics (drawings, photographs, plots, maps, and footage), existing records, and site visit information. ArchInfo was the GIS programme used for mapping and the spatial representation of the data. In this way, the data could be utilized for analysis and interpretation as well as acting simply as a record archive.

A selection of 19 field-based techniques appropriate to image documentation of the motifs and panel structure was tested within the RAPP, including photographic methods, drawing techniques, technical surveying, and laboratory analysis. Several were adapted directly from standard archaeological site survey and planning techniques, but not all of them had previously been used for recording rock-art panels in England. Table 2.2 lists all the techniques evaluated in relation to whether they dealt with panel context, panel content, or panel attributes.

Table 2.2 List of rock-art recording techniques assessed by RAPP during fieldwork in Northumberland and West Yorkshire in 1999. (Source: Darvill et al. 2000, tab. 7.1)

Panel Content					
Panel Context	Non-Contact optical methods	Non-contact drawing methods	Contact methods	Combined methods	Panel Attributes
Total Station	SLR photography Digital photography	Representative	Tracing		Rebound Hammer
			Carbon and wax Rubbing		Geological identification
Global Positioning System	Photogrammetry Laser scanning	Scaled planning	Damp cotton Foil impression Moulding and casting	Epigraphic survey	Soil sampling Lichen Identification Weathering attributes recording

Several recording techniques may be required in combination to cover the complete range of features associated with a particular rock-art panel from its situation in the landscape to unique details present in a single symbol. RAPP differentiated among those methods and techniques for recording images and those for monitoring and quantitatively determining the state of the panel under different conditions and over the course of time, although some methods may be suitable for both purposes.

Recording techniques to document panel content are generally considered to be of two kinds: those that require direct contact with the stone surface and those that do not. However, this division is not always as clear as it may sound. Some contact may occur when using so-called non-contact methods, for example when making measurements of motifs for drawings, but, overall, non-contact methods do not involve the application of materials that could cause chemical or physical damage. For the sake of site preservation, non-contact methods are recommended whenever possible, and contact methods are only used on stable and robust panels if absolutely necessary. In fact, some consider all contact methods inappropriate except where sites are about to be destroyed (Wainwright 1985).

The visual clarity or visibility of rock-art depends upon the conditions under which the panel is observed. Therefore, sites should be visited several times and some recording methods should be repeated under various conditions in order to obtain the most complete record possible. Furthermore, it has been demonstrated that different people will produce very different results using similar recording methods on the same panel (Moore 1991). Swartz (1991 and 1997) addresses both of these issues by suggesting the formation of recording teams (to include a recorder and a checker) and that two teams should visit each site separately to record the same features observed under varying weather conditions and throughout daily and possibly seasonal cycles. Although such repetition may not be possible for all field research, the suggestion to have records cross-checked by different people while in the field and under different conditions is indeed very valid.

No single recording technique provides a total record under all circumstances, although laser scanning comes very close. As Table 2.3 shows, techniques also differ widely in the training required for their use, the degree of access needed, the time required for implementation, limitations caused by weather conditions and/or location, and of course the cost of the equipment. All these factors have to be balanced against one another and in relation to the actual working environment for the survey and the level of available resources.

Looking at the experimental results from applying different techniques to the same rock-art panel, it is clear that some methods, such as the use of foil or damp cotton as photographic aids, were of limited use on this particular kind of rock-art but that they should not be discredited immediately as they may prove useful elsewhere. Perhaps most noteworthy was the opportunity to compare and contrast the field results from different methods.

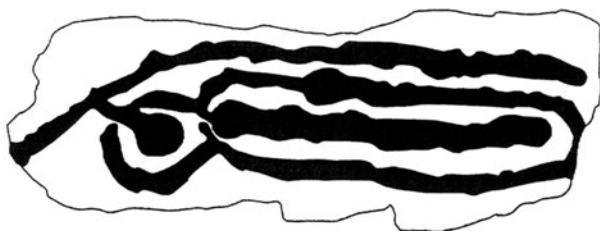
Figure 2.1 shows comparative motif plans from four traditional recording methods. It is impossible to say which is the 'best', although the scale

Table 2.3 Summary matrix assessing field-recording technology and its application to rock-art documentation. (From Darvill et al. 2000, tab. 7.4)

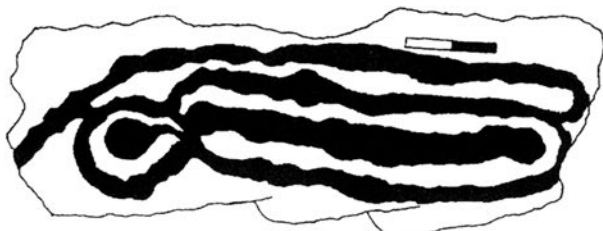
Technique	Training	Access	Expense / Equipment	Time	Weather / Conditions	Location
Photography (SLR & digital)	✓	✓	✓	✓	Weather dependent	✓
Epigraphic Survey	✓	✓	✓	✓	Weather dependent	✓
Damp Cotton Photography	✓	✓	✓	✓	Weather dependent	✓
Foil Impression	✓	✓	✓	✓	Weather dependent	✓
Photo Grammetry	Training Required	Requires equipment transport	£	⊕	Weather dependent	Limited by access to Panel
Total Station Panel Outlines	Training Required	Requires equipment transport	£	✓	✓	✓
Total Station / GPS Surface Modelling	Training Required	Requires equipment transport	£	⊕	✓	✓
Total Station Motif Recording	Training Required	Requires equipment transport	£	⊕	✓	✓
GPS Panel Positions (Garmin handheld)	✓	✓	✓	✓	✓	Limited by tree cover

GPS Panel Positions (Survey grade)	Training Required	Requires equipment transport	££	✓	✓	Limited by tree cover
GPS Panel Positions (Beacon)	Training Required	✓	£	✓	✓	Limited by tree cover
GPS Panel Outlines (Beacon)	Training Required	✓	£	✓	✓	Limited by tree cover
GPS Panel Outlines (Survey grade)	Training Required	Requires equipment transport	££	✓	✓	Limited by tree cover
Laser Scanning	Training Required	Requires equipment transport	££	⊕	Weather dependent	Limited by access to Panel
Scale Drawing (Motifs / Panels)	✓	✓	✓	⊕	✓	✓
(Planning Frame, Baseline, Different Scales) Datums surveyed in GPS / TS						
Scale Drawing (Weathering / Damage Observations)	✓	✓	✓	✓	✓	✓
Tracing	✓	✓	✓	✓	✓	✓
Carbon / Wax Rubbing	✓	✓	✓	✓	Weather dependent	✓

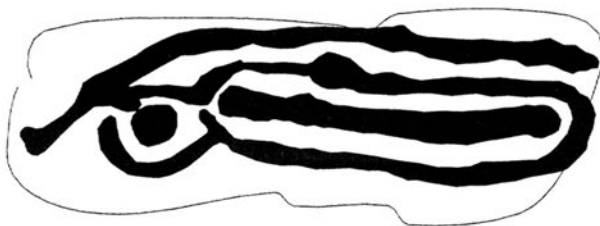
Note: ✓ indicates that the technique is not problematic with regard to the evaluation criteria used; £ and ££ indicate high levels of cost; ⊕ indicates high time requirement.



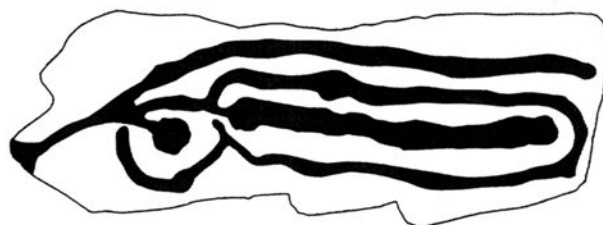
Tracing



Epigraphic Survey



Total Station



Scale Drawing



Figure 2.1 Comparison of motif plans using tracing, epigraphic survey, total station survey with mini-prism, and scale drawing recording techniques for panel 8008, Rivock Edge, West Yorkshire. (From Darvill et al. 2000, fig. 7.16)

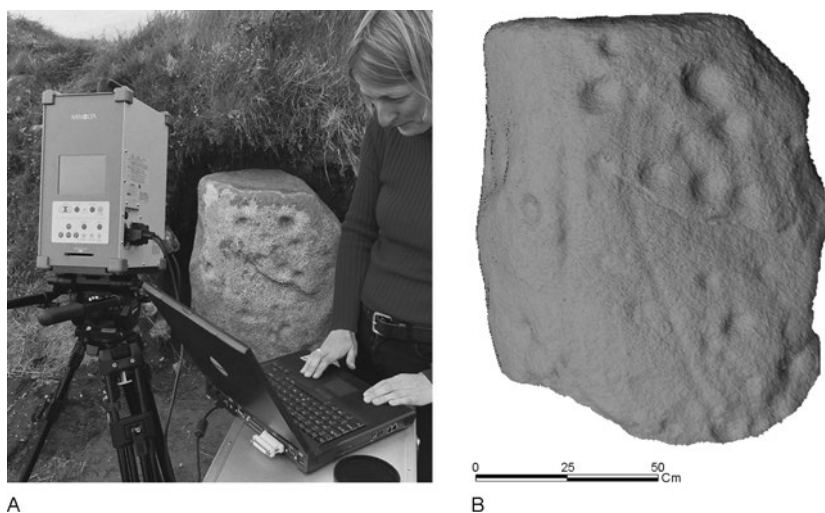


Figure 2.2 Laser scanning rock-art. A: Scanner in use recording a rock-art panel at Ballacricyrt I, Arbory, Isle of Man. B: Resulting scan. (Photograph by Timothy Darvill; image capture and processing by Kate Welham and Robert Nunn. Billown Neolithic Landscape Project, copyright reserved)

drawing is probably the most considered. What is important to note, however, is that the form of the cup-and-ring symbol towards the left-hand side of the motif as shown in the figure is significantly different in the result of the epigraphic approach.

A laser scanner capable of recording colour was found to be the most objective and effective means of fully recording a rock-art panel currently available, providing both quantitative and qualitative data (Figure 2.2). Digital data recordings of surface dimensions and colour could be used for a number of monitoring purposes. Additionally, the various imaging and replication options available make laser scanning the single most output-productive and versatile method of recording of those tested in the field trials. Since this method is 3-D, quick, and requires no direct surface contact, laser scanning is perfectly suited for recording petroglyphs, and further application of this method should be considered. The downside is that the equipment is expensive and not very portable, so its use in remote locations is far from easy.

MANAGEMENT THROUGH PROTECTIVE MEASURES AND PUBLIC ENGAGEMENT

Effective management of open-air rock-art sites requires a good knowledge of their overall character and distribution as well as adequate documentation of the individual components of the resource, including a good level of

information about the risks that sites face and the opportunities available to ensure a secure future.

An assessment of the regional, national, and international importance of rock-art in Britain reveals its value as both an academic resource and a very visible and publicly accessible component of the historic environment. At the international level, protection is afforded to a few rock-art panels in England, namely those within the Stonehenge and Avebury and Associated Sites WHS (see Chapter 20) and perhaps also within the Hadrian's Wall WHS, but no sites in England are inscribed on the World Heritage List as rock-art monuments.

Nationally, about one third of known rock-art sites lie within a National Park, which generally means conservation-minded development control and the promotion of the area for tourism, recreation, and public education. The *Ancient Monuments and Archaeological Areas Act 1979* defines a number of protective designations for archaeological sites, two of which are relevant to rock-art.

Guardianship is a form of direct management to secure the survival of sites, and they are usually accessible to the public. There are currently about 400 Guardianship sites in England, but none were established to secure the future of open-air rock-art. However, some Guardianship sites contain rock-art panels, usually as monument-based examples as at Castlerigg Stone Circle, Cumbria; Stonehenge, Wiltshire; Ballowall Barrow, Cornwall; and Roughting Linn, Northumberland.

A second form of designation is known as Scheduling, and this applies to about 14,000 ancient monuments in England, approximately 6 per cent of all recorded monuments, on the grounds that the sites are of national importance. Scheduling does not confer any right of public access to the site. Determining the number and proportion of rock-art panels that have been Scheduled is far from easy because of ambiguities in the available records. However, taking a sample of information from three county-based SMRs, it appears that 27 per cent of recorded panels in these counties were Scheduled at the time of RAPP (Darvill et al. 2000, 49–50). The effectiveness of Scheduling as a site management tool has been investigated by others (for example, Darvill and Fulton 1998; Glass 1989), and it remains to be seen if Scheduling is effective as a means of protection for rock-art. From observations made in the field (in Northumberland and West Yorkshire), it appears that Scheduling might improve awareness on the significance and vulnerability of certain rock-art sites (and certainly the level of archaeological information). In practical terms, however, Scheduling has little effect regarding potentially damaging activities (such as cattle poaching, browsing animals, atmospheric pollution, and visitor damage).

Among the many dangers faced by open-air rock-art sites is the rise of visitor interest in them. It is a double-edged sword, because on the one hand, public interest undoubtedly acts to secure their protection through education and awareness, while on the other hand, it increases erosion through footfall and genuine engagement with the stones as well as

providing targets for vandalism of various kinds. As a result, a full consideration of public access and associated public education programmes should be a key part of integrated conservation planning at local, regional, and national levels.

In England, there is not much in the way of visitor-friendly rock-art displays (Darvill et al. 2000, 131–3), and even within Britain as a whole, the rock-art centre at Kilmartin in Argyllshire, Scotland, is something of an exception (Butter 1999).

Of Northumberland's rich rock-art heritage, the sites of Roughting Linn and Lordenshaws are among the most widely known. At the time of RAPP, Roughting Linn, the largest rock-art site in England, was enclosed by a wooden fence. Visitors could access the site via a gate, while animals were kept out. Beside the panel, a notice board was set up in the early 1970s. By contrast, Lordenshaws is located close to a well-visited prehistoric hill-fort. It receives some publicity by being included in a leaflet titled *Lordenshaws—an historic landscape* published by the Northumberland National Park authorities. An Internet site on Lordenshaws, maintained by Northumberland County Council, includes brief information on the rock-art. Beside the occasional nineteenth-century graffiti, a new 'cup-and-ring mark' was hammered into the rock with a metal tool on top of prehistoric petroglyphs in the late 1990s. Beneath the design, the words "rock map" were engraved. Since the site is not enclosed, visitors walk on the rock and possibly across the petroglyphs, adding to the erosion of the rock surface.

The Yorkshire region represents another major concentration of rock-art in England with about 640 sites identified to date (Ilkley Archaeological Group 1986). Some of the motifs are unique to this area, such as a 'ladder' design. Despite the fact that many of the major sites are Scheduled Monuments, few are actively managed. Next to none is equipped with any explanatory signs or panels, and only the 'Swastika Stone' on Woodhouse Crag, Ilkley, is singled out for public attention (Figure 2.3A). This outcrop carries a rare *swastika* motif; it was enclosed with metal railings in the late nineteenth century in order to prevent direct access to the rock surface, and these have remained in place ever since. A brass panel was bolted onto the rock directly beside the petroglyph in the late nineteenth or early twentieth century, but its text is now outdated. The only other marked petroglyphs in the region, although no longer *in situ*, are the Panorama Stones, once one of the finest examples of rock-art in the area. The petroglyph panels were originally situated on the upland area of Ilkley Moor, on Panorama Ridge, but in the 1890s when a reservoir was built at the site, stones were moved into Ilkley town. During transport, one of the three panels was broken, and the two pieces were cemented together.

Further afield, rock-art panels are presented in a low-key way on Gardom's Edge in the Peak District, Derbyshire, where a circular walk of about 3.6 km passes beside a decorated panel (Moors for the Future 2012), although vandalism has meant that a fiberglass replica is what is actually



A



B

Figure 2.3 English rock-art and the public. A: Visitors at the Swastika Stone enclosed by its nineteenth-century fence on Ilkley Moor, Ilkley, West Yorkshire. B: Replica rock-art panel made of fiberglass as part of a public self-guided walk at Gardom's Edge, Derbyshire. (Photographs by Timothy Darvill. Copyright reserved)

visible in the ground today (Figure 2.3B). Another decorated stone from the area is on show in nearby Sheffield City Museum. Other displays of *ex situ* open-air rock-art panels can be found at the Yorkshire Museum in York, where several cup-marked boulders can be seen flanking the pathway leading to the main building, and Bristol City Museum sometimes displays the decorated cover-slab from a cist at Pool Farm, Priddy, North Somerset, with its cup-mark and footprint motifs (Coles et al. 2000).

There is no question that much more could be done to develop and promote open-air rock-art in England, and at minimum cost. Chapters 3 and 4 show the way forward using Web-based technologies that can now be delivered through smart phones and tablets to remote locations. Critical here is recognizing the 'human' side to our activities as well as a 'professional' side. English Heritage have usefully proposed what might be termed the 'heritage cycle' to focus attention on the four successive phases: understanding, valuing, caring for, and enjoying aspects of the historic environment (English Heritage 2008). Public engagement is a fundamental aspect of all four phases in the cycle, and by creating public support, there is a real chance that some of the big problems of conservation and management can successfully be addressed.

CONCLUSIONS

RAPP demonstrated the great potential of open-air rock-art sites in England and the value of these sites both as an archaeological resource yielding information on our prehistoric past and as heritage assets of interest to the public. The key features that underpin the importance of British rock-art were identified as (Darvill et al. 2000, 47):

- Open-air rock-art sites represent a widespread and relatively numerous class of prehistoric monument.
- The material remains are a long-lived phenomenon that link into other aspects of material culture.
- It is the earliest apparently abstract expression by cultures living in the British Isles.
- It appears as the earliest known physical representation of human and animal forms in the British Isles.
- The incidence of rock-art in many different situations allows it to help connect otherwise diverse components of the archaeological resource.
- British rock-art is part of a European phenomenon which, although in some ways distinctive, provides evidence for the investigation of links and connections with other regions.
- Some elements of British rock-art, notably cup-marks, connect to one of the most widespread and ancient styles of 'art' in the world.
- The ancient authors of rock-art in Britain made extensive use of natural rock surfaces and thus provide an archaeological link between the natural world and the human mind.

A wide range of survey methods for the plotting and georeferencing of panels is now available, and a selection of these was investigated and subject to field trials within two sample transects. It is concluded that the most effective system involves combining survey-grade GPS to provide survey stations, followed by GPS or (in wooded areas) total station plotting of individual panel outlines and the recording of reference points on panel surfaces. A range of contact and non-contact methods of recording motifs on panel surfaces was tested and evaluated. Each had strengths and weaknesses, and a critical factor was what the images produced were intended for. In creating a basic record of British rock-art, it was found that drawing and conventional photography provided high-quality images at modest cost. At the other end of the spectrum, laser scanning, although costly, provided an extremely high-quality record of the panel surface in the form of a digital model of the micro-topography. The data generated by this method can be used to make replica surfaces as well as graphic images. For detailed long-term monitoring of panel surfaces, digital imaging through laser scanning provides the best available method of high-resolution recording.

An experimental GIS-based record system was established to provide a means of storing and manipulating available records. By using multiple layers, the system can be sensitive to the various sources of data available. It is recognized that for the creation of a National Rock Art Index, it will be necessary to collect a consistent set of information and that appropriate data standards will need to be developed and agreed upon. Current approaches to the presentation and display of rock-art in Britain and abroad were reviewed. It was found that in England, there is relatively little active management and presentation of rock-art for public access.

What RAPP emphasized was the urgent need for further work on British rock-art, as it is under considerable threat and is a relatively understudied component of the historic environment. Luckily, in the first decade of the twenty-first century, a number of exciting projects were established to move forward the agenda set by RAPP (see Barnett and Sharpe 2010), and some of these are discussed in Chapters 3 and 4.

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NOTE

1. Specifically excluded from RAPP was all Palaeolithic mobiliary and cave-art; all later prehistoric, Roman, and medieval decorated stonework such as grave-slabs, memorial stones, crosses, and mobiliaries; small pieces of shaped rock that are decorated or ornamented in various ways, for example carved stone balls and plaques; and hill-figures cut into the downland of Southern England.

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3 The Preservation and Care of Rock-Art in Changing Environments A View from Northeastern England, United Kingdom

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INTRODUCTION

Open-air ancient stone monuments, including standing stones and carved rock-art panels, exemplify Britain's rich prehistory and provide a visual link to our ancestors. These nonrenewable heritage resources have great cultural, aesthetic, and tourism value and are frequently designated as Scheduled Monuments; some are also inscribed as World Heritage Sites. Often, these monuments provide an important testimony to a time without written records and are irreplaceable. Despite their perceived immutability, open-air ancient stone monuments are under mounting pressure because of increasing population densities associated with urban expansion, pollution, agricultural activity, and climate change (Brimblecombe et al. 2011). As a result, a proportion of open-air ancient stone monuments is falling into disrepair and may ultimately vanish from the countryside.

In spite of their apparent vulnerability, strategies for specifically addressing the management of open-air ancient stone monuments are limited. This is partly because of their perceived longevity but also because most scientific information on stone integrity and resistance to change is biased towards studies of the historic built environments (e.g. Fort et al. 2006; Prikryl and Smith 2007; Smith and Warke 1996), which do not always translate to the issues faced by open-air monuments in the countryside. As an example, the nature of the stone used in open-air ancient stone monuments often differs from that used in the construction of historic built structures. Unlike the stones used in historic built structures, open-air ancient stone monuments usually involve stone that is not 'worked' to any great degree, having been carved *in situ* within essentially rural landscapes where they are subject to differing ecological and physical pressures compared with modern urban settings. As such, significant gaps exist in our understanding of the key factors that influence the state of open-air ancient stone monuments, especially given increasing human intrusion in the countryside and forecasts of dynamic changes in our climate over the next century or so.

As background, research into physical, chemical, and, to a lesser degree, biological weathering (biodegradation) of rock carvings has been performed since the 1970s (Bakkevig 2004). However, only recently have more extended scientific studies on rock deterioration been performed to better inform open-air monument management (e.g. Giesen et al. 2014; Macedo et al. 2009; St. Clair and Seaward 2004). Although this current study does not provide new data on deterioration mechanisms, its aim is to highlight key issues pertinent to open-air ancient stone monument preservation with a particular focus on management approaches that might be implemented now to future-proof such structures during periods of environmental and climatic change. Within this context, the objective is to consider four issues related to open-air ancient stone monument preservation. First, we will examine and clarify differences between the terms ‘resilience’ and ‘resistance to change’ within the context of site management. Second, pressures and threats to open-air monuments will be summarized, including how such pressures might alter under different climatic conditions. Third, ancient rock-art panels across the countryside in northeastern England will be used as a case study for discussing management questions related to environmental change. These panels were selected partially because they have rarely been studied in an holistic manner but also to demonstrate differences in open-air ancient stone monument integrity relative to the integrity of other kinds of stone-built monuments. Finally, management implications will be discussed for enhancing the resilience of open-air ancient stone monuments, including the development of formalized condition assessment schemes to help prioritize sites for management-related intervention. The ultimate goal is to stimulate the development of formalized frameworks for heritage management that both consider present and future climatic conditions and could be translated to other similar scenarios.

RESILIENCE VERSUS RESISTANCE TO CHANGE

‘Resilience’ is a term applied in many disciplines, ranging from engineering to anthropology, but its meaning often differs. In fact, the term is frequently misused, which further confuses its implications, especially in the management of complex systems. The term describes a system’s ability to remain functionally consistent over time and under stress and also its ability readily to recover its original state after disturbance. Therefore, we define resilience to mean the ‘quality or state of being flexible’ at the system level. With this in mind, open-air ancient stone monuments are innately not resilient. Although, in comparison to other materials, stone is typically highly resistant to change, it is not literally resilient because when stone deteriorates, it does not return to its original state. Open-air ancient stone monuments deteriorate in a way that is nonreversible and permanent. Therefore, the first key objective in management is to maintain the current state of an open-air

ancient stone monument for as long as possible, which means creating and/or retaining resilient environments around the site so that changes in condition are minimized. As such, management should focus on providing environments surrounding open-air monuments that are intrinsically stable in themselves, which will in turn maximize the monuments' tendency to remain stable by keeping local conditions as consistent as possible (e.g. moisture conditions, drainage, exposure to air, animals, etc.).

As an aside, open-air ancient stone monuments are, by definition, old (sometimes up to 6,000 years old) and their presence in current landscapes argues that a high level of resistance to change must exist. However, we also must consider that such monuments may be the remnants of a much larger collection, much of which has already been lost during past centuries, with today's survivors representing a self-selecting group of more resistant specimens. While past resistance to change is related partially to the selection of particular kinds of stone by the original creators of the monuments, population densities, agricultural intensity, and pollution were much lower in the past, and temperature and precipitation patterns have been relatively consistent for the last 10,000 years (Bond et al. 1997). However, growing evidence suggests that environmental conditions that facilitated long-term resistance to change in the past may not continue into the future (Giesen et al. 2014). Therefore, contemporary approaches to monument management must consider increasing populations, greater exposure to pollution, and other broad threats, such as gradual or sudden changes in climate (Broecker 2010).

PRESSURES AND THREATS

To consider how open-air ancient stone monuments might be affected by future conditions and, in turn, help define appropriate management solutions for preservation, it is first important to establish the types of threats that might affect their longevity. But it is not completely clear which of the current and/or future threats are of greatest importance. Although it is reasonably certain that most threats will differ over space and time, some will be predictable, others not, and still others are unknown at this time. This variability makes developing management strategies difficult and suggests that the best general approach for open-air ancient stone monument preservation is to:

- Better understand the science behind the processes of deterioration
- Develop methods for prioritizing sites for protection and immediate action
- Refine monitoring approaches in relation to monument state in order to identify where deterioration of consequence might be occurring

To start, we will summarize various pressures and threats that are 'known', somewhat predictable, and often controllable. After that, we will present

specific data on rock-art in northeastern England. Then we will discuss less controllable factors, such as sudden climate change. As will become apparent, many factors that affect monument integrity are hard to define and quantify. Therefore, creating resilient environments around open-air ancient stone monuments regardless of future conditions is of great importance to management.

KNOWN PROCESSES

The processes responsible for stone decay must be understood to successfully prevent, treat, and/or manage open-air ancient stone monuments; failure to do this can lead to inappropriate strategies that can amplify original problems or trigger new deterioration scenarios. Many processes affecting open-air stone monument decay are similar to or the same as those influencing built stone structures, yet key differences also exist. Mutually significant decay processes between built and nonbuilt monuments include physical breakdown (e.g. flaking, granular disintegration, cracking); chemical breakdown (e.g. staining, pitting, and scalloping/fluting); alternation and deposition (e.g. recrystallization and crusts); biological weathering (e.g. lichen, ephilithic algae, endolithic algae, and vegetation growth); and direct human impacts (e.g. repair, cleaning, quarrying, and graffiti; modified listing from Smith 2010, 126–35). However, processes unique to open-air ancient stone monuments include other human impacts (e.g. turf removal); agricultural intrusion (e.g. ploughing, field clearance, controlled burnings and plantings, and increased nitrate levels from fertilizers); animal activity (e.g. persistent trampling or rubbing the rock surfaces and contact with their waste); and linked ecosystem impacts (i.e. altered grazing patterns, vegetation change, and altered exposure; Greeves 2009). On a synoptic level, the two key differences between open-air ancient stone monuments and built stone structures stem from where they generally are found (i.e. rural settings as against urban settings) and the rock types used (i.e. mainly natural outcrops as against quarried stone supplied).

The net product of these factors is that different pressures are imposed on open-air ancient stone monuments in comparison to built stone structures; specifically, impacts on open-air ancient stone monuments are often more ecological in the sense that direct cause-and-effect relationships are less predictable. The classic example of how open-air ancient stone monuments differ from built stone structures may be seen in the preservation of Callanish on the island of Lewis, Scotland (Bohncke 1988; Dark 2006). Callanish is one of the iconic standing stone structures in Britain and is quite well preserved. However, this preservation is largely a consequence of changing climatic conditions not long after Callanish was abandoned. For reasons that are only partially understood, precipitation, drainage, and vegetation patterns altered in the region, resulting in accelerated rates of peat

accumulation and burial of the stones (Bohncke 1988). This burial protected the stones from both human impact and weathering and resulted in their preserved state today. This story is very pertinent here because it shows how cascading factors in an ecosystem can dramatically alter the preservational state of an open-air ancient stone monument at a given site. However, it also shows why climate change matters (positively in this case) and why considering such change in management strategies must be important relative to long-term preservation.


THREATS TO ROCK-ART IN NORTHEASTERN ENGLAND

Until recently, scant attention had been paid to the threats facing British open-air ancient stone monuments beyond a few major sites such as Stonehenge and Callanish, especially open-air rock-art panels and sites (Darvill et al. 2000; Darvill, Chapter 2). In order to begin rectifying this situation, Barnett and Diaz-Andreu (2005) canvassed 13 rock-art recorders and researchers in 2003 and 2004 by asking about their perceptions regarding the factors influencing the decay of British rock-art. Although based largely on anecdotal evidence, this survey, which addressed physical/chemical, biological, and human factors, provided the first synthesis of the factors influencing the deterioration of British rock-art.

Between 2002 and 2004, at roughly the same time that Barnett and Diaz-Andreu were undertaking their survey, Mazel, with the support of Stan Beckensall, the doyen of British rock-art studies, undertook a comprehensive project, the Beckensall Archive Project, to record the rock-art of Northumberland in northeastern England. Based on the extensive archive developed by Beckensall over more than 40 years of fieldwork, the primary aim of the Beckensall Archive Project (BAP) was to create a user-friendly website, supported by a database, to provide the basis for future research, educational outreach, and wide public access and understanding of rock-art panels (Mazel 2005; 2007; Mazel and Ayestaran 2010). In addition, the BAP aimed to improve understanding of the vulnerability of and threats to the carvings by natural and anthropogenic processes and develop an appreciation of future management and conservation requirements. This aspect of the BAP was achieved through the completion of on-site panel report forms, which included the collection of information relating to conservation and management issues. In fact, human and animal interaction with rock-art was recorded at 575 of the 720 panels studied during the BAP (Table 3.1).

Conservation and management information also was recorded during the Northumberland and Durham Rock Art Pilot Project (NADRAP) between 2004 and 2008 (Oswald et al. 2006; Sharpe et al. 2008), but this information has yet to be collated. It is worth noting, however, that several volunteer recording teams collected the NADRAP information, while the BAP

Table 3.1 Past destruction and current threats to Northumberland rock-art based on the recording of 575 panels recorded between 2002 and 2004.

Nature of past destructive factor or current threats	N	%	
Quarrying	93	16.2	
Livestock scratches	60	10.4	
Plough damage	16	2.8	
Turf removal	16	2.8	
Plantation	11	1.9	
Driven on	8	1.4	
Burning	6	1.0	
Graffiti (ancient)	4	0.7	
Relocation of rocks during farming activities	2	0.3	
Candles	2	0.3	
Chalking	1	0.2	
Graffiti (modern)	1	0.2	

material was collected by a single recorder (Mazel) and is therefore likely to represent a more consistent dataset. However, when the NADRAP data are collated, it will be useful to compare these two datasets.

Table 3.1 presents a summary of the destructive factors and threats to Northumberland rock-art identified during the BAP. These issues can be grouped into three categories: past destructive factors, recent interference by visitors, and modern agricultural practices. In terms of past factors, it would appear that quarrying (Figure 3.1) has been most detrimental to the rock carvings in that one in six panels (i.e. 16%) display evidence of damage through this activity. However, the survey results probably underestimate the impact of quarrying because some (possibly many) rock-art panels may have been removed completely. For example, the presence of carvings on rocks incorporated into stone walls and the foundations of bridges and houses provide evidence that carved rocks have been quarried away. However, quarrying is nowadays closely controlled in many upland landscapes and is no longer considered to represent a major threat to the conservation of rock-art.

Considering the impact of farming practices in northeastern England, about 80 per cent of the panels were considered threatened by cows and sheep walking on them, although only 10 per cent showed actual evidence of damage in the form of scratching (Table 3.1). It is likely that most if not all of the plough-damage relates to past practices, although one instance was noticed where recent ploughing had gouged within 0.4 m of a carved panel. Panels being driven on by other vehicles (1%), burnt accidentally or through



Figure 3.1 Rock-art in the landscape: Evidence of quarrying on a rock panel at Lordenshaws, Northumberland, UK.

controlled moorland burning (1%), and/or covered with plantation litter (2%) represent other threats to the rock-art, although more work is needed to understand fully the extent of such factors.

While about 10 per cent of the panels showed evidence of human visitation (e.g. modern cairns, paths, litter), turf removal was noted at only 3 per cent of the panels. Furthermore, contemporary graffiti and wilful human damage was not apparent as a major factor influencing the state of rock-art in northeastern England. A distinction was drawn between ancient and modern graffiti and, while the number of observations was low (four and one, respectively), it is noteworthy that the majority of the graffiti was believed to predate the twentieth century. Interference with rock-art panels by candles placed on the rocks and chalking was not deemed a major threat to rock carvings recorded in the database, although they do exist.

Many of the destructive factors and threats recorded by Mazel (Table 3.1) are consistent with those reported by Barnett and Diaz-Andreu (2005), although the apparent low human impact on the rock carvings recorded by Mazel differed somewhat from the perceptions of Barnett and Diaz-Andreu's respondents. In addition to the threats listed in Table 3.1, respondents to Barnett and Diaz-Andreu's survey also noted a range of chemical and biological agents that they believed threatened rock-art, although no direct proof

of impact was shown. However, Giesen et al. (2014) recently showed that panel height above the landscape and high soil salt levels were most associated with greater rock-art deterioration at Northumberland sites, suggesting physical and chemical factors are important.

While the ongoing threats to the rock-art noted previously can (and should) be mitigated through the implementation of effective management strategies, it is becoming increasingly appreciated that management strategies need to consider a wider range of pressures using a systems approach. Respondents to Barnett and Diaz-Andreu's (2005) survey were on the right track when they made a link between the increasing prevalence of lichens and changes in the local environmental conditions (Macedo et al. 2009). In themselves, lichens do not necessarily constitute a problem, as they can act as either a bioprotective or a biodestructive agent (St. Clair and Seaward 2004). Nevertheless, this observation highlights the potential for more subtle impacts that climate change or pollution might have on the long-term future of rock-art and open-air ancient stone monuments in general.

CLIMATE CHANGE AND ITS MANIFESTATION

Many inaccuracies and misunderstandings exist about climate change, especially its spatial and temporal effects. For the purpose of this discussion, the assumption is that climate change is occurring and it must be considered in relation to open-air ancient stone monument preservation. Therefore, it is critical that we consider the range of past, current, and future expressions of change that might affect sites such as rock-art panels in northeastern England. Prior to discussing implications, a few key points must be clarified about climate change. First, climate change does not necessarily mean global warming. Climate modelling shows that different areas of the world will be affected differently by changes in atmospheric conditions. Figures 3.2A and B show three scenarios representing possible changes in surface temperature by the end of the twenty-first century (Solomon et al. 2007), while Figure 3.2C shows equivalent predicted precipitation patterns over the same time frame (Meehl et al. 2007). As Figures 3.2B and C show, temperatures are expected to increase in some places, especially polar regions, whereas other areas, such as the temperate margins, will become much drier.

Most climate-change models show that change will occur everywhere but that these changes manifest themselves quite differently at the local level. For example, in northeastern England, where rock-art panels are fairly common, available models generally predict more intense and locally dynamic precipitation events, especially in the winter, but only slightly warmer air temperatures (Giesen et al. 2014). The same models predict that the south in England will be drier all year round and generally warmer, particularly in the summer. From a management perspective, these predictions are useful because they imply that greater differences will exist between wet and dry seasons in the future. Higher and more variable rates of local runoff might

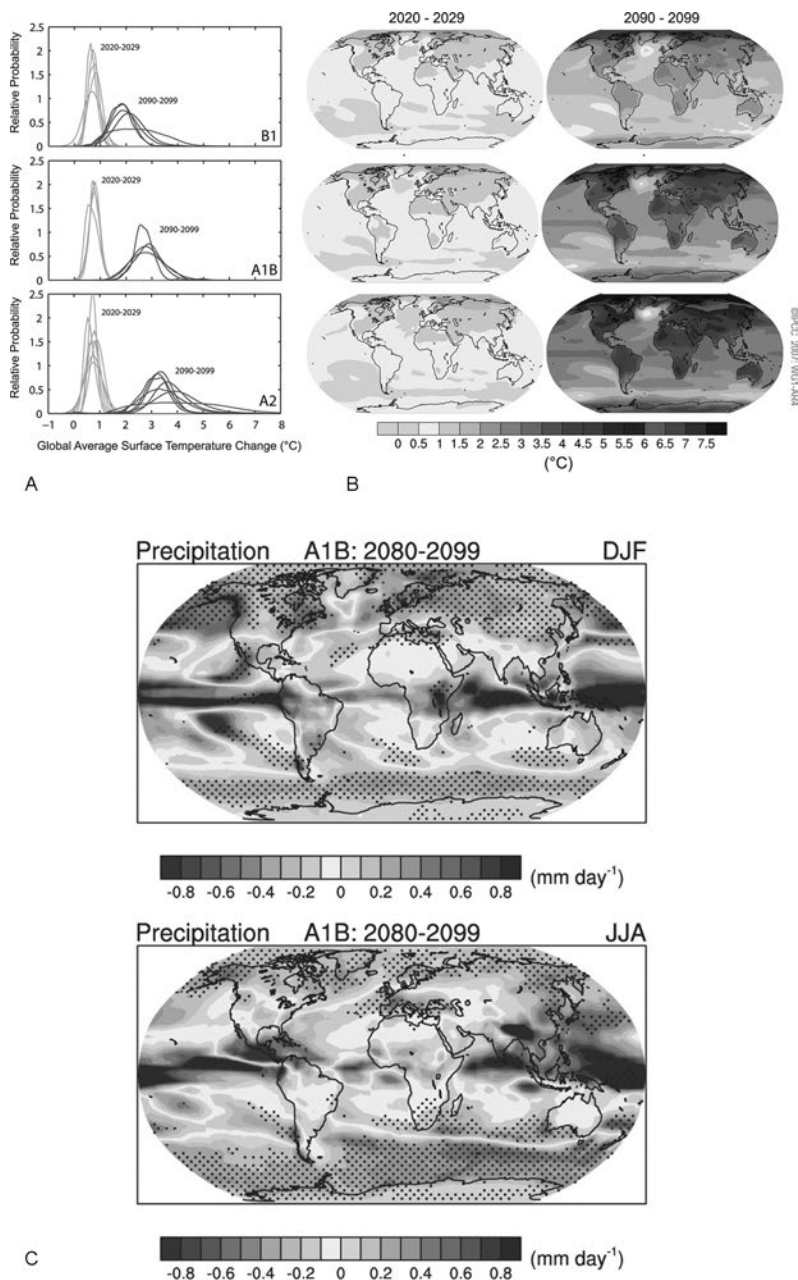


Figure 3.2 Climate change models. A: Projected changes in average surface temperatures. B: Global surface temperatures through the end of the twenty-first century, including variability in predictions based on different model assumptions. C: Projected relative changes in global winter (DJF; December, January, and February) and summer (JJA; June, July, and August) precipitation patterns by the end of the twenty-first century based on IPCC panel predictions. (A and B reproduced with permission from Solomon et al. 2007, fig. TS.28; C modified and reproduced with permission from Meehl et al. 2007, fig. 10.9).

be expected such that on-site drainage conditions must be considered carefully. However, the resolution of most predictions is rather coarse and, in fact, the line between 'north' and 'south' is approximate. As such, we contend that one must plan for different futures and embed as much resilience as possible into local open-air ancient stone monuments.

Although spatial variation of change is significant (and somewhat obvious), two points related to climate change are potentially more important for future-proofing open-air ancient stone monuments. First, all climate predictions become much less reliable the farther into the future they are made. As an example, A2 scenario in Figure 3.2A and B (a scenario that assumes current human behaviour does not significantly change) shows that predicted temperature changes among models vary by only 0.5° C by 2029, but predictions for the same locations differ by ~5° C for 2099, which implies that greater uncertainty exists in forecasted conditions farther into the future. Such broad predictions partially result from the fact that each climate-change model assumes different levels and types of uncertainty in their structures, which become differentially amplified or suppressed over time based on the type of uncertainty and the form of the model. Variations also result from the fact that each model assumes slightly different initial conditions and weighs the drivers of climate change differently, including human behaviour. Although this imprecision is worrying, the key for managing open-air ancient stone monuments is the need to be innately cautious when making management decisions, especially until modellers have a better grasp of trends and the likely human responses to climate change have been established.

The final point related to climate change and the protection of open-air ancient stone monuments is of a more fundamental nature, stemming from the behaviour of complex systems as energy levels increase. Complex systems respond to increasing energy (e.g. a generally warming atmosphere) and are characterized by sudden changes in system-state as energy increases. Earth's atmosphere does not behave in a linear manner, especially as energy levels become higher. Specifically, as energy increases (exemplified by warming, more intense precipitation, etc.), complex systems innately bifurcate; they jump between broadly differing states and, as such, sudden or dramatic change becomes innate (Broecker 2010). Heritage management must have contingencies against the impact of sudden change on resource stature, which should include consideration of the fact that the exact nature and timing of change is impossible to predict.

The practical consequence of these natural phenomena is that climate-driven changes of conditions surrounding open-air ancient stone monuments will probably not be gradual or linear; consequently, management approaches must be designed with consideration of sudden change in mind. Unfortunately, exactly predicting sudden change in complex systems is impossible; therefore, we feel it is essential that any climate change management of open-air ancient stone monuments be underpinned by improved, more sensitive methods for monitoring of their state relative to those mechanisms of deterioration that are of greatest concern. Given that sudden changes will not be readily predicable (consider the difficulty of predicting earthquakes, another manifest response of complex systems), research is needed on the development

of sensors and monitoring equipment that can be calibrated to detect changes in the underlying stable state of a given site. The results of these studies can inform managers of interventions to enhance the resilience of the local environment around open-air stone monuments. Therefore, the goal of management in this respect is to create buffer environments around monuments so that catastrophic changes in state are less likely to take place, and, if such change does occur, it can be mitigated and managed more effectively.

MANAGEMENT APPROACHES FOR THE FUTURE

It will be evident from the data and insights presented that the future-proofing of open-air ancient stone monuments is far from straightforward. Managers need to grapple with a wide array of issues facing heritage sites, including:

- Identification of which sites/panels should be preserved
- Where sites are located in the landscape
- What is the best way to preserve each site
- Who should pay for preservation
- The nature and extent of public access to sites

It is not surprising, then, that, as with all heritage resources, clear and far-sighted management planning is a vital first step in the care of open-air ancient stone monuments.

As background, an identified monument is usually included within or added to an inventory or register (in England known as Historic Environment Records, or HERs), where baseline data are recorded about its location, age, size, function, type, state, and level of significance. These initial appraisals can vary considerably and often lack standardized condition information. Further, open-air ancient stone monuments are rarely checked on a regular basis (or at all in some instances) until they become part of a dedicated research (or monitoring) project, whereupon heightened interest may raise their profile enough for them to be incorporated into a management plan. Fortunately, the NADRAP and the BAP have provided a valuable baseline for rock-art panels in northeastern England. However, the issue of prioritizing sites for attention and intervention remains, as there simply are not enough resources to manage all sites and panels everywhere. Therefore, condition assessment and risk evaluation must underpin sound management. Managers not only need to know the current condition of open-air ancient stone monuments in their stewardship, but they also must have a basic understanding of the mechanisms that contribute to deterioration in order to evaluate current and future risk. To achieve this, a simple-to-use and relatively rapid formalized scheme is needed in order to help managers proactively identify those open-air ancient stone monuments in most need of remedial intervention. Furthermore, a formalized assessment scheme would allow managers of different sites to compare data and evaluate outcomes based on a common approach and terminology.

Such a staged systematic approach to condition assessment was first developed by medical clinicians as a tool for the assessment and treatment planning for cancer patients (Hermanek and Sobin 1987). Their model was based on many decades of research into the extent of cancer spread and the predicted extent and success of treatment. Although deceptively simple, the model is very well grounded and scientifically robust and provides an internationally recognized triage system for cancer. This ‘staging system’ approach goes beyond basic description by incorporating a risk assessment based on the evaluation of current condition and the identification of actual and potential risk factors. This, in turn, enables an assessment of ‘prognosis’ or long-term outcome if no intervention is undertaken and gives an indication of the extent of intervention required. In fact, this terminology is not arbitrary because the medical model provided inspiration for development of such a staging system for use on historic buildings (Warke 2010; Warke et al. 2003).

Although this system was developed primarily for built structures, it has since undergone successful modification for application to archaeological stonework closer to the kind found at open-air ancient stone monuments where intervention and limited financial resources exist, but where the majority of archaeological structures are of similar age and archaeological significance and exhibit similar levels of deterioration. This new system was trialled successfully at Petra in Jordan with the preparation of field-recording data-sheets for the Palace Tomb at Petra to illustrate a viable condition assessment scheme. In practice, parallel assessments are performed among similar types of sites, and management priority is placed on the sites that show the greatest need based on quantitative comparisons using standard guidance criteria within a stage assessment grid (Figure 3.3). At Petra,

		Nature of manifestation and extent of spread			UNIT	
		U	A	S		
Outcome STAGE	Good	1	U0 U1 U2	A0 A0	S0 S0	U0: No deterioration detectable U1: Some surface alteration with minimal breakdown affecting only small isolated parts of the facade U2: Well-developed surface breakdown but involving less than 10% of the facade U3: Well-established surface breakdown with loss of original surfaces affecting a minimum of 10% of the facade A0: Small isolated areas of deterioration A1: Positive involvement of adjoining elements but affecting less than 10% of the facade A2: Positive involvement of adjoining facade elements affecting 10–30% of the facade A3: Extending localised involvement of adjoining blocks affecting more than 30% of the facade S0: Deterioration restricted to specific sections of the facade S1: Deterioration affects distant unconnected portions of the facade involving more than 50% of the total surface area
		2	U1 U2	A1 A1	S0 S0	
		3	ANY ANY	A2 A3	S0 S0	
	Poor	4	ANY	S1 S1	S1	

Figure 3.3 General guidance criteria for assignment of Staged Assessment for monuments (adapted from Warke et al. 2003).

this approach led to the Palace Tomb being prioritized as being in urgent need of intervention primarily because of the unstable nature of the stone block work that presented a high risk in terms of potential injury to visitors and the catastrophic loss of archaeological integrity.

The significance for open-air ancient stone monuments of the assessment scheme for Petra does not lie in the specific issues encountered at Petra but in the broad value of using a formalized assessment scheme as a management tool; it enables prioritization of individual monuments in greatest need of urgent intervention based on a standard guide. Therefore, we recently developed such a model for managing open-air ancient monuments, which is designed to be rapid and easy-to-use, and allows a more formalised condition assessment and risk evaluation (CARE) (Giesen et al. 2014).

However, we still do not have adequate details on destructive mechanisms affecting open-air ancient stone monuments. Thus, in refining such a CARE scheme, topics requiring further investigation include:

- The proximity of the monument to current human and agricultural activity
- The regional location of the monument relative to changing forecasted climatic conditions
- Altered spatial demographics of human movement due to climate change
- The influence of ground vegetation on exposure conditions

In the particular case of rock-art panels, the key now is to gain more scientific and other information on what dictates rates of deterioration and also on management approaches that enhance site resilience, both factors that are critical for developing the most suitable CARE criteria. In fact, such work is underway for the protection of rock-art in northeastern England (and see Chapter 4), but it is our intention to apply it to similar sites and open-air ancient stone monuments around the world.

CONCLUSIONS

The future of open-air ancient stone monuments is not guaranteed, as environmental conditions and human agencies prompt deep-seated changes. Therefore, it is incumbent upon us to understand factors that have most contributed to the preservation of such monuments in the present-day landscape and then develop sustainable management approaches to enhance long-term site resilience. We are partway there with regard to rock-art panels in northeastern England, but questions remain. The mechanical basis of decay at open-air ancient stone monuments is largely a scientific matter requiring better understanding of the possible impacts of changing climatic conditions. However, building heritage management expertise, especially in developing a sound and workable CARE system, will help prioritize decisions

about resource deployment within an environment characterized by ever-diminishing funding for archaeological resource management.

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4 Pride and Prejudice

The Challenges of Conserving and Managing Rock-Art in the Landscape of Northern England, United Kingdom, through Public Participation

Kate E. Sharpe

INTRODUCTION

Rock-art is more accessible than much prehistoric archaeology in England, both physically and intellectually. Most is found in the open landscape: no excavation is required, and the excitement of ‘discovery’ is open to anyone with keen eyes and determination. Further, as noted by Barnett, “absence of an orthodox interpretation makes rock-art more intriguing to people from a wide range of backgrounds, who feel more able to assign their own interpretations and values than they might if an entrenched academic explanation were available” (2010, 26). The lack of prescribed meaning makes rock-art a very ‘democratic’ part of the historic environment.

Rock-art in the English landscape is also more easily visited today than at any time in the past. GPS equipment is widely available and accurate coordinates are easily obtainable. A quick Internet search and data download are sufficient to take one directly to any panel of interest. The *Countryside Rights of Way Act 2000* has opened up previously inaccessible areas, and websites may even include advice on the best routes to take, where to park, the optimal season or time of day to visit, and the nearest pub or tea room. Since its launch in 2000, a website accompanying Julian Cope’s book *The Modern Antiquarian* (Cope 1998) has become a major repository of news, information, images, and debate—all contributed by enthusiasts who have visited ancient sites across Britain, Ireland, and other parts of Europe. Further, whilst interactive websites built by virtual communities have made rock-art more accessible, technology has also made it more attractive. The latest photographic equipment can produce incredible images showing clearly defined carvings set in appealing landscapes (Figure 4.1).

The aesthetic and intellectual allure of these mysterious markings is clear, but are people interested in visiting rock-art in the field? There are no formally managed rock-art sites in England, so information is largely anecdotal, but a recent survey as part of the Rock Art Mobile Project (RAMP: see below) recorded that 63 people visited the Lordenshaws panel in Northumberland on one day in 2010. ‘Virtual’ visits to rock-art also provide a



Figure 4.1 Rock-art in woodland at Rivock Edge, West Yorkshire. (Photograph by Mike Short. Copyright reserved.)

proxy indicator. In the two weeks following its launch in 2005, the website *Northumberland Rock-art: Web Access to the Beckensall Archive* (NRA 2005) was visited by 20,983 unique visitors. Over the next 12 months, the total reached 50,000 (Mazel and Ayestaran 2010, 146).

An increasing interest in the ancient past is also borne out by a recent Council for British Archaeology report (Thomas 2010). This records that the number of volunteers involved with local archaeological groups and societies has doubled since 1987, with at least 2,030 groups and 215,000 individuals currently taking part in a variety of activities across Britain. So how can we harness the curiosity and enthusiasm that leads people to join archaeology groups or to visit prehistoric sites and direct them towards recording, managing, and protecting those same places?

This chapter considers three rock-art projects in northern England which involved significant public participation. Around 200 members of the local community were directly involved, but many others—families, friends, land owners, local businesses—also played a part. The Northumberland and Durham Rock Art Pilot Project (NADRAP) was a pilot study undertaken between 2004 and 2008 and designed to explore the potential of training local people to record rock-art. A follow-up project, Carved Stone Investigations:

Rombalds Moor (CSIRM) ran between 2010 and 2013 in West Yorkshire. Although separately funded and independent of NADRAP, CSIRM incorporated the methodologies developed and lessons learned from the pilot. The third initiative considered is the Rock Art Mobile Project (RAMP), which between 2010 and 2011 developed innovative, user-led visitor experiences incorporating, amongst other material, some of the data and images collected by the NADRAP volunteers. The following discussion draws on direct experience working within each of the project teams and on the ideas and opinions expressed by participants. Details of the organizations, funding bodies, and key personnel of each project are provided in the acknowledgements at the end of the chapter.

THE STATE OF THE ART

Despite its accessibility compared to other archaeology, rock-art has not always been easy either to find or to find out about. Only a decade ago, records consisted of a disparate set of regional catalogues and local databases, each created using different approaches and to differing standards. Some predated technologies such as GPS and digital photography, resulting in less accurate, more subjective records. Despite these limitations, many excellent gazetteers were published (e.g. Beckensall 1999, 2001; Ilkley Archaeology Group 1986; Morris 1989), some specifically aimed at visitors. In one publication, Morris states, “More than anything else, this book is intended as a guide for those who wish to visit some of the sites” (1981, 3). Yet few panels were protected or maintained, for example with walkways or fences, or had interpretation; most were not even signposted (see Chapter 2). Often the only clue to their location was the mysterious “Cup-marked Rock” annotation on Ordnance Survey maps.

The rapid expansion and uptake of the Internet in the late 1990s brought new ways to share information about prehistoric sites. Enthusiasts began to link up and create online gazetteers with maps and photographs (see Brouwer and van Veen 2010 for a detailed account of one such example). Although websites provided an alternative information source, a key reference for British rock-art remained a series of publications by independent researcher Stan Beckensall. His books (e.g. Beckensall 1999, 2001) reflect the methodologies of the time and balance information with inspiration, while his distinctive black-and-white drawings provide a uniquely personal interpretation of the rock surfaces that he describes. Between 2002 and 2004, Beckensall’s extensive collection of photographs and drawings was digitized by a team at Newcastle University, who also recorded the panels and built an interactive website. The result, *Northumberland Rock-art: Web Access to the Beckensall Archive* (NRA 2005), put English rock-art on the map, both literally and metaphorically, reaching a worldwide audience and developing a loyal following (Mazel and Ayestaran 2010).

The increased public exposure to information about English rock-art was not paralleled by an increase in protective measures or active management and presentation. Rock-art remains an unexploited component of the heritage ‘package’. There is, perhaps, good reason for this apparent neglect of a potentially valuable tourism asset: many examples are in remote locations within challenging terrain. They are often on private land or in areas with restricted access at particular times of the year (e.g. the nesting or shooting seasons), and there is concern that promotion may lead to increased human impact on the carvings and their surroundings. In the late 1990s, however, English Heritage recognized both the potential value of rock-art as an archaeological and heritage asset and the mounting problems it faced. They commissioned a review of the current state of research, conservation, management, and presentation of rock-art in England as the Rock-Art Pilot Project (RAPP). The final report concluded that “there is an urgent need for further work on British rock-art as it is under considerable threat and is a relatively understudied and undervalued component of the historic environment” (Darvill et al. 2000, 10; and see Chapter 2). The report recommended the development of a national recording strategy, and in response, NADRAP was initiated.

NADRAP had two aims: to explore the potential of trained volunteers for recording and evaluating the carved stones and to work with local people to increase awareness and pride in their rock-art. A key objective was to produce baseline data for around 1,500 panels across northeast England, including a detailed assessment of current condition and potential risks. Longer term, it was hoped that the methodology could be exported to other regions and, ultimately, enable the creation of a comprehensive database for the entire corpus of English rock-art (for a detailed account of NADRAP, see Barnett 2010). A subsequent recording project has since enabled the NADRAP ‘toolkit’ to be applied to the Rombalds Moor area of West Yorkshire. CSIRM was a volunteer-led project that added a further 500 panels to the database. (See Brown et al. 2012).

A central tenet of both projects was the inclusion of public participation. It was believed that:

- With minimal training and inexpensive equipment, volunteers could undertake baseline recording for a large number of panels, allowing limited professional resources to be directed towards specialized, technical studies
- Skills and experience gained by participants would create a valuable local capacity for future projects, whilst the wide range of knowledge and perspectives they brought would enrich and enhance the project
- The projects would increase awareness and create a legacy of pride both locally via the participants and more widely through the associated website and publications
- Information collected on conservation and risk factors would inform future management decisions, identifying panels in need of intervention and those which could sustain increased footfall

But do community projects such as these really contribute to the long-term conservation of rock-art? Or does the promotion just lead to more visitors and place the panels at greater risk?

AMPLIFICATION AND OPTIMIZATION OF RESOURCES

More than 100 volunteers contributed 1,500 working days to the NAD-RAP project, effectively one day per panel recorded, including time spent on fieldwork, data processing, and other sundry tasks. The cost saved allowed the available budget to be directed toward specialist work, including laser scanning, detailed landscape surveys (Oswald and Ainsworth 2010), and geological evaluations (Jefferson and Jefferson 2010), which significantly enhanced the basic record.

With lessons learned from the pilot study, the subsequent CSIRM project provided more representative data. Mid-way through the project participants had contributed 829.5 hours, during which time they had recorded around 300 panels. However, this figure does not include an unrecorded amount of time spent by one extremely dedicated volunteer developing a new methodology for producing survey plans (see following sections) and preparing the base maps and recording forms used in the field. This has undoubtedly contributed to the impressive recording rate. The fieldwork may also have been aided by the more densely clustered distribution of rock-art in the project's study area compared to Northumberland and Durham but hopefully also reflects a more focussed, extended training programme and refined recording methodology. Costs have undoubtedly been saved, but at a time of severe economic circumstances and limited budget, the CSIRM project was less concerned with specialist studies and more focussed on realizing the baseline recording objectives which, without volunteer input, may not have been achievable at all.

The volunteer model appears to represent good value for money but is this at the expense of 'professional' standards? A recent Council for British Archaeology survey notes barriers to communication between paid archaeologists and the voluntary sector, suggesting that at least some professionals may have preconceptions and prejudices, "possibly stemming from particular experiences in the past or from groups whose practices or methods cause concern" (Thomas 2010, 48). A similar divide is apparent between academia and community archaeology. Marshall notes that "in Britain, community archaeology is commonly located within heritage management and outside the remit of serious academic research" (2002, 214). This combination of negative experiences and lack of integration among community archaeologists, heritage managers, and academics perhaps explains a degree of mistrust amongst professional practitioners in the data produced by unpaid amateurs. Reservations may also be a natural reaction to a perceived move away from restricted top-down archaeological practices. The more flexible

'bottom-up' approach possible with community-based projects means that fieldwork can be organized in an inclusive, non-hierarchical way which is open to volunteer contributions and ideas (see Faulkner 2000 for a detailed discussion). But do amateur results really make the grade?

An important aim of the recording projects was for each volunteer team to work unsupervised to a shared standard and to achieve similar results. This was a significant challenge—to ensure a consistent, accurate dataset of wide-ranging and technical information without over-managing the participants to the degree that they became frustrated and disengaged. During NADRAP, these issues were explored using techniques to encourage 'best practice' (see Barnett 2010 for details). One finding was the extent of the learning curve experienced by many participants; it was some time before they became comfortable with the recording process. However, once they became confident, participants were able to pass on their knowledge and mentor other team members. A small, core group became extremely proficient, developing and improving the methodologies far beyond expectations. The NADRAP experience led to the use of a more phased approach for the CSIRM project, with the initial training period followed by an extended 'trial' phase in the field, with further feedback before the main recording stage.

The involvement of so many individuals with diverse abilities, perceptions, and opinions meant that consistency was an issue. The use of tick boxes helped, and recording forms were simplified and clarified as NADRAP progressed, further limiting subjectivity. Improved forms were developed for the CSIRM project, and these were further refined through discussion with the participants during the trial phase.

For a pilot study, NADRAP was ambitious in its aim to record around 1,500 panels across Northumberland and Durham. The wide geographical coverage was addressed by setting up five local teams to cover specific areas. This inevitably led to inconsistencies as teams developed their own working practices, an issue which was partly resolved by cross-checking and regular project get-togethers. The smaller-scale CSIRM project began with just two teams, each with around 18 members. Several months into the main recording phase, following the natural dropout of a few members, the teams joined forces, eliminating the inconsistency issues experienced with NADRAP. The smaller number of target panels (*c.* 450) in a more compact study area, together with a realistic time frame (based on experience from the pilot), ensured that all panels were recorded to a high standard. In fact, an immense commitment of time and effort from a few key participants put the recording phase well ahead of schedule.

The NADRAP records met their primary objective of providing baseline information. However, there were limitations: some aspects of the recording process remained challenging. Scaled plans of the rock-art and its surrounding area proved most demanding, with walkover surveys of the immediate environment not always as insightful as if done by an experienced field

archaeologist (Oswald and Ainsworth 2010). These problem areas must, however, be set against the very high standards achieved by volunteers working on photographic and photogrammetric recording (see following sections), which exceeded all expectations.

In summary, although the training and management of a large number of volunteers proved to be very time consuming, the pilot study indicated that this approach had the potential to provide a more efficient use of available resources. The CSIRM project incorporated the lessons learned. For example, issues with surveys have been addressed, largely by the participants, who brought their own expertise and experience to bear on the problems. Initial reviews of the records created and the rate of recording suggest that CSIRM has demonstrated the true potential of amateur participation in the data collection process, although it must be acknowledged that this is largely due to the efforts of a few extremely committed individuals. Yet public involvement in heritage projects is about more than costs and standards. As Marshall observes, “Community archaeology represents an opportunity. We need it, not because it is politically correct, but because it enriches our discipline.” (2002, 218).

ENRICHMENT AND CAPACITY BUILDING

Both NADRAP and CSIRM participants contributed far more than their time, bringing a variety of skills and experience, and perspectives that challenged traditional archaeological approaches. Their expertise included computing and teaching, art and design, surveying, geology, photography, and surveying. They also provided crucial local knowledge, helping with the logistics of access, understanding the terrain, and negotiating land-ownership issues. Skills such as leadership, teamwork, and organizational ability were also of great value. Some volunteers motivated and inspired their teammates; others took on less prominent, though no less critical, responsibilities such as data entry.

From the NADRAP, two contributions are worth particular note: the creation of an interim database and the development of photogrammetry methodology. One participant created a user-friendly database, allowing volunteers to input data from the paper recording forms. This was crucial to the success of the project, allowing concurrent data entry and validation. The same volunteer has since assisted the CSIRM project, providing an updated interface to match the revised recording forms. Expertise like this is invaluable: an external software developer would have been costly. Further, the familiarity of the volunteer with the recording form and his direct experience in the field resulted in a quicker design process and more nuanced result.

A second significant volunteer contribution was the enhancement of the photogrammetry recording technique to produce high-resolution 3D models.

This low-cost, non-intrusive method was initially developed by English Heritage in partnership with Loughborough University (Bryan 2010; Bryan and Chandler 2008; Chandler et al. 2007). A small group of volunteers became adept at both field-recording and data processing and further developed the technique based on their growing experience.

Initially intended as a small trial, photogrammetry was ultimately applied as standard, with stereo-images captured for almost all panels and 420 models created. The technique has potential applications in research, presentation, and conservation monitoring and has been adopted by a number of other initiatives both in Britain and worldwide. The methodology was included in the CSIRM project from the outset (Figure 4.2).

The CSIRM project has also benefitted hugely from the expertise of participants, specifically in the development of methodology for the production of location sketches, which show the panel in relation to archaeological and topographical features. These proved difficult for the NADRAP participants, but two of the CSIRM volunteers simplified the process using satellite imagery and digital imaging software to produce preliminary plans. Team members with limited surveying or drawing skills used these in the field to produce accurate results with a unified appearance.



Figure 4.2 The Carved Stone Investigations: Rombalds Moor project: A photogrammetry team at work. (Photograph by Barry Wilkinson, CSIRM participant. Copyright reserved.)

In return for their expertise and experience, both projects provided the participants with extensive professional training in various aspects of the recording methodology, both in the classroom and in the field. The skills and knowledge gained represent a valuable asset that could be mobilized for future heritage-related or volunteer-led projects. A number of the NADRAP volunteers have since applied their new talents to excellent effect within the CSIRM project and the RAMP project (see what follows) and contributing to Altogether Archaeology community projects in the North Pennines (Altogether Archaeology 2012).

One story merits further mention. Midway through the NADRAP project, a dedicated volunteer was offered a salaried position as a volunteer coordinator, assisting with the day-to-day organisation of the fieldwork. This role was instrumental in the successful completion of the project. In addition to managing the volunteers, the volunteer coordinator made a significant contribution to the development and implementation of the photogrammetry technology. The experience gained allowed him to make the transition to a consultancy position on the CSIRM project. His technical expertise has also led to opportunities to share his knowledge on a professional basis, providing advice and training for heritage bodies and academics. This clearly demonstrates the long-term benefits of the training and opportunities provided by volunteer projects, not only for the individuals involved but for future projects that may also gain, either from improved methodologies or from the expertise of the volunteers who transfer their skills. Other benefits of volunteer involvement are less tangible but no less valuable.

