Guest Editorial

The Middle Palaeolithic in the desert and its implications for understanding hominin adaptation and dispersal

1. Introduction: into the desert

The mid-latitude desert belt extending from the Atlantic coast of North Africa, through the Middle East and deep into Asia is one of the fundamental environmental and biogeographical features of the modern world. Although today much of this region can only be inhabited as a result of complex cultural adaptations to these arid environments (e.g. irrigation, camel domestication, etc.), a rich variety of archaeological evidence attests to the occupation of the desert belt during the Pleistocene. The aim of this volume of Quaternary International is to explore the Palaeolithic occupation of this desert belt, and highlight these regions as critical to understanding changes in hominin behaviour and demography that have occurred during the Middle and Upper Pleistocene.

As several papers in this volume discuss, the mid-latitude desert belt has undergone profound climatic and environmental changes in the Pleistocene, which continue in the Holocene. This dynamism is clearly one of the central features of this area. Deserts are typically defined as regions receiving less than 250 mm mean annual rainfall, with semi-arid regions receiving between 250 and 500 mm mean annual rainfall (MAR). Fig. 1 shows average modern rainfall values. However, behind such averages lies dramatic annual, decadal and centennial variability in rainfall that can have profound impacts upon contemporary occupants of these drylands at a generational scale.

During the Middle and Upper Pleistocene, there was significant variability in humidity at millennial timescales, somewhat removed from the experience of the hominin inhabitants of these regions. Within these broad scale variations finer scale fluctuations would also have occurred. For the purposes of this introduction, we refer to those regions that experienced arid (< ~250 mm MAR) conditions during the LGM as the ‘desert’ (e.g. Braconnot et al., 2003), although many now are characterised by semi-arid conditions. It must also of course be noted that we have a poor grasp on past precipitation levels. Short and long term variability in humidity in these desert regions is likely to have played a driving role in the colonisation and occupation of the mid-latitude arid belt by hominin populations, as well as, ultimately, their extirpation. Previous publications on the archaeology of desert environments include Barker and Gilbertson (2000), Veth et al. (2005) and Mol and Sternberg (2012). Most previous research has focussed on the Holocene, and significant questions remain in relation to the Pleistocene occupation of arid environments.

As the mid-latitude desert belt separates the African and Eurasian landmasses, these landscapes are likely to have been the location of major changes in hominin demography during the Pleistocene. These demographic changes relate to both the expansion and dispersal of hominin populations and changing patterns of behaviour and hence survivability. The dispersal of Homo sapiens from sub-Saharan Africa into Eurasia must have involved the colonisation and occupation of the mid-latitude arid belt. Given the analogous environmental and climatic settings of North Africa and southern Asia, the binary opposition of Africa and Eurasia appears to be an unproductive approach to understand how hominins were able to expand into new, diverse habitats. Rather than the current focus upon modern human dispersals ‘Out of Africa’, we suggest a reorientation towards understanding the dispersal of hominins ‘into the Saharo-Arabian Belt’.

It is important to recognise that the opportunities to exploit new resources made available in the deserts by the onset of enhanced humidity were not solely the preserve of modern humans. The colonisation of these desert environments during periods of humidity did not only occur from Africa, but also from Eurasia, in what Dennell (2009, 2013) have characterised as the “scramble for Asia”. It is within these desert landscapes that the earliest contact between modern humans and Neanderthals, including potential interbreeding (e.g. Green et al., 2010), may have occurred. Given this situation the organisational heuristic of the ‘Middle Palaeolithic’ offers a more objective way to compare hominin behaviour in the desert belt than framing variation in terms of inter-species contrasts, when hominin fossil material is rare and spatially biased. Simple associations of forms of technology and particular hominin species should be avoided.

The Middle Palaeolithic covers the period from around 300,000 to 30,000 years ago. We use the term Middle Palaeolithic synonymously with Middle Stone Age, in contrast to many recent debates on the use of these terms and the purportedly European character of the former and African character of the latter. Such dichotomies (e.g. Africa equals H. sapiens and Europe equals Neanderthals) are typically formulated at the expense of Asia. They also downplay the complexity of the evolutionary process in areas like Africa. The creation of the term ‘Middle Stone Age’ reflected the early 20th century belief that although broadly comparable to the Eurasian Middle Palaeolithic the MSA was both younger and more short-lived. Goodwin and Van Riet Lowe (1929) are quite explicit in their claim that the MSA reflected the dispersal of either ideas or populations of ‘Mousterians’ from the north. Now that the initial premises for the separation of the MSA have been disproven, the distinction between ‘Middle Stone Age’ and ‘Middle Palaeolithic’ is largely arbitrary, and the latter term has taxonomic precedence, although we respect the
choice of scholars to use terminology of their own choosing. For this reason in this introduction we often use the terminology the authors of the particular paper being discussed use.

Previous publications have addressed particularly regions within the desert belt, including North Africa (Hublin and McPherron, 2012), North Africa and the Levant (Wendorf and Marks, 1975), and Arabia (Petraglia and Rose, 2009). More thematic concerns have included the nature of Levallois technology (Dibble and Bar-Yosef, 1995) and ‘transitions’ in the Middle Palaeolithic (Hovers and Kuhn, 2006). While our knowledge of the Middle Palaeolithic has improved dramatically in recent years, a number of significant biases remain. In spatial terms, most of our knowledge of the Middle Palaeolithic comes from Europe, the Levant and South Africa. This volume contributes towards a partial restoration of this bias. Likewise, much of our understanding comes from deeply stratified cave sites (e.g. Tabun). Open air and surface sites are common parts of the record and all forms of material culture need to be studied in order to understand the past.

This focus upon colonisation of desert landscapes by hominins, and the interaction of dispersals and behavioural evolution, has a number of ramifications. Firstly, the directionality of hominin colonisation of the deserts will be linked to resource availability, rather than any pre-determined destination. As a result, the dispersal of human populations to the Maghreb should be placed on equal footing with their dispersal to the Thar Desert, particularly as similar distances are covered from a potential East African area of endemism. Developing a broader understanding of how Pleistocene hominins were able to adapt to these environments will enable a more detailed assessment of particular hypotheses proposed by researchers (e.g. whether modern humans first passed through the Sinai or crossed the Red Sea at the Bab-al-Mandab).

