Coastal Research Library 20

Geoffrey N. Bailey
Jan Harff
Dimitris Sakellariou *Editors*

Under the Sea: Archaeology and Palaeolandscapes of the Continental Shelf

COST
EUROPEAN COOPERATION IN SCIENCE & TECHNOLOGY

Springer

Coastal Research Library

Volume 20

Series Editor
Charles W. Finkl
Department of Geosciences,
Florida Atlantic University,
Boca Raton, FL, USA

The aim of this book series is to disseminate information to the coastal research community. The Series covers all aspects of coastal research including but not limited to relevant aspects of geological sciences, biology (incl. ecology and coastal marine ecosystems), geomorphology (physical geography), climate, littoral oceanography, coastal hydraulics, environmental (resource) management, engineering, and remote sensing. Policy, coastal law, and relevant issues such as conflict resolution and risk management would also be covered by the Series. The scope of the Series is broad and with a unique cross-disciplinary nature. The Series would tend to focus on topics that are of current interest and which carry some import as opposed to traditional titles that are esoteric and non-controversial. Monographs as well as contributed volumes are welcomed.

More information about this series at http://www.springer.com/series/8795

Geoffrey N. Bailey • Jan Harff
Dimitris Sakellariou
Editors

Under the Sea: Archaeology and Palaeolandscapes of the Continental Shelf

Springer

Editors
Geoffrey N. Bailey
Department of Archaeology
University of York
York, UK

Jan Harff
Institute of Marine and Coastal Sciences
University of Szczecin
Szczecin, Poland

Dimitris Sakellariou
Institute of Oceanography
Hellenic Centre for Marine Research
Anavyssos, Greece

ISSN 2211-0577 ISSN 2211-0585 (electronic)
Coastal Research Library
ISBN 978-3-319-53158-8 ISBN 978-3-319-53160-1 (eBook)
DOI 10.1007/978-3-319-53160-1

Library of Congress Control Number: 2017938016

Printed on acid-free paper

This Springer imprint is published by Springer Nature
The registered company is Springer International Publishing AG
The registered company address is: Gewerbestrasse 11, 6330 Cham, Switzerland

COST is supported by the EU
Framework Programme Horizon 2020

COST (European Cooperation in Science and Technology) is a pan-European intergovernmental framework. Its mission is to enable break-through scientific and technological developments leading to new concepts and products and thereby contribute to strengthening Europe's research and innovation capacities. It allows researchers, engineers and scholars to jointly develop their own ideas and take new initiatives across all fields of science and technology, while promoting multi- and interdisciplinary approaches. COST aims at fostering a better integration of less research intensive countries to the knowledge hubs of the European Research Area. The COST Association, an International not-for-profit Association under Belgian Law, integrates all management, governing and administrative functions necessary for the operation of the framework. The COST Association has currently 36 Member Countries. www.cost.eu

Preface

This volume is one of two volumes that are the outcome of a conference held at the University of Szczecin in September 2013 to mark the end of the SPLASHCOS Action. SPLASHCOS—Submerged Prehistoric Archaeology and Landscapes of the Continental Shelf—is a research network funded under the EU's COST (Cooperation in Science and Technology) programme as COST Action TD0902 (TD standing for Trans-Domain), which ran officially from November 2009 to November 2013. The conference itself served two purposes: first, to review progress in the work of the Action over the preceding 4 years and, second, to act as an open scientific meeting for anyone interested in the conference themes whether or not they were formal SPLASHCOS members. In the event, the meeting drew over 100 participants from across Europe and from further afield in Australia, China, South Africa and the USA.

The aim of this volume is to present a selection of the papers from the Szczecin meeting that cover the various themes addressed during the SPLASHCOS Action. It is aimed at all those with an interest in the sea floor of the continental shelf and the archaeological and social impact of sea-level change—especially archaeologists, marine scientists, geographers and cultural-heritage managers, but also commercial and governmental organisations, policymakers and interested members of the public.

The original aims of the SPLASHCOS Action, as set out in the COST Memorandum of Understanding, were to promote research on the archaeology, climate and palaeoenvironment of the drowned landscapes of the European continental shelf; to stimulate collaboration across national and disciplinary boundaries; to bring together interested parties from the worlds of academic science, commerce and government; to encourage participation and training of young and early-stage researchers; and to facilitate exchange of ideas, planning of research projects, application for research funds and dissemination through publications and other media. Target audiences included not only the disparate scientific disciplines concerned with researching the continental shelf—archaeology, marine geology, geophysics, biology, climatology, palaeoenvironment and oceanography—but also wider audiences including government officials responsible for the marine environment and its cultural heritage, industrial operators working on the seabed, funding agencies, school children and a wider public. In short, our aim was to promote an emerging new field, variously labelled as 'submerged landscape archaeology', 'submerged prehistoric archaeology', 'continental shelf archaeology' or 'continental shelf prehistoric research', as an integrated discipline in its own right, and to plant it more firmly on the international research agenda and in the wider public consciousness.

COST Actions are the longest-running form of European funding, intended to foster coordination of research and transfer of ideas and expertise across national boundaries within Europe and its neighbouring countries. Funds are provided for regular meetings, workshops, conferences, training programmes, research planning and coordination and publication, but not for the conduct of new research programmes (see http://www.cost.eu/about_cost). During its 4-year history, the SPLASHCOS Action grew to include 25 member states and an active membership of over 120 individuals from a wide range of institutions and disciplines. The Management Committee, comprising representatives from all member states, with Geoff Bailey and Dimitris Sakellariou as elected chair and vice-chair, respectively, held 8 major meetings in different European centres and a number of smaller workshops, organised 16 training schools or smaller short-term missions that provided experience and training to 65 early-stage researchers, stimulated a wide range of publications and successful applications to national and European funding agencies for new research and created a strongly international and interdisciplinary sense of common purpose. Details of SPLASHCOS activities and achievements can be found on the dedicated website at http://www.splashcos.org/.

In practice, activities were focussed around a core group of individuals who led the work through four formally constituted Working Groups (WGs): Archaeological Data and Interpretations (WG1) led by Anders Fischer; Environmental Data and Reconstructions (WG2) led by Jan Harff; Technology, Technical Resources and Training (WG3) led by Ole Grøn and Tine Missiaen; and Commercial Collaboration and Outreach (WG4) led by Julie Satchell. Some of this work is in preparation for publication elsewhere, notably the work of WG2 and WG1, dealing, respectively, with the Quaternary geology and palaeoenvironment of the European continental shelf and the underwater archaeological record. These volumes are intended to provide a comprehensive overview of the current state of knowledge around the European coastline and in all the major marine basins. A third volume already published is the outcome of a conference session organised at the 34th International Geological Congress in Brisbane in 2012, with papers made available online in 2014 and the final volume published in 2016 as a special publication of the Geological Society of London: *Geology and Archaeology: Submerged Landscapes of the Continental Shelf* (edited by Jan Harff, Geoff Bailey and Friedrich Lüth), which includes examples from across the world. Web-based guides to techniques and resources and to collaboration with marine industry are available online on the SPLASHCOS website, and a searchable website with maps and information about all known underwater prehistoric archaeological sites in European waters has recently been posted online at http://www.splashcos-viewer.eu.

The original conference was structured around the Working Groups, and we have adopted that structure as a basis for organising this volume, but with some modification in the light of the contributions finally delivered. All the chapters have been extensively rewritten, updated, comprehensively edited and independently reviewed. The geographical focus is primarily European, but we have not attempted to include a comprehensive range of examples from all the marine basins around the European coastline—that is the task of the other SPLASHCOS volumes. Our chapters focus on issues of method and interpretation and on wider issues of management and outreach. They also include examples from other parts of the world, and many of the discussions of method and interpretation presented here, though focussed on European case studies, have worldwide relevance.