RAISING AWARENESS: DEVELOPING PRIDE

The third assumption of the NADRAP model was that it would increase awareness amongst local communities and reach a wider audience through a website and publication. But do volunteer projects like these expand local interest and understanding, or do they simply preach to the converted, attracting participants with an existing appreciation of their local heritage? Have the conservation messages made a difference, or has the extra promotion created more risk? No empirical data are available, and it may be too soon to observe any long-term impact, but anecdotal evidence indicates a number of positive results and just one negative effect (see following sections).

The NADRAP volunteers were recruited through the local press and contact with local archaeology groups. Only 40 per cent, however, were members of archaeological societies, and many of the most committed individuals had no previous experience of heritage or voluntary work. For CSIRM, potential participants were invited (through local advertisements) to attend a launch event, after which they submitted application forms. This was intended to

open the project to a wider audience and to limit dropout rates by ensuring that applicants were fully informed and committed. Despite the untargeted approach, almost all the 39 applicants had experience of local rock-art, with 22 also having visited panels outside of West Yorkshire; 23 had volunteered before, and 10 had contributed to rock-art projects. These figures may reflect the high incidence and accessibility of carved panels in the local area, inspiring a wider interest. The existing knowledge amongst the participants may reduce the impact of the project compared to NADRAP, but bringing together these like-minded individuals should create a strong focus for future conservation and management.

The ‘cycle of understanding’ (English Heritage 2011, 11–12) states that improved understanding leads to valuing, which, in turn, leads to caring. In theory then, community involvement which brings more people into contact with rock-art and with the issues of preservation and management should have a positive effect. Project participants contributed to this process both informally, by cascading information to family, friends, and colleagues, and in a more organized way, representing the project at local archaeology and heritage events with illustrated talks and demonstrations or leading guided walks. Some wrote articles for local journals or for the England’s Rock-Art website (ERA 2013). Ideally, the mechanism for dissemination could be more formalized and coherent, perhaps within a framework encouraging and empowering volunteers to give talks and be involved in education programmes.

The key means by which the projects raised awareness and engaged and informed the public was through the England’s Rock Art website (ERA 2013) and brochure (Sharpe et al. 2008), both produced by the NADRAP. The website, which is maintained by the Archaeology Data Service in York, provides access to the ERA database created by the volunteers: records for more than 2000 panels, including tens of thousands of images, and many 3D models. The website and brochure were both designed to convey important messages about the conservation and management of rock-art, with a ‘Rock-art Code’ for visitors and landowners. Images by photographer Brian Kerr feature prominently. Produced in optimal conditions, these present an idealized version of the rock-art which might attract new (potentially harmful) visitors. However, it could also be argued that the appealing images help to promote the carvings, evoking a sense of wonder and making them more valued than would be the case with less evocative pictures.

The ERA website drew 17,705 unique visitors (Google Analytics) in the fortnight following its launch in 2008. Over the last four years, the site has welcomed more than 60,000 visitors from 145 countries. In 2012, 52 per cent of visits were repeats, with 66 per cent from the UK suggesting a loyal local user community. The brochure has also proved popular and has been widely distributed both in England and further afield. It has proved a valuable tool for heritage professionals involved in discussions

with landowners and tenant farmers. Whilst there has been no formal measure of the success of these methods in increasing awareness, there has certainly been no increase in reports of damage to rock-art. However, one incident highlights the need for caution: a remarkable stone discovered in 2006 during NADRAP was exposed for recording purposes and then recovered for protection. It has subsequently been uncovered several times by members of the public who may not be aware that it is situated within a Scheduled Monument, which means that any work to the site (including uncovering the stone) requires formal consent from the Secretary of State.

PRIDE OF PLACE: PRESERVATION VERSUS PRESENTATION

Both NADRAP and CSIRM were developed on the premise that rock-art is part of a shared heritage and that details of its whereabouts should be in the public domain. Both projects were designed to raise awareness and improve access to information, yet this was a cause of unease for some participants who raised concern about increased risk of damage, if unintentional, from additional visitors, a fear shared by many heritage professionals and some landowners. Yet in order for these conservation issues to be addressed, a more comprehensive understanding of the current state of the rock-art is needed, something also provided by both volunteer projects.

A key element of the recording process was a detailed appraisal of the condition of each panel, with respect to physical and chemical weathering due to wind, rain, and frost, and the effects of biological agents such as lichen, moss, and tree roots. Human- and animal-derived damage (e.g. graffiti and hoof-scratches) were noted, and the volunteers also evaluated future risks from animals, vegetation, people, vehicles, dripping or flowing water, or simply exposure to high winds.

The ERA database can be interrogated to identify panels in need of urgent attention or at high risk, as well as those suitable for managed access. The data fed directly into English Heritage's *Heritage at Risk Register* in 2011 will inform decisions, allowing better targeting of resources. But how can we steer people away from vulnerable examples and towards more stable panels suitable for visitors? The ERA data has helped to do exactly this through a third project of relevance to the present discussion and has also been key in the selection, by English Heritage, of 17 rock art sites (covering 74 panels) to receive Scheduled Monument status.

NEW INTERPRETATIONS

RAMP developed an innovative solution to the presentation of rock-art, delivering an interactive visitor experience via mobile phone technology (see Galani et al. 2011 for a detailed account). The project did not aim to attract a

new audience but rather to opportunistically enhance the experience of people already visiting rock-art or out walking nearby. Of the 63 people visiting the extensively decorated 'Main Rock' at Lordenshaws on May Day in 2010, few were aware of the existence of more than 100 additional rock-art panels in the immediate vicinity. Those who were aware of the carvings knew little about them. They were appreciative of information offered (the ERA brochure) but expressed concern about the intrusive effect of interpretation panels or protective fences which might detract from the experience of encountering the rock-art in its 'natural' setting. The RAMP project, then, set out to tackle the problem of providing information in a way which would enhance rather than diminish the rock-art experience. The solution, delivery via the users' own mobile phone, requires minimal signage, limited intrusion into the landscape, and little future maintenance. Further, only visitors already in the vicinity are drawn to the rock-art.

RAMP drew on public participation in a number of ways. The identification of suitable panels was based primarily on ERA data (i.e. collected by volunteers) such as surface stability, appearance (e.g. visibility, vegetation cover), accessibility (footpaths and terrain), and archaeological and landscape context. The final three sites were selected in consultation with local heritage managers and stakeholders. They were judged able to withstand increased attention, were physically accessible, and were of interest in terms of motifs, archaeological context, and location (most with extended views).

The second element of public participation was more direct: around 40 local people were involved in the design process. Workshops involving field visits and discussions were used to explore expectations, perceptions, and preferences in relation to rock-art, archaeology, and the wider landscape, to existing images and descriptions of carvings, and to less traditional interpretations such as music, poetry, and art. Participants were also asked about their mobile phone usage patterns and experience. Several themes emerged, informing both the technical solution and the interpretive content.

The participants were also asked to test prototypes, and their feedback was used to refine the final product (Figure 4.3A). The participatory design process led to a more considered and more personal result in terms of content, tone, and presentation than might have been produced by professional archaeologists working in isolation. The archaeological content is derived largely from information and images in the ERA database (including plans and photographs from the Beckensall Archive), representing a third element of public participation (Figure 4.3B).

As a result of the project, visitors to three rock-art sites in Northumberland who have Internet-enabled phones are able to access maps, directions, images, plans, descriptions, and audio material, providing a new dimension to their encounters with rock-art. Small signs are placed at each start point, with smaller signs on footpath markers along existing routes. These provide



A



B

Figure 4.3 Rock Art Mobile Project. A: RAMP participants test the mobile phone rock-art experience. B: Screenshot of mock-up showing interactive RAMP content based on Beckensall drawing. (Photographs: A: Aron Mazel. Copyright reserved. B: Debbie Maxwell. Copyright reserved.)

directions to the mobile phone-optimized RAMP website (RAMP 2008), accessed using a Web address or via a QR code printed on the signs. The website also has a direct link from the ERA homepage. The virtual visits to the website since its launch may well reflect physical visits to each of the three rock-art locations.

CONCLUSIONS

This chapter has reviewed some of the ways in which public participation can be used to record, protect, and conserve rock-art through the collection of data, the education and inspiration of local communities, and in the design of novel, non-intrusive solutions the delivery of interpretations. The involvement of trained volunteers allowed limited professional resources to be optimized with thousands of panels recorded using a standardized approach. The NADRAP pilot led to improvements in the methodology which have resulted in more consistent, higher-quality records in the CSIRM project, hopefully removing any lingering prejudices regarding the merit of ‘amateur’ contributions. The successes of the photogrammetry methodology and the new surveying technique demonstrate the potential for unexpected outcomes from the broad-ranging skills of the volunteers; these, together with their detailed local knowledge, make up for any lack of formal archaeological training and experience.

Both recording projects achieved their goals in terms of community engagement, although the longer-term impact remains to be seen. Although a number of NADRAP participants have since contributed to other projects, the full potential of the volunteer resource created has not, perhaps, been fully exploited in the years since the project ended. This may be related to changes in priorities forced by recent economic circumstances but is perhaps a further lesson from the pilot to be applied to the CSIRM project.

Finally, the data produced by the volunteers have already proved valuable in terms of prioritizing ‘at-risk’ panels and in identifying suitable sites both for protection and interpretation. RAMP exploited the NADRAP data, demonstrating new possibilities for rock-art interpretation which address the concerns of both heritage managers and visitors. By targeting resilient but engaging panels and removing the need for intrusive information boards, RAMP delivers a low-risk, low-maintenance, but greatly enriched visitor experience. It is hoped that the personal insights and reflections offered by the project participants will ensure that the text, images, and audio resonate with visitors, foster enthusiasm, and inspire new personal connections both with the carved stones and with the landscapes in which they are found.

This last aspiration is perhaps a key part of the solution to protecting and managing rock-art for future generations and should not be overlooked or underestimated alongside more tangible, science-based approaches. We have been lucky in England, in that our cup-and-ring-marked stones have suffered relatively little modern vandalism. This is something we can rightly be proud of but should not take for granted. As rock-art comes within reach of more people, both physically and electronically, the need to educate and inspire pride may also become more important.

At the RAMP workshops in Northumberland, participants were encouraged to explore the environment through sensory engagement with the

landscape and the rock-art, including exploring the carvings with their fingertips. Several participants claimed that by touching the hollows and tracing the grooves, they were able to feel a connection with the carver, putting their hands where human hands had once been long ago. One response was particularly revealing:

I think often perhaps we are told that things are fragile and “Don’t Touch it” and, you know, “[Don’t] look at it”, and, “Not too near it” and, “Don’t walk on it”, and by not touching it, we make it lost. Whereas I felt an interesting thing where I was running my hand through some of the cup marks and I thought, hmm, perhaps if this has been done so many times and I remove another thirty little grains from the outside of weathering then I’m also taking part in that process. Michael, Rth3
(Galani et al. 2010, 12).

For archaeologists and heritage managers concerned primarily with conservation, this deliberate act of ‘erosion’ may raise eyebrows. Yet Michael’s experience of a deep connection between past and present is perhaps worth further consideration. His physical engagement with the carving prompted a realization of his personal contribution to the longevity and continuity of rock-art and a sense of pride in his part in that. Graham and colleagues (2009) suggest that “the historic environment contributes towards a distinctive sense of place and a sense of continuity which can support a greater sense of people’s self-esteem and place attachment”. This is a type of experience that each of the three projects described here has encouraged in different ways. Community-based initiatives such as these ensure that local people become engaged stakeholders and feel a sense of ownership and responsibility for the panels in their own neighbourhood: this may be the best chance of long-term survival for many carvings.

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5 Irish Open-Air Rock-Art

Issues of Erosion and Management

Elizabeth Shee Twohig and Ken Williams

INTRODUCTION

The aim of this chapter is to examine the evidence for the weathering and erosion patterns of carvings at open-air rock-art sites in Ireland and to discuss the general position regarding management and presentation of these carvings. We will discuss not only the carvings on natural boulders and outcrops, predominantly ‘cup-and-ring’ motifs (which in Ireland are usually referred to as ‘rock-art’) but also examples of exposed carvings on passage tombs, as these are subject to similar weathering agencies. The discussion concentrates on the situation in the Republic of Ireland where the vast majority of sites are located.

No specific survey or formal pilot project has been completed for rock-art in Ireland, and our observations arise from discussions we have been having since we began to collaborate in documenting and recording carvings at a range of sites in Ireland, particularly in Co. Meath at the passage tombs at Knowth and at the rock-art and passage tombs of Loughcrew, and to a lesser extent at other rock-art sites across the country. We have found it interesting to make comparisons between older recordings, both drawings and photographs, made by one of us (EST) over a period of 45 years and more recent records, and in particular with KW’s photographs, which have been taken since 2003. As the monochrome photographs published in the chapter do not do full justice to the conditions of the stones, we have posted colour versions on a dedicated Gallery page at: www.shadowsandstone.com/Other/IrishRockArt/ (short URL: <http://smu.gs/R4tw1l>).

LEGISLATION AND MANAGEMENT

In Ireland, the majority of open-air rock-art occurs in the Irish Republic. Here the formulation and implementation of policy relating to the protection the archaeological heritage is the responsibility of the National Monuments Service (NMS), itself a section within the Department of Arts, Heritage and the Gaeltacht (AHG) that until June 2011 was known as the Department

of the Environment, Heritage and Local Government (AHG 2013; NMS 2013). Irish rock-art can be difficult to categorize.

For example, while a carved outcrop is clearly classifiable as a 'site', a smaller carved boulder, sometimes termed 'mobiliary art', may be regarded as an 'archaeological object'. This has implications for the management of the archaeological heritage because responsibility is split between two bodies depending on whether something is seen as a site/monument or as an archaeological object.

Sites and monuments are the responsibility of the NMS, but archaeological objects which are found and which have no known owner are in the care of the National Museum of Ireland (NMI). This is now an autonomous semi-state institution established under the provisions of the *National Cultural Institutions Act 1997* and has been managed by its own board since 2005 in accordance with roles defined by the *National Monuments Acts 1930–1994*. Mobiliary rock-art is sometimes brought into the NMI for safekeeping, one of the first such pieces being the stone found on a fence near Loughcrew at the end of the nineteenth century (Coffey 1897), which is now displayed in the museum's central court. Generally, however, rock-art tends to be kept in the reserve stores, such as other pieces from the same area which were acquired by the NMI during the twentieth century, including a cist cover and two pieces found while ploughing (Shee Twohig 2001; Shee Twohig et al. 2010). But some mobiliary pieces still remain in the field and are susceptible to damage, for example the carved stone which lies on a wall at a stone circle at Ballinvally (Shee Twohig 2001). Mobiliary rock-art has often been built into walls or moved to the side of a field, to private gardens, or to old buildings as at Forenaghts, Co. Kildare (Figure 5.1). Others have been brought indoors to public buildings such as local museums, heritage centres, libraries, or churches. The standard of documentation often leaves much to be desired, such as the case of a stone from Mothel, Co. Waterford (Shee Twohig 1997), erroneously published as being in the NMI but which was in fact at University College, Cork, where it has now been remounted for display.

As noted above, archaeological sites and monuments in the Republic of Ireland are managed by the National Monuments Service of the Department of Arts, Heritage and the Gaeltacht. Almost all sites in the field are catalogued on the Sites and Monuments Record (SMR), which consists of numbered lists of sites and monuments and accompanying maps on which these are marked. These lists were in many cases based initially on examination of cartographic, documentary, and aerial photographs, with the results of fieldwork only being available for some counties. To date, lists contain summary information on all certain or possible archaeological sites and monuments dating to before 1700 AD (with some later ones also being included), with approximately 150,000 sites listed in 1999, with further sites added to the lists since then.

Listing on the SMRs does not afford any legal safeguard for sites: protection is provided mainly by their listing on the Record of Monuments and Places (RMP). The RMP was introduced in the *National Monuments*



Figure 5.1 A moss-covered boulder at Forenaghts, Co. Kildare, now resting against the gable end of ruined medieval church. (Photograph by Ken Williams. Copyright reserved.)

Amendment Act 1994 (Section 12.3) and is based on information from the SMRs. Sites listed in the RMP require that two months' written notice is given to the AHG of any intention to carry out works to an archaeological monument. A higher level of protection is provided for sites classified as National Monuments in State Care, which includes those that are in the ownership or guardianship of the Minister for AHG. There are only approximately 1,000 sites in these categories, but they include a substantial number of passage tombs with carvings and only two rock-art sites (see what follows). These sites are managed by the Office of Public Works on behalf of the AHG, but the NMS is responsible for their archaeological care (AHG 2013). A summary of the legislation and lists of National Monuments and the SMRs is available on the NMS website (NMS 2013).

Sites in Northern Ireland are managed by the Northern Ireland Environmental Agency (NIEA) of the Department of Environment of Northern Ireland under the Historic Monuments and Archaeological Objects (Northern Ireland) Order 1995. State Care Sites and Monuments are in ownership or guardianship, while 1,800 Scheduled Monuments also receive a level of protection. The Northern Ireland SMR holds information on approximately 15,000 sites. An account of the relevant legislation and the management of archaeological sites in Northern Ireland is provided by the NIEA (2013).

PASSAGE TOMBS

In regard to the protection of prehistoric carvings, the largest passage tombs, most of which have been excavated and restored, have the greatest level of protection through legislation, as they are in the ownership of the state, and many are actively managed to facilitate visitor access. The passage tombs of Newgrange, Knowth, and Dowth in the Boyne Valley, Co. Meath, lie in an area which was inscribed on the World Heritage List in 1993 (Brú na Bóinne/Archaeological Ensemble of the Bend of the Boyne; Smyth 2009). This is one of only three World Heritage Sites in Ireland, the others being Skellig Michael, Co. Kerry, and the Giant's Causeway, Co. Antrim. The Brú na Bóinne sites had 230,000 visitors in 2013, with access via mini-bus to Newgrange and Knowth being managed through the Visitor Centre.

Exposed carvings in these passage tombs include 91 of the 124 surviving kerbstones which encompass the cairn of the passage tomb at Knowth; some of the kerbstones were uncovered in the early 1940s (Macalister 1943), but most were found during George Eogan's excavations from 1962 onwards (Eogan 1986). Many were in poor condition and have undergone considerable conservation in the 1990s. Initially, some stones were treated by the application of acrylic adhesive and infilling of lacunae with epoxy, and later others were repaired with lime mortar (Gowen et al. forthcoming). In the late 1980s, a precast canopy of overhanging horizontal concrete slabs was paced above the kerbstones, which projects over them to prevent a runoff of rainwater percolating down from the mound. The site is closed to visitors from November to late March, and during that period, the kerbstones are completely covered in heavy plastic sheeting. It is clear that these measures have been effective, demonstrated by the fact that in the course of checking the carvings at Knowth in 2008 and 2009, we have been able to document several instances of finely incised lines and other details which had not previously been recorded and which have survived quite well on the kerbstones (e.g. on Knowth 1 Kerbstone 86).

The kerbstones at Newgrange are not as extensively carved as those at Knowth, and only some of them are protected by a canopy similar to that at Knowth, though Kerbstone 1, at the entrance, is covered with plastic at night during winter. At Newgrange, the carvings on the kerbstones seem to be reasonably resilient, apart from the development of some patination and lichen growth, and a number of the more elaborately carved ones have been uncovered since the 1890s (O'Kelly 1982, 39). Harding's claim that the carvings on Kerbstone 52 had deteriorated between 1979 and 1989 is not convincing, as his photograph from 1989 is of notably poorer quality than the 1979 one (Harding 2009, pl. 5).

At Dowth, the third of the great passage tombs in the Boyne Valley, the kerbstones are partially exposed (O'Kelly and O'Kelly 1983), and this site has not been conserved or made accessible in the same way as the other two

major passage tombs in the area. Other excavated passage tombs in Ireland have also been restored, probably the most effective being the pioneering work done in the 1960s at Fourknocks, Co. Meath, where the reconstruction cleverly incorporated openings through the mound which allow slanting light to penetrate into the interior and illuminate the carvings inside. Attempts to replicate this effect at some of the smaller tombs at Knowth (Gowen et al. forthcoming) have not been so effective. At Tara, Co. Meath, the only extensively carved stone lies just inside the entrance and has developed growths of green algae. However, the conditions at this site have recently been assessed, the mound has been re-instated and a new facade built (2011–2013).

Other passage tombs have had minimal upkeep and conservation. Sess Kilgreen, Co. Tyrone, a decorated passage tomb in Northern Ireland, is a Scheduled Monument but is heavily overgrown with weeds in the summer-time, and the stone surfaces are covered in mosses and green algae which were not present in the 1960s. Photographs from the early 1970s of an isolated upright carved stone that stands in a nearby field indicate that the carvings on this stone have suffered from the effects of cattle rubbing. Nearby is Knockmany, the only passage tomb with carvings in Northern Ireland which is in state care, but which is locked into a very unsympathetic concrete structure (Collins and Meek 1960).

At Loughcrew, Co. Meath, those passage tombs that are open to the elements have moss growing on many of the carved surfaces. They also suffer from the growth of weeds inside the tombs, and up to recently, the orthostats in most tombs were being rubbed by shelter-seeking sheep, though in recent years steps have been taken to exclude the animals. The carvings at Loughcrew have been exposed for more than 150 years, since their discovery through ‘excavation’ in the 1860s. Drawings made by G. V. du Noyer at the time of discovery provide an excellent record of the carvings (Frazer 1892–3). A single standing stone which may be the last remnant of a low-lying passage tomb named Cairn O was reported as having some cup-marks (Conwell 1873, 65) which by the 1960s were almost completely weathered away. However, the stone fell over around 1970, and a number of carvings were found on the base of the stone that up until then had been protected by being in the ground. This suggests that the carvings were probably more extensive originally but had weathered away on the exposed upper part of the stone, with only the deeper cup-marks being visible in Conwell’s time. However, since 1970, the carvings have become weathered.

There has been a notable deterioration in the condition of the carvings in the passage tombs at Loughcrew since the late 1960s when they were fully recorded (Shee Twohig 1981), following works to kill off moss by using a 10 per cent solution of formaldehyde, a practice generally used by the Office of Public Works at that time. The carvings in Cairns L and T are better preserved than those in the unroofed tombs, although the outermost, more exposed orthostats at the passage entrances of Cairns L and T exhibit green

algae growth. These roofed tombs are now gated, and public access to Cairn T is monitored during the summer months. Hopefully, this will put an end to the practice of chalking in the carvings that was quite commonly seen on photographs up to recently.

Nearly 150 years ago, in a letter to the *Meath Herald* published on 14 October 1865, George V. Du Noyer called for the erection of fencing around the passage tombs at Loughcrew “to prevent the inroads of the idle, ignorant and wanton . . . who have already commenced the work of mutilation”. The largest kerbstone at Loughcrew, and one of only three with recorded carvings, is frequently used as a photographer’s prop, and during the summer of 2012 the stone was damaged by stone-throwing youths (Figure 5.2A).



A



B



C

Figure 5.2 Irish open-air rock-art on public view. A: The sole visibly decorated kerbstone from Cairn T at Loughcrew, Co. Meath. Traditionally known as ‘The Hag’s Chair’, it is often climbed and used as a prop for photographs. B: A section of the kerb at Knockroe, Co. Kilkenny, showing the recently erected covering structure that protects the very weathered carvings on the kerbstone opposite the entrance to the south-western tomb. C: The most highly decorated panel of rock-art in the Derrynablaha group of carvings, Co. Kerry: a recent photograph demonstrates that the condition of the carvings remains relatively unchanged since the panel was recorded and photographed in the 1960s. (Photographs by: A and C: Ken Williams. Copyright reserved. B: Elizabeth Shee Twohig. Copyright reserved.)

The most recently excavated passage tomb, at Knockroe, Co. Kilkenny, has a large number of carved stones in each of the two small chambers and on a number of the kerbstones (O'Sullivan 1987). A conservation plan was completed in 2011 following preliminary inspection and analysis carried out in 2004 (Quinlan 2011). A conservation programme of cleaning and stabilization of the surfaces of the southwestern tomb's orthostats was carried out in 2006. As Quinlan reported: "the conservation work involved the injection of a synthetic resin along the fracture edges of the finer separating flakes within and adjacent to the decorated areas, followed by the removal of organic growths using a biocide and water washing" (Quinlan 2011, 18). Meanwhile, it was proposed that temporary coverings should be put in place to protect the principal elements of the monument from the effects of precipitation and possible frost action (Quinlan 2011, 29). One of the carved kerbstones has been covered as an experiment for the first phase of this scheme (Figure 5.2B). In the longer term, it is proposed to protect the individual chambers and the decorated kerbstones with removable coverings, and studies are to be carried out to establish how best this can be done (Quinlan 2011, 25).

OPEN-AIR ROCK-ART

Open-air rock-art has been found extensively in Ireland, with known concentrations mainly in counties Kerry, Carlow, Louth/Monaghan, and Donegal. Isolated examples are known across much of the rest of the country, and experience suggests that systematic fieldwork where suitable rocks exist would fill in a lot of the blank areas of distribution.

Most known sites have now been included on the RMPs, and the lists and maps can be consulted (NMS 2013). While the listings on this database are comprehensive and regularly updated, the legacy of a sometimes inconsistent classification system makes searching for records relating to open-air rock-art somewhat confusing. A large number of the known sites are listed under the 'Rock-art' heading, including panels consisting purely of cup-marks. However, there is a separate listing of surfaces that feature only cup-marks under the heading 'Cupmarked Stone'. At least one site consisting of typical cup-and-ring motifs (Clonasillagh, Co. Meath) is classified under 'Decorated Stone'. In Gaeltacht areas such as the Dingle Peninsula, Co. Kerry, rock-art appears on Ordnance Survey maps under the designation 'snoíodóireacht'.

Only one rock-art site, Boheh, Co. Mayo, is in state ownership and is best known for the dramatic views from it of the sun 'rolling' along Croagh Patrick Mountain twice a year (April 18 and August 24; Bracken and Wayman 1992; Van Hoek 1993). The site features on the Clew Bay Archaeological Trail, bringing many visitors all year round, most of whom unfortunately

stand on the carved surface to admire the view of Croagh Patrick. The only rock-art site in state guardianship, Clonfinlough, Co. Offaly, has carvings comprising mainly stylized crosses, which seem likely to date to the medieval period (Shee Twohig 2002).

Although there is no programme of objective measurement or monitoring of rock-art in place in Ireland, comparison of our 1960s and 1970s recordings with more recent photographs suggests that rock-art generally does not appear to have suffered any appreciable deterioration over the past 40 years. However, this impression may be in part due to improved methods of photography, with controlled low-level lighting now being much better developed. One of the most impressive collections of carved outcrops was discovered at Derrynablaha, Co. Kerry, in the early 1960s (Anati 1963; O'Sullivan and Sheehan 1996, 89–96). A number of carvings were very fresh at the time of discovery because of the removal of a thin peat covering that protected them (Figure 5.2C). These have now developed a light growth of lichen, but the actual carvings still appear quite sharp when photographed with a low-angled flashlight. Likewise, a stone at Shanacashel, Co. Kerry (O'Sullivan and Sheehan 1996, fig. 70), has survived well, but this may be largely because of a light covering of leaves and vegetation; a 2010 photograph shows the motifs as clearly as one taken in 1964.

Examples of rock-art which have survived less well include the piece found during ploughing at Fournaghts, Co. Kildare, in 1975 (Shee 1975–6). As noted, this stone was propped against the wall of a nearby church ruin, but the shady, damp location and generally humid conditions have facilitated the development of a considerable growth of algae and moss on it since then.

Rock-art has been found in recent years on a number of erratic sandstone boulders immediately to the north and west of the passage tomb cemetery at Loughcrew, Co. Meath, mainly in the townland of Ballinvally (Shee Twohig et al. 2010). The carvings on the boulders on the higher ground (above 170 m above OD) are quite weathered but do not have any moss growth. The lower-lying boulders tend to have moss growing on them, though the amount of moss seems to vary on a seasonal basis. Photographs taken since 2004 of the most extensively carved boulders (ME 009–094 in the Archaeological Survey) show considerable variation in moss growth during the past five years, probably depending on levels of water present in the ground around the carved surfaces.

Cultural factors may be having a more detrimental effect on rock carvings than natural factors. Many carved surfaces are flush with the ground, which allows cattle or sheep to trample on them quite easily. The lowest of the aforementioned carved surfaces at Ballinvally, Co. Meath, has been heavily trodden and also shows signs of erosion from cattle droppings.



A



B

Figure 5.3 The changing state of rock-art panels. A and B: Surface-level section of outcrop featuring a unique style of rock-art at Magheranaul, Co. Donegal, had been used as part of a trackway for farm machinery at some point between A taken in 2007 and B in 2010. (Photographs by Ken Williams. Copyright reserved.)

The mechanical side of farming can also damage carved stones. Van Hoek has documented carved surfaces at Ballinloughan, Co. Louth, which had been partially destroyed through land clearance during the mid-1980s (Van Hoek 1985), and he also reported damage to some stones at the important site of Magheranaul, Co. Donegal (Van Hoek 1987). More recently, in 2010, at Magheranaul, tyre marks on a partially covered carved outcrop showed that tractors had been driven across the surface not long before (Figure 5.3). This incident was reported to senior management in the NMS, and we were assured that the farmer would be notified by letter that the site was at risk and would be subject to inspection.

CONCLUSIONS

Overall it does not appear that natural weathering is having a very dramatic effect on rock carvings, though the particular local conditions will largely determine the extent of deterioration. Covering of the kerbstones at Knowth

during winter has definitely helped preserve them, and about 40 years of exposure during the summer period appears to have caused little damage to those particular carvings.

Cultural factors can be a major issue, and passage tomb carvings in unsupervised locations have been more at risk from damage by human interference than rock-art in the open landscape because they are visited more often. Although in some ways the lack of awareness of rock-art as part of the archaeological heritage may have protected the sites from damage from large visitor numbers, it also means that some may be damaged due to sheer ignorance of their significance, and the obvious remedy for this lies in educating the public about these site. As noted, open-air rock-art enjoys little official management, but some local initiatives have seen sites being signposted or marked in recent years. Examples include a number of carved outcrops, boulders, and tomb capstones in the Burren area, Co. Cavan, which have been documented in the past decade by Gaby Burns and Séamus Ó hUltacháin (Ó hUltacháin 2011); boulders and tomb carvings at Loch a'Dúin in the Dingle Peninsula, Co. Kerry (O'Connor 2006), signposted by a community group led by an archaeologist from the area; and an initiative to raise awareness of carvings in Co. Wicklow by University College Dublin postgraduate student Clíodhna Ní Lionáin (Ní Lionáin 2013), probably Ireland's first rock-art blog. The refusal of a planning application in 2010 for the erection of a mobile phone mast in the rock-art filled landscape of Coomasaharn, Co. Kerry, is an encouraging development and shows awareness of the sites and their landscape context.

It must be recognized, however, that our observations are largely arbitrary. Recording of the carvings is uneven in quality, and although passage tomb art has been drawn and photographed systematically by means of measured drawings, tracings, and photography, only a selection of rock-art has been recorded by these methods. Recent developments would now enable more complete and faster recording through laser scanning and/or photogrammetry and high-quality side-lit photographs. England's Rock-Art Database (ERA 2008 and see Chapter 4), comprising a database for carvings in Northumberland and Durham, provides a model which might be adopted or adapted for Ireland, while work in Sweden and Norway has given the lead in matters of conservation. Since 2000, the Office of Public Works in Ireland has been commissioning conservation plans for important sites in state ownership, but Knockroe is the only site with carvings to have benefitted from such a study (Quinlan 2011). Condition assessment and risk evaluation investigations need to be undertaken more extensively, at least on a sample of the carved stones, and with follow-up studies scheduled to assess the levels of deterioration. This would provide a more objective assessment than we have been able to present here and enable correct actions to be taken for the preservation of what is, after all, the beginning of Irish art and an important part of early European art.

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6 The Open-Air Rock-Art Site at Leirfall, Central Norway, within the Context of Northern Scandinavian Rock-Art Conservation and Management Practices over the Past 50 Years

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INTRODUCTION

The open-air rock-art site at Leirfall, Central Norway, has been known since the early twentieth century. It is the largest locality in this region of Norway that is rich in open-air rock-art panels and is one of the few that is open to the public. For the past 50 years, it has acted as a field laboratory for *in situ* research into the documentation, conservation, and management of fully exposed, rural, open-air rock-art in Central Norway. Leirfall is representative of other exposed open-air rock-art sites and the management challenges confronting cultural heritage managers not only in this region but also across Northern Scandinavia. The aim of this chapter is to present the biography of Leirfall within the context of evolving developments in Norwegian and Northern Scandinavian open-air rock-art management practices and to further contribute more generally to discussions of site management in cold regions.

THE LEIRFALL SITE

The Leirfall rock carvings are situated on the northern side of the east-west-orientated Stjørdal Valley, in the region of Trøndelag in Central Norway (63° 46' N / 11° 32' E), approximately 10 km east of the Trondheim Fjord (Figure 6.1). These carvings form one of 20 known sites with Bronze Age-style rock carvings in the municipality of Stjørdal (Sognnes 2001).

The site lies in damp terrain on the western side of Solemsbekken Creek at Leirfall farm. It comprises five separate exposed engraved panels (Leirfall I–V) executed on a naturally smoothed rock outcrop facing southeast. The panels are aligned more or less vertically up the steep wooded slope of an

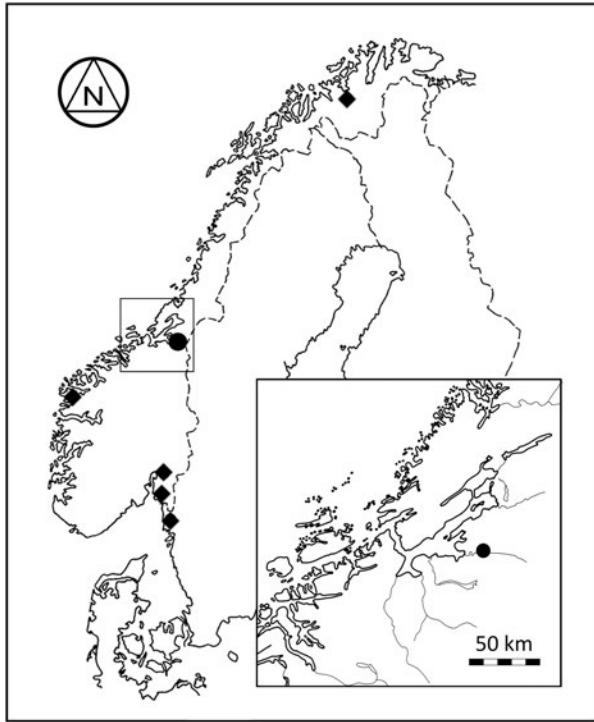


Figure 6.1 Map of Scandinavia showing the location of the Leirfall rock-art site in central Norway (●). Other rock-art sites referred to in the text (◆): Hjemmeluft, Vingen, Ekeberg, and Begby in northern, western, and southern (2) Norway respectively, and Litsleby in western Sweden. (Map: Turner-Walker and Peacock after Sognnes)

old river terrace bordered by cultivated fields. The tree cover comprises Norwegian spruce, birch, bird cherry, and grey alder, while the ground cover is grass, berry bushes, ferns, and shrubs.

The first panel (Leirfall I) was reported in the 1920s (Petersen 1926), and shortly after World War II, two further panels (II and III) were discovered. Leirfall I and II are located alongside the creek, whereas the larger Leirfall III panel lies approximately 50 m to the west at the same elevation as Leirfall II. Marstrander (1970) began documenting the carvings in the early 1960s, and during his work two more panels were found nearby: Leirfall IV and V. The site was purchased by the Norwegian government in 1971. It is curated by the NTNU University Museum together with Nord-Trøndelag County Council, with maintenance and conservation financed by the Norwegian Directorate for Cultural Heritage.

The rock outcrop at Leirfall is medium-grained, calcite-rich greywacke sandstone with a porous outer weathering zone where quartz, muscovite, and calcite are the dominant minerals. Other minerals present are chlorite,

feldspar, zircon, and tourmaline (Prestvik 1981). Microscopic analysis revealed no calcite minerals in the weathering zone. The rock surface is characterized by small, cubic holes remaining from oxidized and dissolved iron pyrite (FeS_2) crystals. Leirfall III, the largest panel in Tøndelag, is executed on a sloping, semidomed rock outcrop measuring around 400 m² (Figure 6.2).

Across the surface of Leirfall III, the thick greywacke layers are bisected by narrow, curving, and well-developed foliated phyllitic strata that are heavily weathered and disintegrating where exposed (Figure 6.2). The panel is also crossed by three main fissure planes, two of which cross one another at right angles. This network of fissures and bands physically breaks up the panel into a natural patchwork of subpanels that provided a framework for grouping figures and, furthermore, was incorporated into design motifs (Brox Nilsen 2005).

Taken together, the Leirfall panels feature more than 1,200 figures ranging in date from approximately 1800 to 1 BC. The panels feature numerous carvings rendering horses, and imprints of shoe-soles, often in pairs and oriented to the dip of the rock (Sognnes 2011). Cup-marks are few compared with other Bronze Age sites in Scandinavia. There are few boat images, although several types are represented. Geometric designs, especially rectangles, dominate some of the subpanels at Leirfall III. On this panel there is a group of human figures forming a ‘procession’ in two parallel rows (Marstrander and Sognnes 1999; Sognnes 2001; see Figure 6.2).



Figure 6.2 Part of the main Leirfall panel (Leirfall III) with engravings viewed from the lower right-hand corner. (Photograph by Kalle Sognnes. Copyright reserved.)

Open-air rock-art sites in Norway are subjected to a range of natural processes, including freeze-thaw cycles, biomediated physical and chemical weathering, and solar insolation; Leirfall is no exception. The consequences of these processes include exfoliation, cracking, air pockets, flaking, biological accretions, and biogeocorrosion. During past periods when site vegetation was not kept 'in check', soil, turf, roots, trees, and bushes have encroached up to and onto the panels. Leaf-litter from overhanging trees accumulates on panel surfaces, providing a reservoir for water and thus contributing to the growth of mosses and biofilms. Lichens also colonize the exposed rock surfaces. Panels I and II are frequently inundated, whereas Leirfall III is subjected to water seepage that until recently was combined with farm effluent from the field up-slope. The panels inevitably suffer from the wear and tear of site visitors. However, the site's rural setting safeguards it from damage through other human-caused agencies such as acid rain, local urban and industrial air pollution, and long-range air pollution.

CULTURAL HERITAGE IN CRISIS

Reports of discoveries of rock-art in Norway began to appear in the nineteenth century, and rock-art entered the Norwegian archaeologists' research agenda in the 1920s. Rock-art has been found at more than 1,700 localities (totalling approximately 31,000 images) throughout the country. The deterioration and disintegration of engraved rock surfaces was recognized early on but rarely documented. More than a century ago, Rygh (1908), an early pioneer in Norwegian rock-art research, highlighted the preservation problems pertaining to rock carvings. He recommended that landowners cover the panels with soil. Baltzer (1911), active in Bohuslän, Sweden, during the same period, warned of the need to keep panels vegetation free. Gullman (1992) reports the deliberate reburial with clay in the 1920s of a rock-art site on Gotland, Sweden.

In the latter half of the twentieth century, increasing claims were made that ongoing deterioration (as the result of weathering and, later, human-caused factors including acid rain and pollution) of exposed rock-art sites in Northern Scandinavia was accelerating at an alarming rate (Hagen 1970; Strömberg 1959). Sognnes (2005) noted that this coincided with the growing expectation that rock-art should be available for the viewing public. The Arts Council of Norway financed a four-year project between 1976 and 1980 to map the conditions at a selected number of sites (Michelsen 1978; Michelsen and Mandt 1981), including Leirfall (Sognnes 1981). The project's recommendations led to the initiation in 1981 of the five-year *Rock-art Project* (RAP) funded by the Ministry of the Environment to study suitable conservation methods for threatened sites (Michelsen 1992). In the early 1990s, the National Council for Cultural Heritage Norway commissioned the first nationwide survey of the condition of rock-art. The need

for further study was again emphasized (Dahlin et al. 1991), and in the intervening years, the university museums continued to carry out individual projects. Ongoing efforts to raise public and political awareness (Dahlin and Mandt 1993; Helberg 1997; Solli 1997) eventually led to the launch of the Norwegian Rock-Art Project (NRAP) that ran from 1996 through to 2006 (Hygen 2006).

NRAP, financed by the Norwegian Ministry of the Environment and administered by the Directorate for Cultural Heritage, aimed to protect 300 of the total known rock-art sites in Norway. Protection was defined as documentation, the development of a management plan, conservation works, and follow-up. Research into the causes of breakdown and the development of methods to minimize damage were an integral part of this national project. Leirfall was included in this programme. National research centres and national and regional institutions developed subprojects, which were then commissioned by the Directorate upon application. One outcome was national guidelines for documentation, management, presentation, and monitoring of rock-art in Norway (Bjelland and Helberg 2007).

This period saw similar developments in Sweden. Both the Air Pollution Programme (1988–1991) and the Air Pollution and Heritage Programme (1992–1995) initiated by the National Heritage Board addressed the seemingly disastrous deterioration of stone buildings and monuments, including exposed open-air rock-art. Their express purpose was to study the influence of pollution (Gullman 1992; Österlund 1996). Both projects produced a general inventory of rock carvings; however, it was not possible to differentiate between damage caused by natural as against anthropogenic factors (Gullman 1992). The National Heritage Board pointed out that established techniques and methods to preserve rock-art did not exist. Several large EU-funded projects followed: Interreg IIA Rock Carvings in the Borderlands (RCB) between 1996 and 2000; RockCare between 1998 and 2001, managed by the Heritage Board within the EU Raphael/Culture 2000 programmes; and Baltic Sea Region Interreg IIIB Rock-art in Northern Europe (RANE) between 2002 and 2005 (Bertilsson and Lødøen 2006; Kallhovd and Magnusson 2000). A central focus of these projects, run concurrently with NRAP, was documentation and recording of rock-art. Research into chemical and physical weathering and remedial conservation was also undertaken.

The results of these large projects were disseminated principally through internal reports and institution-based serials, with the result that not much of it reached wider academic and practitioner communities. It is unavailable for comparison with or synthesis with various other approaches and results. Little has been published in peer-reviewed books and journals nationally or internationally. Moreover, there is no useful overview of the results and conclusions from these projects (Goldhahn 2008). This has led to criticism and debate over their goals and the value of the results within the Norwegian research community (Bakkevig 2004; Bjelland 2005; Walderhaug 1998;

Walderhaug and Walderhaug 1998; Walderhaug Sætersdal 2000). Much of the debate centres on the role of weathering, methods and extent of conservation intervention, and the role of lichens.

LEIRFALL IN CRISIS?

Leirfall was included in several surveys that led to the establishment of NRAP. However, were Leirfall open-air panels really in a state of accelerating deterioration? The 1976 to 1980 survey concluded that although the rock surfaces at Leirfall were deteriorating, it was not a major crisis (Sognnes 1981). Visual comparison of Leirfall III documentation from 1967 with that from 2008 to 2009 revealed little damage to the engravings themselves. By documenting the fractures, fissures, and exfoliation, the recent tracings illustrate why the figures are grouped in eight or nine narrow segments running from northwest to southeast across the panel and why some figures are incomplete. This is especially the case in areas where layers of extensively weathered phyllite bisect the sandstone surface and where horizontal fractures intersect vertical open ledges of phyllite, leading to exfoliation (see Figure 6.2).

One boat figure illustrates damage due to a “blistered rock” surface. Marstrander’s 1967 photo-documentation shows three small holes which developed into one large hole by 1996 but which appear further unchanged in 2012. The situation for the Leirfall III engravings is similar to that of other sites in Norway, where few figures have been damaged during the last century as a result of natural deterioration. Documentation at Leirfall in the 1960s focused on the images rather than the medium into which they were carved. The evolution of exfoliation at surface level and subsequent deterioration is difficult to monitor and track (Walderhaug and Walderhaug 1998), and the Leirfall III surfaces can be crushed simply by treading on them because they are open to the viewing public.

THE NORWEGIAN ROCK-ART PROJECT AT LEIRFALL

The NTNU University Museum contributed several subprojects to NRAP that studied registration, documentation, and the development of management plans for several sites in Central Norway, including Leirfall (Sognnes 2000). Research into remedial conservation (of the type practised at rock-art localities in Northern Scandinavia) such as consolidation methods, mortars and cements, formulations for in-painting, and methods for the removal/reduction of surface accretions were not pursued.

Of particular focus was the establishment at Leirfall in October 1997 of a weather station and a five-year environmental monitoring programme based on systematic data acquisition in order to investigate the

impact of thermal cycling and insulation surface covering on the largest Leirfall panel. Surface wetness and temperature were monitored hourly using the Wetcorr® system developed by the Norwegian Institute for Air Research (Dahlin et al. 1998; Haagenrud et al. 1984). Three rock surfaces were included in the study: the Leirfall III panel (one wet and one dry zone), a weather station reference panel, and a section of bedrock without engravings. The bedrock test panel was an unexposed outcrop from which the turf was lifted. Half of this panel was covered with an isolating layer of geotextile, a 5-cm-thick sheet of mineral wool and 10 cm of replaced turf (giving a total of 15 cm). The remaining half of the panel was covered with 15 cm of replaced turf only. Both halves were monitored.

Hourly values of air temperature and wetness were compared to records from the Norwegian Meteorological Institute (DNMI) weather station at nearby Værnes and showed an excellent match between the datasets. Long-term trends in air temperature and surface temperature, and wetness on both exposed and covered rock surfaces, were studied. Results confirmed that the exposed panel (monitored for 62 months) was subjected to multiple freeze-thaw episodes between October and April. No freeze-thaw episodes were recorded on the turf-covered panel (monitored for 43 months). The most vulnerable periods were when the rock surface was not covered with an insulating layer of snow and in the early spring. The annual number of episodes on the exposed rock surface varied greatly over the five-year period (40, 24, 40, 24, and 41 with an annual average of 34) highlighting that monitoring programmes of one to two years' duration do not give a representative picture. To date, no other site in Scandinavia has been monitored as intensively or extensively.

Total variation in temperature over the course of one year was about 51° C for the air and 41° C and 13° C for the exposed and covered rock surfaces, respectively. In the summer months, the rock surface has a higher maximum temperature (in excess of 30° C) than the air but smaller diurnal differences. Large diurnal variations in temperature are considered to contribute to physical weathering, although there is debate regarding the threshold difference. At Leirfall, the average number of days per year with a temperature difference of 15° C and 20° C was 36 and 10, respectively, concentrated between April and June.

Comparing rock surface wetness with local DNMI rainfall records demonstrated a good correlation between surface water and rainfall, with periods of dryness between showers. Both surface probes showed increasingly prolonged periods of full saturation after the first two years. A similar degradation in performance after three years was evident on the weather station probe, ruling out an accumulation of wet leaves on the probes as an explanation. The degradation in performance must be attributed to either a slow deterioration of the Wetcorr® probes or, more likely, the formation of a hygroscopic biofilm on the sensors' surfaces.

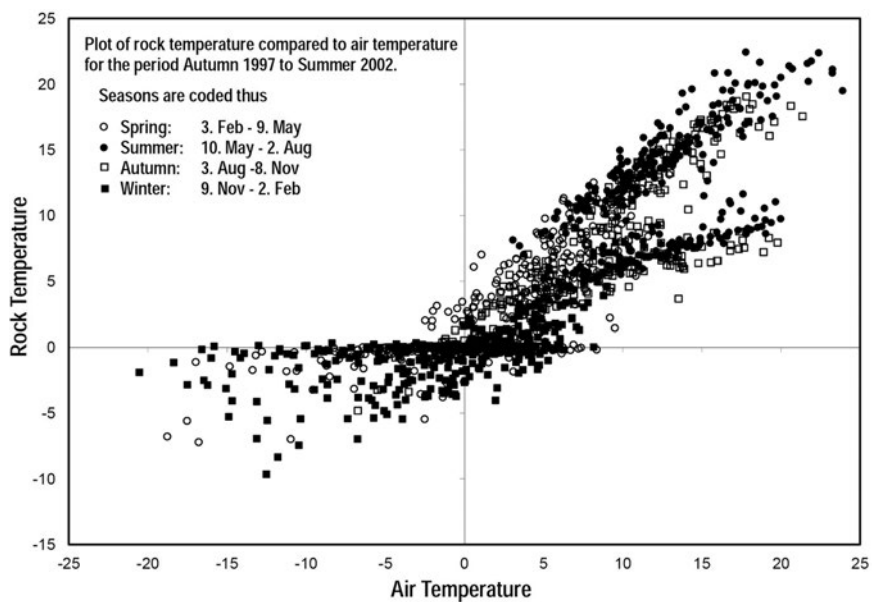
One of the major factors influencing rock surface temperature was solar gain. A plot of air temperatures versus rock temperatures over the five-year period (Figure 6.3A) shows many 'winter' temperatures cluster around zero irrespective of air temperature due to an insulating layer of snow on the surface. There are two linear trends in the temperatures above freezing, clearly illustrating the influence of sunshine versus cloudy weather—the higher trend line representing sunny periods. Close inspection of the surface temperature data for 'winter' months showed there was at least one plateau in the temperature (at minus 0.7° C) as it dropped below zero. This period represents the freezing of surface and capillary water. As temperatures rise, melting occurs at zero.

The Leirfall III panel was divided into two-metre squares and the orientation and dip of the surface in each square was measured (Figure 6.3B). The average cumulative insolation in kilowatt hours per square metre (kWh/m²) falling on each two-metre square for each month was calculated. In December, solar radiation falling on the rock surface is effectively zero, even when there is no snow cover. In contrast, in June the radiation falling on the steeply sloping south-facing rock surface is more than 9 kWh/m². The probes were mounted in a location that received only 4 per cent less insolation than the maximum, whereas the square receiving the minimum got 15 per cent less radiation than the maximum. The area of the rock with the most friable and loose surface receives the highest solar radiation and thus would be expected to experience the strongest swings in temperature between cloudy and sunny periods.

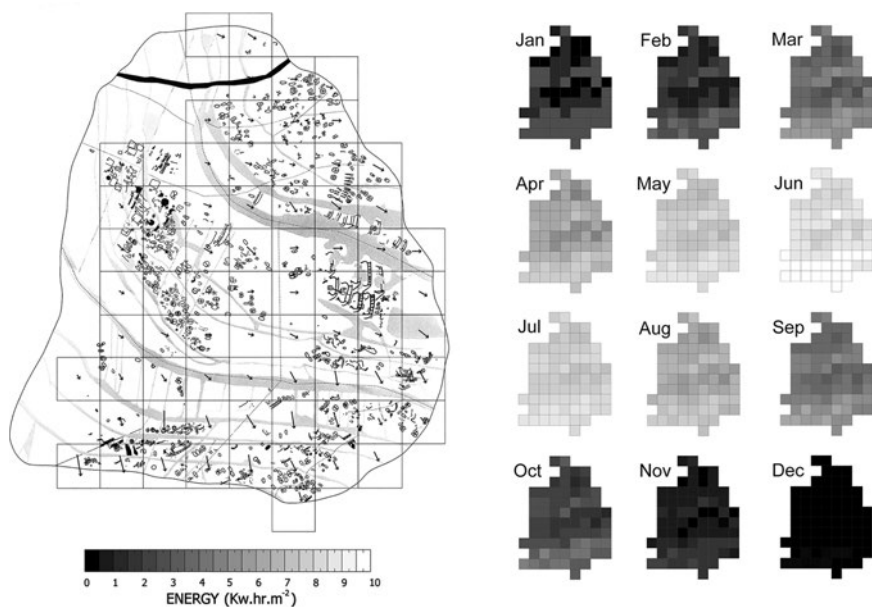
Concurrent with the monitoring project carried out at Leirfall were several similar field studies in Northern Scandinavia that employed the Wetcorr® system; in particular, Ekeberg (Dahlin et al. 1998) and Begby (Dahlin et al. 1999; Dahlin et al. 2001) in southern Norway and Litsleby (Dahlin et al. 2001; Kallhovd and Magnusson 2000) in the Tanum UNESCO World Heritage Site in Sweden. Temperature and wetness data were collected for much shorter periods: Ekeberg was monitored for 11 months, Begby and Litsleby for 17 months. All monitored an open-air rock-art panel; furthermore, Begby monitored a turf-covered surface and Litsleby monitored a 'winter-covered' (10-cm-thick mineral wool) panel, each for one six-month winter period in 1998 to 1999.

Other projects included the investigation of winter covering at the Vingen site in western Norway and the Hjemmeluft locality in the Alta UNESCO World Heritage Site in northern Norway (Lødøen 2010), where temperature and wetness of uncovered and covered panels were monitored. Insulating mats (5–15 cm thick) were installed on 1.4-m-square and 6.6-m-square test areas on exposed rock outcrops. Monitoring details are not reported; however, the period did cover the same 1998 to 1999 winter period as the monitoring at Begby, Litsleby, and Leirfall.

Starting with the southernmost locality, potential freeze-thaw episodes of the rock surface for the year monitored were 93, 71, and 50 for Litsleby



A



B

Figure 6.3 Monitoring temperature at Leirfall III. A: Plot of rock temperatures on the panel surface compared to air temperatures for the period autumn 1997 to summer 2002. B: Leirfall III divided into 2-metre squares showing orientation and dip of surface (left). Average cumulative insolation (Kwh/m²) falling on each 2-metre square per month (right). (Graphics by: Gordon Turner-Walker. Copyright NTNU University Museum.)

(Dahlin et al. 2001), Begby (Dahlin et al. 1999), and Ekeberg (Dahlin et al. 1998), respectively, compared to an average of 34 at Leirfall, the northernmost locality of the four. At these southern sites and Vingen, there were more episodes, and they were spread over the late autumn to early spring, reflecting shorter and less frequent periods of snow cover. In contrast, Hjemmaeluft, with a permanent snow cover from December to April, experienced fewest freeze-thaw episodes.

With the exception of Leirfall, covering with insulating mats and turf did not prevent the surface rock temperatures from falling below zero but significantly reduced the number of potential freeze-thaw episodes and buffered the amplitude of temperature swings. During longer cold periods, the temperature of the covered rock surface fell to the same minimum as the air, with a time lag of several days. The covered surfaces at Begby and Litsleby experienced 16 and 11 below-zero episodes, respectively, over the six-month winter period (Dahlin et al. 2001), whereas Hjemmaeluft experienced generally below-zero temperatures with few potential freeze-thaw episodes. Covering had no significant effect during permanent snow cover. As for Leirfall, winter covering was most effective in autumn and spring before snow covering when there are larger and more rapid changes in diurnal temperature. Increasing insulation thickness to more than 5 cm had a negligible additional buffering effect (Lødøen 2010). Test panels at all the other sites were a few square metres in area on exposed rock outcrop that extended beyond the covered zones. Ingress of cold air will have contributed to reduced insulation in periods without snow cover. The test panel at Leirfall was an unexposed rock outcrop and therefore more representative of reburial than seasonal covering.

Large variations in daily temperature were investigated at the other sites. The southern sites experienced 15° C, 20° C, and higher variations spread over the period March through to October. For example, the numbers of variations at Ekeberg for the year monitored were 149 and 49 for 15° C and 20° C, respectively, compared to an average of 36 and 10 per year at Leirfall. Those at Hjemmaeluft were concentrated in May to July, similar to Leirfall.

DOCUMENTATION

Documentation has been a central focus of rock-art research. Traditionally, the images were recorded rather than the natural textures and fissures of the rock 'canvas'. Numerous recording techniques and technologies have developed, including tracing, rubbing, chalking/in-painting, moulding, photography, and, more recently, digital photography, video scanning, and 3-D laser scanning. RCB, RockCare, and NRAP made major contributions to the development not only of recording techniques and rock-art databases but also standardized procedures through documenting the state of preservation at a large number of sites.

The Scandinavian tradition of filling in engraved images with paint as an aid to both documentation and visitor enhancement has been practised since the mid-twentieth century and may well be a carryover from the even longer practice of painting Viking Age rune stones. It is highly controversial and the subject of much criticism and debate, especially internationally. A range of paint formulations was investigated within the NRAP and RCB. In-painting is being discontinued in Norway, but it is occasionally used at sites open to the public.

The engravings on Leirfall III have been in-painted in the past. Prior to 1972, they were painted on at least three occasions with white, blue, and red paint. It was chemically removed in 1972 and replaced with a linseed oil-based red paint. The engravings were in-painted again in 1975 and 1983. Leirfall III was last painted in 2001 when the NTNU University Museum was requested to test paint formulations being investigated by NRAP.

Some of the Leirfall rock engravings were recorded in the first half of the twentieth century. Marstrander undertook the first systematic mapping in the 1960s following standard procedures of his time. The vegetation was cleared from the panels, and, before tracing, the outlines of the carvings were chalked in to make them more visible. The carvings were photographed and traced onto semitransparent paper sheets covering the entire panel. At that time, Leirfall was the largest rock-art site ever recorded in Norway, and Marstrander's work was exemplary for its time. Shortly after, transparent polyethylene film was introduced and subsequently used to record the Leirfall I images, which Marstrander had only partially documented. Further recording, carried out by Sognnes in the 1980s, did incorporate fractures and exfoliation (Marstrander and Sognnes 1999).

Leirfall was extensively documented during NRAP. Methods continued to be tracing and digital photography. Registration complied with the Norwegian Rock-Art Documentation Standard and was entered into the Norwegian Rock-Art Database, both under development at that time (Helliksen and Holm-Olsen 2001; Kallhovd and Magnusson 2000). All features of the rock surface, including geological and botanical components and the surrounding environment, became as important to document as the figures. Crustose lichens such as *Porpidia macrocarpa*, the fungus *Verrucaria*, green algae *chlorophytes*, and numerous moss species were identified on the rock surfaces. Most recently (2008–09), all features of Leirfall III were systematically retraced and photographed, and the tracings have been scanned to produce a digitalized overview of the entire panel. Due to the cold, wet climate of Central Norway, the frottage or rubbing method, a now widely used standard in Sweden, has proved to be impractical. The frottage technique is based on rubbing large sheets of paper placed on rock surfaces with a soft sponge wrapped in carbon paper, followed by fixing by rubbing the sheet with fresh grass. The panels at Leirfall have yet to be documented using photogrammetry, video-scanning, or 3-D laser technology, techniques that were investigated in the Air Pollution project and the ensuing RCB, RockCare, and RANE projects with varying success. Technical development

within the field is rapid. Recently a 3-D topographical model of Leirfall III was created upon which the latest digitalized documentation has been overlaid to create a 3-D image of the entire panel.

CONSERVATION AND MANAGEMENT

By the 1980s, remedial conservation was being carried out at rock-art localities in most regions of Norway. This coincided with the increase in alarming reports of the deterioration of open-air rock-art sites. Surface vegetation and films were treated with a range of biocides followed by scrubbing. More invasive (not necessarily knowledge-based) interventions were introduced, including adhesives to consolidate crumbling areas of rock surface; adhesives or mixtures of adhesive, Portland cement, and sand to readhere loose pieces; infilling of lacuna with a mortar of cement, adhesive, and sand; and in-filling of large crevices with gravel and cement mortar. Many of these interventions have proved to be unstable (Bakkevig 2004), but Hygen (1996) argues that many preservation interventions resulted from desperation among managers of threatened rock-art because panels were “literally falling apart before their very eyes”. In Central Norway, other than the practise of in-painting engravings, invasive conservation methods to stabilize disintegrating or exfoliating panels or disintegration of the supporting rock substrate have not been implemented.

The Leirfall site has a long history of efforts to make the panels available to the viewing public, including removal of turf, mechanical cleaning and in-painting of the engravings, chemical removal of surface micro-vegetation, reduction of surrounding woodland, and installation of visitor facilities such as signage, walkways, and parking facilities. Much of this work was carried out on an ad hoc basis using local volunteers. Remedial activities from 1970 until 1990 were sporadic and incompletely documented. The surface micro-vegetation of one or more panels was treated in 1989 and 1994 with the biocide Pingo®. Pingo® (dialkyl dimethyl ammonium chloride 5–10%, sodium meta-silicate 0–1%, and isopropanol 1–5%, produced by Jotun), has been widely used in Norway to reduce lichen cover on rock-art surfaces.

When the Leirfall site was documented in the 1960s, it was surrounded by an open landscape of uncultivated pastureland that, as the result of changing agricultural patterns, returned to woodland. In 2001, the site was cleared of overhanging and encroaching vegetation. However, by 2004 the engravings were again covered with soil and decomposing leaves, and shrubs and shoots had reestablished themselves around the panels. In 2005, a site management programme was established for Leirfall that continues today. The site was returned to its 2001 state and has since been held in check, requiring an input of two person-months per year.

To reduce the presence of biofilms and other surface flora at Leirfall, the rock surface and fissures are manually cleaned in the autumn of vegetation with brushing, sprayed with undiluted denatured ethanol (0.2 l per m²),

then covered with plastic sheeting to delay evaporation. This method was investigated at Vingen during NRAP (Lødøen 2010), and has since been promoted by the Norwegian rock-art guidelines (Bjelland and Helberg 2007). Repeated treatment is necessary to fully remove lichens. Although the guidelines outline treatment for lichen removal, they do not comment upon whether removal is recommended.

Trials were carried out with denatured ethanol and Pingo® and found both to be effective (Lødøen 2010). However, following treatment with Pingo®, recolonization by algae was quicker upon exposure, and its use is not recommended by the guidelines. Studies to investigate methods to reduce surface biological activity were also carried out at Litsleby during RCB (Dahlin et al. 1999; Kallhovd and Magnusson 2000). These entailed covering the rock surface with a range of materials such as geotextile and insulation in various combinations; however, surfaces were not treated with a biocide prior to covering.

At Leirfall, to buffer the rock surface against potential freeze-thaw events, the covered, ethanol-treated surface is overlaid with a winter covering of purpose-made, reinforced PVC-enclosed insulation mats (6 m × 1.2 m × 0.05 m) held in place with sandbags and cables (Figure 6.4). When uncovered in the spring, the rock surface is rinsed to remove detached micro-vegetation. Several sites in Central Norway are being managed in this way. Experience gained thus far shows that (a) the time required for successive retreatment of panels is shorter and (b) lichens are less time consuming to remove from rock panels of finer-grained stone than the medium-grain sandstone of the Leirfall panels. The winter-covering method was trialled at Vingen and Hjemmeluft during NRAP (Lødøen 2010) and is also promoted by the Norwegian rock-art guidelines. This two-step combination of ethanol treatment and winter covering is now practised at many sites in Norway. The programme is proving effective, especially in eliminating surface growth, but



Figure 6.4 Leirfall III winter covering with PVC-enveloped insulation mats, secured with cables and sandbags. (Photograph by: Heidrunn Stebergløkken. Copyright NTNU University Museum.)

most managers report it to be very labour intensive (Hykkerud 2011) and now question whether it is financially viable in the longer term.

Approximately 15 person-days are required each year to treat and winter-cover the panels at Leirfall. Four of the five panels have been treated since 2005; however, on several occasions the winter covering has not been removed from selected panels for the summer due to reduced resources. Comparative investigations of the practicalities of both winter and long-term covering are being carried out at Hjemmeluft (Hykkerud 2011). Permanent covering, consisting of a layer of geotextile covered with a layer of soil, has been carried out at several sites in Central Norway. Several sites in southern Norway have been reburied (Berg et al. 2007; Ernfridsson et al. 2010).

CONCLUSION

The open-air rock-art site at Leirfall in Central Norway has been known since the early twentieth century. It is a site with a long tradition of intervention; however, a cautious approach since the 1980s led to it not being subjected to what has proved to be a range of unstable remedial interventions widely implemented at sites in other regions of Norway. Its research contribution to the Norwegian Rock-Art Project, a five-year investigation of the impact of thermal cycling and insulating covering on exposed rock-art surfaces, far exceeded similar projects in Northern Scandinavia in both scope and duration. It highlighted that monitoring programmes of one to two years' duration do not give a representative picture of climatic impacts over time, thus calling into question the long-term applicability of the results of other shorter studies.

Today, the focus is on site management. The engravings are no longer in-painted, nor are the surfaces scrubbed with quaternary ammonium biocides. Labour-intensive efforts are invested each year to reduce surface accretions on exposed rock surfaces and buffer them against freeze-thaw episodes, and the financial sustainability of this work of making the site available to the public is coming into question. Deacon (2006) observes that due to the absence of an indigenous descendent community, decisions regarding the opening and closing of suitable rock-art sites to the public in Scandinavia can be made based on perceived significance of the rock-art and ability to sustainably manage it. Leirfall is the largest open-air rock-art locality in Central Norway, and recent experience points to the need for a more realistic approach to its management.