Secondly, as the availability of water is a limiting factor upon the occupation of these desert landscapes, developing a more detailed, regional understanding of chronometrically constrained palaeoenvironmental variability is critical. Orbital scale global climatic changes form a coherent backdrop to Middle and Upper Pleistocene palaeoenvironmental variability, well characterised by $^{18}$O marine and ice cores such as SPECMAP. However, localised terrestrial proxies present evidence for how a particular region has responded to these large-scale climate changes. Significantly, a millennium of humidity in the desert belt may not be apparent in records from the North Atlantic, but may have had dramatic impacts upon hominin demography, and the archaeological record for occupation of these regions.

Thirdly, the means to compare archaeological assemblages between North Africa and southern Asia are paramount to the investigation of hominin dispersal and evolution. The majority of the desert belt, such as much of the Sahara, Arabia and Iranian Plateau, are known through rare excavations and a larger number of deflated surface assemblages. Any assessment of the archaeological record of the mid-latitude desert belt must transcend both the diverse nature of the archaeological record, and the terminologies that have been developed to describe it.

The key to addressing a number of these issues is to promote engagement between archaeologists and palaeoenvironmental researchers working across the mid-latitude desert belt. This volume of Quaternary International comprises the proceedings of the Middle Palaeolithic in the Desert conference, held at Wolfson College, University of Oxford, on the 13th and 14th January 2012, with the aim of promoting such engagement. In total, 27 papers were presented over two days at the conference, by teams based in 13 different nations, and working across the Sahara, Arabia, the Levant,
Iran and India. Other papers in this volume were provided by colleagues who were unable to attend the conference. In the following sections, we will outline the main themes of the papers in this volume under the titles of ‘Biogeography and environmental change’, ‘North African Archaeology’ and ‘Southern Asian Archaeology’, although the latter two sections are broadly contiguous as organised from west to east. Following this the implications of the papers will be discussed.

2. Biogeography and environmental change

Evidence for ancient climate change in today’s deserts and bordering semi-arid areas has long been recognised, and palaeolakes and palaeorivers are some of the characteristic features of the arid belt. However, it is only in recent times that techniques to date (most of the Upper Pleistocene, let alone earlier times, lies beyond reliable radiocarbon age) and analyse climatic and environmental change have been developed.

Dennell (2013) reviews the environmental history of Asian deserts. Against a dynamic character of growth and contraction from well before the Pleistocene, there appears to have a strong trend towards aridification from the Middle Pleistocene onwards. This was a driver of geographical isolation and therefore hominin speciation and cultural developments. Aside from summarising their history and interaction with hominins, Dennell reminds us that there is considerable variation between deserts. An example relates to winter temperatures.

Finlayson (2013) proposes the Water Optimisation Hypothesis, suggesting that Homo occupy an intermediate position on the humidity spectrum, preferring semi-arid to semi-humid environments over either extreme. His analysis of 357 sites occupied by Homo between 200 and 10 ka indicate a number of hotspots for human habitation. While noting interesting insights into the organisation of settlement patterns across northern Eurasia, North America and the Pacific Rim, Finlayson (2013) highlights the mid-latitude arid belt as an optimal region for Pleistocene hominin occupations. The role of these desert landscapes is characterised as crucibles of human evolution and central to Pleistocene hominin expansions, rather than corridors that were rapidly traversed. This analysis suggests H. sapiens and H. s. neanderthalensis addressed different contexts in a similar manner, corroborating the suggestion that shared requirements for access to water resources exist at the genus level, although greater mobility in sapiens populations may have permitted deeper penetration into the aridity gradient.

Boivin et al. (2013) focus on the possibility of a successful ‘Out of Africa’ dispersal of H. sapiens in Marine Isotope Stage (MIS) 5. They describe the flora and fauna which hominins could have used to disperse through what is today desert. Their efforts make a contribution to the need to translate evidence for environmental change to a human scale. With climatic amelioration they model a spread of ‘Sahel’ type vegetation through areas such as Arabia, which would have provided seeds, fruit, herbivores, etc. Along riverine corridors additional resources such as both larger and small game, as well as birds, and fish and various plants, would have been available. Conversely, during more arid periods the desert expanded, and this seems to have been an unlikely time for hominin dispersals.

Drake et al. (2013) present the first large scale comparison of palaeoenvironmental data from the Sahara and Arabia. They use a probability density function (PDF) approach to understand the temporal distribution of indicators of humid conditions and geographical information system (GIS) analysis to understand spatial variation. While their analysis reveals a broad similarity between Arabia and the Sahara, it also shows some interesting differences. Both areas show evidence for an MIS 3 pluvial, but this occurred several thousand years later in the Sahara than Arabia. While both the Sahara and Arabia show evidence for periodic humid episodes in the glacial period of MIS 6, these also seem to occur at slightly different times. They relate these differences to the varying responses of the weather systems involved. MIS 5 was wet in both areas, and environmental change was broadly synchronous in this phase.

Parton et al. (2013) present the most detailed lacustrine evidence yet published on the MIS 3 pluvial in Arabia. In contrast to traditional dates putting this late in MIS 3 (~40–20 ka), their study shows this occurred rather earlier (ca. 61–58 ka). Their evidence comes from a multiproxy analysis of lake sediments in the Sharjah Emirate of the United Arab Emirates. Other evidence for humidity between ~60 and 50 ka in Arabia include alluvial deposition in central Saudi Arabia (McLaren et al., 2009) and in Wadi Surdud, Yemen (Delagnes et al., 2012, 2013; Sitzia et al., 2012). Parton et al. (2013) suggest that a northern movement of monsoonal precipitation led to repeated lake formation in early MIS 3.

Atkinson et al. (2013) describe Upper Pleistocene and early Holocene palaeoenvironmental change in the United Arab Emirates. Their evidence consists of sedimentary sequences from two sites, both dated by a suite of optically Stimulated Luminescence (OSL) estimates. Humid conditions in the area, evidenced by features such as the presence of river gravels, occurred in MIS 5e, 5a and 1 (early Holocene). The Holocene Wet Phase in Arabia offers an analogy for earlier, Pleistocene, pluvial episodes (see also e.g. Parker, 2009; Groucutt and Petraglia, 2012). The MIS 5 evidence provides landscape scale evidence for increased humidity and context for emerging evidence of hominin occupation in southern Arabia, at sites such as Jebel Faya (Armitage et al., 2011; Bretzke et al., 2013). Atkinson et al. (2013) offer a contribution towards understanding palaeoenvironmental change at a landscape rather than site level and demonstrates that areas such as the Rub al-Khali were transformed during periods of increased precipitation.

