



Single-grain OSL chronologies for Middle Palaeolithic deposits at El Mnasra and El Harhoura 2, Morocco: Implications for Late Pleistocene human–environment interactions along the Atlantic coast of northwest Africa

Zenobia Jacobs^{a,*}, Richard G. Roberts^a, Roland Nespoulet^b, Mohammed Abdeljalil El Hajraoui^c, André Debénath^b

^a Centre for Archaeological Science, School of Earth and Environmental Sciences, University of Wollongong, Wollongong, NSW 2522, Australia

^b Muséum national d'Histoire naturelle, Département de Préhistoire, UMR 7194, 75013 Paris, France

^c Institut National de Sciences de l'Archéologie et du Patrimoine, 10001 Rabat, Morocco

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ABSTRACT

Optically stimulated luminescence (OSL) measurements were made on individual, sand-sized grains of quartz from Middle Palaeolithic deposits at two cave sites (El Harhoura 2 and El Mnasra) on the Atlantic coast of Morocco. We were able to calculate OSL ages for 32 of the 33 samples collected from the Middle Palaeolithic deposits, including the earliest and latest Aterian levels at both sites. These ages reveal periods of occupation between about 110 and 95 ka (thousands of years ago), and at ~75 ka. A late Middle Palaeolithic occupation of El Harhoura 2 is also recorded at ~55 ka. Our single-grain OSL chronologies largely support previous age estimates from El Mnasra and other sites along the Atlantic coast of Morocco, but are generally more precise, reproducible and stratigraphically more coherent (i.e., fewer age reversals). We compare the single-grain ages for El Harhoura 2 and El Mnasra with those obtained from single- and multi-grain OSL dating of Middle Palaeolithic deposits in the nearby sites of Contrebandiers and Dar es-Soltan 1 and 2, and with records of past regional environments preserved in sediment cores collected from off the coast of northwest Africa. A conspicuous feature of the new chronologies is the close correspondence between the three identified episodes of human occupation and periods of wetter climate and expanded grassland habitat. Owing to the precision of the single-grain OSL ages, we are able to discern gaps in occupation during Marine Isotope Stages 5 and 4, which may represent drier periods with reduced vegetation cover. We propose that these climatic conditions can be correlated with events in the North Atlantic Ocean that exert a major control on abrupt, millennial-scale fluctuations between wet and dry periods in northwest and central North Africa.

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Introduction

In recent years, there has been resurgence of research into the Middle Palaeolithic (MP) and Middle Stone Age (MSA) archaeological records of Africa. This is partly due to the widespread interest in issues relating to the origins of *Homo sapiens*, the dispersal of *H. sapiens* within, and out of, Africa, and the origins and development of modern human behaviour. The North African fossil evidence has been integrated into models dealing with origins of *H. sapiens* and their spread within Africa (Hublin et al., 1987; Hublin, 1992, 2001), with long-standing suggestions that the emergence of anatomical features particular to *H. sapiens* should

not be restricted to sub-Saharan Africa (Hublin, 1992). By contrast, models dealing with the origins and development of modern human behaviour and the dispersal of *H. sapiens* out of Africa to populate the rest of the Old World are based largely on MSA finds and chronologies from sub-Saharan Africa (e.g., Jacobs and Roberts, 2008; Jacobs et al., 2008a).

The North African MP assemblages have rarely been integrated into such models, due to the low number of stratified Mousterian sites and the chronological uncertainties associated with the Mousterian and Aterian industries. From palaeoenvironmental records and geophysical data, it is now clear that the Sahara has not always been a biogeographic barrier between sub-Saharan and North Africa (e.g., Osborne et al., 2008; Drake et al., 2011), so it is important to construct a chronological framework for the MSA and MP assemblages in these regions to facilitate a pan-African synthesis of modern human evolution and migration. An improved understanding of the

* Corresponding author.