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7 Experiences Documenting Petroglyphs at Lake Onega, Russia, 1998–2012

Nadezhda V. Lobanova

INTRODUCTION

Lake Onega petroglyphs (Figure 7.1) constitute a precious part of the European prehistoric cultural heritage that reflects in a specific form the spiritual life and the way of living of the Neolithic people who inhabited the area more than 6,500 years ago. They are one of the largest concentrations of rock-art in Northern Fennoscandia and are distinguished by the metaphoric character, whimsicality, and ingenuity of the images. The history of the discovery and study of the petroglyphs on the eastern shore of Lake Onega began a long time ago and is still ongoing. This process is nourished by the unceasing interest both specialists and the general public exhibit for those unusual and mysterious archaeological monuments, as well as by the advancing search and recording techniques that help gain new information.

The Onega petroglyphs were first discovered in the mid-nineteenth century when just a few dozen panels with mainly single images were found on two capes (Grewingk 1855; Shved 1850). Over the years, the number of the images grew and the territory where they were found became significantly wider (Ravdonikas 1936; Savvateev 1982; Ernits and Poikalainen 1990). New data emerged which significantly improved our perception of the rock-art sites, styles, development, date, and the nature of their creators' material culture (Lobanova 1995a, 1995b). New discoveries continue to be made (Lobanova 2010). Moreover, underwater investigation of the Onega petroglyphs is very promising. So far, about 20 motifs have been recorded on rock outcrops that were cut off from the mainland and are now situated on the bottom of the lake (Lobanova 2010, 21; Savvateev 2007, 37).

For the last 15 years, expeditions led by the author have been carrying out field-studies of rock-art on the eastern shore of Onega Lake with financial support from Norway, the Ministry of Culture of the Republic of Karelia, the RAS Presidium, and the RSSF. The chief goal was preparing detailed and comprehensive documentation (including cultural and natural contexts) and the creation of an electronic database of identified petroglyphs. This work also included such aspects as developing effective measures for conservation, monitoring, and presenting of rock-art sites (Helskog et al. 2008; Lobanova 2006).

Burkitt also published some data in five illustrative tables (Burkitt 1925, tab. 43–46). Hallström's report contains drawings and photographs of the petroglyphs at Cape Peri Nos that were later moved to the Hermitage Museum in St Petersburg in 1934, the so-called Hermitage Rock (Figure 7.2A). They are now exhibited in the prehistoric galleries of the museum. It may be noted, however, that at least one panel was blasted off its host rock surface by directed explosion (Figure 7.2B), in the process destroying a unique birth-giving scene and several other petroglyphs. It cannot be ruled out that some split-offs resulting from the removal of rock-art panels ended up on the lake floor. In 2009, having compared Hallström's drawings with materials in the museum and measurements taken from the blasting site, the author determined where exactly one group of petroglyphs originated (Figure 7.2C).

Documenting Onega rock-art continued in the 1930s by Russian archaeologists A. Bryusov, A. Linevsky, and V. Ravdonikas. In 1934, Bryusov, from Moscow, organized a special expedition aimed at photographing selected panels (Bryusov 1940), but his pictures have never been published. Linevsky, from Pertozavodsk, made many valuable and interesting observations about the rock-art as visible at different seasons (e.g. late spring, summer, and early autumn). His approach involved the detailed analysis of the visible panels, including the topography of image groups and clusters, their order of appearance, statistical data, and the nature of the figures and motifs as the basis for further research. In his book *Petroglify Karelii* (Linevsky 1939), he attempted to identify the chronological sequence of images and interpret the meaning of individual motifs. In doing so, he employed, in a straightforward manner, ethnographical models for the lifestyles of indigenous northern nations. In spite of the bias and the lack of evidence behind his ideas, Linevsky's contribution has been quite substantial, promoting interest in the subject and spurring scientific discussions that are still ongoing. Linevsky employed a very complex technique of rock-art tracing. He divided the rock face into equal squares (the size of a standard paper sheet), wetted it with water, and then traced the contours of the motifs with an indelible pencil. Paper was then placed onto the squares and pressed tightly to the rock with a hand or a brush. This procedure yielded a mirror image of the carvings that was later transferred via carbon paper to another blank sheet of paper (Linevsky 1939, 19–52). Unfortunately, this technique was often rather inaccurate, and Linevsky himself often preferred to use Ravdonikas's field-data.

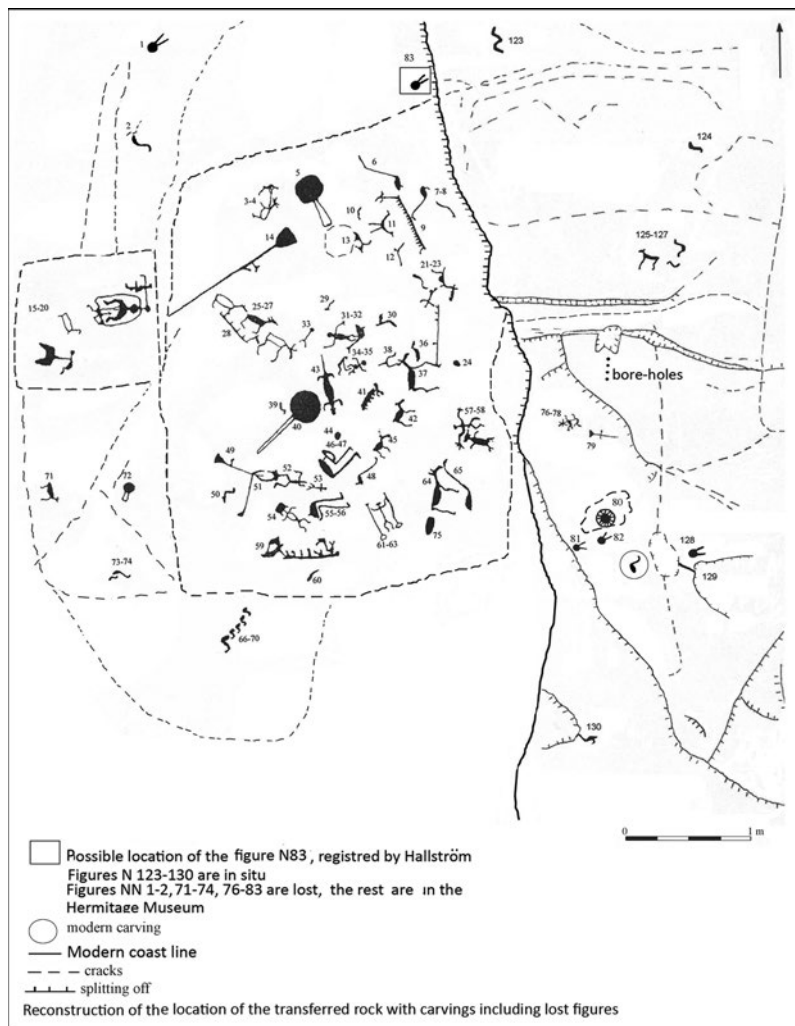
V. Ravdonikas, from St. Petersburg, is deservedly recognized as one of the founders of Russian rock-art studies. Together with others, he worked on the eastern shore of the lake during just one field-season in 1935, producing a massive body of documentation that underpinned the publication of a monograph titled *Naskal'nye izobrazheniya Onezhskogo ozera* (Lake Onega Rock Carvings) the following year (Ravdonikas 1938). It offers a detailed catalogue of all the petroglyphs known at that time along the eastern shore of Lake Onega. It is stated in the introduction to the book (Ravdonikas 1938, 21) that the total number of published images is more than 700,



A



B



C

Figure 7.2 The Hermitage Rock. A: The panel as visible in 1910. B: The original location of the panel in 2010. C: Reconstruction of the whole Hermitage Rock panel. (Images by: A: Hallström. B and C: Lobanova. Copyright reserved.)

whereas in reality only 488 figures were included in the catalogue. However, the locations of all the recorded panels were schematically mapped, and a paper by B. Zemlyakov briefly describing the geology of the area and the ancient sites found nearby is included as an appendix. The monograph was highly praised at home in what was then the USSR and abroad; for a long time it served as a model for such publications. Despite various flaws such as the lack of holistic compositions for groups comprising many motifs, negligence of micro-landscape features (natural fissures, potholes etc.), occasionally inaccurate linking of figures and figure contours, and some inaccurate depiction of cardinal directions, the book is still of high scientific value.

Ravdonikas's expedition used a more advanced technique to record panel surfaces, developing ideas applied in 1910 and 1914 by Hallström (1960, xiv), that enabled the recording of fairly large areas. The petroglyphs were smeared thoroughly with a whiting solution that was then transferred to tracing paper and photographed (Ravdonikas 1938, 21). Such copies were generally accurate, although they did not always properly portray the mutual arrangement of petroglyphs on very large panels (such as those on Cape Besov Nos). In addition, both Ravdonikas and Linevsky produced gypsum and paper casts of some carvings (Ravdonikas 1938, tabs. 77–80). Sometimes they detected petroglyphs underneath lichens, which were removed with an acid solution in order to facilitate recording. The author found in his own fieldwork that the acid-cleared rocks are now the most difficult to record because new lichen species have colonized the surfaces very densely.

The 1930s were quite productive in terms of the study of Lake Onega petroglyphs, both *in situ* and *ex situ*. It was during this period that the main lines and methods for research into the subject were drafted. However, fieldwork still had a long way to go. In 1972 to 1980, targeted long-term fieldwork programmes often spanning all three summer months in a season were directed by Y. Savvateev at the Onega petroglyphs and nearby settlements. The author of this chapter was an active participant in this work. Searching for new groupings, copying and updating previous records, and preparing cartographic materials were among the activities undertaken. New methods for detection and recording were applied, and as a result, 11 new clusters of sites were discovered: at the mouth of the River Vodla, on Bolshoi Golets, Moduzh, Malyi Guriy, and Koryushkin Islands. Some panels were discovered underwater. Several Mesolithic and Bronze Age sites were excavated on capes Kladovets and Besov Nos and along the banks of the River Chjornaya. All in all, more than 800 panels (separate figures) had been recorded by the early 1980s. The original plan was to publish a new complete catalogue of the sites, touching upon issues of dating, cultural affiliation, and interpretation alongside a systematic analysis of archaeological materials from neighbouring sites to identify those contemporary with the rock-art. Alas, the manuscript was never published, and only some scattered fragments of the data and sketches of the most curious figures have made their way into the literature (Savvateev 2007).

In the 1960s and 1970s, both new and previously known carvings in the lower reaches of the Vyg River and on the eastern shore of Lake Onega were recorded in more detail than ever before (Savvateev 1982; 2007, 315–25). Members of Savvateev's expeditions made carbon rubbings on long rolls of white paper using graphite powder or graphite rods. To make the motif outlines more distinct, the same panels were copied several times. However, carbon copies bear the imprints not only of the carvings but also of the surrounding or overlying natural fissures and dents. Therefore, the natural and anthropogenic imprints had to be compared and differentiated. Rubbings quite often helped to identify carvings on rugged, eroded rocks, where visual searches were useless, and in this a series of unique filled solar and lunar signs was unexpectedly detected in the area between capes Peri Nos II and III (Savvateev 2007, 164).

In addition to rubbings, Savvateev experimented with polymerized rubber castings, but these were soon abandoned because the material left dark rectangles on the rock which remained visible for several years (Savvateev 2007, 320). An attempt was also made to copy the carvings found underwater in Cape Kladovets (Tsutskin 1974, 34). To this end, a piece of white plastic was first mounted on a wooden frame and a thick mastic bar was used to take the copy.

In 1982 to 1993, Onega rock-art was the object of study by amateur researchers from Tartu and Tallinn (Poikalainen 1995). They discovered three previously unknown clusters of petroglyphs. A detailed catalogue of rock-art on the Kochkovnavolok Peninsula and Bolshoi Golets Island was soon published (Poikalainen and Ernits 1998), representing nearly one sixth of all known Lake Onega petroglyphs. The work includes all the necessary information about the petroglyphs, including notes on their wider context.

While giving credit to the efforts of enthusiastic amateur researchers from Estonia, one cannot ignore the errors in their recordings: poorly preserved or shallow figures were inaccurately or incompletely documented; some images were identified in error; and images were overlooked. These faults may be attributed firstly to poor preservation of rock-art in Kochkovnavolok, secondly to inadequate use of carbon rubbing, and thirdly to the survey process where each visit to a site adds to the information pool. The carvings were photographed, and their contours were drawn in considerable detail on a computer in Estonia, away from the site, where natural defects could no longer be distinguished from man-made signs. Working in Kochkovnavolok Peninsula later on, the author of this chapter eliminated these faults, identified deviations from the contours of some images, and pinpointed natural features of the rock previously interpreted as humanly produced carvings. Following multiple verifications undertaken in Kochkovnavolok, more than a hundred petroglyphs previously recorded there by Estonian researchers were recognized as natural phenomena. They all appear as unintelligible, shapeless indentations or stripes.

In the late 1980s, a petroglyph documentation method proposed by an Estonian fabric artist was used (Selisaar 1991, 136–7). The procedure is as follows. A piece of wet, light-coloured cotton fabric is placed onto a cleared rock-art panel (the area must be horizontal and smooth). This is preferably done in warm, sunny weather because the fabric then dries quicker on top of the carving so that the motif appears as a lighter area against a darker background. Features such as traces of erosion, scars, and dents are also visualized in great detail. The author of the technique argued that the resulting image on the fabric reliably reflected the original but that it vanished quickly after the fabric had dried out. As a result, neither the author nor other members of the Estonian team used this rather user-unfriendly documentation method very extensively.

RECENT AND CURRENT RESEARCH

Since 1997, the author has regularly carried out archaeological expeditions to Lake Onega to work on the petroglyphs. An immense amount of work has been accomplished, some of it well beyond the scope of the original plan to cover a wide range of issues related to the rock-art of Karelia. A major output of the project is the Petroglyphs of Karelia database management system. This database comprises topographic plans, photographs, and carbon copies of the images, detailed descriptions (both overall and motif specific) stating the dimensions, orientation, elevation above water level, carving depth, condition, parametrical data, and suggested interpretations of some figures or groups (Lobanova 2003). Every year this body of knowledge on the petroglyphs is enhanced with new additions.

Lichen specialists from the Forest Research Institute of the Karelian Research Centre and from the Petrozavodsk State University surveyed the sites in 1997 through 1999. Their studies played a great role in the development of appropriate methods and tools for the conservation of Lake Onega rock-art, aiming to determine the effect of lichens on the carving-bearing rock surface and find ways to reduce their degrading impact (Fadeeva and Sonina 2000). Monitoring of the lichen biota helped reveal those groups of carvings most that were most problematic from the conservation perspectives. These include panels on the Kochkovnavolok Peninsula, where a substantial proportion of the carvings are covered in lichens of various types and shapes, and panels at Cape Karetskiy Nos. In both areas, it was recognized that the most sensitive areas were the upper parts of carved rock outcrops. This led to the preparation of preservation measures that could be implemented as soon as possible. It was recommended that measures for protecting petroglyphs against detrimental biogenic impacts should be case specific, taking into account all the factors influencing the development of the lichen biota.

Material obtained in the course of recent studies was compared with previous field-documentation. This work was extremely important for measuring

changes to the physical state of the rock-art sites through damage and the loss under the influence of natural and anthropogenic factors. Despite the fact that Onega petroglyphs suffer from the negative influence of natural factors (e.g. weathering, storms, and ice hummocks), in most cases they successfully resist nature. The comparison of field-research data (rubblings and photographs) from the 1930s through to the 1970s with the recently obtained information shows little change due to natural forces. Regrettably, the petroglyphs are damaged much more by vandalism wrought by ignorant visitors because the sites do not receive proper protection from the state.

Reliable documentation of rock-art is the basic prerequisite for further scientific interpretation. Researchers kept this in mind when working out fieldwork principles and methods with regard to local specifics. It is suggested that one cannot establish procedures for documenting rock-art panels too strictly, as these must be constantly improved, modified, and adjusted to local conditions. Life has shown that to study such a peculiar stratum of antiquities, one needs a different, well-grounded, and well-tested technique, including unconventional, novel research procedures, differing from those applied to ordinary archaeological sites and objects. These originate from meticulous and time-consuming fieldwork. It is only while working at a certain site that one develops the scientific means of finding and recording the images, determining their mutual arrangement, and understanding their natural and cultural contexts.

Every researcher beginning to study petroglyphs at a site can and must verify the accuracy of previous documentation and then choose and master the technique most suitable for the given type of rock and the particular qualities of the rock-art motifs. Earlier records are essential since they can be used to identify how the destructive factors (both natural and anthropogenic) have changed the visibility and preservation of the panels. Likewise, one cannot avoid subjective bias in petroglyph studies, except for the rare cases of perfectly preserved carvings. Even the most advanced techniques cannot guarantee absolute reliability, but documentation repeated over several years, in a range of natural/climatic conditions and with a combination of methods, will tangibly improve the reliability and integrity of the data. A rock-art specialist must rely on verified data and his or her own practical experiences.

Even the early stages of rock-art study, finding and recording panels, is rather complicated. Many carvings are poorly, if at all, discernible in daylight, especially where the rock surface is wave smoothed, overgrown by lichens or mosses, weathered, or covered in glacial scars, abrasion marks, and recent dents. The highly accurate identification and contour recording of even the most discernible images together with the determination of groupings, arrangements, and clustering of motifs is hardly ever an easy task. In practice, images in the Onega complex can only be observed and recorded from late spring (May) to early autumn (September), excluding rough-water days in the summer season and regular storm periods starting

mid-August. Contours of the most low-lying Onega carvings are heavily wave smoothed, which means that carbon copies cannot be taken in certain situations, although some of the images may be discernible. Images situated higher up get overgrown with lichens and may sometimes be covered with mosses or algae. Sections of some rock-art panels have split off and most of these are now underwater, close to the capes but also at some distance from the shore. Several fragments of rock weighing from 100 kg up to 2 tons were found on Cape Peri Nos VI, some 11 to 12 m higher than where they originally stood. It has yet to be determined what natural processes caused such 'migrations' and when these occurred. Specialized studies involving geologists and geomorphologists are needed for that, but there is reason to believe that the dislocations took place during prehistoric times.

Predictive assessments of potential changes to rock-art panels under natural conditions and humanly induced impacts is also desirable but requires detailed knowledge of the site. It is especially difficult to record and attribute palimpsests, overlapping images, and poorly preserved figures. Such carvings have to be examined repeatedly, always checking the copy against the original at the site. A good way to produce accurate documentation is to apply various techniques that complement and refine each other and which do no damage to the rock surface. At present, in addition to reliable identification and recording of individual figures and their affiliations with other (neighbouring) motifs, *in situ* documentation of rock-art includes the development of effective measures and realistic plans for their conservation, monitoring, and presentation, similarly to what is being implemented in Karelia (Helskog et al. 2008).

Speaking of the challenges involved in the search for and identification of petroglyphs, all researchers working in the Karelian territory stressed that the carvings are best discerned in oblique sunlight during the early morning or late evening. Unusual conditions have also been noted in other periods of the day when previously overlooked images come forward unexpectedly. For instance, Bryusov (1940, 212) recollected an occasion when heavy rain followed by strong wind quickly dried the smooth rock surface, leaving darker patches in depressions that enabled the recording of previously unidentified motifs. Another example occurred late in the autumn of 2002 when the author observed 'snow copies' of carvings on a rock on the Kochkovnavolok Peninsula where the petroglyphs are especially degraded even though originally they were amongst the deepest carvings in Karelia. A thin sheet of snow covered the rocks but was a darker hue along the contours of the figures, thereby making the deeply carved motifs stand out.

Since 2004, a method of recording rock-art using a black plastic shelter has been employed in Karelia, an approach borrowed from Norwegian colleagues. Quite a few new petroglyphs were detected and the outlines of previously known examples were detailed (Lobanova 2007). In fact, this has proved to be one of the most effective techniques currently available. It produces the same high-light-and-shadow effect as low-angle sunlight but

can be done in any weather. Furthermore, under a black plastic shelter, one can inspect unhurriedly and methodically any rock surface. No doubt, the researcher's acute vision and previous experience with the technique are important factors. Photography of the carvings sheltered by a sheet of black plastic also brings good results, and the search for petroglyphs using this method yielded many unexpected results. For example, a well-known image in Cape Besov Nos, which Ravdonikas interpreted as a 'trident – ritual symbolic image' (Ravdonikas 1938, 95) and Hallström (1960, 349) took for an anthropomorph, legless but with a long phallus partially split off the surface, seems to have a rather different meaning. We believe it is a typical beluga whale-hunting scene. A similar composition can be found in the same panel. Several shallow-carved figures that researchers had previously overlooked were detected among large swan-figures in the left-hand side of the panel on the same cape. One more famous example of a non-precise copy is the so-called image of a masked human being in Cape Karetskiy Nos, discovered by Ravdonikas (Autio 2000, 188; Hallstrom 1960, 349; Ravdonikas 1938, tab. 4). In accordance with our recording, these figures seem to represent an animal (wolf or fox) and a swan. During the documentation work carried out between 2000 and 2012, the author used the same technique in Cape Koryushkin Nos and found a new group of images, which possess some features suggesting a chronological attribution to the earliest phase of Onega rock-art (Figure 7.3).

Carbon copies (rubblings) still are among the most unbiased methods for recording rock-art, although one that remains controversial because it is a 'contact' method. Moreover, the interpretation of rubblings must be done in the light of results from other techniques, such as photography and interpretative descriptions. On rubblings, it is often impossible to distinguish a humanly made carving from natural features of the rock, so this has to be done *in situ*. The first thing to consider is the very nature of the object. Petroglyphs usually have fairly even edges, and the pecking marks inside the figure are about the same depth. The depth inside the contour of a natural dent varies, the edges are uneven, ragged, and no pecking marks can be seen. Application of long-fibred cotton (so-called mycalent) paper for rubblings, which is so popular in Siberia, is a practice adopted at Lake Onega quite recently (Lobanova 2010). The difference between a mycalent copy from a regular one is that it will show the relief of both the image and the surrounding rock. Such rubblings are also very good for use in museum displays and exhibitions.

Photographic recording of rock-art is also important. An essential factor in the photography is side light, which enhances contrast. This is why in sunny weather, researchers shaded the carving-bearing rock area with black cloth and aimed a large mirror at the area. By tilting the mirror, it is possible to get sharp and prominent photographs of the carvings. The same effect was created on dark nights by a large spotlight on the research vessel (Savvateev 2007, 320). Since the 1970s, colour photography has been growing ever

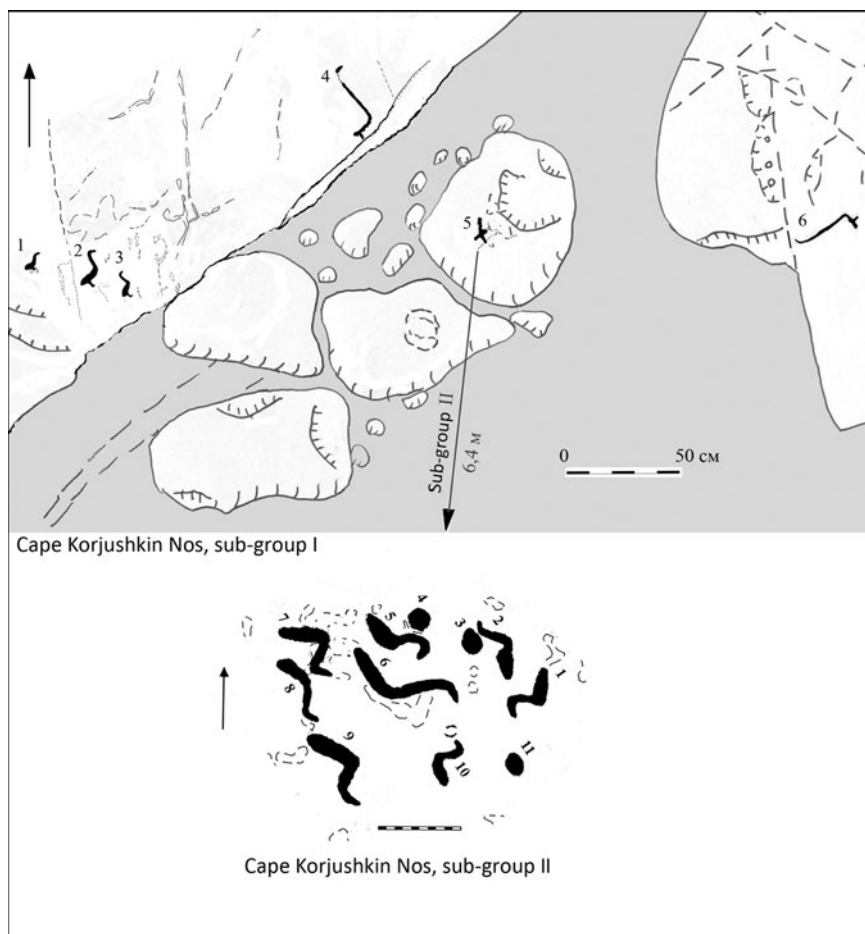


Figure 7.3 Recording Lake Onega open-air rock-art. A: Photograph of boat motifs (Cape Peri Nos III) covered with lichen taken under a black plastic shelter. B: Plan of location (Subgroup I) and tracing of Subgroup II of the most recently discovered (2010–12) rock-art site in Lake Onega, Cape Korjushkin Nos. (Photograph A: by I. Georgievskiy. Copyright reserved. B: Image by Nadezhda Lobanova, copyright reserved.)

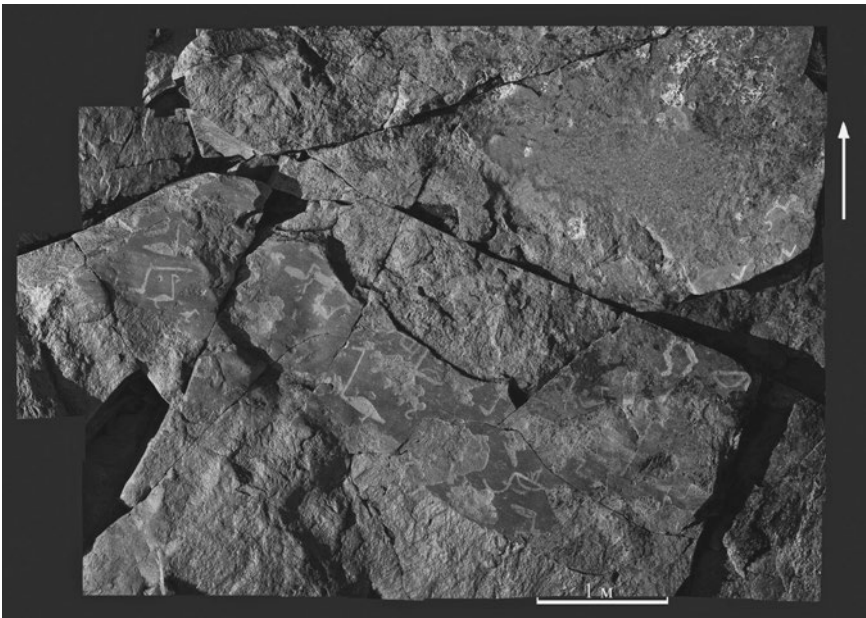
more popular, to become particularly important in the twenty-first century because of advancing digital information technologies.

The first underwater photograph of petroglyphs found on detached rock fragments (lighted with a flashlight in a box) was taken by E. Tsutskin (Tsutskin 1974). In 2008 divers from St. Petersburg repeated the experience (Drankevich 2008), but the images were recorded with a digital camera.

In the last few years, composite photography of rock-art imagery has been consistently carried out in Karelia, allowing the full coverage of a

specific group of petroglyphs no matter how large the outcrop. The originator of the technique is the photographer I. Georgievskiy (Lobanova 2010, 20–21). First a grid of between 40×60 cm and 80×100 cm is delineated on the rock face. Each square is then numbered and photographed, preferably under the same weather and light conditions. The images are then processed on a computer and the images joined together as a composite. The output is a photograph of the whole group of petroglyphs, showing quite accurately and reliably their mutual arrangement on the rock face (Figure 7.4). A similar recording procedure was used on rock-art panels in Finland (Taskinen 2005, 420). Composite photographs are now available for all large groups of petroglyphs from Lake Onega, and the plan is to apply this procedure to another rock-art sites in Karelia, namely the White Sea petroglyphs. The source photographic material can be used for various purposes, first of all in museum exhibitions and to monitor the condition of the sites.

It is not only data-collection activities that matter; also important are cataloguing, storing, and systematizing records of rock-art, especially because not all field-materials have been published. In Karelia, this work is at a very early stage. Old photographs and carbon copies from different years are being digitized. A substantial part of the materials in storage is, unfortunately, in very poor physical condition. In the 1960s and 1970s, images were reproduced on photosensitive paper (so-called blueprint paper), which has become very



Figures 7.4 Recording Lake Onega underwater rock-art: composite photograph of the Kladovets Nos rock-art panel in 2009. (Photograph by I. Georgievskiy. Copyright reserved.)

brittle over the years and easily is torn into narrow strips when unrolled. Therefore, such carbon copies must be handled with great care and repaired for digitization.

CONCLUSION

The thorough and comprehensive study of the rock-art heritage in Karelia is a priority task. By combining various methods and techniques (survey and recording using black plastic shelters, normal paper and mycalent paper copies, and composite photographs), it is possible to identify more reliably the sites, panels, and motifs that comprise the rock-art resource and at the same time facilitate further interpretative work. Well-documented field-data are also instrumental in developing effective and sustainable measures for conserving, monitoring, and presenting the petroglyphs.

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8 'Preservation by Record'

The Case from Eastern Scandinavia

Liliana Janik

INTRODUCTION

Conducting research at open-air rock-art sites poses a number of questions that in very general terms can be categorized as two kinds: one linked with the research question under investigation, the other with the past, present, and future state of rock-art itself. Rock-art preservation can be a subject of research in itself. However, in this chapter, I present the accomplishments of the 'preservation by record' approach that we have achieved during recent work at Zalavruga beside the Vig River, part of the White Sea rock-art complex, in northern Russia. Preservation by record is a key concept in heritage management. It applies where preservation *in situ* (keeping a site in an unchanged state) is impossible or impractical and involves making a detailed and comprehensive record before the material is lost. In the case of the White Sea rock-art, complex 'preservation by record' becomes essential when rock surfaces are stripped bare of any vegetation and the area is too big to install a protective cover.

This chapter describes work carried out in the last few years by combining the efforts of different specialist teams and research objectives. The British team worked toward creating 3-D records of rock-art panels in which all the carvings were recorded by a 'soft' brass-rubbing technique that recorded not only the petroglyphs themselves but also the state of the rock they have been pecked into. By comparing our records with published and archive materials from the 1930s and 1970s, we expanded the 'preservation by record' archive of the 'here and now' to create a picture that is relevant to understanding the rock-art history in the White Sea area. The Russian team produced photographic records of the carvings by colouring the petroglyphs and photographing them, as well as providing geological expertise on the rock composition and degradation. Combined efforts by the British and Russian teams explored the flora growing on rock surfaces and in the crevices, as in the area surrounding the decorated rock outcrops. This we hope will allow future monitoring of the dangers caused by the plants to the rocks on which they grow. Norwegian funding allowed the construction of walkways and information boards. All these

efforts came together at a time when interest in the heritage of Russia and the development of local business links dramatically increased. By presenting some of the results of ‘preservation by record’ in this chapter, I hope to contribute to debates about the conservation and management of open-air rock-art in eastern Scandinavia and beyond.

WHITE SEA ROCK-ART

The first rock-art in the White Sea region of northern Russia (Figure 8.1) was discovered and recorded at Besovy Sledki by A. M. Linevsky in 1926. But this discovery was not accidental. The location of this and other nearby sites was shown to archaeologists by members of the local community, and so it is perhaps better to speak of their introduction to the outside world rather than their discovery *per se*.

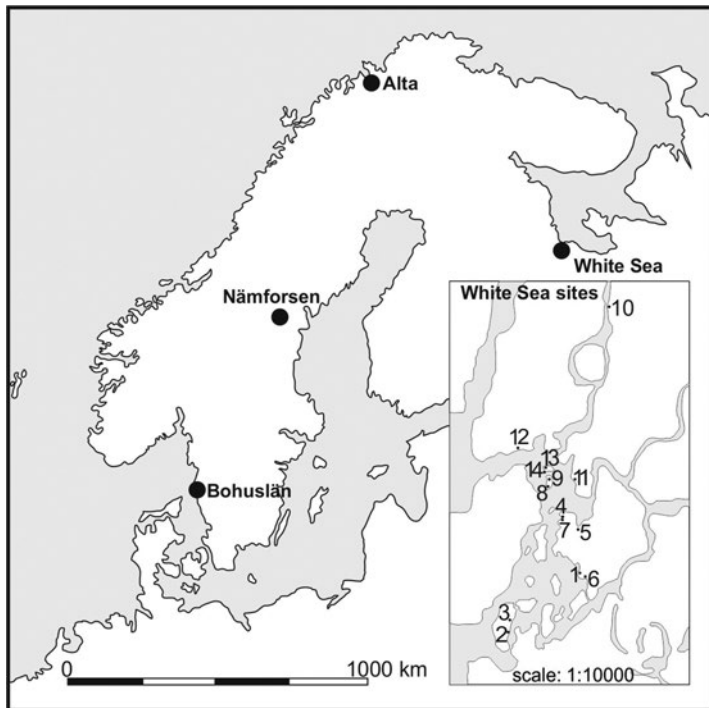


Figure 8.1 White Sea region. A: Location of rock-art sites in White Sea region. Numbering follows the chronology of sites: 1. Erpin Pudas III; 2. Besovy Sledki South (S); 3. Besovy Sledki South (N); 4. Erpin Pudas I South (N); 5. Erpin Pudas II; 6. Erpin Pudas IV; 7. Erpin Pudas I South (S); 8. Nameless Islands IV; 9. Nameless Islands III; 10. Zalavruga; 11. Nameless Islands I; 12. Zolatec I; 13. Nameless Islands II North (N); 14. Nameless Islands II South (S).

Besovy Sledki remains relatively inaccessible. The southern part of the site is covered by a hydroelectric power station, and although the northern part is under a purpose-built museum, designed to house the carvings *in situ*, the museum has been closed for several of years because of the poor state of the structure. In 2012, however, an assessment was carried out to see what was needed to make the building safe, and once the necessary improvements have been made, the rock carvings at Besovy Sledki will be publicly viewable again.

Through the middle decades of the twentieth century, various archaeologists and research groups discovered and documented a number of different rock-art sites, which were subsequently published in two major monographs: V.I. Ravdonikas's *The White Sea Petroglyphs* (1938) and Y.A. Savvateev's *Zalavruga* (1970). Taking into account this published data and the need to look at the rock-art from the contemporary perspective (for example, how the carvings inform us about past landscape, or how we can construct the chronology and sequencing of the carvings) a new project has recently been undertaken to record and understand the carvings with two objectives. The first was to address a series of new research questions informed by current methodological and theoretical debates. The second was to examine the destructive impact of environmental and climatic changes on the rock-art and to assess the damage done since the art was first recorded in the early twentieth century.

The carvings at Erpin Pudas were first noticed by Linevski, while the majority of carvings and locations were discovered and recorded by a team lead by V.I. Ravdanikas in 1936 (Ravdanikas 1938). Ravdanikas led a group of archaeologists who were surveying and recording the estuary of the Vig River before the building of the hydroelectric power station. During this research season, part of the complex at Zalavruga was discovered and documented. Although this part of the site has been called Old Zalavruga since it was found first, according to the chronology for the site, the carvings here are actually the youngest from the Zalavruga complex as a whole. The majority of the existing rock-art at this location was uncovered by a team directed by Savvateev between 1963 and 1968 and forms what is now called New Zalavruga. Carvings on the Nameless Islands were found by the same team (Savvateev 1970). Over the past decades, a new rock-art site at Zolotec I has been discovered and recorded (Georgievskij and Lobanova 2012; Lobanova 2007).

PRESERVATION BY RECORD

The rock-art complexes located in the old riverbed of the estuary of the Vig River are fully accessible to the contemporary visitor because of the low water level caused by the construction of the hydroelectric power station, although the relative visibility of the rock-art varies from location to location. Some of the groups are easily detectable, while others are

more difficult to see. Some major factors in the relative visibility of the rock carvings are differential weathering that causes some rock surfaces to crumble and a lack of resolution between carved and not-carved rock surfaces. This led to a rethinking of the strategy of how to ‘preserve’ the rock-art for future generations while creating the most accurate record possible for future archaeologists. These issues were foremost in our minds when we were structuring the research questions and priorities for the Rock Art of the White Sea Project. Our thinking was informed by the principle of ‘preservation by record’ set out in *Planning Policy Guidance 16: Archaeology and Planning* (colloquially known as PPG16) that was introduced by the British government in 1990 for England and Wales. This far-reaching document provided a conceptual framework for the long-term approach we adopted that foresaw future rock-art destruction or alteration resulting from processes of weathering and climatic and environmental change. Environmental conditions, exposure of the rock surface to the sun and frost, and the accumulation of water in rock crevices have already caused damage and destruction to some carvings. It was therefore necessary to create an alternative to ‘preservation *in situ*’, and for this reason we adopted an approach that would at least secure ‘preservation by record’.

We employed the archaeological practice of structured recording and the PPG16-inspired concept of ‘preservation by record’. Due to logistical and financial constraints, the Rock Art of the White Sea Project focused on the recording of the Zalavruga site, and we treated the site foremost as an archaeological site rather than as a set of rock-art depictions. We hoped that such an approach would provide us with a focus on the site as a whole, so that we could produce a record of the site as an entity, rather than just the carvings. Our intention is to make our records of the site and the carvings it contains accessible from different parts of the world as a comprehensive digital data set.

LOCATION AND CHRONOLOGY

Despite two monographs covering the White Sea carvings published in the twentieth century, as well as several articles (Lobanova 2007; Savvateev 1967, 1968), much basic information about the location of rock-art sites in the estuary of the Vig River was missing. This was probably because of reluctance on the part of the Soviet authorities to create maps accessible to the public. Such reluctance extended to the introduction of deliberate mistakes in general atlases, not providing scales for the maps, and misleading map users by giving inaccurate distances between the locations. Using a map created before the Second World War at the relatively small scale of 1:10000, walking the area of the estuary of the Vig River with Dr Nadezhda Lobanova, and recording the particular rock-art site locations using modern

methods (Janik 2010; 2012), we created a new map of the White Sea rock-art sites (Figure 8.1).

The second task we undertook as part of our new survey was to establish the most accurate possible relative and absolute chronology. Savvateev (1970) provided the original chronology for the carvings, but this was based on a pottery typology and the elevation of the carved rock surface assessed using only one measurement point. This meant that we did not know if the elevation given was from the middle of the rock-art panel, the top, or the bottom. What was also needed was a sequential chronology of the Zalavruga carvings that would allow us to recreate the development of this particular site since it contained more than 2,000 images, the greatest number of images at any site in the White Sea region.

It is important to acknowledge that despite the Vig River estuary being located near the town of Belomorsk, close to the hydroelectric power station and a number of small villages, it is still not easy to access. From the closest road, there is a lengthy walk across a dry riverbed full of artificially deposited rocks, natural outcrops, forest, and waterlogged areas. The frequent rain, strong winds, and flooding of the area by water released from the power station creates a challenging environment for archaeological research; we are constantly mindful of health and safety requirements and have to adjust approaches accordingly. During the 2009 season, the elevation of all recorded rock-art panels was established, except for Besovy Sledki, where we had no access to the pavilion structure that had been erected to protect the carvings. By combining the data on elevation with the changes in water levels, we were able to establish a revised chronology for the White Sea rock-art (Table 8.1) based on the elevation of decorated rock surfaces dated by radiocarbon determinations and the elevation of particular carvings (Janik 2011).

The Zalavruga site was also dated in a way that allowed us to distinguish seven discrete phases related to the geomorphological levels established by Devatova (1976) in the late 1970s. In pragmatic terms, we were thus able to calculate which images were most likely to have been carved first (Figure 8.2).

At the same time as documenting the archaeological evidence at the site, we also undertook a full assessment of the flora growing on and in crevices in the rocks, as well as in the area surrounding the rocks. This work was carried out by Dr L. Shiplina from the N.I. Vavilov All Russia Research Institute of Plant Industry in St. Petersburg. It allowed us to assess the danger that plants present to surviving rock-art, as well as their negative influence on exposed rock surfaces. In addition, a reference collection was gathered and is in the process of being incorporated into the wider herbarium collections of the George Pitt-Rivers Laboratory in the University of Cambridge and the herbarium of the N.I. Vavilov All-Russia Research Institute of Plant Industry, St. Petersburg.

Table 8.1 Dating of particular White Sea rock-art sites. Radiocarbon dates were calibrated by the author using OxCal v3.10 (Bronk Ramsey 2005).

Non-cal BC Dates	Rock-Art Site	cal BC 95.4% Dates
5625–5527	Erpin Pudas III	4495 BC (85.4%) 4445 BC– 4370 BC (91.4%) 4340 BC
5557–5379	Besovy Sledki S	4405 BC (51.5%) 4350 BC– 4265 BC (60.4%) 4230 BC
5557–5379	Besovy Sledki N	4405 BC (51.5%) 4350 BC–4265 BC (60.4%) 4230 BC
5459–5414	Erpin Pudas I (N)	4345 BC (69.8%) 4320 BC–4330 BC (95.4%) 4255 BC
5254–5218	Erpin Pudas II	4070 BC (84.3%) 3990 BC–4045 BC (95.4%) 3980 BC
5147–5083	Erpin Pudas IV	3975 BC (95.4%) 3950 BC–3880 BC (77.6%) 3800 BC
4945–4929	Erpin Pudas I (S)	3715 BC (66.3%) 3690 BC–3710 BC (95.4%) 3655 BC
4937–4768	Nameless Island IV	3715 BC (69.3%) 3690 BC–3600 BC (63.1%) 3550 BC
4814–4332	Nameless Island III	3560 BC (50.0%) 3530 BC–2930 BC (94.1%) 2900 BC
4775–3666	Zalavruga	3590 BC (84.8%) 3520BC–2130 BC (50.2%) 2080 BC
4523–4479	Nameless Island I	3220 BC (40.2%) 3170 BC–3330 BC (69.7%) 3210 BC
4539–4049	Zolatec I	3360 BC (39.1%) 3330 BC–2530 BC (52.9%) 2490 BC
4258–4153	Nameless Island II N	2900 BC (95.4%) 2880 BC–2780 BC (67.9%) 2670 BC
4014–4001	Nameless Island II S	2575 BC (76.0%) 2510 BC–2570 BC (68.8%) 2520 BC

THE CARVINGS

Drawing on the concept of preservation by record as our framework for recording the site of Zalavruga has allowed us unprecedented access to accurate information about the carvings once we returned from Russia. This was achieved as a result of our deployment of archaeologically based

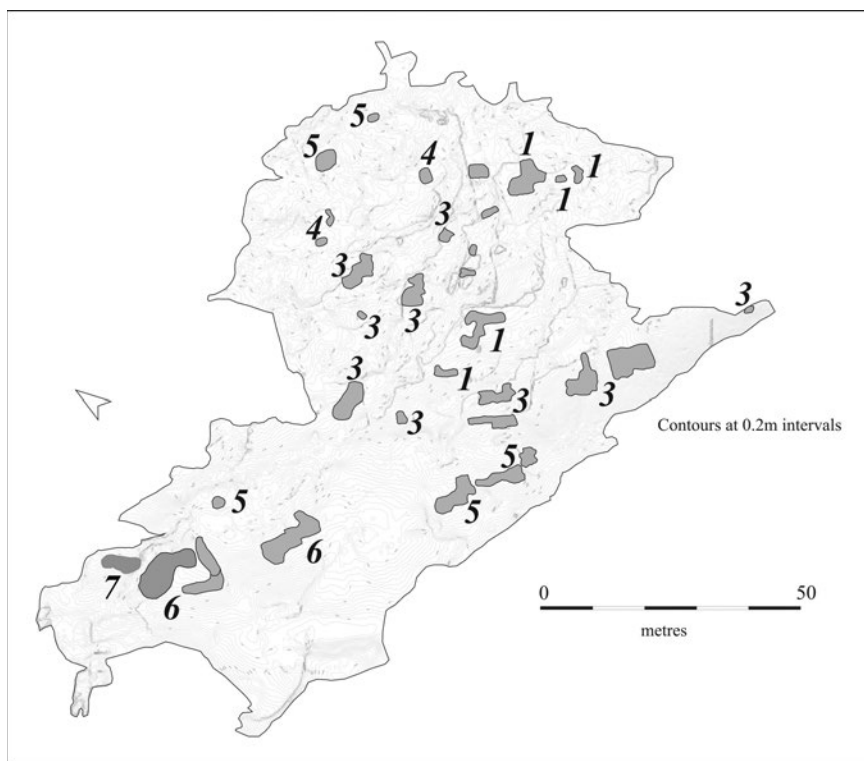


Figure 8.2 Map of Zalavruga. Each group is numbered according to the phase during it was were created.

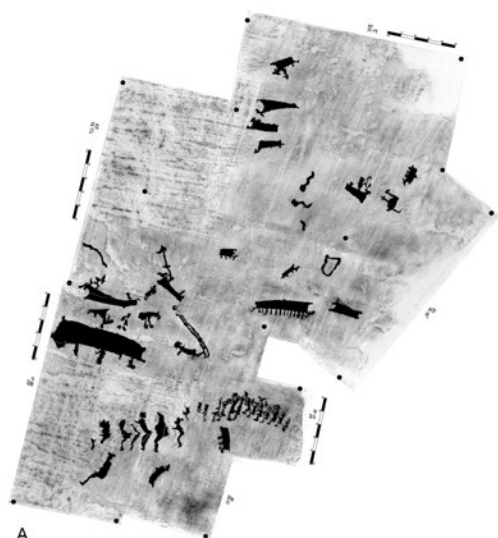
documentation rather than focusing only on the carvings. We created a ‘total’ archaeological documentation, mirroring the process of excavation, as if the archaeological artefacts and the context of their deposition were going to be lost. In the case of the White Sea rock-art, the process of ‘excavation’ can be seen as being analogous to the process of ‘weathering’. Although weathering takes immeasurably longer than archaeological excavation, the result (the disappearance of the archaeological remains) is much the same.

Such documentation within this framework had to take into account the specificity of the archaeological data about the carvings themselves and their location on the rocks. To do this, we needed to establish a degree of accuracy that would allow us to document the particular images and their relationship to other depictions, as well as their placement on the rock surface. Further, the preservation of the carvings required as objective a record as possible. This was achieved by the repetition of ‘blind recording’. First, following the advice we received from Russian colleagues, we used various techniques of rubbing in recording the images. These were modified by the

Cambridge team using ‘soft’ rather than ‘hard’ rubbing. We used our hands, protected by latex or rubber gloves, as these proved to be much more sensitive for applying graphite powder on the paper, instead of the hard surface of a wooden implement or the sole of a shoe as typically used by our Russian colleagues. Further, we repeated rubbings of a number of groups of carvings to create comparable images that could be evaluated by direct comparison with each other, as well against the depictions published by Ravdanikas and Savvateev. Sometimes we found previously unrecognized images, while at other times we could not find the carvings presented in the publications. It was essential that not only one researcher would see the carved images transformed into paper, but that we had agreement between team members as to what we saw. Sometimes we repeated rubbings of the same images during different research seasons in varying weather conditions, which produced different moisture within the rubbed rock and gave us a different take on the area we were looking at.

The areas we rubbed were defined using a method that proved to be simple but successful and allowed us simultaneously to document a number of rubbings while recording elevations of the images. While rubbing particular carved areas, we recorded elevations using a Total Station and theodolite. In this way, we were able to record an area of 8,500 m² as if it were any archaeological site. We created a 3-D record of all the rock surfaces, which in turn allowed us to record the corners of each sheet of paper covering the carvings in preparation for rubbing. The elevations of the recorded paper equalled the elevations of the images ‘transferred’ from the rocks to the paper with the help of graphite. Every sheet of paper was numbered at the four corners so that overlapping pieces of paper shared the same numbers, allowing us the overlay images and see the relationships between them using this simple grid. The rubbings were photographed on return to Britain and linked by the numbers coded on the corners of each sheet. These numbers also related to the elevation of the rock surfaces, which allowed us to fix the absolute locations of the carved images. The images of the carvings were highlighted in red using the CorelDraw computer program, and they were then ‘draped’ onto a virtual 3-D image of the rock surface, allowing us to visualize and analyse the precise locations of the carvings (Figure 8.3). The rubbings also provided us with tangible records of the rock surface, which over time will serve as a benchmark for the assessment of the degradation of the rock surfaces.

The resulting maps showing both concentrations of depictions and individual carvings showed for the first time the accurate locations and elevations of the rock-art in the White Sea region and are now used by Russian colleagues in their work and publications (Georgievskij and Lobanova 2012, 69). In this way, we achieved our objective of full reconstruction of the carvings that is already proving its worth as a research tool, as well as securing the preservation by record through the creation of an archive of the White Sea rock-art at the start of the twenty-first century.



A



B

Figure 8.3 Recording rock-art in the White Sea region. A: Numbers of separate sheets of paper with the rubbings. Black dots indicate the point with numbers for which elevation has been measured. Rubbings of carvings are outlined and filled with black for better visibility. B: Three dimensional reconstruction of the rock surface with carvings.

PRESERVATION BY RECORD AND A RESEARCH ARCHIVE

One of the most unexpected outcomes of our investigations at Zalavruga was being able to establish the extent of losses to the rock surfaces themselves. First, by looking at the rock surfaces, we noticed that one of terraces located in the highest part of the site ended in a straight line, an observation supported by the recording. The edge of this straight line posed questions as to how it was possible that such a clear-cut edge existed in one part of the site but not another and how such a straight edge could be created through factors linked with geological and geomorphological formations. The answer came from the local community, from whom we learned that in the 1960s, the site was used as a quarry. This revelation brought unexpected implications about how many of the carvings had possibly been lost due to stone extraction. Such loss of rock, and therefore possibly carvings, was also news to our Russian colleagues.

A second important result of the recording has been a recognition of the importance of the reconstructed rock surface for the interpretation of the sequence of depictions of skiing. The recording *in situ* corresponded to the independent measurements of the rock surface, pointing towards use of the elevation of the rock as a representation of a real landscape (Janik et al. 2007). By following the ski traces found in the snow and lines carved into the rocks, we have shown how the rock surface mimics the natural landscape and the movement of the human body following the elk. This showed correlations between rock surfaces/natural landscape and human body movement/carvings depending on skiing techniques suited to different terrains. In this part of our study, we concluded that the prehistoric artists were using a memory of the physical actions they gained during skiing in various types of landscape; we drew on our model of the perception of vision so we could understand how they ‘translated’ the acts of skiing into their visual reconstruction of the landscape.

Further post-fieldwork analysis undertaken in England using the preservation-by-record archive is investigating the distances between individual motifs to assess their clustering and associations at Zalavruga in Russia and comparing them to data from Nämforsen in Sweden (Sapwell 2013). This in turn creates the basis to build interpretations of particular rock-art images and the role they played in being the signifiers of communal cohesion versus more individualistic approaches as conveyed visual narrative.

At present we are working on the preparation of a monograph on the White Sea rock-art along with an interactive webpage that will provide free and open access to the carvings and our interpretations as a part of the preservation by record archives.

WHITE SEA ROCK-ART AS CONTEMPORARY HERITAGE

The primary objective of the Cambridge team was carrying out fieldwork to provide preservation by record of the largest of the White Sea rock-art sites and full recording of the carvings located at other sites. Our research efforts

contributed directly to raising the profile of the importance of the carvings as local and national heritage. Several interviews were given to local newspapers, and the numerous lectures and talks were given to visiting tourists. In addition, our presence on the sites year after year was used by the local museum and tourist agencies in stressing the international significance of the rock-art in this region. The Cambridge team was also part of Russian and Norwegian work geared towards the 'preservation *in situ*' of the Zalavruga site. Our research and this collaborative work were undertaken alongside making the White Sea rock-art accessible as a tourist destination following the collapse of the Soviet Union.

Since the initial turbulence of the post-Perestroika period, both individual and group tourism has started to flourish in Russia because earlier restrictions on travel were lifted. Tourism has become an important part of the local economy: the number of tourists has increased from a few dozen to several hundred a week during the summer season. For the first time since the Bolshevik Revolution, the secret Solovetsky Islands that feature in Alexander Solzhenitsyn's 1973 account of the Archipelago Gulag have been opened to visitors and worshipers as an Orthodox Christian monastery and museum of Soviet oppression. Thousands more people are now using the Belomorsko-Baltiyskiy Kanal linking the Baltic with the White Sea, built by forced labour during the Stalinist era to encourage movement north from St. Petersburg via Karelia to the White Sea. Russian cruise ships disembark tourists for short visits to see the rock-art, while individuals and groups travelling by land stop to see the carvings. Both groups have created the need for guides to provide information and coordinate visits. The local tour agencies and the local museum have become expert in supplying guides for the diverse groups visiting Zalavruga.

The local population also takes part in meeting this demand, and since 2007 local schoolchildren (visited daily by their parents) have established a camp at the rock-art site supplying *ad hoc* on-the-spot guiding services while also making and selling rubbings of their favourite images. Most importantly of all, this camp ensures a constant presence that is vital in preventing vandalism at the site, for example by stopping visitors from lighting bonfires on the rock surfaces. Prior to this, events leading to the damage of the site were, in my opinion, inevitable, since the carved rocks were not marked and visitors were able to have their picnics or barbeques near the carvings to celebrate their visit and the glory of the place. What these visitors did not know was that the majority of carvings were poorly preserved and almost invisible; we now know that almost all areas of exposed rock were carved. Norwegian government funding was essential in creating walkways and viewing platforms that have effectively focused the visitors on particular walking routes around the rock-art, as well as allowing tourists to appreciate the full extent of the site. To build these facilities, local carpenters were employed in 2009, and as a result, bonds of responsibility and pride in the site have been created: one of the carpenters now spends his free days looking after the site. A year later, a local artist used the remains of the timber to build a souvenir stand.



Figure 8.4 Zalavruga site, walking platforms.

He now lives here and provides continuous protection for the site during the tourist season (Figure 8.4). In such ways, the Zalavruga site, with its exceptional complex of rock-art depictions spanning the period 4495 cal BC to 2080 cal BC (5625 to 4000 BP), has been established as a place where preservation *in situ* has been adopted as an organic rather than as an imposed way of managing the site. These new developments in ‘preservation *in situ*’ have in large measure been facilitated by the research which underpinned the new ‘preservation by record’ central to the White Sea Rock Art Project.

Also of interest are the ways in which this local heritage site is becoming a focus for the process of democratization, where local interest groups and individuals become active in acts of rock-art preservation and in which the initiatives come from the bottom up, from the local community, rather than top down from the government or Party as in the previous century.

FUTURE CHALLENGES

The twin concepts of ‘preservation by record’ and ‘preservation *in situ*’ are well exemplified in *Planning Policy Guidance 16: Archaeology and Planning* (DoE 1990), through which they were deployed to create a framework for preservation and documentation of the English and Welsh heritage. This chapter has shown that these concepts can be used in other parts of the world as a successful extension of a pragmatic approach to caring for archaeological heritage. The future challenges for the Cambridge team in this context are,

first, to use the ‘preservation by record’ archive to create new interpretations and understandings of White Sea rock-art; second is to make these accessible at the Zalavruga site itself for the benefit of tourists and the local community, which has found a new engagement with preserving the rock-art itself.

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9 Aspect and Rock-Art Conservation

Preliminary Meteorological Data Regarding the Côa Valley, Portugal, Open-Air Rock-Art Complex

António Pedro Batarda Fernandes

INTRODUCTION

This chapter presents preliminary data on patterns of microclimate in relation to the famous panels of late Pleistocene rock-art now preserved within the Côa Valley Archaeological Park, Portugal. The climatic data were obtained from four weather stations established within the Park as part of a programme of postgraduate research under the supervision of Professor Timothy Darvill, focused on the creation of a conservation urgency intervention scale (Fernandes 2014). This work dealt with the identification and utilization of key variables to assess the condition of outcrops carrying panels of rock-art in the Côa Valley. The overarching goal of research was to find ways of better informing, managing, and, more importantly, prioritizing future conservation interventions. Baptista and Fernandes (2007) summarize the discovery and character of the Côa Valley rock-art, while Fernandes (2007, 2008) provides a detailed description of the conservation issues at the Côa and the actions pursued to date.

In spite of the benign dry and warm weather conditions (coupled with low human interference resulting from the chronic economic underdevelopment of the region) that allowed the long-term survival of the Côa Valley rock-art over a period of more than 20,000 years, evidence of incomplete motifs that can be attributed to fracturing of the host rock is relatively common and constitutes a clear indication of the relentless impact of weathering processes. Climate patterns are one of the most decisive factors in such processes. More than 1,000 outcrops carrying rock-art have been identified in the Côa Valley with panels present on a range of differently oriented slopes (see Figures 9.1 and 9.2). For this reason, analysis of microclimates within the Côa Valley was instrumental in ascertaining whether aspect differently determines weathering rates.

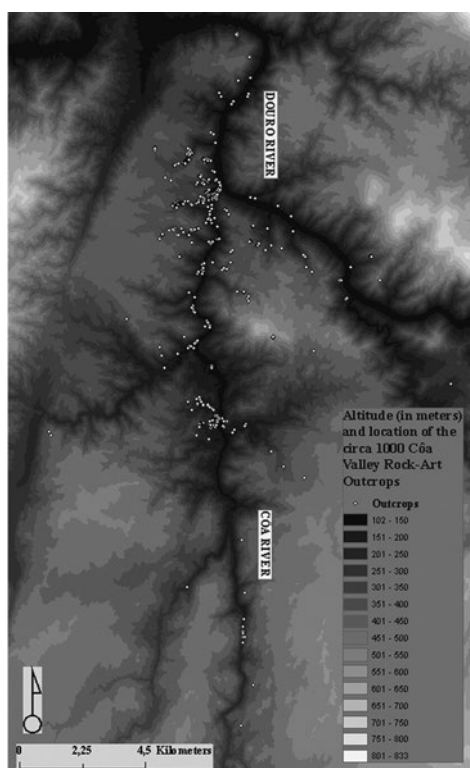


Figure 9.1 Location and altitude of the Côa Valley rock-art outcrops.



Figure 9.2 Two-headed horse motif in Fariseu Rock 1, a technique used by Palaeolithic artists in the Côa to portray animal motion.

ASPECT AND WEATHERING

In geomorphology, the term ‘aspect’ is used to signify the cardinal orientation of a slope or any other element in the landscape such as an outcrop or boulder face (see Figure 9.3 for aspect characterization in the study area). For archaeological conservation, the ways in which aspect may influence the weathering dynamics of stone are determined by complex and poorly understood interconnected processes. These include rock expansion and retraction cycles, solar exposure, biological weathering, and low-temperature weathering mechanisms or aeolian erosion. For instance, as solar exposure determines temperature and moisture in any exposed surface, rock expansion and retraction cycles (which play a major role in weathering phenomena occurring on rock surfaces) will differ according to aspect, which in turn influences the degree of weathering experienced by particular panels or outcrops (Weiss et al. 2004). Díez Herrero and colleagues investigated



Figure 9.3 Aspect in the area of study. Map produced in the ArcView 9 suite using a 10 m resolution Digital Elevation Model (DEM) supplied by Instituto Geográfico Português (www.igeo.pt).

how solar exposure affects the conservation of painted rock-art and of its rocky support (Díez Herrero et al. 2006). They concluded that sandstones and siltstones carrying rock-art panels weathered at different rates according to their solar orientation. It was suggested that rock faces exposed to the southeast weather at a slower pace than those orientated to the west, a fact the authors connected with the different times of the day at which these surfaces received sunlight (Díez Herrero et al. 2006, 1005).

Aspect also determines the amount of solar radiation reaching vegetation. In turn, this will determine not only vegetation growth but also existing species in differently facing slopes (Bennie et al. 2008). For instance, mosses, in sunny temperate northern hemisphere climates, tend to grow on the north side of rock outcrops and boulders (or trees) since these organisms require a moist and shaded environment to live in (Porley and Hodgetts 2005, 80–1). Thus, north-facing rock-art panels will be more prone to the detrimental effects of moss colonization; even if these organisms only impact the host rock by weakening already frail rock surfaces, the presence of such plants always prompts biochemical weathering processes (Altieri and Ricci 1997; Bland and Rolls 1998, 159–61). Conversely, other species demand sunlight to develop (including many shrubs, trees, and some lichens) and these will be more profuse and reach larger dimensions on south-facing slopes and surfaces (Bennie et al. 2008, 48).

Case studies from around the world serve to emphasize the point. Hall and colleagues concluded that there are noticeable dissimilarities in the biological weathering of differently oriented granite boulders in the Kunlun Mountains, China (Hall et al. 2005). Working on the Drakensberg mountain range in South Africa, Grab (2007) discovered that there was a marked difference in surface temperature readings and those taken at a depth of 0.1 m between rock faces sampled on south- as against north-facing slopes. The author suggested that weathering processes are thus controlled, to great extent, by the thermal characteristics of the rock itself. By contrast, Paradise (2002) investigated the connection between weathering and aspect at the ancient sandstone quarries around Petra, Jordan. Here there was greater weathering of southern faces, which Paradise ascribed to daily heating and cooling cycles. He also noted that high weathering rates are better explained by external factors (available humidity and insolation) than by intrinsic characteristics of the rock itself such as its density. Finally, there is an interesting example from a fluvial island in the Columbia River in Oregon, United States, where the scarcity of rock-art panels with a north-facing aspect is linked to ‘enhanced’ weathering by lichen colonization and freeze-thaw cycles (Loubser et al. 2000).

CLIMATE IN THE LOWER CÔA VALLEY¹

The *Iberian Climate Atlas*, based on the Köppen Climate Classification system, categorizes the area of the Iberian Peninsula where the Park is located as “temperate with dry or hot summer” (AEMET and IM 2011, 15–18).

This type of climate, which extends over much of Iberia with a predominance in its southern half, is characterized by an average temperature for the coldest month of between 0° C and 18° C and for the hottest month of higher than 22° C. The area has low precipitation, on average less than 400 mm per year.

MICROCLIMATIC DATA

Microclimatic monitoring of rock-art sites can provide useful data on the connection between climate and observed weathering phenomena. In accordance with what has been done in rock-art sites elsewhere (e.g. Hoerle and Salomon 2004), the Park installed, in January 2004, a weather station at the Penascosa rock-art site, henceforth referred to as PEN1, with a west-facing aspect.² Later, in March 2010, three further stations were added on north-facing (Vale de José Esteves station: VJE), east-facing (Canada do Inferno station: CINF), and south-facing (Penascosa 2 station: PEN2) slopes in order to try to characterize microclimatic variations connected with different aspects.³

Air Temperature

Monthly average temperature values for 2011 were consistently higher (by an excess of 1° C), during the hotter months of the year, in CINF, the station installed in the east-facing slope of Canada do Inferno. The south-facing station, PEN2, presents the second-highest average temperature values during summer months. Moreover, when comparing CINF and PEN2 values with monthly average temperature recorded by the west-facing PEN1 in the period 2004 to 2008, summer temperatures present a similar curve in spite of the fact that the new stations recorded slightly higher values than PEN1. Indeed, this signifies that 2011 was a hotter year than average for the region as recorded by PEN1 in the period 2004 through 2008. A comparison of spring values further confirms this assumption. Table 9.1 summarizes data

Table 9.1 Average values for 2004 through 2008 in PEN1 and 2011 total values for the remaining stations.

