Vertebrate Paleobiology and Paleoanthropology Series

Jean-Jacques Hublin
Shannon P. McPherron *Editors*

Modern Origins

A North African Perspective

Springer

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Preface

Modern Human Origins in North Africa

In September 2007, we hosted a conference at the Max Planck Institute for Evolutionary Anthropology (Leipzig, Germany) on modern human origins from a North African perspective. In doing so, we brought together scholars working on climate, chronology, archaeology, and physical anthropology. The goal was to have an integrated view of current research in a geographical area and time period of importance for questions concerning the origins of modern humans, both biologically and culturally, and their subsequent spread from Africa to the rest of the world.

Currently within Africa the rich sub-Saharan archaeological record is the best documented for this time period, particularly in South Africa. However, one of the weaknesses of the South African record is the relatively few fossil hominins these deposits have yielded. In contrast, the North African record, especially that of the western Maghreb, is quite rich. The North African record, however, as many of the chapters in this volume make clear, is flawed by early and poorly published excavations that produced datasets either riddled with too many questions of provenience or too incomplete and biased to answer the questions we have today. Fortunately, the situation has started to change, particularly in the last decade, and there are now a large number of ongoing projects at many of the classic North African sites. Work is especially active in the Moroccan cave sites, including Jebel Irhoud, Rhafas, Taforalt (Grotte des Pigeons), Dar es-Soltan I, El Mnarsa, El Harhoura, Contrebandiers, Ifri n'Ammar, and Mugharet el 'Aliya. In Libya, Haua Fteah is now being re-excavated, and in Tunisia a program is underway to re-investigate the known sites and survey for new sites. In Algeria, new studies are being conducted at Bir-el-Ater, the eponymous site of the Aterian. These works have already forced a complete revision of the Aterian chronology, resulted in the discovery of significant new fossil material from well-documented archaeological contexts, and, more gradually, produced a better understanding of the lithic technologies and subsistence practices of these early modern humans.

Climate

Our view on the ancient peopling of Africa is biased by the current development of desertic areas, and of the Sahara in particular. The emphasis often put on the high genetic diversity of sub-Saharan populations should be put into perspective. Today the Sahara is virtually empty of human occupation but this was not always the case during the Pleistocene. As demonstrated in the contribution by Smith (Chap. 3), the sedimentological and geochemical evidence suggest that it is only after 70 ka that humid events became less intense, although they were still significant. Marine sediment cores off the coast of North Africa (NW African margin and Alboran Sea) also provide indications of these climatic fluctuations during the late Middle and Late Pleistocene. The climatic pattern driven by monsoonal variations seems to be modulated after about 60–70 ka by the influence from high-latitude processes due to the lower amplitude of the precessional cycles. According to Moreno (Chap. 1), the data indicate an increase in Saharan wind intensity during the Dansgaard/Oeschger stadial periods and the Heinrich events. However, most of the Mousterian or Aterian sites mentioned or analyzed in this volume predate this period of increasing aridity, and their geographical distribution extends into areas that are today covered by desert. During Marine Isotope Stage (MIS) 5 in particular, large bodies of water sometimes covering tens of thousands of square km developed in the Sahara, allowing an intense human occupation and population exchange between the Maghreb and the rest of Africa. This period is crucial for the evolution of the modern populations involved in the last Out-of-Africa event and possibly for the emergence of modern behavior in Africa. According to Geraads (Chap. 4), although the first half of the Middle Pleistocene of northwestern Africa is characterized by open landscapes, some more humid and/or forested areas, likely inhabited by early *Homo sapiens*, are documented during the second half of this period. It is during the Late Pleistocene that an increase in aridity reduced the faunal diversity. However, it is still difficult to reject the permanent human occupancy of large parts of the area, at least at some elevation. As underlined by Larrasoaña (Chap. 2), North Africa holds a key location in the gateway to Eurasia. Although in northeastern Africa the "green Sahara" periods broadly correlate with Acheulian and Mousterian archaeological sites, Aterian sites are linked to spring deposits and mountain areas during a prolonged arid period. This author suggests that environmental fluctuations controlled the exchanges with the Near East and that the burst of arid conditions after 70 ka might have driven some of the late Middle Stone Age populations of northeastern Africa "out of the desert" into Eurasia. In Chap. 11, Hawkins also links this shift from wetter to drier conditions in northeastern Africa to a shift from MSA to Aterian. In her view, the Aterian is an adaptation to drier conditions requiring greater mobility and better projectile technologies to increase the effectiveness of hunting.

Biology

A very rich fossil record documents human evolution throughout the Middle and Late Pleistocene in North Africa. The main questions surrounding the interpretation of this material relate to the first evidence of a modern morphology and to the continuity between late Middle Pleistocene populations and recent humans in the area. In Chap. 15, Bräuer supports a model of gradual emergence of *Homo sapiens* with different grades. When comparing the evolutionary processes in northern, eastern, and southern Africa, it is difficult to assess the distinct roles of the different regions in the emergence of modern populations. It is therefore suggested that interregional migration and/or gene flow during periods of a "green Sahara" might have led to complex patterns. Supporting previous studies on the Jebel Irhoud material, Harvati and Hublin (Chap. 12) confirm that the facial morphology observed on these late Middle Pleistocene hominins is close to that of early modern humans from the Near East. It also relates to later populations in the area associated with the Aterian assemblages at Dar es-Soltan II. In contrast, the later Ibero-Maurusian humans, post-dating the peak of the last glacial maximum, seem to be morphologically closer to European Upper Paleolithic populations. The culmination of aridity represented by MIS 2 likely resulted in the final isolation of the Maghreb from the rest of Africa, with the development of more population exchanges around the Mediterranean Basin via the Levant. The Aterian hominins are of utmost importance as they likely immediately predated the last Out-of-Africa exodus at the origin of the modern peopling of Eurasia. Although it is difficult to argue for any direct connection between the hominins who inhabited the western Maghreb and the first modern Europeans, they might give us a good picture of the populations who lived between the Nile Valley and the Atlantic Coast between 100 and 50 ka. Hublin and collaborators (Chap. 13) used the dental evidence to show that although very robust and still displaying some primitive features, these populations can be related to other early modern humans in Africa and the Levant. Importantly, this material sheds new light on the interpretation of the very first modern humans known in western Eurasia. The Nazlet Khater 2 (Egypt) skeleton is dated to MIS 3 and represents a population much closer to the gate of Eurasia. Crevecoeur's analysis of this specimen (Chap. 14) reinforces the notion that the populations of this time period still retained several archaic features, notably in the face and mandible.

