Stone tool assemblages and models for the dispersal of *Homo sapiens* out of Africa

Huw S. Groucutt a,*, Eleanor M.L. Scerria a, b, Laura Lewis a, Laine Clark-Balzana a, James Blinkhorn c, Richard P. Jennings a, Ash Parton a, Michael D. Petraglia a

a School of Archaeology, Research Laboratory for Archaeology and the History of Art, University of Oxford, New Barnett House, 28 Little Clarendon Street, OX1 2HU, Oxford, UK

b PACEA, Université de Bordeaux, Bâtiment B19, Avenue des Facultés, 33405, Talence Cedex, France

c McDonald Institute for Archaeological Research, University of Cambridge, CB2 3ER, UK

**Abstract**

The dispersal of *Homo sapiens* out of Africa has been extensively researched across several disciplines. Here we review the evidence for spatial and temporal variability in lithic (stone tool) technologies relative to the predictions of two major hypotheses: 1) that a single successful dispersal occurred 60–50 thousand years ago (ka), marked by a trail of geometric/microlithic technologies, and 2) that multiple dispersals occurred, beginning much earlier (probably in Marine Isotope Stage [MIS] 5), associated with Middle Palaeolithic technology in its early phase. Our results show that Late Pleistocene geometric/microlithic technologies exhibit significant temporal and regional differences between each other. These differences suggest independent, convergent origins for these technologies, which are likely to have been repeatedly re-invented. In contrast, we identify similarities between East African lithic technologies from MIS 8 onwards and Middle Palaeolithic assemblages as far east as India by MIS 5. That this constellation of technological features – particularly an emphasis on centripetal Levallois reduction reflecting interchangeable preferential and recurrent methods, along with particular retouched forms such as points – transcends ecologies and raw material types suggests that it is unlikely to entirely reflect technological convergence (analogy). Our results indicate an early onset of multiple dispersals out of Africa. The hypothesis of an early onset to successful dispersal is entirely consistent with the possibility of further subsequent (post-MIS 5) dispersals out of Africa. Testing such hypotheses through quantified comparative lithic studies and interdisciplinary research is therefore likely to significantly advance understanding of the earliest *H. sapiens* dispersals.

© 2015 Elsevier Ltd and INQUA. All rights reserved.

1. Introduction

Most researchers accept that *Homo sapiens* evolved in Africa in the late Middle Pleistocene, despite a still limited fossil record (e.g. McBrearty and Brooks, 2000; White et al., 2003; McDougall et al., 2005; Shea, 2011; Smith and Ahern, 2013; Stringer, 2014). Genetic analyses have been widely cited in the competing models for subsequent dispersals into Eurasia (e.g. Mellars et al., 2013). While such genetic analyses have typically been dominated by single locus mitochondrial DNA and Y-chromosome based models, emerging whole-genome evidence is congruent with multiple models for the dispersals of *H. sapiens* (Scally and Durbin, 2012; contra Mellars et al., 2013 and Clarkson, 2014).

Here we use lithic (stone tool) technology, by far the most abundant form of evidence for hominin behaviour in the Pleistocene, to test two major models for the dispersal of *H. sapiens* out of Africa. The first of these is the hypothesis that there was a single dispersal ~60–50 ka, marked by a trail of geometric/microlithic technologies around the Indian Ocean Rim (Mellars, 2006; Mellars et al., 2013). Proponents of this model suggest that geometric microliths in assemblages from southern and eastern Africa and South Asia exhibit a high degree of morphological and typological similarity (Fig. 1). This similarity is argued to provide good evidence for demographic connections and dispersal. Alternatively, the second model proposes that successful dispersal out of Africa began much earlier, probably during MIS 5 (~130–75 ka) and was associated...

* Corresponding author.

E-mail address: huw.groucutt@rlaha.ox.ac.uk (H.S. Groucutt).
Fig. 1. Examples of geometric microliths from South Africa and South Asia (illustrations modified from Kaplan, 1990; Deraniyagala, 1992; Deacon, 1995; Soriano et al., 2007; Wadley and Mohapi, 2008; Clarkson et al., 2009; Wijeyapala, 1997).
with Middle Palaeolithic (synonymous with ‘Middle Stone Age’ in Africa) technology during at least its early phase (SOM 1) (e.g. Petraglia, 2007; Petraglia et al., 2010; Armitage et al., 2011; Dennell and Petraglia, 2012; Boivin et al., 2013; Groucutt and Blinkhorn, 2013; Blinkhorn and Petraglia, 2014; Groucutt and Petraglia, 2014). The hypothesis of an early onset to multiple dispersals into Asia is compatible with subsequent dispersals out of Africa, perhaps during periods such as MIS 3.