The second volume arises from a parallel workshop incorporated in the Szczecin conference, representing the final meeting of the separately organised CoPaF Project *Coastline Changes of the Southern Baltic Sea—Past and Future Projection*, which ran from 2010 to 2014, in parallel with SPLASHCOS Working Group 2, led by Jan Harff and funded by the Polish Ministry of Science and Higher Education. The two projects thus have overlapping membership, but complement each other in their objectives and primary focus. In this volume, the emphasis is on examples from the marine basins of Western Europe and the Mediterranean, on archaeological investigations of submerged landscapes extending back into the Pleistocene or on the archaeological implications of environmental reconstruction. The CoPaF volume focusses on the geological and climatic conditions that have shaped changes in sea-level and coastline configuration during the past millennium in the southern Baltic and the likely trajectory of future changes and comprises contributions mainly from Germany, Poland, Lithuania and Estonia.

In producing these volumes, we thank, first and foremost, the COST Office, who provided administrative and financial support throughout the Action and funds for the Szczecin conference. We thank, in particular, the COST science officer, Luule Mizera; the COST administrative officer, Leo Guilfoyle;

the COST rapporteurs, Dr. Ipek Erzi (Scientific and Technological Research Council of Turkey, TUBITAK) and Prof. Daniela Koleva (Sofia University St. Kliment Ohridski); the COST external evaluators, Prof. Peter Veth (University of Western Australia) and Prof. Dr. Gerold Wefer (MARUM, University of Bremen); and the grant holder and administrative secretary of SPLASHCOS, Cynthianne DeBono Spiteri, all of whom gave invaluable advice and support.

We also thank the University of Szczecin for hosting the conference and generously providing facilities and hospitality and Helmholtz-Zentrum Geesthacht and Szczecińska Energetyka Ciepina (SEC) for additional financial support. We are also indebted to Prof. Andrzej Witkowski (University of Szczecin), who acted as chair of the Local Organising Committee and, together with the other Committee members, Prof. Marian Rębkowski, Dr. Przemyslaw Krajewski, Dr. Karolina Bloom, Marcin Wroniecki, Marta Chmiel and Michal Adamczyk, ensured the efficient organisation and smooth running of the whole enterprise.

We also express our gratitude to the many individual specialists who acted as peer reviewers and who have contributed significantly to the final outcome. Finally, we acknowledge the following institutions, who generously contributed towards the production of this volume: the European Research Council through ERC Advanced Grant 269586 DISPERSE, the German Archaeological Institute Berlin, the Hellenic Centre for Marine Research and the University of York.

York, UK — Geoffrey N. Bailey
Szczecin, Poland — Jan Harff
Anavyssos, Greece — Dimitris Sakellariou

Contents

Chapter 23
Africa-Arabia Connections and Geo-Archaeological Exploration in the Southern Red Sea: Preliminary Results and Wider Significance

Geoffrey N. Bailey, Dimitris Sakellariou, Abdullah Alsharekh, Salem Al Nomani, Maud Devès, Panos Georgiou, Manolis Kallergis, Stefanos Kalogirou, Leonidas Manousakis, Prokopis Mantopoulos, Matt Meredith-Williams, Garry Momber, Ioannis Morfis, Ioannis Pampidis, Ioannis Panagiotopoulos, Panagiotis Renieris, Grigoris Rousakis, Vasilis Stasinos, and Spyros Stavrakakis

Abstract We report on a preliminary exploration of the submerged landscapes in the Saudi Arabian sector of the southern Red Sea aboard the Hellenic Centre for Marine Research (HCMR) Research Vessel, AEGAEO, in May–June 2013. The survey sampled areas of the continental shelf down to the shelf margin at ~130 m depth in the vicinity of the Farasan Islands and combined high resolution acoustic techniques with sediment coring to reconstruct features of the now-submerged landscape of potential archaeological significance, including geological structure, topography, palaeoenvironment, and sea-level change. The region is currently of wide interest and significance: to archaeologists because it is currently regarded as one of the primary pathways of dispersal for early human populations expanding out of Africa during the Pleistocene, in which the extensive but now-submerged shelf region may have played a key role; and to marine geoscientists because the Red Sea offers unusual opportunities as a 'laboratory' for investigating Pleistocene sea-level change. Preliminary results

G.N. Bailey (✉) • M. Meredith-Williams • G. Momber
Department of Archaeology, University of York, the King's Manor, York YO1 7EP, UK
e-mail: geoff.bailey@york.ac.uk; m.meredith-williams@latrobe.edu.au; garry.momber@maritimearchaeologytrust.org

D. Sakellariou
Institute of Oceanography, Hellenic Centre for Marine Research,
46.7 km Athinon-Souniou Av, Anavyssos, P.O. Box 712, 19013 Athens, Greece
e-mail: sakell@hcmr.gr

P. Georgiou • M. Kallergis • S. Kalogirou • L. Manousakis • P. Mantopoulos • I. Morfis
I. Pampidis • I. Panagiotopoulos • P. Renieris • G. Rousakis • V. Stasinos • S. Stavrakakis
Hellenic Centre for Marine Research, 19013, Anavyssos, Greece
e-mail: pgeorg@hcmr.gr; manolis@hcmr.gr; skalogirou@hcmr.gr; sailor@her.hcmr.gr; prokopis@hcmr.gr; gianmor@hcmr.gr; gpamp@hcmr.gr; jpanagiot@hcmr.gr; prenie@hcmr.gr; rousakis@hcmr.gr; stasinos@hcmr.gr; stavrak@hcmr.gr

A. Alsharekh
Department of Archaeology, King Saud University, P.O. Box 2627, Riyadh 7524-12372, Kingdom of Saudi Arabia
e-mail: asharekh@hotmail.com

S. Al Nomani
Saudi Geological Survey, P.O. Box 54141, Jeddah 21514, Kingdom of Saudi Arabia
e-mail: nomani.sm@sgs.org.sa

M. Devès
Institut de Physique du Globe de Paris, 1 rue Jussieu, 75238 Paris Cedex 05, France
e-mail: deves@ipgp.fr

G.N. Bailey et al. (eds.), *Under the Sea: Archaeology and Palaeolandscapes of the Continental Shelf*, Coastal Research Library 20, DOI 10.1007/978-3-319-53160-1_23

indicate that the submerged landscape was characterised by a complex topography with fault-bounded valleys and deep basins, some of which may have hosted, at least intermittently, fresh water during periods of lowered sea level.

23.1 Introduction

The southern end of the Red Sea is currently of high interest in relation to the nature and direction of human expansion into Asia and Europe from a presumed African cradle of early human evolution. The current consensus is that there were at least two major episodes of expansion out of Africa: an earlier one involving the earliest members of the genus *Homo* (*H. ergaster* or *H. erectus*) at about 1.8 mya, and a later dispersal by the earliest members of anatomically modern *Homo sapiens* between about 150 and 60 kya (Grine et al. 2009; Groucutt et al. 2015). The conventional view is that the primary pathways of movement and the most attractive environments involved a land route via the Nile Valley and the Sinai Peninsula, and thence northwards via the Levant to Anatolia, and eastwards to Iran and the Indian Subcontinent. In this view, the Arabian Peninsula has typically been ignored as a predominantly arid and infertile cultural backwater, largely bypassed by the major flows of early populations. More recently, however, a number of new sources of evidence have focussed attention on the Arabian Peninsula as a key region for early human settlement and a gateway to onward expansion to Eurasia, especially through the 'southern corridor', referring to southern Arabia and its coastal regions, and especially in relation to the dispersal of *Homo sapiens*. These indications include growing evidence for an Arabian archaeological record extending back to the early Pleistocene, similarities in stone tool technology in East Africa and Arabia, palaeogenetic inference, evidence for periodic climatic 'greening' of Arabian deserts during the Pleistocene, evidence that for much of the glacial-interglacial cycle lowering of sea level reduced the southern Red Sea to a narrow and shallow sea channel dotted with islands that could easily have been crossed with minimal equipment or seafaring expertise, and growing evidence for a greater time depth in the Pleistocene for early developments in seafaring and exploitation of marine resources (Petraglia and Rose 2009; Lambeck et al. 2011; Bailey 2015; Bailey et al. 2015; Erlandson and Braje 2015; Petraglia et al. 2015).