Bretzke et al. (2013) also focus on the environmental evolution of south-eastern Arabia. They present an analysis of sedimentary sequences of the site of Jebel Faya, Sharjah Emirate, UAE. Jebel Faya preserves evidence for hominin occupation in the Upper Pleistocene, with three layers producing archaeological material which the excavators argue demonstrates a dispersal of H. sapiens from Africa around the transition from MIS 6 to 5 followed by autochthonous evolution and the creation of a regionally distinctive material culture (Armitage et al., 2011). Bretzke et al. (2013) demonstrate variation in particle size and phytolith assemblages to show Assemblage C, dating to MIS 5e, was deposited in sediments during a time of increased precipitation and an environment characterised by grasses and trees. The younger archaeological layers are associated with decreasing levels of C3 grasses and increasing levels of C4 grasses with decreasing age, indicating that the human occupations were associated with conditions which became less wet in a stepwise fashion. Archaeologically sterile layers at the site contain sediments demonstrating an arid landscape and a paucity of vegetation.

Finally, in terms of papers in the volume focussing on biogeographical and environmental data, Cordova et al. (2013) present a geoarchaeological study of the Azraq Oasis, Jordan. Their study repeats the evidence for environmental fluctuation in the mid latitude arid belt described in other publications, but offers two significant nuances. Firstly, they demonstrate that wet conditions at Azraq are asynchronous with other environmental records and, secondly, that the area appears to have acted as a refuge for hominin populations when surrounding areas became arid. Given the location of the Azraq Oasis, as a nexus of South-West Asia, their results have implications for the understanding of cultural and demographic factors in the Middle Palaeolithic. As regional climates deteriorated it is logical to assume that hominin populations
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contracted into areas which retained water and other critical resources. These refugia have typically been postulated rather than demonstrated, and while much more research needs to be conducted at Azraq, as elsewhere, its importance has clearly been demonstrated. It must also be remembered that alongside ‘classic refugia’ it is probable that ‘cryptic refugia’ also played a role in determining patterns of hominin demography (Bennet and Provan, 2008).

3. North African archaeology

Several papers focus on the Middle Stone Age/Middle Palaeolithic of North Africa, offering analyses and descriptions of recent surveys, collections and excavations as well as reinterpretations and applications of novel methodologies. Several lithic techno-complexes have been described in North Africa, but how these vary and relate to one another is poorly understood. The analyses of lithic technology offered by these papers complement recent advances in our understanding of hominin fossil morphological variability and arguments relating to ‘symbolic’ behaviour.

Scerri (2013) presents a comparative analysis of six North African lithic assemblages, which have previously been described as ‘Aterian’, ‘Nubian Complex’ and ‘Middle Stone Age’. Her analysis both seeks to cast light on the history and context by which the Aterian was defined and then uses Principal Components and Correspondence Analyses to compare the selected assemblages. She demonstrates that lithic variability in North Africa does not neatly articulate with traditional named industries. For instance, the Aterian in northeast Africa is more similar to the ‘Nubian Complex’ in that area than it is to the Aterian in northwest Africa. From the results of her multivariate analyses Scerri (2013) suggests that the North African Middle Stone Age record reflects aspects of population structure, which is both important in understanding demography in North Africa and in providing context to a possible source area of out of Africa dispersals. Her results contradict traditional narratives, which she argues reflects an “interpretation before description” approach. Finally, Scerri’s paper illustrates the utility of quantitative methods comparing multiple measures of similarities and differences and the power of these methods to transcend traditionally qualitative and overly regional analyses.

Arzarello et al. (2013) offer new data on recently discovered Middle Stone Age sites in the Tafiliat and Drâa Valley areas of the Moroccan Sahara. Their paper presents a description of the different reduction sequences seen at the studied sites. Similar reduction schemes – Système par surface de débitage alterné (an opportunistic approach), Levallois, discoidal, core on flake and laminar reduction methods were used at the Middle Stone Age sites in the Moroccan Sahara, but in varying frequencies. The Aterian assemblages, for instance, feature low levels of discoidal debitage and relatively high levels of laminar debitage, alongside the production of distinctive ‘tanged’ (pedunculated) tools for which the Aterian is most well-known. This study, along with several other papers in this volume, shows the information which can be gathered from surface sites, which while lacking good chronological control, possess desirable features such as excellent spatial visibility.

Cancellieri and di Lernia (2013) describe and contextualise Middle Stone Age sites of the Messak plateau in southwestern Libya. The sites are again from surface contexts, so precise chronology remains unclear. The spatial information of the surface record is again prominent, and by conducting systematic surveys Cancellieri and di Lernia (2013) were able to discover hundreds of sites. Their clear and explicit methodology offers a good example of a survey methodology suitable to arid environments. As an example of the typotechnological diversity of the Messak area, Cancellieri and di Lernia (2013) describe the site of AU 10/578. With its features such as a Nubian core, a bifacial foliate, and backed pieces, they describe it as being similar to the Lupemban of sub-Saharan Africa. Other sites include tanged artefacts and bifacial foliates, and are ascribed to the Aterian. By extrapolation from sites such as Un Tabu, they suggest that the Aterian in their area dates to MIS 4.

Foley et al. (2013) describe the results of recent fieldwork in the Ubari sand sea and Messak plateau areas of central Sahara (Libya), in the context of evolutionary and demographic processes of the wider African Middle Stone Age. North Africa was where MSA adaptations, hypothesised to have evolved in the East African centre of endemism for H. sapiens, were tested. A rich Middle Stone Age record is present in their survey area, and indeed a majority of sites either included or were exclusively MSA, including many with Aterian characteristics. They describe the excavation of the MES11-T2 site. A number of different reduction strategies are attested. Large blade production and façonnage methods are found in the Messak assemblages and are described in detail. Foley et al. (2013) suggest some similarities with Lupemban and Sangoan industries found in Sub-Saharan Africa. The diversity of MSA assemblages can be taken as indicating the adaptive and technological flexibility of hominins, but improved chronological control is needed to substantiate such ideas.