The two models we evaluate were chosen over others in view of the fact that *H. sapiens* reached Australia by ~50 ka (SOM 2), which is incongruous with the notion that successful dispersal out of Africa did not happen until less than 50 ka (e.g. Bar-Yosef, 2007; Klein, 2009; for a recent review of models see Groucutt and Petraglia, 2014). The emerging fossil record in southeast Asia also indicates the presence of *H. sapiens* before 50 ka (e.g. Mijares et al., 2010; Demeter et al., 2012).

A fundamental premise in our use of lithic data to elucidate hominin dispersals is that there are various influences on patterns of similarities and differences. The meaning of similarities and differences therefore depends on theorisation of the relationship between these influences and the patterns observed. Therefore, a key point is that it is overly simplistic to invoke merely dispersal and cultural diffusion to explain similarities in lithic technology. Three major mechanisms can be posited to explain similarities in lithic technologies; 1) branching (i.e., descent and dispersal), 2) blending (i.e., cultural diffusion, including stimulus diffusion) processes, and 3) convergence (i.e., independent origins). Branching and blending can together be seen as different forms of social interaction, in contrast to convergence where similarities do not reflect such contacts. How to separate the process behind observed similarities has long troubled archaeologists (Kroeber, 1931; Binford, 1968; Clarke, 1968; O’Brien, 2010). Aside from the topic of this paper, numerous other debates revolve around distinguishing diffusion/dispersal and convergence (e.g. Scerri, 2012; O’Brien et al., 2014). In attempting to differentiate between cultural contact/dispersal and convergence, a full and unbiased assessment of technological similarities and differences is required, together with an understanding of their wider context. More widely, developing methodologies to distinguish forms of cultural interaction from technological convergence is one of the most urgent tasks for archaeology.

At the outset it must also be emphasised that while in Europe the Middle Palaeolithic (or MP, used here synonymously with the Africanist term ‘Middle Stone Age’) is associated with Neanderthals, in Africa it is associated with the origin and the majority of the existence of *H. sapiens*. In Asia the situation does not neatly resemble either Africa or Europe. The reasons proposed for variability in Middle Palaeolithic lithic technology range from a heavy emphasis on raw material factors (e.g. Clark and Riel-Salvatore, 2006; Klein, 2009) to a focus on cultural aspects (e.g. Rose et al., 2011). Variability in the Middle Palaeolithic is often described in terms of ‘industries’ (technocomplexes, etc.). Such constructs can be an aid to discussion, but are also often problematic. For example, industries are defined using variable and largely incompatible criteria. Key examples include the ‘Aterian’ and ‘Nubian Complex’ of North Africa. The former is largely defined in terms of retouched tool typology, with an emphasis on tanged/pedunculated tools. In contrast the Nubian Complex is defined by the prevalence, at an
unspecified frequency, of a particular type of Levallois core reduction method. However, as Scevola (2013a; Scevola et al., 2014a) has demonstrated, ‘Aterian’ assemblages in northeast Africa are more similar to local ‘Nubian’ assemblages than they are to Aterian assemblages from northwest Africa (see also Bibble et al., 2013b; Shea, 2014). Such findings bring the reality and utility of frequently cited industrial nomenclatures into doubt.

With the above caveats in mind, our aim in the present paper is to evaluate Palaeoanthropic assemblages from Africa and southern Asia and search for patterns of similarities and differences in particular technological traits (see also Tostevin, 2012; Scevola et al., 2014a). In reviewing technological variability and whether certain assemblages can be related to the dispersal of Homo sapiens we both test the hypotheses presented above and construct new hypotheses to be tested by interdisciplinary studies.

