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Lithics of the North African Middle Stone Age: assumptions, evidence and future directions

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Summary - *North Africa features some of the earliest manifestations of the Middle Stone Age (MSA) and fossils of our species, Homo sapiens, as well as early examples of complex culture and the long distance transfer of exotic raw materials. As they are elsewhere, lithics (i.e., stone tools) present by far the most abundant source of information on this cultural period. Given the importance of North Africa in human origins, understanding the character and distribution of MSA lithics is therefore crucial, as they shed light on early human behaviour and culture. However, the lithics of the North African MSA are poorly understood, and their technological variability is frequently obfuscated by regionally specific nomenclatures, often repeated without criticism, and diverse methods of analysis that are often incompatible. Characterising dynamic technological innovations as well as apparent technological stasis remains challenging, and many narratives have not been tested quantitatively. This significantly problematizes hypotheses of human evolution and dispersals invoking these data that extend beyond North Africa. This paper therefore presents a description of the lithics of the North African MSA, including their technological characteristics, chronology, spatial distribution and associated research traditions. A range of interpretations concerning early H. sapiens demography in North Africa are then re-evaluated in the light of this review, and the role and power of lithic data to contribute to such debates is critically assessed.*

Keywords - *North Africa, Middle Stone Age, Lithics, Aterian, Nubian Complex.*

Introduction

Across Africa, the abandonment of large cutting tools and an increased emphasis on prepared core technologies and hafting marked a profound technological re-organisation of hominin material culture. These technological changes define the Middle Stone Age or MSA, some of the earliest examples of which are found in North Africa. In this region, the early MSA is found in association with the oldest known fossils of the *Homo sapiens* clade, both dating to ~315 thousand years ago (ka) (Hublin *et al.*, 2017; Richter *et al.*, 2017, see also Scerri, 2017 for an overview of all aspects of the North African MSA). Some 170 thousand years later, the same region featured some of the earliest regional expressions of MSA technology and complex culture (d'Errico *et al.*, 2009; Richter *et al.*, 2010). These events and processes have been linked to the environmental fluctuations of the Sahara Desert, which facilitated periodic dispersal in and out of the region, while largely isolating North African populations from the rest of the continent (Drake *et al.*, 2011; Scerri *et al.*, 2014a; Groucutt *et al.*, 2015; Scerri, 2017). MSA stone tools from North Africa are therefore frequently included in studies of population dynamics and out of Africa dispersals (e.g., Garcea, 2001; Beyin, 2006; Armitage *et al.*, 2011; Usik *et al.*, 2013; Scerri *et al.*, 2014b; Groucutt *et al.*, 2015).

However, the stone tool technology of the North African MSA – the most abundant source of data relevant to the above debates – is currently

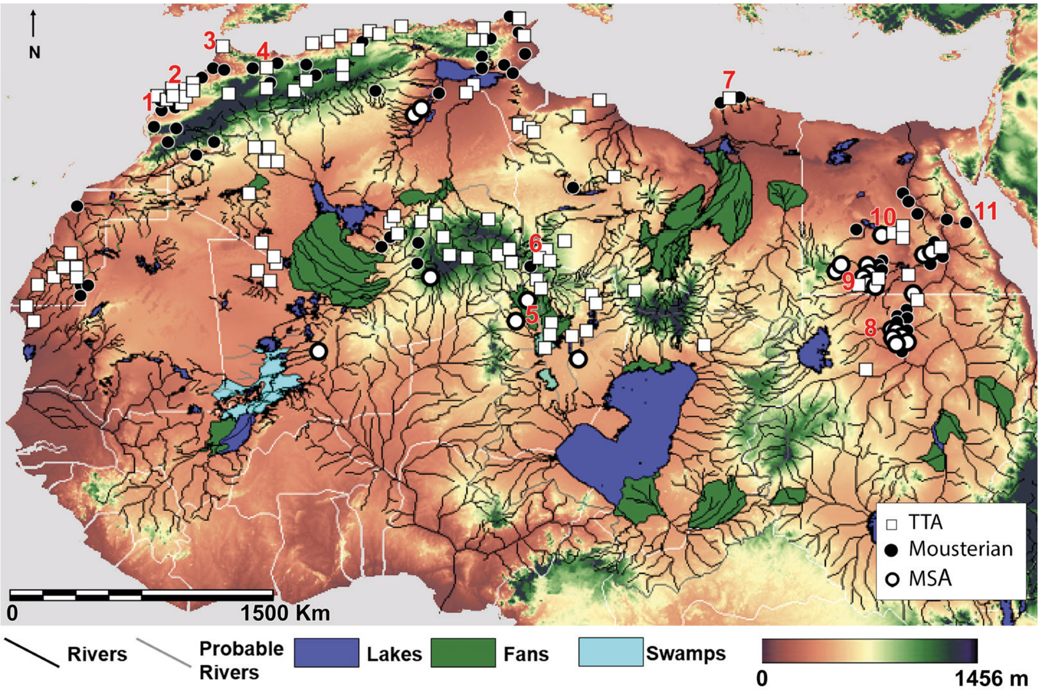

Fig. 1 - North African topography, palaeohydrology and distribution of a range of reported MSA sites north of 18° described as either Aterian (tanged tool assemblages or TTAs), Mousterian or MSA, with key sites numbered. The meaning of these terms is discussed in the text. Site clusters can be noted along the coastal and hinterland regions, the central Saharan mountains and the Nile region. Numbers indicate approximate locations of the following key sites: 1) Jebel Irhoud; 2) Benzu Cave; 3) Contrebandiers, El Mnasra, Dar es Soltan; 4) Ifri n'Ammar, Taforalt, Rhafas; 5) Adrar Bous; 6) Uan Afuda, Uan Tabu; 7) Haua Fteah; 8) Saï Island; 9) Bir Tarfawi/Bir Sahara; 10) Kharga and Dakhleh Oases; 11) Sodmein. Base map from Drake** et al.**, 2011. The colour version of this figure is available at the JASs website.

not well understood. This is particularly the case for the early MSA (Marine Isotope Stages [MIS] 8-6, ~270-130 thousand years ago or ka) and late MSA (typically MIS 4-3, ~70-30ka, although isolated examples indicated a persistence into the terminal Pleistocene) in North Africa, that have received less attention than the 'mid-MSA' (MIS 5, ~130-70ka) recently associated both with the emergence of complex culture and *Homo sapiens* dispersal out of Africa. There are several reasons why the stone tool technology of the North African MSA continues to be poorly understood. Firstly, there is a dearth of dated, spatially representative sites, particularly for the early and late MSA sites. The difficulties of working in hyperarid, desert conditions – often in areas suffering political instability - mean that MSA sites have been discovered either in coastal and hinterland regions, or in the vicinity of oases towns in the Sahara (Fig. 1). Many reported MSA localities consist of surface scatters and chronometric information is only available for a handful of sites (see Scerri, 2017). Secondly, the effects of the region's research history, and the number of different research traditions employed in the interpretation of North Africa's MSA archaeological record has resulted in a plethora of named stone tool industries which often lack critical assessment (Scerri, 2017; see also Shea, 2014 for a discussion on problems of nomenclatures).

The degree to which key technological features of the North African MSA, such as tanged tools (Scerri, 2013a) or Nubian Levallois reduction methods (Guichard & Guichard, 1965) 'stand' for populations in a culture-historical sense, or are convergent developments in similar environments is far from clear - an issue that significantly problematizes dispersal hypotheses invoking these data. The continuity and significance of these technological features beyond this MIS 5 timeframe are also not well understood. Some continuity into MIS 4 has been observed in locations across North Africa (Van Peer, 2004; Jacobs *et al.*, 2012; Cancellieri & di Lernia, 2013), and linked to later dispersals often considered to have contributed significantly to the ancestry of contemporary non-African populations (Pickrell & Reich, 2014; Veeramah & Hammer, 2014). In the light of these issues, this paper reviews and synthesises the technological character of the North African MSA over the Middle and Late Pleistocene and considers how such cultural data can shed some light on overarching questions regarding the region's role in modern human origins and dispersals.

Terminology

Material culture in North Africa between ~315-30ka is typically referred to as 'Middle Palaeolithic' (MP) or 'Middle Stone Age' (MSA). These divisions in nomenclature are an outcome of geopolitical and research history, the latter of which viewed North Africa as distinct from sub-Saharan Africa, and placed it on the fringes of the European Upper Palaeolithic (Scerri, 2013a). Historically, lithic industries from North Africa were classified by French scholars as Mousterian, because of the presence of sidescrapers, notched pieces, and the use of Levallois technology. The use of the term Mousterian in the North African context prevails until the present day (see discussion in Dibble *et al.*, 2013). Other scholars have stressed that the use of largely European terminology is not appropriate in African contexts (see Kleindieinst, 2006), as it creates artificial divisions within African industries, most of which are termed as MSA (e.g. Garcea, 2004, 2012). In reality, large regions of North Africa form part of a biogeographic zone that spans Africa and Eurasia (see Holt *et al.*, 2013; Groucutt & Blinkhorn, 2013), which calls such heuristic divisions into question, as shall be seen. With these historical and biogeographical caveats in mind, we use the term MSA for the sake of convention.

Conversely, we limit references to named stone tool industries and instead focus on describing lithic variation itself. There is an array of different nomenclatures referring to assemblages or assemblage groups in the North African MSA that is primarily the result of the research history behind these divisions. While the specifics of this history and the industry names and referents are discussed elsewhere (Scerri, 2013, 2017, respectively), the key point is that many of these stone tool assemblages and industrial entities lack consistent or coherent definition, critical assessment and/or quantitative comparison. For these reasons, it is more instructive to focus on descriptions of variation, which can sometimes be obfuscated by the use of such terms (see also Appendix for summary). For the sake of clarity, the below Table 1 lists industrial terms associated with the North African MSA that are addressed in this paper.

Beginnings: The early MSA in North Africa

The earliest MSA in the North African Middle Pleistocene is currently documented in the northwest, dating to ~315ka at Jebel Irhoud in Morocco (Richter *et al.*, 2017) and ~250ka at the Benzu Rockshelter in Ceuta (Ramos *et al.*, 2008). Uncertainty in dating currently means that it is difficult to evaluate the degree, if any, of overlap between the Early Stone Age (ESA) and MSA in this region. However, the production of small Levallois flakes alongside handaxes in Casablanca has been interpreted as supporting a local Earlier to Middle Stone Age transition (e.g., Raynal & Ochietti, 2012), matching

Tab. 1 - Industry names proposed for and associated with the North African MSA, together with descriptions, as well as other 'Upper Palaeolithic' industries mentioned in the text.

INDUSTRY NAME	DESCRIPTION
Aterian	Typically described as a 'Mousterian' with tanged tools, bifacial foliates and Levallois and dated to between ~145-30ka. Distribution roughly corresponds with North Africa from the Nile westwards.
Dabban	'Upper Paleolithic' industry with blades, chamfered blades, endscrapers and burins described at Haua Fteah and Hagfet ed Dabba in Cyrenaica, Libya. Dated to between ~45-15ka.
Denticulate Mousterian	'Mousterian' industry with high indices of denticulates described in the Western Desert region. Undated.
Emiran	'Upper Paleolithic' tools made on volumetric blade cores and Levallois cores, ventrally and basally thinned 'Emireh' points found in the Levant from around ~47ka and proposed as possibly present in northeast Africa in the form of Emiran points.
Generalized MSA	Levallois or discoidal technology with generic retouched tools (e.g. scrapers, denticulates) found across North Africa and largely undated.
Khargan	Small Levallois and discoidal cores, flakes with high levels of steep, marginal retouch, non-geometric microliths. Distribution is within the Western Desert, undated but unlikely to be older than MIS 4.
Khormusan	Recurrent centripetal and preferential Levallois, small bladelets from single platform cores, denticulates, burins, use of diverse raw materials. Found in Egypt and Sudan, mostly on the eastern Nile. Dating uncertain, but possibly around late MIS 5 and MIS 4.
Levalloiso-Mousterian	Term referring to MSA layers dating to between ~75-65ka at the site of Haua Fteah.
Lupemban	Bifacially flaked lanceolate points, core axes, backed blades generally associated with Central Africa. Poorly dated.
Mousterian	Classic Levallois and discoidal technology, side retouched pieces, retouched points, denticulates and notches. Assemblages found across North Africa. Dated to between ~250-30ka with the youngest and oldest dates coming from the Maghreb region.
Nubian Complex	Prominent use of Nubian Levallois reduction, thinned tip points, truncated-facetted pieces and other tool types. Argued to be particularly prominent in northeast Africa, in MIS 5.
Nubian Middle Paleolithic	Nubian Levallois cores, bifacial foliates, high Levallois index, bifaces and abundant side scrapers, low index of 'Upper Paleolithic' types. Undated and found in Egypt and Sudan.
Nubian Mousterian (Type A and Type B)	Low Levallois (incl. Nubian) and blade indices, discoidal cores, near equivalent proportions of 'Middle' and 'Upper Paleolithic' types. Type A has no bifaces, Type B includes bifaces. Undated. Generally found close to the Nile.
Pre-Aurignacian	Discoidal and classic Levallois cores. Side-scrapers and 'Mousterian points', with some notched forms and rarer blades from a small number of blade cores. Found at Haua Fteah in Cyrenaica and likely to date to within MIS 5.
Safahan	Flakes and blades from single platform cores and production of thin Levallois flakes. Found in Egypt and dating to around ~62ka.
Sangoan	Post-Acheulean industry featuring core axes, picks, flakes, and large planes. Associated with Equatorial and southeastern Africa. Dating uncertain.
Sbaikhian	Thick bifacial foliates, core axes. Undated and reported in Algeria.
Taramsan	Blade production from an adapted Levallois system. Argued to represent a transitional industry in Egypt between ~50-45ka.