Reynolds (2013) presents a discussion of the lithic assemblages of Haua Fteah (Cyrenaica, Libya) (cf. McBurney, 1967). Reynolds (2013) presents both a re-evaluation of the McBurney lithic archive and insights from the recent fieldwork of the Cyrenaica Prehistory Project. Following, McBurney's classification, the two major phases of interest for the present volume are the ‘Pre-Aurignacian’ and ‘Levalloiso-Mousterian’. The former is known from a small excavation into the deeper layers of the site. Reynolds (2013) argues that the typology and technology of the Pre-Aurignacian are actually broadly the same as those found in the younger Levalloiso-Mousterian, while features such as the presence of core management elements in the Pre-Aurignacian, but not in the Levalloiso-Mousterian, may indicate differences in how the site was used. Reynolds suggests that the Haua Fteah lithics are similar to ‘Tabun-C’ type assemblages from the Levant, which may reflect the existence of south–east Mediterranean biome/cultural area, or technological convergence.

Goder-Goldberger (2013) presents the results of a detailed analysis of the ‘Khormusan’ site of 1017, located near the Nile’s Second Cataract (see also Marks, 1968). As with other Khormusan sites, 1017 is an excavated site in a region dominated by surface scatters. The chronology of the assemblage is, however, uncertain. Goder-Goldberger argues that the Dibeira-Jer formation in which 1017 occurs may date to around MIS 5a, somewhat older than previously suggested. Goder-Goldberger (2013) argues that 1017 and other Khormusan sites demonstrate the use of a wider variety of raw materials than other Middle Palaeolithic industries in the area and that there is a correlation between raw material types and the forms of technology used.

Finally, in terms of North African Middle Stone Age sites, Beyin (2013) describes a new assemblage from coastal Eritrea, collected from a site called Asfet. Diverse core morphologies are present, and the greater numbers of blade than discoidal cores or Levallois/prepared cores presents an interesting example of the technotypological variability of the Middle Palaeolithic. Retouched tools from Asfet include both larger bifaces and small points. Beyin suggests that the evidence from Asfet indicates that the region played a significant role as both a hominin refugium and part of a dispersal corridor into southwest Asia. Clearly much more fieldwork needs to be conducted in areas like Eritrea, but with the recent discoveries described by Beyin (2013) the potential of the area has been demonstrated and the Asfet assemblage can now feature in debates on typological and technological variability and their implications.
4. Southern Asian archaeology

In compiling this volume a major aim was to attempt to encourage a fusion of research in Africa and Asia, and for our basic contextual units to be biogeographical rather than modern-political. Several papers in the volume present new information on Asian sites. It is hoped that over time researchers in Africa and Asia will move towards adopting similar nomenclatures and methodologies, aiding comparisons through space and time.

Culley et al. (2013) present a major analysis of the ‘compositional integrity’ of the commonly discussed ‘B, C and D’ facies of the Levantine Middle Palaeolithic, defined in the mid-twentieth century by Dorothy Garrod (Garrod and Bate, 1937). In addition, the provision of their datasets as supplementary files constitutes an extremely useful resource for future scholars. The character of the Levantine facies has several implications for our understanding of hominin evolution in South-West Asia. The ‘C’ type assemblages (e.g. Hovers, 2009) are found with fossils attributed to H. sapiens at sites such as Skhul and Qafzeh. ‘B’ type assemblages have been found with Neanderthal fossils at sites such as Kebara and Amud. The idea of a neat distinction between the facies has, however, received criticism and it appears that diversity in the Levantine Middle Palaeolithic is not merely temporal, but also spatial. As Goren-Inbar and Belfer-Cohen (1998, 214) describe, almost the entire range of core variability is represented at most Levantine sites. In such a situation simple qualitative distinctions between assemblages/facies are problematic, and the quantification of variation assumes paramount importance. To Culley et al. (2013), their results indicate that the C and B facies cannot be separated as coherent and discreet industries.

Delagnes et al. (2013) discuss the character and context of the MIS 3 (~55 ka) Middle Palaeolithic assemblages of Wadi Surdu, western Yemen, and particularly the site of Shi’bat Dihya 1. The character of faunal remains and the presence of gypsum precipitation and formation of calcrites both indicate that the environment was semi-arid to arid. The Yemen Highlands, often cited as a possible refugial area, are likely to have a critical role to play in hominin demographic processes in Arabia. Delagnes et al. (2013) discuss the wider picture of MIS 3 lithic technological variation across the Saharo-Arabian arid belt in MIS 3, a time of population contraction in contrast to the expansion and dispersals of MIS 5.

Usik et al. (2013) analyse recently discovered Middle Palaeolithic assemblages from Dhofar, south-western Oman. Virtually all of the identified Pleistocene sites in Dhofar come exclusively from surface scatter. Usik et al. (2013) therefore focus their analysis on particular assemblages which have good spatial integrity, as indicated by features such as the presence of refits, the similarity of weathering and homogenous technology. From their collections Usik et al. (2013) were able to identify numerous refitting constellations which, along with an analysis of particular morphological and technological features, they use to describe the main elements of core reduction variability in the ‘Nubian Complex’ sites of Dhofar. To Usik et al. (2013) their assemblages fall within an “Afro-Arabian Nubian Technocomplex” (cf. e.g. Guichard and Guichard, 1965; Van Peer, 1998; Rose et al., 2011). Within the Dhofar ‘Nubian Complex’ Usik et al. (2013) argue for a distinction between ‘Classic Nubian’ sites and an industry they define as the ‘Mudayyan’. The Mudayyan material is both smaller, some very diminutive indeed, and features some morphological and technological differences with the ‘classic’ material, such as a flattening of debitage surfaces. They suggest that the Mudayyan is a younger, derived form of technology flowing from the earlier classic Nubian. The younger age is supported by the consistently significantly reduced levels of weathering/patination seen on the Mudayyan material, and on geomorphological grounds as the sites are closer to eroding sources of raw material (>Leptolithic’ and Holocene assemblages are closer still, giving a relative chronology).