Lowering of sea level would have exposed an extensive area of shelf, reaching a maximum width of about 100 km on either side of the southern Red Sea, with a relatively narrow and shallow sea-channel separating the two sides (Figs. 23.1 and 23.2). Both mapping of palaeoshorelines (Lambeck et al. 2011) and the stable isotope composition of the Red Sea as measured in deep-sea cores from the Red Sea (Siddall et al. 2003) demonstrate that a marine connection between the Red Sea and the Indian Ocean would have persisted throughout the lowest sea-level stand of the LGM, and most probably for earlier low stands, at least for the past 400,000 years. In other words, there would not have been a dry-land passage from Africa to Arabia at any time over that time span. However, a narrow channel dotted with small islands would have persisted for long periods during the glacial-interglacial cycle, affording relatively short and easy sea-crossings of no more than a few kilometres. For earlier periods of the Pleistocene, the topography of the southern channel is less clear because of uncertainties about the impact of plate motions and tectonics, but it is worth noting that ongoing separation of the Arabian and African plates is mostly accommodated in the Danakil depression rather than in the area of the Red Sea.

Over the past decade a series of investigations has been devoted to exploring both the onshore and offshore archaeological record of Southwest Saudi Arabia as a joint Saudi-British and international project (Bailey et al. 2007a, b, 2015; Bailey 2009; Alsharekh and Bailey 2014). Here we report on a joint archaeological and geoscientific exploration of the continental shelf around the Farasan Islands (Fig. 23.2), which was conducted in May–June 2013 aboard HCMR's Research Vessel AEGAEO with the aim of exploring systematically the submerged landscapes. This project developed as an international and interdisciplinary collaboration arising directly out of the SPLASHCOS COST Action

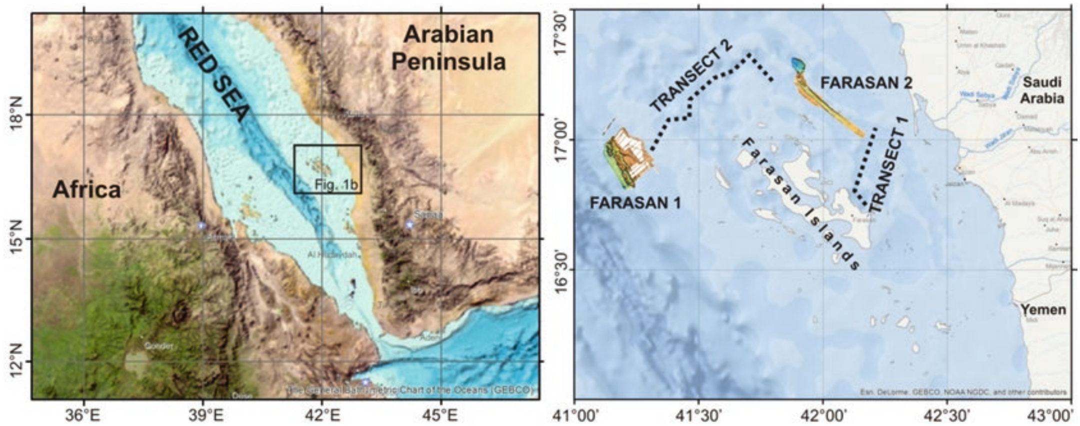

Fig. 23.1 (**a**) (*left*) general relief map of the Southern Red Sea area with the location of the area of interest indicated in the *black box*; (**b**) (*right*): GEBCO bathymetry of the area of interest with the location of the survey areas Farasan 1, Farasan 2 and Transects 1 and 2

(www.splashcos.org; Bailey and Sakellariou 2012) and within the ERC-funded DISPERSE project (Bailey et al. 2012). This work builds on three strands of earlier investigation: one concerned with the impact of sea level change and submerged landscapes on the potential connections between Africa and Arabia and the dispersal of early humans expanding out of Africa during the Pleistocene (Bailey et al. 2007a, b; Lambeck et al. 2011); a second with the impact of active tectonics on the early landscapes of human evolution (King and Bailey 2006; Bailey and King 2011; Bailey et al. 2011); and a third with field investigation of the mid-Holocene shell mounds on the Farasan Islands and the search for earlier submerged shorelines and archaeological remains associated with them (Bailey et al. 2007a, b; Alsharekh and Bailey 2014).

In this chapter we concentrate on the deep-water survey of the offshore landscape. The main objectives of the cruise were to reconstruct the broad outlines of the now-submerged landscape on the shelf, to understand the underlying Quaternary geology and the role of active tectonics and sea-level change in shaping the changing topography, and to identify specific locations that might have preserved archaeological evidence of past human activity.

23.2 Materials and Methods

The marine survey comprised a wide variety of geological-geophysical techniques: (1) multi-beam bathymetry by using two hull-mounted systems (20 kHz and 180 kHz); (2) high-resolution sub-bottom profiling with a 3.5 kHz pinger; (3) deep-towed, 110/410 kHz, digital side scan sonar imaging; (4) deep penetrating airgun 10ci seismic profiles; (5) gravity coring, with cores 3–5 m long; (6) box coring, 40×40×60 cm; and (7) ROV dives to visually inspect sites selected from the bathymetric, acoustic and profiling data.

Two areas (FARASAN 1 and FARASAN 2) and two seismic transects (TRANSECT 1 and TRANSECT 2) were systematically surveyed (Figs. 23.3 and 23.4). The data set comprised about 500 km^2 of seabed morphology mapped with the multi-beam systems, 170 nautical miles (105 km) of airgun seismic profiles, 250 nautical miles (155 km) of 3.5 kHz sub-bottom profiles and 140 nautical miles (87 km) of side-scan sonar lines. Eighteen gravity cores and two box cores were recovered and five dives of the Max Rover ROV were accomplished.

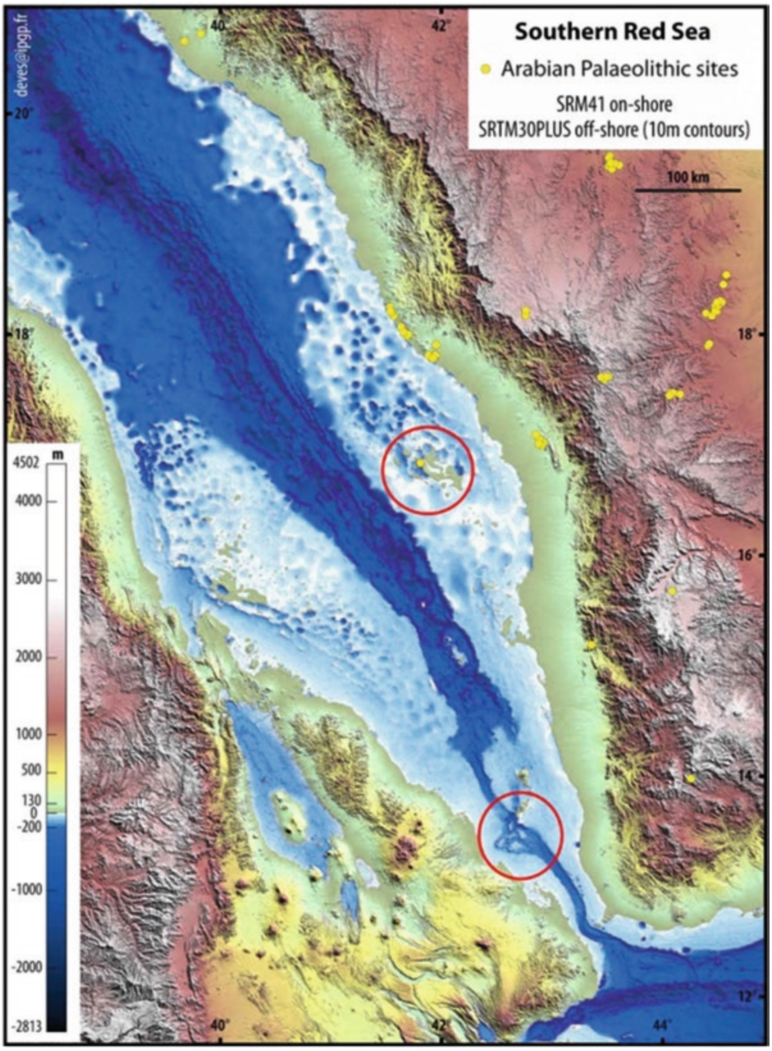

Fig. 23.2 Enhanced satellite imagery of the southern Red Sea. *Light blue* area indicates the extent of the submerged landscape exposed at – 120 m. The upper *red circle* indicates the position of the Farasan Islands. The lower *red circle* indicates the group of islands that emerge in the region of the Hanish Sill at low sea level with sea crossings of less than 4 km. ASTER GDEM is a product of METI and NASA (created by Maud Devès)

