

## ENCYCLOPEDIA of GEOARCHAEOLOGY

## **Encyclopedia of Earth Sciences Series**

### ENCYCLOPEDIA OF GEOARCHAEOLOGY

### **Volume Editor**

Allan S. Gilbert is Professor of Anthropology at Fordham University in the Bronx, New York. He holds a B.A. from Rutgers University, and his M.A., M.Phil., and Ph.D. in anthropology were earned at Columbia University. His areas of research interest include the Near East (late prehistory and early historic periods) as well as the Middle Atlantic region of the USA. (historical archaeology). His specializations are in archaeozoology of the Near East and geoarchaeology, especially mineralogy and compositional analysis of pottery and building materials. Publications have covered a range of subjects, including ancient pastoralism, faunal quantification, skeletal microanatomy, brick geochemistry, and two co-edited volumes on the marine geology and geoarchaeology of the Black Sea basin.

### **Associate Editors**

Paul Goldberg Department of Archaeology Emeritus at Boston University 675 Commonwealth Ave Boston, MA 02215, USA paulberg@bu.edu

Vance T. Holliday Departments of Anthropology and Geosciences University of Arizona 210030 Tucson, AZ 85721-0030, USA vthollid@email.arizona.edu Rolfe D. Mandel Department of Anthropology University of Kansas 1415 Jayhawk Blvd 622 Fraser Hall Lawrence, KS 66045, USA mandel@kgs.ku.edu

Robert S. Stemberg Department of Geosciences Franklin and Marshall College 3003 Lancaster, PA 17604-3003, USA Rob.Stemberg@fandm.edu

### **Advisory Editors**

Zenobia Jacobs School of Environmental and Earth Sciences University of Wollongong Wollongong, NSW 2522, Australia

Panagiotis Karkanas
Ephoreia of Palaeoanthropology & Speleology of Southern Greece
Athens, Greece

Joseph Schuldenrein Geoarchaeology Research Associates Yonkers, NY, USA

Sarah C. Sherwood University of the South Sewanee, TN, USA R.E. Taylor, Emeritus, Department of Anthropology University of California at Riverside, Riverside CA, USA

Claudio Vita-Finzi Natural History Museum South Hill Park, London, UK

Jamie Woodward Geography, School of Environment and Development The University of Manchester, Manchester, UK

#### Aims of the Series

The Encyclopedia of Earth Sciences Series provides comprehensive and authoritative coverage of all the main areas in the Earth Sciences. Each volume comprises a focused and carefully chosen collection of contributions from leading names in the subject, with copious illustrations and reference lists. These books represent one of the world's leading resources for the Earth Sciences community. Previous volumes are being updated and new works published so that the volumes will continue to be essential reading for all professional earth scientists, geologists, geophysicists, climatologists, and oceanographers as well as for teachers and students. Go to http://link.springer.com to visit the "Encyclopedia of Earth Sciences Series" online.

### **About the Series Editor**

Professor Charles W. Finkl has edited and/or contributed to more than eight volumes in the Encyclopedia of Earth Sciences Series. For the past 25 years he has been the Executive Director of the Coastal Education and Research Foundation and Editor-in-Chief of the international *Journal of Coastal Research*. In addition to these duties, he was Professor at Florida Atlantic University in Boca Raton, Florida, USA. He is a graduate of the University of Western Australia (Perth) and previously worked for a wholly owned Australian subsidiary of the International Nickel Company of Canada (INCO). During his career, he acquired field experience in Australia; the Caribbean; South America; SW Pacific islands; Southern Africa; Western Europe; and the Pacific Northwest, Midwest, and Southeast USA.

### **Founding Series Editor**

Professor Rhodes W. Fairbridge (deceased) has edited more than 24 Encyclopedias in the Earth Sciences Series. During his career he has worked as a petroleum geologist in the Middle East, been a WW II intelligence officer in the SW Pacific, and led expeditions to the Sahara, Arctic Canada, Arctic Scandinavia, Brazil, and New Guinea. He was Emeritus Professor of Geology at Columbia University and was affiliated with the Goddard Institute for Space Studies.