Vahdati Nasab et al. (2013) present an analysis of lithics from the site of Mirak, central Iran. The Iranian Middle Palaeolithic is, along with the areas discussed above, poorly known. Most of what is known is from the caves and rockshelters of the Zagros Mountains area. They describe the Mirak assemblage as being focussed on flake production and being highly Levallois and, as has been previously described for Iranian sites, featuring high levels of retouch. As more recent work (e.g. OlSzewski and Dibble, 1993; Otte et al., 2009; Vahdati Nasab, 2011) transcends earlier descriptions (e.g. Skinner, 1965), the variability of the Middle Palaeolithic in Iran is becoming ever more apparent, and the information from Mirak adds another dimension to this. Although a surface site, Vahdati Nasab and colleagues argue that Mirak has good spatial integrity. They argue for a ‘situation’ understanding of sites such as Mirak, particularly in relation to factors such as differences in mobility. Along with the distribution of other known sites, Vahdati Nasab et al. (2013) suggest that Mirak lies on a dispersal corridor across Iran. This extends from the north of the Zagros Mountains and skirts the Alborz Mountains and central desert. Alongside a route south of the Zagros Mountains, this may have been a major route for hominin dispersals across Iran.

Blinkhorn (2013) presents a reanalysis and contextualisation of the site of 16R Dune, from the Thar Desert of western India. The Thar Desert marks the eastern limit of the modern Saharo-Arabian biogeographic zone (e.g. Holt et al., 2013) and therefore a zone of transition, and hence necessarily of hominin adaptation, to the ‘Oriental’ realm. The presence of the highland chain to the north is also likely to have channelled hominin dispersals in South Asia into the environs of the Thar Desert. During periods of climatic amelioration the Thar Desert would have acted as a gateway to the mosaic environments of the Indian peninsula. 16R Dune is a frequently cited locality as one of the few examples of a South Asian sequence with multiple archaeological horizons and chronometric age estimates. Blinkhorn (2013) reviews and synthesises the sedimentary, archaeological and chronometric evidence from 16R Dune. A significant point to emerge is that archaeological material previously dated to 26 ka and previously referred to as ‘Upper Palaeolithic’ is actually of Middle Palaeolithic character, and dates to between 40 and 80 ka. Considering this against competing theories of hominin dispersals, Blinkhorn (2013) argues that evidence from 16R and elsewhere in the Thar Desert does not support the idea of a post MIS-5 dispersal of H. sapiens associated with backed and crescentic lithics and ‘symbolic’ material culture (Mellars, 2006). In contrast the evidence is what would be predicted given the dispersal of H. sapiens through the ameliorated environments of south Asia in MIS 5 (see also Boivin et al., 2013).

5. Discussion

5.1. Scales of analysis and the environmental context of adaptation hypotheses

Developing our understanding of the relationship between environmental change and hominin behaviour, demography and dispersal necessitates advances in a number of fields, and as ever, the question of scale is key. Fig. 2 contrasts modelled estimates of rainfall in MIS 5e and the Last Glacial Maximum. These demonstrate the significant differences in environmental characteristics between arid and humid periods. With arid periods, for which the Last Glacial Maximum provides an example and analogue, the desert regions expanded to their maximum extent. Conversely, during humid episodes such as the Last Interglacial, vast areas were transformed into desirable habitats for hominins. It must be
Fig. 2. Maps indicating modelled annual rainfall: a) during the Last Glacial Maximum (LGM) (above; following Braconnot et al., 2003); and b) during peak humidity of the Last Interglacial (Marine Isotope Stage 5e) (below; following Otto-Bliesner et al., 2006).
emphasised that the models shown in Fig. 2 only reflect precipitation in particular areas, and other sources of humidity, such as rivers from neighbouring regions of greater rainfall, will also have played a role in environmental amelioration at a landscape level. These models offer only the broadest scale picture of change in these regions over the timescale of a glacial-interglacial cycle; beyond the scale of hominin experience, but are valuable to appreciate the dramatic nature of environmental change.

There is a clear need to move beyond simplifications, such as the idea that ‘interglacials’ saw a uniform transformation of the desert into a desirable human habitat, while ‘glacials’ led to regional extinction. Within thousands of years of increased rainfall, what would the effect of a few hundred years of climatic deterioration be? And how would such a temporary trend appear in environmental records? Likewise, a few hundred years of increased humidity in a generally arid period may not be much in palaeoenvironmental terms, but in such a time a human population could undergo dramatic demographic expansions and, in theory, disperse for thousands of miles. A significant limiting factor remains the coarse nature of our chronological control, as error ranges of thousands of years make establishing clear links between environmental changes and hominin demography problematic. Similarly, there is clear evidence for spatial variation in palaeoenvironmental records. This applies both at a broad scale (e.g. Drake et al., 2013), a medium scale (e.g. Cordova et al., 2013) and at a localised level (e.g. Blinkhorn et al., 2012).

5.2. The archaeological context of hominin adaptation

From the archaeological papers in this volume, many common themes are evident in terms of how hominin behaviour and hence ‘adaptation’ are understood. It is clear that a great proportion of the archaeology of the desert occurs on the surface, reflecting a frequent dominance of erosional over depositional processes in arid zones. While this has clear downsides, such as a lack of precise chronological context, several papers also describe the benefits including spatial visibility and the potential for refitting. It must not be forgotten that virtually all Palaeolithic archaeological material is initially deposited on the surface, and only some of it subsequently buried after variable lengths of time and after being subject to numerous natural and cultural modifications. Recent developments in the archaeology of surface contexts show their great potential and the need to develop suitable methods (e.g. Fanning et al., 2008). Some buried assemblages are more promising for behavioural reconstruction than others. In contrast to taphonomically complex caves and rockshelters, sites such as those in Wadi Surdud (Delagnes et al., 2013) appear to have been rapidly covered in alluvium shortly after formation and therefore have excellent spatial preservation.

The example of the Wadi Surdud is also pertinent in terms of research strategy. The choice to deliberately target the area between the Yemeni highlands which are largely stripped of sediments and the lowlands which are largely covered in Holocene sediments rewarded the discoverers well. A combination of systematic surveys and collections of surface material, anchored in terms of chronology and environmental contextualization offered by nearby excavated sites offers the best way forward for the elucidation of the archaeology of the Middle Palaeolithic of the desert. The chronology of the Khormusan and the Iranian Middle Palaeolithic are examples of two key areas which urgently need to be dated, and it is clear that a lack of good chronological control is currently a major limiting factor on our understanding of Middle Palaeolithic variability. Most of the papers in the volume deal with lithic artefacts, and the diversity of approaches demonstrated show the numerous ways in which they can be approached.