Archaeology

One of the themes arising from the conference and apparent in the chapters included here is Paleolithic nomenclature. It is unclear what we call or how we define some of the archaeological units that form the basis of the record for this time period. So, for instance, while there are a few researchers with strong opinions, there seems to be a large amount of uncertainty about what to call non-Aterian assemblages that post-date the Acheulian and pre-date the Iberomaurusian. For some these assemblages are Mousterian, for some they are Middle Paleolithic, and for others they are Middle Stone Age. The problem is that each of these terms carries with it certain implications. To call these assemblages Mousterian, or Moroccan Mousterian as suggested during the conference, links them to Europe and recalls the time when fossil hominins from North Africa were considered to be Neandertals. This nomenclature also reinforces the notion of the Sahara as a barrier that divides Africa with, in this case, a sub-Saharan Middle Stone Age versus a North African Mousterian. However, as discussed, it is clear that the Sahara was not a barrier during times relevant to the discussion.

Working with materials from the Western Desert of Egypt, Hawkins (Chap. 11) defines all Levallois based industries, including the Aterian, as Middle Stone Age. In Chap. 9, Garcea addresses the terminology problem directly and argues strongly for keeping the North African materials integrated into the African nomenclature, thus favoring a Middle Stone Age attribution. Garcea makes the point that the continued use of European terms mainly stems from European research traditions in North Africa and even considers that it could be derogatory to continue using European terms to describe African assemblages. Essential to her argument too is the association of biological types with stone tool industries. Thus, Middle Paleolithic assemblages, including the Mousterian, were made by Neandertals, and Middle Stone Age assemblages, including all of those in North Africa, were made by modern humans. In contrast, while primarily concerned with the definition of the Aterian, Richter and collaborators (Chap. 5) call these industries Middle Paleolithic.

The question of how exactly the Aterian should be defined (Bouzouggar and Barton, Chap. 7) and the related question of whether there are interstratified examples of Aterian and [other] MSA assemblages (Aouadi-Abdeljaouad and Belhouchet, Chap. 10; Richter et al., Chap. 5) remain problematic. Most cite Tixier's (1967) definition of the Aterian as a Mousterian industry with Levallois technology, including Levallois blades, a high frequency of faceted platforms, numerous side-scrapers, relatively abundant points, and a high frequency of end scrapers often made on blades. The key item for the Aterian, however, is tanged pieces. Tixier's definition included the tenet that a noticeable proportion of the pieces, sometimes as much as 25%, included proximal tangs, often bifacially prepared. Finally, the Aterian is also characterized by some bifacial foliates.

Bouzouggar and Barton (Chap. 7) recall that earlier definitions of the Aterian also noted the existence of small discoidal and Levallois cores. They further discuss their presence in the Aterian of Contrebandiers, El 'Aliya, El Mnasra and El Harhoura. Small flake production is now well-documented from a variety of Lower and Middle Paleolithic contexts based on a number of technologies including small Levallois and single surface cores, truncated-faceted techniques, Kombewa, and simple flaked-flake techniques. In some cases, small flake production is a response to raw material constraints (either size or availability), while in others small flakes were desired end-products. Bouzouggar and Barton also wonder whether the small cores themselves could have been used as tools. The techniques of small flake production, the use of small flakes, and whether these exist throughout the Aterian are areas of research that deserve more attention.

It is clear that the presence of a tanged piece makes an assemblage Aterian. What is less clear is what to do with industries that post-date the Aterian, based on either absolute dates or interstratifications, and that lack typical Aterian elements. In this volume, for instance, two sites are reported where MSA assemblages overlie Aterian assemblages. First, at the Moroccan site of Ifri n'Ammar (Richter et al., Chap. 5), a deep sequence contains interstratified layers of Aterian and MSA/MP industries with the only difference between the two being the presence of tanged pieces and the percentage of notched pieces. Second, the recently excavated open-air Tunisian site of Aïn El-Guettar in the Meknassy Basin contains a well-stratified Aterian level below a Middle Paleolithic horizon separated by 1.4 m of sterile deposit. Aouadi-Abdeljaouad and Belhouchet (Chap. 10) conclude that the Mousterian and the Aterian are contemporaneous cultural groups, while Richter and collaborators prefer to group both into a Middle Paleolithic that contains at least two variants, one with tanged pieces and the other without, without chronological significance.

Given how important tanged pieces are in defining Aterian assemblages, we need a better understanding of the prevalence of tanged pieces in Aterian assemblages in general, as well as of the functional role of the tang. With regard to the former, Bouzouggar and Barton (Chap. 7) show the percentage of tanged pieces varying between as low as 1.4% and as high as approximately 30% at Dar es-Soltan I, with the caveat that the latter is almost certainly elevated due to collection biases. These numbers, however, are relative to other tools in the assemblage. To better understand their prevalence, data are also needed on assemblage size, artifact densities, raw materials, and more difficult measures like site function or context (e.g., open-air versus shelter, proximity to quality raw materials, etc.). These kinds of data should appear in the coming years as the assemblages from new excavations are published.