	CINF	PEN2	VJE	PEN1 (Average 2004/08)
Nr. of days with temperature $\geq 25^{\circ}$ C	194	199	162	161.8
Nr. of days with temperature $\leq 0^{\circ}$ C	27	31	23	50
Total precipitation (in mm.)	326.6	333.2	370.8	386.24
Nr. of rain days	96	96	96	82.8

regarding days with temperature $\geq 25^{\circ}\text{C}$ and $\leq 0^{\circ}\text{C}$ recorded by all four stations. Regarding days with temperature $\leq 0^{\circ}$, quite surprisingly, considering the north-facing aspect of the slope where it stands, VJE presents the lowest figure (but do see note 3). Values for days with temperature $\geq 25^{\circ}\text{C}$ are again higher for PEN2 and CINF, with VJE presenting the lowest value, which is also the closest to the average recorded by PEN1 in the period 2004 through 2008. Diurnal temperature variation (DTV) recorded by all the stations generally follows what would be expected in the geographic context of the Côa Valley, with values reaching circa 30°C in the warmest days and about half that value in the coldest. In fact, inland dry areas are more prone to experience higher DTVs, in the order of 30°C , than coastal humid zones that typically experience amplitudes of half that value or less (Ahrens 2007, 63). It is noteworthy to mention that VJE, the north-facing station, has systematically recorded the lowest values and that PEN1, the west-facing station, reached the highest.

Precipitation

Total precipitation values gathered by new stations (CINF, PEN2, and VJE) show that VJE reached the highest value, which is also the closest to the average recorded by PEN1 for the 2004 to 2008 period (Table 9.1). Rain-day values recorded by the new stations are higher than the average value measured by PEN1 in the 2004 to 2008 period (Table 9.1). On the other hand, daily and hourly highest recorded precipitation values are again fairly similar in all three new stations and indeed PEN1, considering only hourly values (Fernandes 2014, 65–9). As for daily records, PEN1 recorded a higher value than the other stations. Such a discrepancy is expectable since the PEN1 data-series comprises a longer period of time, thus increasing the probability of recording more extreme values. Moreover, the highest recorded daily value by regional weather stations for the period of 1961 to 1990 was of 124.8 mm in Moimenta da Beira (IM 2010), well below the probable maximum daily precipitation values set for the region of 297–388 mm (Brandão et al. 2001, 16–7). The same publication indicates that areas in Portugal where extreme rainfall events are more likely to occur do not coincide with the Park's location.

Rock-Face Temperature

Temperature sensors installed in rock faces and connected to the Park's weather stations are located on all major aspect classes (with the exception of the western aspect): CINF-B (east), PEN2-B (south), and VJE-B (north).⁴ Tables 9.2 and 9.3 summarize recorded temperature data for 2011 by CINF-B and PEN2-B.

For comparison and verification purposes and also to partially counter the noted limitations regarding VJE-B, data gathered during 2011 by temperature sensors installed by Joana Marques (TMPJM)⁵ in outcrop faces located in all major aspect classes are also discussed. Contrary to what occurs with the Park's sensors, the south-facing sensor recorded the highest

Table 9.2 Temperature values recorded by CINF-B in 2011.

	CINF-B (° C)		
	Highest	Average	Lowest
January	26.6°	9.3°	-3.1°
February	34.7°	11.5°	-1.8°
March	40.1°	15.2°	1.8°
April	46.5°	23.3°	9.4°
May	52.3°	27.4°	12.3°
June	57.1°	31°	13.2°
July	55.9°	33.1°	15.8°
August	58.3°	32.5°	14.7°
September	54.3°	29.1°	13.3°
October	50.4°	23.6°	6.4°
November	35.4°	13.4°	4.8°
December	33°	9.2°	-1.8°
Highest/Lowest	58.3°	—	-3.1°
Year Average	45.3°	21.5°	7°
Nr. of days with temperature $\leq 0^{\circ}$ C		13	
Nr. of days with temperature $\geq 25^{\circ}$ C		295	

Table 9.3 Temperature values recorded by PEN2-B in 2011.

	PEN2-B (° C)		
	Highest	Average	Lowest
January	22.2°	8.2°	-3°
February	29.3°	9.2°	-1.9°
March	34.2°	12.9°	0.9°
April	45.2°	20.3°	9.2°
May	50.1°	25°	10.9°
June	54.6°	36°	22.9°
July	55.3°	31.8°	15.8°
August	57.1°	31.1°	14.2°
September	50.9°	26.9°	12.1°
October	46.8°	20.7°	6.1°
November	27.2°	12.1°	5°
December	18.3°	7.5°	-1.5°
Highest/Lowest	57.1°	—	-3°
Year Average	40.9°	20.1°	7.5°
Nr. of days with temperature $\leq 0^{\circ}$ C		14	
Nr. of days with temperature $\geq 25^{\circ}$ C		235	

monthly average temperature, immediately followed by the east-facing one. Only the north-facing sensor has reached lower values than the air temperature measured by the Park's stations.

Rock-Face Wetness

Leaf wetness (LW) sensors⁶ have been installed in CINF, PEN2,⁷ and VJE. CINF-LW attained the highest values, being only, marginally, surpassed by VJE-LW in August 2010. Recorded values for PEN2-LW until August 2010 hint that in the remainder of the analysed period, this sensor would have, more or less consistently, attained the lowest values. Individual days,⁸ in which no precipitation occurred, were also analysed in detail. Data from the 14 March 2010 shows that CINF-LW attained the highest values (being completely humid during the greater part of the evening). Nevertheless, while CINF-LW underwent a rapid increase until reaching the upper limit, it then witnessed a swift decline; VJE-LW suffered several relatively abrupt drops and increases, namely in the period 01:30 to 03:00 GMT (Fernandes 2014, 107–8).

Solar Radiation

VJE, the north-facing station, recorded the highest amount of solar radiation in 2011 (see Figure 9.4 and Table 9.4). Even considering and discounting expectable fluctuations caused by changes in cloud cover that, at any particular moment, may affect a station, VJE consistently and throughout four days analysed in detail recorded the highest values (Fernandes 2014, 108–10; see also note 3). It is therefore likely that daily solar radiation values at any given location are subject to variations that are random in origin—that is to say, those connected with shifting sky conditions. Hence, only the total yearly amount received by a given station should be considered when trying to establish if distinct aspects imply different amplitudes in the solar radiation-influenced weathering mechanisms affecting slopes and outcrops.

Wind Direction and Speed

The 2011 wind direction regimes differ widely among the three stations. Moreover, they do not concur with the established prevailing wind direction for Portugal, which is from the northwest (Azevedo 1990, 14–15). Evidently, one year recording, especially when comparing with a data-series spanning several decades, does not allow clear-cut conclusions. Nevertheless, in CINF and PEN2, during 2011, wind predominantly blew from directions that are perpendicular to the orientation of the slope itself (east and west in CINF and south and north in PEN2). VJE, probably due to the noted altitude issues of its location, presents a more varied wind direction regime, being that northern directions account only for about 8 per cent of recorded wind. These differences probably find a partial explanation in specific micro-topographical factors, namely, in the case of PEN2 and VJE, the precise configuration of the river valleys. It is believed that the only noteworthy conclusion is that,

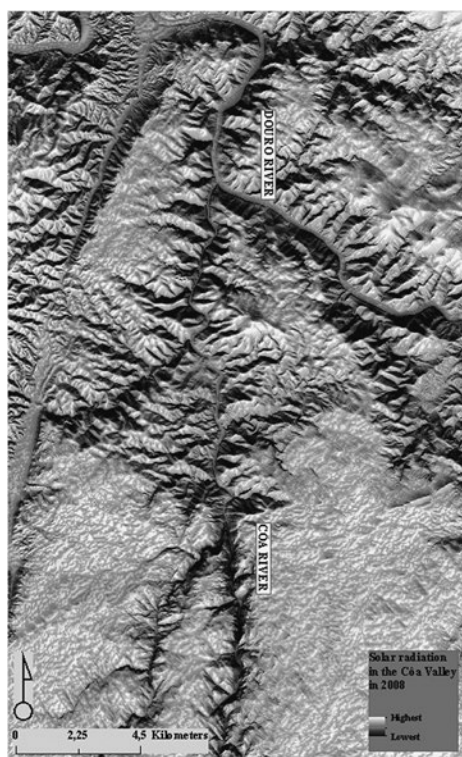


Figure 9.4 Solar radiation in the area of study. Map produced in ArcView 9 using a 10 m resolution DEM supplied by Instituto Geográfico Português (IGEO—www.igeo.pt). It depicts average solar radiation in 2008.

Table 9.4 Solar radiation values for CINF, PEN2, and VJE for 2011.

Total (in Kcal/cm ²)	CINF	PEN2	VJE
January	3.74828958	4.10688279	4.01135688
February	6.44897763	6.78567366	6.89401953
March	9.32514426	9.55304271	10.01008719
April	14.43888864	14.4635391	15.99191064
May	18.23170392	18.41109732	19.79836326
June	19.58627466	20.75596695	22.13961921
July	20.00576268	21.89556675	22.86155934
August	16.86424869	16.74942831	18.63994221
September	13.34678292	13.09524498	14.37003513
October	9.71970219	10.17620892	7.50006378
November	3.89358963	4.32572553	4.27205808
December	3.56511042	4.15340892	3.68629776
Year	139.1744752	144.4717859	150.175313

during 2011, calm percentages were much lower for VJE than for PEN2 and especially CINF. The different altitude of VJE may explain the discrepancy. Moreover, differences in wind-speed regimes may also be attributable to the higher elevation at which VJE is situated (Fernandes 2014, 69–70).

Daily and Hourly Temperature Variation

If data presented previously are important for microclimatic characterization, analysis of daily and hourly temperature variation is arguably more decisive to establish what impact these variables may have on the weathering of differently facing outcrops. Hence, a few days and, within these, hours were selected for detailed analysis. The 13 March 2010 has been chosen since all of the Park's three rock-face temperature sensors were working at that time. Moreover, it was a winter day with air temperatures reaching values below 0° C. On that day, while air temperatures plunged below 0° C (although barely in the case of VJE), rock-face temperatures did not exceed such a threshold. Moreover, while VJE temperature values (both VJE and VJE-B) remained quite steady⁹ and were similar to air values recorded by the other stations, PEN2-B and specially CINF-B, records rocketed during the afternoon to reach, in the case of the last-mentioned, 31.2° C; this gives the remarkable DTV value of precisely 30° C. Reasonably high variations in rock-face temperature are also noteworthy. For instance, in the period from 11:00 to 11:30 GMT, PEN2-B values declined precisely 3° C, while from 11:00 to 11:15 GMT the drop was approximately half that value (Fernandes 2014, 102–7).

The hottest day in 2011 (26 June) displays some striking dissimilarities and similarities when comparing with colder days. For instance, while DTV values for rock-face temperatures are considerably higher (almost 35° C for CINF-B), air temperature shows less variation, especially around the hottest period of the day. Moreover, rapid changes in rock temperature show similar amplitudes to those of cold days (Fernandes 2014, 102–7).

Two days were chosen to set the measuring interval at one minute, one of them being the 8 of February 2012, in which air temperatures reached values below 0° C. A fact that was already hinted at by readings at 15-minute intervals becomes clearer: besides reaching lower temperatures, PEN2-B undergoes less significant temperature changes than CINF-B. In the analysed period (30 minutes), PEN2-B suffered a circa 2° C amplitude variation, while CINF-B reached circa 4° C. The 6 July 2012 was also recorded at one-minute intervals by both the Park's B sensors in operation and TMPJM sensors. Since it was a cloudless day, sky conditions cannot account for the discrepancies observed.¹⁰ While values from the Park's B sensors generally follow the already identified trend, in spite of the fact PEN2-B (the south-facing sensor) presents higher values than CINF-B, TMPJM's display intriguing values. First, VC5-B (the east-facing sensor) shows an increase about an hour after sunrise (which occurred at 06:03 GMT)¹¹ similar to those presented by the Park's B sensors, albeit not reaching such elevated temperature values.

Nevertheless, the increase began about two hours earlier than in CINF-B (also east facing), a fact that has to be connected with the higher altitude of VC5-B. This suggests that the sun started to shine upon the location of the sensor about an hour after sunrise, contrary to the roughly three hours it took before reaching CINF-B. The discrepancies between the values recorded by the east-facing VC5-B and the south-facing VJERTS-B sensors are, however, harder to explain, especially considering the PEN2-B (south-facing) temperature increase curve. It should be also highlighted that only at VJERTS-B did the temperature not exceed the highest measured air temperature of the day. If the temperature curves for CA1-B (west) and VJE16-B (north) are within expected values, the lack of significant correspondence throughout the day with the values at VJERTS-B is quite inexplicable without considering the (apparently decisive) role of micro-topographic issues (Fernandes 2012, 102–7).

DISCUSSION: ASPECT AND ROCK-ART CONSERVATION

The information presented regarding daily and hourly temperature variations does not allow definite conclusions to be drawn about the correlation between aspect and rock-art conservation. However, the data obtained by the Park's weather stations suggest that eastern aspects suffer the highest daily temperature ranges, although this does not follow through into extremes in the rate of temperature change per minute (1°C was the highest value recorded by rock face sensors). In fact, rates of temperature change per minute recorded at the C  a are not as extreme as those described by Meiklejohn and colleagues, who mention values of more than 2°C per minute, which “may be sufficient to induce cracks along grain boundaries” (Meiklejohn et al. 2009, 976) occurring at their test site.

All the days analysed in greater detail suggest that rates of temperature change per minute are similar in all considered aspects. DTV values follow a slightly different pattern, with the southern aspect presenting almost all of the highest values, closely followed by east. However, available data from TMPJM sensors suggest that southern aspects (followed by eastern, western, and northern) suffer greater DTV values and also rates of temperature change per minute. These findings are confirmed by the number of days measured by the Park's stations in 2011, with average air temperature of $\geq 25^{\circ}\text{C}$, with the south-facing station at the top of the list, followed by the east- and finally by the north-facing stations.

Available wetness readings, on the other hand, suggest that eastern faces suffer the highest dampness levels. Precipitation data suggest that slopes and outcrops possessing a northern aspect are indeed more prone to enhanced weathering and erosion processes prompted by rainfall. In fact, VJE recorded the highest precipitation values by a relatively considerable margin. The southern- and eastern-facing stations present quite similar values. Nevertheless, this can be a punctual yearly fluctuation, as the higher

average 2004 to 2008 values for PEN1 imply. Besides variation between different years, it is very likely that fluctuations among diversely placed stations occur. Precipitation data recorded by the Park's stations in 2010 confirm such an assertion, as VJE did not (barely) reach the highest amount of precipitation (which occurred in PEN2), also being quite higher in PEN2 in September than in the other two stations. Conversely, sudden high precipitation episodes do not offer any conclusive insight regarding different aspects, since 2011 values are fairly homogenous. Moreover, highest precipitation values reached by PEN1 during 2004 to 2008 were relatively low (Fernandes 2014, 65–9).

Data for 2011 place the north-facing station (VJE) as the one receiving the highest amount of solar radiation. This is a perplexing result because not only the specialized literature but also empirical knowledge suggests that, in the Northern Hemisphere, north-facing slopes receive the least amount of solar radiation. Moreover, a DEM-based calculation of total solar radiation in the region during 2008 clearly suggests that north-facing slopes received much lower amounts than slopes with other orientations (see Figure 9.4). The same calculation also provided 2008 solar radiation values for the precise location of several outcrops with rock-art. Not surprisingly, north-facing outcrops present the lowest values.¹² Thus, a higher probability of higher wetness levels occurs on slopes possessing such an aspect; the divergent total results delivered by the Park's stations must be interpreted bearing in mind their different precise locations (see note 3). The same criteria must be applied to the interpretation of information delivered by the detailed analysis of how sky conditions (daily but also hourly) may differ significantly among the different locations of the stations.

Data supplied by the Park's stations are also inconclusive regarding wind direction and speed patterns. The precise location of the stations does not allow relevant inferences on the relationship among wind regimes, different aspects, and erosion. Therefore, it is suggested that aeolian erosion randomly affects differently oriented outcrops, with those located on sheltered slopes and at lower altitudes suffering less erosion. However, to further validate this suggestion, a longer data series would be required.

The most noteworthy conclusion that can be inferred from the analysed data is that, at the level of the rock surface, temperature does not drop below 0° C (the essential condition for low-temperature weathering mechanisms to begin acting) as much as it does when air temperature values are considered. Moreover, TMPJM sensors did not record any value below 0° C during 2011. On the other hand, data pertaining to particular days suggest that PEN2-B (the south-facing sensor) suffers slightly but marginally longer daily periods in which temperatures remain below 0° C. Moreover, while PEN2-B experienced an extra day when temperatures were below 0° C compared to CINF-B (14 against 13), it did not record the lowest temperature and presents a higher yearly lowest average value than CINF-B (7.5° C against 7° C) does (Fernandes 2014, 103). It is therefore suggested that the specific impact that different weather variables have on rock weathering and erosion patterns is likely to

be variable in nature, at least in the short term. For instance, solar radiation greatly determines the occurrence and character of expansion and retraction cycles. It might be suggested that outcrops that receive more solar light (south-facing in the Northern Hemisphere) will be more prone to the detrimental impact of solar radiation than those located on less exposed aspects. Conversely, it is also true that outcrops located in areas more exposed to solar light will 'dry up' faster after a rainfall event. Since water circulation on the slopes is one of the factors that can enhance the risk of rock fall and increase physical weathering, a faster drying up of the slope might reduce such a risk.

Some authors suggest that on north-facing slopes, "less sunlight permits less frequent wetting and drying cycles" than those occurring on south-facing ones (Paradise 2002, 1). If, generally speaking, in the Northern Hemisphere, north-facing slopes are more exposed to moisture-based weathering because of higher humidity, lesser quantities of sunshine dictate that south-facing ones will be more prone to insolation weathering. East- and west-facing slopes will therefore be positioned halfway between these two extremes.

If the present survival of the Côa Valley rock-art complex is considered, it transpires that, since engraved outcrops located in east- and south-facing slopes vastly outnumber those located on the other two aspects considered, moisture-based weathering has a greater impact in differential conservation statistics. Nevertheless, this assumption will only be valid if indeed roughly equal percentages of 'engraversable' outcrops exist in all aspects. In fact this is not the case, since there is an overall prevalence of southeasterly oriented outcrops. Therefore, Aubry and colleagues (2012) suggest that (engraved or not) northwest-facing outcrops have suffered most from physical and biological weathering. Another possible explanation is that, because of regionally specific landscape formation processes, northwest-facing outcrops were not exposed in such great numbers as southeast-facing ones. If this is indeed true, to differentiate the condition of outcrops on the basis of aspect positioning is pointless, since the distribution of engraved outcrops throughout the four categories is much more dependent of the 'real' physical existence of outcrops than of differential conservation issues.

On the other hand, one of the conclusions that can be inferred from the data presented here is that microclimate variables are dependent of the precise location being measured. Micro-topographical features, for instance, vary widely and are dependent on the specific 'architecture' of each slope. Hence, slopes may possess slightly concave recesses that will determine the existence of areas remaining in the shade for longer periods than surrounding areas. Vegetation cover (mainly from mature bushes and trees) will also influence the extent of shaded areas in a slope. Shade, of course, will have an obvious influence on temperature or solar radiation measurements at ground level. Moreover, besides the altitude of a specific location, contour lines may also affect microclimate variations, as sunlight will differently affect exposed ground according to the steepness or otherwise of the slope.

Sky conditions are yet another factor that might influence the amount of sunlight that different slopes will receive during a given period. The only way to accurately measure weather variables taking into account these micro-topographical constraints would be to install weather stations on all rock-art outcrops in the Côa Valley. Obviously, that would be impossible. Even the halfway solution of carefully choosing a more reduced but still relatively large number of outcrops would be hindered by the same land ownership issues that prevented a better positioning for VJE (see note 3).

CONCLUSION

The weather data analysed here are inconclusive by being insufficient to establish a relationship between aspect and the differential weathering of rock outcrops carrying rock-art in the Côa. Weather variables are complex to interpret, and a time-limited study such as this does not allow the recognition of distinctive trends clearly enough to draw strong conclusions. When longer data series have been collected by the stations that exist in the Park, it may be possible to identify trends that can help in determining aspect-based risks.

Nevertheless, some clues emerge, and it is possible to cross-tabulate the conservation intervention scale with the aspect of all 40 outcrops contained in the sample studied as part of the wider research (Fernandes 2014). The most significant inference that can be drawn is from the values attained by south-facing outcrops. Of the 12 (thus 30 per cent of the total sample) south-facing outcrops, only two are positioned in the top half of the list of sites at greatest risk, albeit quite modestly at 17th and 19th. Hence, at least in the case of the sample considered, it can be said that south-facing outcrops are in a less worrisome overall condition than those on other aspects. This suggests the preferential conservation of panels with such an orientation and that moisture-based weathering dynamics may have a more harmful role than those motivated by solar radiation and insolation. It can be also suggested, since most schist panels (engraved or not) in the Côa Valley have a southerly aspect, that it can be expected that these panels were engraved in largest numbers. Hence, the statistical probability of a larger portion of south-facing engraved panels surviving until the present in better conservation conditions will be higher.

NOTES

1. Due to space constraints, graphs regarding the recorded and discussed weather variables are not presented on this occasion. However, these are fully available in Fernandes 2014.

2. A WatchDog Model 700, complying with the norms established by the World Meteorological Organization for this kind of equipment (WMO 1996), installed at an altitude of 130 meters above sea level. Data were recorded at intervals of 15 minutes from its launch until September 2006 and of 30 minutes from then on. Unfortunately, since PEN1 has been malfunctioning since the end of 2008, data regarding the west-facing slope where this station is localized will not be available for direct comparison with CINF, PEN2, and VJE. Moreover, if PEN1 was fitted with two rock temperature sensors, these have been installed at a depth of 60 cm inside two distinct outcrops. Furthermore, PEN1 does not have leaf wetness and wind speed and direction sensors installed.
3. Three WatchDog Model 2000, complying to the norms established by the World Meteorological Organization for this kind of equipment (WMO 1996), with the exception of wind speed measurement, which is carried out at a height of 1.5 m above the ground instead of the recommended 10 m. In all three new stations, surface temperature and wetness sensors have been installed. VJE was installed at an altitude of 300 m above sea level, while CINF and PEN2 were installed at altitudes of 150 m and 170 m, respectively. Unless stated otherwise, measuring intervals were set at 15 minutes. Unfortunately, some caveats prevented the 'perfect' positioning of VJE, the north-facing station. On the one hand, the stations needed to be installed in properties owned by the Park since no funds were available to buy or rent land for that purpose. On the other, having the stations installed in the rock-art sites owned by the Park, open for public visits and guarded by security personnel, would make it easier to prevent vandalism or even theft of the stations. The choice of site for the north-facing equipment was complicated since no entire slope with that orientation possessing rock-art is located in a property owned by the Park. Hence, the option was to install the north-facing station near the new C  a Museum in terrains owned by the Park. Regrettably, this location results in having the station installed at a somewhat elevated altitude (regarding the overall context of C  a rock-art) and not at the point (the shaded foot of a north-facing slope) where it would have been expectable to gather more 'extreme' climate data.
4. WatchDog External Temperature Sensor 3367 measuring temperature with a resistance-based sensor, possessing a range/resolution of -32°C to 100°C and accuracy of $\pm 0.6^{\circ}\text{C}$. Unless stated otherwise, measuring intervals were set at 15 minutes. Unfortunately, sensor VJE-B was vandalized in June 2010, and it was not possible to replace it. Hence, data from VJE-B are only available from 1 March 2010 until 31 May 2010.
5. These sensors (DS1923 Hygrochron Temperature/Humidity Logger iButton with 8KB Data-Log Memory with an operating range of -20°C to 85°C and 0.5°C or 0.0625°C measuring resolution) were installed in different outcrop faces in the course of the PhD that was concluded recently by biologist Joana Marques on lichen colonization in the area of the Park (Marques 2013). VC1-B had a measuring interval set at 30 minutes, while CA1-B recorded every hour until 11/03/2011 and, from then on, every 30 minutes. Sensors VJERTS-B and VJE16-B had measuring intervals set at 1 hour. The former was launched only in 02/07/2011 and the later on 15/04/2011, while VC1-B and CA1-B recorded the complete year. VC1-B and CA-1-B sensors suffered minor data loss that occurred in three different periods of the year, having the longest a 13-day span. All considered, these losses account for just over 9 per cent of the whole year. Hence, these failures are not believed to greatly affect total values.
6. WatchDog Leaf Wetness Sensor 3666, measuring wetness using a 0 to 15 scale in which 0 corresponds to totally dry and 15 to completely damp.

7. Unfortunately, the sensor installed in PEN2 stopped functioning in August 2010, and it has been impossible to replace it.
8. Of these, the 14 March 2010 provided the most noteworthy data.
9. Indeed, the rock-face sensor even recorded lower values during the afternoon than air temperature sensors due to the positioning of the sensor in a shaded area.
10. At this point, it should be noted that an analysis of the discrepancies between the values provided by TMPJM and the Park's sensors must take into account that TMPJMs do not directly measure surface temperature, diverse measuring resolutions, or altitude dissimilarities, but mostly the fact that the Park's sensors are located in the Côa River valley, more open than the tributary waterline valleys where TMPJM sensors are positioned.
11. Sunrise determined by resorting to www.sunrisesunsetmap.com.
12. Although DEM-based estimates refer to 2008, it is proposed that, discounting minor punctual fluctuations, these are also valid for 2011 regarding aspect-based distribution of solar radiation since the topographical setting of the region has not changed.

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10 Lonely Stones

Preservation of Megalithic Art in the Iberian Peninsula

Fernando Carrera Ramírez

ROCK-ART PRESERVATION POLICIES: LIGHTS AND SHADOWS

Several highly interesting projects on the display and protection of Iberian rock-art have been undertaken in recent years. There is no space here to give an exhaustive account of them, but there are many sites where successful results have been obtained. Nevertheless, there is still a tendency to focus on isolated areas rather than whole landscapes; interventions are usually undertaken to underpin the public display of particular sites, thereby sidelining the preservation of the archaeological heritage as a whole. This way of acting, very popular among politicians, grants a privilege to some unique sites but ignores all the rest, leaving them to inevitable deterioration. This chapter aims to promote a discussion on the preservation of Iberian megalithic art.¹

Fortunately, in Spain (Fernández and Villalón 2009; Querol and Martínez 1996) but also at an international level (ICOMOS 2005), implementing a comprehensive system of cultural heritage management is gaining ground. This perspective considers that heritage assets are not isolated items; rather, they have a lot in common with the environment (whether natural or cultural) of which they are a part. Such a wide point of view favours rock-art, which is characterized precisely by its dispersion in a landscape which used to be prehistoric but which in the modern world is subject to the pressures exerted by human activity. Foz Coa, Portugal, for example, illustrates rather well the way in which a balance has to be struck between proposed new development and the conservation of archaeologically rich landscapes.

In the case of megalithic art, it is important to consider site management and conservation in the context of the landscape as a whole. With this aim in mind, we have worked in a number of sites in the northwest of the Iberian Peninsula. This group has an essential characteristic: the existence of prehistoric art on the inside faces of stones forming the chambers of megalithic monuments. The total number of monuments that have been examined in this study is 92. Of these, 68 are located in the Spanish region of Galicia (only 23 of them still have paintings), 19 in Portugal, and 5 in other Spanish regions (Figure 10.1).

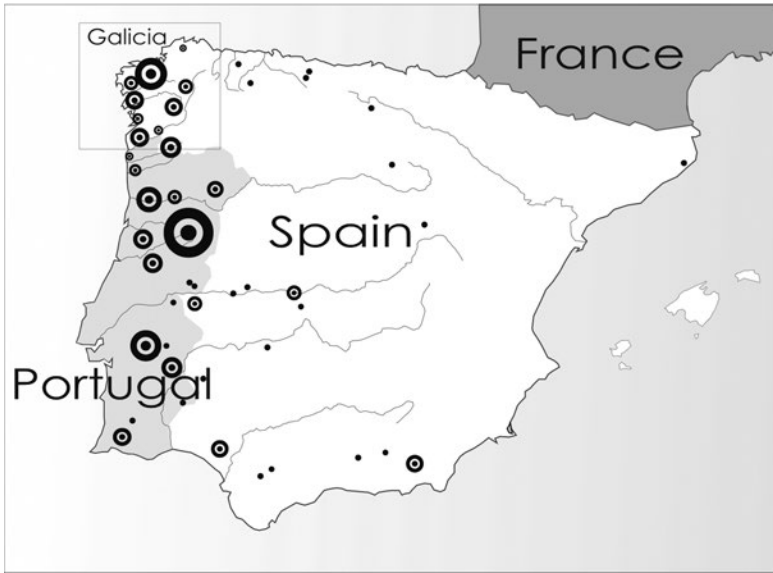
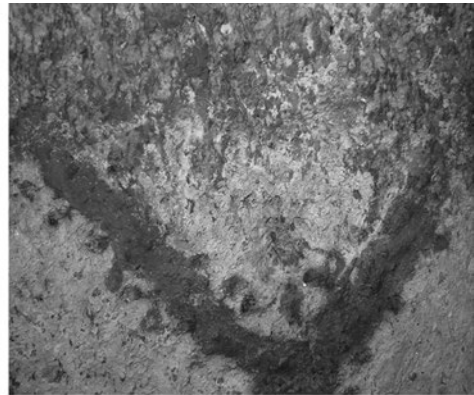


Figure 10.1 Current distribution of sites with megalithic art in the Iberian Peninsula



A



B

Figure 10.2 Decorated stones at dolmens. A: Details of complex painting at Dombate, A Coruña, Spain. B: Painting in Dolmen de Antelas, Viseu, Portugal. (Photographs by Fernando Carrera Ramírez. Copyright reserved.)

Megalithic painting is represented by two types of technique: one that we have named ‘simple’ is based on the direct application of paint to a stone (Figure 10.2A), while a second technique, known as ‘complex’, involves the application of a whitish plaster to the stone with painting on the prepared plastered surface (Figure 10.2B). The palette is limited to white, black, and red: charcoal for black, white clay for white, and coloured earths for red.

Natural deterioration of this painting is very fast: washing away by rainwater or localized climatic changes (e.g. relative humidity) favour its dissolution or its detachment. That is the reason paint is only present in undamaged sites where the rock-art is in some way protected from rain or when it is discovered as a result of recent archaeological excavations. Despite this, about 60 per cent of the registered changes to decorated panels do not originate in natural processes but rather arise directly or indirectly from human actions. Some of those actions (vandalism) are unpredictable, but most of them are measurable and foreseeable and may therefore be controlled.

AN OVERALL MANAGEMENT PLAN

Measures to impede the deterioration of rock-art panels at megalithic tombs will only be effective if they are a part of a series of planned interrelated actions; that is the reason we talk about an overall plan. If we are to ensure preservation, an improvement in the knowledge and the popular appreciation of rock-art is not only a requirement but also its result. As a preliminary step, it is necessary to understand the nature and extent of the resource represented by the archaeological sites in some detail. This will be useful for both designing protective measures and improving promotional messages.

The current management plan for cultural heritage in Spain is based on a federal administration (regions) which regulates, designs, authorizes, and coordinates practically all interventions involving the archaeological heritage. This plan leaves decisions in a very few hands; those decisions can therefore be hasty, subject to a number of different interests, and often ineffective. It should be noted especially that the present system sidelines other administrations, mainly those most directly responsible for the destruction/protection of sites: landowners and the institutions that represent them such as neighbourhood associations. Moreover, throughout Spain there are at least as many diverse, uncoordinated solutions as there are regions.

A fundamental decentralization of the management system is required in order to enable the integration of local and neighbourhood administrations in the design and implementation of the actions for heritage protection and promotion. The ultimate goal is for the main administrations (national, regional, etc.) to become a consultancy body for the coordination of the initiatives promoted by other organizations.

At the same time, it should be pointed out that the promotion of historical knowledge is the core objective of any archaeological activity, and this essential aim has been neglected in recent decades. Indeed, we believe that promotion should come to be considered a priority that, as in the case of management itself, must diversify in order to reach all the spheres of society. Only a clear, ambitious approach in this sense will enable the recognition of the archaeological heritage as something that belongs to the general public.

In this general outline, we consider that the first step is to know the nature and state of preservation of the archaeological sites to be protected. In this

study, we examine only a few megalithic monuments, but all of them should be taken into account. This task is known as quantitative assessment. Once this work has been carried out, we will be in a position to design and schedule actions aimed at:

- Improving legal protection and other executive actions that will create a system for preventing or controlling development and change (indirect protection)
- Implementing a series of actions intended to slow down active degradation processes (direct protection)
- Executing projects aimed at exhibiting a representative group of sites (direct promotion)
- Programming formative activities so as to favour public appreciation (indirect promotion)
- Promoting research in order to broaden and improve the knowledge of the site (qualitative assessment).

CULTURAL HERITAGE ASSESSMENT

When we talk about cultural heritage assessment, we are referring to the possibility of examining the potential that every component of a given set of heritage sites is a cultural resource. Such assessment determines which sites possess more cultural significance than others; assessment is therefore essential when it comes to designing the policies of heritage management, as it facilitates the selection of those resources most appropriate for display and it can facilitate the organization (priorities, intensity) of direct protective actions or research. This approach is widespread at an international level (e.g. Australia ICOMOS 1999; Darvill et al. 1987; de la Torre 2005; Mathers et al. 2005), but it is only now starting to develop in Spain.

In the work plan we suggest, such assessment would be regarded as a component of the quantitative information obtained as a result of conventional cataloguing. However, it has become independent of this work because of the degree of subjectivity involved, something that requires solid theoretical foundations. The assessment criteria adopted (Lipe 1984) do not exclusively depend on scientific parameters, as these also include symbolic, aesthetic, and economic dimensions. All these criteria have enabled an analysis of the following items (rated on a scale of 0–4):

- Economic: importance of the preservation actions needed at the site; importance of display actions (if they are proposed); tourism potential; ownership of existing land and infrastructures (access, etc.)
- Symbolic: importance of scientific knowledge about the site; importance of popular knowledge (immediate social environment); existence of local initiatives aimed at preservation or display and symbolic potential (the site's ability to transport the visitors to a remote past of which they are a part)

Table 10.1 List of sites according to the results of the cultural heritage assessment (only the first ten items of the list have been included). Top score is 4.

Monument	Cultural Heritage Assessment
Dolmen de Dombate (Spain)	3.7
Dolmen de Alberite (Spain)	3.3
Dolmen de Antelas (Portugal)	3.2
Anta dos Juncais (Portugal)	3.2
Forno dos Mouros (Spain)	3.0
Mota Grande (Spain)	3.0
Coto dos Mouros (Spain)	3.0
Arquinha da Moura (Portugal)	3.0
Anta Grande do Zambujeiro (Portugal)	2.9
Dolmen de Axeitos (Spain)	2.8

- Historical/scientific: representativeness and specificity; current historical value (published knowledge); potential historical value (potential to generate knowledge in unexcavated sites); scientific value of preserved megalithic art
- Aesthetic: aesthetic value of preserved megalithic art; monumentality of megalithic architecture; value of the natural environment.

Using these criteria, it has been possible to establish a classification of the most relevant monuments from a cultural heritage point of view (Table 10.1).

THE RISK MAP AS A FRAMEWORK

The Risk Map (Carta del Rischio)² was created by the Istituto Superiore per la Conservazione ed il Restauro in Italy. In essence, it combines a GIS application in which a map is used as a base onto which all kinds of information gradually build up. There is a georeferenced catalogue of monuments, archaeological areas, and other items to be protected. On this basis, many data on alteration risks are gathered and classified into three groups for subsequent analysis:

- Static structural risk: earthquakes, floods, volcanoes, avalanches, landslides, coast phenomena, etc.
- Environmental risk: indexes of erosion, pollution, climate, etc.
- Anthropogenic risk: depopulation, demographic concentration, tourist pressure, thefts, etc.

It is an extraordinarily interesting tool which comprehensively shows the risks to be faced by a specific heritage item depending on the territory in

which it is located ('Pericolosità Territoriale'). In Spain, it has only been applied experimentally in the region of Andalusia, despite much interest as an essential tool for the prevention of alterations elsewhere. At the same time, this general information must be compared with more detailed data about the state of preservation of each particular site or area and the specific risks that threaten its future. In Italian terminology, this is known as 'Vulnerabilità Individuale', which we refer to as a 'diagnosis report'. The existence of these two types of information—territorial risk and individual vulnerability—allows us to adopt a truly efficient policy for the management of heritage sites.

It is obvious that each territory is affected by specific threats and dangers. In the area used for this study, it is important to take into account socio-economic factors related to particular forms of ownership and mixed farming, along with the changes that are currently taking place to these ways of life. At a deeper level, it is also indispensable to consider interactions between people and heritage within the rural environment and also the evolution and impact of changing land use in relation to economic and symbolic values (cf. Darvill 2007). These approaches have never been fully accomplished but, if carried out through study of landscape change, would probably be of great relevance in designing appropriate management actions (e.g. promotional).

CATALOGUE, DIAGNOSIS, VULNERABILITY

Unable to undertake the monumental task of producing a Risk Map, the best that could be achieved was the preparation of a vulnerability analysis by means of a complex cataloguing and diagnosis system.³ Cataloguing is the starting point of any policy aimed at protecting cultural heritage, especially assembling detailed information on the state of preservation, the potential risks, and any corrective measures necessary. This statement is even more valid in the case of such a scattered and unstable heritage as prehistoric rock-art.

In such a context, it is essential to have a report that registers in depth any visible alterations as well as any others that could presumably take place in future. This imperative task will enable the drafting of immediate protective measures. It should be noted that we are referring to actions affecting the archaeological resource as a whole rather than individual sites. These measures usually deal with human actions such as agricultural and forestry activities, communications, and urban planning. With all these factors in mind, a cataloguing and diagnosis data sheet with the following characteristics was established:

- A report permitting an exhaustive registration of routine data such as geographical features, socio-economic matters, archaeological traits, etc.
- A report favouring a parallel diagnosis of the state of preservation of the sites and the future risks that may threaten such preservation

- An appropriate organization of the data adjusting the intensity in the cataloguing work to the different kinds of sites (with or without megalithic art) and to the objectives of the action (protection or display)
- A design which favours rationality and objectivity in the registration process, so that evaluations and decisions could be obtained from the automatic assessment of quantitative data, eliminating, as far as possible, any personal opinions
- It should be noted that our intention is not only to apply all this to the listed monuments but also to extend it to other types of sites and geographical areas.

A diagnosis (or vulnerability) report has been prepared for each of the sites we have visited. During our fieldwork, we indicated on a standardized data sheet any relevant alteration means, agents, and processes for each of the elements at each site: environment, barrow stability/architecture, engravings/stone, painting (Table 10.2). More importantly, we have also indicated whether the process is active as well as the risk of the alteration being reactivated in the future (in four categories: low, medium, high, or imminent risk). One of the most significant conclusions we have drawn from our work is the predominance of the actions related to destructive human activity (60%) over natural deterioration processes.

In the same report, a different corrective action of a specific intensity is suggested to alleviate each of the active alterations. Such corrective actions must be executed with a certain priority: if the risk is high, the action is urgent, while intensity has more to do with the nature of the required action (Table 10.3). This working method enables the criterion for conservation to prevail over any others: actions are always intended to slow down an active alteration. It has also been agreed to include the concept of potential risk; this is when no alteration has been identified yet, but it is nevertheless expected to happen in the future. Finally, we have also taken into consideration another kind of intervention, known as exhibitivive, aimed at improving the appreciation and understanding of the different items of the site, at a

Table 10.2 Extent of alteration and levels of risk in one of the studied sites (Casa dos Mouros). Top score is 4.

Affecting	Deterioration extent	Deterioration risk
Painting	3	2.8
Engravings and stone	2.33	2.33
Stability and architecture	2	2
Barrow	2	2.5
Environment	3	3

Table 10.3 Priority and intensity of the actions suggested for one of the studied sites (Casa dos Mouros). Top score is 4.

Affecting	No. of actions	Priority	Intensity
Painting	5	2.2	2.2
Engravings and stone	3	2.33	1.67
Stability and architecture	1	1	3
Barrow	2	2	2
Environment	1	3	2
Action proposals	No. of actions	Priority	Intensity
Adhesion/consolidation	1	1	1
Reburial	1	3	1
Visitor management	1	3	2
Cleaning	2	2	2.5
Structure	1	1	3
Drainage	1	1	3
Maintenance	1	1	2
Ownership	2	3	2
Promotion	2	3	2

more advanced level than mere preservation actions. The whole list of proposed interventions is as follows:

- Vegetation management
- Adhesion or consolidation actions
- Shelters
- Reburial
- Access intervention
- Signage
- Visitor management
- Structure stabilization
- Drainage
- Climate control
- Maintenance
- Changes in the regime of ownership
- Changes in the environment
- Promotion actions
- Agreements with bodies
- Cleaning

The processing of these data has made it possible to compare the extent of alteration, the level of risk, and the priority and intensity of the suggested

Table 10.4 Comparison of level of alteration, risk, priority, and intensity in the group of the studied Portuguese sites. Top score is 4.

Site	Deterioration extent	Deterioration risk	Priority of actions	Intensity of actions
Antelas	2.0	1.6	1.4	2.2
Arquinha da Moura	2.0	2.0	2.0	1.6
Fojo	3.2	2.7	2.3	2.1
Fontão	2.6	1.6	2.0	1.5
Cunha Baixa	2.1	1.8	1.9	1.9
Juncais	2.8	1.6	2.4	2.1
Picoto do Vasco	1.7	1.5	2.3	1.3
Tanque	2.7	2.4	2.1	2.3
Pedralta	2.2	2.0	1.9	1.6
Cimo de Vila	2.0	2.5	2.2	1.5
Afife	2.4	2.9	2.2	2.0
Barrosa	2.8	1.3	2.6	1.2
Juncal	2.9	3.0	2.8	1.9
Aliviada	3.2	2.8	2.5	1.8
Châ de Arcas	2.3	2.4	2.2	2.2
Portela do Pão	3.0	2.7	2.8	2.2

intervention in each monument (Table 10.4). All this information allows us to know, for instance, that nearly 83 per cent of the alterations remain active and that there is a certain risk of replication. Indeed, we can verify that there is a good number of relevant monuments (Afife, Juncal, Pedra Moura, Pedra Cuberta, etc.) at a medium/high level of risk which urgently need preservation actions. Furthermore, the analysis of the reports shows that all of the elements that are a part of the megalithic monument present similar average levels of risk, even though they are a bit higher in the case of painted monuments (Figure 10.3). Finally, the intensity of the interventions is obviously higher in the case of the actions related to architecture.

AUTOMATIC ACTIONS

The objective of all the previous work was to facilitate, purposely, the planning of the actions over the whole group of studied sites, from urgent interventions to others aimed at the display of sites. However, when it is considered that the system has been designed for a very wide range of heritage

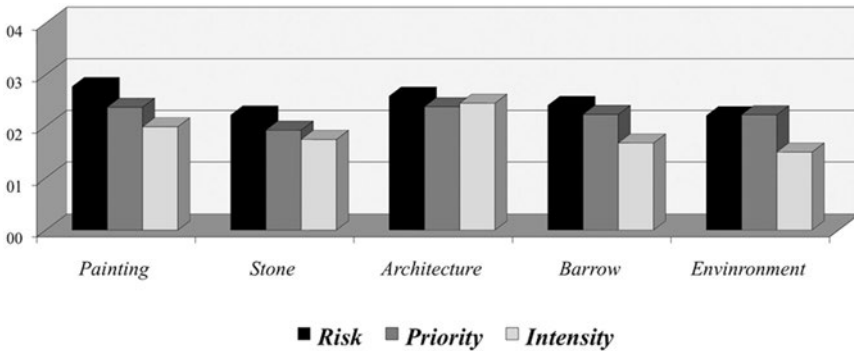


Figure 10.3 Average levels of risk, priority, and intensity in the whole group of studied sites. Top score is 4.

sites (megolithic sites in Galicia alone number several thousand), it is also understood that the proposal is minimising key matters:

- The economic resources allocated to the protection of the cultural heritage are unfortunately limited.
- The economic factor (productivity, profitability) is essential in our current society.
- Deterioration processes are mainly related to human activity.
- Due to all of the above, any actions to be executed must be effective not only from an economic point of view but also with regard to their contribution to the improvement of the public appreciation of cultural heritage.

Considering all this, we decided that it would be necessary to filter the results in order to increase their public effectiveness, without forgetting that there is a series of actions (low in number and intensity) which must not be waived because of their urgent need. It then becomes necessary to divide the group into two parts: on the one hand, those sites that can be exhibited (with a variable intensity) and, on the other hand, those for which we suggest mere preservation actions. In order to do this, the classification established from the analysis of the cultural heritage assessment does not seem to be enough, and we should consider other parameters.

In an attempt to bring assessment closer to social sensibility, two indexes have been created: Action Index (AI)⁴ and Cultural Efficiency Index (CEI).⁵ Both of the indexes emphasize economic factors (Table 10.5) by connecting the cultural heritage assessment to data related to the costs of interventions (intensity, priority, and the number of actions necessary).

The 'best' monuments (whose display is recommended) have been chosen not only because of their high cultural heritage assessment scores but also due to the fact that their alteration risks are low and they only need minimal preservation actions. At the other extreme, certain sites require complex protection

Table 10.5 Cultural heritage assessment, cultural efficiency index, and action index in the group of the studied Portuguese sites.

Site	Cultural Heritage Assessment (CHA)	Action Index (AI)	Cultural Efficiency Index (CEI)
Antelas	3.2	2.7	1.2
Arquinha da Moura	3.0	2.5	1.2
Fojo	2.0	2.0	1.0
Fontão	1.7	2.1	0.8
Cunha Baixa	2.1	1.5	1.4
Juncais	3.2	2.7	1.2
Picoto do Vasco	2.5	0.7	3.6
Tanque	2.4	3.0	0.8
Pedralta	1.5	2.1	0.7
Cimo de Vila	1.2	1.2	1.0
Afife	2.2	3.1	0.7
Barrosa	2.2	1.0	2.2
Juncal	2.1	2.6	0.8
Aliviada	1.2	2.4	0.5
Châ de Arcas	2.2	2.4	0.9
Portela do Pão	2.4	1.4	1.7

actions, and hence their AI decreases. It is essential to remember that in order to calculate this index, actions which are as much for preservation as for display are taken into consideration, even though not all of them will be executed.

DIRECT INTERVENTIONS

From all the data, we have tried to offer a specific scheme of action by suggesting both protection and display actions (Table 10.6). Decisions have been made from the abovementioned indexes by setting the limit between both solutions in a cultural heritage assessment (CHA) greater than 2.5 and a cultural efficiency index (CEI) higher than 1 (top score is always 4): when these two circumstances occur, it is advisable to exhibit the site to the public. The selection of sites to be exhibited has been consciously restricted because of the economic costs of such interventions and the limited resources allocated to archaeological heritage. The main criterion has been the protection of rock-art with the lowest investment possible. Obviously, all this information does not predetermine the future of each site, which will only be exhibited if there is enough interest and finance.

It is important to clarify that when we talk about display, we are not referring to very complex and expensive projects. On the contrary, even in the case of the

Table 10.6 Cultural heritage assessment, cultural efficiency index, and proposal of action for certain monuments in the northwestern area of Galicia.

Monument	Cultural Heritage Assessment CHA	Cultural Efficiency Index CEI	Proposal of action
Pedra da Arca	1.9	3.0	Reburial
Pedra Moura	2.2	1.0	Reburial
Anta de Serramo	1.6	1.6	Reburial
Pedra Vixía	1.3	2.8	Reburial
Casa dos Mouros	2.5	0.9	Minor action
Arca da Piosa	2.5	0.9	Minor action
Parxubeira	2.2	0.8	Minor action
Casota de Berdoias	2.0	2.4	Minor action
Fornela dos Mouros	1.5	2.5	Minor action
Pedra Cuberta	2.7	1.1	Intense action

sites we selected for their display, only the actions that are strictly necessary to ensure the preservation of rock-art or their architecture have been suggested. It should also be noted that all estimations have been carried out considering the current situation, without taking into account any future excavations that might improve the cultural heritage assessment (and thus alter the CEI), as has happened with the most recent excavations. In the same way, the existence of intact archaeological levels adds to the ‘potential’ value which has been considered in the analysis of the cultural heritage assessment (scientific criteria).

Four types of actions relevant to the whole group of sites can be proposed. The complexity of the proposals increases as the cultural heritage assessment and cultural efficiency index rise:

- **Reburial.** This action is carried out over monuments that are not going to be exhibited because their cultural heritage assessment is low. This technique consists of a simple reburial with suitable sediments, whether it be applied to the whole monument or just to its most vulnerable parts such as those with prehistoric art (Figure 10.4A). Actually, these monuments will often remain partially visible, so this proposal does not prevent them from being selected for simpler display actions with broader objectives (cultural routes, for example). This group also comprises some monuments which possess a high cultural value but are to be reburied because of the intensity of the excavation and/or display actions needed. Moreover, the group includes some significant sites which have experienced faint attempts at display but whose poor state of preservation requires an urgent reburial.
- **Display with minor direct action.** This is the group of sites with the lowest cultural assessment within those singled out as appropriate for display. Their state of preservation is very diverse: from cases of acceptable

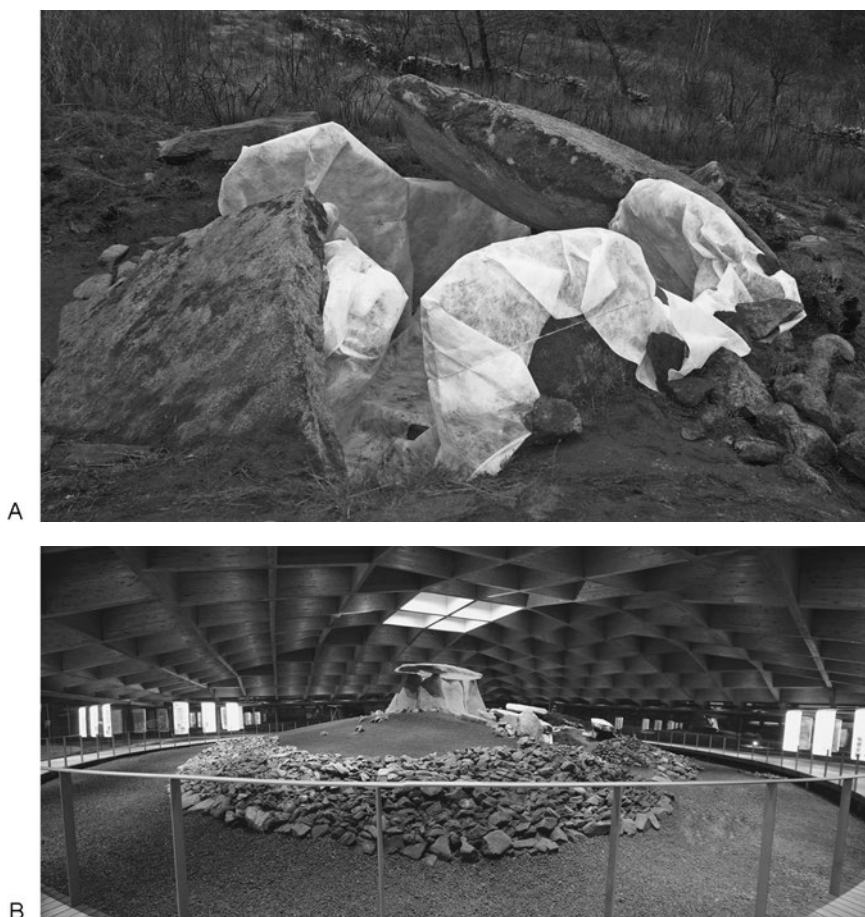


Figure 10.4 Managing Iberian megaliths. A: Process of reburial of a monument with prehistoric paintings at risk. Please notice the geotextile which covers the painted stones. B: Protective cover at Dolmen de Dombate, A Coruña, Spain. (Photographs by Fernando Carrera Ramírez. Copyright reserved.)

states to others of real deterioration where there is no rock-art or even a barrow. In all these cases, the measures we propose are rather simple, and the advisable increase of interventions in the most important cases will be subject to social and administrative interests. Actions are very varied: from tree felling, scrub clearance, path repairs, or simple stabilization to partial reburial of the preserved paintings. In some cases in which the ownership is divided among many people, it is highly recommended that a public administrative body buy the whole site.

- **Display with intense direct action.** Monuments that have enough cultural relevance to recommend their display, even though it is necessary to make some previous works (of variable importance) which really differ depending on each particular case: stabilization of the structure, reburial

of paintings, direct actions over parietal art, and so on. Furthermore, in most cases it is advised to make agreements with local institutions (neighbourhood associations, for instance) in order to ensure appropriate care and maintenance of the sites. Additionally, better signage of the sites as well as some changes in the regime of ownership are often recommended.

- **Singular display actions.** Although with different criteria, this last level represents a very considerable investment in display actions for especially important monuments that have very significant panels of visible rock-art, including, for example, the provision of reconstructions and shelters. The complexity of this kind of project requires decisions beyond the analysis we are developing here, so no sites have been added to the list of those which currently show this type of intervention including Antelas, Dombate, and Juncais (Figure 10.4B).

To the three last groups we must add an action which is common in all three cases: improvements in the signage, which would include certain information which virtually all the visited sites currently lack. This signage could be extended, maybe at a lower level, to the undisplayed monuments, which could nevertheless form another display group related to routes that take advantage of other cultural or natural resources.

INDIRECT ACTIONS

The analysis of the diagnostic data sheets has made it possible to propose a wide number of actions (about 20 per cent of the total) intended to act indirectly over the environment (legal, social) of the monument.

Changes in the Regime of Ownership

In a considerable number of cases (19), we suggested that the only way of eliminating alteration risks was to modify the regime of ownership, which should come to be public. We are talking about monuments of a certain relevance (with an average cultural heritage assessment of 2.3) which are exposed to more or less serious risks because of the fact that the territories where they are located, that is, mainly mixed farms and forestry areas, are used for purposes that are negative for heritage conservation. Consequently, it has been estimated that they should be allocated a moderate economic investment (intensity 1.7) which will ensure the disappearance or reduction of such risk.

Agreements with Bodies

In a noticeable number of cases (34), we consider that risks would be significantly reduced provided that a series of cooperation agreements was reached by those institutions (state, regional) in charge of heritage and those we have named as promoters, that is to say, not only the local administration but also

minor administrative bodies of a diverse legal status. At least in the north-west of the Iberian Peninsula, institutions of this kind have excellent administrative and associative capacities. Therefore, we think it is essential to take advantage of such potential, which, in turn, entails positive symbolic effects.

These institutions are usually the legal owners or, at least, the beneficial owners of the land in which the sites are located. Thus they could take charge of maintenance work, whether it be of great or little complexity. The variety and the objectives of these agreements are very diverse, just like the detected risks themselves. Generally speaking, they are activities of a certain priority (2.3) but with a low intensity (1.2).

At monuments located on private land, the owners themselves could take charge of simple maintenance tasks such as scrub clearance, land delimitation, and the like. This idea would require not only imperative measures (legal, protective rules) but also the opening of channels of cooperation that are unimaginable today. For instance, we understand that the administration could provide those institutions (and maybe individual owners) with clear criteria and work methodologies for conservation works, perhaps by means of prototype projects, which are also claimed to be necessary for certain direct protection tasks (signage, etc.).

Another indispensable requirement for the right execution of all of the aforementioned is the existence of a conveniently published official catalogue and guide whose existence has been officially announced to the land owners.

Cultural Heritage Legislation

Above all, indirect protective actions deal with legal aspects and, in general, with the administrative management of those activities that can affect cultural heritage. Research undertaken to date has singled out some of the weaknesses of legal rules and administrative procedures. In general, it can be said that a certain inefficiency in the legal protection of rock-art has been detected in the two states studied (Spain and Portugal). Even though the legislation is wide, it does not seem to have been able to successfully eliminate humanly prompted deterioration. Therefore, it will be essential to consider the necessity of creating new regulations and, consequently, we will need to allocate enough human and economic resources to the design and control of their effectiveness and the improvement of mechanisms for their application.

It is believed that the main goal of the future development of new rules should be the regulation of the competences that the different administrations and institutions have concerning cultural heritage. They should probably focus on promoting protection rather than imposing sanctions. In fact, instead of rules, we consider it is more important to design specific tools of coordination, guidance, and incentives. This does not mean rejecting a rigorous system of control and inspection; this is especially important in relation to influencing other administrations and influential companies. This implies the active cooperation of the security forces as well as proposals for new

strategies. Within this work plan, we consider that it is of vital importance to encourage and support people and groups such as heritage enthusiasts and local associations who show a degree of interest in the archaeological heritage.

Promotion

The importance of promotion is not restricted to supporting the place of the discipline; it is also important in terms of encouraging positive attitudes towards the sites and monuments that represent the cultural heritage. As explained, it is anthropogenic factors that have caused the greatest damage to the archaeological heritage in general and, more particularly, to the megalithic monuments and associated rock-art. In turn, this can be explained by a general lack of knowledge concerning their value and significance, something which facilitates the destruction of a heritage that should be perceived by society as a worthwhile source of knowledge and entertainment. Only if we are able to change this perception and gain such recognition will we make it possible for the archaeological heritage to escape from its current state of emergency as it is punished by constant, multiple misfortunes, mishaps, and hardship. Consequently, we consider promotion to be the primary task in any programme aimed at the preservation of archaeological heritage.

As well as exhibited sites and archaeological museums, there exists another level which is intended to shape a positive ideology: educational measures. This generic, indirect way of shaping new understanding does not essentially depend on specialist technicians or on the administrations which are close to us. But it does depend upon influencing the established system in terms of curriculum content and design. Analysis of the place of the archaeological heritage in the existing Spanish education system from primary school to university reveals a devastating poverty of content; this balance needs to be redressed.

Education as a means of promotion takes time, and we should not expect a quick fix here. In the long term, the aim is to modify social dynamics and instil a new sense of pride in the heritage. Such actions must take into account not only professional responsibilities but also personal initiatives. Although it is obvious, these thoughts underline the importance of the fact that those promotional measures that we control must be absolutely effective.

CONCLUSION

Space precludes exploring other dimensions of the work in progress, but in conclusion we would like to emphasize the two parallel paths that have been proposed for the preservation of megalithic art in Iberia. The first is direct and focuses on establishing stable infrastructure and the display of materials and structures. The second is indirect and deals with the social responsibilities played out through attention to legislation, ownership, promotion, and education.

ACKNOWLEDGEMENTS

The text of this chapter was translated into English by Macarena Muradás Sanromán.

NOTES

1. This is a brief summary of a much wider and more detailed document (Carrera Ramírez 2011).
2. Much more detailed information is available on the Istituto Superiore per la Conservazione ed il Restauro website: www.cartadelrischio.it/.
3. We have also carried out an ambitious documentation programme which is not present in these pages.
4. The Action Index (AI) of each site is the result obtained after adding the average priority of the preventive actions to the average intensity of the exhibitive actions and dividing the result by the total number of actions.
5. The Cultural Efficiency Index (CEI) is obtained by dividing the Cultural Heritage Assessment (CHA) by the Action Index (AI).

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11 The Conservation of Spanish Levantine Rock-Art in Aragón, Spain, Using 3-D Laser Scanning

Manuel Bea and Jorge Angás

INTRODUCTION

Spanish Levantine rock-art was inscribed on UNESCO's World Heritage List in 1998 because of its unique artistic manifestation (Sanz 2012; Utrilla et al. 2012). It captures vividly and expressively ways of life at a crucial moment in the development of prehistoric societies, the transition from the Mesolithic to the Neolithic.

The distinctive features of this particular style of rock-art are fundamentally defined as follows. They appear in open-air rock shelters, affected by sunlight and other climatic phenomena. Their geographical distribution is reduced to the eastern third of the Iberian Peninsula, mainly in mountain areas and abrupt landscapes. Representations tend towards naturalism, especially depictions of animals. Human figures play a leading role to the extent of showing formal variations in its conception which enable the identification of different phases of development. The themes depicted are varied in nature (economic exploitation, hunting, war, social, and symbolic). There is a typological and functional diversity or territorial hierarchy evident in the shelters themselves (Bea 2012). And, finally, the techniques employed are almost exclusively pictorial.

Despite common characteristics, which define Spanish Levantine rock-art as a distinct artistic style, there are evident variations in terms of themes, sizes, location, territorial distribution, and the morphology of common motifs. These peculiarities can be measured in space and time (Villaverde et al. 2012), making it possible to identify phases of development, internal evolution, and regional or identity markers. The complexity of the rock-art provides much raw material for studying and analysing the graphic manifestations of poignant ideas.

OPEN-AIR ROCK-ART SHELTERS

As highlighted, one of the defining characteristics of Spanish Levantine art is the exclusive use of open-air rock shelters, exposed to natural and humanly prompted causes of deterioration (Figures 11.1). Furthermore, in

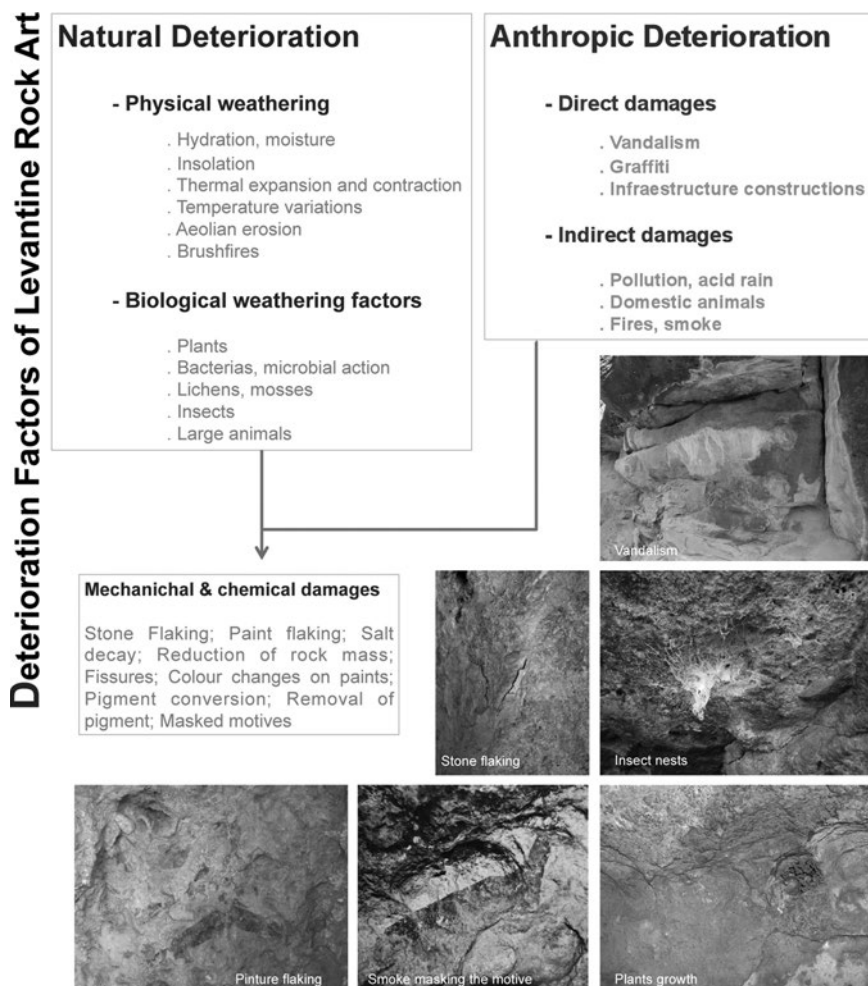


Figure 11.1 Main natural and human deterioration factors affecting Spanish Levantine art.

many cases, paintings are located in areas affected by acute depopulation and impoverishment, factors that add to the physical difficulties of accessing the sites, and goes some way towards explaining their neglect in terms of protection, preventive conservation, and even basic monitoring over the past century or so.

Only in the last few years have any measures been taken in terms of conservation, restoration, and prevention works in open-air shelters in

Aragon. These actions were enforced by regional legislation which secures the protection of rock-art and by the creation of so-called cultural parks.¹ Nevertheless, despite these efforts, there is still no standard protocol of action that would allow an integrated study of rock-art shelters, something which is especially necessary for their conservation and restoration (see Chapter 10).

Our project outlines basic courses of action aimed at effectively implementing the World Heritage Convention for these sites, including the elaboration, approval, and application of a conservation and damage-prevention programme. In this regard, we consider it necessary to first present a proposal that will set a standard protocol of action so critical for the increase in knowledge, protection, and dissemination of these fragile and exceptional sites.

The geometric recording of rock-art stands out among the courses of action we propose. With it, sites are revealed to us from a physical and structural perspective, allowing for a detailed study of previous conditions regarding pigments and decorated surfaces. Periodic geometric recording, following our proposed methodology, will also shed light on the alterations and factors affecting the degradation of the rock-art. The second course of action involves elaborating and executing a programme of works, addressing what measures should be taken and specifying the most adequate conservation methods to apply.