5.3. Hominin adaptation to arid environments

A key theme this volume sought to address was the notion of hominin adaptation to arid environments. In previous works on the archaeology of desert areas, for example the chapters in Veth et al. (2005) and Barker and Gilbertson (2000), it has mostly been argued that ‘adaptation’ to arid environments was essentially a Holocene phenomenon. Specialised technical solutions to the limited availability of water developed in Holocene societies, it has been suggested, while in the Pleistocene it appears that hominins tended to track favourable environments (Finlayson, 2013). There are, however, complications to this narrative. As far back as the Early Pleistocene, the sites of Bizat Ruhama and Nahal Hesi in the Negev may demonstrate occupation in open and semi-arid environments (Yeshurun et al., 2011). At the palaeolakes of Bir Tafawri and Bir Sahara in southwest Egypt repeated lake formation during humid periods of the Middle and Upper Pleistocene correlates with a rich archaeological record (Wendorf et al., 1993). At the site of Bir Sahara-12 (BS-12) several features described as ‘water holes’ were identified, dug through several layers of sediment (Campbell, 1992). Campbell (1992) argues against an explanation such as animal burrowing on the grounds of the smooth sides of the features. The putatively human dug water holes were dug next to a basin in marshy conditions, and may have acted as shallow wells to access seasonally fluctuating water. To Campbell (1992) the findings demonstrate Middle Palaeolithic adaptation to arid conditions. Outside the area this volume focuses on, such as in Australia, debates continue on whether Pleistocene humans were occupying arid areas (e.g. Smith, 1987, 2013) or rather largely inhabiting environmentally ameliorated landscapes (e.g. Hiscock and Wallis, 2005). Even if the early human occupation of arid areas in Australia is firmly demonstrated, the specific characteristics of this area – such as the character of the fauna there – mean that it is problematic to generalise to the mid latitude arid belt.

There are various ways in which ‘adaptation’ to aridity can be understood, and archaeologists should aim to be more precise in their use of the term. The mere presence of hominins in an arid environment can be taken as an indication of adaptation, but as discussed above the problem of the incongruence between the scales of resolution of environmental changes and those of human societies are currently hard to reconcile. We may see adaptation to aridity in other ways, such as in terms of technological change, either in terms of a single ‘transition’, or in terms of change over time correlating with environmental variation. If there is a biological basis to the ability of hominins to occupy arid environments, it is perhaps more likely to be in terms of ‘pre-adaptation’ than adaptation as such. The evolution of features such as extended working memory and larger social networks would have aided in the colonisation of arid environments. From such bases, contingent and repeated processes of cultural adaptation occurred which built on, but did not automatically flow from, the derived social and cognitive features of hominins. Adaptation to aridity can be interpreted both in terms of the ability to survive arid conditions, and to rapidly colonise them during periods of amelioration. The difference between ‘adaptation’ in a ‘positive’ sense, i.e. an increase in the frequency of fitness increasing traits, versus ‘change’ in a neutral or negative sense, perhaps flowing from the isolation of populations and decreases in population density, needs to be considered. ‘Change’ reflecting post MIS-5 isolation can perhaps be seen at Haua Fteah (Reynolds, 2013) and SD-1 (Delagnes et al., 2013).

Several papers in this volume address the question of hominin adaptation to arid conditions. Dennell (2013), for instance, critiques the notion of ‘coastal adaptation’ in the Upper Pleistocene, instead seeing inland routes as being key, in part aided by the
light body frame of tropically evolved *H. sapiens*. This may have given *H. sapiens* a selective advantage over Neanderthals in marginal habitats, but Dennell argues that for our species adaptation to deserts in a meaningful sense occurred in the Holocene, or perhaps the Terminal Pleistocene. Finlayson (2013) argues that the adaptation of *H. sapiens* needs to be understood in terms of a wider *Homo* adaptation, and that proximity to water was a key part of this. The many similarities between the context and features of sites occupied by *H. sapiens* and Neanderthals indicate a similar niche as water dependent omnivores (Finlayson, 2013). Like Dennell (2013), Finlayson (2013) and Boivin et al. (2013) criticise the recently popular idea of the special role of coasts in human adaptation and dispersal (e.g. Stringer, 2000). Boivin et al. highlight both the paucity of empirical evidence for the special role of the coast, as well as theoretical reasons why it is likely to have been overstated. Boivin et al. (2013) suggest that dispersals out of Africa were associated with the expansion of terrestrial habitats to which *H. sapiens* were already adapted.

Several papers discuss the relationship of morpho–technological characteristics of lithics to adaptation. Arzarello et al. (2013), for instance, see the continuation of the basic methods of lithic reduction, albeit in different frequencies, in the Moroccan Sahara as perhaps indicating population continuity and technological change through time. Canevalieri and di Lernia (2013) suggest that Aterian assemblages in the Messak area of Libya may reflect an MIS 4 contraction of hominins to highland areas. Foley et al. (2013) see the desert belt as a testing ground for MSA lithic adaptations, although they also emphasise that dispersals into North Africa may represent range expansions in a similar habitat during humid periods rather than adaption to desert as such. Industries such as the Aterian, Foley et al. (2013) argue, must be seen within the Mode 3 diversity of the Middle Stone Age. This diversity gave hominins flexibility, and in this sense any robust understanding of the lithic technology of the desert belt must be rooted in the technology of hominins in centres of endemism, such as East Africa.

Goder–Goldberger (2013) sees the Khormusan as an example of an East African derived lithic adaptation where a greater correlation exists between raw material and lithic types compared to some other Middle Palaeolithic industries. Along with the technological variability of the Middle Palaeolithic, Goder–Goldberger reminds us that understanding raw material economy, is an aspect of casting light on hominin adaptation, when most recent work focuses on reduction strategies. Scerri (2013) criticises the idea of the Aterian as an arid adaptation, and instead orientates its features more towards population structure and the role played by hafting in Middle Palaeolithic technology. Indeed, it could be argued that much of the character of the Middle Palaeolithic as a whole reflects a shift to hafting lithics, and that this composite technology would have aided the survival of its users. The prevalence of ‘Nubian’ technology in Dhofar (Usik et al., 2013) can be seen as a reflection of adaptation to a perhaps marginal environment.