patterns seen elsewhere in the continent (see Scerri, 2017; e.g. Tryon & McBrearty, 2002; Barham *et al.*, 2015). Similar but undated assemblages have been reported from surface sites in the Sahara, sometimes described following a French *facies* classification, as 'Mousterian of Acheulean tradition' (Antoine, 1939; Aumassip, 2004), where the bifaces are supposed to be directly derived from the Acheulean. Others have also proposed an occupational hiatus between the late Acheulean and the early MSA, suggestive of a repopulation event resulting from climatic amelioration (Aumassip, 2004). The MIS 8 dates from Jebel Irhoud cast doubt on the latter hypothesis, at least into the Maghreb, although it should be noted that the localised climate record is not sufficiently well understood to rule out dispersals during generally glacial/arid periods.

This early northwest African MSA is frequently described as 'Mousterian' (Tab. 1). At Jebel Irhoud the MSA is described as being characterised by a highly retouched assemblage, consists of Levallois technology with points obtained through retouch (i.e. 'Mousterian points'), plentiful side and end retouched pieces ('scrapers') and denticulates made mainly using local raw materials (chert, quartzite and quartz) (Richter *et al.*, 2017) (Fig. 2a-e, Appendix). In contrast, there is little debitage, problematizing the identification of particular reduction methods and the extent of their use. At the very least, both preferential and recurrent Levallois methods have been identified, together with non-specific blanks. The low numbers of cores suggest that knapping largely occurred off site (Hublin *et al.*, 1987; Hublin *et al.*, 2017). At Benzu cave, the raw material used is predominantly local and unretouched lithics prevail over retouched tools, suggesting on site core reduction. Sandstones and radiolarites, as well as lower amounts of chert, were used to make mostly small flakes, abundant scrapers, notches, denticulates and retouched points, often made using Levallois reduction methods (Ramos-Muñoz *et al.*, 2016) (Fig. 2f-i). Use-wear analyses are argued to suggest that woodworking was carried out with scrapers, but that unretouched tools were used on soft tissues (Ramos-Muñoz *et al.*, 2016). The technological descriptions are indicative of similarities between Jebel Irhoud and Benzu Cave, particularly when accounting for sampling differences. Apparently similar, undated assemblages typically described as 'Classic Mousterian' are found in the northern Sahara to the Western Desert of Egypt, as well as non-desert hinterland regions (Aumassip, 2004). The paucity of sites dated to the early MSA therefore probably reflects a lack of research rather than the absolute rarity of these sites. However, an apparent lack of differences between Mousterian assemblages of all ages in North Africa also makes it difficult to make chronological assumptions based on technological similarities.

In the later Middle Pleistocene, MSA assemblages are found at Ifri n'Ammar in Morocco, in layers dating to ~171ka, and again at Benzu Cave in layers dating to ~173ka (Fig. 2j-l). While Benzu 3b is reported to be similar to preceding layers (Ramos-Muñoz *et al.*, 2016), there are some differences at Ifri n'Ammar. Here, the assemblage also features high levels of scrapers, denticulates and notched pieces. However, there are also relatively high numbers of unretouched blades, compared to the apparent focus on production of pointed tools and flakes at Jebel Irhoud and Benzu. At Ifri n'Ammar, the Levallois method is also uncommon, although it includes preferential and recurrent cores and Levallois flakes, points and blades (Nami & Moser, 2010; Richter *et al.*, 2010). Raw materials are varied throughout the sequence and include flint, chert, chalcedony, quartzite and basalt. While some of the raw materials are local (~20km or less), others come from the Ain Zohra hills, some 50km to the west (Nami & Moser, 2010). It is likely that at least some of these differences are the result of chronological gaps between the ages of these sites, as well as the function of the sites themselves (i.e., hunting stands, residential sites, etc.).

In the absence of further later dated Middle Pleistocene sequences from this region, it is difficult to draw any firm conclusions on the basis of observed variation. However, significant similarities between the early MSA in northwest

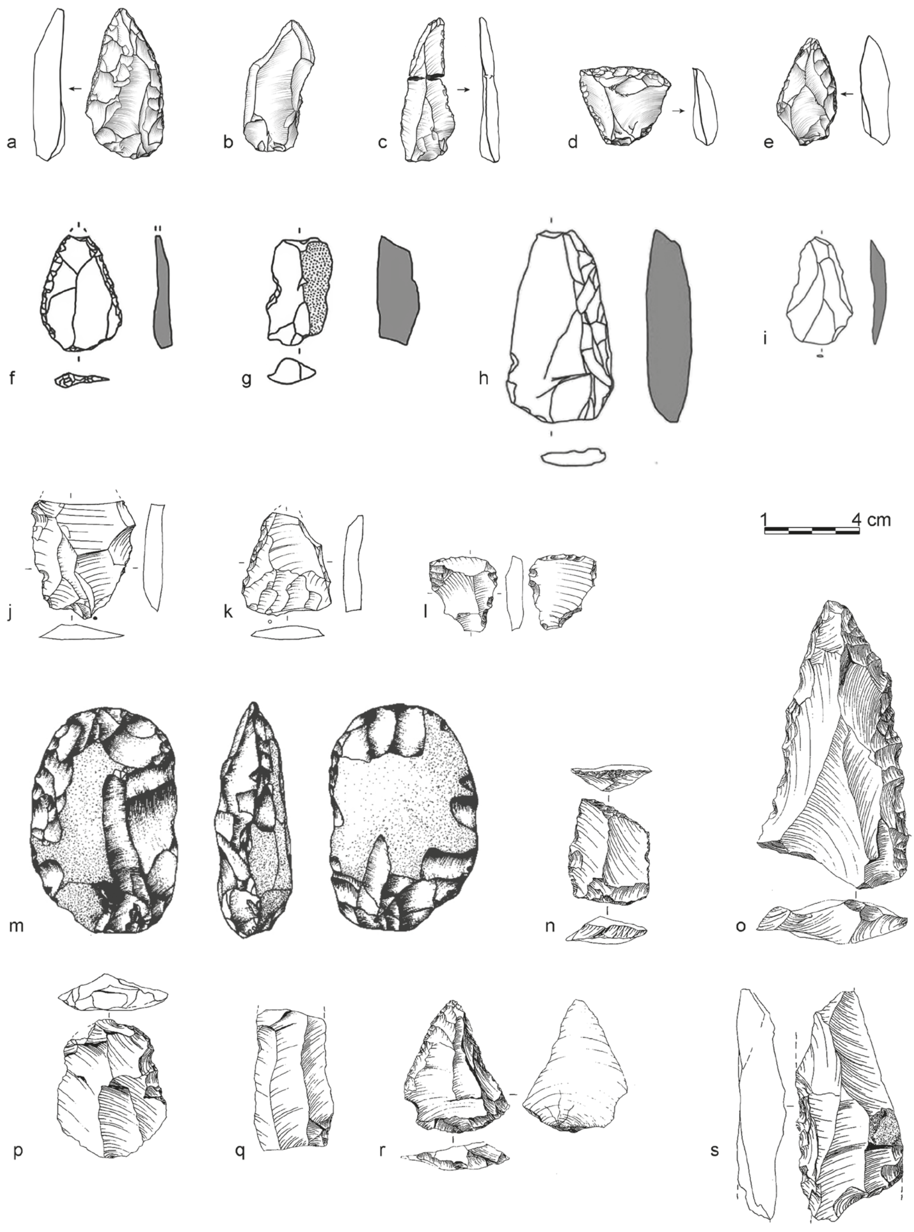

Fig. 2 - Early MSA lithics. a: convergent scraper; b-c: Levallois flakes; d: déjété scraper; e: retouched point; f: convergent scraper or retouched point; g: notch; h-j: Levallois flakes; k-l: retouched Levallois flakes; m: core axe from Sai Island; n: truncated piece; o: retouched point; p: endscraper; q: Levallois blade; r: Mousterian point; s: side scraper with denticulate retouch; (a-e: ~300ka, Jebel Irhoud, from Richter **et al.*****, 2017; f-i: ~250ka, Benzu Cave, from Ramos-Munoz*** **et al.*****, 2016; j-l: ~171ka, Ifri n'Ammar, from Nami & Moser, 2010; m: ~220, Sai Island, from Van Peer et al., 2004; n-s: ~175ka, Sand Pan sites at Bir Tarfawi, from Wendorf*** **et al.*****, 1993).***

Africa and the European Mousterian have been suggested for some time (e.g., Hublin *et al.*, 1987; Aumassip, 2004). Some researchers have suggested that it seems unlikely that such apparently wide-ranging similarities are purely convergent, leading to questions concerning connections across the Straits of Gibraltar (Ramos *et al.*, 2008). However, without detailed, quantified comparisons between these regions, such claims are speculative. It should be noted that broad similarities in the generic components of Middle Palaeolithic assemblages across vast distances Eurasia are also apparent. The Middle Stone Age and Mousterian/Middle Palaeolithic are also in many senses synonymous, and there is considerable variability within each of these entities. Arguably, the apparent similarities are more likely to reflect comparable lifeways than cultural contact, given the distances, topographic barriers and ecological diversity of the continent. In addition to this, there is no evidence for the long distance transport (i.e., over 50km) of raw materials in the early MSA of North Africa.

The clearest indication of technological change within the early MSA in northwest Africa comes with the appearance of the Aterian technocomplex (see Table 1 and below) at Ifri n'Ammar, which at ~145ka preserves the only known Aterian site to date to within MIS 6, although dating results are scattered and errors are large (Richter *et al.*, 2010). The early presence of Aterian tanged tools may either suggest a dispersal of new populations into the region, or the local development of stone tool technology by existing populations, which has been suggested based on other Aterian sites in Morocco (Mercier *et al.*, 2007). This latter hypothesis is supported by evidence for periodic relatively 'wet' episodes in MIS 6 (Drake *et al.*, 2013) and would fit with a certain degree of technological continuity at Ifri n'Ammar, where the lithics from the two different units excavated at the site apparently differ only in terms of the presence/absence of tanged tools (Richter *et al.*, 2010). This is further discussed in the section on the mid-MSA.

In northeast Africa, the early MSA appears to be located close to the Nile, although this may also be an outcome of where research has been conducted. Saï8-B-11 appears to document the appearance of the MSA from ~220ka, although it is interstratified with Acheulean material indicating an overlap between the ESA and the MSA (Van Peer *et al.*, 2003). The Lower MSA assemblages from the site are characterised by local quartz flakes from discoidal and multiplatform cores, low numbers of Levallois cores, abundant (around 56) core axes (thick bifaces, blunted on the distal end, see Figure 2m), rare foliates and blades (just one in each case in this layer), hammerstones and grinding stones (Van Peer *et al.*, 2003). Early MSA sites featuring these technological elements are also found at other Middle Nile Valley sites such as Khor Abu Anga (Arkell, 1949) Arkin 8 (Chmielewski, 1968) and Al Jamrab (Spinapolice *et al.*, 2018). Al Jamrab presents two different human occupations. The lower occupation is characterised by bifacial production, and the upper occupation can be described as a MSA with preferential and current Levallois methods and thin, finely made cordiform handaxes. In both layers, local raw materials predominate. An early MSA dating to ~230 ka has also been documented at the Bir Tarfawi and Bir Sahara palaeolakes in southwestern Egypt, where there is a late persistence of the Acheulean (Wendorf & Schild, 1992; Wendorf *et al.*, 1994). These early sites appear to be defined primarily by an extremely low Levallois index and discoidal debitage strategies in combination with façonnage technology in the form of core-axes (Fig. 2n-s). At a few stratified sites (e.g. Saï 8-B-11) the introduction of blade production systems is observed in later assemblages, in association with very small numbers of large, thin symmetrical foliates or lanceolates. Similarly, at Dakleh Oasis, MSA levels have been dated to 220±20 ka (Kleindienst *et al.*, 1999) and are characterised by the exploitation of a variety of raw materials, including Tarawan chert, grey to brown quartzites and chalcedony (Hawkins & Kleindienst, 2002).