With regard to the functional role of tanged pieces in Aterian assemblages, here again, relatively little is known. The presumption has been that tools are tanged to accommodate hafting and that tanged pointed pieces are evidence of stone-tipped spears used for hunting. The latter have been used to pull the Aterian into the African MSA with an emphasis on regional point traditions and, in part, to support the idea that more efficient hunting characterizes an emerging modern human behavioral package. There are certainly impressively symmetrical, well-made, tanged points that one could easily imagine as armatures, but this has yet to be convincingly demonstrated. In addition, use-wear studies to date provide alternative interpretations, and the underlying variability in tanged pieces paints a more complex picture. Garcea reviews this topic explicitly in Chap. 9. She notes that tangs are present on a wide variety of pieces, including those that are retouched and unretouched and those that are pointed and non-pointed. This aspect of tanged pieces is clear whenever one looks at a recently excavated or collected assemblage that does not suffer from collection bias. Garcea also argues that the stem portion of the tanged pieces in her studied assemblage was too short to have provided an effective haft for a projectile and that the tangs themselves show use-wear patterns indicative of scraping activities and not of hafting. In Chap. 7, Bouzouggar and Barton review data which show that tanged pieces were rarely used as projectiles and instead find evidence for working hard and soft materials and for cutting activities even when the piece has a pointed morphology. Garcea is careful not to exclude the possibility that some tanged pieces were in fact hafted, and evidence that tanged pieces were used for cutting or scraping does not exclude the possibility that they were hafted. Still, it seems that until evidence can be presented in support of Aterian points as armatures and even in support of hafting, we should remain cautious in our interpretation of the behavioral significance of the tang technique. Here again, we should expect more data soon on factors such as the technology of blank production for tanged pieces, blank selection for tanged pieces, retouch on tanged pieces, and the relative frequencies of techniques such as basal thinning in the assemblage.

At the same time, however, while the Aterian's distinctive tanged pieces can be used to recognize a techno-complex that extends over much of what is today arid North Africa, it is also clear that there is considerable regional and likely chronological variability within the Aterian such that we should not expect to be able to generalize findings from one set of sites to the whole of the Aterian.

Chronology

Raynal and Occhietti (Chap. 6) and Richter et al. (Chap. 5) tackle chronological issues. Since the application of ESR, TL, and OSL methods to North Africa, it has become clear that the Aterian is older than previously supposed based on radiocarbon dates and chronostratigraphy. The question now is just how old the Aterian is. Along the Atlantic littoral zone south of Rabat a number of Aterian deposits have now been dated and shown to extend to the last interglacial MIS 5e. This finding is supported by Raynal and Occhietti with the additional technique of amino acid analysis. To find older Aterian one has to look elsewhere, as the basal deposits in these cave sites were formed by the high beach stands of MIS 5e. Thus, it is perhaps not surprising that still older Aterian has recently been announced from the site of Ifri n'Ammar (Richter et al., Chap. 5). The oldest Aterian at this site has been dated to 145 ± 9 ka based on thermoluminescence dating of 9 heated lithics. It remains to be seen how much older both the Aterian and the preceding MSA/MP will go or whether additional, equally old Aterian sites will be found. On the other hand there are now relatively few sites, especially in the Maghreb, with late dates, and there may be a gap between the final Aterian and the Ibero-Maurusian in these locations (Garcea, Chap. 9).

Subsistence

One potentially important avenue to more fully explore is diet, especially considering the location of several of the better known Aterian sites that are currently being investigated along the coast south of Rabat where marine resource consumption is a possibility. As Steele notes in Chap. 8, debates over the effectiveness of MSA hunting strategies, and more recently the role of marine resources in the diet have figured prominently in discussions concerning the origins of modern human behavior. These debates have resulted in an emphasis on zooarchaeological studies. For North Africa, however, zooarchaeological studies have lagged behind, but this is changing. As in South Africa, there are numerous North African cave sites, especially in northwestern Africa, with good faunal preservation, being studied with a growing concern for identifying dietary changes. Until recently, most reports have emphasized the paleoenvironmental or chronological value of fauna and listed only the presence or absence of species. Despite numerous coastal sites, evidence for Aterian consumption of marine resources is still slim. In Morocco, coastal sites such as Dar es-Soltan I, El Harhoura I, and Murgharet el ‘Aliya show the presence of several species of fish and of marine molluscs, and at Murgharet el ‘Aliya, monk seal is also reported from the Aterian. This is the only marine mammal reported from a Late Pleistocene Moroccan assemblage (Steele, Chap. 8). However, the abundance and taphonomy of these occurrences are not yet well documented. Marine diets are easily detectable using stable isotope analysis, but to date there are no stable isotope studies on North African hominins. With current methods the problem will be poor collagen preservation in these relatively low latitude sites with high mean annual temperatures, and it remains to be seen whether this can be overcome. In the meantime, we should soon expect a series of more zooarchaeologically-oriented reports coming from the new excavations, and it will be especially interesting to get an evaluation of marine resources in the diet from the coastal sites south of Rabat currently under excavation.

Conclusion

The Middle to Late Pleistocene record has become the focus of intense research in large part driven by questions and debates surrounding the origins of modern human behavior and anatomy. Despite a long history of research in the area, North Africa has, until now, not featured prominently in these debates, with the focus instead being on East and particularly South Africa. The assessment of the North African evidence has suffered from two biases. One is related to the current geographical situation in which the Maghreb is separated from the rest of Africa by a major natural barrier representing the largest desertic surface of the planet. Although today the Maghreb is primarily connected to the Mediterranean Basin, this situation is relatively recent at the scale of the Pleistocene. It is only during the Late Pleistocene that the aridity in the region dramatically increased, although relatively “green” episodes are documented during MIS 5 and 3. It is therefore important to realize that exchanges of fauna and human populations were possible among North, East, and Central Africa until the eve of the last Out-of-Africa event, as documented by the large number of archaeological sites dating from this period in various parts of the Sahara. A second important bias results from the history of research conducted in the area. More than anywhere else in Africa, the studies in the Maghreb were conducted by European archaeologists who exported European models and developed the notions that “Neandertaloid” populations produced the “Middle Paleolithic” industries in the area. This is partly because this local “Mousterian” was by default considered to be roughly contemporary to the European Mousterian assemblages, and the Aterian was assumed to represent a sort of “transitional” assemblage chronologically centered on the European Middle/Upper Paleolithic boundary. One of the main advances in African archaeological studies has certainly been the reassessment of the chronology of these industries and of the antiquity of their makers. The North African paleoanthropological record is gradually being reconnected to the rest of the African record.