We highlight in particular the importance of Delagnes et al.'s (2012, 2013) discoveries in Wadi Surdud, Yemen for discussions of Middle Palaeolithic hominin adaptability. The context of the sites in thick deposits of rapidly accumulated alluvium gives excellent insights into the context of hominin occupation (see also Sitzia et al., 2012). Given the excellent spatial preservation and palaeoenvironmental reconstruction, in the case of Wadi Surdud it is clear that hominin occupation occurred in at least semi-arid conditions. This may be evidence for the increased survivability of Middle Palaeolithic compared to earlier hominins, and perhaps such survivability through dramatic environmental changes in part explains the ability of hominins to successfully disperse through south Asia in the Upper Pleistocene.

### 5.4. Hominin dispersals

The other central theme that many papers in the volume address is the dispersal of hominin populations. With the rise of the ‘Out of Africa’ paradigm – particularly premised on genetic evidence, supplemented by fossil evidence and at least congruent with archaeological findings – dispersals assumed a key role in understanding hominin evolution in the Upper Pleistocene. With recent discoveries, including evidence for the interbreeding of *H. sapiens* and ‘archaic’ hominins, there is perhaps an emerging trend towards a less narrow focus on dispersals in narratives of Upper Pleistocene hominin evolution. While fossil and genetic evidence still suggests that *H. sapiens* originated in Africa, and that therefore dispersals retain a fundamental importance in explaining the origins of modern populations across the rest of the world, recent advances in understandings of mutation rates have severely problematized many genetically derived ideas on dispersals. As reviewed by Scally and Durbin (2012), direct measurement of mutation rates, in contrast to traditional very coarse estimates which were then extrapolated to make very precise archaeological claims, suggest that many of the hominin biological processes of the Middle and Upper Pleistocene occurred rather earlier than often suggested. The timing of the dispersal of *H. sapiens* out of Africa is one area affected, and the new estimates are congruent with the idea that a phase of dispersal correlated with the climatic amelioration of MIS 5 rather than occurring subsequently when humans would have had to pass through extremely arid environments. The latter might be taken as indicating a fundamentally different, ‘modern’, type of human behaviour, while the movement through familiar habitat types suggests a more ecologically ‘normal’ type of dispersal process. Dispersals as a research theme are undeveloped in the study of human origins (but see Gamble, 1993), and the simplicity of many narratives has led to some criticism of dispersals in archaeological narratives (e.g. Clark, 1994). The foundations of hominin dispersal are broadly the same as for biological organisms as a whole (e.g. Clobert et al., 2012), while more research is needed to cast light on the uniquely hominin elements of dispersal. Given the global distribution of humans by the Holocene, an evolutionary process has clearly occurred in which hominins were able to disperse into various habitat types. Such ‘cosmopolitan’ behaviour is rare in nature.

### 5.5. Beyond ‘Out of Africa’ 2

Boivin et al. (2013) make the pertinent point that the fossil evidence of southern Asia, taken on face value, indicates that the dispersal of *H. sapiens* was from east to west. They make this point as a reminder of the problems of pre-Holocene fossil evidence, which is rare over vast areas (e.g. Asia) and absent in many (e.g. Arabia). The distribution and characters of hominin fossils, like the genetic evidence, is telling a story, but it is one which has perhaps been interpreted too directly. Rather than being overly empiricist – for instance, downplaying preservation biases in fossil representation and demographic effects on genetic evidence – more heavily modelled and theorised perspectives are needed. A robust approach roots archaeological, fossil and genetic evidences in terms of biogeography and palaeoenvironments, and uses the evidence from different disciplines to test hypotheses.

Many contributors to this volume associate dispersals through the mid-latitude arid belt with periods of climatic amelioration. As discussed above, the extent to which occupations of what are today arid areas reflect ‘adaptation’ is a poorly resolved topic. Marine Isotope Stage 5 has been, in particular, highlighted as a key time for dispersals in the mid latitude arid belt (e.g. Boivin et al., 2013; Delagnes et al., 2013; Usik et al., 2013), in
contrast to regional contraction and population separation post-MIS 5. This emphasis on MIS 5, however, is not incongruent with both later (e.g. early MIS 3) and earlier dispersals, the latter perhaps occurring in MIS 6 (e.g. Frumkin et al., 2011) and/or MIS 7 (e.g. Dennell and Roebroeks, 2005). Jones (2012), for instance, suggests that *H. sapiens* may have reached India by MIS 6. We sympathise with views which argue that several dispersals of *H. sapiens* across southern Asia probably occurred (e.g. Dennell and Petraglia, 2012). Dispersals are likely to have occurred at a variety of spatial and temporal scales. The papers in this volume suggest the need to move beyond the simplistic notion of ‘out of Africa’, or at least to use this term in a loose and heuristic sense. In reality this process should, at a minimum, be divided into two components: 1) "into the Saharo–Arabian belt", 2) "out of the Saharo–Arabian belt"/ "into the Palaeartic/Oriental zones".

Dennell (2009, 2013) emphasises the idea of a post-MIS 6 "scramble for Asia". Much attention for this has focussed on the dispersal of *H. sapiens* in MIS 5–3. He makes the significant point that Neanderthals were also dispersing into Asia to the extent that late in their existence they were primarily an Asian species. This is a reminder of the complexity of the Upper Pleistocene world, and that both hominin anatomy and behaviour were spatially and temporally diverse. This complexity has provided the framework for the consideration of areas with little fossil evidence and diverse lithic assemblages, such as Iran (e.g. Vahdati Nasab et al., 2013) and India (Blinkhorn, 2013).

The implications of the evidence from North Africa for understanding population dispersal and continuity can be interpreted in different ways. To Arzarello et al. (2013) the common technological substrate of Middle Stone Age sites in Moroccan Sahara assigned to different techno–complexes indicates technological, and therefore presumably population, continuity. Cancellieri and di Lernia (2013), argue for a pre-MIS 5 dispersal of hominins with a Lupemban type material culture (see also Foley et al., 2013) followed by, ultimately, contraction into upland areas by hominins with Aterian lithics in MIS 4. Goder-Goldberger (2013) also argues for a northwards dispersal of Sub-Saharan hominins. Such examples highlight the likely complexity of the Middle and Upper Pleistocene in Africa, where dispersal and adaptation occurred. The role of interaction between populations is also likely to emerge as a key topic, and it is probable that increasing evidence will emerge for the biological and cultural diversity of Middle and Upper Pleistocene African hominins.