E-mail address: zenobia@uow.edu.au (Z. Jacobs).

timing, duration and (dis)continuity of these archaeological records, and their relation to changes in climate and environment, can help establish the sequence of events that may have led to certain key turning points in the history of *H. sapiens* populations both south and north of the Sahara.

Early *H. sapiens* in Morocco are associated with two MP industries, the Mousterian and Aterian. The Mousterian is similar to other Mousterian assemblages of the Near East and Europe: it is flake-based and displays some use of Levallois technology (McBurney, 1975; Bordes, 1976; Wendorf et al., 1993; Aumassip, 2001). It differs in other aspects of technology, however, and the assemblages are commonly deficient in retouched tools, with mainly side-scrapers. The Aterian industry includes elements not seen in Mousterian assemblages, such as stemmed artefacts (Reygasse, 1919–1920; Tixier, 1959), bifacial and unifacial points (Debénath, 1992; Marean and Assefa, 2005), worked bones (Ruhlmann, 1951; Howe, 1967; El Hajraoui, 1994), shell beads (Bouzouggar et al., 2007; d'Errico et al., 2009), pigment use (Nespoulet et al., 2008) and structured fireplaces (El Hajraoui, 2004; Nespoulet et al., 2008).

Recent dating projects in North Africa have specifically focussed on constraining the age of the Aterian, using four different techniques: optically stimulated luminescence (OSL) dating of sediments, thermoluminescence (TL) dating of burnt stones, electron spin resonance (ESR) dating of tooth enamel, and uranium-series dating of flowstone. Ages obtained using these methods indicate that the Aterian probably began well beyond the range of radiocarbon (^{14}C) dating, so the choice of an appropriate dating method is critical to resolving the antiquity of the Aterian (Wrinn and Rink, 2003; Bouzouggar et al., 2007; Mercier et al., 2007; Barton et al., 2009; Richter et al., 2010; Schwenninger et al., 2010).

Dating studies in Morocco have focussed on two geographic areas: 1) the Témara region on the Atlantic coast, which represents the westernmost extent of the known distribution of Aterian assemblages, and 2) the northeast region, inland from the Mediterranean coast (Fig. 1). The published ages for the Aterian (i.e., assemblages that contain stemmed pieces) appear to differ between these two regions, despite the same dating techniques being used. In the Témara region, the Aterian deposits at Dar es-Soltan 1 (Barton et al., 2009; Schwenninger et al., 2010), El Mnasra (Schwenninger et al., 2010) and Contrebandiers (Schwenninger et al., 2010; Jacobs et al., 2011) have OSL ages, all self-consistent, of between 123 ± 9 and 92 ± 6 ka (thousands of years ago). The oldest and youngest individual ages were obtained for samples OSL6 from Dar es-Soltan 1 (Level 1) and SC31 from Contrebandiers (Layer 4d), respectively.

Much younger OSL ages (70 ± 4 , 62 ± 4 and 59 ± 10 ka) have also been obtained for a second occurrence of the Aterian, higher up the stratigraphic profile at Dar es-Soltan 1 (in Ruhlmann's Layer C2; Barton et al., 2009) and at Contrebandiers (in Roche's Trench; Schwenninger et al., 2010), but see Jacobs et al. (2011) for a discussion of the reliability of the latter age estimate. These ages fall within the range of ages (85 ± 4 to 60 ± 5 ka) published for the Aterian at sites in northeast Morocco, including Taforalt (Bouzouggar et al., 2007), and for the proto-Aterian levels (Layer 3a) that underlie the undated Aterian levels (Layer 2) at Rhafas (Mercier et al., 2007). Bracketing ages of between 60 and 35 ka for the Aterian have also been reported for the site of Mugharet el 'Aliya, near Tangiers, based on ESR dating of tooth enamel (Wrinn and Rink, 2003). At Dar es-Soltan 1, the two discrete pulses of Aterian occupation (i.e., assemblages containing diagnostic stemmed points) were separated by layers with no stemmed points, and the same pattern was identified at Ifri n'Ammar. At the latter site, TL dating of burnt stones yielded weighted mean TL ages of 145 ± 9 and 83 ± 6 ka for the Aterian assemblages containing stemmed points (Richter et al., 2010).