2. Geometric microliths in Africa

2.1. The Howiesons Poort

The Howiesons Poort (HP) variant of the southern African Middle Palaeolithic has been the subject of much recent discussion (e.g. Henshilwood, 2011). As shown in Fig. 2, HP sites are known from across southern Africa, virtually all south of 25° S. Additional sites, particularly from the interior, may be present, but this area is less intensively studied and so sites with possible HP material such as Wonderwerk Cave are not included here. The HP is restricted to the far south of the African continent, with even the most northerly sites being well over 4000 km from Asia, as the crow flies. The distribution of sites typically reflects areas of higher rainfall, which in places includes areas close to the coast. This can be distinguished from coastal adaptation as such. As discussed in SOM 3, despite being one of the most thoroughly researched elements of the African Palaeolithic record, the chronology of the Howiesons Poort remains unclear. Some scholars argue for a precise and short chronology of ~65 to 60 ka (Jacobs et al., 2008), while others suggest that the HP might have begun much earlier, around 109 ka (Triolo et al., 2013). Elsewhere, lithic technology that appears similar to the HP has been dated to several thousand years earlier than suggested by the original Jacobs et al. (2008) chronology (Brown et al., 2012). The environmental context of the Howiesons Poort is discussed in SOM 4.

Several studies document different methods of blank production in assemblages attributed to the HP (e.g. Stewart et al., 2013; de la Peña and Wadley, 2014). The specific ‘Howiesons Poort blade cores’ (Villa et al., 2010; Porraz et al., 2013) found at some sites are not reported from outside South Africa. In terms of retouched forms, backed tools are typically considerably larger than in the African Late Palaeolithic (‘Late Stone Age’) (Lombard, 2005; Henshilwood, 2012) and South Asian Late Palaeolithic (Fig. 1). In fact, there is considerable variation even within the backed tools (e.g. Villa et al., 2010). More widely, it is important to note that the iconic backed geometric (particularly crescent-shaped) microliths are not the dominant form of retouched tool in many HP assemblages. Where backed tools are common, these are often not of geometric form. For example, of 421 backed tools in Howiesons Poort levels at Klases River, only 143 (34%) are geometric (Villa et al., 2010, Table 4). While in the case of Diepkloof, backed tools constitute 15%, 6% and 47% of the early, middle and late HP layers respectively (Porraz et al., 2013) and 19% at Rose Cottage Cave (Lewis et al., 2014). In the early to middle Howiesons Poort at Diepkloof pieces esquillèes and strangulated-pointed pieces are the dominant retouched forms (Porraz et al., 2013).

An additional important feature of the Howiesons Poort is the retention of more classically MP-like/mode 3 elements including unifacial and bifacial points (Lombard et al., 2010) and Levallois/discoidal cores (Wurz, 2013). These features are not typically found at other localities with backed technologies discussed below such as the Naisiusiu Beds (Olduvai Gorge, Tanzania) and microlithic sites in South Asia. The mixture of ‘primitive’ and ‘derived’ traits is found at well-excavated sites with excellent stratigraphic resolution (e.g. Soriano et al., 2007; Vogelsang et al., 2010; Porraz et al., 2013). The HP is neither a homogeneous entity nor an equivalent of the European Upper Palaeolithic.

2.2. East Africa

Turning to East Africa, Mellars et al. (2013) describe a number of assemblages as being ‘Howiesons Poort-like’. In the present paper we refer to East African MIS 3 ‘Late Palaeolithic’ sites, a terminology subsuming more regionally specific terms such as Later Stone Age, Upper Palaeolithic, and South Asian Microlithic (James and Petraglia, 2005). In Zimbabwe several assemblages combine MP technology with laminar and backed crescentic artefacts. These assemblages are known under a plethora of different industrial names, such as the Umguzan, Bambatan, Tshangulan, and Magosian. Willoughby (2007, pp. 292) suggests that most sites assigned to industries such as the Magosian reflect palimpsests of different time periods. Mellars et al. (2013) cite locations such as Pomongwe Cave, Zimbabwe as supportive of their model. Our review of the literature on this site suggests no evidence for HP-like material (Cooke, 1963; Willoughby, 2007). The deeper layers of the site (13b–27a) are classic MP, while layers 13a to 10 were initially described as Magosian. Published figures from the site do not show anything that looks HP-like sensu Mellars et al. (2013). The main retouched tool types at Pomongwe Cave in the Magosian are semi-circular and circular scrapers (Cooke, 1963). Following the ‘Magosian’, the archaeological material continues into the Holocene. The evidence suggests that the Magosian here belongs to the Late Palaeolithic, perhaps with some mixing of the sediments and lithics.