We suspect that another conference may be required a few years from now to help begin to incorporate and integrate this new work. In the meantime, however, what we have tried to do here is to take a kind of snapshot of where we are.

Reference

Tixier, J. (1967). Procédés d'analyse et questions de terminologie concernant l'étude des ensembles industriels du Paléolithique récent et de l'Epipaléolithique dans l'Afrique du Nord-Ouest. In W.W. Bishop & J.D. Clark (Eds.), *Background to evolution in Africa* (pp. 771–820). Chicago: University of Chicago Press.

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Part I
Paleoenvironment and Chronology

Chapter 1
A Multiproxy Paleoclimate Reconstruction over the Last 250 kyr from Marine Sediments: The Northwest African Margin and the Western Mediterranean Sea

A. Moreno

Abstract Marine sediments are one of the best archives of past climate change because they are essentially continuous in character and their age can be determined relatively easily. The study of grain-size and geochemical composition of marine sediments off the shore of the Northwest (NW) African margin and in the western Mediterranean during the past years has shed some light on the forcing mechanisms for dust input and wind strength in the North Canary Basin, and the climatic teleconnections between high and low latitudes during the glacial–interglacial transitions. On an orbital scale, the records show that changes in insolation associated with precession and eccentricity cycles are the major drivers in controlling dust input to the North Canary Basin. A particular response is observed during glacial terminations when maxima in productivity and grain-size are detected as a likely consequence of subtropical anticyclonic circulation intensification due to higher insolation but lower sea surface temperature (SST) over the North Atlantic. Then, the strengthened trade winds forced upwelling and had the ability to carry coarser particles at terminations. On a millennial timescale, Saharan dust variations appear to be strongly related to periods of strengthened atmospheric circulation in high northern latitudes, that is Dansgaard-Oeschger (D/O) cold stadials. Therefore, the study of marine sediments off the coast of NW Africa and in the Alboran Sea provides evidence of changes in climate and landscape distribution on land during the last 250 kyr that can be useful for understanding the origin of human populations and the patterns of their dispersal out of Africa ca. 50 ka.

Keywords Marine sediments • Multiproxy approach • Northwest African margin • Paleoclimate reconstruction • Western Mediterranean

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Paleoclimate Reconstruction from Marine Sediments

Understanding the main patterns that controlled climate variability in the northern African region over the last several hundreds of thousands of years is essential to place investigations about the evolution and dispersal of modern humans in a broad climatic context. Such a study requires paleoclimate archives with enough resolution and well-constrained chronologies to reveal climate variations on land that potentially influenced human evolution. Unfortunately, the lack of well-dated and continuous terrestrial records in that area prevents direct inferences of past climate changes. Some paleolake records (e.g., Schuster et al. 2005) and spring-deposited carbonate rocks (e.g., Smith et al. 2007) are available in the North African region and, although they are not continuous in time, their study is providing directly datable stratigraphic context for some archaeological investigations. Marine records from the NW African margin and the Mediterranean (see also Larrasoaña 2012) have contributed to the understanding of climate variability from that region complementing those on-land studies, since they are essentially continuous in character and their age can be determined relatively easily.

A number of parameters recorded in the marine sediments provide information about the climate and landscape distribution on land. For example, the pollen content accumulated in marine sediments off the coast of Africa is an indicator of changes in the vegetation cover of the neighboring lands (Hooghiemstra et al. 1992; Dupont et al. 2000). Other very useful indicators are those that can provide information about the source of the sediments. Thus, grain-size and mineralogy or geochemical composition of the terrigenous particles have proven to be dependent on the source area (Bergametti et al. 1989a; Grousset et al. 1998) and the type of transport (fluvial vs. eolian) (Matthewson et al. 1995; Stuut et al. 2005). In areas such as the NW African margin or the Mediterranean, under the influence of

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dust from the nearby Sahara Desert, discriminations in the time intervals when eolian or fluvial fractions in the sediments were dominant will indicate the alternation between wetter and drier periods (Moreno et al. 2001).

Paleoproductivity variability (i.e., the organic primary production in the ocean during the past) can be inferred from the associations of marine organisms accumulated in the sediments (diatoms, foraminifers, radiolarian, etc.) or by indirect proxies, such as some geochemical elements that are enriched under high-productivity areas (e.g., Barium, organic carbon) (Fisher and Wefer 1999). Along the NW African coast, oceanic productivity is linked to trade winds and the Canary Current systems through the outgrowth of coastal upwelling and upwelling filaments (Nykjaer and Van Camp 1994). Upwelling is an oceanographic phenomenon that involves the wind-driven movement of dense, cooler, and usually nutrient-rich water towards the ocean surface, replacing the warmer, usually nutrient-depleted surface water. Thus, in the case of NW African coastal upwelling, the location and pressure gradient of the Azores' high-pressure center are the main forces behind upwelling intensity and the resulting productivity pattern in this upwelling region. From the study of paleoproductivity variations in the sediments of the North Canary Basin, changes in trade winds and Canary Current intensity should be detectable. Finally, comparison with other studies from high latitudes and the analyses of the obtained proxy data in terms of cyclicities (Moreno et al. 2005) allow us to infer the order of investigated atmospheric and oceanic processes and explore the climate teleconnections among high and low latitudes.