# ENCYCLOPEDIA of GEOARCHAEOLOGY

edited by

### **ALLAN S. GILBERT**

Fordham University, Bronx, NY, USA

With Associate Editors

### PAUL GOLDBERG

Boston University, Boston, MA, USA

### VANCE T. HOLLIDAY

University of Arizona, Tucson, AZ, USA

### ROLFE D. MANDEL

University of Kansas, Lawrence, KS, USA

### ROBERT S. STERNBERG

Franklin & Marshall College, Lancaster, PA, USA



ISBN: 978-94-007-4827-9
This publication is available also as:
Electronic publication under ISBN 978-1-4020-4409-0 and
Print and electronic bundle under ISBN 978-94-007-4828-6

Springer Dordrecht, Heidelberg, New York, London

Printed on acid-free paper

Cover photo: Photograph of Structure 4 at the Ceren archaeological site, El Salvador, which functioned as the bodega (storehouse) for Household 4 in an ancient Maya village. The village was buried by tephra from the nearby Loma Caldera volcanic vent in about AD 650. The various layers of the phreatomagmatic eruption resulted in extraordinarily good preservation of structures, including the thatch roofs, as well as the foods and artifacts stored within the buildings. Image courtesy of Payson Sheets, University of Colorado.

Every effort has been made to contact the copyright holders of the figures and tables which have been reproduced from other sources. Anyone who has not been properly credited is requested to contact the publishers, so that due acknowledgement may be made in subsequent editions.

All rights reserved for the contributions: Arctic Geoarchaeology: Site Formation Processes; Ceramics; Dendrochronology; Living Surfaces; Paleopathology; Paleodemography: Methods and Recent Advances; Zhoukoudian

### © Springer Science+Business Media Dordrecht 2017

This work is subject to copyright. All rights are reserved by the Publisher, whether the whole or part of the material is concerned, specifically the rights of translation, reprinting, reuse of illustrations, recitation, broadcasting, reproduction on microfilms or in any other physical way, and transmission or information storage and retrieval, electronic adaptation, computer software, or by similar or dissimilar methodology now known or hereafter developed. The publisher, the authors and the editors are safe to assume that the advice and information in this book are believed to be true and accurate at the date of publication. Neither the publisher nor the authors or the editors give a warranty, express or implied, with respect to the material contained herein or for any errors or omissions that may have been made.

## Dedicated to Rhodes W. Fairbridge

(1914–2006) with appreciation

### **Contents**

Editorial Board	xiii	Archaeomineralogy George Rip Rapp	46
Contributors	XV	George Rip Rapp	
Preface	xxvii	Archaeoseismology Tina M. Niemi	47
Acknowledgments	xxix	Arctic Geoarchaeology: Site Formation Processes Kelly E. Graf	57
'Ain Ghazal	1	Keny D. Graj	
Rolfe D. Mandel and Alan H. Simmons		Artifact Conservation  Dennis Piechota	58
Akrotiri Aetokremnos, Cyprus	3	Dennis I tecnota	
Rolfe D. Mandel and Alan H. Simmons		Atapuerca Carolina Mallol	62
Alluvial Settings	4	Carolina Manoi	
C. Reid Ferring		Beringia, Geoarchaeology  Joshua D. Reuther and Ben A. Potter	65
Amino Acid Racemization	14	ooshwa D. Rewher and Ben II. I oner	
Kirsty Penkman		Big Eddy Site, Missouri  Edwin R. Hajic	74
Analysis of Carbon, Nitrogen, pH, Phosphorus, and Carbonates as Tools in Geoarchaeological Research <i>Michael F. Kolb</i>	15	Blombos Cave Magnus M. Haaland and Christopher S. Henshilwood	75
Anthrosols Vance T. Holliday	24	Boxgrove Richard I. Macphail	76
<sup>40</sup> Ar/ <sup>39</sup> Ar and K–Ar Geochronology <i>Leah E. Morgan</i>	27	Built Environment  Joseph Schuldenrein	77
Archaeological Stratigraphy Julie K. Stein and Vance T. Holliday	33	Burned-Rock Features Alston V. Thoms	89
Archaeomagnetic Dating Stacey Lengyel	39	Cactus Hill, Virginia Daniel P. Wagner	95