PURPOSE

The singularity of this project is reflected in the combination of new technologies used for recording rock-art, the aim being to establish a lasting model. We would like to offer accessible tools that will enable all users (restorers, curators, researchers, etc.) to interact with gathered information and facilitate any work related with the conservation of rock-art surfaces and motifs.

We are currently compiling a detailed record of the present condition of the sites using 3-D models. It is essential to direct methodologies towards achieving standard procedures in order to develop future quality control and follow-ups. Interoperability and the communication and sharing of information are achieved through standardization, specification, and simplification. This also facilitates the understanding of the process-chain that leads to the final result, making it possible to analyze each of the steps individually.

Fourteen rock-art sites (Table 11.1) were selected for study according to a range of key characteristics: geographical location, orientation, altitude, initial state of conservation, and so on.

Table 11.1 Rock-art sites included in the study and a summary of their technical specifications.

Shelter	Municipality	Province	Phase-shift 3D laser scanner	Structured- light 3D scanner	Year of scanning
La Vacada	Castellote	Teruel	•	—	2007
Plano del Pulido	Caspe	Zaragoza	•	—	2007
Roca dels Moros	Cretas	Teruel	•	—	2008
Els Gascons	Cretas	Teruel	•	—	2008
La Fenellosa	Beceite	Teruel	•	—	2008
El Arquero	Castellote	Teruel	•	•	2011
Ceja de Piezarrodilla	Tormón	Teruel	•	•	2012
Paridera del Tormón	Tormón	Teruel	•	•	2012
Cabras Blancas	Tormón	Teruel	•	•	2012
Cerrada del Tío Jorge	Tormón	Teruel	•	•	2012
Prado de las Olivanas	Albarracín	Teruel	•	•	2012
Prado del Navazo	Albarracín	Teruel	•	•	2012
Arpán	Asque	Huesca	•	•	2012
Chimiachas	Alquézar	Huesca	—	•	2012

METHODOLOGY

The introduction of 3-D laser scanning in the twenty-first century is certainly an advance that complements rather than replaces earlier techniques used in recording the heritage assets (Angás and Leorza 2009; Angás and Serreta 2010). In the context of our study, the field application of 3-D laser technology serves both to integrate other recording techniques (photogrammetry and topography) and as a methodology in itself (Forte 2006; Roecker 2008).

Selecting the best and most appropriate technique to apply at any given rock-shelter depends on a variety of factors and the specific characteristics of the site itself. Currently, the use of 3-D laser scanners is so varied that it becomes necessary to establish what their exact use and aims will be in a particular context. Especially important is adapting to the required scale of work and finding an equilibrium among resolution, precision, time,

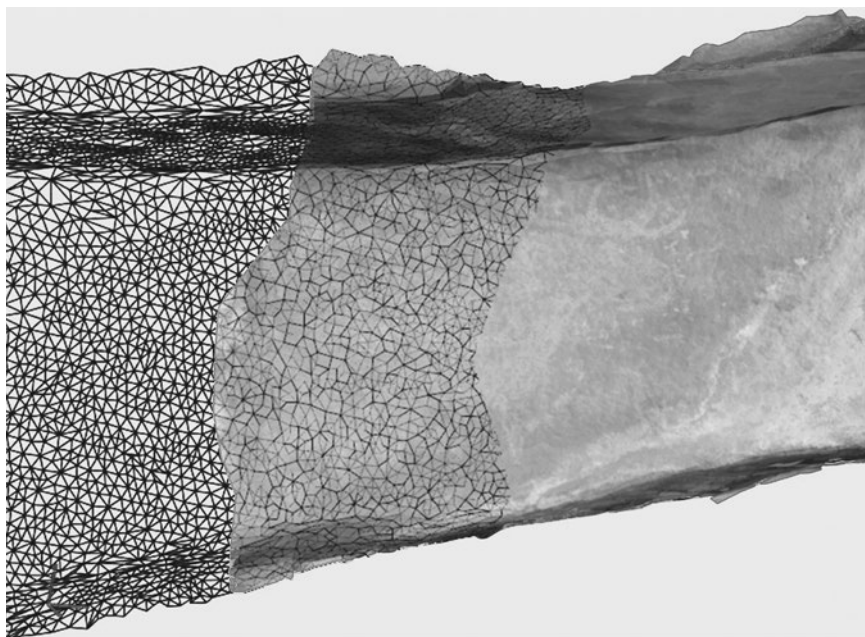
and cost. There are many diverse solutions available, and it is necessary to assess the kind of technology that best fits the needs of a particular project. Amongst the most useful in an archaeological context are aerial (UAV, LIDAR technology), terrestrial (flight time and phase-shift laser scanners), and close-up and dimensional metrology (triangulation laser scanner, structured white light scanner, and laser tracker).

Attention also needs to be paid to the equipment selected for each project. In the case at hand, the following tools were used:

- Phase-shift 3-D laser scanner (Leica HDS 6100), chosen because of its speed and high resolution (500,000 pts/sec) since the distance from the shelter at which it would be used was not going to exceed 20 m.
- Structured-light 3-D scanner (Artec MHT) to capture the rock-art panels in detail. This system offers various advantages that complement the 3-D recording of the shelter. It is very useful to reach areas of shelters which are difficult to access because of its range, light weight, and size. Technically, it offers a spot size resolution of 0.2 mm and a resolution of 0.5 mm. Nevertheless, there are limitations when trying to capture a rock-art panel, in terms of registered distance (70 cm) and maximum surface (5 m²), due to the great amount of information to be recorded (Figure 11.2).
- Georeferencing with GNSS (global navigation satellite systems) and point controlling with a total station. GPS devices have been used to georeference locations, according to permanent networks of active geodesy, in this case circumscribed to the region of Aragon (ARAGEA 2012).

Although the application of a 3-D scanner generates an original texture for the walls of a rock-art shelter, the chromatic RGB value for each point (x,y,z) has to be optimized by adding a layer of textures to the three-dimensional model. These textures are obtained from images taken with a digital reflex camera calibrated with different parfocal lenses of 24 mm and 50 mm. A calibration chart of 24 standard colours (*X-Rite Colour Checker*) is later used for the radiometric adjusting of the images. The point of applying standard colours is precisely to adapt the radiometric adjustment and achieve maximum homogeneity for each of the paintings and the models obtained. Photographs were obtained in RAW format so as to register all the brightness and temperature values without modifications or any kind of image compression.

With these specifications, the complete scanning of shelters was performed with a phase-shift 3-D laser scanner (HDS 6100), obtaining a point-cloud density of 2 mm. For areas requiring more detailed treatment, a structured-light 3-D scanner (Artec MHT) was used. A detailed digital model was perfectly integrated into the network generated by the laser scanner by using common coordinates, previously acquired from the laser measurements of a total station.



A



B

Figure 11.2 Steps for the geometric reconstruction of a rock-art panel. A: From left to right: triangulation of the cloud of points captured on the scanner; assignment of the colour vertex after triangulation; final colour assignment to the 3-D model. B: Final image.

With the resolution used, it is possible to thoroughly record and control diachronic change in surface morphology—for example, the emergence of new fractures and the evolution of existing ones, exfoliation, internal bulging that may not be perceptible to eyesight, or any shifting of the surfaces. The proposed methodology will be again applied to each rock-art site after an agreed interval of time, initially estimated to be around five years. The aim is to monitor the evolution of the site and identify areas with morphological changes through the comparison of the assembled 3-D models.

CONCLUSIONS

The methodology applied at rock-art sites in Aragon was designed to obtain a thorough record of every open-air rock-art shelter. By performing regular scans (every five years), it will be possible to study the evolution of the sites. This can include assessing the impact of new factors leading to weathering and erosion and monitoring the progress of previously recognized patterns. It will also be possible to determine the degree of any damage sustained at each shelter, document rates of weathering and erosion, and assess the urgency of intervention works. We will then be in a position to establish individual norms of conservation not only for each shelter but also for each painted area or panel within a given site.

As discussed in several studies (e.g. Ashley and Perlingieri 2012), digital technology applied to rock-art offers a wide range of possibilities. For our project, we propose to use the information gathered not only for conservation but also to underpin more general research and dissemination programmes. In terms of conservation, the geometric and graphic records will aid in the identification of erosion mechanisms and in the choice of appropriate management measures so as to mitigate the impact of degradation. At the same time, with the help of Web servers, 3-D PDF files, CDs, DVDs, or cloud-based data networks can be created. In this way, heritage that is in danger of disappearing or of being closed to public view can be innovatively visualized and appreciated.

ACKNOWLEDGEMENTS

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NOTE

1. The promulgation of the Law for Cultural Parks normalized a long process, which goes back to the 1980s. The concept of ‘cultural park’ was created after years of increasing discoveries of rock-art sites. The initiative distinguishes places with exceptional concentrations of cultural heritage in valued natural settings and aims at protecting these areas as well as promoting local development. The importance of rock-art in Aragon is such, that of the five existing parks, four centre their main activity around it (Cultural Parks of Albarracín, Maestrazgo, Río Martín, and Río Vero).

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WEB RESOURCE

ARAM Project: <http://proyectoaram.tecnitop.com> Accessed 22/04/2014.

12 Conservation Programs in Chaco Culture National Historical Park, USA

Outgrowths and Consequences of Rock-Art Recording Projects

Jane Kolber and Donna Yoder

INTRODUCTION

Chaco Canyon is located within the boundary of a National Park, a UNESCO World Heritage Site, in the southwestern United States. Rock-art covers many of the cliff walls and boulders within the Park, and much of it has now been systematically recorded. This rock-art documentation provides valuable archives for research. Interpretive trails with accompanying guide booklets were developed in response to increased public interest in visitation, appreciation, and understanding of these images. Park employees were provided training to present informative research, for example, about rock-art. A volunteer site steward programme was established. When vandalism occurred and the culprits were caught, the damage could be assessed. Educational exhibits were produced and placed at the site of the vandalism. The Native American tribe that owns the part of Chaco Canyon outside the Park boundary became aware of the recording work and authorized an archaeologist and rock-art recorders to conduct an archaeological survey of the rock-art on the tribal portion of the canyon. A rock-art conservator was brought in to teach the preservation staff how to remove vandalism. A book on the rock-art of the ancient Chacoans is currently in preparation.

Jane Kolber is a rock-art specialist who has been recording since the early 1970s. She has directed field-schools, recording workshops, and projects, taught classes, and organized symposia in the United States and other countries on aspects of recording and conserving rock-art. She chaired the American Rock Art Research Association's Conservation Committee. The Chaco Rock Art Reassessment Project for which she is the primary investigator has been ongoing since 1996.

Donna Yoder is a rock-art and a records management specialist. She served as treasurer of the American Rock Art Research Association and as vice president for membership and recording secretary for the Arizona Archaeological and Historical Society. She has participated in a number of archaeological and rock-art field-schools and recording projects. She is the field director for the Chaco rock-art projects.

Documentation is the first step in the conservation of a rock-art site. However, finalized and submitted recordings are not the end of a project. The data collections and projects do and should emerge with wider audiences both while the recording process is being carried out and after it is completed. The documentation of the rock-art at Chaco Culture National Historical Park produced, and is continuing to produce, auxiliary programmes.

CHACO CANYON ROCK-ART

Chaco is a UNESCO World Heritage Site in the southwestern United States (Figure 12.1). It is known for having the largest prehistoric structures in the United States, created by an advanced, skilled civilization whose influence dominated a vast surrounding area. The study of the enormous and impressive great houses, complex road systems, and other aspects of the Chacoan society has been extensive, but little attention has been paid to the vast body of rock-art which fills the south- and east-facing cliff walls and many of the boulders of the 10-mile-long canyon within the Park boundaries.

Reasons for the neglect of the rock-art probably resulted because of the difficulty in seeing it, the unimpressiveness of that which can be easily seen, and the reluctance of many archaeologists working in the United States to study rock-art as it cannot easily be dated.

In the mid-1970s, the Archaeological Society of New Mexico's Rock Art Field School began a cursory recording programme based upon a prior archaeological survey. Each summer from 1975 to 1980, a week-long session was devoted to documenting about 500 rock-art sites noted by the



A



B

Figure 12.1 Chaco is located in a barren area surrounded by the Navajo Nation and accessed by unpaved roads. A: Location map. B: Pueblo Bonito in central or 'Downtown' Chaco Canyon is the largest of 14 great house complexes.

initial archaeological survey. In an effort to complete the project in 6 years, a 2-week session was scheduled in 1980. The following year, a mop-up crew finished the project (Crotty 2000, 112–13).

OUTGROWTH PROJECTS

The first and most widely known project that came out of the first rock-art field-school was the Solstice Project. Anna Sofaer was a member of a recording team assigned to Fajada Butte. Around noon on 21 June, our summer solstice, she and Jay Crotty happened to be near the rock-art site and observed the phenomenon that became known as the Sun Dagger (Crotty 2000, 113).

They observed a slice of light shine through two vertical slabs and descend down the center of the spiral behind the rocks. Sofaer instituted the Solstice Project, drawing a great deal of attention to the site, especially through several films shown on the Public Broadcasting System channel. Drove of curious visitors and researchers flocked to the site, trampling it. The soil eroded and the slabs shifted, changing the way the phenomenon occurs. The increase in visitation also caused the chimney access to the top of Fajada to crumble. Fajada Butte was closed in 1982 with access restricted to those with a permit; it became a closed area of the Park in 1990 as it became too dangerous to climb the butte. The Park Service initially stabilized the Solstice Marker by raising a low retaining wall followed by building up soil around the slabs in 1990. The Park further stabilized the site in 1997 and 2011. Rock-art sites on Fajada were reassessed against the 1970s documentation and rerecorded in the spring and fall of 2011.

According to Chaco archaeologists Dabney Ford and Roger Moore (2012), sandstone slabs in front of the spiral have not moved since 1990, but some of the slabs show natural erosion on their outer edges. Park personnel will probably inspect the site again in 2014.

Based on the data gathered by the 1970s Archaeological Society of New Mexico Rock Art Field School in Chaco, a new recording project began in the mid-1990s, adding new techniques and more detail, eventually including digital processes.

Chaco is a unit of the National Park Service, surrounded by the Navajo Nation Tribal Lands. It is very far from cities and centers of commerce and only accessible currently by unpaved, sometimes impassable roads. The staff is quite small with many responsibilities. We've made an effort to include as many of the staff in our project as possible. We've given slide shows to the entire staff; many of them have spent days with us in the field, some helping us record; and to others we have given tours of the rock-art sites. Through these efforts, we've gained their support and assistance in protecting the rock-art, for which not much interest had been previously demonstrated (Figure 12.2). When Jane gave a tour to the preservation crew, the men who stabilize the ruins, many of them teased her but helped her. When she took them to a religious panel, they did not go close to it. A seasonal ranger developed an educational handout about rock-art, which has just been published, for the general public.



Figure 12.2 Navajo ceremonial figures were no longer portrayed on rock surfaces after the influx of many Euro-Americans. (Photograph by Helen Crotty. Copyright reserved.)

While at the Park, Jane always gives presentations to the public on Chaco rock-art just as the Park rangers present programmes to the visitors on different subjects. One of the Navajo Park rangers was interested in giving her own rock-art talk to the visiting public. She also began giving presentations to children and adults at schools and chapter houses, the local tribal government centers, in the surrounding areas, about the importance of Chaco rock-art and its protection.

Having lived and taught among the Navajo people, the principal investigators developed an interest in their culture. When funds became limited, we applied for a grant, the focus of which was the Navajo rock-art of Chaco. This adjunct project led to several additional projects.

We had always felt it important to obtain the native people's opinion about the rock-art. After years of friendship with one of the Park rangers, she told us that her family would like to know about the work that we were doing. Her family had been expelled from the land after the federal government established the Park. With some bitterness, they settled outside the Park boundary on land with 'one plant growing'. She invited us to her home, where she and her family had built a new shelter and butchered a sheep for a reunion of her relatives. We talked about the Navajo rock-art project and showed them photographs and drawings included in our documentation. The next day we took about 50 of the extended family, four generations, to visit rock-art sites in the area where some of them had lived before being expelled. One elderly man found a horse that he had drawn on the cliff face when he was a boy. Members of the family said that their mother, the earth, had welcomed them back. They had thought they were not allowed to go back into the Park. Although the animosity still exists between the Park and this family, it has begun to ease. It is hoped that they will eventually play an important role in the protection of the rock-art of their ancestors.

After the Historic Preservation Division of the Navajo Tribe received a copy of the report from the Chaco Navajo Rock Art Project, they asked us to lead a project to both record the rock-art and survey the archaeological sites in Chaco Canyon outside of the National Park on Navajo Nation land, which extends for many more miles on each side of the Park boundary.

This was an important outgrowth of the Navajo Rock-Art Project, as this area has had little archaeological survey work and no rock-art documentation. The Navajos have been very protective about letting anyone visit those lands. In addition, the Navajo Historic Preservation Division has offered assistance to prepare our Chaco Navajo report for publication.

During a private high school visit to Chaco, students were caught vandalizing a panel in the campground. Catching a vandal is a rare occurrence. A rock-art conservator was consulted to estimate the cost of repairing the panel. Since the panel was difficult to access and not many would see the repaired panel, the Park administrators decided to use the money that the students' parents were fined to make educational exhibits for the campground area (Figure 12.3). A university graduate student presented a poster at an archaeology conference detailing the legal case and its outcome. She also wrote her master's thesis based on our recording files.

Other research projects have used data that have been collected. One student wrote a paper on a hidden site, postulating it as a girls' seclusion site. A Puebloan woman, probably descended from the people who lived in the canyon prehistorically, thought it was a boys' site. A Native American who has worked on our recording team for many years has now completed his doctoral degree and hopes to organize a rock-art field-school in an area where only a few sites were documented by the Navajo Rock Art Project. Now on the faculty of the University of Arkansas, William Rex Weeks and Fred Limp of the Center for Advanced Spatial Technologies have successfully



Figure 12.3 Presenting Chaco rock-art: signs placed so that visitors could more readily see and appreciate the rock-art as well as to give them an incentive to help preserve it.

completed one of their high-resolution scanning sessions. Rex and another Arizona State University graduate, Jennifer K.K. Huang, organized a symposium on Chacoan rock-art for the International Federation of Rock Art Organizations in May of 2013, from which a publication will be produced.

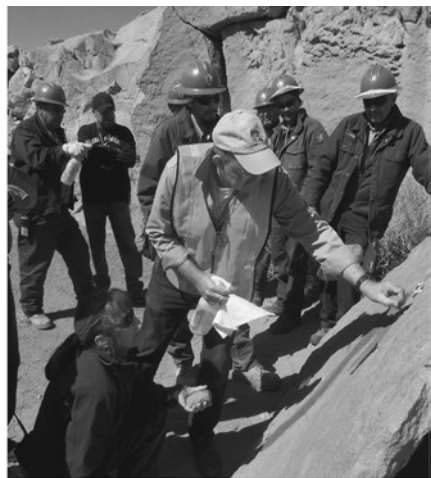
All the rock-art recording documents, along with other Chacoan rock-art materials located in various depositories, are in the process of being assembled into a central Chaco digital storage as well as placed into the newly built Chaco archives housed in the Hibben Center in Albuquerque, New Mexico.

Interest in rock-art has greatly expanded in the United States in the recent past, especially by the outdoor-going public. When we recorded in public areas of the Park, we were often questioned about the rock-art by visitors. A rock-art trail between Pueblo Bonito and Chetro Ketl and an explanatory booklet were developed, as well as the expansion of a booklet for an existing rock-art trail (Figure 12.4A).

Over the years, vandalism has increased in the areas highly impacted by visitors, such as along established trails and in the campground. Using the recording documents as a base, a site steward programme has been set up with volunteers from nearby communities. They periodically visit rock-art sites, monitoring them for any signs of natural or human-imposed change. In March 2012, Johannes Loubser, an archaeologist and rock-art conservator, visited Chaco at the invitation of the Park. He showed Park Service staff, including archaeologists and the preservation crew, site stewards, and Jane Kolber techniques for removing graffiti that was not directly on top of glyphs (Figure 12.4B).



A



B

Figure 12.4 Monitoring Chaco rock-art. A: This Park Guide shows two of the most common rock-art elements in Chaco. B: Johannes Loubser demonstrating proper and effective graffiti removal techniques to the Park archaeologists and preservation crew. (Photographs courtesy of the National Park Service, Chaco Culture National Historical Park. Copyright reserved.)

Approximately 1 month later, our rock-art team spent several days documenting the graffiti and rock-art on the west side of the campground. On our last day in the Park that session, Dabney Ford and Roger Moore, Park archaeologists, Jane, and Donna spent several hours removing graffiti from one of the sites documented a few days earlier. Campers questioned us about what we were doing and expressed regret that other campers damaged the rock-art and rock surfaces in the campground.

In Loubser's report to the Park, he recommended removing the remainder of the graffiti from the campground, laying out roped walkways, installing graphic interpretive signs, disseminating interpretive brochures, keeping the area tidy, and monitoring long-term results of graffiti removal and possible recurrence of vandalism. He stressed using positive messages on signage (Loubser 2012, 13). As a result of Loubser's recommendations, roped walkways were installed. Although further graffiti has been reported by the site stewards in the campground, no new graffiti was noted behind the roped walkways.

CONCLUSION

Perhaps the most important outcome of the survey and documentation programme is the Park's recognition of the importance of its rock-art and the need to conserve it. Since the onset of the rock-art recording projects at Chaco Cultural National Historical Park, other National Parks have started rock-art recording projects, and more effort has been put into the conservation and preservation of the rock-art in the United States. However, we are still striving to implement further protection of the rock-art.

ACKNOWLEDGEMENTS

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13 Managing Chaos

Vandalism and Rock-Art at the Okotoks Erratic, Alberta, Canada

Jack W. Brink

INTRODUCTION

In some parts of the world, humanly induced damage is the single greatest threat to the integrity and survival of rock-art, especially at open-air sites. This is especially true in parts of the globe with the greatest population densities, exponentially increasing opportunities for contact, and conflict, with rock-art sites. Much human damage comes through land-surface development from such sources as roads, housing, mines, and agriculture as well as from climate change. Sadly, a great deal of damage to rock-art sites stems from vandalism. Vandalism is often intentional in that the perpetrator is obviously aware that the rock-art exists on a surface. It may be unintentional when the rock-art is faint or obscure. There is no way to calculate the worldwide impact of vandalism at rock-art sites, but I believe that every professional working in the field would confirm that the problem is massive, global, and demanding of immediate attention.

In Alberta, Canada, there is a rock-art site that must rank among the most vexing and challenging. This is especially so in terms of the *frequency* with which graffiti can appear at the site; weekly, daily, hourly. The site of Okotoks has become a nightmare for legally responsible managers, and, with my permission, has been subjected to undesirable and likely controversial graffiti removal treatments. In this chapter, I introduce the site and its rock-art and discuss the nature of the vandalism before moving on to review a method that has been used to remove graffiti and evaluate and illustrate the results. Finally, I present some concluding remarks about the dilemma heritage managers face in trying to balance tourism and public access to open-air rock-art sites with the need to protect a site from thoughtless vandals.

THE OKOTOKS BIG ROCK

The word 'Okotoks' translates from the Blackfoot language as 'Big Rock.' The name was given by the resident indigenous people to a very large boulder that is known as a 'glacial erratic.' Erratics are glacially transported rocks that

lithologically are out of place moved beyond their normal range of distribution and thus diagnostic of long-distance transport. Extending along the eastern flanks of the Rocky Mountains of Alberta and northern Montana, there is a linear scatter of these rocks known as the Foothills Erratics Train (Stalker 1956). This is a north-south distribution of a specific type of quartzite called the Gog Group (Gadd 1995) that originated in the Athabasca River valley of central western Alberta. Sometime near the end of the Pleistocene, between 12,000 and 17,000 years ago, a massive rockfall took place in the upper reaches of the Athabasca River valley (Jackson et al. 1997). The side of a mountain came crashing down on top of the valley glacier. Millions of tonnes of beige to pinkish Gog Group quartzite rode eastward out of the Athabasca Valley on top of a narrow valley glacier. This valley glacier emerged from the front ranges of the Rockies and butted up against a southwest-moving massive continental sheet of ice. As the two ice fronts crushed against each other, the force of the continental mass turned the smaller valley glacier to the south and caused it to run along the eastern flanks of the Rockies as far as northern Montana. As the ice melted, the cargo of Gog material was dropped, forming the line of rocks known as the erratics train (Jackson et al. 1997).

There are thousands of rocks in the erratics train, ranging in size from pebbles to massive boulders. Okotoks is by far the largest erratic. It is about the size of a two-story house and is estimated to weigh 16,500 tonnes. It is broken into two main pieces that I will refer to as the east and west boulders (Figure 13.1). Like most of the erratics, the Big Rock sits on the level prairie to



Figure 13.1 The Okotoks Erratic looking north at the south-facing side, west boulder to the left, east boulder to the right. Arrows point to three previously known locations of rock-art. (Photograph by Jack Brink. Copyright reserved.)

the east of the Rocky Mountains, and like all the larger pieces, it is visible for a considerable distance. The larger erratics would certainly have been recognized by local Indigenous people as unusual rock types for the area. Large erratics are prominent landmarks today and probably have been for some time.

ROCK-ART AT OKOTOKS

That the Okotoks erratic attracted special attention from resident Aboriginal groups is demonstrated by the presence of red ochre images painted on a number of surfaces on the rock. The rock-art at Okotoks has never been specifically described and published, although a number of publications have mentioned its existence and have provided a few select images (Fowler 1950; Habgood 1968; Keyser and Klassen 2001; Leechman et al. 1955). Historically, rock-art has been recognized at three locations on the rock, all on the south-facing side: on the ceiling of a protruding ledge on the west boulder about 2 m above ground surface; on the east end of the east boulder, again on the ceiling of a small rock ledge about 1.5 m above the ground; and a few meters west of this on a vertical surface 2 m above ground (Figure 13.1). In recent years, thanks to improved methods of red pigment detection, it has been learned that there is much more ochre at Okotoks than previously known. Photography using cross-polarized light and the use of the image-enhancement software program DStretch has demonstrated the existence of areas where red ochre appears to have been smeared or wiped across the rock surface. Confirmed and suspected red ochre imagery is now known from a number of new locations, including several on the south-facing side of the two main boulders, at the east end and northeast corner of the eastern boulder, and several places inside the extensive network of cracks that riddle the eastern boulder.

Rock-art images long known at Okotoks include those shown in Figure 13.2 (for colour versions of these and other rock-art images from this chapter, see <https://sites.google.com/site/managingchaosvandalism/home>). Figure 13.2A is the panel at the west end of the site located on the ceiling under the overhanging ledge. It is a complex assortment of geometric symbols including ‘+’ marks; small circles; rows of small rectangles, some with lines struck through the middle; rows of inverted ‘V’ shapes, many of them with dots of red at the apex; several pointed objects; and a variety of other geometric forms. Some of the inverted V shapes have a horizontal line through them, forming what could be an anthropomorph. There is also a clear bear paw with five claws and one or more lines with pointed ends that could be arrows or spears. On the northern Plains, this type of geometric art has been called Vertical Series (Keyser and Klassen 2001, 281–94). As a rock-art tradition, it is poorly known, relatively rare, and not well described. It has been suggested that Vertical Series may be a very late rock-art style that developed during and after first contact with Europeans and that it was, in effect, an ideographic system of communication, verging on a proto-written language (Keyser and Klassen 2001, 281; Sundstrom 1987, 1990). Figure 13.2B illustrates rock-art at the east end of the south-facing rocks, again underneath an

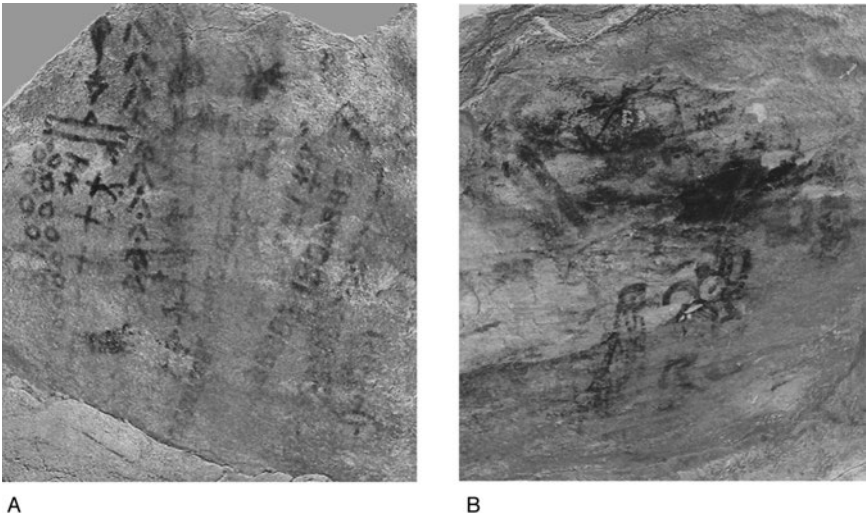


Figure 13.2 Okotoks Erratic rock-art images. A: Panel at west end of west boulder of the erratic, on down-facing surface. DStretch used to enhance red. Note mineral deposit that has washed down the centre of the panel covering some of the rock-art. B: Panel at east end of the east boulder of erratic, on down-facing surface. DStretch used to enhance red. (Photographs by Jack Brink. Copyright reserved.)

overhanging ledge. Here there are some of the same geometric forms, including inverted Vs with dots and small circles, also several indistinct smudges of red ochre. There is also one likely anthropomorph standing next to two curious circular motifs consisting of small circles with dots in the middle and curved radiating spokes, as if spinning wheels. Another known rock-art location at Okotoks shows a square-bodied anthropomorph with raised arms, several ‘#’ symbols, a column of geometric shapes that look like the letter ‘H’ and a backward ‘N’, and a number of indistinct smudges and smears. Some of the geometric shapes seen at these three panels are nearly identical to ones found at Vertical Series sites in the Black Hills of South Dakota more than 1000 km to the southeast (Sundstrom 2004, fig.14.7).

What became apparent with advances in pigment enhancement was that broad areas of the two main boulders had been smeared with red ochre. Occasionally these are easily recognized through identification of a clear hand-print or by finger swipes combined with a few geometric forms. There are several examples of this treatment on the south- and southeast-facing surfaces of the two segments of the Big Rock. Many of them appear only as swaths of red stain on the rocks, lacking any identifiable features. Interestingly, this type of rock-art (handprints, finger swipes, smearing of large areas of the rock) is classed as a separate artistic tradition known as Foothills Abstract (Keyser and Klassen 2001, 151–73). It is believed to be distinct from Vertical Series art, and the two generally are not found at the same sites, although exceptions are known (see Keyser et al. 2012, 212–16). It appears that the Okotoks erratic

has two separate traditions of rock-art. None of the rock-art at Okotoks is dated, and we have no meaningful guess except to say that it does not appear recent (as in, within the last hundred years). If Sundstrom (1987, 1990) is correct that Vertical Series art is associated with the time of contact on the Northern Plains, then the Okotoks pictographs are less than 300 years old.

Problematically, the Gog Group quartzite is high in iron content, resulting in sections of the boulders that have a distinct orange-red colour that is visually (including when using DStretch) similar to what is clearly red ochre. A number of areas of the Okotoks erratics exhibit pronounced red iron staining, occasionally in direct association with red ochre finger swipes, smears and geometric figures. This makes it difficult to separate those areas that were smeared with red ochre from natural iron stains. This has important implications for the following discussion of graffiti removal. Clearly it is critical to know what stains are humanly produced as opposed to those naturally occurring. Generally, iron stains tend to have sharp borders and edges, whereas ochre smears appear more diffuse and scattered with indistinct edges. Also, what appear to be ochre smears are often located on high points or projecting (often rounded) surfaces of the rocks, seldom occurring in concavities or recessed areas, whereas iron stains show no such restriction and are found on all configurations of the rock.

Despite these clues, there are a number of places on the Big Rock where it remains difficult to discern the origin of the red stain. It is these previously unknown ochre stains that are of special relevance to this chapter. They cover broad areas of the rock, they are often found on vertical and projecting surfaces where modern vandals could encounter them, and they are not easily seen by visitors who might avoid them if their identification as rock-art were known. Two of the previously known panels (Figures 13.2A and B) are situated on the ceilings of down-facing surfaces. They are generally unknown and invisible to the visiting public. They do not occur on surfaces that anyone would tend to examine, and defacement of them with graffiti would be pointless as the vandalism would be invisible to all others. The previously known anthropomorph and associated geometrics that are located on an exposed, south-facing panel are situated high above the surrounding ground surface, beyond the easy reach of vandals. Thus, these three panels have generally avoided defacement at the Okotoks erratic. It is the newly discovered rock-art at Okotoks, the exposed south-facing surfaces with ochre smears, faint handprints and geometrics, that is most threatened by vandalism.

VANDALISM AT OKOTOKS

It is hard to overstate the extent and frequency of vandalism that is occurring at the Big Rock. For decades the site attracted only occasional visitors and the very rare occurrence of spray-painted graffiti. That all began to change in the 1980s. The Big Rock was once in a remote location, some 8 km from the nearest town of Okotoks. A few decades ago, the town had a couple thousand

residents. Today it has 25,000. The exponential growth of the town can be linked with the growth and urban expansion of the city of Calgary located some 20 km to the north. The population of Calgary has nearly doubled in the past 30 years (to 1 million in 2012), and along with that growth has been a flight from the city to ‘country living’ in such towns as Okotoks. Once situated in lightly populated farmland, housing subdivisions now encroach to within 2 km of the erratic and more are being built. The historic site that was little known a few years ago is now a signed, interpreted historic destination with parking lot, trail, bathrooms, and interpretive signage (signs explain the geological history of the erratic and discuss its significance to Blackfoot people but intentionally do not mention the existence of rock-art images). Schoolchildren visit the site, teenagers play there, picnics are held, and local workers even drive the short distance over the lunch hour, climb the rocks, and have their lunch before returning to work. Teenagers have weekend parties where much alcohol is consumed. Large furniture, such as couches, has been dragged up to the rocks. Trash litters the ground.

It comes as no surprise, then, that this prominent landform has suffered an exponentially increasing amount of damage. Beginning around 2005, the site has suffered nearly continuous vandalism in the form of painting and writing on the rocks with materials ranging from felt-tipped markers to spray paint. Figure 13.3 shows a sample of vandalism from recent years. As Okotoks is a



Figure 13.3 Vandalism at Okotoks Erratic. Graffiti on rock surface—photograph taken in 2009. (Photograph by Jack Brink. Copyright reserved.)

designated historic site owned and under the management of the Alberta government, there comes a point at which defacement of the rock cannot simply be ignored and left unaddressed. This point came in 2007 following a particularly serious occurrence of defacement. Local law enforcement officials were advised of the damage, which is a violation of the Alberta Historical Resources Act, and were asked to increase their monitoring of the erratic. Meetings were held with town officials and, based on the assumption that local teenagers were the most likely culprits, with representatives of the Okotoks school system. A pipe ceremony with Blackfoot elders, government managers, and local officials was held on site to discuss options and to try and bring some healing spirit to the increasingly sad situation. It was shortly after this ceremony that the decision was made to try and remove graffiti from the Big Rock.

GRAFFITI REMOVAL AT OKOTOKS

The Department of Culture of the Alberta government is responsible for the care and maintenance of its developed and interpreted historic sites. Staff of this department possess the equipment and training for use of a portable, high-pressure water spray system. The equipment consists of a large water tank, heater and compressor, power source, long flexible hose, and metal spray nozzle. The equipment is capable of delivering 4.5 gallons of water per minute at 3,000 PSI (pounds per square inch) using a 414,000 BTU water heater (R. Johnson, personal communication, 2011). The end of the spray nozzle is a 25 mm needle-nose rotating tip that sprays water in a narrow circle. It is a powerful tool that easily strips paint and other substances from most surfaces.

The first use of this equipment to remove graffiti from the Big Rock occurred in October 2007. It happened without my knowledge or supervision. I found out about the event a few days later and contacted the relevant authorities. I explained my concern over the use of the equipment without the requisite supervision that could indicate where rock-art images were located. The individuals were aware of the existence of rock-art at the site but assumed that it was in hidden areas unaffected by graffiti. They promised not to use the equipment again without first contacting me, a promise that they have kept.

The first test of the equipment at the site was documented in photographs taken during the work. Although these were subsequently provided to me, it was impossible in hindsight to assess whether there was any adverse impact to rock-art images. Within months of the first treatment, new graffiti was appearing on the erratic. By the spring of 2009, the situation was again extremely serious, with many large names and slogans spray painted on the rocks, including much profanity. Managers of the site felt that another removal of the graffiti was needed and I was contacted. I agreed to accompany the crew to the site to inspect all areas that were slated for graffiti removal.

The second use of the spray equipment occurred in June 2009. The crew and I went to each location on the two large boulders that had graffiti

and carefully looked for signs of red pigment. The great majority of the defacement was in places where no red staining was evident. I watched and documented removal of graffiti from these locations. There were, however, several places where graffiti was placed alongside of or directly on top of what I felt was either definitely or likely humanly applied pigment. I decided to initiate a test case allowing monitored removal of graffiti that lay overtop of what I believed was likely humanly produced red ochre stains.

The word 'PUNK' had been painted in large letters at the western side of the east boulder (Figure 13.3). The diagonal bars of the letter 'K' were partially painted over what I felt was a smear of red ochre. The smear was mostly a vertical swipe of red colour lacking definition but with diffuse boundaries that do not fit the appearance of iron stains. More convincing, there were several places in the smeared area where what appeared to be finger swipes were visible (Figure 13.4A). I inspected the area prior to treatment and took close-up digital photographs. The spray operator began removing the letter 'K', working towards the diagonal bars where the red stain was located. As graffiti was removed, which happened quickly, I frequently stopped the operation to inspect the surface of the rock. I should note that this was traumatic work. It was exceedingly difficult to watch 3,000 PSI of hot water used on a rock surface that I believed had culturally applied pigment on its surface. But defacement of the rock had reached the point where leaving all the graffiti in place was a decreasingly viable option, where the existence of graffiti was itself a form of loss of integrity of the rock-art, and where I felt it was necessary to test the effectiveness of the spray system on a pigment panel that (should it be lost) had relatively low interpretive potential. The day will likely come when one of the fine, highly significant panels of art at Okotoks will be vandalized, and it seemed that we need to know if there are options for dealing with this situation. All the options available with respect to the Okotoks erratic were unpalatable ones.

At the completion of the test, my inspection indicated that the red-stained areas seemed unaffected by the spray treatment. Figure 13.4B illustrates the rock surface following removal of the letter 'K' (compare with Figure 13.4A). If correct that the red-stained area shown in these figures is red ochre and not natural iron, then the implication is that the high-pressure water sprayer is effective at graffiti removal yet does not remove underlying rock-art. It must be stressed that this finding is entirely subjective in that it is based on my personal impressions from before and after inspection of the rock surface and subsequent examination of the photographs. It is entirely possible that some loss of red pigment did occur but on a finer scale than I was able to observe. It is equally possible that continued use of the spray equipment in the exact same place would eventually reveal a gradual and noticeable loss of pigment. I can't dismiss these possibilities, nor can I state categorically that there was absolutely no damage to the underlying pigment.

Based on the results of the first test case, I then permitted graffiti removal in another area where I suspected that red ochre underlay or was immediately

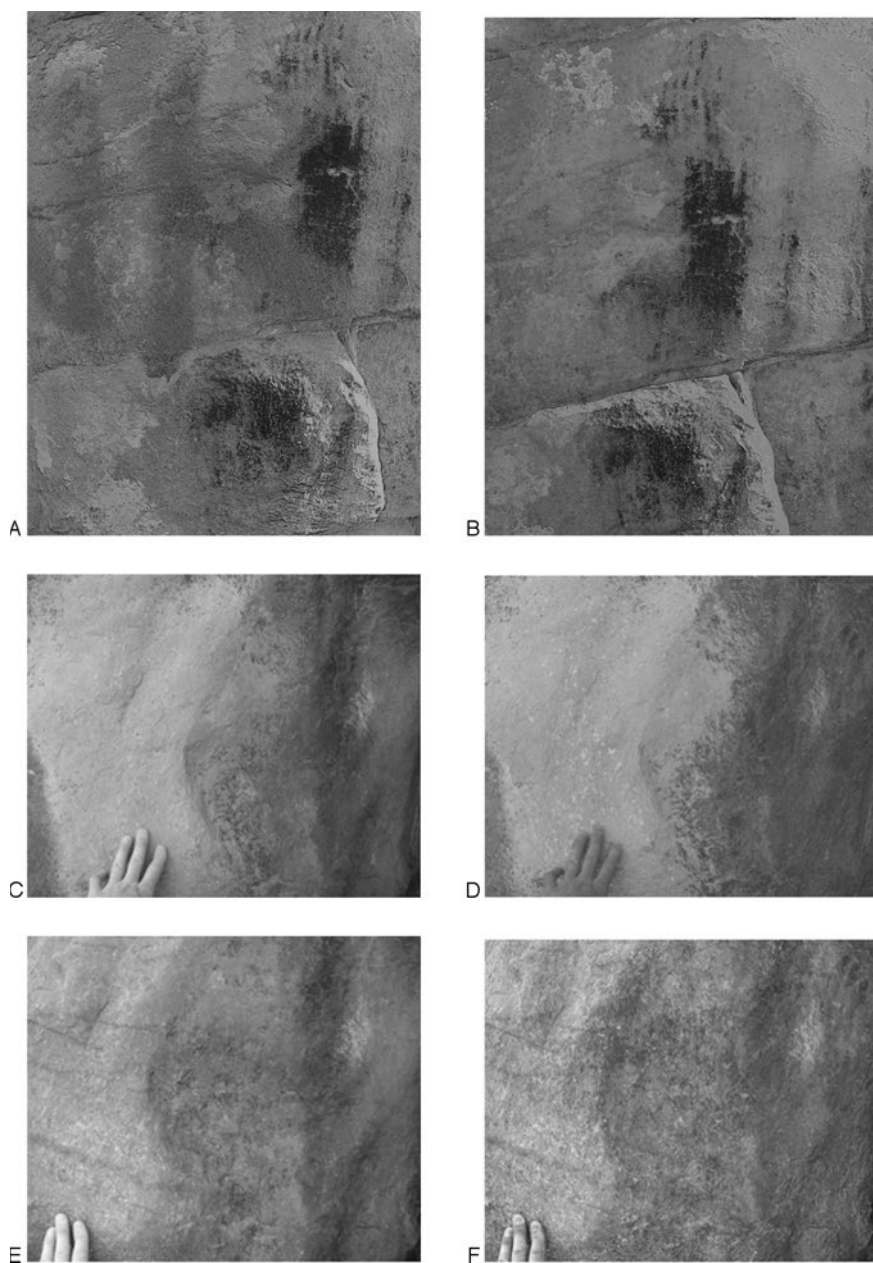


Figure 13.4 Vandalism paint and rock-art images. A: Dstretch of photograph showing black spray paint letter “K” over top of red ochre finger swipes. B: Same area as A after high-pressure spray removal of letter “K”, finger swipes still present. C: Old paint applied in 1960s to cover graffiti. Note red pigment at right. D: Dstretch of C showing handprint at upper right. E: Same area as C with paint from 1960s removed. F: Dstretch of E showing red pigment underneath the previous paint and handprint at upper right. (Photographs by Jack Brink. Copyright reserved.)

adjacent to graffiti. At an unknown date in the past, believed to be the 1960s, the town of Okotoks had tried to discourage vandalism by applying light green paint overtop some of the graffiti. In some cases, paint was placed over what I now believe to be red ochre. It was not known if the pressure sprayer would remove very old paint, but we decided to try. The test area was at the southeast corner of the east boulder about 2 m above ground surface. Figure 13.4C shows the old paint overtop the rock, and Figure 13.4D enhances the red pigment. In the upper right of Figure 13.4D you can see the fingers of a hand located to the right side of a natural black streak in the rock. More pigment seems to be placed around and under the green paint. Figure 13.4E shows the study area following high-pressure spray removal of old paint, and Figure 13.4F is a DStretch image of the same photograph. The handprint appears unaffected, and although it was not directly covered with green paint, the pressure sprayer clearly contacted this adjacent area. More red staining, believed to be ochre, has appeared from underneath the green paint. It does not appear that the substance believed to be ochre was adversely affected.

Since the initial unsupervised graffiti removal, there have been four additional events (as of 2012). I supervised two of these, two others were relatively minor events for which I inspected photographs beforehand and determined that my presence was not required, and the first event, as mentioned, occurred without my knowledge.

DISCUSSION

A number of issues are relevant for discussion. First, if indeed the red ochre satins are not affected by the high-pressure spray treatment, why is this the case? Second, assuming there will be no let-up to the incidences of vandalism at Okotoks, are there any alternatives to removal of the graffiti using other techniques? Third, what future directions might be taken at Okotoks to alleviate the unfortunate situation of nearly constant defacement?

As stated, it cannot be categorically claimed that the spray treatment did no damage to the underlying rock-art. Rather, this is the observation I have made from an admittedly subjective assessment. Techniques may exist to measure more precisely the effects of pressurized spray on the rock surface, such as portable laser scanners, x-ray fluorescence, and light reflectivity. The first can potentially detect minute changes to the topography of the rock surface measured in microns, the second might allow assessment of any changes in mineralogy, and for the third, the use of a reflectance photometer may allow an objective assessment of changes in reflective colour. To my knowledge, none of these techniques are currently being used in a situation similar to that of Okotoks. In addition, computer-generated comparisons of photographs taken before and after graffiti removal, using specialized software and extremely high-resolution images, is an option that would add rigor to my subjective assessments. As the problem isn't going to go away, these options can all be explored.

If it is correct that the spray treatment did not damage the red ochre, there are several explanations for why this might be the case. First, the ochre may have penetrated into the rock surface, thus giving it an adhesion and durability that it would not have if it were entirely confined to the outer surface. It is possible that the pigment was absorbed into the outermost surface of the rock to an extent that it has become bonded with the rock. This can't be refuted, but it seems unlikely. Quartzite is one of the hardest rocks known (7 on the Mohs scale; Gadd 1995, 71). The Gog Group in particular, being almost entirely quartz, is extremely hard and dense, formed of metamorphosed sandstone where quartz sand grains are cemented with quartz (Gadd 1995, 71). It is a dense, non-porous rock that seems to have no space for absorption of an applied substance. If a piece with pigment could be removed and examined under a microscope, it might be possible to determine if the ochre has absorbed into the rock surface; however, intentional removal of a chip is not an option. On the basis of what is known about quartzite, it seems unlikely that the pigment has survived water spray treatment because it has absorbed into the rock structure.

It is not uncommon for mineral layers to be deposited over top of rock-art. This is clearly the case at another rock-art site in Alberta (Magne and Klassen 2001) where the mineral deposit has no doubt helped preserve the images. But these situations occur on rock surfaces that are prone to mineral deposition, especially carbonates. Nearly pure quartz, like the Gog Group, would not be expected to weather out minerals that then flow over the rock surface. However, some unidentified precipitate is being deposited at the Big Rock. This can be seen in the center of Figure 13.2A, the main panel on the west boulder, where there is a downward-trending streak of mineral deposit that has obscured some of the red ochre artwork. (At a meeting on site with Blackfoot elders, I was asked if something could be done to alleviate this situation, like installing an artificial drip line to redirect water flow, an option that is being considered). Clearly a mineral deposit of some kind is forming on parts of the Okotoks erratic. Visual inspection suggests this is clay mineral, but this remains unproven. Given what can be seen in Figure 13.2A, it seems logical to conclude that mineral deposition is also occurring on other parts of the rock.

Although quartz generally does not produce a precipitate, material may be added to the rock that has this effect. Annual rain and snow can bring aeolian-born materials to the rock surface, where they become part of the formation of weathering rinds (Mahaney et al. 2012, 595). In addition, there is organic activity on the surface of rocks that results in the deposition of organic matter. This matter lies on the surface, where it can assist in the formation of and become incorporated into weathering rinds (Mahaney et al. 2012, 595). Acid rain may be responsible for depositing minerals onto the erratic that were previously not present in the bedrock. These in turn may dissolve and oxidize, assisting in the formation of weathering rinds (Oguchi 2001). At the moment, the best explanation for why the red pigment stains at Okotoks did not seem to be affected by the high-pressure spray is that they may be protected by a fine veneer of mineral deposit. However, this remains to be proven.

The second point of discussion concerns other remedial measures that might be used to remove graffiti in place of the high-pressure spray. Rock-art conservation is a complex and contentious matter, and a review of the array of issues including methods, protocols, and ethics is beyond the scope of this chapter (see Loubser 2001; MacLeod 2000; Whitley 2011). Aside from ethical issues of *should* rock-art be conserved (Brink and Blood 2008; Government of Canada 2011, 119–21; Klassen 2008), there are questions as to what actually works and what is practical and achievable with available resources. The short answer to the question is that yes, there are always other measures that can be employed to deal with graffiti at rock-art sites. After an especially severe case of vandalism at Okotoks in 2007 a professional rock-art conservator, Dr. Claire Dean, was brought to examine the site. Her report (Dean 2007) outlined an array of recommended remedial actions. For graffiti removal, Dean (2007) recommended a staged test treatment using chemical (solvent) cleaning, mechanical cleaning, and possibly laser technology. Although Dean was not asked to provide estimates, the recommended work would clearly be costly and time consuming. I am not suggesting that this type of work is not warranted at Okotoks. The issue at this particular site is that within days or weeks of the conservators leaving the site, there would be new graffiti. The time and expense of careful graffiti removal may be fully justified with treasured and non-renewable heritage resources, such as Okotoks, but it is not sustainable on an ongoing basis. Which leads to the third topic, future directions.

There are always other options for site protection, but in the case of Okotoks, there don't seem to be any attractive ones. The most obvious solution to ending vandalism at the site is to completely envelop the erratic with an impervious wall, fence, or building. Currently the site is ringed with a single steel cable, about 0.75 m off the ground, held by wooden posts. You can easily step over the cable and approach the rocks. There is a prepared hiking path outside the cable that fully encircles the erratic. Most people walk around the path, don't cross the cable, take pictures, and go home. But some don't obey the subtle (cable) command to stay back, and these are the people who may be especially inclined to inflict damage. A more substantial fence would only be seen as a challenge to vandals and would likely be climbed or torn down in short order. To truly prevent vandalism, the site would have to be ringed with an extraordinarily strong, tall fence or wall. While likely effective, this treatment would essentially end all viewing and interpretation of the historic site. It would also completely rob the site of its powerful and sacred character and destroy the context of the setting of the site on the landscape, attributes that have a great deal to do with why rock-art was put there in the first place.

Likewise, putting an enclosed building over top of the erratic would control access and eliminate vandalism. A building of sufficient size would be very expensive and would require a huge government commitment to staff and maintain it. The chances of this being funded are less than remote. A shelter over the site would also have the same effect of disassociating the erratic from the landscape as would a massive fence. This solution was employed at the

Peterborough Petroglyph site in Ontario. While the building arguably has protected the majority of the site, it remains a controversial and expensive solution (Bahn et al. 1995; Zawadzka 2008). It would be possible to install sophisticated electronic surveillance equipment including multiple cameras with motion detectors, lights, and night vision and then to prominently sign the existence of these security measures, hoping to deter vandals. It is unknown if this would be effective; people partying and consuming alcohol might not care and might make it their mission to vandalize the equipment. If the equipment was linked to local law enforcement offices, it would still take some 10 to 15 minutes for responders to arrive at the site, ample time for damage to be done.

If there are simple, effective, inexpensive, sustainable solutions to preventing vandalism at Okotoks, we haven't discovered them. Increased public education is often cited as the solution, arguing that an educated public is likely to be respectful of the importance of historical resources. No doubt this is true much of the time, but the history of the Okotoks site indicates that it is precisely the times this approach doesn't work that massive damage occurs. For many years, existing signage at Okotoks has asked visitors to respect and not deface the site, has identified the importance of the rock as a sacred place to Blackfoot people, and has stated the legal penalties for defacement (fines of up to \$50,000 and/or 1 year imprisonment). Clearly this has not been an effective deterrent. Regular presentations by archaeologists or site managers to high schools in the area, stressing the importance of the site, would likely have a positive effect on many, but again would probably not deter the more hard-core individuals determined to leave their marks on the rock. Also, this would involve making the existence of the rock-art known to the public, something which is not currently the case and which is of debatable benefit.

What is certain is that the population of the local area will continue to grow and will continue to encroach towards the site. Escalating numbers mean increasing contact between people and the Okotoks erratic. Regrettably, we have no reason to believe that vandalism will cease or even decline and ample reason to believe it will continue. If this is the case, we have a long future of having to make decisions regarding what to do with graffiti at Okotoks: leave it and let visitors, including descendant Aboriginal groups, see the site in defaced condition; remove it using quick and inexpensive techniques such as high-pressure spraying that might damage underlying rock-art; or remove it using expensive, time-consuming techniques that pose less threat to damaging the rock-art but which may not be economically sustainable.

CONCLUSION

The Okotoks erratic, in southwestern Alberta, can be seen as a model of modern-day problems that face open-air rock-art sites in highly developed parts of the world. It is the 'perfect storm' of management situations: a well-known, prominent landmark that will continue to attract large numbers of visitors and rock-art that is largely unknown, some of which is hardly

visible but faces directly towards the visitors, and with sheer rock walls that will prove hard to resist as a suitable canvass for those wishing to leave a message. To date, graffiti has been effectively removed using a high-pressure spray system. Observation and documentation of several of these events *suggest* that, in the few instances where red ochre pigment was believed to underlie graffiti, the water spray did not negatively affect the pigment. This is an assessment that cannot currently be proven. Even if it could be, there is no assurance that *repeated* use of the same technique would not eventually cause damage to the rock-art.

It is stressed that this chapter is not reporting on the management of graffiti removal at Okotoks as a recommendation for similar treatment at other rock-art sites. Almost certainly, use of high-pressure spray would severely damage the great majority of other occurrences of rock-art. If indeed red ochre is not being adversely affected at Okotoks, it may be due to there being a thin coating of mineral deposition occurring overtop of the rock-art. Likewise, I am not recommending continued use of the technique at Okotoks. Rather, the point is to bring attention to a wider audience of challenges and issues that are currently being faced at one specific site, knowing that others either are or will soon be facing similar dilemmas. Attempting to responsibly manage the Okotoks site has proven an exasperating experience for all involved. The site is being subjected to frequent and extensive bouts of vandalism, and no remedial or preventative solutions are currently known that are affordable, sustainable, or acceptable. Hopefully, at some point in the future there will be a better fate to report for the Big Rock.

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14 The Conservation Diagnostic Process in Colombian Rock-Art Research

Guillermo Muñoz and Judith Trujillo

INTRODUCTION

From the first decades of the twentieth century, the visitors of European Palaeolithic caves were mainly interested in discovering and recording groups of motifs, as well as describing and identifying their component elements. Debates concerning approaches to recording and interpretation arose in the middle years of the same century. Detailed descriptions were further developed, transcriptions of panels were made, and attention was given to reconstructing the original composition, spatial structure, function, and meaning. Interpretations were initially based in an evolutionary sequence, from the ‘primitive’ images (Palaeolithic naturalistic representations) through to ‘elaborate’ images (Neolithic synthetic representations). But such a scheme based on traditional methods suffered numerous and important objections because both kinds of image were placed into the same spaces (Leroi-Gourhan 1966). Better description of motifs encouraged interest in a more detailed appreciation of murals in areas that could not be observed because of damage. Geology allowed the study of minerals, and the first studies on the alteration and conservation of rock-art sites were carried out. Henry Breuil set up the first colour palette for classifying the pigments composing the main colours of prehistoric rock-art paintings (van Riet Lowe 1945).

Throughout these early studies, the preservation and conservation of rock-art was not considered an important topic of research, and it was not until the 1970s that interest in this field became established. Environment and the condition of the rock surface underlying the art began to be recorded alongside details of the form and composition of the images. Still, however, the interest that guided the study was the interpretation of the ‘language’ implicit in the rock-art itself. There was little consideration of environmental conditions existing at the time the rock-art was made and still less on the changing conditions that have influenced and will continue to influence the survival of the panels themselves. As one commentator asserted, “The researcher of rupestrian art played a discoverer role, interested more on digging up and interpreting than on conserving” (Soleilhavoup 1978). No one thought that the explanation of a historical fact out of its context provides only an incomplete vision of the studied object (Trujillo 1998).

In 1967, Peter Ucko and Andrée Rosenfeld drew upon historical and reflexive thinking to challenge the traditional Breulinian arguments. Both authors, feeling the need to deepen existing knowledge, made several studies of rock-art in Australia and organized a seminar focused on open-air rock-art conservation at the Institute of Material Culture and Conservation; the event was sponsored by the Museum of Canberra and published in 1977 (Rosenfeld 1977; and see Ucko 1977). At this international meeting, a theoretical perspective aimed at opening up new ways of thinking and questioning the need, sense, and function of rock-art recording came to the surface. Andrée Rosenfeld proposed that answers should be directed, on the one hand, toward a set of archaeological questions and, on the other hand, toward a wide spectrum of themes on the state of places where such rock-art is found. Following this approach, research is based on the need to record rock-art so that it can be managed as cultural heritage whose on-going care depends upon the research itself and on monitoring the alteration and deterioration of the rock-art panels. Another pathway open to rock-art researchers and scientists includes both the technical analysis and the reflexive consideration of the cultural origins and social context of the rock-art. Technical studies must be developed into more detailed descriptions, supported by laboratory work, to examine the physical, chemical, and biological processes in order to provide information for a full assessment of a site (Trujillo 2010).

Worrying accounts about the condition of European caves increased the number of studies aimed at addressing the conservation problems experienced at Lascaux and Altamira, where high visitor numbers resulted in the growth of microorganisms that in turn endanger the rock substrate and pigments at these sites. Thus, whoever wants to know the state and conservation of the rock-art has the duty of studying the research developed about these caves.

Scientific research aimed at describing, in great detail, the way that rock-art changes over time under different environmental conditions provides the basis for constructing models of how things might change in future. The works of Vouvé (1983) and Brunet, Vidal and Vouvé (1985) demonstrate the concern in Europe for the conservation of these sites (Rosenfeld 1977). Research started in Europe with the aim of studying the deterioration caused by the massive presence of tourists, including the multidisciplinary effort regarding the cave of Lascaux, France. The behaviour of air within the confined underground spaces, the gradual and problematic increase of temperature, and the disproportionate, almost uncontrollable increase in the number and variety of microorganisms and bacteria were factors that framed much of the research.

Physical models competed with biological ones and simulations. But it is now recognized that the methodological perspectives and models employed by different research teams were not always compatible. Each team arrived at a diagnosis of the complex situation in Lascaux by taking into account only the factors that fit its own model. In summary, besides the complexity of the situation, there were different diagnoses and opposing decisions concerning the best solution to address the pressing conservation issues (Brunet and Malaurent

2009). One interesting line of development was the creation of mathematical models to analyse the changing atmosphere within the cave, which drew heavily on equations that could be resolved by measurements of the inner and outer environments of the cave. These measurements were derived from sensors that recorded variations in humidity and temperature, absolute and relative, within their surroundings. In this way, it is possible a record a representative set of measurements that make it possible to model various scenarios that can help determine whether the caves should be closed to the public.

Monitoring caves with rock-art (Malaurent et al. 1993; Vouvé et al. 1997) has influenced studies on the conservation of open-air rock-art by emphasizing the value of data from nearby meteorological stations, measuring local environmental indicators, and analysing the influence of biological and physical dynamics in the conservation of both the rocky substrate and, in the case of paintings, pigments. Two kinds of studies, made in different latitudes, are identified by Robert Bednarik (2007) with reference to the scientific study of rock-art sites: firstly, the work of François Soleilhavoup in the studies about the Sahara (1985, 1994) and, secondly, the recording and analysis systems for conservation produced by the Grupo de Investigación de Arte Rupestre (GIPRI) in Colombia (Muñoz 1998; 2006). Both studies are pioneering works that deserve to be followed, for they focus attention on the need to discriminate different aspects of the conservation problem by thinking about the processes of alteration and change within and around a rock-art site.

Getting the right level of detail in assessment studies is important. Bednarik (2007, 60) summarizes many of the main points, saying that:

the principle of micro-geomorphic mapping of rock-art panels is simple: whereas traditional recordings are almost universally limited to the perceived rock-art motifs, Soleilhavoup and Muñoz (GIPRI) include also information on other features of the rock panel, such as areas of exfoliation, lichen presence, taphonomic rock markings, patination, mineral accretions and salt efflorescence. The benefits of this cartography are not limited to those for the scientist, who is likely to refer to such micro-topographical information for a variety of analytical reasons, they are also of great significance to issues of rock-art conservation. Indeed, in the latter area it seems self-evident that this form of recording is essential. The neglect hitherto of such an important tool of rock-art research is symptomatic of a field dominated by non-scientific, humanistic preoccupations, such as what is depicted and why. It is part of the general pattern that has led to the shortage of empirical information about rock-art, and the abundance of meaningless claims about meaning.

From a scientific viewpoint, GIPRI has developed several kinds of formal structures for discriminating features of the rocks, pictorial groups, and the precise location of rock-art panels in a given region. Most of the rock-art

studied by GIPRI is located in two distinct regions: moist tropical zones and high plateau areas, 2,475 m above sea level. This methodological approach was developed as a work in progress at the same period in which different researchers, in different latitudes, also tried to develop their own methods without losing sight of the need to propose a unified strategy for research procedures (Anati 1977; Apostolides 1975; Bain 1975; Berkeley 1974; Clewlow and Wheeling 1978; Clouten 1974; Walker et al. 1979; Webster 1966).

GIPRI designed its approach in a way that tried to correct unsuccessful approaches by earlier Colombian researchers. One of the most outstanding features of Colombian rock-art research was the low-quality literary descriptions of motifs, with lengthy texts devoted to the surrounding area, the motifs, and their formal characteristics. Maybe this tendency was due to the absence of photographic equipment, although in many cases this shortfall was replaced by the work of draughtsmen and illustrators. The first studies were carried out in the nineteenth century by Jorge Isaacs and Lázaro María Girón (Muñoz 1995). These studies varied in quality and insight, presenting illustrations (water colours, drawings, etc.) that did not depict many of the important details of the original motifs. Hence, GIPRI initially devoted itself to tasks related to the relocation and mapping of panels, and, more importantly, to producing accurate visual depictions of rock-art panels, including the structural shape of the host rock, its context, and the discrimination of the different pictorial groups and their characteristics (Muñoz and Trujillo 2010; Figure 14.1). Thus, an evaluation of traditional interpretations, in terms of both content and form, was possible.

A HISTORY OF THE CONSERVATION

From the very beginning of research in 1970, different data recording formats were used for different scales of study: the panel, the site, the environment, and so on. These have gradually been standardized, respecting various criteria following acquired experience. Photographic records have increased in importance, especially with the availability of digital photography. Likewise, archaeometric studies of pigments and the experimental work on the techniques of making petroglyphs have become available.

By 1978, most of the documentation work was based on two major influences. First was the influence of architecture concerning the spatial referencing of rock-art panels. From the outset, descriptions include accounts of the rock materials, the pictorial groups, and, in most cases, the surrounding environment, including descriptions of trees and low-lying vegetation, the inclination of the place, the presence of gaps, and the contribution of organic material. A second influence is the use of scales and Cartesian description systems, produced by the Institute Agustín Codazzi, to determine the geographic location and the precise distances among the elements within pictorial groups. Moreover, some initial commentaries regarding the state of preservation were

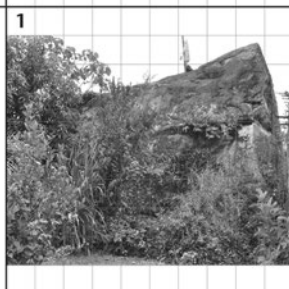
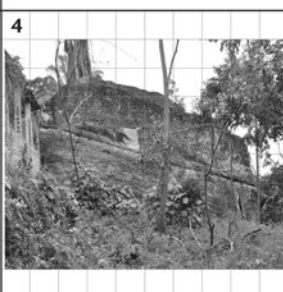
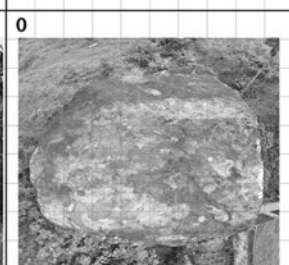
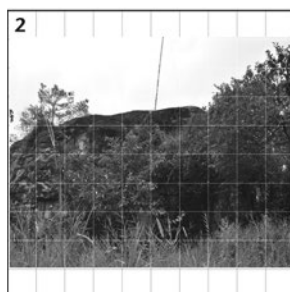
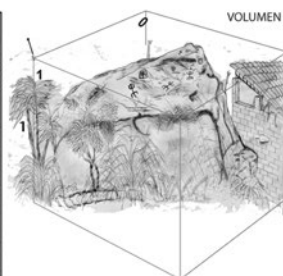
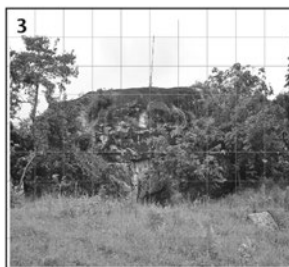
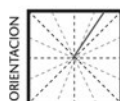


2 LEVANTAMIENTO GENERAL YACIMIENTO

CÓDIGO

Col	Cu	EIC	11	Pe	011
País	Depto.	Municipio	Zona	Modalidad	Número

Criterios: Exprese gráficamente los levantamientos del yacimiento en sus cinco vistas. Localice en el plano 0 la cara superior. Reconstruya su volumen. Incluya su orientación y escala utilizada.