In the NW African margin, due to the oceanographic setting and conditions on land, sedimentation rates recorded on most of the marine cores are generally low. In those cases, the studied cores allow a description of climate changes at the scale of the solar insolation variation (e.g., 10–100 kyr). However, higher sedimentation rates are attained closer to the coast, due to the influence of river inputs, and this allows us to resolve rapid climate variability (Kuhlmann et al. 2004b; Tjallingii et al. 2008). Thus, both orbitally-driven changes and rapid climate variability can be detected in the same area, which provides us with the opportunity to carry out the analysis of climate change at different time scales. In this chapter, I review the main data published recently on the NW African margin, although my primary focus is on two cores from the North Canary Basin (GeoB 5559-2 and GeoB4216-1) and one core from the Alboran Sea, western Mediterranean (MD95-2043) (Fig. 1.1), whose main data have been previously published elsewhere. GeoB 5559-2 and GeoB4216-1 cores were obtained from a region where a strong interaction between the atmospheric and ocean circulation systems is currently occurring: trade winds drive seasonal coastal upwelling while dust storm outbreaks from the Sahara Desert are the major source of terrigenous sediments. However, this present-day situation was certainly different in the geological past, when river inputs were also very significant during some time periods (Holz et al. 2007). The results from these two cores allow us to describe climate variability over the last 250 kyr, in association with main changes in the amount of insolation that is received at that latitude (30°N) from the sun (solar insolation) and how the reconstructed climate oscillations were driven by the variability and cycles of the orbital parameters (eccentricity, with a cycle of 100,000 years, obliquity (41,000), and precession (19,000 and 23,000 years). The three main orbital parameters, also called Milankovitch parameters, are the response to the gravitational pull of other planets and represent variation in the Earth's orbit and rotation patterns.

To explore the abrupt climate changes that occurred over the last 50 kyr in detail, a marine core from the Alboran Sea (western Mediterranean) with enough resolution and well-constrained chronology was selected to be included in this review. The investigation of dust supply to the western Mediterranean on a centennial scale has allowed us to focus on the climate variability of this region during Oxygen Isotope Stage (OIS) 3 (Moreno et al. 2002a) and provide climate data that may help to explain modern human migrations. OIS 3 is a very peculiar time period because it was characterized by high climate variability observed as abrupt temperature shifts (called Dansgaard-Oeschger (D/O) cycles) in ice cores (Dansgaard et al. 1993), marine sediments (Bond et al. 1997) and terrestrial sequences (loess; Rousseau et al. 2007), lakes (Brown et al. 2007), and speleothems (Wang et al. 2008) from all over the world (Voelker 2002). These D/O cycles occur for as little as 10–20 years, and constitute a jump of 7–10°C in mean annual atmospheric temperatures over both Northwest Europe and the Greenland ice sheet. Nowadays, the most accepted hypothesis for D/O variability relates to instabilities in global thermohaline circulation (THC) (Clement and Peterson 2008), a phenomenon referred to as oceanic conveyor belt circulation by Wallace Broecker in the 1980s (Broecker et al. 1985). THC oscillations have major global climatic implications and are significant modulators of continental environmental conditions. The THC hypothesis for abrupt climate change at a D/O scale relies on modeling experiments that have demonstrated that different THC modes are possible, both at present and during the last glacial period (Ganopolski and Rahmstorf 2001). The three main modes are: (1) a warm mode with strong convection in the Nordic Seas, (2) a cold mode with weaker convection occurring south of the Greenland–Scotland sill, and (3) a "collapsed" mode with virtually no deep-water formation in the North Atlantic and severe cooling. Transitions between these modes appear to be most clearly associated