23.3 Results

23.3.1 Survey Area Farasan 1

Swath bathymetry mapping (Fig. 23.3) shows a relatively flat, 70–80 m-deep platform, which dips slightly towards the SE and occupies the outer part of the shelf. A shallower terrace, at approximately 40 m depth occurs at the north-eastern edge of the surveyed area. A deeper terrace is preserved locally at about 120 m depth on the steep slope off the shelf edge. Elongate or irregularly shaped flat-topped ridges are located at a short distance off the shelf edge. They tops of the ridges are at depths of about 80–90 m, very similar to the depth of the 80 m terrace on the shelf, and are separated from the shelf by deep and steep-sided troughs.

Airgun single-channel seismic profiles across the shelf and the ridges show that the steep, SW-facing slope off the shelf edge and the SW- and NE-facing slopes on both sides of the shallow ridges are controlled by normal faults running NW–SE, parallel to the rift axis of the Red Sea (Fig. 23.4). The latter is characterized by the deposition of massive, up to 2,500 m thick evaporites (salt deposits) in

geoff.bailey@york.ac.uk

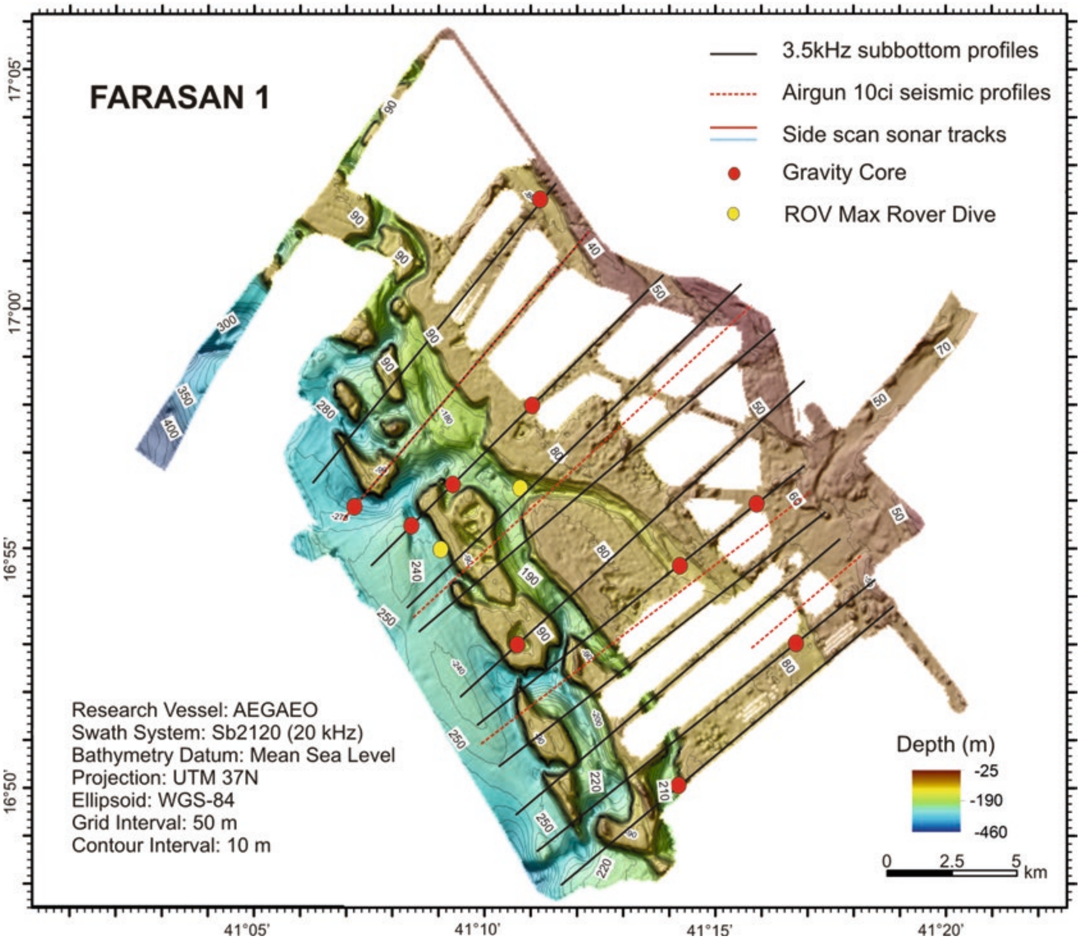

Fig. 23.3 Swath bathymetry and location of seismic and subbottom profiles, side scan sonar track-lines, gravity cores and ROV dives in the Farasan 1 survey area

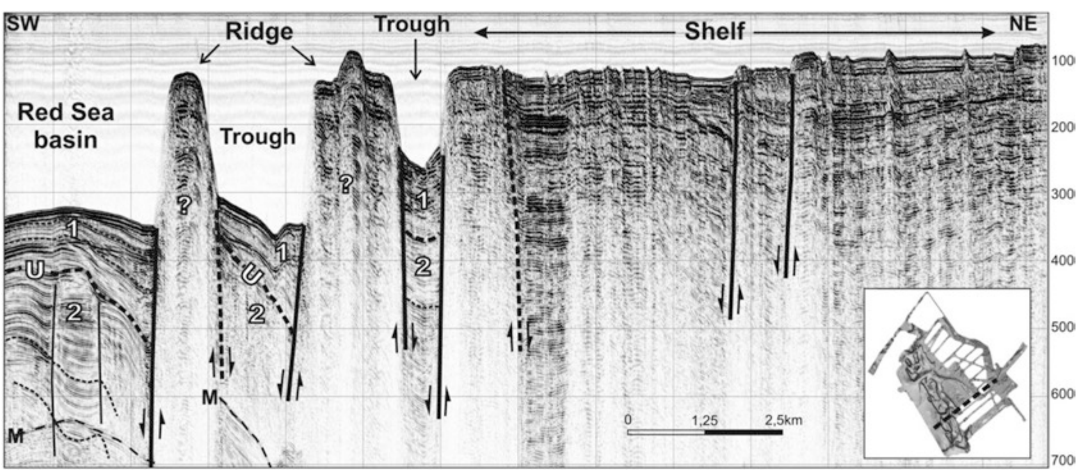

Fig. 23.4 Airgun 10 cubic inches single channel seismic profile across the outer Farasan shelf, in Farasan 1 area

the Middle to Late Miocene (Bosence 1998). Shallow Pleistocene marine reef-limestone, underlain by Miocene salt and deformed by salt diapirism, forms the bedrock of the Farasan Islands (Bantan 1999). We expect that a similar stratigraphic succession prevails underneath the continental shelf around the Farasan Islands. Evidence for extensive salt flow towards the axis of the Red Sea has been provided by Augustin et al. (In press). On the basis of the observed stratigraphy on the Farasan Islands and the extensive salt flow observed on and underneath the seabed, we suggest that the flat-topped ridges, mapped off the shelf edge, are blocks dragged away from the shelf by salt flow that may occur in the deeper stratigraphic levels. This suggestion can explain both the steeply sloping sides of the troughs between the ridges and the similarity in height between the ridge tops and the continental shelf in the surrounding areas.