viii	CON	ITENTS		
Canals and Aqueducts in the Ancient World Charles R. Ortloff	96	El Mirón Cave Lawrence Guy Straus and Manuel R. González Morales	210	
Casper Site, Wyoming Vance T. Holliday		Electrical Resistivity and Electromagnetism  Alain Tabbagh	211	
Çatalhöyük Neil Roberts	105	Electron Probe Microanalyzer  J. Victor Owen	219	
Cave Settings Panagiotis Karkanas and Paul Goldberg	108	Electron Spin Resonance (ESR) in Archaeological Context	224	
Ceramics Charles C. Kolb	118	Mathieu Duval Eolian Settings: Loess	233	
Cerén Payson Sheets	128	Marcelo A. Zárate  Eolian Settings: Sand	239	
Chemical Alteration Panagiotis Karkanas	129	Andrew S. Goudie Ethnogeoarchaeology	245	
Chronostratigraphy Daniel Richter	139	Georgia Tsartsidou  Experimental Geoarchaeology	251	
Climatostratigraphy Philip L. Gibbard	141	Richard I. Macphail		
Coastal Settings	145	Field Geochemistry Richard E. Terry	263	
Patrick D. Nunn  Colluvial Settings	157	Field Survey  John Bintliff	271	
Charles A. I. French  Cosmogenic Isotopic Dating	170	Fission Track Dating Barry Kohn	274	
Ari Matmon		Fluorine Dating <i>Matthew R. Goodrum</i>	275	
Data Visualization Erich C. Fisher and Curtis W. Marean	173	Forensic Geoarchaeology  J. M. Adovasio	276	
Dendrochronology  Jonathan G. A. Lageard	180	Fourier Transform Infrared Spectroscopy (FTIR) Francesco Berna	285	
Dmanisi C. Reid Ferring	197	Gas Chromatography Ruth Ann Armitage	287	
Dolní Věstonice, Pavlov, Milovice <i>Jiří Svoboda</i>	198	Geoarchaeology, History Christopher L. Hill	292	
Dumps and Landfill Joseph Schuldenrein	199	Geochemical Sourcing Michael D. Glascock	303	
Dust Cave, Alabama Sarah C. Sherwood	205	Geographical Information Systems (GIS) Kenneth L. Kvamme	309	
Eastern Sahara: Combined Prehistoric Expedition Christopher L. Hill	209	Geomorphology Carlos E. Cordova	314	

	CONTENTS		ix
Geophysics Apostolos Sarris	323	Java (Indonesia) O. Frank Huffman	451
Gesher Benot Yaʻaqov Nira Alperson-Afil	326	Kebara Cave Paul Goldberg	453
Glacial Settings Christopher L. Hill	327	Kennewick Man Gary Huckleberry	455
Glass J. Victor Owen	336	Kostenki, Russia Vance T. Holliday and John F. Hoffecker	456
Grain Size Analysis Gloria I. López	341	Koster Site, Illinois <i>Edwin R. Hajic</i>	457
Great Plains Geoarchaeology Vance T. Holliday and Rolfe D. Mandel	348	La Micoque Christopher E. Miller	459
Grimaldi Caves Francesco G. Fedele	366	Lake Mungo and Willandra  Jim Bowler	460
Ground-Penetrating Radar Lawrence B. Conyers	367	Landscape Archaeology <i>Tim Denham</i>	464
Harappa Joseph Schuldenrein	379	Lead Isotopes A. Mark Pollard	469
Harbors and Ports, Ancient Nick Marriner, Christophe Morhange, Clément Flaux and Nicolas Carayon	382	Liang Bua Kira E. Westaway	473
Harris Matrices and the Stratigraphic Record Edward Cecil Harris	403	Lithics <i>M. Steven Shackley</i>	476
Haua Fteah Chris O. Hunt	410	Living Surfaces Erin C. Dempsey and Rolfe D. Mandel	486
Hearths and Combustion Features Susan M. Mentzer	411	Loessic Paleolithic, Tajikistan Richard S. Davis and Vance T. Holliday	492
Hohle Fels Christopher E. Miller	425	Luminescence Dating of Pottery and Bricks <i>Ian K. Bailiff</i>	494
House Pits and Grubenhäuser Richard I. Macphail	425	Magnetometry for Archaeology Jörg W. E. Fassbinder	499
Inductively Coupled Plasma-Mass Spectrometry (ICP-MS) Hector Neff	433	Mass Movement John F. Shroder and Brandon J. Weihs	515
Inundated Freshwater Settings  Jessi J. Halligan	441	Metals Vincent Serneels	521
Isernia Francesco G. Fedele	447	Microstratigraphy Paul Goldberg and Richard I. Macphail	532
Isochron Dating Jan D. Kramers	448	Minnesota Messenia Expedition (MME) George Rip Rapp	537