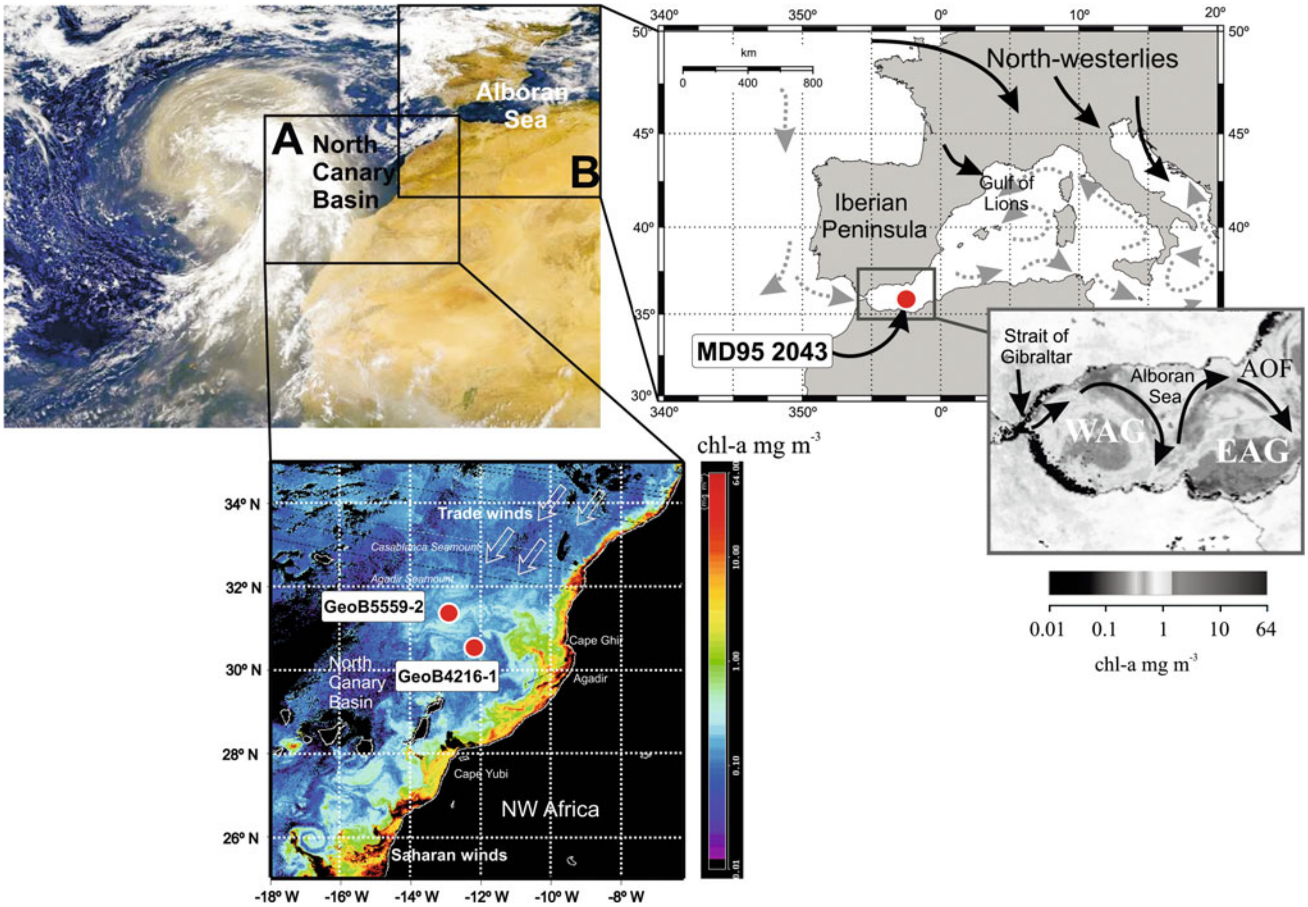
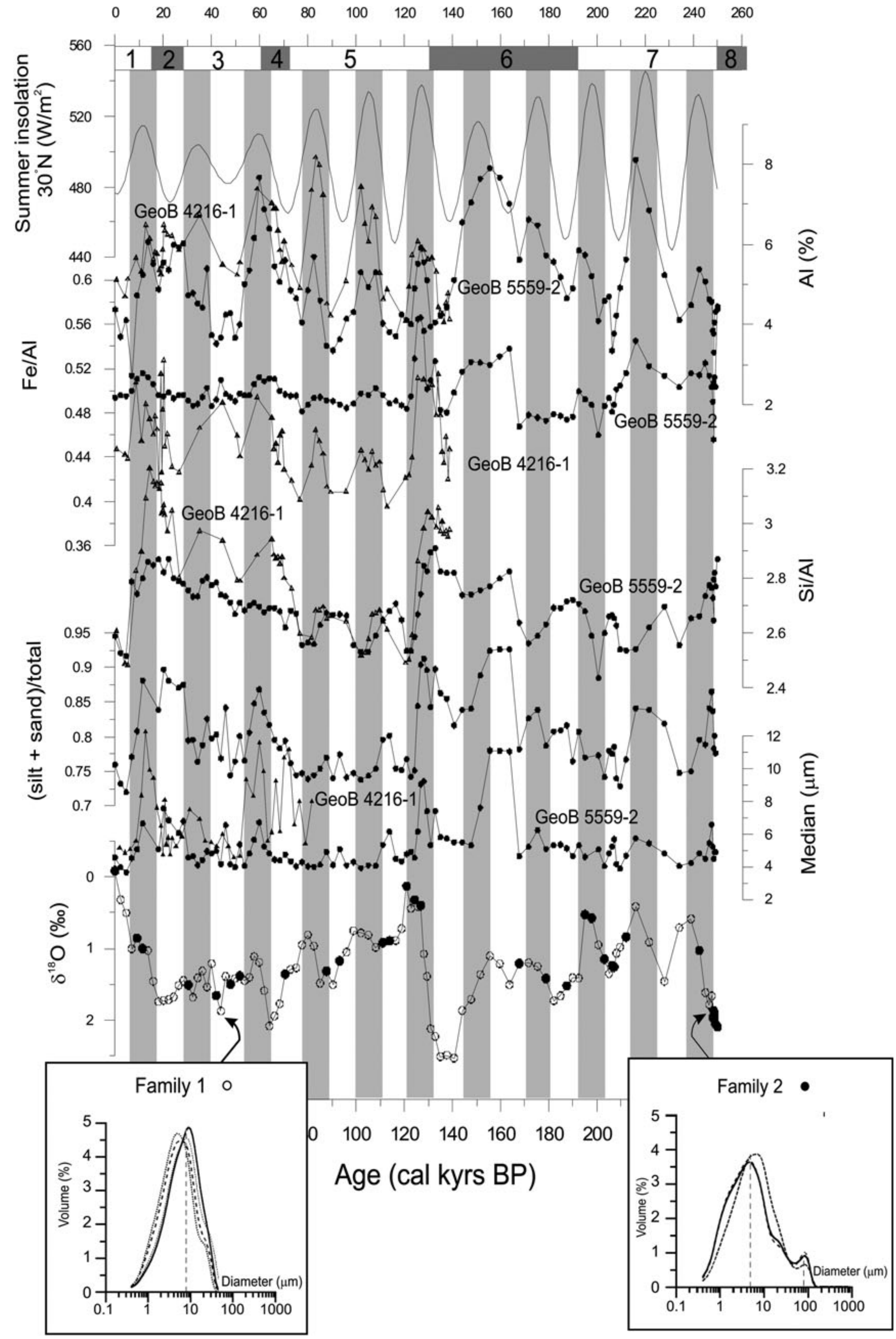


Fig. 1.1 Location of the studied cores in the North Canary Basin and the Alboran Sea. The satellite image shows a massive Saharan dust plume that affected the NW African margin and the western Mediterranean. The photograph was taken February 26, 2000, by the SeaWiFS Project and the Distributed Active Archive Center, Goddard Space Flight Center, Greenbelt, MD, USA. **a** Surface pigment concentration (mg m^{-3}) in the North Canary Basin as observed by SeaWiFS during an extraordinary Cape Ghir filament event on the 19th March 1998 (processed by Davenport). **b** Location of IMAGES core MD95-2043 in the Alboran Sea and present-day dominant oceanographic circulation represented by dashed arrows. The enclosed satellite picture represents the surface pigment concentration (mg m^{-3}) as observed by SeaWiFS on May 1999 (Fabrés et al. 2002). Both anticyclonic gyres (Western Alboran Gyre and Eastern Alboran Gyre) and the position of the Almeria-Orán Front are also indicated

with D/O cycles. The record of D/O cycles in low latitudes in the NW African margin, clearly discussed in recent studies (e.g., Jullien et al. 2007; Mulitza et al. 2008; Tjallingii et al. 2008; Itambi et al. 2009), points to an important role for atmospheric circulation and, likely, for dust transport and its effects on climate, to transfer rapid climate variability on a hemispheric scale.