These northeast African assemblages have frequently been referred to as 'Sangoan' and even 'Lupemban' for the upper MSA units at

Saï, on the basis of the presence of core axes and bifacial foliates (one in the Lower MSA layer and one in the Upper MSA layer) (Van Peer *et al.*, 2003). However, it is advisable to be circumspect with the use of these terms. Core axes and foliates represent a huge and varied taxonomic category over enormous territories of Africa and cannot be assumed to represent cultural links without significant comparative study (Cornelissen, 1995). Furthermore, the Sangoan and Lupemban themselves remain poorly understood (e.g. Taylor, 2016), yet most of the elements thought to be representative of these industries, such as picks, backed flakes and significant numbers of blades, are absent in North Africa. There is also some evidence that characterizations of the northeast African early MSA as having a limited use of the Levallois method may be an outcome of sampling from a very small number of sites. For example, at Kharga Oasis, preferential and recurrent Levallois cores similar to those reported in northwest Africa have been documented and chronometrically dated to ~230ka (Hawkins *et al.*, 2001). It is possible that other similar undated assemblages are of the same age, and erroneously assumed to be younger on the basis of typology, however further dated information for the early MSA timeframe is lacking. At Haua Fteah, the lowest occupation has now been dated to MIS 6 (~150ka, Jacobs *et al.*, 2017), and is associated with animal bones and teeth, shell fragments, charcoal. However, the small quantities of lithic debitage recovered is too fragmented for designation to any particular technological strategy (Rabett *et al.*, 2013).

In central North Africa, MSA type lithic technology is dominated by largely undated and undiagnostic Levallois technology with little or no retouched artefacts. It seems probable that some of these assemblages may date to the Middle Pleistocene. However, the expanse of the Sahara, its difficult working conditions and geo-political problems mean that a detailed chronological assessment of MSA stone tools in the region is currently hard to envisage (See section on undated occurrences).

North Africa during MIS 5 (~130-70ka)

Sites appear to increase in frequency with the beginning of the Last Interglacial (~130ka), although the degree to which this expansion had parallels with the previous MIS 7 interglacial, is not known. The lithic technologies associated with MIS 5 sites in North Africa are markedly more varied, compared with the assemblages of the earlier MSA. 'Mousterian' industries do not cease with MIS 5, but either continue alongside others, or change to include new, derived characteristics. There are also examples of dramatically increased transport distances of both raw materials and other objects, such as shells (d'Errico *et al.*, 2009). Variation among MIS 5 assemblages have resulted in a number of different industrial nomenclatures. We describe their referents critically, in turn.

The Mousterian

In the Maghreb region, assemblages described as 'Mousterian' persist into MIS 5 and beyond. Such MIS 5 assemblages have been described as featuring Levallois and discoidal-based technology, with numerous 'side and endscrapers', together with a lesser number of retouched ('Mousterian') points, denticulates, truncated and naturally backed pieces and rarer burins. For example, they are present at Contrebandiers on the Atlantic coast of Morocco and Taforalt and Rhafas caves in the Moroccan Rif, Benzu Cave in Ceuta, Retaimia and Cap Ténès in Algeria, and Sidi Mansur, El Guettar, and Oued El Akarit in Tunisia (Camps, 1974). Similar, but undated assemblages have been identified in the "Bas Sahara" region, which comprises the northern band of the Sahara Desert (Aumassip, 1979). A direct link has also been drawn between these sites (particularly El Guettar) and French Mousterian sites, giving an attribution to "La Ferassie Mousterian", for the presence of Levallois technology with blades and points, together with sidescrapers (Camps, 1974).

Most of these 'Mousterian type' industries are perceived to be broadly limited to the Maghreb. However, at Haua Fteah, a site located in Cyrenaica, Libya, MSA industries made from local raw material are evident under another name. The 'Pre-Aurignacian' and 'Levalloiso-Mousterian' (see Table 1) are characterised by discoidal cores, a high percentage of faceting and Levallois flakes struck from small radially-prepared Levallois cores (Reynolds, 2013). Blade forms are, by contrast, rare although a small number of blade cores are present. Formal tools are mostly described as side-scrapers and Mousterian points, with some notched forms (McBurney, 1967). Over time, there appear to be differences in core reduction methods (e.g. core scar patterns and an increase in the use and diversity of Levallois reduction, see Jones, 2016). Burins and resharpening through burination is particularly distinctive and prominent at the site (Reynolds, 2013). These assemblages appear at least from MIS 6 and continue until ~43.5ka when blade-based, non-MSA industries emerge (Douka *et al.*, 2013). Several studies have also identified distinctive features (e.g. resharpening by burination) over the MSA sequence at Haua Fteah (Moyer, 2003; Reynolds, 2013; Scerri, 2013a), perhaps as a result of the Gulf of Sirte, which is a natural biogeographic barrier.

In the Sahara, assemblages with Levallois debitage (and sometimes without) but few or no retouched tools are typically associated with the MSA in the place of a 'Mousterian'. At the Libyan site of Uan Afuda, a layer featuring some Levallois technology and a generic MSA toolkit (see Table 1) has been dated by thermoluminescence (TL) and OSL to between ~90 and 69 ka (Cremaschi *et al.*, 1998; di Lernia, 1999). The human occupation of the shelter during the Late Pleistocene was not intense, and has been attributed to the Aterian on the basis of the comparison with the nearby shelter of Uan Tabu, where complete Levallois and non-Levallois reduction sequences have been described (see below). By extension, similar assemblages in the Sahara, principally in the Messak and the Fezzan, are thought to represent an early stage of the MSA (Cancellieri & di Lernia, 2013; Foley *et al.*, 2013), but the lack of a chronological context for those sites does not permit any certain attributions.

A 'Mousterian type' industry using local raw materials is also well described at Adrar Bous in Niger (Clark, 1982). While undated, these assemblages overlie the Acheulean and underlie the Aterian (see below). They are described as featuring side scrapers, notched and denticulate forms with a Levallois debitage. The association between the stratified 'Mousterian/Middle Palaeolithic' assemblages from Adrar Bous and the lake suggests they correlate with a period of significantly increased humidity such as MIS 5e or MIS 7.

Further east in the deserts of Egypt, various Levallois and 'Mousterian-based' assemblages have been described as 'Nubian Mousterian' and 'Nubian Middle Palaeolithic' (Marks, 1968a). The 'Nubian Mousterian' was distinguished by the presence of Nubian cores, a method of Levallois point production by the creation of a distinctively steep median-distal ridge. In addition to Nubian Levallois methods, Marks (1968a) also identified a further Levallois method which he terms 'para Levallois' in which a platform and subsequent removal was created laterally to the long axis of the core. Wendorf and colleagues (1993) also noted many assemblages characterised by denticulate retouch and it is clear that many of these assemblages are not associated with Nubian cores. Indeed, Wendorf and colleagues (1993) instead cite the frequency of denticulate retouch as a specifically northeast African MSA feature, likely to correlate with a greater emphasis on specific tasks, for example woodworking or plant processing. It also seems possible that finer retouch was limited by the poor quality of the raw material in this region. At Bir Sahara and Bir Tarfawi in the Western Desert, MSA assemblages described as including centripetal Levallois cores, endscrapers and sidescrapers have been dated to ~105 and ~114ka (Wendorf *et al.*, 1993). Further east, Sodmein Cave in the Red Sea Mountains has yielded assemblages dating to ~119ka (Mercier *et al.*, 1999), apparently characterised by Levallois technology, denticulates, burins and blades (Vermeersch *et al.*, 1994). However, very little has been published on these assemblages. There is currently no published evidence of long distance transport within the dated examples of these assemblages.

The Aterian

While retaining what is described as a 'Mousterian sub-stratum', other assemblages feature additional componentsthat distinguish such assemblages from the more generalised MSA (Tab. 1). The 'Aterian' is synonymous with assemblages containing tanged or pedunculated tools and is named after the site of Bir el-Ater in Algeria (see Scerri, 2013a for a history of discovery).

Tanged tool assemblages have a broad distribution in North Africa, from the northwestern seaboard to the Western Desert of Egypt, with a southerly extent seemingly corresponding with the edges of the Sahara. The temporal range of the Aterian is also expansive, commencing from ~130ka (and possibly earlier at Ifri n'Ammar, see Figure 3) to about ~30ka. Unsurprisingly perhaps, the Aterian has proved difficult to define. Too few sites across the temporal and spatial range of the Aterian have been dated, and stratified sites are a minority compared to the large number of surface, undated collections. For these reasons, it is difficult to identify the factors driving the high degree of spatial variability seen among Aterian assemblages.

Tanged tools vary both within and between assemblages. Although tang form is remarkably consistent, the tool component ranges in size and in type (Scerri *et al.*, 2013b). The numbers of tanged tools also vary considerably in the assemblages, with frequencies seldom exceeding 10% of the tool-kit, although the percentages reported from surface collections tend to be higher because of selective sampling (Tomasso & Rots, 2017). The presence of the tangs has been automatically linked with hafting. However, less is known about the different functional aspects of the tanged tools. Some scholars have cast doubts on the exclusive hafting function of the tangs (e.g. Garcea, 2012), suggesting that tangs had uses as notches (Falzetti *et al.*, 2017). In at least some cases, differences appear to have been the product of resharpening, problematizing extensive categories of tanged tool types (Iovita, 2011).

With such ubiquity and apparent homogeneity among the tanged component of these assemblages, attention has been given to other distinguishing lithic features in the attempt to understand the spatial variation of the Aterian. In northwest Africa, such distinguishing features include small (i.e. 5-7cm long on average) bifacial foliates, and 'Y' shaped tools within an otherwise typically 'Mousterian' assemblage (Dibble *et al.*, 2013), however they are by no means always present. A number of (Bordesian) typological studies in the Maghreb (Morocco in particular) have asserted that there is no difference between 'Mousterian' and 'Aterian' assemblages, apart from the presence of tanged tools (e.g. Nami & Moser, 2010; Dibble *et al.*, 2013).

In the central Sahara, Y shaped tools are also present in many surface contexts (e.g. Aumassip, 2001; see also Scerri, 2013 and Scerri *et al.*, 2014a). At Uan Tabu in Libya, one of very few stratified Aterian sites in the Sahara, tanged tools in the upper part of the sequence were found with Levallois (recurrent and preferential, including Nubian Levallois) and blade production as well as generic MSA implements (Garcea, 2001). These levels have been OSL dated to 61±10ka. Adrar Bous, in Niger is not chronometrically dated, but is associated with a large palaeolake requiring the levels of rainfall associated with interglacials such as MIS 5e. The site features a number of buried Aterian assemblages containing Y shaped tools, small bifacial foliates and larger lanceolates. A critical feature at this site is the presence of tanged and other associated tools made from a green silicified tuff originating up to 200km away – the longest transport distance record for any North African MSA site (Clark, 2008). In the use of diverse raw materials, long distance transport and variety of different types, the Aterian at this site is markedly different from the preceding 'Mousterian', suggesting that patterns seen in Morocco cannot be generalized to other regions of North Africa. At Seggedim, buried bifacial foliates were also tanged (Tillet, 1983). Crescent tools are also present in many Aterian sites, especially in the Sahara, (Hassi M'Rara, Tarbend, Ouagla) (Camps, 1974). To the east, so called 'Upper Palaeolithic' tool types are recorded, 'Y' shaped tools are absent and the foliates in Aterian assemblages are rarer and much larger (see Scerri, 2013a,b; Scerri *et al.*, 2014a).