The dispersal related interpretation of the Khormusan advanced by Goder-Goldberger (2013) is different to that previously stated which sees it as a phase of an evolving ‘Nubian Complex’ in northeast Africa (e.g. Van Peer, 1998; Usik et al., 2013). Such examples demonstrate the diverse ways in which the record can be interpreted, and the varying results which spring from alternative methodologies. Scerri’s (2013) interpretation of lithic variability in North Africa indicates population structure in North Africa (see also Reynolds, 2013) and it may be in such population structure that pertinent factors relating to dispersals eastwards will be found. The analysis by Culley et al. (2013), and specifically their claim that the ‘C’ and ‘B’ facies of the Levantine Middle Palaeolithic should not be separated also has implications for our understanding of dispersals. These facies have been correlated with *H. sapiens* and Neanderthals respectively, so if Culley et al.’s results are accepted, they perhaps challenge the notion of repeated dispersals into the Levant associated with particular forms of technology. Alternatively, they may say more about the character of Bordesian systems. More widely, Culley et al.’s work is a pertinent example of the various ways even the record of the small area of the Levant can be interpreted. When this is considered, the clear complexity of Middle and Upper Pleistocene hominin evolution across Africa and Eurasia is evident. In the case of the Levant we suspect that many surprises lay in wait. That the Skhul and Qafzeh hominins represent a population dispersal from Africa in MIS 5, for instance, has become an orthodoxy, but alternative narratives are possible and must not be rejected out of hand.

Usik et al. (2013) interpret the Middle Palaeolithic assemblages in Dhofar in terms of dispersals. To them the morphology and technology of Nubian reduction are sufficient evidence to indicate population connections between NE Africa and Arabia. The significance of some distinctive features of the Dhofar material in contrast to other areas, such as the prevalence of ‘Dihedral Chapeau du Gendarme’ striking platforms, remains to be understood. Nubian cores have been identified across a wide area (e.g. Beyin, 2013; Cancellieri and di Lernia, 2013; Foley et al., 2013; Goder-Goldberger, 2013; Scerri, 2013). Most authors in 2013 who discuss Nubian technology at least broadly support the interpretation made by Rose et al. (2011) and Usik et al. (2013).

Boivin et al. (2013) criticise the notion of a single dispersal of one population along the coast of Africa around 60 ka. They dispute the evidence for this model from a variety of disciplinary perspectives and instead conclude that successful dispersal out of Africa probably occurred earlier and by terrestrial routes. Rather than seeing the occupation of the Levant as a fleeting and failed dispersal, as is often described, they see the tens of thousands of *H. sapiens* occupation of the area as a window into the early and long term occupation of southern Asia. In highlighting difficulties with fossil and genetic evidence, Boivin et al. (2013) emphasise the importance of archaeological data in multidisciplinary analyses of hominin adaptation and dispersal. Vahdati Nasab et al. (2013) present a number of potential continental dispersal routes across the Iranian Plateau, supported by archaeological evidence that is currently lacking for coastal routes. Blinkhorn (2013) describes evidence from India that is congruent with the early dispersal of *H. sapiens* out of Africa, while a young Middle Palaeolithic in South Asia does not fit neatly with the idea that a revolutionary change in human behaviour led to population dispersal around 70–60 ka.

Fig. 3 shows various examples of Middle Palaeolithic cores from North Africa and the Middle East. All but one is Levantoid cores, of different forms. How should such lithic variability be interpreted? Considerably more research needs to be done to clarify which features can be classed as indicating population dispersals, versus those which reflect adaptation and drift. The connection between the products of individual hominins and population wide technological ‘concepts’, and how these relate to adaptation and dispersal, is not self evident. Idiosyncrasies are likely to offer evidence for dispersals, but to be robust these should be of a character which is not a desirable trait in an engineering sense. It is likely that from a common (i.e. ‘Mode 3’) technological substrate, various forms of technology were repeatedly reinvented. Those which gave a selective advantage, i.e. perhaps those which produced blanks which were strong, suitable for hafting etc., may have become a focus of reduction. Caution is needed in making claims for dispersal and adaptation from lithic artefacts, but the potential of their study also needs to emphasised. Robust insights will be based on quantified approaches to spatially and temporally representative samples.

6. Closing remarks

In this introduction we have sought to both describe the papers in this volume and consider their relationship to the heuristics of adaptation and dispersal. The volume highlights research which brings together palaeoenvironmental scientists and Palaeolithic archaeologists. Considering the balance between adaptation (broadly change through time) and dispersal (broadly change...
through space) remains a central task. From the papers in this volume some common threads have been repeated. Contributors are agreed on the significance of environmental change on hominin demography and behaviour. The importance of lithic artefacts, which in arid environments often occur on the surface, has been reinforced by several of the papers. On the whole it seems that adaptation to aridity does primarily relate to the Holocene, but improved survivability in at least semi-arid conditions and behavioural flexibility can perhaps be seen in terms of pre-adaptation and adaptation to semi-arid environments. The papers demonstrate a move towards understanding dispersals in biogeographical terms, and an emphasis on interior over coastal routes. Considerably more survey and excavation needs to be undertaken in the desert belt, and archaeological sites dated and situated in terms of palaeoenvironmental fluctuation. The mid latitude-arid belt has been established as a key zone for at least the later phases of hominin evolution and dispersal. The need to move towards understanding the past based on spatially and temporally representative samples necessarily implies a move to greater research investment in the desert, whose potential the papers in this volume clearly demonstrate. The archaeology of the desert impels us to move beyond simple notions of African versus non-African, and instead to see hominin behavioural change/adaptation and population dispersal as two faces of the same evolutionary and cultural process in which the mid latitude arid belt played a crucial role.

Fig. 3. Examples of variability in Middle Palaeolithic core technology from the desert belt. All photos by H. Groucutt except 6 (courtesy of E. Scerri). 1 – Warwasi Cave, Iran; 2 – TH-268, Oman; 3, 7 – Tor Faraj, Jordan; 4 – TH-205, Oman; 5 – TH-59, Oman; 6 – Garet Umm Ali, Algeria; 8 – 1010-8, Sudan; 9 – JSM-1, Saudi Arabia; 10 – JKF-1, Saudi Arabia.
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