It is reasonable to assume that the ridges were exposed above sea-level during the last low sea-level stand during Marine Isotope Stage (MIS) 2 and probably during older, Pleistocene low sea-level periods, forming thus a series of flat islands, the 'prehistoric Farasan Archipelago', separated from the LGM-coastline by deep troughs. Normal faults dipping in a SW direction also crosscut the shelf and are responsible for the slight morphological anomalies, mainly depressions and incised valleys.

Holocene sediment deposition on the outer shelf is very limited and restricted to small depressions and valleys (Fig. 23.5). The sedimentological description of gravity cores indicates lacustrine-type sedimentation below the thin Holocene marine drape in the isolated depressions on the 80 m-deep terrace. The seismic stratigraphy of the seabed sub-surface displays horizontal sedimentary sequences in these depressions deposited presumably during the Pleistocene in relatively shallow waters, as shown by Bantan (1999) for the exposed sedimentary formations on the Farasan Islands.

23.3.2 Survey Area Farasan 2

This area comprises a 120 m-deep valley, bounded by NW–SE trending normal faults (Fig. 23.6). The valley is incised into the 70–75 m prominent terrace, which forms a prominent feature of the inner shelf and becomes narrower towards the north-west. A narrow gorge on the sea floor at the north-western tip of the valley connects it with a >200 m-deep, depression. The latter is presumably the result of the solution of a Miocene salt diapir and hosts a >250 m-thick sedimentary sequence of Quaternary age, possibly extending back into the Pliocene.

A terrace at about 112 m depth can be mapped along the flanks of the valley and is covered by seismically transparent Holocene deposits (Figs. 23.6 and 23.7). This terrace is interpreted as an indicator of the water-level in the valley during the last low sea-level stage. Gravity coring penetrated the

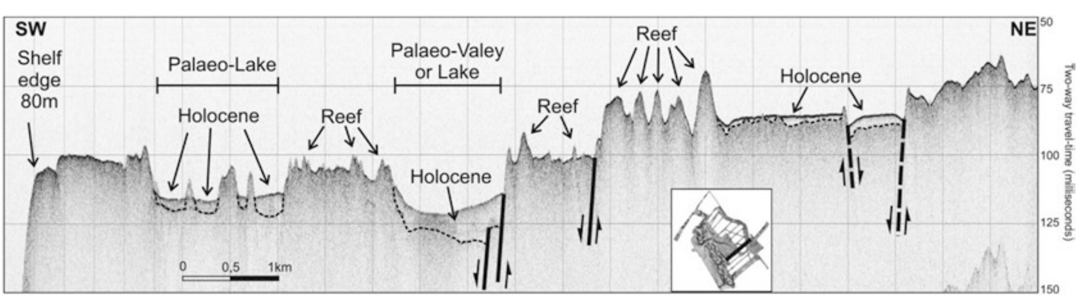

Fig. 23.5 Subbottom profile (3.5 kHz) across the shelf of Farasan 1 survey area. Note the seismically transparent sedimentary infill of the shallow depressions which is interpreted as marine Holocene deposits. The numerous small ridges are coral reefs developed during the last sea-level rise

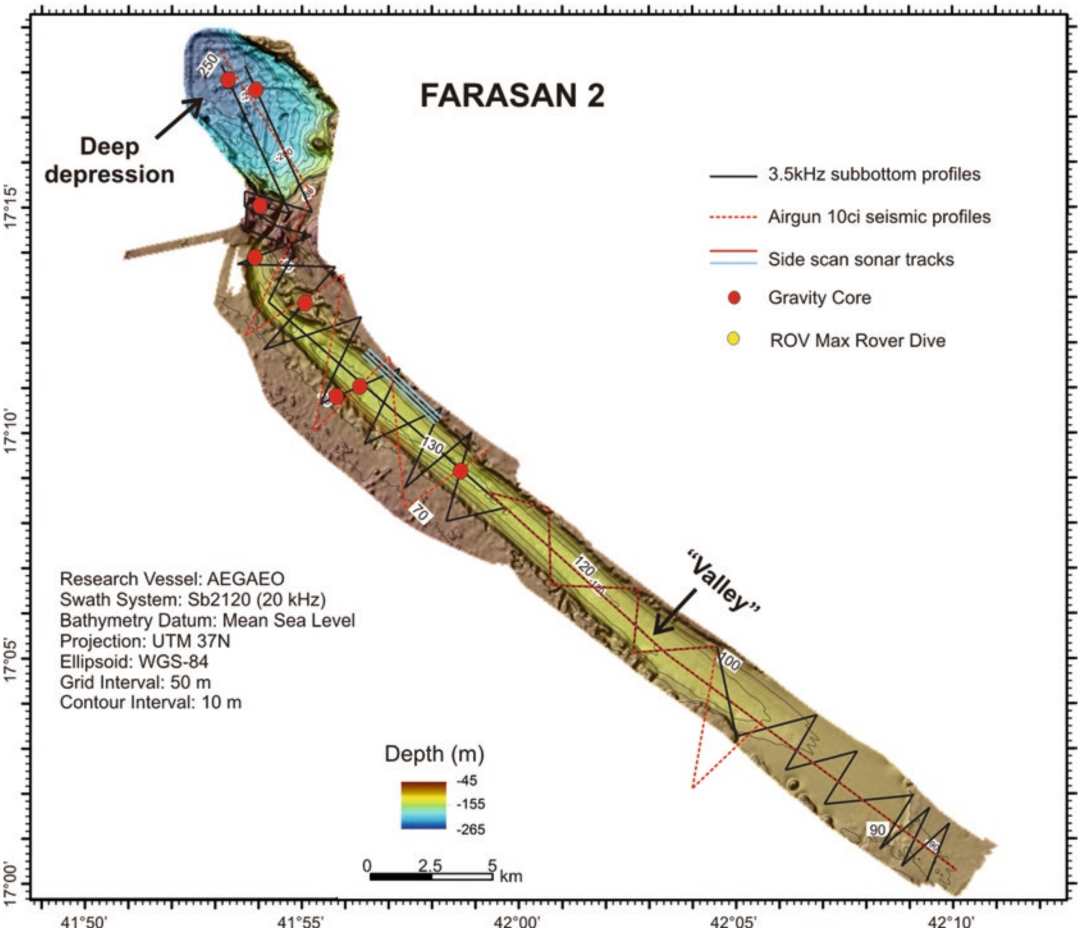

Fig. 23.6 Swath bathymetry and location of seismic and subbottom profiles, side scan sonar track-lines, gravity cores and ROV dives in the Farasan 2 survey area

Holocene fine-grained, marine sediments, and recovered gypsum fragments presumably of Miocene age from the substrate at about 2–2.5 m below the seafloor.

Preliminary laboratory analyses on sediment cores from the deep depression reveal lacustrine-type sedimentation below the 1–2 m-thick Holocene marine silt deposits. Thus, both the 120 m deep valley and the >200 m deep depression in Farasan 2 area may have been lakes during the Last Glacial Maximum. One more core recovered from a small, 102 m deep depression located on the northern slope of the valley revealed evidence of lacustrine sedimentation (Fig. 23.8). Holocene marine silty sand prevails in the upper part of the core. Gradual coarsening of the grain size between 80 and 147 cm below the seafloor indicates a shallow marine to coastal environment. A sharp erosional contact at 147 cm separates the upper part of the core from the lower part, which is characterized by grayish to bluish-whitish colours. The sedimentological characteristics along with the increase in magnetic susceptibility below 147 cm indicate a significant change of the depositional environment from marine above to lacustrine below. Geochemical, micropalaeontological and geochronological analyses on the recovered marine and presumably lacustrine sediments of core FA13 and other cores are in progress, with the aim of shedding light on the environmental conditions (freshwater, saline or otherwise) prevailing in these lakes during the periods of lowered sea level.