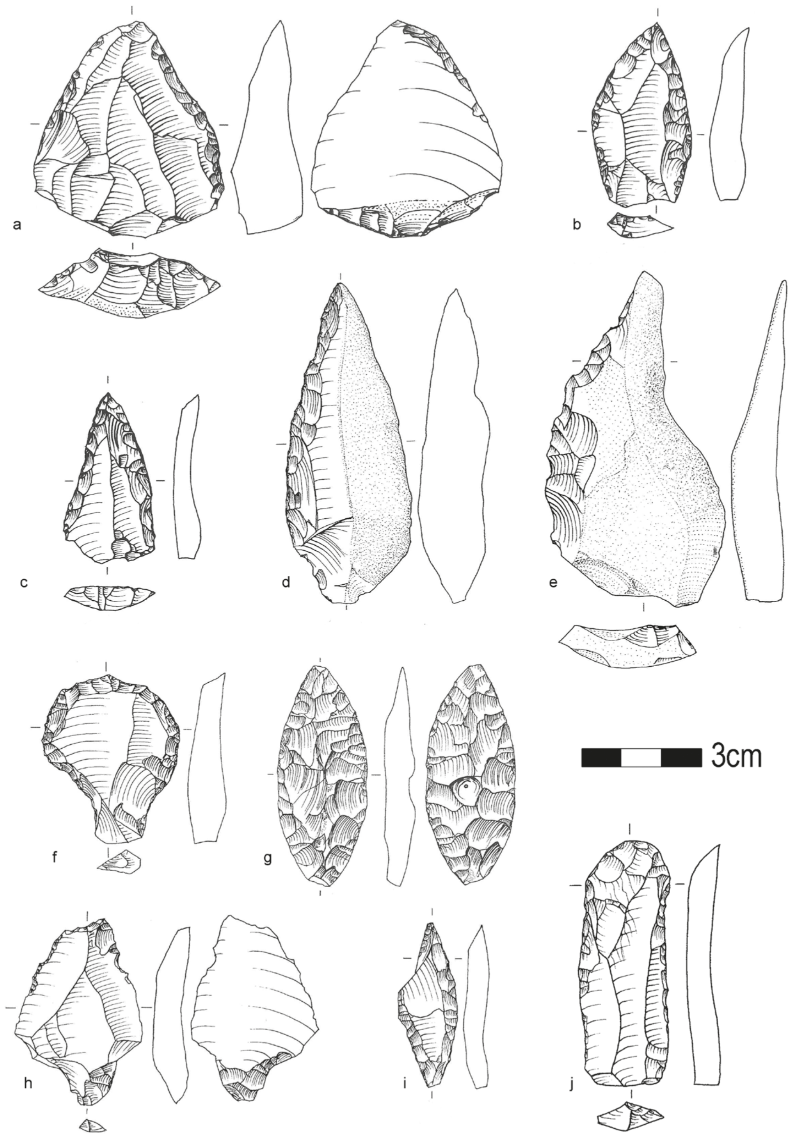

Fig. 3 - Artefacts from Ifri n'Ammar TTA, Upper OS (~83ka); a: convergent scraper; b: Mousterian point; c: elongated Mousterian point; d: elongated convergent scraper; e: denticulate; f: tanged end-scraper; g: bifacial foliate; h: tanged retouched triangular flake; i: 'piercer'; j: endscraper on blade. From Nami & Moser, 2010.

More general components of Aterian assemblages are indeed often shared with MSA assemblages from sub-Saharan Africa. Common elements, such as bifacial retouching and basal thinning, are also found, differentially, throughout Africa during the MSA, as are foliates (McBrearty & Brooks, 2000) that are more similar to those found in the Fauresmith than they are to bifacial tools of the MAT (Camps, 1974). Small Levallois cores have also been noted in MSA contexts without tanged tools in North Africa (e.g. Sidi Saïd, Oued el Akarit, general surface sites from the southern Sahara, see Camps, 1974). It is unclear whether such small sizes are always a function of reduction intensity, or whether such cores were sometimes being used as tools for specific tasks. A micro-Levallois is well attested in many African MSA contexts, where the production of very small Levallois flakes (<2.5cm) is not strictly linked with raw material availability (e.g. at Porc Épic, and at Gademotta see Douze, 2012).

In terms of the stratigraphic and chronological relationship of the Aterian with the MP/MSA, when sequences are available, the Aterian is systematically younger than any "Mousterian" or MSA level, such as in Taforalt and Rhafas (Morocco), Tit Mellil (Sahara), and immediately capped by the Iberomaurusian. The 'Mousterian' has also been found underlying the Aterian in the Sahara, at Adrar Bous (Clark, 2008). In the Jebel Gharbi, the Aterian is stratigraphically separated from the early MSA, as at Wadi Ghan, where lava flows including early MSA artefacts lie below the deposit with Aterian artefacts (Garcea & Giraudi, 2006; Garcea, 2010). However, taking into account only well dated and stratified sites in Morocco (Dibble *et al.*, 2013), Mousterian/MSA layers and Aterian are broadly contemporaneous, with an overlapping chronology and evidence of interstratification.

Making sense of this spatial and temporal variability is to some extent problematized by the use of the term 'Aterian', which suggests that all such tanged tool assemblages are part of a coherent whole that persists across vast areas and timescales. It is certainly true that this form of socket hafting seems to have been remarkably successful and appears to be highly spatially and temporally standardised. However, quantified studies of whole assemblages in fact found that distance and the palaeohydrology of MIS 5e North Africa best predicted technological similarities and differences (Tab. 2) (Scerri, 2013a; Scerri *et al.*, 2014a). Conversely industrial nomenclatures such as 'the Aterian' or 'Nubian Complex' (see Table 1 and below) did not stand up to scrutiny as predictors of variation. We therefore use the term tanged tool assemblages (henceforth TTAs) in order to describe the variability and extent of Aterian assemblages in order to limit suggestions inherent in the name 'Aterian' that tanged tool assemblages in their completeness represent a distinct monolithic tradition from their contemporary non-tanged tool assemblages in North Africa. However, we recognise that TTAs are still a key distinguishing feature of the North African MSA and therefore phylogenetically meaningful.

What seems clear is that any attempt to define the Aterian across the whole of North Africa will be futile. There are of course commonalities. Tixier's (1967) description of the Aterian as a Levallois based technocomplex, often featuring blades and with a high proportion of sidescrapers and ubiquitous tanged tools is largely correct. The full suite of Levallois reduction methods is also variously found across different Aterian assemblages, as is common in different MSA assemblages across Africa. These include centripetal preferential, unidirectional convergent, Nubian (see Guichard & Guichard, 1965; Usik *et al.*, 2013) and recurrent centripetal methods. However, there is a significant amount of spatially variability across North Africa.

Given that the limited number of well dated deep sequences have so far not yielded any significant temporal differences in Aterian assemblages within specific areas, it seems probable that variation among TTAs cannot be understood outside of their geographic context. TTAs do not significantly extend into the Sahel, if at all, and current data indicates a lack of substantive links between West Africa and northwest Africa. However, this is maybe the result of the scarcity of archaeological investigations in the Sahel. Tanged tools recovered from Tiemassass in Senegal are undated and found in a mixed context and may date to a Terminal Pleistocene or Holocene time period (Niang & Ndiaye, 2016). An early report of a TTA described as 'Aterian' in Arabia is untenable (see Scerri, 2012) and is a likely representation of tanged Holocene implements known as Fasad

Tab. 2 - Regional differences among tanged tool assemblages (TTAs).

	NORTHWEST AFRICA	CENTRAL SAHARA	NORTHEAST AFRICA
Tools	Small bifacial foliates Shouldered, tanged and basally thinned tools Core Axes? (Sbaikhian) Small tanged convergent and side retouched flakes	Large bifacial foliates Shouldered, tanged and basally thinned tools Core Axes Denticulates and notches Medium sized tanged flakes with no retouch	Small and large bifacial foliates Shouldered, tanged and basally thinned tools Core Axes Denticulates and notches Very large tanged tools and elongated points Small and thin intensively retouched tanged points
Cores and reduction methods	Nubian Levallois technology decreases towards the Atlantic coast Small Levallois cores Convergent Levallois cores Relatively higher Levallois index to other regions in North Africa	Nubian Levallois technology Small Levallois cores	Nubian Levallois technology Small Levallois cores
Retouch on tool edge	Regular Retouch High levels of retouch intensity Invasive retouch	Resharpening by burination Retouch is not invasive	Invasive retouch
Typical blank shapes	Ovoid flakes	Laminar flakes	Laminar and ovoid flakes

Points. There are no credible reports of MSA TTAs further south than the modern limit of the Sahara, in the Nile Valley and east of it. The only possible exception may be the site of Magendohli in the western side of the Sudanese Nile Valley (Fig. 4). Here, tanged points and scrapers were found in surface and undated buried contexts together with side and endscrapers, burins, notches, denticulates, blades and retouched points (Carlson, 2015). The tanged elements are somewhat crude, as far as can be judged from old photographs, but the assemblage is consistent with other North African TTAs. Beyond Magendohli, the absence of TTAs in the eastern desert seems striking. Suggestions of possible tanged tools from Nile Valley sites and further east at Sodmein Cave (e.g. Rots *et al.*, 2011) do not stand up to scrutiny. A small number of other genuine tanged tools in the Nile Valley are likely to represent washed in artefacts, as they were found on the surface among a number of very different pieces, including Holocene material (Singleton & Close, 1980; pers. obs.). As such, these finds represent minor traces of TTAs reaching the edges of the Nile Valley. Perhaps most strangely, no tanged tools are found at Haua Fteah, the deepest and most complete sequence in northeast Africa. Previous reports of tanged tools from the site are double notched tools or upside down Tayac points (Moyer, 2003), which is not thought to be generally characteristic of finished tanging in the North African MSA. Yet genuinely tanged tools have been found in the landscape close to Haua Fteah (Reynolds, 2013), although the closest known buried TTA site is some 175km away in Hagfet et Tera cave at the western edge of the Jebel Akhdar (McBurney, 1960; McBurney & Hey, 1955). It possible that the surface finds around Haua Fteah are holoports – that is, artefacts transported to an area at a later cultural or chronological stage.

Most TTAs are also made predominantly from local materials (0-25km). Local materials are reported from numerous dated sites across North

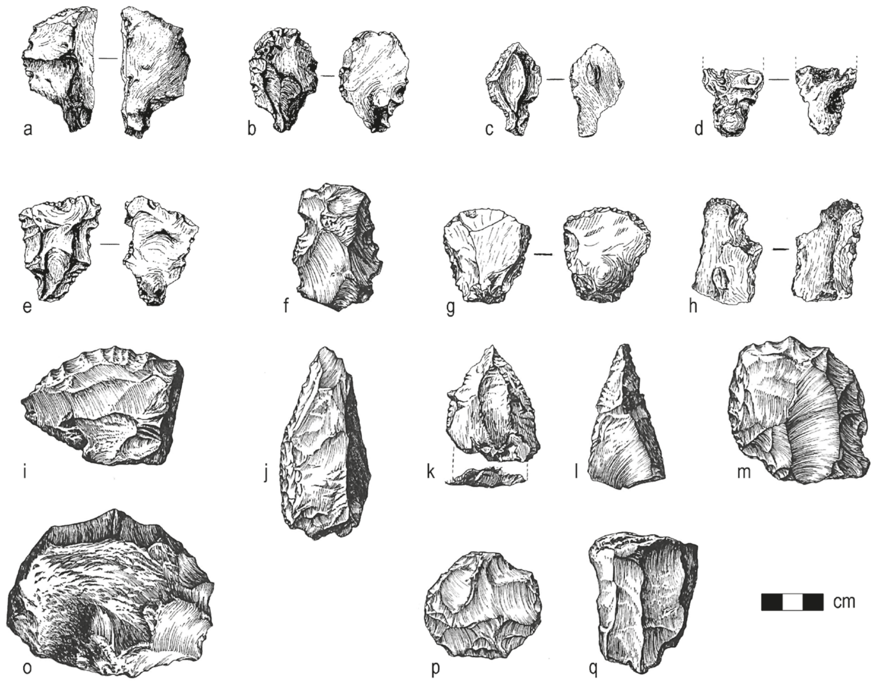

Fig. 4 - Assemblage from Magendohli in the Nile Valley of Sudan. a-b, e: tanged scrapers; c: tanged point; d: broken tanged tool; f: denticulate; g: side scraper; h: nosed scraper; i: transverse scraper; j-k: retouched Levallois points; l: Levallois point; m-o: centripetal preferential Levallois cores; p: recurrent centripetal Levallois core; q: blade core. After Carlson (2015).