Present-Day Oceanographic and Atmospheric Setting

The study region roughly lies in the eastern boundary current system, where the Azores Current transports the cold waters from the North Atlantic southwards. One branch of this current enters the Mediterranean Sea through the Gibraltar Strait, while the other branch goes south, where it forms the Canary Current. The Canary Basin lies in the recirculation regime linking the Gulf Stream with the North Equatorial Current via the Azores and Canary Currents (Fig. 1.1a). At this latitude, coastal upwelling is driven by the interaction between the trade winds and the Canary Current. Although the upwelling zone is restricted to the coast, satellite images have shown that large upwelling filaments develop at special coastal positions, such as Cape Ghir, Cape Blanc, and Cape Yubi (Davenport et al. 2002). In the Alboran Sea, the surface water mass that enters from the Atlantic Ocean through the Gibraltar Strait is called Modified Atlantic Water (MAW) (Millot 1999); this term describes a quasi-permanent anticyclonic gyre, the Western Alboran Gyre (WAG), in the west, and a more


Summer insolation 30°N (W/m²)
Fe/Al
(silt + sand)/total
δ18O (‰)
Al (%)
Si/Al
Median (μm)
GeoB 4216-1
GeoB 5559-2
1
2
3
4
5
6
7
8
Age (cal kyrs BP)
Family 1
Family 2
Volume (%)
Diameter (μm)

◀**Fig. 1.2** Downcore profiles of grain-size and geochemical proxies from GeoB 5559-2 and GeoB 4216-1 cores. From *bottom* to *top*: Oxygen isotope variability (GeoB 5559-2) where samples are classified in terms of grain-size distributions (*white dots*: Family 1-unimodal; *black dots*: Family 2-bimodal); Median of the terrigenous fraction (both cores); (Silt+Sand)/Total as a grain size indicator of coarser sediments and Si/Al and Fe/Al ratios and percentage of Aluminium (both cores). Note that when data from both cores are represented, *black dots* are from GeoB 5559-2 and *black triangles* are from GeoB 4216-1. Geochemical study of Core GeoB 4216-1 has been carried out in the first 6 m. To compare with these results, variation of summer insolation at the latitude of the studied cores is also plotted. Intervals with maximum summer insolation (= minimum precession index) are shaded

variable circuit, the Eastern Alboran Gyre (EAG), in the east, (Fig. 1.1b). Two main factors influence surface productivity in this area: (1) the speed of the inflowing jet of cold and less-saline surface waters from the Atlantic Ocean that interacts with saltier and warmer waters from the Mediterranean (Perkins et al. 1990), and (2) westerly winds (so-called Poniente) associated with the progression of atmospheric low-pressure centers into the Mediterranean region (Parrilla and Kinder 1987). Both processes favor the development of anticyclonic gyres that promote upwelling and primary productivity. In addition, the availability of nutrients via fluvial input further supports high productivity in the Alboran Sea, as is clearly evidenced by the close correlation between high chlorophyll concentrations and fluvial discharge from southern Iberian rivers (Fabrés et al. 2002).

In the study area, summertime climates are dry and hot due to the influence of the atmospheric subtropical high-pressure belt. In contrast, the subtropical high is displaced southward during winter, which allows mid-latitude storms to enter the region from the open Atlantic and bring increased amounts of rainfall to the Mediterranean. Therefore, the westerlies are located over the Mediterranean area in the winter and displaced towards northern Europe in the summer. On a decadal scale, much of the present day climate variability in this region has been linked to a natural mode of atmospheric pressure variation, the North Atlantic Oscillation (NAO; Hurrell 1995). NAO activity is defined as the difference between normalized winter sea-level atmospheric pressure between the Azoric high pressure and Icelandic low pressure cells. Although this oscillation is more pronounced during winter, it is present throughout the year. Winters with high NAO indices are characterized by a deepening of the Icelandic low associated with a stronger Azores anticyclone. The related changes in the large-scale meteorological situation lead to a northward shift of the North Atlantic westerlies, which provide much of the atmospheric moisture to northern Africa and Europe. In the case of a high NAO index, this shift yields drier conditions over southern Europe, the Mediterranean Sea, and northern Africa, together with changes in the storm tracks in these regions (Hurrell 1995). During low-NAO years, northwesterly winds are weaker and are guided to mid-latitudes, thus bringing higher precipitation to the Mediterranean and large areas of North Africa.

The interplay between Saharan air masses and the Azoric high-pressure cell constitutes another meteorological pattern that defines the climate of this region. Both the North Canary Basin and the Mediterranean Sea are located in the path of long-range atmospheric dust transport off the coast of northwestern Africa (Prospero 1996). Dust input to the North Canary Basin is controlled by the northeast trade winds and the Saharan Air Layer (SAL) wind systems. At present, major dust outbreaks that carry dust towards the Atlantic Ocean and Europe are linked with the northern branch of the SAL wind system (Torres-Padrón et al. 2002). These Saharan winds transport particles from the rim of the South Sahara and Sahel regions. The highest occurrence of dust outbreaks occur in winter and summer, related to two dominant meteorological scenarios. In winter, dust events are favored to occur when the Azores High is weakened and the Intertropical Convergence Zone (ITCZ) is southwardly located. Bergametti et al. (1989b) observed that dust transport from the Sahelian regions occurs when the incursion of a polar depression cuts the Azores High into two anticyclonic cells, an oceanic and a continental one. In contrast, dust outbreaks appear in summer when the high pressure is centered on the Azores, in combination with a low pressure cell over northern Africa, which favors dust transport from a northern source (Torres-Padrón et al. 2002). Until now, two origins for dust have been accepted in the literature: the Sahelian origin and the northeastern Morocco origin (Chiapello et al. 1997). Evaluation of back trajectories and isobaric meteorological maps shows that Saharan air masses dominate the Mediterranean region whenever the Azores High is displaced westward and the North African High is strengthened and centered over Algeria (Rodriguez et al. 2001). The development of summertime thermal lows over the Iberian Peninsula apparently stimulates this meteorological setting through intense heating of the land surface. In addition, an apparent relationship was found among the NAO and the Saharan dust load transport, indicating larger dust load transport to the Atlantic when NAO is at its positive phase. It is demonstrated that the long-term increase of the desert dust load corresponds to the upward trend of the NAO since the early 1970s. Both interannual variability and decadal increases in African dust export, as observed in Meteosat images and mineral aerosol in Barbados, are thus apparently controlled by climatic conditions expressed by the NAO index (Moulin et al. 1997).