ESCALA 1:0,83 m

2. LEVANTAMIENTO GENERAL YACIMIENTO

Figure 14.1 Registration forms used in GIPRI's methodological approach. Visual description permits the discrimination of pictorial groups as well as the features of individual motifs. The forms describe 'Rock of the Sun', Mesitas de El Colegio, Cundinamarca, Colombia.

also included. Through this description process, several factors that deserved to be systematized and differentiated have been identified.

The next step was the identification of available bibliographic references that could help in giving the finishing touches to the documentation models

adapted for the different categories that needed to be addressed (conservation, interpretation, etc.). The research of Brunet and colleagues (Brunet et al. 1985) and Soleilhaviour (1985) prompted the final elaboration of the system, which includes, for this stage, coloured strips and textures describing the effects of erosion and decay, whether by human agency or by the presence of macro- and microflora. In the same way, the effects of solar radiation, wind, humidity, and temperature all undoubtedly produce chemical and physical alterations, and these were also recorded.

For some years, the criteria used during fieldwork were not backed up with laboratory analysis, but many questions were formulated as research topics for the future. The scheme created by Vouvé was fundamental; it represented a cube-shaped deposit to simulate the extraordinary dynamics of the changes that befall a rock exposed to the elements. Following these influences, GIPRI devoted much effort to the description of the internal dynamics of the rocks, albeit superficially, by using some of the most affected sites, for example, the Roca de La Cuadrícula in La Poma, Cundinamarca.

By developing lecture programmes about rock-art in several academic institutions (the National Pedagogical University, the National School of Conservation and Restoration, and the University Externado of Colombia), GIPRI prompted a number of theses devoted to rock-art conservation (Arango 1995; Bateman and Martínez 1999). In 1998, GIPRI, based on work undertaken over the preceding decades and with the collaboration of the archaeologist Gonzalo Correal Urrego, and the coordination of the GIPRI director, Guillermo Muñoz, attempted to develop an overall methodological model for recording, studying and conserving Colombian rock-art (Muñoz 1998). Unfortunately, the resulting two volumes remain unpublished. The first volume deals with theoretical problems concerning the history of research in an international context, as well as the links between the history of science and philosophy and its influence on archaeological issues. The volume includes an account of the history of research in Colombia and a summary of the process developed by GIPRI since the beginning of the research programme. The second volume presents 12 examples of rock-art panels, each including a description of motifs and statements about their state of conservation.

SYSTEM FOR RECORDING AND DOCUMENTING DETERIORATION AND ALTERATION FACTORS

One of the tasks carried out by GIPRI was the definition of zones in which rock-art occurred and then their systematic recording using a mandatory formal structure in order to organize information about particular places and their peculiarities. This systematic work (Muñoz 2006) has required the creation of a Geographical Information System (GIS) that is able to incorporate the distribution of the deposits, the zone sheets, and the conservation sheets for every site. All this information is accompanied by geological, geomorphologic, and

climate data and descriptions of the type of soil, vegetation, and land use. Besides the descriptions of the rock-art motifs, a form to record alteration and deterioration processes was developed and is incorporated within the overall record for each site. But even a descriptive work with subtle discriminations and high-quality data on the most singular aspects of the rock is not enough. It is also mandatory to care for the original rock as well as to develop strategies for conserving the rock-art. A researcher who does not take account of the erosion and decay processes but only draws the motifs to try to make a relationship to a respective past or present human group or to develop an aesthetical theory does a disservice to the full potential of his or her work.

The central target of rock-art research has been regaining cultural appreciation of the imagery and sites by means of detailed graphic and photographic documentation. In turn, these materials become a source for future studies drawing on different perspectives. The factors that directly affect the condition of the rock-art surfaces and outcrops are taken into account. For instance, under high temperatures, the surface layer both expands and contracts. This process produces gaps and microspaces that are replaced by other elements, a process which also fosters exfoliation and detachment from the substrate. It is even more harmful when the temperature drops and the rock contracts. Water attains its highest volume at 4° C, and since this is the average evening temperature in cold-climate areas, this fact explains why crystals are formed in the rock, producing microgaps and further exfoliation (Figure 14.2A)

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PROYECTO DE DOCUMENTACION DE ARTE RUPESTRE
SISTEMA DE REGISTRO Y ARCHIVO DE DATOS
FORMATO DE YACIMIENTO

01 NOMBRE DEL YACIMIENTO: "Piedra La Candelaria" 02 CODIGO: C-001-001-001-001

030 Proyecto: Manantial Encanto Mumbo 2000-2005 040 Coordenadas de salida: 0011-47-0011-0011-0011-0011
050 Instituciones: GIPRI, UTA, IPI, IPI 060 Párrafo Histórico: 001-001-001-001-001-001
070 Registrado por: GIPRI 080 Coordenadas de salida: 001-001-001-001-001-001
090 Fecha: Noviembre 07 Mayo 08 100 Laboratorio Digital: CUADRICULA

1. ENTORNO

110. Formación Geológica: Crítico superior, Formación Guadalupe.

120. Litología: Areniscas duras poco estables.

130. Geomorfología: Articuladas, direccionales y fallas, hasta la fuente bajada hacia tierra caliente.

140. Tipo de suelo: Húmedo con baja fertilidad.

150. Vegetación: Bosque seco montano bajo (BS - MB). Se pueden distinguir las siguientes especies: Papayillo, Tamo, Lato, Betamo, Cedrillo, Draga, Salvia, Mera, Pimiento, Birden, Cerezo, Equiso. Auto se observan algunos cedros, robles, duraznillos y gacajos. En terrenos abiertos subsisten también reducidos de plantas arbóreas: Sarracenia, abelotas, chinos, corra, corrión. En los pantanos crecen los juncos y ciprésicos, en las cañadas y laderas abunda el cheques.

160. Utilización actual del terreno: Las comunidades precolombianas, poblaron buena parte de estas áreas, establecieron cultivos e iniciaron la transformación del paisaje vegetal. En la actualidad se está organizando un parque con fines de reforestación con vegetación primaria y para realizar recreación pasiva. El uso se llama: Parque Ecológico la FOMA, organizado por la Cámara de Comercio en el programa de HOJAS VERDES.

170. Condiciones climáticas

171. Temperatura media: 12 - 18°C

172. Pluviosidad media: 500 - 1000 mm

173. Velocidad Vientos: _____

174. Punto de rocío: _____

175. Humedad relativa: _____

OBSERVACIONES Las condiciones del intertempo y la humedad del techo de la roca, son los mayores factores de alteración. Sobre el grupo principal de dibujos, hace algunos años (más de 25), se ha podido observar la presencia de unas áreas blancas que han venido ampliándose poco a poco, deteriorando el dibujo y con ello las pinturas. El otro factor que genera en el sector norte, donde había capa orgánica (sedimentos), destruyendo de esta forma la posibilidad de encontrar algunos elementos, que pueden asociarse a las pinturas. En la parte superior de la roca existe un pozo que en todas las temporadas tiene agua y que se filtra en la parte profunda. Debido al excesivo agua que se acumula en la parte superior de la roca, se han generado manchas de color café sobre estas paredes y desplazamiento de la película de las pinturas, además de incremento pronunciado de líquenes y hongos orgánicos diversos.

A

CONVENCIONES

02 CODIGO: C-001-001-001-001

Factores de alteración

Preservación	Alteración	Preservación	Alteración	Preservación	Alteración
Capacidad	Resistencia	Resistencia	Resistencia	Resistencia	Resistencia
Resistencia	Resistencia	Resistencia	Resistencia	Resistencia	Resistencia
Resistencia	Resistencia	Resistencia	Resistencia	Resistencia	Resistencia

Deterioros

Preservación	Alteración	Preservación	Alteración	Preservación	Alteración
Preservación	Alteración	Preservación	Alteración	Preservación	Alteración
Preservación	Alteración	Preservación	Alteración	Preservación	Alteración
Preservación	Alteración	Preservación	Alteración	Preservación	Alteración

Microflora

Color	Nombre	Color	Nombre
1. Líquido Fruticoso	1. Líquido Fruticoso	1. Líquido Fruticoso	1. Líquido Fruticoso
2. Líquido Fruticoso	2. Líquido Fruticoso	2. Líquido Fruticoso	2. Líquido Fruticoso
3. Hongos amariados	3. Hongos amariados	3. Hongos amariados	3. Hongos amariados
4. Hongos amarillos	4. Hongos amarillos	4. Hongos amarillos	4. Hongos amarillos

Macroflora

Color	Nombre	Color	Nombre
1. Líquido Fruticoso	1. Líquido Fruticoso	1. Líquido Fruticoso	1. Líquido Fruticoso
2. Líquido Fruticoso	2. Líquido Fruticoso	2. Líquido Fruticoso	2. Líquido Fruticoso
3. Hongos amariados	3. Hongos amariados	3. Hongos amariados	3. Hongos amariados
4. Hongos amarillos	4. Hongos amarillos	4. Hongos amarillos	4. Hongos amarillos

2. CONVENCIONES

B

Figure 14.2 GIPRI recording forms. A: Climatic Conditions Form describing environment, lithology, geomorphology, and current land use. B: Conservation Form 2. Graphical conventions are used to identify active alteration and deterioration factors.

After the climatic-conditions form, a second form was used to make reference to solar radiation, winds, microflora, macroflora, and pollution. In this way, all the aspects linked to the alteration factors were put together in one place within the database.

A graphical convention table identifies alteration and deterioration factors by means of the colours assigned to each one (Figure 14.2B). In this model, only deterioration visible on the rock surface is taken into account; microscopes are not available to identify small-scale indicators. Active alteration factors are registered according to a two-fold system as being either passive or active. Quantification of the deteriorated area is assessed as a percentage of the overall area of the panel. The two measurements needed to determine this are made by approximation.

Further forms are employed to describe rock-art motifs and symbols using colour bars and textures in a first stage. These field measurements serve as an initial diagnostic that is widened and confirmed with laboratory analysis.

DIGITAL LABORATORY AND MACROPHOTOGRAPHY

GIPRI developed computerized descriptions based on saturated photographs in order to enhance some of the descriptions made on site. The use of photographs (either saturated or not) permits a detailed record in wide panorama of the weathering dynamics which affect the rock and the paintings or engravings. Professional 14.7-megapixel digital cameras capture with precision the different existing colours that go beyond the capacity of the human eye. The process starts when a sequence of photographs of a given site or panel is taken, setting the camera on a tripod to obtain detailed photos of a wide area. Usually, this process is carried out for one side of the site/panel only; sometimes a pictorial group is chosen. The sequence of photographs is then unscrambled by manipulating up to 20 images at a time. The result is a 350-megapixel composite photograph, which becomes the raw material to support and accompany the different forms described earlier (Figure 14.3). The composite image is also used both to describe pictorial groups and to delineate conservation issues. A recent development was the use of a robot, which takes photographs with higher precision and automatically unscrambles the sequence.

The digital laboratory form is composed of several fields relating to the initial photograph. These fields contain information that can be displayed using photographic software. In the case of paintings, it is possible to change tones and colour temperatures, to superimpose different pigments, and to analyse pigment colour in relation to the possible variations caused by the age of the materials and colour changes caused by the alteration of constituent minerals. Equally, filtering out and highlighting areas of green colouration permits the delineation of areas colonized by lichens, fungi, and algae on the surface of the rock-art panels. Use of colour-saturation levels also allows the identification of damaged areas due to salt and the loss of pigments or parts

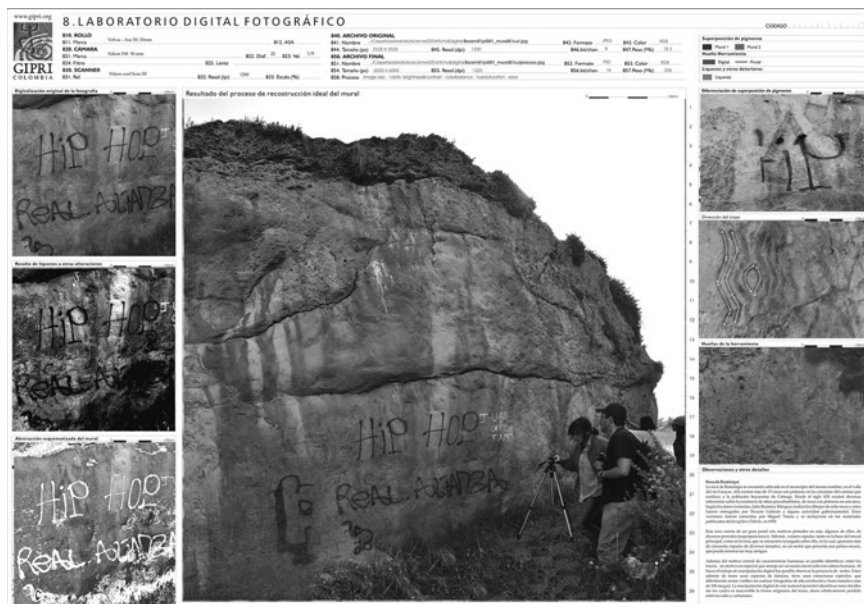


Figure 14.3 GIPRI digital laboratory and macrophotography recording: Digital Laboratory Form. It is composed by several fields derived from a large photograph. These fields contain information that can be displayed by using the photographic software. (Paintings at Chivo Negro, Bojacá, Cundinamarca.)

of engraved motifs. The precise points where the drawings start and end can also be observed. Finally, these same photographs can be desaturated of all the colours except those of the pigments of the painting so that particular motifs can be observed, without interference, in their present condition. A further exercise permits additions to be made in the same colour as the original pigment so that deteriorated areas can be restored on the computer image and the original painting reconstructed in a way that looks very like the original.

It is hoped that in future, these optical approximations can provide the basis for monitoring, recording, and calculating the rate and extent of deterioration and alteration. Joining all the datasets together, it may be possible to establish links among climatic factors, humidity, and temperature as a means of understanding the dynamics of small areas located either on the surface or at the junction between the natural rock surface and the carvings or pigments that it supports. Such monitoring is just as important for areas that have been the subject of conservation works as for other parts of the site or panel.

Some macrophotographs can be used to detect and map the presence of particular minerals on the surface of panels. Concerns have arisen in the last few years regarding the whitening of paintings, a problem for which no scientific explanation has yet been developed. The only recommendation from

conservation experts involves avoiding the natural wetting of the surfaces; however, this is quite difficult to achieve since rock-art sites are located in the open air.

ANALYSIS OF THE COMMON DETERIORATIONS IN ROCK-ART

Physical and chemical analyses of common forms of deterioration found on rock-art paintings were carried out. These forms of deterioration have destroyed many of the motifs at certain sites, and due to their solidity and concentration, they seem to have been active for a long time. At some sites it is easy to observe that these concentrations grew up under motifs and, across the years, have lifted pigments. In other cases, whitish spots appear on paintings, occasionally covering them wholly.

The site chosen for sampling was the Grid rock since this rock-art panel/outcrop is in a fairly advanced state of decay. Two samples were taken, one from an outer layer containing the whitish crust and the other from an inner layer that seems to include the same concretion. Analyses were carried out at Centre de Spectroscopie Infrarouge, Musée de l'Homme, in Paris, coordinated by Dr François Fröhlich, as part of the master's degree programme completed by one of the authors (Trujillo 2008). Using Fourier infrared spectrometry (FTIR), two kinds of inorganic elements were detected in the concretions. For the surface sample, the results revealed the presence of silicon oxide (SiO_2), or hydrated silicon dioxide. Such material can appear through biogenic causes: secretions from microorganisms that become mineralized by permanent contact with water.

This process by which a living organism produces minerals as an outcome of its metabolism is called biomineralization. But another way in which these minerals can appear is through the presence of unicellular algae of the kind that are present in both marine and fresh water. These algae are cells that photosynthesize but have a silica cover (Trujillo 2008).

The results of the FTIR analysis of samples from the inner layer are also very interesting. The material corresponds mostly to an uncommon mineral called monohydrocalcite ($\text{CaCO}_3\text{H}_2\text{O}$) and results from an algae biomineralization process occurring in high-humidity environments. This mineral can be transformed into calcite and seriously damage rock surfaces and, hence, rock-art (Trujillo 2008).

The identification of these elements proves that high humidity, because of accumulated rainwater in the upper part of the outcrops, plays a major role in Colombian rock-art weathering. Water circulates inside the rock, thus damaging rock-art motifs. Hence, it can be concluded that humidity is one of the most important factors in the case of both caves and open-air sites. For that reason, it is extremely important to try to avoid the accumulation of water on rock-art surfaces and outcrops, namely by installing gutters and channels.

The final goal would be to avoid the main condition for the biomineralization processes. Permanent monitoring of the sites to detect temperature and humidity changes is ideally required. GIPRI is presently carrying out a detailed study of variations in temperature and humidity at certain sites; with the help of proper equipment, this will include year-round recording.

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15 Conservation of Rock-Art Sites in Northeastern Brazil

*Maria Conceição Soares Meneses Lage
and Wellington Lage*

INTRODUCTION

Northeast Brazil is rich in prehistoric archaeological sites, most of them presenting paintings and engravings. The majority are located in the open-air, consisting mostly of sandstone rock shelters. Many rock-art panels are at risk through natural action linked to the weather, or by human action. However, for more than 20 years, conservation work has taken place in an attempt to slow down the disappearance of such important evidence of past human presence in the region. It began in Serra da Capivara National Park, situated in the northeastern state of Piauí, which arguably contains the highest concentration of archaeological sites in the country. So far, more than 1,300 archaeological sites have been registered in the Park. Although the interventions were aimed at the conservation of rock-art sites, the original purpose was somewhat different. In the beginning of 1985, an attempt was made to directly trace the paintings at the site of Toca da Entrada do Baixão da Vaca using plastic sheeting and felt-tip markers. The work was unsuccessful because of the large amount of insect nests (predominantly wasps) covering the main panel, making it difficult to visualize the paintings. It was decided to remove these deposits mechanically, using soft brushes and wooden spatulas made by a local craftsman specifically for this task. After removal, it was possible to observe more than 280 figures that had not been previously recorded because they were covered by wasp clay deposits, and direct tracing of the paintings could finally be carried out. Only a few years later, in 1991, conservation work began systematically in the Park and continued through to 2009. During this period, conservation interventions expanded to include other rock-art sites located in neighbouring regions.

This chapter presents a summary of the work undertaken in northeastern Brazil, with a series of six case studies starting with the Serra da Capivara National Park (Figure 15.1).

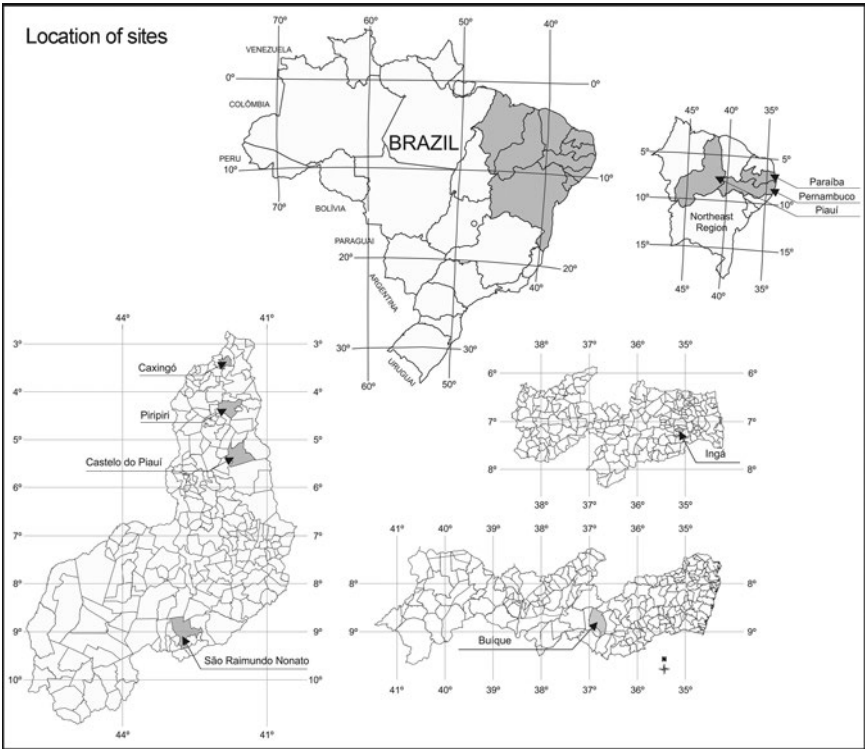


Figure 15.1 Location of sites mentioned in the text.

HOW TO PRESERVE PREHISTORIC ROCK-ART?

The conservation of Brazilian rock-art began in the 1980s, with the chemical analysis of the pigments of different prehistoric rock-art traditions, the subject of a doctoral thesis by one of the authors of this chapter (MCSML) undertaken at the Université de Paris I, France. The main objective of the research was to know whether there were differences in the preparation of pigments that could be related to depictions belonging to different rock-art traditions in the region of the Serra da Capivara National Park. More than 200 samples were analysed representing the different traditions present in the Park (Guidon 1984, 1988; Pessis 2003). The pigments were sampled according to the established classification of the sites, with strict criteria applied to the requirements for analysis and for the integrity of the artwork. Samples were collected from areas of the rock already possessing fractures, ensuring that the paintings were not harmed. Three shades of red pigments (light, medium, and dark) were collected, besides yellow, grey, and black. Some years later, samples of a bluish pigment present in just a few sites in the Park were also collected. Sample analyses were performed at the Laboratoire

de Recherche des Monuments Historiques in Champs-sur-Marne, France, under the guidance of Jacques Brunet, who was responsible for the conservation of many French cave rock-art sites. From the beginning, international guidelines for the protection of cultural heritage were followed. A strict operating sequence was adopted, initiated by the interdisciplinary study of the materials that make up the rock-art and the alterations that accelerate their degradation. These studies were based on the ethical considerations provided by the Venice Charter (ICOMOS 1964) emphasizing respect for the source material, the aesthetics of the artwork, and the reversibility of the interventions (Brunet et al. 1985; Lage et al. 2004).

In addition to these specific guidelines, there was also a concern to meet the requirements of Brazilian laws, regulations, and constitution that determine the rules for the protection of archaeological sites. It is also of the utmost importance to consider the archaeological sites as part of a natural environment and that any conservation action should try to encompass both the cultural and the natural fields.

The conservation projects at rock-art sites should not be undertaken without a thorough study of previous work and the problems it revealed. In our case, the work began by conducting a series of tests and trials to establish a sound interdisciplinary basis. Hence, professionals from different fields brought their expertise to identify origin and structure of the prehistoric rock-art sites and the conservation problems they faced. The results obtained allowed a technical diagnosis of the state of conservation of the sites and directed the course of future interventions. In the view of the authors, conservation work should follow the simple sequence assessment–diagnosis–intervention–monitoring.

Assessment involves field and laboratory work. In the field, tests and observations were performed with the naked eye and using a magnifying glass in order to check the general state of the rock support, the presence of fractures, cracks, the condition of the prehistoric images, and the incidence of degradational agents. The information obtained was recorded on conservation forms containing details about the rock surface, the prehistoric representations, and accumulated alteration deposits. Observations on external influences such as sun exposure, thermal variation, drainage of rainwater, and fire, flooding, pollution, and destruction risks were also recorded. A thorough photographic coverage of the sites was made, which is also useful as a benchmark for future monitoring. The most important aspect of rock-art conservation is the detailed study of the representations, rock panels, and the environment into which they had been inserted.

Following the basic field assessment, areas of the decorated panels were chosen for sampling in order to provide specimens of the rock surface, the alteration deposits, and the prehistoric pigments represented. Other *in situ* measurements are also taken in order to verify weather data, characterize the underlying rock surface, and document the nature of the pigments.

In the laboratory, samples are separated, sorted, catalogued, and subject to review under a binocular microscope. Samples are then subject to specific analyses depending on the nature of the material. A wide range of analytical techniques were used, including energy dispersive spectroscopy (EDS), scanning electron microscopy (SEM), X-ray diffraction (XRD), X-ray fluorescence (XRF) with energy dispersive spectroscopy, and Fourier transform infrared (FTIR).

The results obtained allowed the identification of the chemical composition of the main components sampled: the rock surface, the prehistoric representations, and the overlying alteration deposits present at each site. The measurements taken *in situ* provide data on the potential risks to which the heritage resource is exposed, such as variations in temperature, radiation, humidity, and biological and/or anthropogenic degradation factors such as graffiti, vandalism, pollution, and tourist impacts. These observations were added to the locational data, the assessment data, and information from the samples collected in a series of databases with the photographic coverage of each site attached for reference.

CASE STUDIES

The following six case studies provide a glimpse of the rock-art conservation work undertaken over the last few decades in Northeast Brazil.

Serra da Capivara National Park, near São Raimundo Nonato, Piauí

Serra da Capivara National Park contains one of the largest archaeological complexes of the Brazilian Northeast, consisting mainly of rock-art sites. Such potential is displayed by interdisciplinary scientific research initiated in 1970 and coordinated by Dr. Niède Guidon with funding from the French government and support from the Federal University of Piauí.

It was in Piauí's southeastern region that work on the conservation of prehistoric paintings in the country began. An initial diagnosis of 246 sites in the Park identified problems arising from two separate origins: natural, weather-related mechanisms due to the long time the rock-art motifs have been exposed and anthropogenic actions carried out on purpose or by accident. Among the natural problems, the most serious was linked to the nature of the rock outcrops that support the paintings and engravings because most are formed of very friable sandstone, which suffers rapid degradation when exposed to the elements (Figure 15.2A). This decay process is exacerbated by regional weather patterns, comprising very high temperatures during the day and sudden drops at night, causing the vaporization of interstitial water and intense internal pressure, which hastens the disaggregation of the rocky surface. Another natural agent that accelerates the



Figure 15.2 Rock-art conservation in Northeastern Brazil. A: Serra da Capivara National Park. Reassembly of a rock-art panel with painted pieces found in archaeological soil. B: Sete Cidades National Park. The consolidation of a rock-art panel. C: Pedra do Castelo site. Panel with graffiti before conservation work. D: Pedra do Castelo site. Panel with graffiti after conservation work. Note that the circular engraved motif became more visible. E: Arco do Covão. Vegetation covering a rock-art panel, before intervention. F: Arco do Covão. Rock-art panel shown in E after removal of the vegetation. (Photographs by Maria and Welington Lage. Copyright reserved.)

degradation of the rock-art and its support is the action of rainwater. In this part of Brazil, most of the rainfall is concentrated in a period of 4 months of torrential rain, followed by 8 months of drought. There is also the action of biological deposits formed by substances that originate from plants or

animals, transported and accumulated over the years by the action of water, air currents, or animals. The most common examples of this are:

- Animal faeces, especially from the rock cavy or *Mocó* (*Kerodon rupestris*, rich in vegetable fibers and resins, usually to be found on the floor of the sites or in rock crevices. There are cases where faeces trickle down from the top of the wall onto prehistoric panels.
- Termite galleries formed of scrap wood, clay, and animal secretions. In many cases, these occur directly over rock-art motifs, while in other instances galleries are built in the fractures opened by rock exfoliation. Moreover, the movements of the insects are paramount in rock-art deterioration due to pressure and eventually end up creating incisions on the rocky surface.
- Nests of wasps (*Hymenoptera insecta*), consisting of clay and animal secretions. These deposits are of two kinds: round, about 2 cm in diameter, and rectangular, about 6 cm by 2 cm. In both cases, clay impregnates the surface of the rock and sometimes can even cover entire panels. When fresh, mechanical instruments can easily remove these deposits, but they become harder when they get older, and at this time removal is only possible by chemical procedures. Removal often leaves marks on the panel surface.
- Black graffiti consisting, in general, of charcoal. If fresh, graffiti is easily removed by mechanical instruments.
- Tree branches or vegetable roots formed from cellulosic fibbers and natural resins, which are highly detrimental to conservation because they destroy the rocky surface in three different ways: chemically (the production of humic acids), mechanically (causing the dilation of the rock by roots infiltrating crevices, accentuating the degree of fracturing and disrupting cohesion of the support), and microbiologically (by permanently retaining moisture in the rocky surface, favouring the development of microclimates).

Of the different mechanisms listed, plants, besides presenting a potential fire hazard at the site, are the most threatening as they contribute to the mechanical, chemical, and biological degradation of the rock support. Natural growth of roots and stems penetrates the interstices within the rock formations, forcing them to ‘provide’ necessary space for expansion. Experimental measurements of the force exerted on a rock by roots and stems provided values in the order of 15 atms. Chemical action originates from root tips that have an acidic character with pH values ranging between 2 and 3.8. The root exudes ‘gameleira’ containing very aggressive organic and inorganic compounds such as carbonic, tartaric, citric, and Krebs cycle acids and nitrogen compounds that attack the rocky cement and promote its disaggregation. Lastly, the presence of roots and stems creates a microclimate within the rock, leading to an increase in local moisture retention, thereby creating ideal conditions for the proliferation of microorganisms

(fungi, algae, bacteria, lichens). These microorganisms have a strong degradational action on the rock surface because in time they create a secondary environment favorable to the growth of higher plant species (Lage 2007). Among other dangers provoked by microorganisms, there is the problem of algae that require only light, humidity, and some inorganic salts, which they take from the rock itself. Lichens also have a highly aggressive role in rock degradation through chemical and mechanical action. The chemical process is the most serious, as it produces carbonic acid and oxalic acid excretions, fostering the formation of soluble metal complexes.

Insects, birds, and wild and domestic animals also act negatively on the rocky surface. Besides the direct mechanical action they exert on it, their droppings (guano) are formed of aggressive chemicals such as organic nitrogen (uric acid) or inorganic alkaline phosphates, which become strong acids (H_3PO_4 and HNO_3) and attack the stone, exerting dangerous corrosive action (Lage et al. 2003).

An action plan for the conservation of the diagnosed sites needed to be created, and due to the large number of sites, it was decided to promote a conservation-orientated educational program directed at youngsters living in the region (Lage and Borges 2003). The goal was to enable selected individuals to help in conservation work. These youngsters became part of Museum Foundation of the American Man (FUMDHAM) conservation team, which has been working on the region for the last 10 years. New refresher courses and training for other young people happened five more times. The main mission of the team was to keep the sites free from attack by insects and invasive plants. They were not allowed to take any further action without previous agreement from the conservator responsible for the site. The presence of any problem was quickly recognized by the team, even when there was need to undertake consolidation of the rock surface or install a 'pseudo-gutter' to divert water seeping over a particular rock panel. This systematic work was especially directed at preparing sites for visits by tourists. It was understood that sites should not be opened up to the public unless adequate conservation measures had been put in place. It is necessary first to clear rock-art panels, making them aesthetically attractive in order to promote respect for the integrity of the site. In certain areas of the Park, as in the canyon of Serra Capivara, it was possible to see highly intrusive painted and sometimes engraved graffiti on rock-art panels, such as advertisements for shops, political candidates, religious messages, sentimental wishes, dates, and people's names. Such vandalism cannot be left visible in places open to visitors because it becomes an invitation for new graffiti, leading ultimately to the destruction of the site.

Sete Cidades National Park, Piauí

The Sete Cidades National Park is located in northeastern Piauí and was the first National Park created in the State of Piauí, back in 1961. Initially it had an area of nearly 7,000 ha, which was recently expanded to nearly 15,000 ha.

The main feature of this Park is the presence of geological structures comprising large sandstone boulders, where differential erosion has created intriguing shapes that resemble stone cities, characters in Brazilian and world history, and tortoise shells. This raised many fanciful explanations for the origin of the place. However, archaeological investigation undertaken by researchers from UFPI (Núcleo de Antropologia Pré-histórica) showed that in the past, the place was inhabited by human groups that recorded figurative and non-figurative paintings and engravings on the walls and ceilings of rock shelters. These painted panels were exposed to the elements, posing a range of conservation problems that needed to be addressed.

Conservation work started in 1995, with the survey and cleaning of 13 sites that were open to the public. The same principles and methodology adopted in Serra da Capivara National Park were used. The main goal was to neutralize the action of degradation agents impacting the survival of painted panels and attempt to avoid recurrence of the problem.

With the aim of getting a better understanding of the site and its survival and condition, fieldwork and laboratory analysis were carried out. Interventions in the field consisted of the following interventions:

- Cleaning the sites with the removal of insects nests, shrubs in direct contact with the rock, and low vegetation growing on the shelters
- Application of herbicide in termite galleries close to prehistoric paintings
- Covering up the graffiti engraved on rock-art panels located in the Park
- Laboratory work was conducted at the Department of Chemistry of UFPI and at the Laboratoire de recherché des monuments historiques, France. It consisted of the examination and physical and chemical analyses necessary as a background to conservation work, including the study of alteration deposits and prehistoric pigments.

Both fieldwork and laboratory work included participation by students researching the conservation of sites in Sete Cidades National Park. Something of the results obtained by conservation work can be seen in Figure 15.2B. Unfortunately, work had to be interrupted because of the lack of financial resources, and the sites are now again vulnerable to attacks.

Pedra do Castelo, Piauí

Pedra do Castelo is a sandstone geo-archaeological monument situated in Castelo do Piauí county. Discovered by travelers in the late eighteenth century, it has been used since early colonization of the region as a burial place and for Catholic, Evangelical, and African-Brazilian religious ceremonies. Several legends are associated with the site, which receives a large number of visitors, many of whom are on pilgrimages. Visitor pressure has resulted in the appearance of several different types of impact, including graffiti, dirt and candle wax, the fixing of images with cement and lime onto the rocky

walls, and the collecting of rock debris for use in making teas and infusions. To these can be added natural degradation by saline inflorescence, fracturing of the rock around openings, niches, and doorways, infiltration of light, and insect nests.

Conservation works were undertaken in order to eliminate these recent attacks and allow better visibility of the prehistoric paintings and engravings, giving back to the local community the evidence seen by the first visitors to the place (see Figures 15.2C and 15.2D).

Arco do Covão, Piauí

Arco do Covão is a magnificent archaeological site situated in northern Piauí about 70 km from the coast. It is a large boulder, about 70 m long and 20 m high, forming a shelter. One of the walls of the shelter features the largest concentration of paintings at the site, more than 700 prehistoric images. Some of these paintings are outstanding, especially the positive hand prints, and feature representations rarely observed at other sites. The area is surrounded by lush vegetation, with numerous tall palm trees and a stream of crystal-clear water.

When the rock-art motifs were first documented, the rock wall was completely covered with ‘gameleira’ roots, which presented a serious threat to the integrity of the site and also made the readability of the figures difficult. In 1997 and 1998, conservation work was carried out with the aim of removing these roots. The work involved collaboration with a biologist from the Universidade Federal do Piauí (UFPI) and the Empresa Brasileira de Pesquisa Agropecuária (EMBRAPA), who identified the plant species and guided the use of appropriate herbicides in order to eliminate threatening plants without harming other local species. Conservation work was performed by alternating mechanical and chemical methods (Figures 15.2E and 15.2F).

Pedra do Ingá, Paraíba

Pedra do Ingá is an impressive granite boulder, 20 m long and up to 3.56 m high, located in the riverbed of the Ingá de Bacamarte in Paraíba State. It features figurative and non-figurative engravings and other marks. It is one of the most important rock-art sites recorded in the country and was listed in 1944 as National Heritage. However, it is threatened with destruction through natural and anthropogenic forces. Erosion is an ancient but ongoing process, with some engravings showing that they were executed after exfoliation of the underlying rock. Although important, this site has not been subject to systematic archaeological research and even lacks an established chronology for the rock-art represented. Published accounts only describe and attempt to interpret the engravings. Our study aimed primarily at making a diagnosis of the condition of the site. First the main biological,

chemical, mineralogical, and microbiological components were identified. This assessment allowed the specification of works aimed at the management of the site: cleaning and consolidating the rock-art panel and installing interpretative boards and signs to facilitate public access and appreciation. The site was completely infested by crustose lichens that had settled into fissures in the rock surface. As noted, lichens are highly aggressive to rock through chemical, mechanical, and microbiological processes.

Analysis of water taken from the Bacamarte River was undertaken, samples being collected approximately 10 m upstream of the engraved rock. The results indicated very high levels of pollutants such as faecal coliforms ($> 1,600$ per 100 mL), *Escherichia coli* (c. 540 per 100 ml), and heterotrophic bacteria (6.7×10^4 CFU per ml), which poses great threats to the site and visitors alike. These results indicated that river water is unfit for agricultural use or for bathers. The high content of *E. coli* can cause serious infections, and its presence in water is indicative of contamination with human faeces. Heterotrophic bacteria indicate the occurrence of microbiological pollution and, in the levels presented in the sample collected, means that there are widespread infestations.

Air and surface stone temperature measurements collected during the study indicated that the thermal expansion rate is significant, with great daily variations between surface and air at peak hours.

Overall, it was concluded that the site presents numerous negative factors that are accelerating its destruction, especially its open-air location beside a highly polluted river, exposure to wind, rain, UV and IR radiation, daily thermal variations, seasonal flooding, and biological and humans attacks. All this leads to the degradation of rock walls supporting the rock-art panels, as clearly evidenced by the presence of fissures, fractures, superficial and structural cracks, disintegration of the stone surfaces, and the detachment of rock fragments, some of which carry prehistoric engravings.

The combination of all these processes alongside other factors such as trampling by visitors and domestic animals poses a real threat to the site and needs to be addressed urgently. In the 1990s, a Spanish researcher, Manuel Morales, visited the Pedra do Ingá and pointed out some actions against those agents that threaten the conservation of the site, such as stopping the water seeping over it and reducing the mechanical effect of trampling animals and site visitors. Daily exposure to solar radiation needs also to be reduced in order to decrease the temperature of the rock during the hottest hours.

A related cause of concern is the irreversibility of the degeneration of the rock surfaces and the degradation caused by the presence of microorganisms. Sometimes there are areas that cannot be recovered, so remedial intervention in surviving areas is now urgent.

At a more general level, the Pedra do Ingá and its local environment has been slightly mischaracterized, as it is used as a general recreational area rather than for the appreciation of its archaeological interest. This needs to change

while the engravings are still there, as they clearly illustrate much about the cultural sophistication of the communities that created and used them. For the preservation of this site, the following steps were suggested to the Paraíba delegation of the National Institute of Historical and Artistic Heritage:

- Creation of an environmental preservation area, co-administered by local, state, and federal agents
- Development and implementation of a management plan for the site encompassing its conservation, management, and monitoring
- Creation of awareness campaigns on environmental and heritage education targeted at the local population

Vale do Catimbau National Park, Pernambuco

Vale do Catimbau National Park is located in the southeastern state of Pernambuco covering an area of 62,300 ha. This Park, established in 2002, preserves one of the last reserves of Caatinga in the state, being considered an Area of Biological and Archaeological Extreme Importance. At least 30 archaeological sites with prehistoric occupation dating back 6,000 years have been recorded.

The sites in Vale do Catimbau have serious conservation problems, caused by biological weathering, with the proliferation of plants in the crevices of the rock support. At one site, Loca das Cinzas, large lichen colonies cover prehistoric paintings. On another site, depredation has been caused by vandals who damaged the panels by spreading red paint over them. This situation prompted actions by the Pernambuco National Institute of Historical and Artistic Heritage, who undertook maintenance work at four sites because the loss of such assets would be irreparable for Brazilian prehistory.

Conservation work was carried out from October 2009 to July 2010 and began with a technical assessment. However, an assessment and diagnosis is not only made through field observations and laboratory analysis; it is something much more complex that should really be constructed from a series of studies followed by tests to measure the effects of direct intervention. According to Brunet and colleagues, “a general diagnosis on the state of conservation of the site will only be completed after the intervention work” (Brunet et al. 1985).

The intervention on the four sites consisted of the consolidation of rock panels featuring prehistoric paintings that were loose or starting to become detached from the parent body, the installation of gutters to divert water from prehistoric motifs, and cleaning off deposits, such as dirt, graffiti, salt efflorescence, and bioalterations. During fieldwork, temperature measurements of the rocky support were collected in points inside and outside the shelters. The collection of data occurred three times a day, at dawn, at 14:00 hr, and at dusk. Additionally, an anemometer was used to measure wind speed (in this case, the speed of displaced air masses on the prehistoric panels).

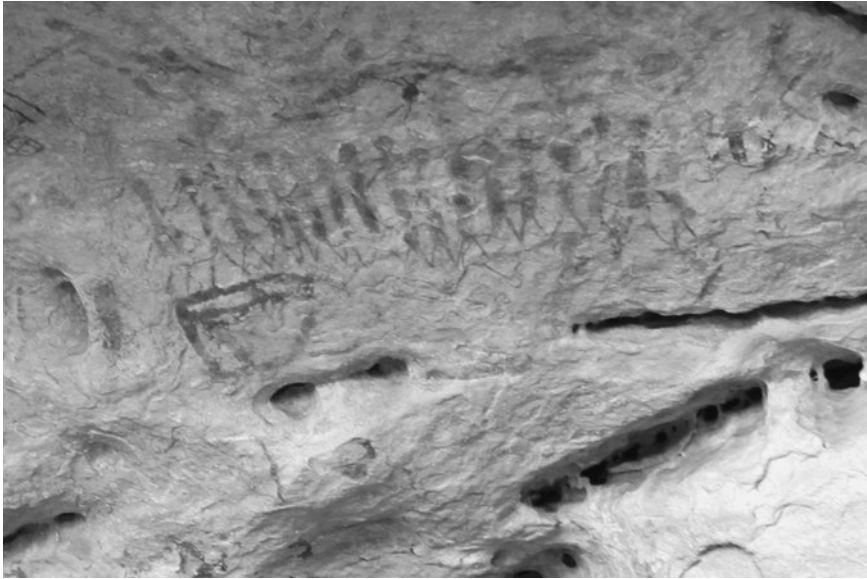


Figure 15.3 Vale do Catimbau National Park. Rock-art panel after lichen removal. (Photograph by Maria and Welington Lage. Copyright reserved.)

The microfissures of the rock support were observed with a portable microscope. Together, these observations were made with the intention of providing a baseline record of the site's condition so that details could be checked and compared over the years and a better understanding developed of the evolution and impact of fractures and other threats.

In practical terms, the methodology used was similar to that employed over the last 20 years at the Serra da Capivara National Park. In some cases it was necessary to use chemicals to stabilize or neutralize the action of deposits, especially those of biological origin, but all were tested and approved in advance of their application. Results of conservation work in Vale do Catimbau can be seen in Figure 15.3.

CONCLUDING REMARKS

It is important to consider the unique character of rock-art conservation. In contrast to other cultural monuments where it is possible to control processes of moisture, evaporation, sunlight, and drainage systems for rainwater, rock surfaces are not so physically limited or so easily defined. At the same time, the conservation of prehistoric rock-art cannot be considered only as a technical operation directed towards minimizing the impacts of damaging agencies such as natural degradation and vandalism. Rock-art is a complex heritage resource that deserves to be preserved but not necessarily

treated as a 'work of art' involving a definitive complete image. Restoring rock-art involves improving our ability to read or comprehend something of what is left of the original representation, as well as avoid the imminent loss of further elements. Conservation requires a deep knowledge of the constituents of the prehistoric paints and the problems that affect them. There is a view among some experts which says that doing nothing may sometimes be the best action to preserve remaining panels, and in some cases they may be right. In rock-art conservation, there are no miracles, just some actions to minimize or slow down deterioration; looked at in the long term, it is impossible for us to prevent their eventual disappearance.

ACKNOWLEDGEMENTS

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16 Past and Present, Traditional and Scientific

The Conservation and Management of Rock-Art Sites in Australia

Melissa Marshall and Paul S. C. Tacon

I worry about that place . . . secret place. That got painting there, inside cave. It got to be looked after because my father, granddad all look after. Now me, I got to do same.

(Big Bill Neidjie, Kakadu National Park, 1985)

INTRODUCTION

Rock-art conservation and the management of rock-art sites have developed in a somewhat reactionary way in Australia—methods and techniques have often changed as a result of the emergence of issues affecting sites. These issues include the arrival of unexpected visitors to sites (from the time of European colonization of Australia to the tourists who are now exploring the country, searching for sites with GPS locations from fellow travel bloggers); the identification and assessment of conservation issues within sites relating to natural impacts (such as water damage and disturbance by animals) and the subsequent development of techniques to deal with these; and the identification, assessment, and emergence of mitigation strategies for human impacts to sites (relating to everything from mining, road creation, and industrial development to tourism and the ability to manage numbers so as to minimize impact on sites).

In this chapter, we explore the history of these conservation and management practices in Australia and the development of strategies to deal with perceived impacts over the last 50 years. It is then shown how the history of these practices and changes in the social environment of Australia have moved towards a shared vision for the preservation of rock-art with a greater emphasis now placed on traditional methods within a ‘caring for country’ framework alongside the exploitation of modern technological applications. A key aspect of this is the re-empowerment of traditional owners to not only guide conservators in their work but also to lead them. The future is bright for the path that this process is now taking in Australia. Where it might lead and some potential implications are also explored in this chapter.

HISTORY OF CONSERVATION AND MANAGEMENT PRACTICES IN AUSTRALIA

The wealth of rock-art recorded in Australia is immense featuring tens of thousands of sites scattered throughout the continent that include many expressive mediums such as painting, drawing, stencilling, printings (sometimes with grass), images made with beeswax, as well as engraving, pecking, and grinding of rock surfaces. All of these techniques culminated in the development of artistic styles unique to the culture of Aboriginal people in Australia. One of the reasons that we still have evidence of these cultural practices is that there were traditional methods for looking after ‘country’—not just rock-art sites—that include the maintenance of cultural protocols, fire and vegetation management, and the ‘refreshing’ or ‘repainting’ of imagery, such as described by Mowarlarli and Peck (1987) and Blundell and Woolagoodja (2005).

With the visits of people from southeast Asia such as Macassans and others from Sulawesi in the last few hundred years (e.g. see Taçon et al. 2010) to the permanent arrival of Europeans in 1788, interest in Indigenous Australian art has always been strong. Throughout the 1800s and early 1900s, many non-Indigenous people set off to explore Australia (Lommel and Lommel 1959; Sturt 1849; Unknown 1861), returning with stories and photographs of their travels, including rock-art sites. Early researchers also added to this documentation and extolled the beauty of many spiritual places to the broader public (Berndt and Berndt 1970; Mountford 1949; Tindale 1974). As interest in Aboriginal people and their culture grew, so did the pressures placed on key sites. Furthermore, the chequered history of Australia’s treatment of Aboriginal people well into the twentieth century made it increasingly difficult for Aboriginal traditional owners and site custodians to look after rock-art sites with traditional methods.

In the late 1960s and early 1970s, pressure began to be placed on government about impacts to rock-art sites from mining, tourism, and development, such as on the Dampier Peninsula (see Bednarik 2006 for the extensive history of impacts; National Trust of Australia 2006; Kakadu National Park [Chaloupka 1974; Gillespie 1983b]; and Quinkan Country on Cape York [Trezise 1971]). The outcomes varied depending on the sites and issues present. For National Parks, like Kakadu and Uluru (Ayers Rock), processes commenced to nominate these Parks for inscription on the World Heritage List. Kakadu National Park, acknowledged for both outstanding natural and cultural values, was added in stages beginning in 1981 (SEWPAC 2011b). Uluru-Kata Tjuta National Park was declared a World Heritage Site initially for its outstanding universal natural values in 1987 and then for its outstanding universal cultural values in 1994 (SEWPAC 2011c).

In Cape York, the Quinkan Reserve, containing outstanding rock-art, was declared an Aboriginal site in 1972, and Quinkan Country was placed on the former Register of the National Estate in 1980. Unfortunately, this register was replaced in 2004 with the National Heritage List, resulting in the Quinkan body

of rock-art losing its statutory protection to be included only on the National Heritage Database (Cole and Buhrich 2012, 68). For the open-air petroglyph sites on the Dampier Peninsula in Western Australia, protection has been more difficult to obtain within the mineral-rich area; the listing of the site complex on the state register was not able to ensure its protection, and it was not until 2007 that it was included on the National Heritage List (SEWPAC 2011a).

Whilst information was being gathered to afford statutory protection to these places, the physical conservation of paintings commenced in the late 1970s. For instance, Gillespie and Chaloupka began the physical conservation of rock-art sites in Kakadu National Park in 1978 with the first installation of silicone drip-lines at Birr (Berry 2011). Within a few years, a number of sites had been treated (Gillespie 1983a, 1983b, 1983c; Hughes and Watchman 1983), and Hughes had published the first report on these types of conservation works within the Park (Hughes 1979). Conservation works continued periodically at sites located in and around Kakadu, with works undertaken at sites in the mid 1980s by Clarke and colleagues (CORLAB 1986, 1987, 1988), followed by a third burst of activity in the mid 1990s by Lambert (1997). Unfortunately, despite this work being undertaken, monitoring of the sites and resulting impacts of the works has not occurred within a long-term framework but relied in many instances upon data collected during a 12-month post, the burden falling to specialists who follow in years to come. This is currently under review as part of doctoral research (Marshall 2010). Kakadu is not alone in this regard, as there have been many instances of researchers working with groups on country to undertake physical conservation works. Long-term issues thus result, as works are not part of a monitoring program and no central records have been retained relating to this.

At the time the initial works began in Kakadu, a number of conservation workshops had been held in the preceding years, and the development of these methods was much debated during this time. These three major workshops debated the problems of deterioration and conservation of rock-art (Hughes 1979, 8) and took place in Canberra in 1972 (reported in Edwards 1975), Perth in 1973 (reported in Pearson and Pretty 1976), and Perth in 1977 (reported in Pearson 1977).

Workshops were then held in Sydney in 1980 (Hughes et al. 1984) and another was held in Canberra two years later (Sullivan and Bowdler 1984), with smaller meetings reported (Rosenfeld et al. 1984). Sullivan (1989, 113–4) went on to conduct further research into the best-practice techniques for the management of sites and identified the following procedure:

- Location and documentation of the site/s
- Assessment of all the values of the site/s
- Production of a statement of significance which summarizes these values
- Research into the management constraints and opportunities available, such as funding, resources, legal and social factors, etc.
- Design of a management or conservation policy for the site
- Application of appropriate management and conservation practices.

This structured procedure remains pertinent today with additional factors to be considered. However, when the physical conservation of a site is required, not even all of these elements are often addressed. Of particular importance is the ability of Indigenous people to guide the practices that are right for their country. In the mid-1980s, a group of Indigenous people in the Kimberley attempted to make use of government employment programs to encourage young people to work and obtain the benefits of cultural continuity. Led by senior elder David Mowarlarli, the group undertook a repainting exercise that varied with results as much as it divided opinions (Bowdler 1988; Mowarlarli and Peck 1987; Sale 1993). Unfortunately for the custodians, the pressure exerted externally on their society meant that they abandoned the experiment.

At this time, a meeting was convened in Burra, South Australia, by International Council on Monuments and Sites (ICOMOS). At the meeting, ethical practices in the conservation of heritage sites in general were discussed, with the result being the adoption of the Burra Charter for heritage practitioners to be guided by (Australia ICOMOS 1999a, 1999b, 1999c). This was the first document of its kind in Australia, and many associations developed their codes of ethics based upon it (AIATSI 2003; Australian Archaeological Association 2003; Australian Association of Consulting Archaeologists 2003a).

The commencement of the publication *Rock Art Research* in 1984 by the Australian Rock Art Association (AURA) covered many of these events and the broader implications for the discipline. Issues were published twice a year and contained a minimum of one article per issue on conservation and management practices for many years, with this reducing dramatically in the late 1990s and into the 2000s. At the time of writing (2012–2013), there appears to be a resurgence in interest, with an article on management now being published once or twice a year.

By the 1990s, many National Parks throughout the country had developed Indigenous ranger teams to work alongside other Park staff to look after sites. Places like the Western Australia Museum and the former Department of Aboriginal Affairs also worked with traditional owners to fence a number of sites in remote regions, such as the Kimberley. Many new techniques were trialled, with varying levels of success. The installation of a boardwalk at Keep River National Park constructed from fire-retardant material provided a valuable lesson in the need for ongoing monitoring of sites (Figure 16.1). A buildup of grass and other vegetation under and around the installation resulted in a bushfire melting the material. It then ignited and exploded into a ball of high-temperature flame, destroying much of the site (Lambert and Welsh 2011; Taçon 2009). In various parts of the country, attempts were made to hinder graffiti, for instance in the Grampians of Victoria, with the construction of metal grills to prevent access to the paintings. However, this introduced other issues and is aesthetically intrusive (Gunn 1983).



A



B

Figure 16.1 Threats to rock-art sites in Australia. A: Fire could destroy Chalawong, southeast Queensland's most important rock engraving site, because vegetation buildup has not been monitored since the installation of a wooden viewing platform. B: This rock-art panel in the Blue Mountains, New South Wales, was covered by several layers of graffiti before suffering deliberate fire damage. It was restored by the local Aboriginal community working with Park rangers. (Photographs by Paul Tacon. Copyright reserved.)

In 1988, the Canberra Institute of Technology was supported by the Australian Institute for the Conservation of Cultural Material and the Getty Conservation Institute to run the only course in the physical conservation of rock-art ever to be held in the country. This resulted in around 20 graduates, many from overseas. Whilst this course has not been held since, there are a number of people who have managed to up-skill in this area through experience working in Parks and with the help of conservation manuals (Lambert 1989; Rosenfeld 1988). The Australian Institute of Aboriginal and Torres Strait Islander Studies (AIATSIS) also developed a Rock Art Protection Program at this time that operated for close to two decades (Ward 1989, 2011). A number of Australian rock-art conservation publications appeared in the early to mid-1990s, but it wasn't until a decade later that conservation and management procedures were described and debated again (Hedges 1989; Lambert 2008; McDonald and Haskovec 1992; Pearson and Swartz 1991; Sullivan 1989; Thorn and Brunet 1996; Ward 1992; Ward and Ward 1996).

TODAY'S VISION: CARING FOR COUNTRY AND THE JOINT MANAGEMENT OF PLACES

In the last decade, a number of advances have occurred in Australia and elsewhere that have revolutionized the conservation and management of rock-art sites in this country. This has included the improvement of joint management arrangements for places; the initiation of programs such as Caring for Country (CFC) and the subsequent Working on Country (WOC) ranger program; the increased legislative protection that has come with the National Heritage List (NHL) and improvements to some state systems, such as the review of Aboriginal Heritage Acts in Western Australia and New South Wales; as well as technological advances in documentation, such as the international RecorDIM initiative (Cancino et al. 2003) and other computer applications (MacLaren 2003) and conservation practices, including those detailed by Lambert (2008) and Steiner (Stadler 2012). Towards the end of the 1990s, a number of National Parks were either handed back to traditional owners (such as in the case of Mutawintji National Park in New South Wales) or entered into joint management arrangements with the groups (such as Mungo National Park in New South Wales and Purnululu National Park in Western Australia). This coincided with reviews of the joint management practices being employed in both Kakadu (Australian National Parks and Wildlife Service 1998) and at Uluru (Australian Heritage Commission 2000a). Key objectives included more meaningful engagement in the management of sites and utilisation of traditional methods to look after 'country'. Whilst both Parks had attempted to engage local Indigenous people in employment opportunities, many were restricted to Community Development and Employment Program (CDEP) positions that came with their own limitations, including sporadic funding.

In 2007, the Commonwealth government developed the Working on Country program, an initiative to recruit Indigenous people as rangers to look after places using both scientific and traditional methods (Commonwealth of Australia 2009). Whilst rangers are engaged to work on anything from weed, fire, and feral animal management to biodiversity studies, they also sometimes work on the protection and management of cultural sites under the guidance of senior cultural advisors (Walter Turnbull 2010). This program has also had enormous social and economic benefits for communities (Allen Consulting Group 2011; Urbis 2012) and provided an additional avenue for researchers to work alongside communities to share both traditional and scientific knowledge. Occasionally, this includes small programs to conserve and preserve rock-art (Figure 16.2).

The development of this program has coincided with the development of Indigenous Protected Areas (identified as ‘our National Parks’ by Indigenous people) and broader Caring for Country plans, such as those produced in the Kimberley region (KLRC 2010). Supporting the collaborative use of traditional and scientific methods has been the development and strengthening of both legislation and procedural guidelines (AIATSIS 2003; Australia ICOMOS 2002; Australian Archaeological Association 2003; Australian Association of Consulting Archaeologists 2003a, 2003b; Australian Heritage



Figure 16.2 Managing and recording rock-art sites in Australia. KNP Indigenous rangers and WOC rangers working together with researchers to look after sites with both traditional and Western scientific methods. (Photograph by Mel Marshall. Copyright reserved.)

Commission 2000b, 2002). Importantly, this has included the creation of the National Heritage List to replace the former Register of the National Estate with greater emphasis on the value or significance afforded to sites. However, this has also been limited in the amount of support that can be provided to groups afforded the task of managing the increase in interest in those places.

The growing use of conservation management plans (CMPs) is providing an additional framework for people to work within. These plans are designed to assess the significance of places, to determine the reasoning behind the need for conservation and management works, and to create a schedule for implementation that can be used by local groups, such as Aboriginal corporations and WOC ranger groups (for examples see Earth Sea Heritage Surveys 2009). This is in keeping with Sullivan's (1989) statement that "the cultural significance of a site is defined as aesthetic, historic, scientific or research value for past, present or future generations" (Sullivan 1989, 113).

The role that technology is contributing to the advancement of practices in Australia is immense. Through the development of devices such as digital cameras, iPads, GPS, and PDAs, the collection of data in the field has been revolutionized. The ability to upload and download digital data rather than double-handle written notes, record with accuracy site locations, and document impacts in great detail continues to improve exponentially each year, pressuring us to improve our methods at a similar pace. The generation of applications to manipulate data improves at a comparable rate, with advances in geographic information systems, photographic software (such as Photoshop), and custom-built applications (such as Ara Iritja and the Kakadu National Park's Cultural Information Management Systems, or CIMS; Ara Iritja Project 2007; Environmental System Solutions 2011).

The development of physical conservation techniques has been by no means as advanced as the computer revolution. However, improvements have been made in many areas. Lambert's recent publication provides a 'how to' in regards to a number of methods to deal with everything from water damage to graffiti and dust removal (Lambert 2008). This is supported by other research at remote locations, such as the termite work undertaken by Brady and colleagues (2010) in the Torres Strait to the use of a laser to 'clean' algae, charcoal, and crystallized salt from a rock shelter in Queensland (Stickley 2012). It should be noted here that while it was claimed that recent laser cleaning of rock-art in north Queensland was a 'world first' (Stickley 2012), the use of laser in rock-art conservation has been taking place in Europe for some time and in the United States since at least 2003, when studies were undertaken in Montana (Pers. comm. J. Claire Dean) and at the Joshua Tree National Park relating to graffiti removal (National Center for Preservation Technology and Training 2009).

Through the combination of the advancements in procedures and technology, along with the intrinsic role that Indigenous people play in guiding these

works, Australia is positioning itself to rejuvenate the processes required to preserve rock-art sites with both traditional and scientific methods.

WHERE TO FROM HERE?

As has been illustrated, perspectives on the conservation and management of rock-art sites in Australia have shifted since the commencement of scientifically driven physical site works in the last 40 years. Whilst the issues placing pressure on these sacred places were similar in nature back then, the impacts of these have grown at an exponential rate. With increasing numbers of tourists accessing remote locations, the expansion of urban development, and mining companies developing new technologies to extract greater amounts of minerals and resources from the ground, there is no time in history when pressure has been greater on Aboriginal people to protect sites.

The increasing re-empowerment of Indigenous people in Australia through programs such as Caring for Country and the recognition of roles people like the WOC rangers play in supporting this have provided Indigenous people with some of the resources required to access places regularly and to strengthen the use of traditional methods. However, funding for such programs is continually under threat. The ongoing support of senior cultural advisors, traditional owners, and site custodians encourages the intergenerational transfer of this knowledge to younger generations as they determine the approaches required at individual sites within their own country, be it traditional or incorporating scientific methods simultaneously. Researchers are also reviewing the role that archaeology as a whole can play in regards to Indigenous natural resource management and the promotion of two-way knowledge sharing (Guilfoyle et al. 2009; Guilfoyle et al. 2013).

Whilst initially researchers and scientists would approach communities regarding the employment of scientific methods to protect sites, Indigenous people are now increasingly turning the tables to drive both the traditional and scientific management regimes (for instance, in the Wellington Range of northwest Arnhem Land). Current research being undertaken by us indicates that, while interest continues to grow in the opportunities science presents to look after sites, Indigenous people are more interested in dealing with impacts prompted by human interaction with places (such as feral animals, dust, rubbish, unauthorized access, and so on) than the natural environment (water, exfoliation, mineralization, and the like). Ways to then record this information employing new technologies are also important, and the systems described such as Ara Iritja, I-Tracker, and CIMS are central to this.

The opportunity that is now presented to us as scientists is that we have 40 years of data to use for a review of the methods that have been employed in the conservation and management of open-air rock-art sites in Australia. In Kakadu National Park, our research into these techniques, such as the installation of drip-lines and the subsequent impacts that this has on sites, is

providing a more complete picture for traditional owners and site custodians to measure against. What we are learning in regards to scientific methods is that we haven't been following the processes described as best practice—documentation, monitoring, and management. The crucial second step is not being followed adequately prior to conservation works being undertaken, in particular with respect to natural impacts, nor following these procedures. Processes that may have been set up at the time of the work are no longer being undertaken, and evidence is mounting that, all too commonly, drip-lines are installed or termite baits are laid, and follow-up on this is limited at best and lacking at worst. Furthermore, wooden viewing platforms are installed without vegetation monitoring programs, risking great fire damage to sites (see Figure 16.3). This is an area that we as experienced practitioners need to improve upon. In 1995, Thorn summarized this well: “none of the previous or current efforts made for the paintings . . . will be of great benefit if the ongoing maintenance and management strategies are not written into the perpetual responsibilities of caring for the site” (Thorn 1995, 1). And as May (2011) identified, his observation could apply to the rock-art site management work as a whole (2011, 37). Whilst she was discussing sites within Kakadu National Park, this philosophy should be adopted as inherent to monitoring within any conservation and management program.



Figure 16.3 Management of rock-art sites open to the public: Interpretative signage and boardwalks to protect subsurface material, such as this example at Nanguluwurr in KNP. In addition to this, visitors walk a kilometre from the car park to access the site, reducing the risk of graffiti. (Photograph by Mel Marshall. Copyright reserved.)

An opportunity is also sorely needed to bring together researchers and practitioners of the conservation and management of rock-art sites in Australia. In 1981, when the Springwood conference was convened, the numbers were few. In today's climate, there are many more people working with various Indigenous groups, and it is time that a second conference was convened to bring people together to share knowledge and skills specific to this.

Australia has never had a national rock-art heritage strategy or a coordinated approach to rock-art conservation. Recent calls for a national rock-art research, conservation, and management policy and framework would provide all professionals in Australia with a standard reference as to what is required when working with Indigenous people to conserve and manage sites (e.g. PERAHU 2013). It would also provide Indigenous people with a reference of what to expect from scientific methods and the benefits, limitations, and impacts that these in turn will bring. Finally, across Australia we need a national project to evaluate what is working and what is not working at rock-art sites open to the public. Once all of this information is readily available, our ability to offer protection to these special spiritual, historic, and highly meaningful places will be increased, something of benefit of us all, especially future generations.