Africa, for example at Kharga and Dakhleh Oases in Egypt, Uan Tabu in Libya and Contrebandiers in Morocco. This follows the pattern seen in earlier MSA sites. However, there are also notable exceptions, such as at Adrar Bous where the transport distances of exotic materials extends to 200km. Similar distances have also been noted in the transport of non-lithic material culture in the form of shell 'beads' (d'Errico *et al.*, 2009). This had led some researchers to suggest that local patterns of mobility and populations fragmentation may have been periodically augmented through long distance aggregation events (Clark *et al.*, 2008; Hawkins, 2012). At Adrar Bous, the previous 'Mousterian' occupation of the site is associated with local raw materials and the differences in raw material transport distances and toolkit diversity within the probably later TTAs is striking. The data from this site is among the best evidence that the 'Aterian' may be more than simply a 'Mousterian with tangs', or at least that technological patterns from Morocco cannot be easily extrapolated to the rest of North Africa. There is also some evidence that occupations associated with TTAs show preferences for different raw materials across North Africa, from the Maghreb (e.g. Wengler, 1990) to the Libyan Desert (Hawkins and Kleindienst, 2002). These differences in raw material exploitation fit well with a shift in mobility patterns associated with environmental changes (see e.g. Scerri *et al.*, 2014a). The connections and degrees of continuity between these populations and others in sub-Saharan Africa and the Levant is still a matter of debate.

The origin of TTAs is itself still contested. Historically, TTAs have been connected to the dispersal of sub-Saharan populations into the Sahara and the Maghreb in particular (e.g.

Caton-Thompson, 1952; Hugot, 1967; Camps, 1974 but also Kleindieinst, 2001). An equatorial origin was proposed as early as 1946 by Caton-Thompson on the basis of the presence of large foliates or lanceolates similar to those known from 'Lupemban' assemblages. However, autochthonic origins within the Maghreb have always been posited (Balout, 1955; Camps, 1974; Aumassip, 2001). These opposing views persist to this day. The date of the earliest TTAs in North Africa broadly coincides with the beginnings of the Last Interglacial, and this has been interpreted as being consistent with dispersals from sub-Saharan Africa (Rots *et al.*, 2011; Bouzouggar & Barton, 2012; Hawkins, 2012). A central corridor through the Sahara (Garcea, 2010; Drake *et al.*, 2011) as well as a Nilotic route (Van Peer, 1998), have both been posited as potential way to disperse into North Africa.

However, more recent work sheds some new light on the issue. Firstly, the antiquity and continuity of the MSA in northwest Africa, together with an equally ancient *H. sapiens* presence negates the need for a northwards dispersal of sub-Saharan Africans to explain the appearance of TTAs (Hublin *et al.*, 2017; Richter *et al.*, 2017). Secondly, the oldest TTAs are northwest African (Richter *et al.*, 2010). At sites such as Rhafas Cave in Morocco, there is a gradual increase in the numbers of these tools (Mercier *et al.*, 2007; Doerschner *et al.*, 2016), although they probably post-date the earliest examples from Ifri n'Ammar. Furthermore, there is no chronologically appropriate precedent for these tanged tools anywhere else in the earlier MSA, and certainly not in equatorial Africa (including the 'Lupembo-Tchitolian', see Cornelissen, 2016). Other components of TTAs, such as bifacial foliates (see Figure 5g) are enormously varied in shape, dimension and technology for production. While some may resemble Lupemban lanceolates, without significant chronological and comparative technological studies links between TTAs and the Lupemban are purely speculative. For example, in northwest Africa, a surface assemblage at the Algerian-Tunisian border was collected containing numerous bifacial tools ranging from thick symmetrical forms to bifacial foliates and coined as the 'Sbaikian' (Balout, 1955). Another 'Sbaikian' assemblage comes from Oued Mahrouguet (Anonymous, 1956) and its bifacial tools show very striking morphological and possibly, technical similarities with the core-axes from Saï 8-B-11. Given these data, it is possible that core axes and bifacial lanceolates evolved independently within North Africa. It therefore seems likely that TTAs are a North African phenomenon with a distribution broadly corresponding to the coasts, hinterlands and the Sahara Desert west of the Nile. The distribution and character of TTAs are therefore not easily explained without some degree of population isolation, in direct contrast to models proposing culture contact or migration from sub-Saharan Africa.

The Nubian Complex

The 'Nubian Complex' (see Van Peer, 1998) is a technocomplex that subsumes Marks' (1968a) 'Nubian Middle Palaeolithic' and 'Nubian Mousterian' as temporal variants of the same technocomplex, (Van Peer & Vermeersch, 2000), the Khormusan (see below and Marks, 1968b), and TTAs in northeast Africa (i.e. the 'Eastern Aterian'). It has typically been described as restricted to northeast Africa in three main areas, the Western Desert, the Nile Valley and the Eastern Desert at Sodmein Cave (e.g. Van Peer, 1998). It is said to be primarily distinguished by the presence of high numbers of Nubian Levallois cores and tool types that only occur in assemblages with Nubian cores (see below). More recently, it has been proposed that this alleged technocomplex extends to most of North Africa (Van Peer, 2016). Chronometric dates are available only for a few sites from northeast Africa, such as Taramsa, Bir Sahara, Bir Tarfawi and Sodmein cave, which constrain this techno-complex in at least Egypt from ~240ka to ~50ka. However most of the desert evidence is constrained between ~140ka and ~70ka.

Although descriptions vary, the Nubian Complex is most classically defined as including Nubian Levallois cores (see Van Peer, 1998).

Stone tool types first used to define the Nubian Complex in the literature include large bifacial foliates (Fig. 5g), and so called 'Nubian end-scrapers' (Van Peer, 2016) (Fig. 5d). Guichard & Guichard (1965) seem to have provided the first descriptions of 'rostro-carinated scrapers' that were subsequently termed 'Nubian end-scrapers' by Van Peer (see Figure 18 in Guichard & Guichard, 1965). These same artefacts are described more simply as endscrapers with 'simple unilateral retouch' in Wendorf and colleagues (1993, see Figure 22.20f, reproduced by Van Peer (2016) Figure 8.2:6 and described as a Nubian Endscraper, shown here in Figure 5d). As far as can be judged from the drawings, these endscrapers seem to feature thick, bladelet-like removals from the distal end, but grade into more typical and carinated endscrapers. The Nubian Complex is also described as including other specifically named types such as Nazlet Khater points (thinned tip points) and truncated-faceted pieces (i.e. a core on flake with a truncation on one or more margins which serve as a platform for the removal of small flakes, see Dibble & McPherron, 2007) (Van Peer, 1998).

Descriptions of the Nubian Complex using these types were later revised to include 'Mousterian points', significant proportions of side scrapers and denticulates, and 'Upper Palaeolithic types' (Van Peer & Vermeersch, 2000), a grouping typically including burins, endscrapers and 'piercers'. Notably, Mousterian points, high numbers of scrapers, denticulates and 'Upper Palaeolithic types' fit assemblages from a range of sites across the region (e.g. Haua Fteah). Truncated-faceted pieces are also common and undiagnostic of an archaeological culture as opposed to a raw material economy, and are largely found beyond Africa as well (e.g., referred to as Nahr Ibrahim cores in the Levant, and in the European Mousterian, see Dibble & McPherron, 2007). Moreover, patterns of attribute sharing appear to be more complex than simply reflecting the presence of absence of particular types. As a result, the Nubian Complex is a contested technological entity (see e.g. Schild, 1998; Kleindienst, 2001, 2006; Scerri, 2013a).

The Nubian complex has been associated with *Homo sapiens*, and the technological system has been characterised as relying on Nubian points with hunting purposes (Van Peer, 1998) in a radiating/logistic settlement system, with quarries and hunting stations (Van Peer, 2001; Vermeersh, 2001). However, it has been more recently suggested that this reliance on points has been overemphasised, because of the paucity of point transport, and the overall scarcity of tools, and the lack of evidence of specialised camps may indicate a highly mobile circulating settlement system (Olszewski *et al.*, 2010). Furthermore, the link between Nubian cores and point production remains unclear, because not all of the production results in both Levallois flakes and points; Levallois points are in fact relatively rare in the assemblages (see also Chiotti *et al.*, 2013), although they could have been transported away from site. In any case, it is difficult to evaluate the role of points in the overall system, since they are scarce in the currently documented archaeological record of this area.

Nubian Levallois methods are typically not the predominant reduction method at purported Nubian Complex sites (see Goder-Goldberger, 2016). Nubian Levallois methods (which should be differentiated from the Nubian Complex) in TTAs are apparently rare at Dakhleh Oasis (Kleindienst, 2003) and at Kharga Oasis, Nubian cores appear in the 'Upper Levalloisian' and 'Khargan' industries (McDonald *et al.*, 2016) (see Table 1) as well as in conjunction with TTAs, and in MSA contexts in the Sinai (Schild, 1998). Thinned tip points, so called 'Nazlet Khater Points' are however also found in TTAs right into the Sahara but are found most commonly in the Nile Valley (Vermeersch, 2001) where tanged tools have no significant presence. Nazlet Khater points are, however, rare in all settings.

Nubian Levallois cores have also been reported in Mauritania (Pasty, 1997), East Africa, as far south as Kenya (Clark, 1954; Kurashina, 1978; Clark, 1988; Tryon *et al.*, 2012; Mussi *et al.*, 2014; Douze & Delagnes, 2016), South Africa (Will *et al.*, 2015), the Arabian Peninsula (Rose *et al.*, 2011), the Levant (Goder-Goldberger, 2016), and India (Blinkhorn *et al.*, 2013).

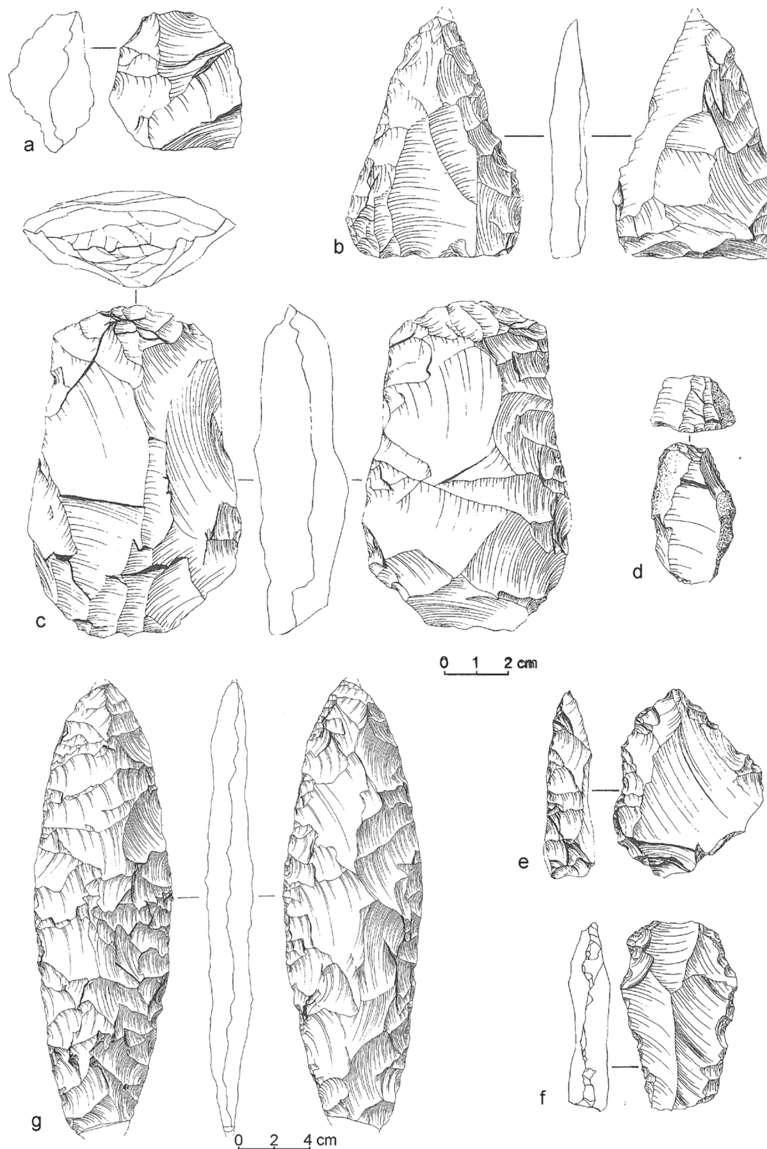

Fig. 5 - Artefacts from BT-14; a: discoidal core; b: probable retouched point made on a recycled core, described as a 'bifacial foliate' in Wendorf* et al.*, 1993; c: Levallois core; d: 'Nubian' endscraper; e: sidescraper; denticulate; f: bifacial foliate (note different scale). Artefacts a-e originate from main excavations dating to Grey Phase 1 (~130ka); Artefact f originates from Area N in Grey Phase III deposits (~96ka). Illustrations reproduced from Wendorf* et al.*, 1993.