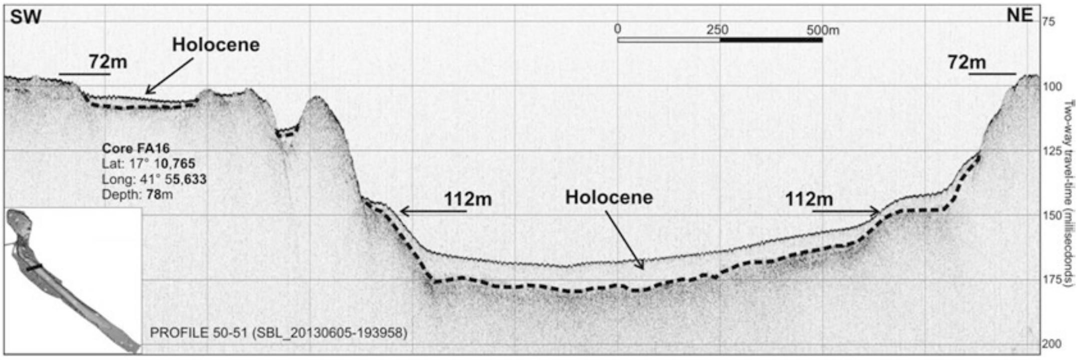

Fig. 23.7 Subbottom profile (3.5 kHz) across the shallow, elongate basin in Farasan 2 survey area. Note the seismically transparent, sedimentary infill of the basin which is interpreted as marine Holocene deposits. The 112 m deep terrace on the flanks is shown on the profile

23.3.3 Combined Results

The observations and preliminary results presented above can be summarised as follows:

(a) The numerous Plio-Pleistocene depressions of varying depth formed on the shelf around the Farasan Islands are due to the solution of Miocene evaporites and represent isolated water-bodies or lakes during the last low sea-level stand and possibly during older Pleistocene sea-level low stands (Fig. 23.9)
(b) The flat-topped ridges mapped off the shelf edge in the Farasan 1 survey area were disconnected from the exposed shelf, forming an island archipelago at a short distance from the LGM-shoreline
(c) The flat shelf observed in both survey areas was exposed during the Last Glacial Maximum and incised by river valleys, while shallow depressions were transformed into basins filled permanently or ephemerally with water, possibly as freshwater lakes
(d) This type of landscape might have served both as an attractor of human settlement and as a favourable location for the preservation of archaeological evidence

23.4 Discussion

The work reported above is still at an early stage, but there are several important outcomes that bring into focus three issues of wider relevance to the investigation of hominin dispersal and expansion. In the first place, it is clear that the landscape exposed at low sea-level stands would have afforded many of the characteristics that are known to be attractive to early human populations, in particular a complex topography comprising fault-bounded basins and topographic bottlenecks such as narrow connecting valleys that could have trapped freshwater and offered both extensive grazing territory for large mammals and also topographic opportunities for capturing them (King and Bailey 2006; Winder et al. 2013, 2015).

The availability of freshwater in this landscape is a key variable, and our results indicate the possibility, though not yet definitive evidence, that many of the basins would have contained, at least periodically, supplies of fresh water. It is well known to fishermen in this region, as elsewhere, that there are springs of fresh water emerging below modern sea level (see also Radić Rossi and Cukrov Chap. 17), and it has long been hypothesised that when sea level dropped, these springs would have

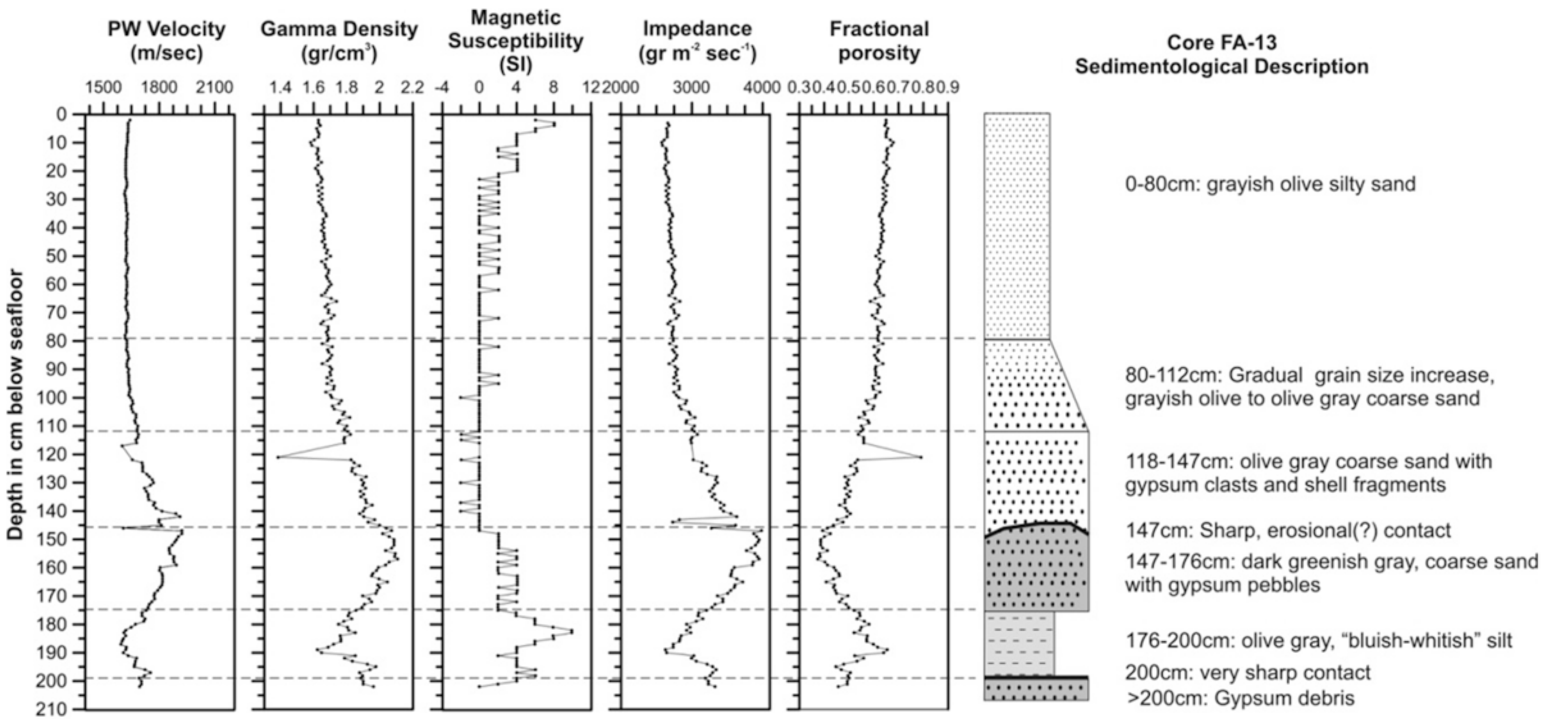

Fig. 23.8 Sedimentological description and multisensor core logger measurements in core FA13. Note the remarkable increase in magnetic susceptibility at and below 147 cm, which corresponds with a sharp, erosional contact between the upper, marine section and the lower presumably lacustrine one. The location of the core is shown on the map in Fig. 23.6