The recently excavated site of Mochena Borago in Ethiopia yielded three lithic assemblages, described here from oldest to youngest (Brandt et al., 2012). The Lower T Group assemblage (>53 ka calBP) consists of a classic East African MP assemblage, with core reduction methods including Levallois and discoidal, and retouched points and scrapers as the most common tool types. There are no geometric microliths. The Upper T Group (~45 ka calBP) is described by the discoverers as being similar to the Lower T group, in terms of proportions of artefact types, core reduction patterns, blank types, etc. (Brandt et al., 2012, pp. 47). Within this pattern of continuity a small number of backed tools (n = 11) appear for the first time, the single complete specimen being a crescent. Finally the S-Group (~43 ka calBP), which “from a technological and methodological perspective ... differ little from the T-Group assemblages” (Brandt et al., 2012, pp. 48), features a higher frequency of backed pieces. This sequence suggests an increasing emphasis on backed technology through time from a local origin, and nothing suggests an abrupt arrival of a radically different technology.

With the Naisiusiu Beds of Olduvai Gorge the situation is again complex. At this locality the lithic assemblage consists of three components (Leakey et al., 1972): 1) material excavated in the 1930s, which was poorly recorded and only a selective sample of which was kept, 2) material collected from the surface of the site, 3) material excavated in 1969. Given this, the ESR dates of ~60 ka – which are possibly problematic given the sheetwash origin of the relevant sediments, as discussed in SOM 5 – can at most be related to the third category and not the whole assemblage. Given the above caveats, Merrick (1975) likewise only studied the material...
excavated in 1969 and describes the small numbers of backed lithics from this assemblage. There are only six complete microliths from the excavation, and these are of varied morphologies. The assemblage appears to be a local variant of a Late Palaeolithic industry (Leakey et al., 1972).

Mumba rockshelter is one of the classic East African archaeological sites. The recent dating of the lower part of Bed V through single grain OSL demonstrates another example of early Late Palaeolithic technology in East Africa (Gliganic et al., 2012). In contrast to Mehlman (1989) and Marks and Conard (2009), who saw Bed V as ‘transitional’, recent analyses have regarded it as being an early Late Palaeolithic manifestation (Díez-Martín et al., 2009; Eren et al., 2013). An important point, however, is that geometric microliths are not found in lower Bed V (aside from one possible example, Mehlman, 1989), but only in Upper Bed V (Díez-Martín et al., 2009), which Gliganic et al. (2012) dated to 49.1 ± 4.3 ka by single grain OSL dating of quartz and 47.6 ± 1.8 ka on feldspar. Aside from the presence of low numbers of geometric microliths in Upper Bed V, there is otherwise technological continuity from lower down in Bed V. This again suggests that geometric microliths emerged within an existing Late Palaeolithic industry.

In the case of Enkypaun Ya Muto (Kenya) a similar process of the emergence of microlithic technology in East Africa from the MP occurred (Ambrose, 1998, 2002). The early Late Palaeolithic ‘Saku-tiek’ industry at the site has small frequencies of backed microliths, with thumbnail scrapers and outils écailles (or ‘scaled pieces’) described as being the dominant retouched types (Ambrose, 1998). Alongside these forms, some more classic MP types including discoidal cores and flakes with faceted platforms were recovered. Beneath this a rather different sort of assemblage, described as the ‘Nasampolai Industry’, was found, although it could not be directly dated. This is described as a unique assemblage, but with extremely low artefact densities. In this case backed blades and geometric microliths are an important part of the assemblage, but the excavator specifically emphasises that it “does not closely resemble” the Howiesons Poort (Ambrose, 1998, pp. 383). Beneath this a flake based MP assemblage was found. The recovery of two geometric microliths within this assemblage may indicate mixing, or rather it may demonstrate the development of microlithic technology in an MP context.

The chronology of the East African Late Palaeolithic is described further in SOM 5 and the environmental context in SOM 6. In summary, available evidence suggests the in situ appearance of the Late Palaeolithic around 50–40 ka. To reiterate, H. sapiens were in Australia by this point, so the emerging chronological data suggests that the Late Palaeolithic of East Africa probably tells us little about the initial dispersal of H. sapiens out of Africa. As none of the technology predicted by the Mellars et al. (2013) model has been found over a vast area of southwest Asia (the environmental fluctuation of which is summarised in SOM 7), despite extensive surveys in some areas including those with very narrow coastal shelves such as southern Arabia, the third component of their model relates to South Asia.