Whether any specific cultural meaning can be ascribed to any of these findings is problematized by a lack of consensus, in at least some cases, regarding whether the aforementioned cores can really be classified as 'Nubian', particularly given the existence of a possible gradation between bidirectional and centripetal Levallois methods and Nubian Levallois cores. Others have argued that these Nubian and classic forms Levallois are not discrete technologies, but rather, variants of just one (Chiotti *et al.*, 2013). Furthermore, in the non-African cases, at least some of the Nubian Levallois cores contain features that can be described as seemingly regional variants, e.g. the 'dihedral-chapeau' platforms of the Nubian Levallois cores from Oman (Usik, *et al.*, 2013).

It is therefore unclear whether the Nubian Levallois reduction method is independently invented in multiple locations as a variant within Levallois technology, or whether it really does represent an ethnographic-scale process of dispersal or social contact within an ever-increasing area. These problems must also be distinguished from the question of the Nubian Complex itself. For example, the quantity of Nubian Levallois cores in non-African Middle Palaeolithic assemblages varies markedly, and it is unclear how many Nubian cores make a Nubian Complex assemblage. Some assemblages from northeast Africa (e.g. Bir Tarfawi) have been described as Nubian Complex without any such cores being present at all (Van Peer, 1998). This notwithstanding, it seems clear that these cores occur in clusters across vast spatial distances inbetween regions that apparently lack them. This can be contrasted with TTAs, that are a far more geographically and temporally circumscribed feature that is truly unique to the North African MSA.

The Khormusan

The Khormusan is represented by assemblages from at least five sites mostly on the eastern Nile, mostly around the second cataract. Geographically it seems to have a limited area, and it is poorly dated. Marks (1968b) described the assemblages as consisting of relatively high numbers of burins and denticulates, lesser numbers of retouched points (distally thinned) and blades, and in terms of production, the use of the Levallois method. However, the tool component of the assemblage is generally low, at 3% (Goder-Goldberger, 2013). Cores include centripetal preferential and recurrent, Nubian, unidirectional convergent and bidirectional Levallois alongside single platform bladelet cores (Goder-Goldberger, 2013).

Khormusan assemblages feature a variety of raw materials, which at the type site 1017 appear to correlate with methods of reduction – bladelet cores appear to be made exclusively on chert pebbles while Levallois cores are made from chert as well as ferricrete sandstone and igneous/metamorphic rock (Goder-Goldberger, 2013). Site 1017, also features hearths, faunal remains, worked bone and ground hematite pigment (Marks, 1968b). Although no reliable published chronometric dates for the Khormusan exist, Goder-Goldberger's (2013) date of ~85-65ka is likely to be a reliable estimate, as it is based on environmental, geological and stratigraphic correlation.

According to Goder-Goldberger's (2013) comparative study, the assemblages from these sites display distinctive similarities to MIS 6 and 5 sites in East Africa (e.g. some possible Aduma cores, see Yellen *et al.*, 2005, p. 46 for a definition). Rose (2004) has also reported small bifacial tools made on local quartz pebbles from northern Sudan which bear similarities to East African assemblages. Marks (1968b) regarded the Khormusan as having affinities with what he then described as the 'Nubian Mousterian', which he contrasted to the 'Nubian Middle Palaeolithic' mainly on the basis of the frequency of types such as Nubian cores and 'Upper Palaeolithic types' (see above, and also Scerri, 2017). Van Peer (1998) has since suggested that the Khormusan emerges from the Nubian Complex, proposing Khormusan sites as 'living site' variants.

It seems clear that earlier researchers (e.g. Wendorf *et al.,* 1968a,b; Aumassip, 2004) were correct to recognise a 'Mousterian'/MP signature in northeast Africa, as small variations on this technological theme are ubiquitous across the region. This signature is defined by varying frequencies of ubiquitous scrapers and denticulates, and to a lesser extent retouched 'Mousterian' points. It would be instructive, at this stage, to quantitatively assess whether these varying type and reduction method frequencies correlate with distinct groups, as has been proposed. Until then, the review of the evidence suggests that the temporal and spatial patterning of lithic variability do not seem to reflect that of a single, monolithic entity. These assemblages in northeast Africa also seem to be a little more varied than they are in northwest Africa, as would be expected given the distances involved and the possible role of the Nile as a conduit for the dispersal of diverse populations. Without greater chronological resolution, it will be difficult to reach any consensus on such issues.

Currently, despite the attention given to innovations in technology and material culture in the Mid-MSA at its beginnings, it is a period that seems to be characterised by regionalised technological conservatism in the long durée, with muted changes over this timeframe. The persistence of the traits characterising the beginning of the mid-MSA is remarkable and may reflect significant fluctuations of small population sizes spread across vast spaces. The changing spatial composition of various assemblages, be they named Aterian or some sub-group of the Mousterian, may also be a reflection of this, alongside a high degree of mobility which may not necessarily have resulted in significant contact between diverse groups.

The Late MSA

There are very few dated MIS 4 (~70-57ka) /3 (~56-29ka) MSA sites in North Africa. The limited evidence suggests dramatic trajectories of change in northeast Africa and stasis in northwest Africa, alongside the abandonment of most of the Sahara. Although it is currently difficult to determine the spatial and temporal homogeneity of aridity, palaeoenvironmental studies indicate that most of the Saharan region may have remained uninhabitable into the early stages of MIS 3 (Drake *et al.*, 2011; Blome *et al.*, 2012; Drake *et al.*, 2013). There is earlier evidence for environmental amelioration in the Levant and the Arabian Peninsula at ~60-55ka. Such amelioration is therefore also likely to have occurred in northeast Africa.

Data suggest that sites became concentrated into small, remaining habitable areas, with the onset of MIS 4 (Scerri, 2017). In the Jebel Gharbi, on the Tripolitanian Plateau, the continued presence of fresh water via underground aquifers, may have permitted continuity of occupation (Mutri & Lucarini, 2008). The assemblages at Jebel Gharbi mostly made using local raw materials, and characterized by a Levallois production system, coupled with blade production both through Taramsan (see below) and volumetric methods. Apart from the tanged pieces and bifacial foliates typical of TTAs, notched pieces and scrapers constitute the bulk of the tool-kit (Spinapolice & Garcea, 2013, 2014). Chronometric dating of stratigraphic sequences correlating with TTAs indicate that this occupation in the Jebel Gharbi may have spanned from ~70-30ka, and therefore most of MIS 3 (Garcea & Giraudi, 2006; Spinapolice & Garcea, 2013, 2014). If this is the case, it would make the TTAs in the Jebel Gharbi among the youngest documented.

Further south, there is some evidence that the TTAs may have contracted into the Central Saharan mountains during arid periods, but a lack of dates render this an open question. Intensive survey in the Fezzan has identified TTAs, together with a non-TTA MSA characterised by the exploitation of local raw material, Levallois recurrent and preferential and Kombewa type cores, and a toolkit consisting mainly of scrapers and notched tools, and to a lesser extent, bifacial foliates (Foley *et al.*, 2013; Cancellieri & diLernia, 2013). As these assemblages were recovered from the surface, they are undated and may be multi-period palimpsests. They have been only tentatively attributed to the MIS 5-4 on the basis of the affinities with dated TTAs from Morocco. However, as no temporal patterns in TTAs have yet been identified, it is difficult to assign chronology on the basis of technological style. In the Central Sahara, wetter environmental conditions are associated with the formation of fluvio-lacustrine systems during interglacial wet phases, and it therefore seems likely that an MIS 5e attribution is possible. However, a later MIS 3 occupation cannot be excluded.

In northwest Africa, MIS 4 TTAs may be present in the Maghreb at Taforalt and Rhafas

Cave, and there are some indications of more humid conditions in this region (Bouzouggar *et al.*, 2007; Mercier *et al.*, 2007; Smith, 2012). However, other investigations elsewhere in the Maghreb have also indicated a lack of occupation during MIS 4 (Jacobs *et al.*, 2012). It therefore seems that occupation in the Maghreb may have been patchier during this time, while allowing for OSL dating error-ranges and preservation.

At Haua Fteah, there is technological continuity within the Levalloiso-Mousterian layers, but occupation always seems to have been intermittent (Jacobs *et al.*, 2017), perhaps reflecting the role of the Gebel Akhdar mountains as a refugium within broader environmental fluctuations. This is consistent with the absence of TTAs at this site, showing at least a certain degree of cultural isolation from the rest of the area.

In northeast Africa, deteriorating conditions may have been somewhat mitigated by the influence of Mediterranean westerlies (Goldberg, 1994; Scerri, 2017), however, few securely dated sites exist to determine the effect of this environmental variation upon occupation continuity. Current indicators are suggestive of hyperaridity during MIS 4, and a decrease in the intensity of Nile flooding (Goldberg, 1994; Williams *et al.*, 2015). The late MSA in northeast Africa is defined by a small number of dated sites in Egypt, which currently suggest a minimum aged presence from ~60-44ka, likely relating to the beginnings of MIS 3. However, terminal MIS 4/ early MIS 3 wet phase identified in the Arabian Peninsula and associated with MP sites may also have affected northeast Africa (Parton *et al.*, 2015; Jennings *et al.*, 2016).

At Kharga Oasis, assemblages featuring small-sized (3.5cm-7.5cm) and mainly Levallois-based artefacts, including small blades and segments, have been described as the 'Khargan' (Caton-Thompson, 1946; Hester & Hobler, 1969; Wiseman, 2001; McDonald *et al.*, 2016). McDonald and colleagues (2016) have proposed an association between these assemblages and higher ground, as well as the spring vents at Kharga and Dakhleh Oases. These assemblages are likely to be no older than MIS 4 based on their positions above dated tufas (McDonald *et al.*, 2016). Egyptian sites, such as Taramsa 1 (Activity Phase IV, ~56ka, Activity Phase V, ~41ka) and Nazlet Khater 4 (~44ka), Nazlet Safaha (~59ka), are all quarry sites with infilled quarry pits dated by OSL. It is therefore likely that the activity phases are slightly older than the depositional dates indicated by OSL, although deposition is assumed to be rapid (Van Peer *et al.*, 2010).

A number of technological changes in the late MSA appear to be evident in northeast Africa, alongside continuity. At Taramsa 1, the 'Nubian Complex' has been argued to develop into a blade production system, which appears to reflect a re-organization of the Levallois system, itself ubiquitous across North Africa (Van Peer *et al.*, 2010). Taramsan blade cores feature a secant plane similar to Levallois cores, but a domed debitage surface allowed a continuous production of blades with the longitudinal convexity of the core maintained intermediately by bidirectional preparation (Van Peer *et al.*, 2010). This bidirectional preparation either resembles Levallois preparation or the removal of small, parallel bladelets, also observed in the illustrations of centripetally prepared preferential Levallois cores from the site (Fig. 6.23-1 and Fig. 6.27-1-2 in Van Peer *et al.*, 2010, see Figure 5, S3).

While Taramsan blade production appears to be a technological innovation, a link to preceding MIS 5 technology has been proposed on the basis of continued occupation at the site and the similar 'triangular shape' of 'Taramsan' blade cores with Nubian Levallois type preparation (Van Peer *et al.*, 2010). The degree to which continuous occupation reflected use by the same population, rather than periodic replacements by other northeast African groups is not clear, however. Also, it is unclear whether the degree of technological continuity between Levallois and Taramsan methods is generic or whether it can be linked specifically to Nubian Levallois methods, as has been proposed. The Taramsan method has also been described in the Jebel Gharbi, broadly in the same chronological range of the site of Taramsa, suggesting a certain degree of spread of technological innovation through the final stages of the North African MSA (Spinapolice & Garcea, 2013, 2014).

Contemporary assemblages from Nazlet Safaha 1 and 2, also in Egypt, have been termed 'Safahan' in view of the presence of a standardized method of Levallois core distal preparation as well as the presence of non-Levallois methods of reduction (Van Peer, 1991; Van Peer & Vermeersch, 2002; Van Peer *et al.*, 2010). In the Safahan method, the distal ridge created by the distal diverging preparation of Nubian Levallois reduction is removed by a blank struck from the distal platform. 'Safahan' and 'Taramsan' industries are also reported at Sodmein Cave, near the Red Sea Coast, where they are found beneath an assemblage described as containing Emiran points, a feature of the Emiran industry more typically associated with the Levant and the Initial Upper Paleolithic (Van Peer *et al.*, 1996) (see Table 1). The designation for these points is based on the presence of basal thinning on two pointed Levallois flakes, one of which has basal thinning on both sides (Van Peer *et al.*, 1996). As basal thinning is a common technological characteristic of the North African MSA (Scerri, 2013b), we consider the implied connection with the Emiran on the basis of a single piece to be problematic. Other sites in the region maintain an unchanged technological character from preceding MIS 5 assemblages (Vermeersch & Van Peer, 2002; Van Peer *et al.*, 2010).