Some Methods to Study Marine Sediment Cores

The NW African margin and the western Mediterranean Sea constitute a large area where many paleoclimate studies focused on the investigation of marine sediments have been carried out. In the North Canary Basin, located between 34° and 28° north latitude in the NW African margin, the recovery of nearly one hundred sediment cores in the framework of the Canary Islands, Azores, and Gibraltar Observations (CANIGO) European Project promoted high-quality paleoclimatic research. Two of these gravity cores, GeoB 5559-2 and GeoB 4216-1, were studied in order to investigate the forcing mechanisms for dust input and wind strength in the North Canary Basin, and the climatic teleconnections between high and low latitudes during the glacial–interglacial transitions (Moreno et al. 2001, 2002a, b, 2004, 2005; Moreno and Canals 2004) (Fig. 1.1a). The two cores are presented here with greater detail but many other cores from the same area were studied by other researchers (e.g., Bozzano et al. 2002; Freudenthal et al. 2002; Kuhlmann 2003; Kuhlmann et al. 2004a, b; Holz et al. 2007) and further south, off the coast of Cape Blanc, the number of records increases exponentially (e.g., de Menocal 1995; Matthewson et al. 1995; Martinez et al. 1999; de Menocal et al. 2000a, b). In addition, and with the aim of exploring the climate variations recorded during OIS 3 in greater detail, the main results from the MD95-2043 core obtained in the western Alboran Sea during 1995 IMAGES-I Calypso coring campaign aboard R/V Marion Dufresne (Fig. 1.1b) are reviewed in this chapter (for more detail, read previous papers in which the data set has been published; Cacho et al. 1999, 2000, 2006; Plaza 2001; Moreno et al. 2002a, 2004, 2005; Sánchez-Goñi et al. 2002; Fletcher and Sánchez Goñi 2008).

The chronological framework for the two North Canary Basin cores was obtained by correlating the measured $\delta^{18}O$ values with the SPECMAP $\delta^{18}O$ chronology (Martinson et al. 1987) spanning the last 250 kyr, from OIS 1 to 8. The age model for the core MD95-2043 was developed by Cacho et al. (1999) and is derived from graphically correlating the down-core sea surface temperature (SST) record with the climatic cycles displayed in the Greenland GISP2 ice core $\delta^{18}O$ record (Meese et al. 1997). According to this age model, the records presented in this study span the time interval from 28,000 to 48,000 cal yr BP with a mean sedimentation rate of 27 cm/1,000 years. The main indicators measured on the three cores and discussed in this chapter are *grain-size distributions* of both the total fraction and the carbonate-organic matter free fraction, and *elemental composition* of the sediments (e.g., Al, K, Ca, Si, Mn, Ti, Fe, Mg Ba, Sr, Cu, Co, Ni, V). To aid in the interpretation of the grain-size records, we modelled end-member grain-size distributions using numerical–statistical algorithms developed by Weltje (1997). Grain-size end-members represent a series of fixed sediment grain-size compositions that can be regarded as discrete subpopulations within the data set from all analyses (Prins and Weltje 1999). In addition, spectral analyses of the entire set of proxies were carried out by the *Analyseries* package (Paillard et al. 1996) to obtain the main cyclicities recorded by each proxy. Thus, we are able to objectively separate the orbital parameters associated with each climatic process represented by the analyzed proxies.

Supply of Saharan Dust to the NW African Margin: The Role of Orbital Parameters

Grain-size distributions of samples from North Canary Basin cores point to two different patterns. The first pattern is characterized by a unimodal distribution (Family 1 in Fig. 1.2), with the mode centred at 8 µm and only 5% of particles coarser than 63 µm. The second pattern (30% of the samples) is characterized by a bimodal distribution with about 10% sand content (Family 2 in Fig. 1.2). The first pattern more commonly appears during full glacial conditions while the second one is the most common at glacial terminations (Fig. 1.2). In addition to this classification, in Fig. 1.2 we show other grain-size parameters, such as the median of the grain-size distributions and a ratio that represents the coarser fraction, that is: (sand + silt)/total ratio (Moreno et al. 2001). In general, a clear precession control (23,000 year cycle) is observed (see comparison with insolation curve, shaded bars in Fig. 1.2), but the glacial–interglacial signal is more evident (100,000 year cycle), pointing to the presence of coarser terrigenous particles during the last three glacial terminations. To combine with the grain-size results, three geochemical markers are plotted in Fig. 1.2: (1) the Si/Al ratio as an indicator of wind strength because terrigenous quartz is more abundant in the coarse dust fraction (Guieu and Thomas 1996; Martinez et al. 1999), (2) the Al percentage, as a proxy of dust input in the NW African margin because it is incorporated into fine-grained, wind-borne clays (Matthewson et al. 1995), and (3) the Fe/Al ratio as a proxy for eolian particles coming from the Sahel area (Bergametti et al. 1989a; Balsam et al. 1995). The two cores shown here are located further to the coast and one of them (GeoB 5559-2) was recovered from a seamount, thus minimizing the amount of river-borne particles.