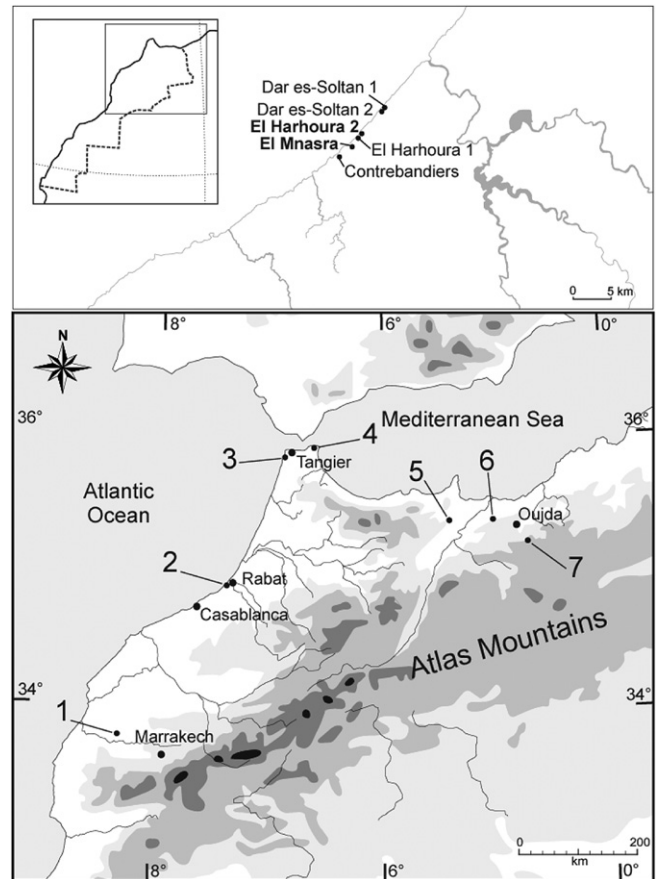


Figure 1. Map of northwest Africa indicating some of the better-known Middle Palaeolithic sites in Morocco: Djebel Irhoud (1), Témara (2), Mugharet el 'Aliya (3), Benzù (4), Ifri N'Ammar (5), Taforalt (6), Rhafas (7). The Témara region includes El Mnasra, El Harhoura 2 and several other sites referred to in this paper, which are marked on the detailed map in the top panel. The inset map shows the location of the geographic area enlarged in the bottom panel.

These new chronologies have implications for our understanding of the timing and culture-stratigraphy of the MP in North Africa. They re-introduce the question of which region of Africa, north of the Sahara, the Aterian originated in and dispersed from, and cast doubt on the Aterian as a single, short-lived culture. The revised chronologies challenge the consensus view, based on models of lithic assemblages and unreliable ^{14}C ages, that the Aterian on the Atlantic coast represents only the middle and later phases of this industry (Roche, 1969; Camps, 1974; Roche and Texier, 1976), and force a re-appraisal of the relationship between the Mousterian and Aterian, and the Aterian and Upper Palaeolithic (UP) Iberomaurusian. Furthermore, it is apparent from these recent studies, primarily of sites in Morocco (e.g., Bouzouggar et al., 2007; Nespoulet et al., 2008; Barton et al., 2009; Richter et al., 2010; Schwenninger et al., 2010), that the North African MP, and in particular the Aterian, can no longer be ignored in models of modern human behaviour and dispersal (Balter, 2011), but should be viewed as part of a pan-African MSA that represents one of the earliest fully modern behavioural adaptations (McBrearty and Brooks, 2000).

To address the implications raised by these recent studies requires an accurate and precise chronology for the entire MP throughout Morocco. Thus far, no single site appears to contain a continuous cultural sequence from the earliest to the latest MP, so finely-resolved dating comparisons between sites are needed. The necessary temporal resolution can only be achieved by conducting

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