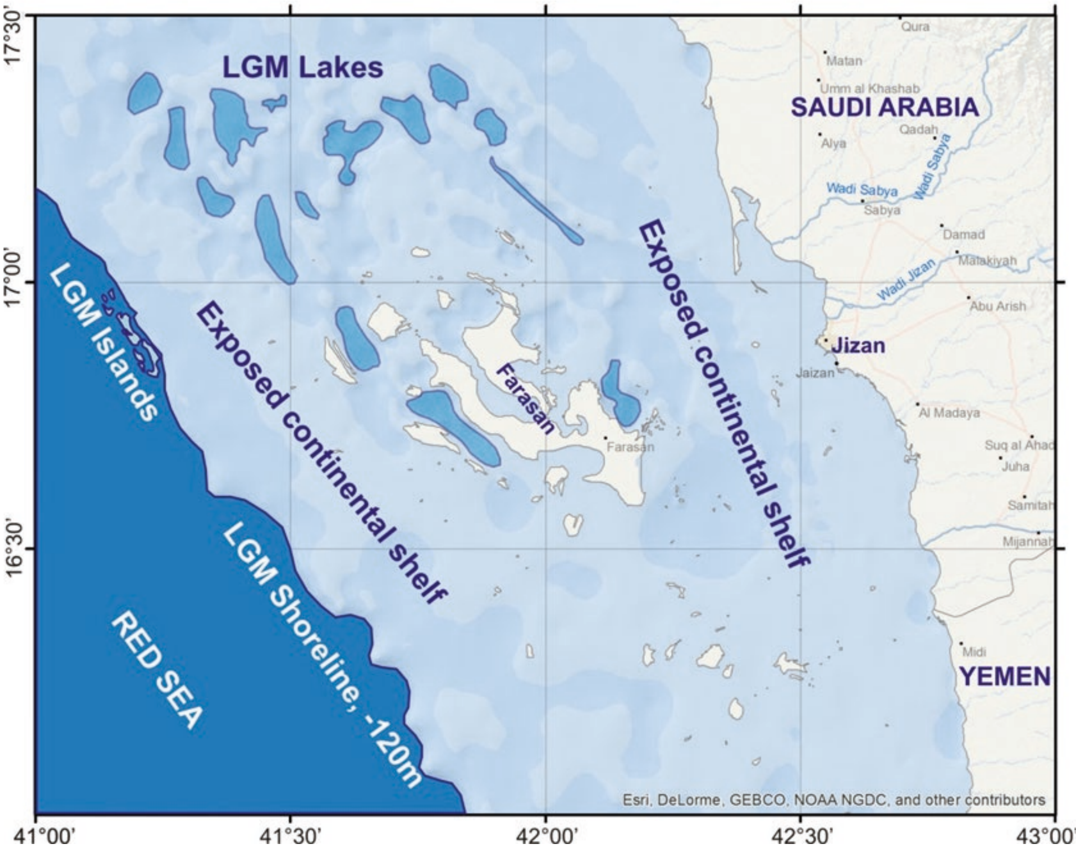

Fig. 23.9 Palaeogeographic reconstruction of the Farasan continental shelf during the Last Glacial Maximum (LGM)

flowed more strongly, providing the possibility of a well-watered and relatively fertile landscape (Faure et al. 2002). The sediment cores that we have recovered from the Farasan survey provide the first opportunity to directly test this hypothesis, and sedimentological and foraminiferal analyses and dating of the sediments by optically stimulated luminescence (OSL) and radiocarbon are currently underway to pursue this.

Moreover, it is clear that these possibilities would have been available during periods of the glacial-interglacial cycle when the mainland of the Arabian Peninsula would have been exposed to conditions of maximum aridity and pressure on the survival of human populations in the region (Bailey 2015; Bailey et al. 2015, Breeze et al. 2016), providing a core area or refugium where populations displaced by the expansion of arid conditions in the interior of the Peninsula could have persisted.

We are still far from finding archaeological evidence of human habitation on the now-submerged landscape, and this brings into focus a second issue, which is the need to better understand the conditions under which archaeological material is likely to survive in underwater contexts, and where to look for it. To facilitate that understanding, our underwater investigations are being carried out in conjunction with archaeological survey on the adjacent mainland. This includes survey for Palaeolithic stone tools in the SW region of Saudi Arabia, demonstrating a time depth of human occupation extending back into the Middle Pleistocene if not earlier, and investigation of mid-Holocene coastal shell mounds, particularly on the Farasan Islands. Both types of investigations are directed towards researching archaeological sites in their wider geoarchaeological and landscape context, and to understanding the conditions under which material traces of human activity are variously accumulated, concentrated, preserved, eroded away, buried by subsequent sedimentation or exposed to discovery.

These investigations in their turn provide clues as to where archaeological materials may have been preserved or exposed on the submerged shelf and the likelihood that they will have survived destruction or burial by inundation during sea-level rise.

The combination of research under water and on dry land is an important feature of the wider research strategy with which the above underwater survey is associated. One reason for this is that the present-day coastline is an arbitrary boundary that cuts across what would have been a seamless territory extending from the mountain watershed of the western Arabian escarpment down to the contemporaneous shoreline as it existed at periods of low sea level, and this whole territory needs to be investigated as a single entity. Proceeding as if the landscape now offshore of the modern coastline did not exist must necessarily result in a highly biased and inaccurate evaluation of the archaeological record and the dynamics of human settlement and range expansion or contraction during the climatic fluctuations of the Quaternary.

Another reason is that the results from one sector can usefully inform on the research design and interpretation of results in the other, and on aspects of methodology that apply to both sectors. Understanding the factors that determine the location and visibility of archaeological sites on land clearly can provide clues as to where to search under water, and this is a well-practised strategy that has proved successful in other contexts (Faught 2004; Evans et al. 2014). However, this is not simply a one way relationship. Our underwater investigations are also influencing the way we think about research on land. In particular they focus on the all-important issue of 'landscape taphonomy' – namely the variables that determine the survival, preservation and visibility of archaeological material and the extent to which such variability confounds the interpretation of geographical patterning in the distribution of archaeological sites. This taphonomic factor is thrown into sharp relief when dealing with submerged landscapes because of the potentially destructive or obscuring influence of sea-level rise. But it is no less potent on dry land, where processes of erosion and sedimentation, and agricultural and industrial developments, may have equally powerful distorting effects on the visibility and recovery of archaeological remains. These are issues that are still at a very early stage of development and point to a new and emerging field of taphonomic investigation in need of future development.

Finally our results highlight the issue of the early development of simple methods for crossing sea barriers and the conditions under which this may have been favoured. We cannot be sure whether the narrow channel that existed at the southern end of the Red Sea during periods of low sea level would have been crossed. But we know from the evidence of early human expansion into Australia and New Guinea that sea crossings involving some form of water craft were being conducted on a regular basis at least 50,000 years ago and to Flores Island at 0.8 million years (Hiscock 2008; Ward and Veth Chap. 24). There is no reason to deny that possibility in other parts of the world. Moreover, it is likely that the earliest sea crossings would have been facilitated in archipelago environments with short travel distances, relatively sheltered conditions, land always in sight, proximity to a familiar mainland, and the prospect of attractive resources on the other side of the sea crossing. The presence of mid-channel islands at the southern end of the Red Sea during low sea level periods (Fig. 23.2) and the presence of islands offshore of the Farasan shelf at periods of lowest sea level (Figs. 23.3 and 23.8) are both examples of the conditions that may have encouraged early experiments in sea travel.

23.5 Conclusion

This is one of the first attempts to apply a suite of underwater techniques to the purposeful and systematic geoarchaeological exploration of a deeply submerged landscape (for comparable examples, see Dixon and Monteleone 2014; Pearson et al. 2014; Flemming Chap. 18; Gaffney et al. Chap. 20). It is clear that a landscape with interpretable features of geological structure, geomorphology, topography, and potential for human settlement lies now submerged on the extensive shelf region surrounding the Farasan Islands. This forms an important first step in archaeological survey and a promising basis for future investigations, but we emphasise that we are still at a very early stage in developing this research agenda, and that underwater archaeological material has yet to be discovered. Nevertheless, the research has clarified ways in which improvements in approach and the deployment of additional technologies can be applied in future work, and sharpened our focus on the issues that need to be addressed when attempting to incorporate submerged landscapes into the interpretation of human dispersal and range expansion during periods of low sea level.