Enormous quantities of raw material were exploited at Taramsa 1 in Egypt, in order to make stone tools that display clear differences to the previous, MIS 5 lithic technology (Van Peer, 1998). The technological features of the 'Nubian Complex' are argued to no longer be present in this region, and various analyses of assemblages from sites as Taramsa 1, Nazlet Safaha as well as from Khormusan sites in Nubia show various trajectories of lithic technological change. At Taramsa, typical MSA technology was replaced and the Levallois production system was progressively replaced by blade production. Chert was intensively exploited and mined, with extraction ditches sometimes descending more than 2m below the former surface (Vermeersch *et al.*, 1998). These trajectories of change have been termed as an 'Upper Palaeolithic' and linked to out-of-Africa dispersals. However, the 'Mousterian' MSA persists in northeast Africa, although it has been given little attention. Recent research suggests that such assemblages appear to be among the youngest in Africa, having been dated to 15.9 ± 1.7 ka in the Nile Valley (Osypiński & Osypińska, 2016), matching patterns seen elsewhere in the continent (Scerri *et al.*, 2017). Further dates on MSA assemblages from the region will clarity what appears to be a complex transition to the LSA that does not necessarily involve a hiatus in occupation or a population replacement.

At Haua Fteah, the MSA comes to an end in MIS 3 at ~40.5ka, with the appearance of a prismatic blade industry commonly referred to as the 'Dabban' (Reynolds, 2013; Douka *et al.*, 2013). Further west, young, MIS 3 dated TTAs only come from the non-desert hinterlands of the Maghreb, where research has taken place. These range between ~40-20ka, although there are problems with some of the contexts and dating techniques (Wrinn & Rink, 2003; Bouzouggar & Barton, 2012; Barton *et al.*, 2015). By the end of MIS 3 (~29ka), TTAs disappeared, with no diachronic technological changes yet identified. However, assemblages described as 'Mousterian' continue even later. At Wadi Noun in southern Morocco, an assemblage featuring side scrapers was dated to ~31ka (Wengler, 2010). An even younger 'Mousterian' level dating to ~26ka at Sidi Saïd in Tunisia was recovered but the dates may not be reliable due to the nature of the sample (Betrouni, 2001, see Doerschner *et al.*, 2016). At Taforalt, the youngest MSA is well dated to ~27ka (Barton *et al.*, 2016), and may mark the end of the MSA across northwest Africa. There is no technological continuity between TTAs and the later Iberomaurusian (~20ka) in the region and apparent morphological similarities between 'Aterian' and Iberomaurusian are dubious (Ferembach, 1986). However, the presence at Taforalt of a flake-based assemblage dated to ~25ka that lacks Levallois components and features few retouched tools (including adzes) can be contrasted to both older MSA and later LSA levels at the site, and indicates that intermittent human occupation in the area continued (Barton *et al.*, 2016).

Undated occurrences

The bulk of the MSA record remains undated and can only be speculatively ascribed to a chronological period. Aumassip (2001, 2004) has described the whole range of the Mousterian facies in North Africa: a Ferassie Mousterian at Retaimia, Typical Mousterian at Cap Ténès (Algerian Maghreb), and references to a 'Denticulate Mousterian' have been made at Brezina (Aumssip, 2001), as well as at Tarf H'Mer in Mauritania (Pasty, 1999), negating the idea that the technological features associated with the 'Mousterian' are absent in the Sahara. The Mousterian of Acheulean Tradition (MAT) is described in the Algerian Sahara and Maghreb, and is sometimes attributed to a direct Acheulean influence (Aumassip, 2001), although largely undated. The definition of MAT is linked to the presence of small bifaces, often cordiform, that are a constant presence from "Mousterian" to Aterian in the Sahara, at sites such as KM 50 (Aumassip, 2001), Tigueguelmine (Reygasse, 1934) and Esseleskine (Lhote, 1943). A giant Levallois Mousterian has been also described (Camps, 1974), both in the Sahara, in sites such Dédé in Eker (giant Levallois flakes on diorite), and in the Hoggar (Tin Tamatt & Hugot, 1962). These industries, because of their dimension and the association with bifaces, have been attributed to the MAT, or to a final stage of the Acheulean (Camps, 1974).

It is currently unclear how similar or different these Saharan 'Mousterian' variants are to those of the Maghreb and the northeast, particularly as chronometric dating is lacking. However, the hypothesis that the suite of technological features referred to as the 'Mousterian' in the Maghreb is not found elsewhere in North Africa is unlikely to be correct.

Discussion

Different interpretations of North African MSA lithic variability, and associated nomenclatures, have been used to forward a range of diverse and sometimes conflicting hypotheses regarding the origin and dispersal of our species, as well as to explain specific local patterns in the North African record. Before evaluating these interpretations alongside non-lithic threads of evidence, we first summarise the above evidence as a hierarchical mixture of different basic substrata along with changing combinations of technological packages (Fig. 6).

In essence, two basic substrata seem to be present in the early MSA. The first consists of discoidal and Levallois technology with retouched points, flakes, denticulates, notches and scrapers (Fig. 6, S1). The second consists of Levallois and discoidal technology with flakes, blades and large, bifacial cutting tools (Fig. 6, S2). These two substrata are variously augmented in the mid MSA with different technological packages. The first variously includes retouched tools described as 'piercers', blades and burins often called 'Upper Palaeolithic types (Fig. 6, P1). The second includes small bifacial foliates and tanged tools (Fig. 6, P2). Although we recognise that these two tools are not always found together, it seems clear that there is a relationship between these tool classes. The third includes large bifacial lanceolates, Nubian Levallois cores and truncated faceted pieces (Fig. 6, P3). Other rarer tool types (e.g. Y shaped tools, crescents, thinned tip points) have less clear patterning, but can be viewed as variable components of these technological packages. In the late MSA we identify the appearance of a new northeast African substratum featuring Nubian Levallois cores, blades and use of the Taramsan method of reduction (Fig. 6, S3). The broad temporal and geographical patterning of these substrata and their changing technological packages is summarised in Figure 6.

Evaluating what light the patterning in Figure 6 sheds on the place of North Africa in recent human evolution can only be tentative, at this stage. A suitable starting point arguably

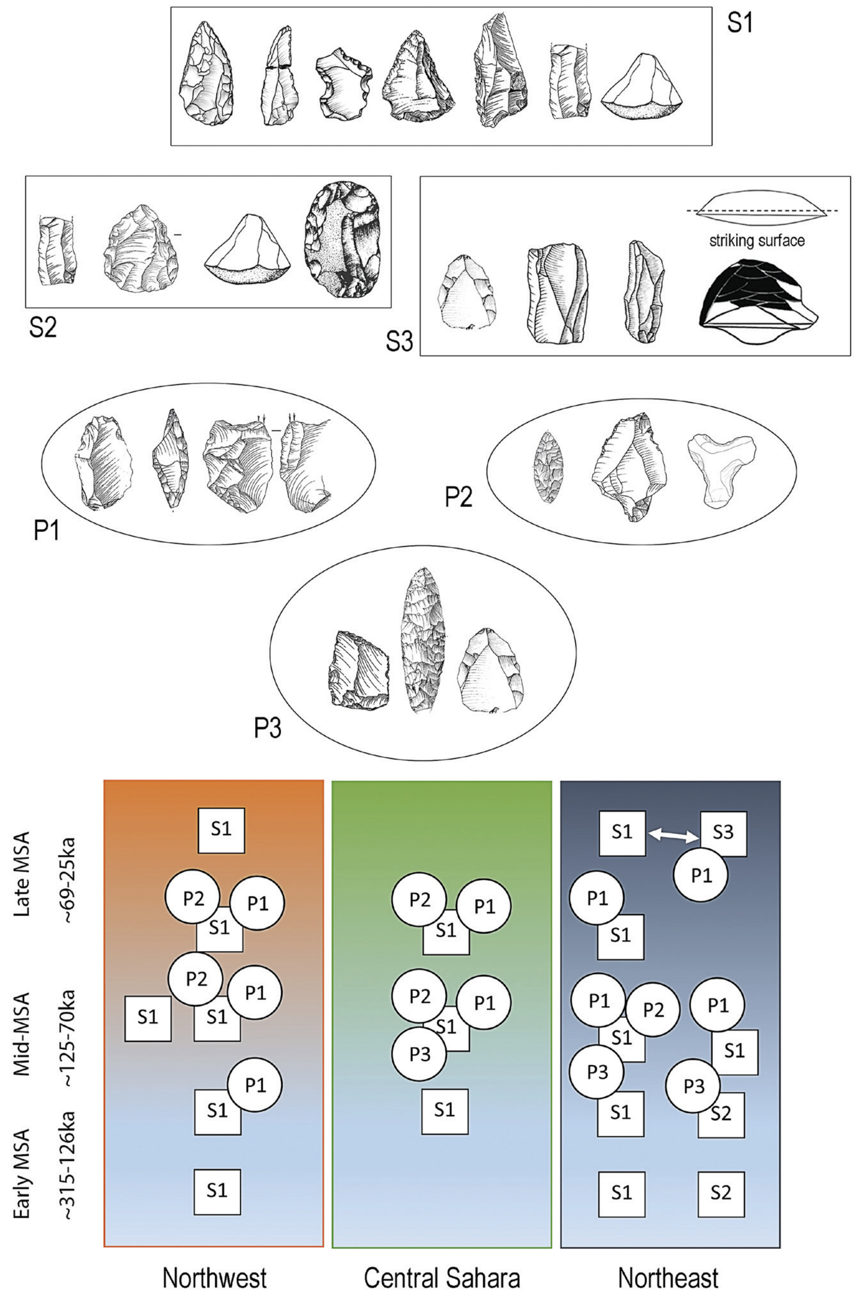

Fig. 6 - Model substrata and technological packages that define the North African MSA. Substrata are indicated by square boxes. S1: 'Mousterian'/MSA, S2: LCT MSA, S3: Taramsan package. Technological packages connecting to substrata are indicated by circles. P1: 'Upper Palaeolithic' types, P2: TTA types; P3: Nubian Levallois and lanceolates. The colour version of this figure is available at the JASs website.

involves considering the goodness of fit between the lithic patterning and other lines of evidence.

Broadly, the Saharan 'pump' hypothesis is well supported as a mechanism for population separation and turnover. The innovation, maintenance and turnovers of new technologies in the MSA is consistent with repeated environmental amelioration and population expansion. Although much of the lithic material of the North African MSA has not been studied comparatively across the region, limited quantitative studies of MIS 5 assemblages also support population fragmentation within North Africa. Differences between earlier assemblages such as those from Jebel Irhoud and Benzu in northwest Africa, and Haua Fteah, Bir Tarfawi, Sai Island and Kharga in northeast Africa, also seem evident, and can at least be hypothesised to be a result of isolation by distance (Fig. 6). Given the size and environmental and topographic heterogeneity of North Africa, it seems likely that both dispersals into the region and re-expansions out of refugia drove the character of the record. These interpretations are comparable to independent fossil, genetic and environmental lines of evidence supporting strong levels of subdivision of structure between a *H. sapiens* metapopulation scattered across Africa (e.g. Stringer, 2016; Scerri *et al.*, 2018).

Key research questions therefore concern exactly how similar the early MSA is within the identified substrata and beyond, and whether the early record evidences a mosaic like pattern of derived technological features in a way comparable to the fossil record; why the MSA appears to emerge across Africa more or less simultaneously (see Hublin *et al.*, 2017; Deino *et al.*, 2018); and whether characteristics of the early MSA such as that in North Africa (i.e. Fig. 6, S1) are really as similar to the European Mousterian as has been claimed. We consider these questions in turn.

The processes driving behavioural change in the record in North Africa are poorly understood, which has implications for understanding how humans originated in this region. Much attention has been given to the more distinctive elements of the North African MSA, such as the technological packages including TTAs and Nubian Levallois reduction methods (see Figure 6). However, there is much about the record that does *not* change and the most common technological features in any region are found across North Africa. Indeed, the early and the very late MSA do not exhibit any strong differences at all indicating a staggering technological conservatism over the best part of 300 thousand years (Fig. 6). This notwithstanding, the patterning of this MSA does not seem to be that of a monolithic entity, and it seems to appear and disappear from certain regions, while remaining a constant presence in others, alongside TTAs. Yet these assemblages rarely form part of any hypotheses aside from continuing debates regarding possible crossings of the Straits of Gibraltar (e.g. Ramos *et al.*, 2008). Detailed studies of the similarities of generalized MSA assemblages in North Africa, together with their spatial and temporal patterning, are likely to reveal significant new information regarding the peopling of the Sahara and intra-African dispersals therein. Currently, and in the absence of such studies, it may be best to conceive of the North African MSA as described above. That is, consisting of lithic sub-strata comprising general types and reduction methods of varying frequencies alongside various techno-typological packages that shift over time (Fig. 6).