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17 Challenges in Conserving Rock-Art at the uKhahlamba Drakensberg Park, KwaZulu-Natal, South Africa

Ndukuyakhe Ndlovu

INTRODUCTION

The management of cultural resources in the uKhahlamba Drakensberg Park (uDP) has seen many kinds of interventions over the years. What characterizes them all is that they were carried out in an uncoordinated fashion. There have been technical interventions such as the application of silicone to divert water flow from painted surfaces, surveys, and the fencing of rock-art sites (see Mazel 1981; Rudner 1989; Ward 1979a, 1979b). More recently, the Provincial Resources Authority has created a custodian policy. Under this policy, custodians are appointed and, after being given basic training, are expected to ‘police’ access to sites declared ‘public sites’. Besides these actions, there has also been a proliferation of scientific studies aimed at understanding various aspects of the sites that have a direct impact in the long-term management of the rock-art. Some researchers have set up environmental stations at rock-art sites with the aim of analyzing microclimate dynamics (Hoerle and Salomon 2004), considering rock structure (Hoerle 2005; 2006; Meiklejohn 1995; 1997), developing management and conservation strategies (Fordred 2011; Hall et al. 2007; Venter 2011), and studying the rate of rock-art deterioration (Leuta 2009). However, no appropriate lessons have been learnt from the many failures that have been registered over the years.

This failure to coordinate efforts to manage cultural resources in the uDP must be understood within a context in which biodiversity was historically favoured and the fact that rock-art conservation was what may be called ‘back-page material’; that is, a matter only discussed briefly in the last few pages of a book or journal. Nonetheless, the need for conservation became prominent when research shifted focus in the 1970s with attempts to understand the motivation behind the production of rock-art coming to the fore. A recent publication by Mazel (2012) provides a detailed historical overview of these failures. While uDP became a World Heritage Site (WHS) in 2000, it cannot be disputed that both anthropogenic and natural causes continue to have a significant negative impact in the rock-art of the uDP. As this chapter shows, unless meaningful interventions take place, the trend will not be

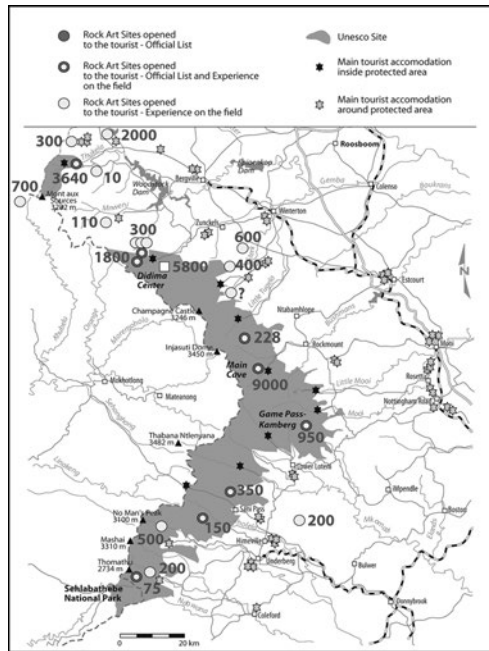


Figure 17.1 Sites discussed in Chapter 17.

abated. Rather than focus extensively on the history of rock-art conservation within this WHS, a discussion is presented of three elements that feature prominently in the management of cultural resources at the uDP past and present: the administration of heritage resources, management approaches, and tourist interest in the rock-art sites. Figure 17.1 shows the distributions of key sites discussed in this chapter.

ADMINISTRATION OF HERITAGE RESOURCES AT uDP

The uDP became South Africa's second World Heritage Site in 2000, following the earlier inscription of Isimangaliso in 1999. The rock-art and biodiversity of the uDP enabled it to be inscribed as the 23rd mixed World Heritage Site (Derwent et al. 2001). Over the years since it was first proclaimed as being of international significance, the management of uDP has continuously attracted criticism from cultural managers and researchers alike in South Africa. They are of the strong opinion that cultural resources within the Park were not getting the attention they deserved in terms of their management (see Mazel 2012). Ezemvelo KwaZulu-Natal Wildlife (EKZNW), the designated management authority for the uDP WHS, is blamed for biases towards biodiversity management and paying only lip service to the management of cultural resources in general and rock-art in particular. Several

attempts have been made to engage with EKZNW with a view to changing this perception (see Mazel 2012). EKZNW have a long and successful history of biodiversity management in the province of KwaZulu-Natal. For example, the former Natal Parks Board, which merged with the KwaZulu Directorate of Nature Conservation to establish EKZNW, is credited with reversing the extinction of the southern species of white rhino. Over the years, many other accolades have been achieved in the field of biodiversity management, which has always been at the core of their functions. By contrast, EKZNW and its predecessors do not have a good track record in the management of cultural resources within their reserves because these have never been part of their direct mandate. Thus, changing the thinking of biodiversity professionals to realize the significance of cultural resources within their properties was always going to be a significant challenge. As Mazel (2012) notes, winds of change began to blow within EKZNW in 2003, when the organization advertised a post for a cultural resources coordinator (Ndlovu 2005). Such an initiative illustrated the realization by EKZNW that its management responsibilities went beyond biodiversity. Sadly, due to the politics of the time, no appointment was ever made, and almost a decade later, there is still no one with the appropriate cultural resource expertise within EKZNW to actively pursue the management of cultural resources and put it on a par with biodiversity. Recently, however, renewed efforts have been made, and the organization is working towards finally making the appointment and is promising that new management structures already accommodate such a position.

While EKZNW can be criticized for not having adapted, particularly when the uDP became a WHS mainly because of its cultural heritage, it is believed that such criticism must be placed within its appropriate context. Therefore, it is argued that proclaiming the uDP as a WHS in the absence of skilled staff to deal with cultural resources was suicidal. It is suggested that the World Heritage Centre lost an opportunity to bring meaningful changes and allay frustrations that had been associated with managing cultural resources for many decades (see Mazel 2012). Had they withheld the inscription of uDP until this matter had been addressed, it would probably have prompted the South African government to put in the necessary resources to appropriately empower EKZNW for the additional responsibility they were soon to be faced with. The other benefit of delaying the inclusion of uDP on the WHS list would have been the opportunity to address the blurring of responsibilities between EKZNW, the KwaZulu-Natal Museum, and Amafa aKwaZulu-Natali. This blurring of responsibilities, particularly between EKZNW and Amafa aKwaZulu-Natali, lies at the heart of the many problems being experienced today and has compounded problems related to the effective management of rock-art in the uDP.

This challenge is also at the centre of the limitations that are clearly evident in the Integrated Management Plan (IMP) for the uDP WHS, which is biased towards biodiversity because of EKZNW expertise. The IMP makes

references to the Cultural Heritage Plan, which is meant to address cultural heritage issues. When the cultural resources document was put into place in 1998, it had the purpose of coordinating efforts in the management of rock-art (Wahl et al. 1998a, 1998b). As a rock-art officer for Amafa aKwaZulu-Natali in 2002, the author began discussions on the IMP for uDP, believing that the designation of uDP as a WHS would have spelled the end of the cultural resources document, as this material was incorporated into the IMP in accordance with the *World Heritage Convention Act* (49 of 1999). In this way, there would be an expectation that the IMP would have as much detail on cultural heritage as on biodiversity heritage. Opposition towards this stance was encountered, particularly from within EKZNW. Given the fact that uDP is a WHS because of both cultural *and* natural heritage, specific measures need to be implemented to ensure that there is greater coordination between the management of these two dimensions.

The problem of not having a credible IMP is the lack of coordination when it comes to managing biodiversity and cultural heritage and prioritizing actions. For example, according to Topp (2009), more than 50 per cent of rock-art sites within the uDP are either directly threatened by fire or have already suffered from controlled burning. A recommendation made in the IMP is to remove all flammable vegetation from the immediate vicinity of rock-art sites and to burn fire breaks where needed. However, for these measures to succeed, there must be synergy between biodiversity and cultural heritage in the IMP. The reality is that there has not been enough integration of the cultural heritage into the current management plan, and a standalone Cultural Resources document is not ideal. Only the appointment of a cultural resources specialist will begin to address challenges of this kind.

Attempts to bring about synergy between biodiversity and cultural heritage will begin to be realized when the blurring of responsibilities between the management authority of the uDP and the Amafa aKwaZulu-Natali (the Provincial Heritage Resource Authority) is addressed. Failure to address this matter indicates signs of weaknesses in the IMP when it comes to the management of the rich rock-art heritage. EKZNW, as the managing authority, should have the mandate to address the heritage of the uDP WHS in its totality and not only biodiversity. Amafa aKwaZulu-Natali should not have a direct day-to-day responsibility over the management of cultural heritage. Instead, as custodians of the provincial *KwaZulu-Natal Heritage Act* (4 of 2008), they should provide advisory functions to EKZNW. Eventually, it is hoped that EKZNW will finally be able to appoint qualified heritage specialists as indicated in the IMP for the period 2012 through 2017. One of the challenges that will have to be addressed by the appointed heritage specialist is managing the prevailing paradigm that is solely focused on a 'what we see' approach (Ndlovu 2009). Management strategies that adequately recognize and consider the various and sometimes competing communal interests in rock-art are urgently needed.

EUROCENTRIC PHYSICAL VERSUS AFRICAN SPIRITUAL: THE CONFLICTING MANAGEMENT APPROACHES

In this section three case studies (Game Pass Shelter, iKanti Shelters, and Mguni Shelter) are discussed as an illustration of the limitations of current management approaches to heritage management and more specifically to rock-art management. The currently applied management practice is founded on the basis of a legislation that favours Eurocentric principles and focuses on the physical aspects of rock-art sites. This has meant the complete exclusion of spiritual issues that are seen as destructive to the aesthetic significance of rock-art. It is now generally accepted that southern African rock-art was not simply a record of what Bushmen, or 'Little Chinese' as they were sometimes called, saw and decided to record on rock faces as a sort of diary of their experiences (Lewis-Williams 1981). Rather, there was a deep religious significance to the things depicted in rock-art throughout this region. Added to this is the widely held perception that Bushmen were brought to extinction because they were seen as being somehow less human (see A. Anderson 1888; W. Anderson 1907; Arbousset and Daumas 1846; Bryant 1929; Dart 1925; Ellenberger 1912; Ergates 1905; Fry 1910; Howard 1910; Moodie 1855; Moszeik 1910; Orpen 1874; Stanford 1910; Stow 1905).

Game Pass Shelter

While it is known that Bushmen did face genocide, there was a significant amount of intermarriage between Bushmen and their neighbouring African communities (see Blundell 2004; Jolly 1986, 1992, 1994, 1995, 1996a, 1996b; 2000; Prins 1990, 1996, 2000, 2009; Wright 1971). This led to the presence of Bushmen descendants amongst the African communities neighbouring the uDP, including the Duma clan. In 2002, this clan requested a revival of a past cultural practice (Ndlovu 2005). They had previously visited Game Pass Shelter for ritual practises as they continued to hold dear what they had learned from their Bushmen ancestors. While there were no direct objections to this request, the regulations accompanying the approval were most disconcerting. There has been no change to these conditions over the years. These conditions are heavily informed by a management approach that has no understanding of African ritual practises but is simply informed by the need to protect the physical outlook of rock-art.

iKanti Shelters

Four rock-art sites at Cobham Nature Reserve to the south of the uDP, collectively known as the iKanti Shelters, have traces of scratching. This scratching was intentionally produced over painted surfaces. It is claimed that African traditional healers use rock-art in their practise by scratching off the painted

surface and mixing the particles with traditional herbs. This is done because rock-art, which traditional leaders accept was done by Bushmen, is seen as a source of spiritual power and thus a significant ingredient in ritual practise. Any management approach that does not understand the value and ritual significance of rock-art to particular sectors of the population is bound to come up short. There may be additional rock-art sites beyond the four iKanti shelters discussed here where similar incidences have occurred. However, it is difficult to ascertain precisely in which other sites such scratching occurs, because southern African rock-art studies do not reference the practise.

Mguni Shelter

A traditional healer in the north of the uDP has made what might be called 'New Age' rock-art in one of the shelters previously painted by Bushmen (Ndlovu 2005). These new paintings depict crosses, stars, and the moon. According to the healer's description of the symbols, crosses stand for an oath, stars are representative of life, and the moon 'captures' prayers to God Almighty. What is evident from the author's interview with the healer is that she has an interest in Bushmen rock-art and sees making paintings on the rock canvas as very important.

Considering the three case studies, to what extent is this spiritual interest in the Bushmen rock-art covered under the current heritage legislation? Today's society must begin to accept that these practises occur and play a critical role in the lives of specific groups of people, some of whom are more or less direct heirs of the original creators of the rock-art. The perception that these practises are simply damaging to the 'beautiful' rock-art is of concern and is contradictory to our understanding that rock-art is a living heritage and that symbols and motifs represented have an ongoing religious significance. Such a physically informed management approach also promotes the view that access to rock-art is defined by limiting laws. Finding some common ground between the Eurocentric focus on physical aspects of heritage and African attachments to spiritual practises is something that needs to be worked on.

TOURISM AND ROCK-ART

Because of the challenges faced by the administration and management of rock-art heritage within the uDP, it is perhaps no surprise that tourism has not flourished as well as might be expected. Considerable investment has been made in promoting rock-art tourism (Figure 17.2), but it does not seem to have yielded the expected benefits.

The volume and economic significance of tourism in South Africa has increased dramatically in the decades since the end of apartheid in 1994. The South African government identified tourism as an important growth

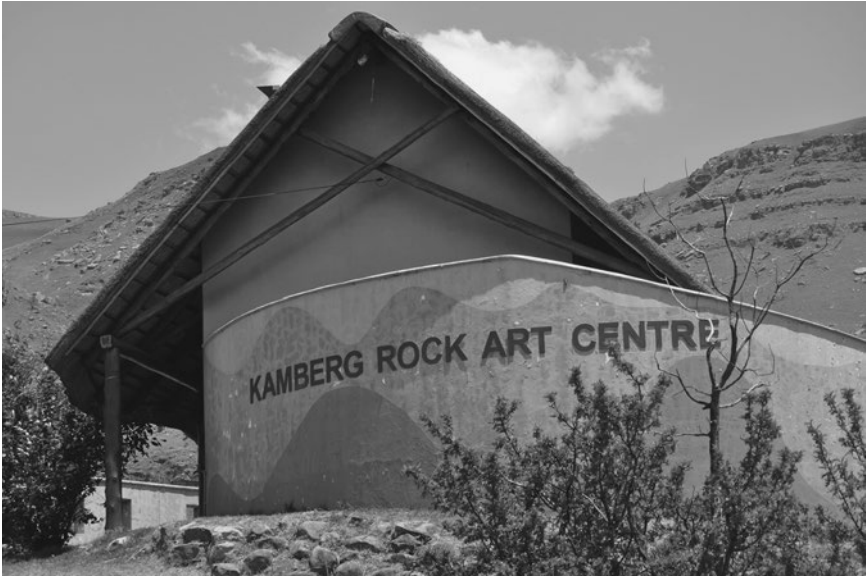


Figure 17.2 The Kamberg Rock Art Centre, KwaZulu-Natal, South Africa. (Photograph by Ndukuyakhe Ndlovu. Copyright reserved.)

sector which could make significant contributions to the country's economy through the creation of employment opportunities (DEAT 1996). Having natural, cultural, and geomorphological sites inscribed on the WHS list was one of the strategies by which South Africa would achieve an exponential increase in the number of tourists visiting the country. Since the formal end of apartheid, South Africa has amassed eight World Heritage Sites. Besides creating jobs through tourism, the government expects tourism to provide tangible benefits to communities, particularly those neighbouring nature reserves which have previously excluded them. Eighteen reasons tourism should be identified as an engine of growth were given in a 1996 white paper on tourism. Tourism driven by cultural resources, which need to be managed to the negotiated benefit of all interested parties within a range of communities, was seen as capable of rejuvenating other sectors of the economy and improving the lives South African people, many of whom still live in poverty (DEAT 1996).

It is often suggested that one of the main benefits of World Heritage status is that it helps promote tourism and assists in improving the lives of neighbouring communities. According to Duval and Smith (2012), World Heritage status was seen as a vital vehicle for improving tourism in the uDP, which had suffered under apartheid. However, there are opposing viewpoints to such general expectations. Some researchers argue that empirical results do not support the notion that inscription promotes tourism except sometimes in the short term (see Cellini 2011; Huang et al. 2012; Yang et al.

2010). Through increasing the number of tourists, the inscription of the uDP was seen as offering EKZNW a great opportunity to assist neighbouring communities in various ways and for them to appreciate the benefits of managing their local cultural and natural heritage. It should be remembered, though, that these communities had previously been excluded from assisting with the management of the uDP because of the 'fortress' approach to biodiversity management. Neither had they ever directly profited from the benefits that accrued from tourism.

Each tourist entering the uDP protected areas pays a community levy. This money has become useful in making a difference in the lives of destitute communities neighbouring the reserves. Besides the community levy, increasing visitor numbers also mean that handcrafts made by these local communities can be sold to a greater number of tourists. While it is reported that tourist numbers have significantly increased since 2000, there has not been an increased interest in the rock-art of the uDP. Duval and Smith (2012) expressed shock that while the uDP is reported to be receiving well over 200,000 visitors a year, rock-art tourism accounted for only about 10 per cent of tourists visiting the uDP. Considering that only 21 out of more than 600 rock-art sites are officially open to the public and that the majority of these 21 sites are not amongst the 'best' painted shelters, the low number of visitors who come to the uDP with a special interest in rock-art should not be surprising.

The criteria behind choosing which of the uDP rock-art sites are opened up to the public are erroneous. A number of these sites may excite rock-art researchers but do not appeal to ordinary tourists. In the author's experience working at the uDP and informally interacting with visitors over many years, it became apparent that tourists are not pleased with most of the selected sites. A number of tourists felt they were being ripped off considering the amount of money they were paying to visit the 'public' rock-art sites at the Cathedral Peak area. It is then suggested that the low amount of rock-art orientated tourism in the uDP is a reflection of the fact that experts, EKZNW, and Amafa aKwaZulu-Natali are out of touch with reality. What appeals to them does not necessarily engender enthusiasm amongst tourists.

The business of designating rock-art sites as open to the public is absurd, as practically all the sites are open to the public. The custodian policy, implemented by Amafa aKwaZulu-Natali at the 21 rock-art sites officially opened for visiting, has failed monumentally. Only a few of these 21 sites provide a 'wow' factor, particularly for someone who is not an expert in rock-art studies. What this clearly indicates is that decisions about the list of sites were management related and the interests of visitors were not properly considered. The authorities were more concerned about how visitors should be policed once they have arrived at a site. With sites such as Goodhope, Esikolweni, and Lower Mushroom, it is not surprising that tourism is so weak.

To illustrate the argument further, a discussion of the situation regarding Didima Gorge is helpful and relevant. This is one of the densely painted areas in the uDP (Pager 1971). According to Mazel (2011), Didima Gorge contains,

in only 17 sites, about 10 per cent of the *c.* 40,000 rock-art paintings known in the uDP. Yet Didima Gorge constitutes only 1 per cent of the surface area of the entire uDP. This represents an average of about 230 paintings per site compared to 60 at other sites across the uDP (see Mazel 1981, 2011). The name Didima is well known in rock-art studies, and a considerable number of tourists who have read popular literature on rock-art are acquainted with it. It was first through the efforts of Harald and Shirley Pager that Didima (which Pager called Ndedema) Gorge became well known. Considering the significance of Didima Gorge, it is appropriate that Didima Camp and the Didima San Rock Art Interpretive Centre nearby were named after it. However, tourists are not allowed to visit any of the sites in Didima Gorge because none of them are considered suitable for public viewing. The major factor is that these sites are highly significant and cannot be exposed to negative anthropogenic impacts that may arise from extensive visitation by tourists. The previous chief executive officer of Amafa aKwaZulu-Natali is quoted as having stated that “the fewer tourists there are at the rock-art sites, the better it is” (Duval and Smith 2012, 14). It is thus no surprise that there seems to be an approach to cultural resources management that promotes the idea that the best practice is to keep people away from the ‘best’ rock-art sites.

While human-originated negative impacts to rock-art are real and cannot be ignored, other factors also need to be considered when deciding on issues regarding access to sites, including natural threats, and the question of who exactly we are managing rock-art for needs to be asked. In respect to the last matter, it may be noted that, under present arrangements at least, one of the most attractive areas in terms of visible rock-art cannot be enjoyed by tourists. When the author was acting as the manager of the Didima San Rock Art Interpretive Centre, many of the tourists arriving there had read about Didima Gorge rock-art and wanted to visit some of the most spectacular sites. They were always disappointed when told that they could not visit those sites or the nearby Eland Cave because they lay within a Special Conservation Area. As mentioned earlier, none of the sites within Didima Gorge or its surrounding areas are listed as ‘public access’ sites. Moreover, while concerned authorities seemingly fight hard to keep people away from enjoying this rich cultural heritage through custodian policy, nothing is being done to tackle the natural factors that are continuously threatening rock-art.

Open-air rock-art sites are, by definition, highly exposed to weathering factors even though a number of paintings and engravings have survived for thousands of years. Therefore, while keeping people away from these sites under the pretext of applying best management principles and supposedly saving them for future generations, the art is fading away without being ‘enjoyed’ by the majority. Only the few who are privileged enough to visit the sites as researchers and/or heritage managers get to appreciate the best that the uDP has to offer in terms of its rock-art. If rock-art tourism is to stand a chance, it is argued that new approaches to management need to be adopted that show adequate consideration of these factors.



Figure 17.3 Didima San Rock Art Interpretive Centre, uKhahlamba-Drakensberg Park, South Africa. Internal displays. (Photograph by Ndukuyakhe Ndlovu. Copyright reserved.)

It is important to recognize that there has been considerable financial investment to improve rock-art tourism and related facilities within the uDP WHS. Two rock-art centres in the uDP, namely Kamberg Rock Art Centre (Figure 17.2) and Didima San Rock Art Interpretive Centre (Figure 17.3), were officially opened in June 2002 and September 2003, respectively. Their opening was under the premise that they would unleash a new era in rock-art tourism. However, based on the author's experience working at uDP, and the figures presented by Duval and Smith (2012), this does not seem to have been the case. Thus, neither centre nor the two combined have been able to substantially increase rock-art tourism.

To help understand why there is a low rate of rock-art tourists who visit uDP, Duval and Smith (2012) look back into history for answers. They argue that for many years, rock-art received the least attention in guidebooks published over many decades. They add that these guidebooks have particularly focused on biodiversity as the major attraction of uDP. While this sounds plausible, the two rock-art centres were, amongst other things, meant to address this historical imbalance. It may also be asked what rock-art enthusiasts have done to change the biased perception afforded to biodiversity. By keeping tourists away from the 'best' rock-art sites as a way of protecting this rich

heritage, the existing stereotype that favours biodiversity is effectively being promoted. In the author's opinion, neither the custodian policy that deems some sites to be 'open' to the public while others are not nor the establishment of rock-art centres has been successful. The latter have failed to improve the image of rock-art and its place on the 'tourism radar', even though they have made some inroads towards achieving that goal. What is behind the low impact of the two rock-art centres in attracting tourism? To answer this question, geographical and other connected factors seem to be to blame and need to be explored with reference to the established visitor centres.

Kamberg Rock Art Centre

Four factors should be considered regarding tourism at Kamberg. First, the Kamberg Nature Reserve attracts a lot of fishing enthusiasts interested in trout, although the number of fisherman has dropped over the last few years (camp manager, personal communication). This has directly affected the number of visitors to the reserve as a whole. Second, the last 9 km of the road leading to Kamberg Nature Reserve is dirt, quite inaccessible to many tourists during the rainy season. Third, there are minimal tourism facilities within a 30-km radius of the Kamberg Rock Art Centre. These three factors have a direct negative impact on the number of people that are likely to visit the Centre. Fourth, 20 community guides were trained and given an opportunity to work at the Centre. Within a few months, frustration and a low level of morale amongst the guides became evident and may be attributed to low visitor numbers. Today, there are fewer than five guides still working at the Centre, a quarter of the original number. This staff instability, coupled with the ineffectiveness of the Kamberg Rock Art Trust, which is supposed to manage the Centre, has severely impacted its administration since 2002. Because of these instabilities, there have been a number of management changes over the years. Recently, in July 2012, the centre was shut down following the resignation of the manager, who, as it happened, had been one of the original group trained as guides. Individually and collectively, these four factors have significantly contributed to the low overall number of tourists that visit the Kamberg Rock Art Centre, and as a result, it has failed to reach the projected heights of 400 visitors per year (Smith 2012, personal communication).

Didima San Rock Art Interpretive Centre

In contrast to the Kamberg Rock Art Centre, the Didima San Rock Art Interpretive Centre is geographically better positioned and thus has the potential to attract more tourists. Moreover, Cathedral Peak Hotel is located within 2 km of the Didima San Rock Art Interpretive Centre and can provide high-class accommodation. It is a family hotel constructed in the late 1930s and is among the first hotels in the country with an international appeal. In addition, there are several other well-established hotels and lodges within a 30-km

radius to suit a range of pockets and tastes. Naturally these nearby holiday establishments provide significant business to the centre. When the author became the first manager of the centre, incentives for guests staying at the holiday establishments to visit the centre were established. This significantly increased the number of visitors to the centre. While this practice has continued, the quality of the management of the centre has declined since the present author stepped down as centre manager, equipment has stopped working, and the quality of the visitor experience has declined. The lack of effective management at the centre has had a negative influence on rock-art tourism, particularly because a number of guides bringing their visitor groups there have, understandably, become frustrated at the poor service they receive. Therefore, this centre has also failed to capitalize on its privileged popular location.

Taking account of the experiences right across the uDP, it can be argued that the administration, the ill-advised custodian policies, and the issues with rock-art centres explain the low number of rock-art tourists. Until these issues are addressed, the sad history of cultural heritage management in the uKhahlamba Drakensberg Park will continue to be of significant concern (see Mazel 2012).

DISCUSSION

The historical challenges facing rock-art management in the uDP have continued to negatively impact the future of this rich cultural heritage. An unresolved management crisis is at the heart of the inability to make a significant leap forward. Had this matter been successfully resolved in 1997, when the KwaZulu Monuments Council amalgamated with National Monuments Council (NMC) to establish Amafa aKwaZulu-Natali, the present crisis could have been avoided or at least minimized. Moreover, as already noted, another opportunity was lost when EKZNW, through the National Department of Environmental Affairs, proposed inscription of the uDP as a WHS. If the management principles and associated plan had been adequately attended to, the situation today would be entirely different. In order to reverse the present situation, it is argued that the management authority of the uDP WHS, EKZNW, should be assisted and empowered to manage the cultural resources of the uDP in the best possible way and under the stewardship of a specialist in cultural resources. Amafa aKwaZulu-Natali should only play an advisory role, through the EKZNW cultural resource specialist, to ensure that there is effective implementation of the provincial heritage legislation. As argued, this piece of legislation needs to be appropriately amended to incorporate a much-needed change in the management of cultural resources.

The politics that blocked the appointment of a cultural resource specialist in 2002 should not be repeated (see Mazel 2012). Such plans have been revitalized by EKZNW, and the organization is well on its way to appointing its

first-ever cultural resources manager. Addressing one of the significant concerns that dates back many years will herald a new phase that will address not only the poor administration of cultural heritage resources but also the biased and ill-advised management approaches and the decisions currently being implemented (e.g. custodian policy). Custodian policy has achieved nothing for Amafa aKwaZulu-Natali. This policy has also played a negative role in the promotion of rock-art tourism by rendering the two rock-art centres discussed in this chapter pointless. It is high time that the organization begin to realize that and let EKZNW take over the management of the rock-art and the rich cultural heritage of uDP.

A well-thought-out strategy that is fully incorporated into the IMP is urgently needed. Such a strategy must coordinate various rock-art research projects being undertaken in the uDP with the aim of putting into good use the findings from these projects. This is currently not the case and, as such, extensive new knowledge is not being incorporated into the management of the rock-art itself.

CONCLUSION

A lot has been written about the problems of managing the cultural resources of the uDP WHS. Many recommendations have been put forward over the years. Most have not even begun to be implemented. It is time for effective recommendations to be implemented. The current liaison committee meetings between Amafa aKwaZulu-Natali and EKZNW must begin to deliver. The balance of power within such a committee must change, and EKZNW must begin to take responsibility for managing the cultural resources at uDP, with Amafa aKwaZulu-Natali as the advisors. Lastly, the current scenario in which the majority of rock-art is kept away from the general public must be addressed.

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18 Non-invasive Methods for *In-Situ* Assessing and Monitoring of the Vulnerability of Rock-Art

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BACKGROUND AND MOTIVATION

England is renowned for the richness of its archaeological heritage: a tangible and often highly evocative link with our ancient prehistoric past and a unique source of information that has the potential to transform our understanding of the lives of our ancestors and how they adapted to and changed their environment. Such remains often form significant features in our surroundings but are also valuable as resources for research, education, leisure, and tourism and for their influence in forging identity and a spirit of place. Rock-art monuments provide a link to our ancient cultural pasts; they possess seeming permanence but are sensitive to their environment. Rapid changes because of anthropogenic land use and climatic variation will cause damage and decay over time. Knowledge of the characteristics of the host rock is vital to inform decisions to ameliorate the impact of decay processes, delaying the inevitable progression of paedogenesis. Effective diagnosis of present conditions is the first step towards conservation, which can then be followed by intervention or conservation measures. Cultural heritage stone conservation more commonly occurs in the built environment subject to urban conditions rather than erosion in the natural environment. The bulk of stone conservation research has been on structures rather than landforms and needs therefore to be adapted for landforms physically altered by humans.

A key problem in cultural resource management is identifying those artefacts in need of immediate conservation by generating clear data for decision makers. It is essential to measure and monitor the extent and severity of decay over time (Prikryl and Smith 2007). Information on the intrinsic properties of the stone that either change with weathering or indicate a vulnerability to weathering processes is needed. *In-situ* methods such as drilling-resistance measurements and rebound hammer have been used to monitor rock hardness as a measure of weathering states for sandstone structures alongside laboratory methods requiring sampling such as mercury intrusion porosimetry (MIP; Doehne and Price 2010, 2, 39). In this chapter, current measurement techniques will be discussed, including the difficulties

of applying them to open-air rock-art sites *in situ* or for continuous monitoring. The increasing emphasis on non-destructive testing and the demand for thorough characterization of materials *in situ* requires the development of advanced diagnostic methods (Torok and Prikryl 2010).

Most deterioration effects in porous stone materials arise as a direct or indirect consequence of water as a result of soluble salts and impurities moving through the rock, solutional material loss from the stone, freeze-thaw, and water availability to organisms responsible for biodeterioration (Rizzi et al. 1996; Wray 1997; Younger and Stunell 1995). Water flows through the porous network as well as through fractures and fissures, forming natural pathways for the flow of weathering agents. Hydric properties of stone are closely related to porosity by the effective radius and the connected porosity. Capillary rise of ground water and associated transport of mineral salts and other pollution into the porous network of the stone has been reported as a significant cause of weathering damage at many cultural heritage sites (Martinec et al. 2010; Park and Shin 2009; Petuskey et al. 1995; Siedel et al. 2010). Sandstones are principally composed of mineral grains, cement, or matrix and pore space. Porosity is defined as the ratio of the volume of pore space to the bulk volume of the material. The volume and distribution of pore space affects the behaviour of stones over time (Yu and Oguchi 2010).

Pore characteristics of rocks are one of the main factors that control the intensity of their deterioration and determine their stability against biological attack. Weathering processes cause progressive changes in rock porosity due to changes in pore-size distribution, pore geometry, pore connectivity, pore infilling, and new pore formation (Tugrul 2004). Significant correlations between the porosity and the pore-size distribution in rocks including sandstones have been used previously to develop durability estimators (Benavente et al. 2004; Molina et al. 2011). However, standard methods to investigate pore characteristics such as mercury intrusion porosimetry and micro computed tomography (micro-CT) require samples to be removed from the site for laboratory analysis.

DURABILITY AND HARDNESS TESTS

Various durability estimators have been proposed linking the strength and longevity of stone. Measurements of hardness, drilling resistance, and strength by ultrasonic wave velocity are well-established approaches and can all be performed at open-air sites *in situ*.

Rebound Measurements

Rebound hammer or Schmidt hammer has become a common tool for assessing the mechanical strength of stone *in situ* (Viles et al. 2011). It was originally developed by E. Schmidt for non-destructive *in situ* testing of concrete. It is

used in geomorphological and cultural heritage investigations to provide a measure of rock hardness from rebound characteristics of rock surfaces (Pope 2000). The rebound distance of a controlled impact perpendicular to the surface is measured by the instrument. There are various models commercially available that do not necessarily provide comparable results. Hardness can be a measure of weathering in some cases, but the relationship to weathering is not simple, as some processes can lead to surface hardening while others cause progressive softening of the rock surface. It should be used with caution on cultural heritage materials; a test strike should be performed on an inconspicuous area to avoid chipping or marking damage to the surface under investigation. Measurements are sensitive to rock fabric, surface texture, moisture content, and the size and mass of the block; it is not suitable for small blocks and can break small blocks on impact. The technique has some issues with operator variance, and, at present, there is no standardized procedure for testing, so this is best used as a relative measure of weathering.

Drilling-Resistance Measurements

Drilling-resistance measurement techniques were initially developed in 1908 for the testing of construction materials (Pamplona et al. 2007). It is a portable microdestructive technique that has been used for *in situ* hardness measurements of stone and other construction materials as well as for cultural heritage applications. Small-diameter (3–5 mm) drill bits are used to make the technique microdestructive, but as a result of the small sample size, multiple measurements may be required to be representative of heterogeneous natural materials. Drilling depths of 10 mm are used to give depth profiles in order to investigate weathering fronts within the stone surface and the penetration of consolidation treatments. Calibration tests need to be performed both before use and at regular intervals during the working life of drill bits to characterize the variability between drill bits and wear effects from repeated use. The presence of moisture can also affect drilling measurements by causing packing effects from dust accumulation in the drill hole, which can cause increased resistance results. While microdestructive, the technique is potentially damaging and may cause disintegration to the material around the drilling hole. Drilling-resistance measurements can provide depth-resolved profiles of material hardness, but the destructive nature of the technique restricts its use, and it cannot be used to survey a whole monument or for continuous monitoring.

Ultrasonic Velocity Measurements

Ultrasonic velocity measurement is measurement of the velocity of compressional waves through a material from the time taken for the ultrasonic wave to pass through a material from a transmitter to a receiver both held

in contact with a coupling medium between the transducer and material surface. The denser the material, the faster the sound travels, and the lower velocity in air enables the detection of voids in the material due to fractures or fissures and can indicate structural disintegration within the material. Stone with high ultrasonic wave velocity tends to have a longer durability (Barbera et al. 2012; Martinez-Martinez et al. 2013; Vasconcelos et al. 2008). If possible, the velocity measured is transmitted through the material to get a direct measurement; if not, measurements can be performed at surface level, giving an indirect measurement back-reflected by fractures or sedimentary structures such as bedding planes in the material. Measurements are dependent on the rock fabric and are affected by discontinuities within the material and can be used topographically to map discontinuities (Siegesmund et al. 2010). Measurements can be made parallel or perpendicular to bedding planes or other sedimentary structures to detect anisotropy. The ratio between measurements can be used to create an anisotropy index. Irregular surfaces can make measurements difficult depending on the shape and size of the transducer. The presence of moisture in the stone can also affect results, as saturated samples can present higher velocities (Kahraman 2007). The technique can be unreliable for assessing the condition of the stone directly below the surface, but it has been used extensively in conjunction with drilling-resistance measurements to link surface softening with weakening of the stone interior.

Electrical Resistance Measurements

The technique measures the resistance between two points attached or tapped in to the surface of the object. The technique is based on the concept that the electrical resistance of a material will decrease when water is present. It is an indirect method; the signal measured does not come from the water but from the conductance of the material, which is affected by water presence as well as various other factors and can be modified significantly by the presence of dissolved contaminants in the water. Resistivity will be further decreased by the presence of ions in the water, giving a falsely high water content result. The measurement can identify moisture difference in the material between measurements, but variation in the presence of salts can cause inconsistency between measurements of the same material. There are various simple but invasive techniques that involve installing different probes into the artefact such as metal screws or wooden dowels, which may influence measurements by their material properties. A non-destructive method using ECG self-adhesive pads has been developed, avoiding the destructive practice of drilling and attaching nails to the rock surface, making it suitable for use on rock-art panels (Mol and Viles 2012; Sass and Viles 2010). The technique allows estimation of moisture distributions

within porous stone. Quantitative estimation of water content from resistivity measurement is less reliable because of the potentially disruptive influence of dissolved salts. Calibration is problematic due to unknown salt content composition and distribution, so it is not easy to measure absolute water content values.

CAPILLARY UPTAKE TESTS

Water absorption tube testing is an *in-situ* method used to evaluate the water absorption of a porous material. When a water column is applied on a porous material, the water penetrates the material. The water volume absorbed after a definite time is a characteristic of the material and may be decreased by surface encrustation and increased by structural disintegration. It depends on the porosity and capillary properties of the material as well as its initial saturation level and can provide an indirect measurement of pore characteristics. The method is used in building construction and conservation to evaluate the results of hydrophobic treatments. It consists of an open cylindrical body which is attached horizontally or vertically to the surface being measured and filled with a set volume of water. Standard measurement time is an hour, requiring the attachment medium to be adhesive enough to hold the pipe in place over that time frame. A compromise must be made between potential damage to the surface from the attachment medium and the equipment staying in place. It is not suitable for severely deteriorated surfaces, as it may not adhere and risks granular loss from the surface. The method can also have difficulties with pipes leaking and falling off during experiments but can give useful results and is cheap and relatively easy to perform.

METHODS IN DEVELOPMENT

The increasing emphasis on non-destructive testing and the demand for thorough characterization of materials *in situ* requires the development of advanced diagnostic methods, providing the motivation for this work. The purpose of this project is to develop non-invasive *in-situ* methods for assessing subsurface conditions of rock-art panels likely to correlate with vulnerability, providing a baseline against which future changes can be assessed.

Optical Coherence Tomography

Optical coherence tomography (OCT) is a 3-D imaging technique that relies on the detection of light scattered back from the sample. It was designed for non-invasive examination of the interior of the eye and the subsurface

structure of biological tissues (Huang et al. 1991). The technique has successfully been used to produce cross-sectional images of paintings and museum artefacts *in situ* (Targowski 2012) and has been used previously on geological materials (Chang et al. 2010; Yang et al. 2004). OCT uses a near-infrared light source and detector array with which it registers the back-scattered light, measuring the travel time using interference between light that has interacted with the sample and a reference beam to produce virtual cross-sectional images of the surface and subsurface non-invasively.

The instrument used is a portable Thorlabs SROCT operating at a wavelength of 930 nm, a full width half maximum (FWHM) bandwidth of 100 nm, an axial resolution of 6.5 μm , and lateral resolution of 9 μm . It is a Fourier-Domain OCT where the reference mirror was kept stationary and the interferometer output is dispersed by a diffraction grating and collected by a linear CCD array. A piezoelectric scanning mirror within the OCT probe enables rapid scanning in the transverse x-range. The probe is attached to a motorized micrometer linear stage to obtain an image cube as the stage scans in the transverse y-direction perpendicular to the x-range of the scan (Figure 18.1A).

Cross-section images are obtained through a fast Fourier transform to retrieve axial information without the need for axial scanning in the system, producing a virtual cross-section for structural imaging with a maximum depth range of 1.6 mm image depth limited by multiple scattering within the sample. Each image is obtained by a series of in-depth scans, that is, cross-sectional 2-D scans consist of a series of consecutive depth scans. The three-dimensional image volumes are formed from consecutive 2-D cross-sectional scans (Figure 18.1B and C).

Oversampling of depth scans within the lateral and transverse resolution range enables spatial averaging; multiple depth scans are performed at a slightly different position and then averaged to increase the effective integration time, thereby increasing the signal-to-noise ratio. Unlike *in-vivo* biomedical applications where rapid acquisition speeds are required to reduce motion artefacts, in this application the sample is stationary and unchanged for the duration of a scan. This enables scanning at speeds which produce multiple depth scans within the lateral resolution of the instrument to create a composite image with improved signal-to-noise ratio. This improves image quality, making boundary detection more effective to differentiate grain structures in the subsurface to a depth of 0.7 mm.

OCT data can be further analyzed to provide quantitative information from imaging of rock microfabric to investigate grain size distribution. The greyscale intensity images produced are segmented into constituent regions of sandstone matrix and grain by a thresholding technique to delineate the boundaries of the grains for automated grain finding to investigate grain-size distributions and matrix-to-grain ratios.

Stone decay produces uneven surfaces by differential weathering of constituent materials and topographical features that may be the result of

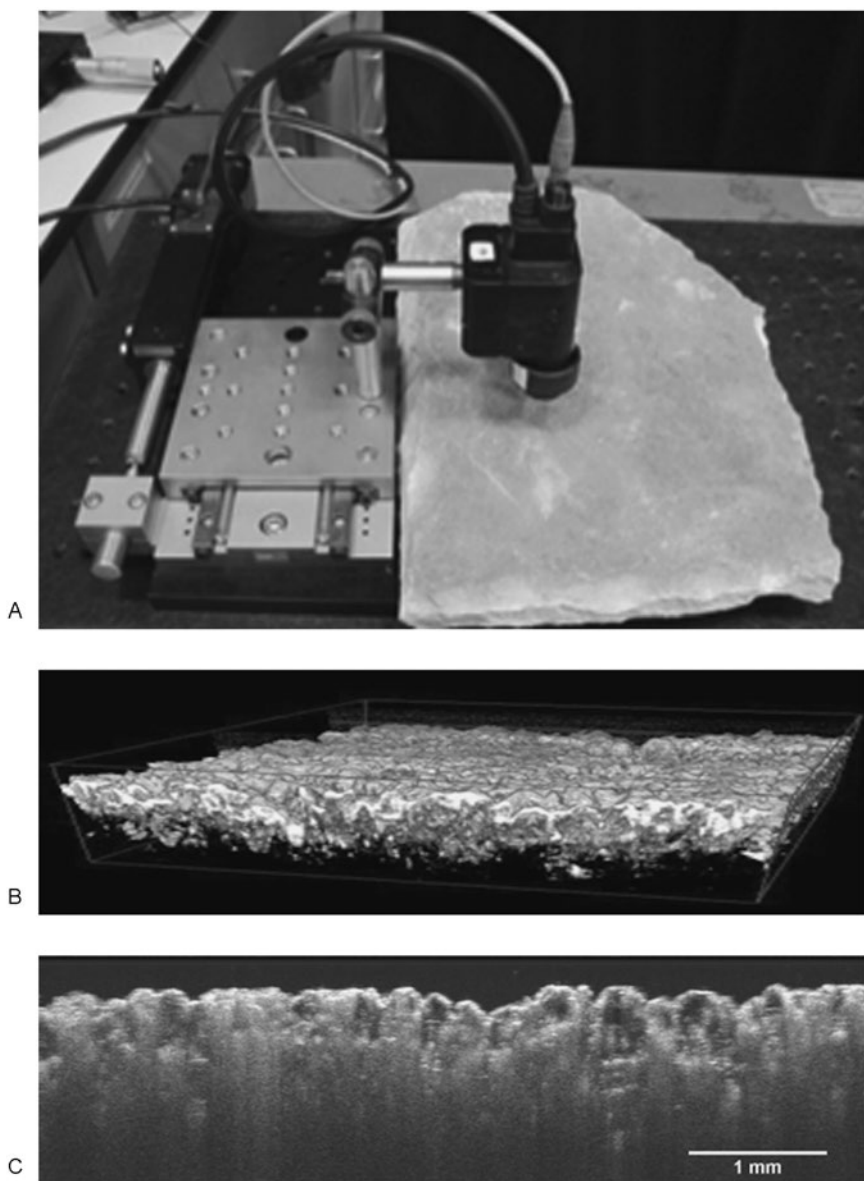
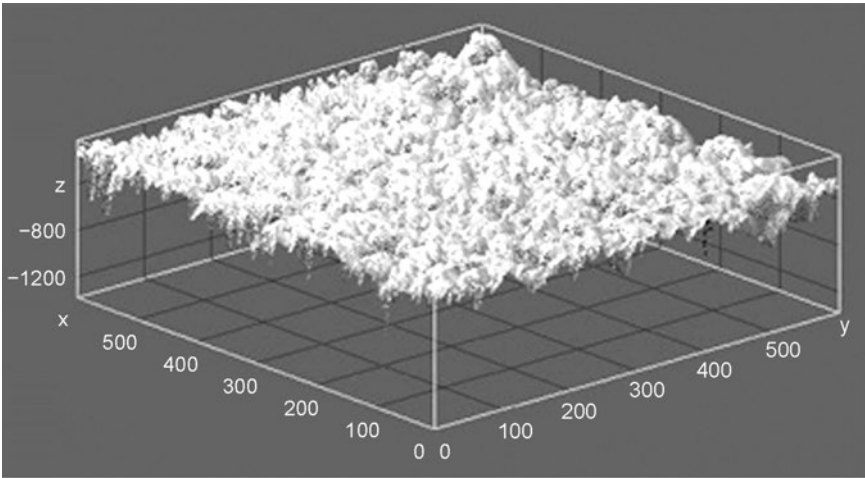
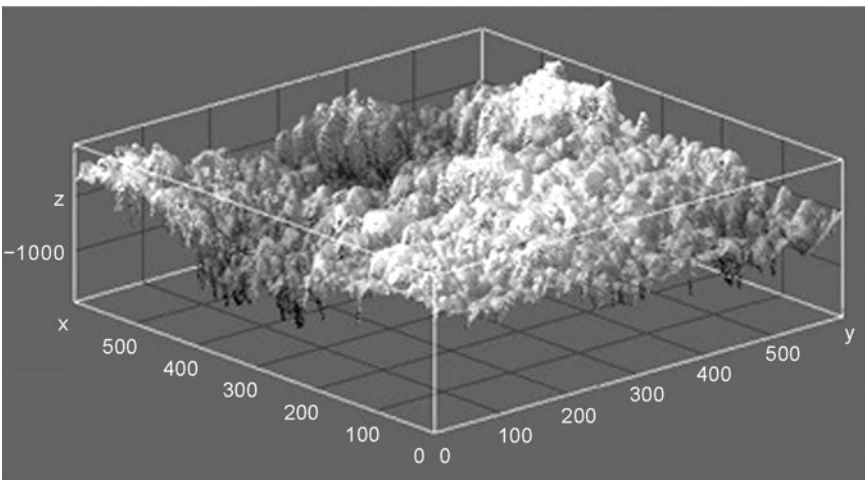


Figure 18.1 Sample analysis. A: Optical coherence tomography probe attached to x, y, z scanning stage. B: Volume rendering of sandstone sample (bounding box 6 mm × 6 mm × 1.6 mm). C: Virtual cross-section image of sandstone sample.



A



B

Figure 18.2 Scans of stone surfaces. A: Unweathered sandstone surface 6 mm × 6 mm scan. B: Weathered surface 6 mm × 6mm.

granular disintegration and material loss (Figure 18.2). These features can be analyzed by measuring surface positions from OCT image volume.

OCT can also be used to monitor the absorption of water into sandstone. As water displaces air in the porous network of the sample, it reduces refractive index mismatch. Water has a refractive index (RI) of 1.33 (cf. air refractive index of 1) closer to quartz (RI of 1.4–1.5), the primary constituent of the sample. The effect of this is to reduce scattering within the sample,

which results in reduced pixel intensity values of the image and reduced multiple scattering.

Hydric properties of rocks have been used for some time as durability estimators for stone and building materials. Liquid invasion into the porous network is controlled by material properties such as porosity and pore-size distribution. Hydraulic conductivity describes the ease with which water can move through the pore spaces of a material. OCT produces non-invasive and non-destructive depth-resolved quantification of hydraulic conductivity in sandstone and other porous materials to determine subsurface changes due to weathering (Figure 18.3). OCT images were recorded over the 10 mm range with no averaging at 1.14 frames per second continuously for the duration of the experiment. Each image is produced from 1,000 depth scans, each producing a column of 512 pixels, representing an image size of 10 mm by 1.6 mm. Measurements are made at a distance of 10 mm from the imbibition point at the sample. Surface water is added at a rate to ensure there is a surface droplet on the sample throughout the experiment, thus matching supply to absorption, preventing water flooding across the sample surface. Rapid assessment at a small (cm) scale minimized fluid losses by evaporation during the experiment, with measurements taking from less than a minute to several minutes in duration. The wetting front can be seen moving across the lateral distance of the scan with time at different depths within the sample to identify any changes in the properties of the sample with depth to 1.25 mm from the surface. It is a non-destructive method using low-intensity light at a safe working distance (1 cm), so examination can be performed anywhere on the panel or repeated over time for monitoring purposes. This method is more representative than sampling for the surface and subsurface but unfortunately has a limited depth range, at a maximum of 1.6 mm depending on the material.

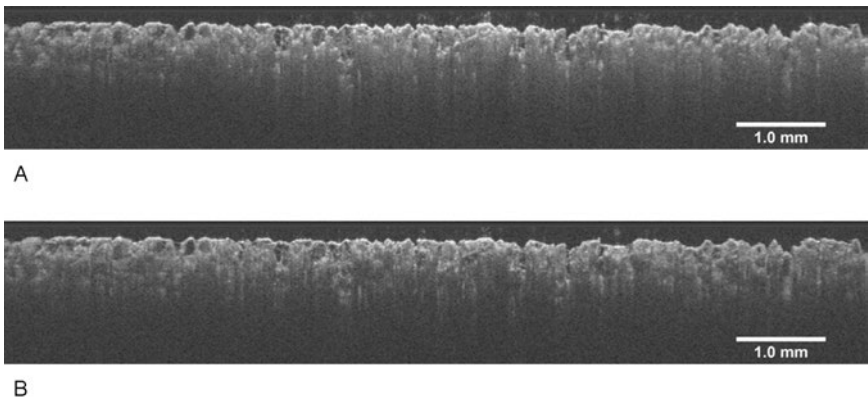


Figure 18.3 Images of sandstone sample. A: Dry. B: Wet.

Nuclear Magnetic Resonance

Nuclear magnetic resonance (NMR) has widespread use in many areas of science and technology, most familiarly in medicine for MRI (magnetic resonance imaging) biomedical purposes. It has also been applied to the analysis of cultural heritage materials such as paintings, paper, wood, and walls and can be suitable for the non-destructive analysis of large objects at an open-air location (Kleinberg 2002; Sharma et al. 2003). It has also been used to assess changes to pore-size distributions following conservation treatments to stone and fresco walls. Mobile single-sided NMR is based on the principles of unilateral inside-out NMR (where the sample is placed outside the magnet), initially developed to travel down bore holes for the purpose of well logging. Oil industry analysis of NMR signals provides information about the fluids in the porous network of the surrounding rock matrix (Blumich et al. 2010). The required magnetic fields are projected out of the instrument into the sample, such as with the NMR-MOUSE® (Mobile Universal Surface Explorer), which is a portable one-sided instrument that can be placed at the site of the measurement, enabling the characterization of near-surface volumes of arbitrarily large objects, such as *in-situ* open-air rock-art panels. The MOUSE® is mounted on a computer-controlled precision lift placed close to the surface to enable depth profiles into materials. The instrument can be used in either a vertical or a horizontal position and can be inverted to investigate materials from their top surface. The sensitive volume is a thin, flat slice parallel to the sensor surface; the instrument is placed close to the surface of the object to achieve maximum depth penetration, and measurements are then made by shifting the sensor laterally away from the object step by step to provide spatially resolved depth profiling of up to 10 mm, but to 3 mm with reasonable experiment durations.

NMR signal is produced by applying a series of radio-frequency pulses to a sample within the polarizing magnetic field which are absorbed and reemitted by hydrogen nuclei. This enables the spatially resolved detection of a hydrogen-containing fluid (e.g. water, H_2O) within the sample. The amplitude of the proton NMR measurement is directly proportional to the amount of hydrogen in the sensitive volume of sample investigated, which provides the water content of the rock, determining porosity in fully saturated samples. Further information is obtained by measuring the rate at which the bulk nuclear magnetization of the water within the sampled volume of the material relaxes to equilibrium after being excited by a radio-frequency pulse. The relaxation time is related to the surface area-to-volume ratio of the water-filled pore space. There are two main components to the NMR signal, one from the fluid close to the pore wall and another from the fluid away from the pore wall independent of pore shape. The resulting NMR signal is a composite of all the NMR signals from the different pore sizes in the volume under investigation. The relaxation curve of the signal is

processed by an inverse Laplace transformation to separate it into its component parts, the distribution of which can be interpreted in terms of pore-size distribution. Hydrogen in water associated with clay minerals within the rock matrix has very short relaxation time and is well separated from the relaxation time for water within the porous network of the stone. NMR measurements are not influenced by the presence of most common soluble containments/pollutants but can be affected by the presence of ferromagnetic minerals such as magnetite (Brai et al. 2007; Keating and Knight 2007, 2008). The technique is capable of providing depth and spatially resolved profiles of porosity and pore-size distribution, which are established factors for weathering, and as such is a valuable tool for non-invasive testing of stone vulnerability. It does, however, have certain limitations, as full fluid saturation of large objects can be difficult to achieve and the low sensitivity of the instrument often results in long measurement time. The method is highly suitable for the analysis of selected spots but of limited use for the extensive mapping of large areas of a monument. This NMR method can form an effective *in-situ* replacement for mercury intrusion porosimetry for the characterization of pore characteristics, removing the need to take samples or rely on proxy materials taken at a safe distance from valuable rock-art panels.

Hyperspectral Imaging

Spectroscopy is the study of light as a function of wavelength that has been reflected or emitted from a material. The wavelength dependence of absorption processes allows us to derive information about its composition from its reflected light using a detector and a means of wavelength selection. Imaging spectroscopy is a means of obtaining a spectrum at each position in a large array of spatial positions so that any one spectral wavelength can be used to make a recognizable image (Liang 2012). PRISMS (portable remote imaging system for multispectral scanning) is a portable system designed for *in-situ*, high-resolution remote hyperspectral imaging. It is a non-invasive technique capable of recording the spectral reflectance per pixel for millions of points simultaneously (Liang et al. 2008).

For near-infrared (NIR) applications, it uses a Xenics InGaAs detector array with illumination provided by a tungsten halogen light source. The system is fitted with an AOTF (acoustic-optical tuneable filter) that provides fast switching between the spectral bands and flexibility in terms of the selection of the central wavelength and bandwidth of the filters. Filter tuning is software controlled from a laptop, the wavelength selected by changing the acoustic or radio frequency waves applied to a birefringent crystal (Liang et al. 2010).

Spectral bandwidth is the width of an individual spectral channel in the spectrometer. The narrower the bandwidth, the narrower the absorption-line feature that can be accurately measured. A 10-nm bandwidth filter set was

used across the full spectral range of the instrument to enable characterization of the continuum slope as well as the feature of interest. Integration times are adjusted for each individual spectral channel to optimize signal-to-noise ratio; 61 filter channels are used sequentially to image the object to produce a final spatial and spectral image cube in x , y , and λ dimensions. Absorption bands are detectable in the spectrum of materials caused by the presence of specific chemical bonds (Clark 1999; Clark et al. 1993). Water is a strong infrared absorber, producing diagnostic spectral features such as OH stretches at $\sim 1,400$ nm and OH H-O-H at $\sim 1,900$ nm. A near-infrared spectral range of 1,000 to 1,600 nm is used to cover diagnostic spectral absorption for water centred at 1,450 nm. Absorptions in a spectrum have two components: the individual spectral line features and the continuum onto which they are superimposed. The depth of an absorption feature is related to the abundance of the absorber. Near-infrared hyperspectral imaging of rock-art panels can be used for the identification and mapping of the presence of water by spectral feature analysis to quantitatively monitor the spatial variation of water through the surface and subsurface of the panel. It can be used in combination with other techniques to accurately record the position of measurements.

Diagnostic Mapping

Structural maps provide investigation with the means for determining the types, arrangement, and distribution of macroscopic fabric elements, as these are important for the properties of the material, and they represent a way of creating a critical weathering inventory and macroscopic description in order to quantify decay (Fitzner et al. 2003). The detailed registration of weathering forms is made by monument mapping, by which spatial distributions of fabric and damage characteristics are mapped and schematically represented in order to contextualize *in-situ* measurements and sampling locations to assist in merging the results from a suite of techniques at different scales.

DISCUSSION

In rock-art studies, it is increasingly necessary to move on from micro-destructive techniques towards non-destructive testing and monitoring methods that can be used portably in open-air locations, removing the need to remove samples or rely on proxy materials to measure characteristics such as porosity and pore-size distribution. Future work depends on an interdisciplinary approach to support the adaptation and application of techniques developed in other fields to conservation science such as NMR, OCT, and hyperspectral imaging, which can be used non-invasively at open-air sites to produce repeatable and quantitative results. Measuring spatially resolved

water absorption with the OCT moves beyond simple characterization to a better understanding of material interaction with its environment and how this will impact its vulnerability. These non-destructive testing methods can be developed for a phenomenological approach, relating empirical observations of weathering phenomena to each other using a suite of measurement techniques with interscale investigation to link visible weathering forms to microscale rock characteristics. The results from this combination of techniques will enable thorough characterization of the porosity of rock and detailed monitoring of progressive changes due to deterioration processes non-invasively at open-air rock-art panels.

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19 Computer-Aided Simulation of Natural Erosion Processes on Rock-Art

A Mathematical Tool for Conservation Studies and Absolute Dating

Paolo Emilio Bagnoli

INTRODUCTION

For open-air rock-art, whether inside or outside a protected area, a full understanding of all the natural physical and chemical deterioration factors affecting the motifs and symbols and the rate at which they act is required in order to develop suitable conservation strategies that minimize the loss of this important heritage while maintaining visibility for visitors. Such understandings usually involve the analyses of the rock substrates based on geological science, but results from such work can also be combined with other scientific disciplines, such as dedicated mathematical modelling, to allow qualitative and quantitative predictions of how rock-art panels are affected by a range of natural phenomena.

This chapter deals with this kind of investigation. The initial intent of the research reported here was to correctly identify and date rock-art sites on marble outcrops of the Apuane Alps in northwestern Tuscany, Italy. The work was aimed at producing a method that would allow computer-aided simulations of cross-sectional profiles of engraved motifs over time in relation to erosion brought about through natural weathering. Since this method requires baseline data concerning the physical properties of the rock substrate and average values for local climatic conditions, it may be configured to simulate any type of rock, surface orientation, geometry of the engravings, and geographical position and therefore may be of general use. Furthermore, as will be shown in the last section, the application of this method together with some careful experimental *in situ* measurements can provide an approximate absolute date for the engravings if certain given hypotheses are satisfied.

The core of the simulations discussed here is the so-called Monte Carlo mathematical technique. This allows information on the macroscopic characteristics of a granular system (i.e. composed of a very large number of microscopic elements) to be replicated through the continuous repetition of

stochastic events taking place at a microscopic scale, such as, for instance, the removal of small rock particles, whose probability laws are supposed to be known. In other words, the model simulates the slow removal of rock particles from a small sample area by climatic factors by running the cycle of erosion at high speed.

The method presented here requires as input data the average erosion speeds of natural physical and chemical weathering and other erosion processes of the carbonate rocks (in the present case, freeze-thaw cycles and chemical dissolution of calcium carbonate into soluble calcium-bicarbonate) and average annual rainfall. It was possible to obtain information on changes to an engraved line or cut in the range 0 to 2000 years and thereby to accurately characterize mathematically behavioural trends in the two main dimensions of the engraving (width and depth) over time.

As it will be shown, drawing on trends delivered by simulations and using accurate experimental measurements based on the current dimensions of engraved lines, it was possible to build an algorithm depicting the time elapsed since the motif was first cut and therefore establish an absolute date for this rock-art image. In the following pages, the simulation procedure is explained in detail and the results of a first application to one of the most important rock-art sites in the Apuane Alps, the Billhook Step (Il Ripiano dei Pennati, mount Gabberi, Camaione, western side of the Apuane Alps), is discussed (Bagnoli et al. 2005).

THE SIMULATION PROCEDURE

The marble block to which the simulation procedure was applied and whose structure is depicted in Figure 19.1A is composed by a regular net of elementary cubic cells representing the smallest material clusters subjected to erosion. Since the lateral dimensions (L_x , $L_y = 15$ cm) of the block can be arbitrarily chosen, the single cell size depends upon the number of cells (n_x , n_y , n_z) along the x , y , and z directions. The horizontal top surface of the block is exposed to the upper environment, while the bottom one must be considered as unlimited. On the lateral sides along the x and y directions, cylindrical-like boundary conditions exist. It means that, with x_i , y_i , and z_i as the coordinates of the centres, the cells placed on the lateral faces having $x_i = 1$ or $x_i = n_x$ may be considered as being in contact with those on the opposite face and having the x coordinates $x_i = n_x$ or $x_i = 1$, respectively.

On the top surface of the block, a parabolic-shaped linear small sign was engraved along the y direction in the centre of the x side. The particular geometry was chosen, together with the cylindrical boundary conditions in the y direction, so that erosion mechanisms may be retained as uniform along the y direction to decrease as much as possible the number of cells in the y direction in order to minimize the calculation time needed for the simulation procedure ($n_x = 1,000$; $n_y = 5$).

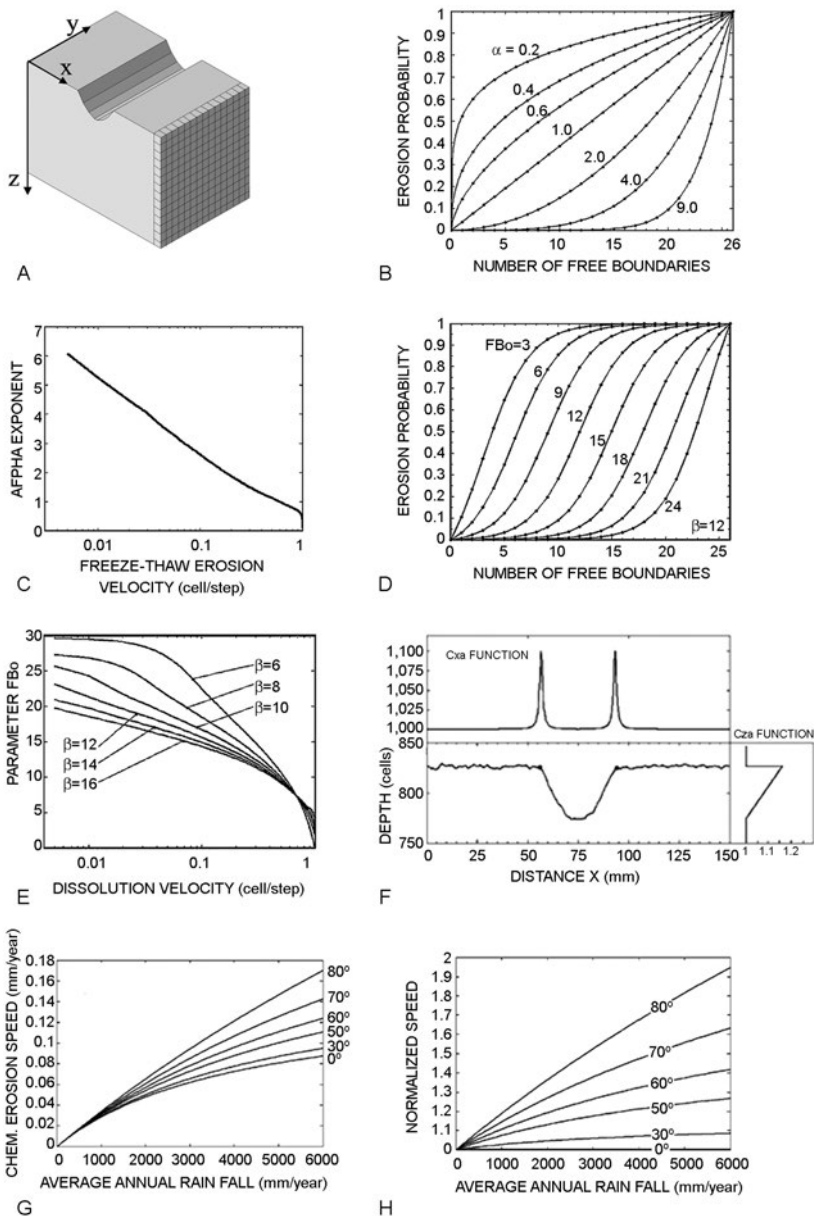


Figure 19.1 Theoretical models of rock-art characteristics and erosion parameters. A: View of the solid used for the simulations and its coordinate system. B: Plots of the P_a probability functions vs. the number of free boundaries FB and for several α values. C: Freeze-thaw erosion speed vs. the α exponent. D: Plots of the P_b probability functions vs. the number of free boundaries FB and for several FBo values. E: Chemical erosion speed curves vs. FBo parameter. F: Horizontal and vertical correction functions Cxa and Cza for the freeze-thaw erosion mechanism. G: Absolute chemical dissolution speed as functions of annual rainfall for several values of the surface angle with respect to the horizontal plane. H: Normalized version of G.