Acknowledgements We thank the Saudi Commission for Tourism and National Heritage (SCTH) for permission to undertake fieldwork, and the President, HRH Prince Sultan bin Salman bin AbdulAziz al Saud, Vice-President, Professor Ali Al-Ghassan, and the Director General, Jamal al Omar, for their support. We also thank HRH Crown Prince Salman bin Abul Aziz Al Saud and the Department of General Survey of the Ministry of Defense for permission to undertake the cruise of R/V AEGAEO. We also thank Lt Fahad Al Shwish, Observer from the Hydrographic Department of the Saudi Ministry of Defense, for his support and valuable assistance in overcoming unexpected logistical difficulties during the cruise, and Captain Theodoros Kanakaris and the crew of R/V AEGAEO for their untiring efforts to ensure the smooth running of the scientific operation during the offshore survey work. The research is funded by the European Research Council through Advanced Grant 269586 DISPERSE under the 'Ideas' Specific Programme of the Seventh Framework Programme. This is DISPERSE contribution no. 35.

References

AlSharekh AM, Bailey GN (eds) (2014) Coastal prehistory in southwest Arabia and the Farasan Islands: 2004–2009 field investigations. Saudi Commission for Tourism and Antiquities, Riyadh

Augustin N, Devey C, Van der Zwan F (In press) A modern view on the Red Sea rift: tectonics, volcanism and salt blankets. In: Rasul N, Stewart I, Nawab Z (eds) The Red Sea, vol Volume 2. Springer, Dordrecht

Bailey GN (2009) The Red Sea, coastal landscapes and hominin dispersals. In: Petraglia M, Rose J (eds) The evolution of human populations in Arabia. Springer, Dordrecht, pp 15–37

Bailey GN (2015) The evolution of the Red Sea as a human habitat in the quaternary period. In: Rasul N, Stewart CF (eds) The Red Sea: the formation, morphology, oceanography and environment of a young ocean basin. Springer, Heidelberg, pp 595–610

Bailey GN, King GCP (2011) Dynamic landscapes and human dispersal patterns: tectonics, coastlines and the reconstruction of human habitats. Quat Sci Rev 30:1533–1553

Bailey GN, Sakellariou D (2012) SPLASHCOS: submerged prehistoric archaeology and landscapes of the continental shelf. Antiquity 86:334. http://antiquity.ac.uk/projgall/sakellariou334/

Bailey GN, King GCP, Flemming NC, Lambeck K, Momber G, Moran LJ, Al-Sharekh AM, Vita-Finzi C (2007a) Coastlines, submerged landscapes and human evolution: the Red Sea basin and the Farasan Islands. J Island Coastal Archaeol 2:127–160

Bailey GN, AlSharekh A, Flemming NC, Lambeck K, Momber G, Sinclair A, Vita-Finzi C (2007b) Coastal prehistory in the southern Red Sea basin: underwater archaeology and the Farasan Islands. Proc Sem Arab Stud 37:1–16

Bailey GN, Reynolds SC, King GCP (2011) Landscapes of human evolution: models and methods of tectonic geomorphology and the reconstruction of hominin landscapes. J Hum Evol 60(3):257–280

Bailey GN, King GCP, Devès M, Hausmann N, Inglis R, Laurie E, Meredith-Williams M, Momber G, Winder I, Alsharekh A, Sakellariou D (2012) DISPERSE: dynamic landscapes, coastal environments and human dispersals. Antiquity 86:334. http://antiquity.ac.uk/projgall/bailey334/

Bailey GN, Devès MH, Inglis RH, Meredith-Williams MG, Momber G, Sakellariou D, Sinclair AGM, Rousakis G, Al Ghamdi S, Alsharekh A (2015) Blue Arabia: Palaeolithic and underwater survey in SW Saudi Arabia and the role of coasts in Pleistocene dispersal. Quat Int 382:42–57. http://dx.doi.org/10.1016/j.quaint.2015.01.002

Bantan RA, (1999, January) Geology and sedimentary environments of Farasan Bank (Saudi Arabia) southern Red Sea: a combined remote sensing and field study. Ph.D. Thesis, Department of Geology, Royal Holloway, University of London

Bosence DJ (1998) Stratigraphic and sedimentological models of rift basins. In: Purser BH, Bosence DWJ (eds) Sedimentation and tectonics in rift basins: Red Sea-gulf of Aden. Chapman & Hall, London, pp 9–26

Breeze P, Groucutt HS, Drake NA, White TS, Jennings RP, Petraglia MD (2016) Palaeohydrological corridors for homini dispersal in the Middle East ~250–70,000 years ago. Quternary Sci Rev 144:155–185. doi.org/10.1016/j.quascirev.2016.05.012

Dixon JE, Monteleone K (2014) Gateway to the Americas: underwater archeological survey in Beringia and the North Pacific. In: Evans AM, Flatman JC, Flemming NC. (eds) (2014)Prehistoric archaeology on the continental shelf: a global review. Springer, New York, pp 95–114

Erlandson JM, Braje TJ (2015) Coasting out of Africa: the potential of mangrove forests and marine habitats to facilitate human coastal expansion via the southern dispersal route. Quat Int 382:31–41

Evans AM, Flatman JC, Flemming NC (eds) (2014) Prehistoric archaeology on the continental shelf: a global review. Springer, New York

Faught MK (2004) The underwater archaeology of palaeolandscapes, Apalachee Bay, Florida. Am Antiq 69:235–249

Faure H, Walter RC, Grant DR (2002) The coastal oasis: ice age springs on emerged continental shelves. Glob Planet Chang 33:47–56

Grine FE, Fleagle JG, Leakey RE (eds) (2009) The first humans – origin and early evolution of the genus homo. Springer, Dordrecht

Groucutt HS, Petraglia MD, Bailey G, Scerri EML, Parton A, Clark-Balzan L, Jennings RP, Lewis L, Blinkhorn J, Drake NA, Breeze PS, Inglis RH, Devès MH, Meredith-Williams M, Boivin N, Thomas MG, Scally A (2015) Rethinking the dispersal of *Homo sapiens* out of Africa. Evol Anthropol 24:149–164. doi:10.1002/evan.21455

Hiscock P (2008) Archaeology of ancient Australia. Routledge, London

King GCP, Bailey GN (2006) Tectonics and human evolution. Antiquity 80:265–286

Lambeck K, Purcell A, Flemming N, Vita-Finzi C, Alsharekh A, Bailey GN (2011) Sea level and shoreline reconstructions for the Red Sea: isostatic and tectonic considerations and implications for hominin migration out of Africa. Quat Sci Rev 30:3542–3574

Pearson CE, Weinstein RA, Gagliano SM, Kelley DB (2014) Prehistoric site discovery on the outer continental shelf, Gulf of Mexico, United States of America. In: Evans AM, Flatman JC, Flemming NC. (eds) (2014)Prehistoric archaeology on the continental shelf: a global review. Springer, New York, pp 53–72

Petraglia M, Rose J (eds) (2009) The evolution of human populations in Arabia. Springer, Dordrecht

Petraglia MD, Groucutt H, Parton A, Alsharekh A (eds) (2015) Green Arabia: human prehistory at the cross-roads of continents. Quat Int 382:1–7

Siddall M, Rohling EJ, Almogi-Labin A, Hemleben C, Meischner D, Schmelzer I, Smeed DA (2003) Sea-level fluctuations during the last glacial cycle. Nature 423:853–858

Winder IC, King GCP, Devès MH, Bailey GN (2013) Complex topography and human evolution: the missing link. Antiquity 87:333–349

Winder IC, Devès MH, King GCP, Bailey GN, Inglis RH, Meredith-Williams M (2015) Dynamic landscapes and complex topography as agents in human evolution: the dispersals of the genus homo. J Hum Evol 87:48–65. doi.org/10.1016/j.jhevol.2015.07.002