The more distinctive elements of the North African MSA are likely to relate to population separation as well as parameters of growth and density. In particular, the distribution of TTAs remains peculiar and unexplained. There is no apparent reason why they are not found in the Nile Valley and eastwards (with the probable exception of Magendohli), or why they are not found in any part of Haua Fteah's deep sequence (is this the outcome of a sparse occupation, or something more?). Yet, apparently contemporary non-TTAs from northeast African assemblages do have similarities with earlier and contemporary assemblages from East Africa (Rose, 2004; Goder-Goldberger, 2013; Groucutt *et al.*, 2015; Douze & Delagnes, 2016). Somewhat counter-intuitively, TTAs also share technological features with assemblages from both the Nile Valley and east of the Nile. Indeed, shared elements are much more numerous than the distinctive elements, which only include tanged tools, and to a lesser extent small bifacial foliates, which are not even shared across all TTAs. Determining whether these differences are explained by site function, complex cultural boundaries or population distribution/isolation remains a major challenge. The exceptional site of Magendohli may provide some clues. It is located approximately 27 miles south of the Khormusan site of ANW 3. ANW 3 is the only known Khormusan site on the western Nile and Magendohli the only TTA site in the Nile Valley, and they are both located close to the second cataract. However, as this cataract is now submerged under Lake Nasser, it is difficult to determine whether such a key physical feature is related to the unusual locations of both Magendohli as a TTA site and ANW 3 as a Khormusan site. It certainly seems unlikely that population isolation alone explains this patterning.

More broadly, it is true that the few large-scale studies of technology have suggested strong patterns of technological regionalisation as well, indicating that North Africa was largely compartmentalised into habitable zones separated by regions of desert (e.g. Scerri *et al.*, 2014). Although mobility among arid land hunter-gatherers is typically high among ethnographically documented groups, raw material transport distances throughout the MSA of North Africa also seem to have been predominantly local (20km or less). Currently, the only notable exception to this pattern is Adrar Bous, where exotic raw material was imported from up to 200km away.

Regarding the broader place of the North African MSA, North Africa is of course physically linked to Eurasia and multiple dispersal events now seem evident (Groucutt *et al.*, 2015; Pagani *et al.*, 2016; Mallick *et al.*, 2016; Hershkovitz *et al.* 2018; Groucutt *et al.*, 2017; Groucutt *et al.*, 2018). Similarities between North African assemblages and others in southwest Asia have also been documented (Scerri *et al.*, 2014; Groucutt *et al.*, 2015, but see also Scerri, 2012 for cases of misidentification). A number of researchers have also observed strong similarities between European Mousterian assemblages and their North African 'Mousterian'/MSA counterparts, although the character of these similarities seems rather broad (Aumassip, 2004; Ramos *et al.*, 2012).

Before attempting major comparative studies, attention should be first paid to framing the kinds of questions to be asked. Detaching the North African record from Eurasia seems to make as little sense as detaching it from the rest of the African continent, as was commonly done in the early part of the 20th century. It is becoming increasingly important to bear this in mind in debates regarding the value of the Middle Palaeolithic versus Middle Stone Age terminologies. This is particularly the case given that the environmental fluctuations of North Africa were often asynchronous with those of other regions of Africa (Blome *et al.*, 2013; Scerri *et al.*, 2018), but often synchronous with conditions in parts of southwest Asia (Drake *et al.*, 2013; Scerri, 2017). Of further note is the fact that the southern limit of Neanderthals in southwest Asia is still unknown.

It is also important to remember that for many years, dispersals out of Africa were associated with Eurasian Upper Palaeolithic and blade-based technologies, with the MSA considered to be too early to play a role in the origin and spread of *Homo sapiens*. This is no longer the case. While caution is absolutely warranted in attributing technological styles to particular taxonomic groups, recent discoveries have validated the important role of lithic technology in key debates regarding the origin and spread of our species. For example, the MSA has long been linked with the manifestations of 'modern' behaviour. This hypothesis was called in doubt by fossil and genetic data suggesting that the divergence of our species post-dated the emergence of the MSA by at least 100 thousand years. Yet genomic and new fossil discoveries bring all the diverse threads of evidence in line with each other (see e.g. Stringer, 2016; Hublin *et al.*, 2017; Deino *et al.*, 2018; Scerri *et al.*, 2018), and the co-evolution of MSA technology and *Homo sapiens* is strongly supported by recent discoveries (Hublin *et al.*, 2017; Deino *et al.*, 2018). Similarly, long-disputed technology-based hypotheses for early dispersals out of Africa have been verified by fossil discoveries (Hershkovitz *et al.*, 2018; Groucutt *et al.*, 2018). On the other hand, despite some scepticism shown towards the link between *H. sapiens* and MSA technology, the Mousterian in Europe at least, has long assumed to be the sole product of Neanderthal populations, even though Middle and not Upper Palaeolithic technologies in the Levant were produced by *Homo sapiens* as well. However, if multiple early dispersals into Eurasia are the case, as they seem to be, we should be cautious about making blanket assumptions regarding the identity of European Mousterian tool makers. To conclude, future technological of the North African MSA must focus on framing research questions that do not build on layers of bias and assumptions. To do this, such studies must have at their core the descriptions of technological variability, rather than an uncritical repetition of industrial nomenclatures that appear to either mean different things in different regions, or which promulgate culture-historical assumptions of ethnographic groups. It is hoped that by describing these different nomenclatures and their referents, along with a critical evaluation of their use, the lithic evidence can be better interpreted and studies made reproducible. In particular, we emphasise that little is known for the North African MSA beyond small areas of intensive research. For these reasons alone, it is advisable to focus on description and detailed comparative study, in particular that which generates quantitative data that may be integrated with other independent lines of evidence. It is only in this way that a comprehensive picture of this key region and time frame can be achieved.

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Appendix - Presence/absence data for key tool types and reduction methods at dated sites across North Africa, including probable corresponding Marine Isotope Stages (MIS), with the caveat that dating errors may span MIS. NE: northeast Africa; NW: northwest Africa; CS: Central Sahara

SITE, LAYER	LOCATION	AGE	MIS CAT	GRIND STONE	DISC. CORE	LEVALLOIS PREFERENTIAL FLAKE CORE	LEVALLOIS RECURRENT CORE
Jebel Irhoud	NW	~315ka	9	0	1	1	1
Benzu Layer V	NW	~250ka	8	0	1	1	1
Bir Tarfawi E-88-14	NE	~220-150ka*	7	0	1	1	1
Sai Island Lower MSA	NE	<223ka	7	1	1	0	0
Kharga Oasis REF-4	NE	~220ka	7	0	0	1	1
Sai Island Mid-MSA	NE	~182ka	6	1	1		
Ifri n'Ammar Lower OI	NW	~171 ± 12ka	6	0	1	0	0
Sai Island Upper MSA	NE	~162ka	6	0	1		
Taramsa 1 Activity Phase I	NE	~165ka*	6	0	1	0	0
1Ifri n'Ammar Upper OI	NW	~145 ± 9ka	6	0	1	1	1
Rhafas 3	NW	135ka	6	0	0	1	1
Ifri n'Ammar Lower OS	NE	~130.0 ± 7.8ka	5e	0	1	1	1
Bir Tarfawi 14C Grey Phase 1	NE	~130ka	5e	1	1	1	1
Kharga Oasis Mata'na Site G	NE	~125ka	5e	0	0	1	1
Contrebandiers 6c	NW	122.3 ± 4.5ka	5e	0	0	1	1
Sodmein Cave	NE	~119ka	5e	0	0	1	
Taramsa 1 Activity Phase II	NE	~117ka	5e	0	1	0	1
Adrar Bous	CS		5e	0	1	1	1
Contrebandiers 5a-c	NW	~116.1 ± 2.9ka	5e	0	0	1	1
El Mnasra Level 7b	NW	~109ka	5d	0	0	1	1
Contrebandiers Layer 4	NW	~107-103.2ka	5d	0	0	1	1
Bir Sahara E-88-11	NE	~105-110ka	5d	0	0	1	0
Bir Tarfawi 14C Grey III	NE	~96ka	5c	0	1	1	0
Taforalt Unit E	NW	~82ka	5a	0	1	1	
Kharga Oasis KO6E	NE	<80ka	5a	0	0	1	1
1017	NE	~84ka	5a	0	1	1	1
Haua Fteah Layer XXXV	NE	~85ka	5a	0	1	1	0
Ifri n'Ammar Upper OS	NW	~83.3 ± 5.6 ka	5a	0	1	1	1
Rhafas 3A	NW	123ka	5e	0	0	1	1
Taramsa 1 Activity Phase III	NE	~78ka*	5a	0	0	0	0
Haua Fteah Layer XXXIII	NE	~73-65ka	5a	0	1	1	1
Oued el Akarit	NE	>70ka	4	0		1	1
Uan Tabu	CS	~60ka	4	0	0	1	0
El Harhoura 2 Level 3	NE	~60ka	4	0	0	1	1
Nazlet Safaha 2	NE	~59ka*	4	0	0	1	0
Taramsa 1 Activity Phase IV	NE	~56ka	4	0	1	1	0
Taramsa 1 Activity Phase V	NE	~41ka*	3	0	1	1	1
Taforalt 'Younger MSA'	NW	27ka	2	0	0	1	0

Appendix - continued

SITE, LAYER	LEVALLOIS POINT CORE	BIFACIAL FOLIATE	BIFACIAL LANCEOLATE	TANGED TOOLS	BLADE	OTHER BIFACE	RET. POINT	OTHER RET.
Jebel Irhoud	0	0	0	0	0	0	1	1
Benzu Layer V	0	0	0	0	1	0	1	1
Bir Tarfawi E-88-14	0	0	0	0	0	0	1	1
Sai Island Lower MSA	1	0	1	0	1	0	0	1
Kharga Oasis REF-4	0	0	0	0	0	0	0	0
Sai Island Mid-MSA	1	0	0	0	1	1	0	1
Ifri n'Ammar Lower OI	0	0	0	0	1	0	1	1
Sai Island Upper MSA	1	0	1	0	1	1	0	1
Taramsa 1 Activity Phase I	0	0	1	0	1	0	0	0
1Ifri n'Ammar Upper OI	0	0	0	1	1	0	1	1
Rhafas 3	0	0	0	0	0	0	1	1
Ifri n'Ammar Lower OS	0	0	0	0	0	0	1	1
Bir Tarfawi 14C Grey Phase 1	1	1	0	0	1	1	1	1
Kharga Oasis Mata'na Site G	1	0	0	0	1	0	1	1
Contrebandiers 6c	0	0	0	0	0	0	0	1
Sodmein Cave	1	0	1	0	1	0	1	1
Taramsa 1 Activity Phase II	1	0	0	0	1	0	0	1
Adrar Bous	1	1	1	1	1	0	1	1
Contrebandiers 5a-c	0	0	0	0	0	0	0	1
El Mnasra Level 7b	0	1	0	1	1	0	1	1
Contrebandiers Layer 4	0	0	1	1	1	0	0	1
Bir Sahara E-88-11	1	0	0	0	0	0	0	1
Bir Tarfawi 14C Grey III	0	1	0	0	1	0	1	1
Taforalt Unit E		1	0	0	1	0	1	1
Kharga Oasis KO6E	1	0	1	1	1	0	1	1
1017	1	0	0	0		0	1	1
Haua Fteah Layer XXXV	1	0	0	0	1	1	1	1
Ifri n'Ammar Upper OS	1	1	0	1	1	1	1	1
Rhafas 3A	0	0	0	1	1	0	1	1
Taramsa 1 Activity Phase III	1	0	0	0	1	0	0	0
Haua Fteah Layer XXXIII	1	0	0	0	1	1	1	1
Oued el Akarit	0			1		0	1	1
Uan Tabu	0	0	0	1	1	0	1	1
El Harhoura 2 Level 3	0	1	0	0	1	0	0	1
Nazlet Safaha 2	0	0	0	0	1	0	0	1
Taramsa 1 Activity Phase IV	0	0	0	0	1	1	0	1
Taramsa 1 Activity Phase V	0	0	0	0	1	1	0	1
Taforalt 'Younger MSA'	1	1	0	1	0	0	1	1