In a regular cubic network, each cell is directly bound to 26 surrounding cells, including those in the diagonal directions. If a cell has all the 26 surrounding boundaries occupied, it means that this cell is located within the bulk of the material. If some of the boundary cells are absent, it implies that the given cell is located at or near the surface.

Defined in this way, the solid may be described, from the mathematical point of view, by a couple of three-dimensional matrices in which the three indices ix , iy , and iz of the elements indicate the position of the cells in three-dimensional space. In the first binary matrix, named AL (active/alive), the elements assume the values *true* if the corresponding cell is still connected to the solid or *false* if it has been previously eroded away. The second integer matrix, named FB (free boundaries), contains the number of unbounded boundaries for each cell. The simulation of the marble erosion process as a function of time was carried out with the following three assumptions, that: (A) the original top surface of the rock is horizontal; (B) only the two above cited erosion mechanisms were taken into account (this implies that any other source of rock deformation, such as mechanical abrasions due to ice motion, is excluded); and (C) the intensity of the erosion mechanisms is uniform along the whole top surface of the sample block.

The simulation procedure is divided into time steps; the duration of each step was conventionally set to one year. Furthermore, within a single time step, the two erosion processes simultaneously occurring in reality were applied in sequence: the first is due to the freeze-thaw cycles while the second is due to the chemical dissolution of calcium carbonate. The sequential application of the two processes instead of their simultaneous action is a reasonable approximation but implies a simplification of the simulation procedure.

The simulation of the surface erosion was implemented using the following method. Two probability distributions $Pa(FB)$ and $Pb(FB)$ were defined as a function of the number of the free boundaries of the cells and for the two erosion processes, respectively. Both the functions Pa and Pb , which increase with the FB values, must be chosen with the following properties:

$$\begin{aligned} P(FB) &= 0 & \text{for } FB &= 0 \\ 0 < P(FB) < 1 & \text{for } 0 < FB < 26 & P(FB) &= 1 & \text{for } FB = 26 \end{aligned} \quad (1)$$

In a single time step, for each 'active' cell close to the top surface (i.e. having the corresponding $AL(ix, iy, iz)$ value true and the $FB(ix, iy, iz)$ value greater than zero), the computer generates a random number S in the range 0 to 1 using a uniform stochastic distribution. The removal or not of the cell is ruled by the following conditions:

$$\begin{aligned} S \leq P[FB(ix, iy, iz)] &\rightarrow AL(ix, iy, iz) = 0 & S > P[FB(ix, iy, iz)] &\rightarrow \\ &AL(ix, iy, iz) = 1 \end{aligned} \quad (2)$$

Once the erosion in the single time step is completed, both the matrices AL and FB are updated. The probability function Pa for the freeze-thaw erosion process was defined as follows:

$$Pa(FB) = (FB / 26)^\alpha ; \alpha > 0 \quad (3)$$

where the exponent α decides the concavity of the curve: upward if $\alpha > 1$ and downward if $\alpha < 1$. Figure 19.1B shows the probability distribution Pa as a function of the number of free boundaries FB and for several values of the exponent α . Note that this parameter is directly related to the average erosion rate Va' (measured in cell/step), so that the amount of the eroded material in a single time step can be finely modulated by changing the parameter α in the probability function. The dependence of the erosion speed on the exponent is shown in the Figure 19.1C. This curve was calculated from many simulation tests performed on a small, flat marble block using only the Pa function with several values of its exponent.

The shape of the second probability function Pb for the calcium-carbonate dissolution process was defined starting from the inverse of the well-known Fermi-Dirac function, ruling the energy electron probability occupation in a semiconductor crystal. Pb can be calculated from the following function $f(FB)$ normalized at $FB = 0$ and $FB = 26$ in order to exactly satisfy the rules defined in Equation 1:

$$f(FB) = 1 - [1 + \exp[(\beta / 26) (FB - FBo)]] \quad (4)$$

This function has two different parameters: β and FBo . The first one (β) rules the shape of the curve from a sharp vertical step (for β going to infinity) to a line (for β going to 0). The second parameter FBo can be defined as the number of free boundaries for which $f(FBo) = 0.5$. The so-built Pb function is shown in Figure 19.1D as a function of the free boundaries FB , for $\beta = 12$ and for several values of the parameter FBo . Also in this case, the average erosion speed due to the calcium-carbonate dissolution process Vb' (measured in cells/step) is directly related to the shape of the Pb curve and in particular to the FBo value, as can be seen from the plots of Figure 19.1E. Here the parameter FBo is plotted as a function of the erosion speed Vb' (cells/step) for several values of the parameter β . Similarly, these curves were calculated by performing several simulation tests on a small, flat marble block and using only the Pb distribution.

The parameters characterizing the two probability distribution functions, α for Pa and FBo for Pb , were chosen according to the values of the average erosion speeds Va and Vb (measured in mm/year) found in literature for environmental conditions similar to those in which the rock under study is

located. The corresponding velocities Va' and Vb' measured in cells/step can be simply obtained from the following relationships:

$$Va' = Va(nx / Lx) ; \quad Vb' = Vb(nx / Lx) \quad (5)$$

where the ratio Lx/nx is the lateral size of the cubic cells. The parameters of the two distribution functions were chosen from the plots of the Figures 19.1C and 19.1E, respectively, used as look-up tables.

EROSION RATE CORRECTION FUNCTIONS

In the description of the simulation procedure set out previously, assumption C, the uniform intensity of both the erosion mechanisms, implies that rates and hence the probability distributions should be always the same for all the exposed cells. This assumption may be quite unrealistic at a small scale since local morphological factors may concur to change erosion conditions. Therefore, in each time step, the Va and Vb rates, and consequently the parameters of the probability functions, must be changed using suitable correction functions depending on the depth of the cells within the engraved motif and on the local morphology of the exposed top surface. The erosion process, due to freeze-thaw cycles, may be considered as slightly more intense at the top surface of the engraved motif than at the bottom, and the increase in percentage must be referred to the original depth of the engraving.

This process may be described by a correction function $Cza(iz)$ which depends only on the z spatial variable of the cells. Furthermore, it must be emphasized that the borders of the motif are subjected to more intense freeze-thaw erosion than a flat surface is. This second modification can be implemented by introducing a further correction function $Cxa(ix)$ which depends only on the x spatial variable. However, this implies that the program needs to recognize, after each simulated time step, the localization of the borders of the engraving using a suitable numerical algorithm. Therefore, for each cell, the velocity Va , and consequently the Va' speed and the parameter α of the probability function Pa , must be corrected using the following relationship.

$$Va(ix, iy, iz) = Vao Cxa(ix) Cza(iz) \quad (6)$$

where Vao is the standard value of the erosion speed. As an example, Figure 19.1F shows a cross-section of the surface under simulation taken at a given time with the horizontal and vertical plots of the $Cxa(ix)$ and $Cza(iz)$ functions, respectively. The maximum values for the two functions are open parameters of the simulation tests, and in any case they do not exceed 20 per cent of the standard value. For the calcium-carbonate

dissolution process, many works can be found in the literature concerning theoretical and experimental studies of erosion on limestone rock surfaces. In particular, the study published by Szunyogh (2005) deals with an accurate mathematical model for carbonate-based rock dissolution which takes into account many environmental parameters, including annual rainfall and the slope of the rock surface with respect to the horizontal plane.

In accordance with the model and assuming a vertical rainfall, the surface-lowering W speed can be written in a compact form as follows:

$$W = (g \, Qa) / [u + Qa \cos(\theta)] \quad (7)$$

Qa is the annual precipitation, θ is the angle of the local slope of the surface with respect to the horizontal plane, and the parameters g and u are defined by the following relationships:

$$g = (k \, Ceq / \rho_{rock}) \, t_d \, S_H \, N_a \, M_{mm} \quad (8)$$

$$u = k \, t_d \, S_H \, N_a \quad (9)$$

where k is the velocity constant of the chemical dissolution at 10 °C and in open-air carbon dioxide content, Ceq is the equilibrium concentration of calcium carbonate, ρ_{rock} is the density of stone, t_d is hours/day rainfall time, and S_H (3,600 sec/hour), N_a (365 days/year), and M_{mm} (1,000 mm/m) are suitable constants applied to convert the parameter dimensions into those used in everyday practice.

From Equation 7, it can be clearly seen that the velocity W is a function of the local slope of the rock surface. Figure 19.1G shows the plots of the W speed versus the annual precipitation (assuming $t_d = 10$ hours/day) for several values of the angle θ , while in the Figure 19.1H, the same plots are drawn normalized with respect to the curve with $\theta = 0^\circ$. On the basis of the model, it can be stated that the dissolution velocity on the sample under simulation in each time step is a function of the local slope of the exposed surface. Therefore, notwithstanding that most of the original surface is nearly flat, the walls of the engraved motif undergo increased erosion with respect to the standard situation. Once a suitable value for the annual precipitation has been set, at the end of each simulated time step, the local slope can be calculated from the absolute value of the surface profile first derivative along the x axis. Of course, in order to eliminate the effects of surface roughness on the derivative function, the surface profile is previously smoothed using a mobile averaging filtering procedure. These data, interpolated within the plots of the Figures 19.1G and 19.1H, allow us to calculate the horizontal correction function $Cxb(ix)$ for the velocity Vb . The corresponding vertical correction function $Czb(iz)$ for the dissolution process may be

built in a similar way to that for the freeze-thaw cycles, but in this case, due to the accumulation of water, the standard value is located at the upper surface, while at the bottom of the engraving, the erosion velocity is higher. Therefore, the local dissolution velocity Vb can be similarly expressed by the following relationship:

$$Vb(ix, iy, iz) = Vbo \ Cxb(ix) \ Czb(iz) \quad (10)$$

where Vbo is the standard value calculated for $\theta = 0^\circ$.

SIMULATION RESULTS

The values of the rock dissolution rates for the two erosion processes were deduced from data found in available literature. Buhmann and Dreybrodt (1985) reported the average erosion thickness due to a single freeze-thaw cycle for several types of rock material. For carbonate limestone, the value is about 5.5×10^{-5} mm. Using this value and considering as a first approximation one cycle per day during 4 months per year, we obtain an average value of 0.010038 mm/year for the erosion speed Va corresponding to a Va' value equal to 0.0669 cells/year in the present simulation model ($Lx = 150$ mm; $nx = 1000$).

As far as the chemical dissolution rate is concerned, we used the data reported by Szunyogh (2005) for the physical parameters in calculating Equations 8 and 9. However, as shown in Equation 7, the most important input parameter needed by the simulation procedure is the average annual rainfall Qa . With the lack of accurate scientific data concerning the local evolution of this parameter in the last 2,000 years, annual rainfall was provisionally deduced from historical data recorded by 11 meteorological measurement stations located around the central massif of the Apuane Alps at various altitudes. The time range represented in the data is about 80 years. A plot of the Qa values for the various stations as a function of altitude was created and a linear regression of the data set calculated. The value used as the most probable one for the rock-art site under investigation was interpolated along the regression line corresponding to 2,150 mm/year. Consequently, the mean chemical dissolution velocity Vb for the horizontal condition ($\theta = 0^\circ$) was calculated from Equation 7 as being 0.0459 mm/year corresponding to $Vb' = 0.3066$ cells/year.

Using these input parameters, several simulation runs were performed on various models in which the initial depth (bo) and width (wo) of the engraved parabolic sign varied in the following ranges: $bo = 3$ to 10 mm and $wo = 5$ to 22.5 mm.

Cross-sections of an engraved line along the x -direction were created for two sample models drawn every 100 years. Attention was given to the borders of the trace as detected by the internal algorithm. The engraved lines are

still observable, despite being subject to weathering and erosion for a long period, notwithstanding the progressive widening of the cut, the smoothing of the borders, and the lowering of the top surface.

From the results of the performed simulations, a general trend in the evolution of the engraved profile may be plotted. In order to smooth the statistically induced roughness of the surface, each curve was obtained by averaging the plots of 10 different simulations with the same parameters. As can be clearly seen, the depth tends to slowly increase through time with a linear trend; the increasing speed ($K1$) was found to be independent of the original depth h_o . On the contrary, the width evolves linearly with the square root of time, except in the initial range, being slope ($K2$) and intercept (w_o') increasing functions of the original depth h_o . This behaviour can be practically described as a function of time t by means of the following set of equations:

$$h = h_o + K1 t ; w = w_o' + K2 (t)^{1/2} \quad (11a)$$

$$K2 = a + b h_o ; w_o' = c + d h_o \quad (11b)$$

where the parameters a , b , c , and d are constants which can be calculated from the plots of Equation 11b as a function of the initial depth h_o . By replacing the square root of time with the variable $x = t^{1/2}$ and knowing the present values of the engraving width w and depth h , the elapsed time from the engraving execution can be obtained from the positive real root of the following third-order algebraic equation:

$$x^3 + (d/b) x^2 - [(a + b h) / (b K1)] x + [(w - c - d h) / (b K1)] = 0 \quad (12)$$

As a first experimental test of the algorithms described, a self-dating procedure was applied to the two simulation curves. For every time step (year), the obtained values for height (h) and width (w) were used as input data in Equation 12, while the trend parameters a , b , c , and d were calculated from the averaging of several simulation tests performed using the same h_o and w_o parameters and the same average annual rainfall Qa . The output value of elapsed time was compared with the initial available value, and the relative error percentage between the true elapsed time and the back-calculated one using the dating algorithm was plotted as a function of time. The dating algorithm is able to estimate the antiquity of the engraving with a relative error in the range of 10 to 20 per cent, at least under the conditions described using a single couple of data for h and w . This first result is quite encouraging for rock-art studies, which mostly use cultural and typological considerations to date motifs and panels.

However, it must be pointed out that the curves are affected by a random error, having a zero mean value caused by the granular nature of the phenomenon responsible for the differences in the real deformation curves derived from the corresponding average trend behaviours. In order to increase the

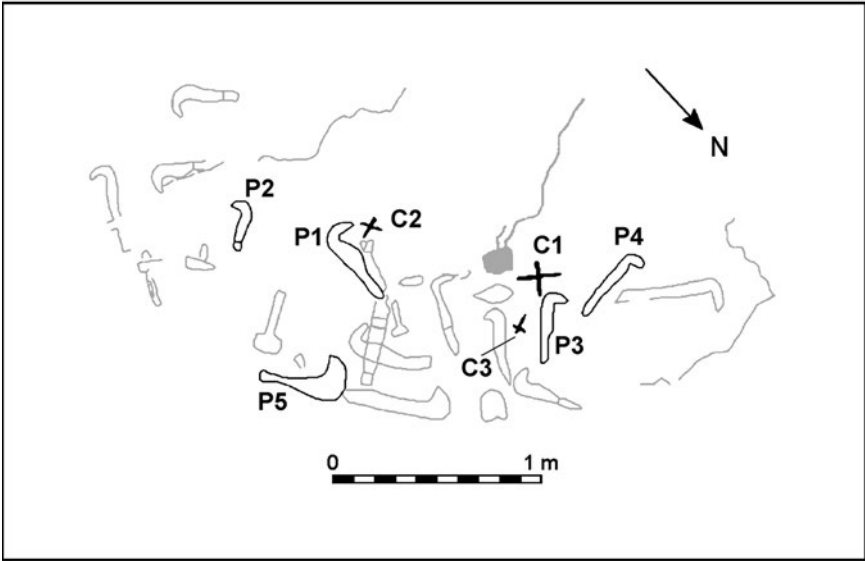
accuracy of the evaluation, at least from the random error point of view, the algorithm must be applied to several experimental measurements of the same sample (i.e. several couples of h and w taken from the same engraved figure) in order to average output values. The second source of error is 'systematically' induced by an inaccurate evaluation of the main parameters controlling the speed of erosion (for instance, average annual rainfall) and therefore causing the same error on all the output data.

EXPERIMENTAL APPLICATION

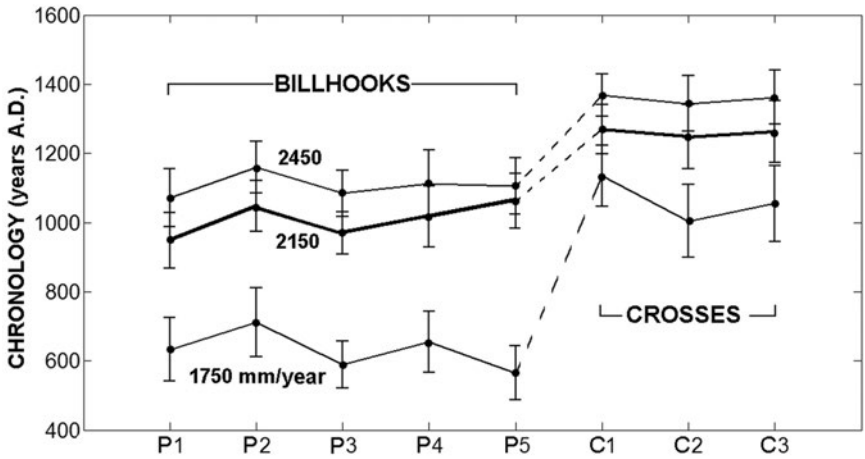
The method described here was applied to a rock-art site known as the Billhooks Step (Italian: *Ripiano dei Pennati*) on the western side of the Mount Gabberi, Camaiore, Lucca, Italy. This flat rock is located at an altitude of 960 m above sea level, on the top of a sharp cliff overlooking the Mediterranean coast (Bagnoli et al. 2005). The rock-art sites in the Apuane Alps feature representations of billhooks (Italian: *pennato* or *roncola*), the curved blades of wood cutters, as the more frequently occurring subject. These motifs are mainly localized on horizontal flat marble (carbonate rocks) surfaces located at high altitudes in prominent positions (Bagnoli et al. 2005). The motifs are life sized, have been executed by engraving a single line forming the edge of image, and present an extreme degree of degradation. The chronology of these motifs is largely unknown because of the lack of similar images at other rock-art sites in Italy. Local literature presents different and contradictory interpretations and dating (some quite startling) regarding these figures, variously placing them in the Celtic-Etruscan age, the Roman period, or as part of the *Silvanus* cult (Citton and Pastorelli 1995, 2001; Sani 2006). Another interpretation generically links these motifs with a 'sheep-herders' culture (Guidi 1992). Some have even suggested a modern origin for these motifs since it is believed that ancient figures cannot be preserved on limestone.

The complete drawing of the Billhooks Step engraved panel can be seen in Figure 19.2A. Several engraved images of billhooks are arranged along the rock together with three crosses, two having a Greek shape and one belonging to the Latin type. Fieldwork, which consisted of measuring several profiles on a selection of figures, was carried out by the author with the help of volunteers.

The dating method was applied to a set of engraved images comprising five billhooks (P1–P5) and the three crosses (C1–C3; see Figure 19.2A). The cross-sections of the engraved lines were captured using a mechanical profiler and photographed with a high-resolution digital camera. The data were then uploaded within a vectorial graphical program (AutoCad) to measure both the height and the width of the engraved line with an estimated resolution of less than 100 microns. For each image under test, up to 10 different profiles were taken in order to average the data. The results obtained are shown in a graphical way for easier reading in Figure 19.2B.



A



B

Figure 19.2 Dating methods applied to the Billhooks Step site, Mount Gabberi, Cernaia, Italy. A: Drawing of the rock-art panel. The images used for the dating experiment are labelled and shown in black. B: Plot of the chronologies of the eight figures for three different values of the average annual rainfall. The standard deviation for each date is also indicated by the vertical segments.

In order to clearly demonstrate the sensitivity of the results in relation to annual rainfall, Figure 19.2B presents the results obtained using two other Qa values (1,750 mm/year and 2,450 mm/year), allowing comparison with the dates calculated using the most probable value (2,150 mm/year) for Qa .

From a careful analysis of calculated results, some important facts may be noted. At first, as expected, the dates are progressively more recent with increases in the average annual rainfall value. This is simply because higher rainfall increases the speed of erosion, which, at least at the altitude considered, is predominantly generated by the effects of rainfall rather than freeze-thaw cycles. The second point that must be noted is the substantial uniformity of dates within the two separate groups of images. The chronologies of around 1000 AD for the billhooks and about three centuries later for the crosses, based on the annual rainfall value of 2,150 mm/year, clearly indicates a medieval date for the engravings.

However, the concentration of dates in each of the two groups does not necessarily imply that all the images in each were engraved at the same time; the uncertainty spans for the single date values (shown by the vertical line attached to each point in Figure 19.2B) corresponds to about a century. This approximation is practically the amount of the random error caused by the combined effect of the granular stochastic erosive phenomena and of the differences in shape of the groove in the various cross-sections of the engraving recorded.

Finally, it must be emphasized that there are clear difference between the dates for the billhooks as against the crosses; even ignoring the data related to the 1,750 mm/year annual rainfall values, it must be considered an extreme. This difference, which is greater than the uncertainty spans due to random error, must be attributed to real historical or cultural reasons rather than a numerical one.

CONCLUSIONS

This chapter presents a method for the absolute dating of rock-art images based on mathematical simulations and careful *in situ* experimental measurement. Even recognizing the uncertainty of some of the input data required by the mathematical analysis, it is believed that the method is very promising for obtaining reliable absolute dates for rock-art under a range of conditions and certainly under the conditions obtaining in the experiments reported here: limestone rocks, horizontal flat surfaces, open-air exposure, and images executed as engraved lines.

The experimental application reported here yielded results which are in agreement with previous attempts at the cultural interpretation of the rock-art (Bagnoli et al. 2005), both from the chronological point of view between the early Middle Ages and the beginning of Middle Ages proper and also for the later dating of the crosses in relation to the billhooks. These results strongly suggest a 'Christianizing' process at what was perceived as a sacred

place or one that remained in use by pagans for ongoing rituals. This procedure typically occurred at the beginning of the Middle Ages.

Although the data obtained for the Billhook Step may be affected by a systematic error because of uncertainties concerning some of the input parameters (e.g. average annual rainfall), it is believed that the chronological analysis of the engravings is internally consistent and therefore useful for demonstrating the validity of the proposed method. This implies that interpretations of the billhooks motifs placing them in the modern age (nineteenth century AD) or in the Etruscan or Roman period, including the ritualistic connections with the god *Silvanus*, can be discarded as completely wrong. The results may be provisionally classified as 'promising' and the associated research considered as the initial phase upon which future investigations can build.

Further research concerning the proposed dating method may involve the enhancement of approaches to validation and/or calibration, including application on other rock-art sites whose chronology may be obtained with some certainty by alternative methods. Other improvements to the method may include a refinement of annual rainfall data by investigating the results of geological researches in the Apuane Alps, a modification of the simulation procedure in order to include long-time fluctuations in the annual rainfall values, and possibly the use of more sophisticated techniques for measuring the profiles of engraved lines such as laser interferometry.

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20 Rock-Art

An Overview of Recent Developments and Initiatives by UNESCO and ICOMOS with Especial Reference to World Heritage Sites

Amanda Chadburn

INTRODUCTION

This chapter seeks to outline some of the recent initiatives undertaken by two global bodies with responsibilities for conservation and preservation, the United Nations Educational, Scientific and Cultural Organization (UNESCO) and the International Council on Monuments and Sites (ICOMOS), with respect to rock-art around the world. Rock-art is arguably the most widespread remains of human culture, found on almost every continent and in almost every region of the world. It is a phenomenon that lasted for at least 40 millennia and is therefore a highly important manifestation of human thinking and expression. The preservation of rock-art, particularly the most significant examples, is therefore highly desirable and a goal of these two bodies.

UNESCO AND ICOMOS

UNESCO was set up in 1945 following the devastation of the Second World War in order to encourage “international peace and universal respect by promoting collaboration among nations through education, science and culture” summarized in their strapline: “building peace in the minds of men and women.” (UNESCO 2014). It works to create the conditions for dialogue and tolerance among civilizations, cultures, and peoples; its overall mission is to contribute to the building of peace, the eradication of poverty, sustainable development, and intercultural dialogue through education, the sciences, culture, communication, and information. It has two global priorities, Africa and gender equality, and a number of overarching objectives:

- Attaining quality education for all and lifelong learning
- Mobilizing science knowledge and policy for sustainable development
- Addressing emerging social and ethical challenges
- Fostering cultural diversity, intercultural dialogue, and a culture of peace
- Building inclusive knowledge

Within UNESCO, there are five specialist sectors, one of which is the Culture Sector. This is responsible for a number of conventions and universal declarations, such as the Convention for the Safeguarding of the Intangible Cultural Heritage and the Universal Declaration on Cultural Diversity. It implements these conventions in order to promote intercultural dialogue, and its overall mission is to advance knowledge, standards, and intellectual cooperation in order to:

- Protect, safeguard, and manage the tangible and intangible heritage
- Promote the diversity of cultural expressions and the dialogue of cultures with a view to fostering a culture of peace

One of UNESCO's flagship campaigns and most successful conventions is its Convention Concerning the Protection of the World Cultural and Natural Heritage, commonly known as the World Heritage Convention, adopted in 1972, which is administered by its Culture Sector. This convention encourages the identification, protection, and preservation of cultural and natural heritage around the world which is considered to be of outstanding value to humanity, a concept known as outstanding universal value (OUV). What makes the concept of World Heritage so important is its universality; by definition, World Heritage Sites belong to all the peoples of the world, irrespective of the territory on which they are located, and it is a global responsibility to ensure their preservation. The World Heritage Convention sets out the procedures by which it should undertake these tasks; for example, a World Heritage Committee of 21 members meets annually, assisted by the World Heritage Centre. Individual states that sign the convention agree to ensure the identification, nomination, protection, conservation, presentation, and transmission to future generations of the cultural and natural heritage found within their territory and give help in these tasks to other states parties that request it.

ICOMOS is a non-governmental organization founded in Warsaw 1965 after the adoption of the Charter of Venice in order to promote the doctrine and the techniques of conservation. It acts as an expert adviser on cultural sites to UNESCO's World Heritage Committee. It evaluates cultural sites proposed for inscription on the World Heritage List to see if they meet the convention's stringent criteria. Additionally, it helps with comparative studies, technical assistance, and reports on the state of conservation of existing World Heritage Sites.

WORLD HERITAGE AND UNESCO'S GLOBAL STRATEGY

World Heritage Sites (WHs) are those which are considered by UNESCO to have OUV, are worthy of the best care, and can be enjoyed by present and future generations. WHs include iconic sites such as the Great Wall of China, the Pyramids of Egypt, and the Great Barrier Reef of Australia. The first World Heritage Sites were inscribed onto the World Heritage List in 1978,

but in 1994, UNESCO considered that the list was Eurocentric and lacked important classes of site. It launched a global strategy for a representative, balanced, and credible World Heritage List to ensure that the list adequately reflected the world's diverse cultural and natural heritage of outstanding universal value. Currently, its global strategy can be summarized as the five Cs:

- Strengthen the **credibility** of the World Heritage List
- Ensure the effective **conservation** of the World Heritage Properties
- Promote the development of effective **capacity building** in state parties
- Increase public awareness, involvement, and support for World Heritage through **communication**
- **Community**

With all this in mind, UNESCO and ICOMOS have undertaken various initiatives to ensure rock-art is identified, preserved, and, where appropriate, inscribed onto the World Heritage List. A good introduction to the range of rock-art sites currently inscribed on the list is presented by Jean Clottes (2008); it includes such open-air rock-art sites such as Alta in Norway, Tanum in Sweden, Foz Côa in Portugal, and Drakensburg in South Africa.

ICOMOS INTERNATIONAL COMMITTEE ON ROCK ART

The ICOMOS International Committee on Rock Art (CAR) was set up to provide expert advice to ICOMOS and UNESCO with respect to their activities on rock-art. Specifically, it:

- Promotes international cooperation in this field
- Establishes links among researchers
- Provides advice to international organisations, including through publications
- Creates a world inventory of rock-art
- Documents rock-art in traditional and digital ways

CAR has also developed a Charter for Rock Art that was adopted in 2007 and regularly publishes *INORA on-line*, the *International Newsletter on Rock Art*.

ROCK ART AT RISK

Both UNESCO and ICOMOS are very keen to ensure that the great wealth of global rock-art is preserved for future generations, and, with that in mind, it has undertaken a series of reviews of rock art at risk, following initial assessments in the mid-1990s such as that by Jean Clottes of France in a report to ICOMOS. Globally, although natural forces such as wind and

water erosion are taking their toll, human activity is the biggest negative impact on rock-art sites, especially as a result of infrastructure projects and economic and industrial activity (Bertillsson 2002, 2007; ICOMOS 2000). Raising the profile of infrastructure projects may not have helped to preserve Neolithic rock at Ningxia, China, destroyed by a new road, nor that in the Draa Valley of Morocco, destroyed by quarrying (Bertillsson 2002). However, it did help raise the profile of the wonderful rock-art at Foz Côa, Portugal, once threatened by the construction of a dam and now inscribed as a World Heritage Site. This is an ongoing initiative (see Chapter 9).

THEMATIC STUDIES

A wide range of thematic studies is underway, both geographically and by other subject areas such as prehistory. These are being undertaken in order to ensure that, given the ubiquity of rock-art globally, it should figure prominently on the World Heritage List. For some parts of the world, rock-art may be the only means of filling known gaps in the list and making it more credible. However, it is difficult for the World Heritage Committee to ensure that the nominations really have OUV if they have not been properly researched. The committee needs to ensure that for rock-art to have OUV, it is the best example or the most pre-eminent survival in a particular geocultural region and that it is truly exceptional. This cannot be done unless comparative studies have been undertaken and the significance of the rock-art of a region of the world is properly understood (ICOMOS 2010, 1).

A number of geographical thematic surveys are underway or have been undertaken, and expert meetings have been held for a number of regions of the world such as Central Asia and the Caribbean. These meetings also have the benefit of capacity building. Such work in the Caribbean is a good example of a geographic thematic study, allowing state parties such as the UK to evaluate rock-art sites on its Caribbean territories such as the Fountain Cavern, Anguilla, which was on the UK's 1999 Tentative List (ICOMOS 2006).

A different sort of study is exemplified by the Thematic Initiative on Prehistory and World Heritage. This was initiated after the World Heritage Committee met in Quebec and decided that prehistory was underrepresented on the list. Discussions were initiated in Seville, Spain, in 2009 and had three strands:

- Human evolution
- Rock-art
- Prehistoric properties associated with major cultural phenomena

The international meeting, Rock Art and the World Heritage Convention, held at uKhahlamba/Drakensburg Park, South Africa, from 3 to 8 April 2009, was set up under this initiative and involved the participation of 44 governmental delegates, advisory bodies' representatives, international

experts, and site managers. The meeting aimed to identify key values, issues, and priorities in the field of rock-art research, particularly its management, conservation, and documentation in relation to World Heritage status, and is typical of such work going on around the world. Initial work on the Prehistory Thematic Initiative has been well documented (UNESCO 2009) and is feeding into the identification of prehistoric sites globally with a view to getting more of these sites on the list.

ICOMOS BIBLIOGRAPHY OF WORLD HERITAGE ROCK ART

As a contribution towards providing information to aid preservation and conservation, ICOMOS decided to publish an online description and bibliography of 31 rock-art sites in 27 countries that are currently on the World Heritage List (ICOMOS 2009).

There is also a World Rock Art Archive Working Group, and plans are underway for the creation of an International World Heritage Rock Art Archive.

STONEHENGE: A CASE STUDY IN RESEARCH AND CONSERVATION

In 2009, UNESCO contacted English Heritage, asking them to complete a detailed questionnaire about rock-art at the Stonehenge World Heritage Site, Wiltshire, in central southern England, UK. This was interesting as, unlike various other World Heritage Sites such as Foz Côa in Portugal, Stonehenge is not normally considered a rock-art site, and this was not the principal reason for its inscription. Indeed, the rock-art elements of Stonehenge were not specifically mentioned in the World Heritage nomination documents or in the Statement of Significance (Young et al. 2009, 26–7) or in the later Statement of Outstanding Universal Value. The questionnaire focussed the minds of the advisers and managers of Stonehenge on the rock-art elements of Stonehenge. They indicated the likelihood of further prehistoric art being discovered through further detailed recording and recommended that mapping the surfaces of the Stonehenge stones should be undertaken as a matter of urgency as proposed in the published research framework (Darvill 2005, 128: Objective 7).

Rock-art at Stonehenge WHS is currently only known on Stonehenge itself; nothing certain has been identified at the Avebury part of the WHS, although some polissoirs are known in the Avebury landscape. At Stonehenge, open-air rock-art panels were identified by Prof. Richard Atkinson on 10 July 1953 (Crawford 1954), when he noticed axe and dagger motifs on Stone 53 whilst photographing the face of the stone under optimum lighting conditions late in the afternoon (see Figure 20.1). As these carvings are readily visible today under most lighting conditions, it is perhaps surprising that they had never been recorded before by antiquarians and archaeologists (see Figure 20.2).



Figure 20.1 Stonehenge, Wiltshire, UK. Axe and dagger carvings on Stone 53 in 1953. (Photograph from NMR 2.42/5 P52379. Copyright English Heritage.)



Figure 20.2 Stonehenge, Wiltshire, UK. Recent photograph of axe and dagger carvings on Stone 53. (Photograph by English Heritage. Copyright reserved.)

During late 1953 and early 1954, several other axe carvings were noted, details of which are well summarized elsewhere (Darvill 2006, 129; Lawson and Walker 1995). Only the surfaces of a relatively few sarsen stones appear to have carvings on them. Before the most recent survey, it was considered that rock-art could be found on four upright sarsens: Stones 3, 4, 53, and 57, with possible carvings on Stones 23 and 29. In 2003, Wessex Archaeology undertook a limited laser scan of the well-known motifs on Stone 53 and discovered more previously unrecognized axe motifs.

English Heritage recently commissioned a laser scanning survey of Stonehenge and the surrounding land, which was undertaken by the Greenhatch Group in 2011. Modern 3-D laser scanning and other digital imaging technology was used to produce the most detailed and accurate digital model yet constructed of this iconic monument. The results were extremely impressive (Abbott and Anderson-Whymark 2012). Virtually every stone at Stonehenge was found to have been worked or shaped, particularly those along the solstitial axis, and the number of rock-art motifs increased dramatically.

All of the previously recorded prehistoric carvings were identified, and numerous new axe carvings and another possible dagger carvings were discovered. There are four main rock-art panels on Stones 3, 4, 5, and 53, but four other carvings have been found on other surfaces of Stones 5, 23, and 53. All these stones had been identified previously as having rock-art, but this new survey showed that many motifs had been missed. By contrast, other tentatively identified carvings such as the Mother Goddess on Stone 57 (Lawson and Walker 1995) and all possible cup-marks were dismissed, the cup-marks being shown to be natural hollows. The results show that the only convincing prehistoric rock-art at Stonehenge is that depicting unhafted bronze axe heads and daggers, presumably of bronze. The exact date of these is difficult to establish, but based on artefact typologies, it is likely that these axes date to *c.* 1750–1500 cal BC (Abbott and Anderson-Whymark 2012, 54). The daggers could be of a similar date, although they also look as though they could be earlier, *c.* 2000 cal BC (they were once mistakenly identified as ‘Mycenaean’ in form). Whatever the exact date, it is likely that the carvings were at least 500 years later than the elements of monument on which they were cut and could have been made as late as 1000 years after the Sarsen Circle and Trilithons were built.

The 2011 survey increased the number of axe carvings at Stonehenge from 44 to 115, effectively doubling the number of early Bronze Age axe-head motifs known in Britain. In fact, 83 per cent of early Bronze Age axe carvings in Britain are now known to be from Stonehenge, as are 50 per cent of the far rarer dagger carvings. The incremental increase in identified motifs is exemplified by the resurvey of Stone 53, where numerous axe carvings were discovered in 2011, despite the fact that the surface had previously been laser scanned as recently as 2003. This shows the value of continued research on even the best known of monuments, particularly with improvements in computing and digital recording.

The rock-art at Stonehenge is well protected. The stone settings in the centre of site are closed to the public and have been since 1978, although

special-access tours are available early in the morning and late in the evening outside normal opening hours. Visitors to Stonehenge are instructed not to touch the stones, and there is round-the-clock security. However, between 1953 and 1978, the site was open and visitors could touch the carvings. Some commentators (for example, Chippendale 1983, 2004, 202–3, figs. 174 and 175) considered that the most obvious carvings of the dagger and axes on Stone 53 were damaged and/or eroded by visitors during this period, but sarsen is an extremely hard stone, and it appears more likely that they simply became discoloured through constant touching leaving grease on the stones. Certainly, Figures 20.2 and 20.3 suggest there has been no physical erosion. However, the solstice and equinox open-access celebrations present

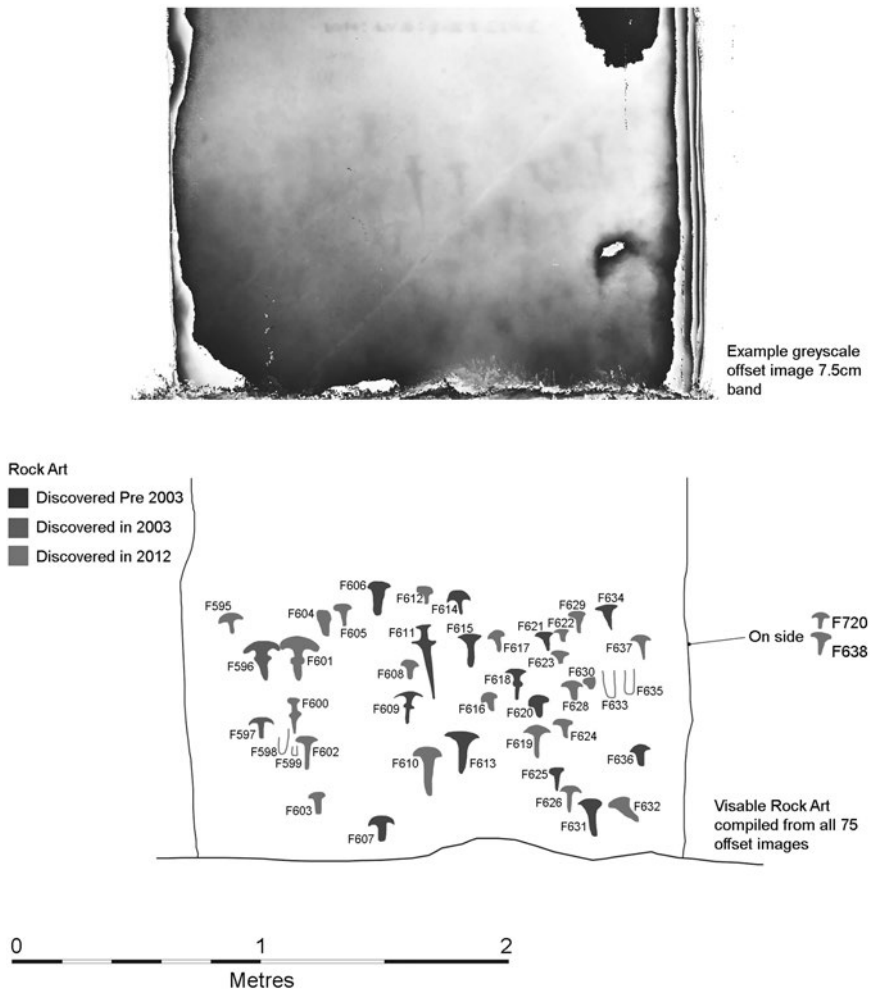


Figure 20.3 New rock-art discovered in 2011 on Stone 53 at Stonehenge, Wiltshire, UK. (Image by English Heritage. Copyright reserved.)

a continuing challenge to managers of the site, as visitors are allowed to roam freely within the circle at these times.

Lichens cover the surface of most of the stones, and this has certainly hindered the identification of rock-art, particularly as many motifs comprise very shallow carvings. There has not yet been an assessment of whether the lichens are adversely affecting the rock-art, and this should ideally be undertaken. It is worth noting that the lichens are a rare and varied colony and represent an important collection of these plants. The carvings are subject to the usual forms of weathering, and there is a need for continued monitoring to ensure they do not erode further.

CONCLUSIONS

Rock-art is valued by UNESCO and ICOMOS and is considered under-represented on the World Heritage List. A wide range of initiatives by these bodies is being undertaken to ensure its long-term preservation *in situ*, by record, and accompanied by assessments of its global significance. The case study of Stonehenge highlights that even the most well known of monuments can be very imperfectly understood. The need for a full and deep understanding of rock-art around the world is critical not only to understanding its significance but also to its ongoing management.

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Melissa Marshall is a PhD candidate at the Australian National University Research School of Humanities and the Arts and the School of Archaeology and Anthropology. Due for completion in 2014, her research focuses on the conservation and management of rock-art sites in Australia, making use of both traditional Indigenous and Western scientific methods, as ways to address environmental and contemporary issues. Study sites include those within Kakadu National Park (World Heritage Area), western Arnhem Land on Mirarr country (Jabiluka Uranium Mineral Lease), and the west Kimberley region. She has also worked as an archaeological and GIS consultant for the past 14 years with many Indigenous ranger groups in the central and northern regions of Australia. She has been based in the Kimberley region of Western Australia for the past nine years and undertakes cultural heritage, site management, geospatial mapping, and research projects with local Indigenous groups and regional Indigenous organizations. She also provides support to them with grant writing and heritage advice, as well as lecturing at an annual field-school in Arnhem Land. She lives in a remote Aboriginal community with her husband and three children.

Aron Mazel has been researching rock-art since the 1970s, which has included recording 350 rock shelters containing 20,000 paintings in the uKhahlamba-Drakensberg (South Africa) and 750 carved panels in Northumberland (UK). Mazel's rock-art publications have covered the distribution of painted themes, the representation of domestic animals in rock-art, seasonality, colonial rock-art, chronology and dating, integrating rock-art and excavation datasets to improve our understanding of uKhahlamba-Drakensberg hunter-gatherer history, and the preservation, management, and public presentation of this vulnerable resource. Mazel is the director of the International Centre for Cultural and Heritage Studies, Newcastle University, Newcastle upon Tyne, UK, and he is also a research associate at the School of Geography, Archaeology & Environmental Studies, University of the Witwatersrand, South Africa.

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Elizabeth E. Peacock is a professor of conservation at the Norwegian University of Science and Technology (NTNU) in Trondheim, Norway, and a professor of conservation at the Department of Conservation at the University of Gothenburg, Sweden. She is a research conservator with extensive practical conservation as well as research experience, including *in-situ* rock-art. Dr Peacock contributed to NTNU Museum's five-year monitoring programme that investigated the impact of thermal cycling and insulating covering on exposed rock-art surfaces.

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Roar Sæterhaug is the retired head of conservation at the NTNU University Museum at the Norwegian University of Science and Technology in Trondheim, Norway. He was instrumental in engaging the conservation laboratory in the museum's regional rock-art preservation activities from the 1970s. Moreover, he led the museum's participation in the Norwegian Rock Art Project (1996–2005) and actively contributed to ensuing maintenance projects.

Kate Sharpe's doctoral research at Durham University explored the contexts of rock-art in Cumbria. She has since worked on a number of participant-led rock-art projects in northern Britain, including the Northumberland and Durham Rock Art Project (2006–2008), which resulted in the England's Rock Art database and website; Rock Art on Mobile Phones at Newcastle University; and Carved Stone Investigations: Rombalds Moor (2010–2013) in West Yorkshire. She edits an informal newsletter, *Rock Articles*, which aims to inspire and connect researchers, heritage managers, and enthusiasts with an interest in British rock-art. Her own research remains focused on Cumbria, where a number of cup-marked outcrops have recently been identified in the central valleys of the Lake District, leading into the fells where Group VI axes were quarried.

Elizabeth Shee Twohig is a research fellow at the Department of Archaeology, University College, Cork in Ireland, where she formerly lectured. She has been working in the area of rock-art studies since the 1960s and has published extensively on the topic. Her 1981 publication *The Megalithic Art of Western Europe* formed the foundation for most subsequent research in that area of rock-art. She is currently involved in helping with the preparation of the corpus of megalithic art from the passage tomb of Knowth for publication and in other rock-art projects in Ireland.

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Paul S. C. Taçon, FAHA, FSA, is chair in rock art research and professor of anthropology and archaeology in the School of Humanities, Griffith University, Queensland. He also directs Griffith University's Place, Evolution and Rock Art Heritage Unit (PERAHU). Prof. Taçon has conducted archaeological and ethnographic fieldwork since 1980 and has more than 80 months' field experience in remote parts of Australia, Cambodia, Canada, China, India, Malaysia, Myanmar, southern Africa, Thailand, and the United States. Prof. Taçon coedited *The Archaeology of Rock-Art* with Dr. Christopher Chippindale (1998, republished four times) and has published more than 190 academic and popular papers on prehistoric art, body art, material culture, colour, cultural evolution, identity, and contemporary Indigenous issues. Much of his current research is related to better situating Australian archaeology and contact history in a Southeast Asian regional context and to more fully involving Indigenous peoples in archaeological research. Prof. Taçon leads the Protect Australia's Spirit campaign devoted to raising

awareness about and threats to Australia's unique rock-art heritage and the establishment of an Australian national rock-art heritage strategy.

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Gordon Turner-Walker is currently a professor of conservation at the National Yunlin University of Science and Technology in Taiwan. During his former employment with NTNU, he contributed to the University Museum's five-year monitoring programme that investigated the impact of thermal cycling and insulating covering on exposed rock-art surfaces. His main contributions focussed on the effects of solar radiation on seasonal and short-term variations in rock surface temperatures.

Patricia B. Warke holds a BSc (Hons) from Queen's University Belfast (1990) and a PhD from the same university (1994). She teaches at the School of Geography, Archaeology & Palaeoecology, Queen's University Belfast, where she is a member of the Environmental Change cluster (Weathering Research Group). Her postgraduate doctoral research involved investigation of rock weathering in contemporary hot, arid environments with emphasis on the role of inheritance effects in development of present-day weathering phenomena. Since then, whilst maintaining an interest in all aspects of arid-zone rock weathering, her research interests have broadened to include study of the decay dynamics of stone in built structures, both archaeological and historical, with an interest in the development of condition classification schemes using a staging system approach.

Ken Williams is a photographer and independent researcher from the Boyne Valley in Ireland. For more than a decade, he has focused on recording and researching prehistoric monuments, megalithic art, and open air rock-art of the Neolithic and Bronze Ages in western Europe and particularly in his native Ireland. Working closely with archaeologists, heritage groups, and other interested parties with the aim of promoting awareness and appreciation of prehistoric field monuments and decorated stones, he strives to produce unique

photographic records that are as evocative as they are informative. His images have appeared in numerous textbooks and academic papers, whilst the first fully illustrated guide to the open-air and megalithic prehistoric art of Ireland, based around his photographic work, is currently in preparation.

Donna Yoder is a rock-art and a records-management specialist. She served as treasurer of the American Rock Art Research Association and as vice president for membership and recording secretary for the Arizona Archaeological and Historical Society. She has participated in a number of archaeological and rock-art field schools and recording projects. She is the field director for the Chaco rock-art projects.

Index

Table numbers in *italic*; Figure numbers in **bold**.

- Aboriginal Groups (Australia) 215, 217, 219, 221–2
- Aboriginal Groups (North America) 176, 186
- acid rain 85
- air temperatures 45, 89, 134
- algae 41, 74–5, 77, 92, 94, 106, 196, 198, 207, 221
- Altai, Russia 2
- Altamira, Spain 2, 190
- Amafa aKwaZulu-Natali, Drakensberg, South Africa 231–2, 236–7, 240–1
- animal activity 41
- animal faeces 206
- Apuane Alps, Italy 259–60, 266, 268, 271
- Archaeological Society of New Mexico Rock Art Field School 168–9
- Arco do Covão, Piauí, Brazil 209, **15.2**
- aspect 32, 42, 125, 127–30, 135–38, 203, 214
- Athabasca River, Canada 175
- Avebury, Wiltshire, England, UK 30, 276
- Ayers Rock, Australia *see* Uluru
- Bacamarte River, Brazil 210
- Ballacricyrt, Arbory, Isle of Man **2.2**
- Ballinloughan, Co. Louth, Ireland 78
- Ballinvally, Co. Meath, Ireland 71, 77
- Ballowall Barrow, Cornwall, England, UK 30
- Beckensall Archive Project (BAP) 42–3, 48
- Begby, Norway 89, 91
- Belomorsk, Russia 116
- Besovy Sledki, Russia 113, 114, 116
- Big Rock, Alberta, Canada 174–5, 177, 178, 180, 184, 187
- Billhook Step, Mount Gabberi, Camaiore, Italy 260, 268, **19.2**
- biodegradation 5, 6, 39
- Black Hills, South Dakota, USA 177
- Blackfoot 174, 179–80, 184, 186
- Blackstone Beck, West Yorkshire, England, UK 21
- blind recording 118
- Boheh, Co. Mayo, Ireland 76
- Bolshoi Golets Island, Russia 103
- Bronze Age 2, 19, 82, 84, 102, 278
- Brú na Bóinne, Co. Meath, Ireland 73
- Burra Charter 217
- Burren, Ireland 79
- Callanish, Lewis, Scotland, UK 41–2
- Cape Besov Nos, Russia 102, 107
- Cape Karetskiy, Russia 104, 107
- Cape Kladovets, Russia 103
- Cape Peri, Russia 100, 106, **7.3**
- capillary uptake test 248
- Caring for Country (CFC) 219
- Carta del Rischio/Risk Map 146–7
- Carved Stone Investigations: Rombalds Moor (CSIRM) 55–61, 63, 66
- Castlerigg, Cumbria, England UK, 30
- Chaco Canyon, New Mexico, USA 167–73, **12.1–4**
- Chaco Culture National Historical Park *see* Chaco Canyon
- Chaco Rock Art Reassessment Project 167
- Chacoan 168, 172
- Chalawong, Queensland, Australia **16.1**

- chemical breakdown 41
 cist-grave art 19
 Clew Bay Archaeological Trail, Co. Mayo, Ireland 76
 climate change 6, 38, 39, 41–2, 45, 47, 50, 174, 3.2
 Clonasillagh, Co. Meath, Ireland 76
 Clonfinlough, Co. Offaly, Ireland 77
 Côa Valley, Portugal 125–40, 9.1–4, 9.1, 9.3, 9.4
 Côa Valley, Portugal 2, 10, 125, 130, 137–8
 Coilsfield, Ayrshire, Scotland, UK 17
 Columbia River, Oregon USA, 128
 community archaeology 11, 59
 Condition Assessment and Risk Evaluation (CARE) 50, 51
 contact methods 2.2
 Coomasaharn, Co. Kerry, Ireland 79
 Copt Howe, Cumbria, England, UK 21
 Cultural Efficiency Index 151
 cup-and-ring 17–19, 21, 29, 31, 66, 70, 76
 cup-marks 2, 19, 32–3, 74, 76, 84, 278
 cycle of understanding 62
- Dampier Peninsula, Australia 215–16
 Derrynablaha, Co. Kerry, Ireland 77, 5.2
 diagnostic mapping 255
 Didima Gorge, South Africa 236–7
 Didima San Rock Art Interpretive Centre, uKhahlamba-Drakensberg Park, South Africa 237–9, 17.3
 digital photography *see* photography
 Dingle Peninsula, Co. Kerry, Ireland 76, 79
 documentation 4, 7–9, 11, 18, 22–24, 29, 71, 82, 86–7, 92–3, 98–100, 104–7, 118, 123, 167–71, 173, 187, 192–95, 215–16, 219, 223, 276
 Dolmen de Antelas, Viseu, Portugal 10.2
 Dombate, A Coruña, Spain 10.2, 10.4
 Dowth, Co. Meath, Ireland 73
 Drah Valley, Morocco 275
 Drakensberg, South Africa 128, 229, 240
 drilling-resistance 246
- earthfast boulders 3, 19
 education 6, 8, 30–1, 62, 66, 157, 186, 211, 244, 272
- Ekeberg, Norway 89, 91
 electrical resistance measurements 247
 energy dispersive spectroscopy (EDS) 204
 England's Rock-art Database (ERA) 62–5, 79
 environmental change 1, 39, 115
 epigraphic approach 29, 2.2–3, 2.1
 ethical issues 8, 10–11, 22, 185, 203, 217, 272
 exfoliation 85, 87, 92, 164, 191, 195, 206, 209, 222
 exposed rock outcrops 3, 89
- Fajada Butte, Chaco Canyon, New Mexico, USA 169
 Fariseu Rock, Côa Valley, Portugal 9.2
 figurative motifs 11, 84, 208–9
 fire 203, 206, 215, 217, 220, 223, 232
 flooding 116, 203, 210, 252
 foil impression 2.2
 Foothills Abstract rock-art tradition 177
 Foothills Erratics Train, Canada 175
 Forenaghts, Co. Kildare, Ireland 71, 5.1
 Fountain Cavern, Anguilla 275
 fourier transform infrared spectroscopy (FTIR) 198, 204
 Fourknocks, C. Meath, Ireland 74
 Fournaghts, Co. Kildare, Ireland 77
 Fowberry Cairn, Northumberland, England, UK 21
 Foz Côa, Portugal 142, 274–6
 freeze-thaw cycles 85, 128, 260, 262, 264, 266, 270
 Fylingdales Fir, Co. Durham, England, UK 21
- Game Pass Shelter, Drakensberg Park, South Africa 233
 Gardom's Edge, Derbyshire, England, UK 21, 31, 2.3
 Geographical Information System (GIS) 22, 24, 34, 146, 194
 geometric recording 161, 11.2
 Glacian style rock-art 19
 Gled Law, Northumberland, England, UK 4.1
 global positioning systems (GPS) 22–3, 53, 55, 163, 214, 221
 Gog Group quartzite 175, 178, 184
 graffiti 31, 41, 44, 63, 167, 172, 174, 178, 180–1, 183, 185–7, 204, 206–8, 211, 217, 221

- Grupo de Investigación de Arte
Rupestre (GIPRI) 191–2, 194,
196, 199, 14.1–3
- Hadrian's Wall, England, UK 30
- Hermitage Museum, St Petersburg,
Russia 100
- Hermitage Rock, Russia 100, 7.2
- Hjemmeluft, Alta, Norway 89, 91,
94–5
- humidity 128, 137, 144, 191, 194,
197–9, 204, 207
- hyperspectral imaging 254–5
- iKanti Shelters, Drakensberg, South
Africa 233
- information boards 66, 112
- Integrated Management Plan 231
- International Council on Monuments
and Sites (ICOMOS) 4, 11, 142,
145, 203, 217, 220, 272–6, 280
- International Federation of Rock-Art
Organizations (IFRAO) 2
- Isimangaliso, South Africa 230
- Joshua Tree National Park, California,
USA 221
- Kakadu National Park, Australia 2,
214–6, 219, 221–3
- Kamberg Rock Art Centre, KwaZulu-
Natal, South Africa 238–9, 17.2
- Kamberg Rock Art Trust 239
- Karelia 98, 104, 106, 108–10, 122
- Keep River National Park, Australia
217
- Kilmartin, Argyll and Bute, Scotland,
UK, 22, 31
- Kimberley, Australia 217, 220
- Kladovets Nos, Russia 7.4
- Knockmany, Co. Tyrone, Northern
Ireland, UK 74
- Knockroe, Co. Kilkenny, Ireland 76,
79, 5.2
- Knowth, Co. Meath, Ireland 70, 73–4,
78
- Kochkovnavolok, Russia 103–4, 106
- Kunlun Mountains, China 128
- KwaZulu-Natal Museum, South Africa
231
- Lake Onega, Russia 98–9, 100, 102–4,
107, 109, 7.1
- Lascaux, France 2, 190
- laser scanning 25, 29, 33, 57, 79,
162–3, 183, 278, 2.2, 2.3 2.2
- Leirfall, Norway 9, 82–9, 91–5, 6.1–4
- Levantine style rock-art (Iberia) 159,
11.1
- lichen 6, 41, 45, 63, 73, 77, 87, 92–4,
102, 104–6, 128, 191, 207, 201,
211, 280
- light reflectivity 183
- Litsleby, Tanum, Sweden 89, 91, 94
- Lordenshaws, Northumberland,
England, UK 31, 43, 53, 64, 3.1
- Loughcrew, Co. Meath, Ireland 70–1,
74–5, 77, 5.2
- Magheranaul, Co. Donegal, Ireland 78,
5.3
- management plans 48, 86, 144, 211,
232
- marble 259–60, 262–3, 268
- mathematical simulations 270
- megalithic art 3, 19, 142, 146, 148, 157
- Mguni Shelter, Drakensberg, South
Africa 233–4
- Mobiliary rock-art 19, 21, 71
- Models (3-D) 59
- Monte Carlo Simulation 259
- monument-based rock-art 19
- moss 74, 85, 105, 106, 128
- Mothel, Co. Waterford, Ireland 71
- moulding 91
- Mungo National Park, New South
Wales, Australia 219
- museums 71, 100, 107, 109, 114, 122,
249
- Mutawintji National Park, New South
Wales, Australia 219
- Nanguluwurr, Kakadu National Park,
Australia 16.3
- natural processes 5, 10, 85, 106, 144
- Navajo Nation, USA 169
- Navajo Rock-Art Project 171
- Neolithic 2, 19, 21, 98–9, 159, 189,
275
- Newgrange, Co. Meath, Ireland 73
- Ningxia, China 275
- non-contact methods 2.2
- Northumberland and Durham Rock
Art Pilot Project (NADRAP)
42–3, 48, 54, 55–63, 66, 3.1
- Northumberland National Park,
UK 31
- Northumberland 2.1

- Norwegian Rock-Art Project (NRAP)
86–7, 91–2, 94
nuclear magnetic resonance 253
- Okotoks, Alberta, Canada 174–81,
183–7, 13.1–4
- Old Berwick, Northumberland,
England, UK 17
- optical coherence tomography 248,
18.1
- paint 2, 18, 87, 91–3, 143–4, 148, 179,
180, 183, 197, 211, 214–5
painting *see* paint
- Panorama Stones, West Yorkshire,
England, UK 31
- passage tomb 70, 72–6
- patination 73, 191
- Pedra do Castelo, Brazil 208, 15.2
- Pedra do Ingá, Paraíba, Brazil 209–10,
15.2
- Peterborough Petroglyph Site, Ontario,
Canada 186
- Petra, Jordan 49–50, 128
- photogrammetry 59–61, 66, 79, 92,
162
- photography 33, 55, 59, 77, 79, 91–2,
107–8, 192, 2.2, 2.3
- pigments 161, 189–92, 196–98, 202–3,
208
- Pleistocene 1, 125, 175
- pollution 30, 38, 40, 45, 85, 86, 146,
196, 203, 204, 210, 245
- Pool Farm, Priddy, Somerset, England,
UK 32
- precipitation 40–1, 45, 47, 76, 129–30,
132, 135–6, 265
- Purnululu National Park, Western
Australia, Australia 219
- QR code 65
- Quinkan Reserve, Queensland,
Australia 215
- rainwater 73, 144, 198, 203, 205, 212
- rebound hammer 245, 2.2
- reburial 85, 91, 153–4
- reconstructions 155
- recording rock-art 8, 23–4, 106–7, 161
- red pigment 176, 181, 183–4
- replicas 31, 33
- resilience 39, 47, 48, 50
- resistance 38, 39–40, 244–7
- Risk Map *see* Carta del Rischio
- Rivock Edge, West Yorkshire, England,
UK 2.1
- Roca de La Cuadrícula, La Poma,
Cundinamarca, Colombia 194
- Rock Art Mobile Project (RAMP) 53,
55, 61, 63–6, 4.3
- Rock Art Pilot Project (RAPP) 9,
17–20, 22, 24–5, 30–1, 33–4, 56
- Rock Carvings in the Borderlands
(RCB) 86, 91–2, 94
- Rock of the Sun, Mesitas de El Colegio,
Cundinamarca, Colombia 14.1
- rock shelter 159, 201, 208
- rock temperatures 89, 91
- Rock-Art Project (RAP) 85
- Rombalds Moor, West Yorkshire,
England, UK 4.2
- roots 63, 85, 206, 209
- Roughting Linn, Northumberland,
England, UK 30–1
- rubbing 8, 9, 41, 74, 91, 92, 103,
105, 107, 112, 118, 119, 122,
2.2, 2.3
- satellite imagery 60
- scanning electron microscopy (SEM)
204
- Schmidt Hammer 245
- Serra da Capivara National Park, Brazil
2, 201–2, 204, 208, 212, 15.2
- Sess Kilgreen, C. Tyrone, Northern
Ireland, UK 74
- Sete Cidades National Park, Piauí,
Brazil 207–8, 15.2
- Shanacashel, Co. Kerry, Ireland 77
- signage 64, 93, 155–6, 173, 179, 186,
16.3
- simulation 259–60, 266, 19.1
- solar radiation 89, 128, 132, 136–8,
194, 196, 210
- Staged Assessment 49, 4.3
- standing stones 3, 38
- stelae 3
- Stjørdal Valley, Trøndelag, Norway 82
- Stonehenge, Wiltshire, England, UK 19,
30, 42, 276, 278–80, 20.1–3
- Sun Dagger effect, Chaco Canyon, New
Mexico, USA 169
- Swastika Stone, West Yorkshire,
England, UK 31, 2.3
- Tara, Co. Meath, Ireland 74
- temperature 40, 45, 47, 88–9, 91,
127–30, 132, 134–7, 163,

- 190–1, 194–5, 197, 199, 204,
210–11, 217
- termite galleries 206
- Toca da Entrada do Baixão da Vaca,
Piauí, Brazil 201
- tourism 4, 5, 7, 11, 30, 38, 56, 122,
145, 174, 214–5, 234–41, 244
- tracing 2.2, 2.3
- tracing 67, 91–2, 100, 102, 201, 2.1
- trail 172, 179
- ultrasonic velocity measurement 246
- Uluru (Ayers Rock), Northern Territory,
Australia 215, 219
- Uluru-Kata Tjuta National Park,
Northern Territory, Australia
215
- underwater rock-art 98, 102–3, 106,
108
- United Nations Educational, Scientific,
and Cultural Organization
(UNESCO) 3, 4, 11, 89, 159,
167, 168, 272–4, 276, 280
- Vale do Catimbau National Park,
Pernambuco, Brazil 211, 15.3
- vandalism 1, 6, 31, 66, 105, 122, 144,
167, 172, 174, 178–9, 183,
185–7, 204, 207, 212
- Venice Charter 203
- Vertical Series style of rock-art 176–8
- video scanning 91
- Vig River, Russia 112, 114–6
- Vingen, Norway 89, 91, 94
- volunteers 42, 54–64, 66, 93, 167, 268
- walkways 55, 93, 112, 122, 173, 8.4
- wasps 201, 206
- weathering 1, 5–11, 24, 39, 41–42,
63, 67, 70, 78, 83–8, 105, 115,
118, 125, 127–9, 134–8, 164,
184, 196, 198, 211, 237, 244–6,
249, 252, 254–6, 259–60, 267,
280, 2.2
- West Yorkshire 2.1
- White Sea, Russia 109, 112–6, 118–9,
121–4, 8.1, 8.1, 8.3
- wind 63, 106, 132, 134, 136, 194, 210,
211, 274
- Working on Country (WOC) 219,
221–2, 16.2
- World Heritage Convention 161, 232,
273, 275
- World Heritage List 3, 30, 73, 159,
215, 273–6, 280
- World Heritage Site 38, 73, 89, 167–8,
215, 229–30, 235, 272–3,
275–6
- x-ray diffraction (XRD) 204
- x-ray fluorescence (XRF) 183, 204
- Zalavruga, Russia 112, 114–7, 121–4,
8.2, 8.4