2.3. Microlithic technology in South Asia

MIS 3 saw the origin of the Late Palaeolithic in South Asia, which has been seen as either an in situ development or as the result of dispersal into the area. To summarise, there is currently no evidence to suggest that the origin of the Late Palaeolithic in South Asia is characterised by a homogeneous transition of core reduction strategies or the character of retouch (James and Petraglia, 2005). Instead an initial phase of blade and microblade production is followed by a proliferation of microlithic technology around 35 ka, as would be expected with an in situ origin of the Late Palaeolithic. Mellars et al. (2013) argue that earlier Late Palaeolithic sites have been concealed by rising sea levels.

Indian sites such as Patne and Jwalapuram 9 (JWP 9) illustrate incremental changes in lithic technology from the Middle Palaeolithic through to the Late Palaeolithic (LP) layers. James’ (2011) technological analysis of lithics from the site of Patne one of the few long stratified sequences in South Asia, supported the conclusions of the excavators (Sali, 1989) that the LP industries can be seen as emerging locally and gradually out of the preceding MP. Discrete differences do occur between the oldest and youngest of the five horizons at the site, which can be dichotomised as MP and LP respectively. However, attribute analysis of the entire sequence illustrates gradual changes in lithic technology between adjacent horizons, rather than the sudden appearance of microlithic technologies (James, 2011). Similarly, blade use appears to be a continuation of MP technological practices elsewhere in South Asia (Misra and Bellwood, 1985). ‘Upper Palaeolithic’ tool types also appear in MP contexts; for example, burins, end-scrapers and microblades are found in MP layers at Bhimbetka (Misra and Bellwood, 1985). Mellars et al. (2013, pp. 10699) argued that the “most remarkable feature” of the hypothesis of an early onset to dispersal is the apparent claim of a rapid and abrupt origin of microlithic technologies in South Asia. They concluded that the early onset hypothesis emphasise the gradual emergence of the Late Palaeolithic out of the preceding Middle Palaeolithic. The proliferation of microlithic technology from ~35 ka can be seen as a result of environmental deterioration and population increase (SOM 7) (Petraglia et al., 2009).

The recently excavated Middle and Late Palaeolithic sites at Jwalapuram offer a critical case study that has been employed differently by the late and early onset dispersal models. This complex of sites includes the youngest MP sites known from South Asia (JWP 20 (~34 ka), JWP 21 (38 ± 2 ka) and JWP 23 (~55 ka) and one of the oldest Late Palaeolithic sites (JWP 9 [35 ka]). Comparison of these assemblages (Clarkson et al., 2012) demonstrates the presence of blade and microblade technologies in the latest MP sites, and the occurrence of Levalliois/discoidal reduction methods in a Late Palaeolithic assemblage (JWP 9D). The presence of bipolar flaking in the late MP assemblages appears unprecedented in the earlier excavated assemblages at Jwalapuram, but continuity is exhibited with the younger Late Palaeolithic assemblages (JWP 9D-B). The ‘typologically distinct’ backed artefacts, critical to the microlithic dispersal model, are lacking in the oldest assemblage at JWP 9, making their first appearance in JWP 9D. At Jwalapuram the backing of blade blanks appears as a progression from the gradual decline in blades >4 cm long and an increase in blades <4 cm long in MP and LP assemblages.

In the case of the site of Mehtakheri (Misra et al., 2013), Mellars et al. (2013, pp. 10703) described the site as a “typical microblade and backed-microlith industry”. The assemblage is indeed dominated by microblade production, but strikingly only two retouched artefacts have been found. These consist of a backed blade ~40 mm long, and another 25 mm long. In chronological terms the OSL estimates extending to ~45 ka appear reasonably consistent within errors, although there are age/depth reversals, particularly in the vital Unit 2 (Section 1). The sediments are sandy silts/silty sands that have been deposited by fluvial processes. Misra et al. (2013) do not report the size of the multigrain aliquots measured or obtained equivalent dose distributions, which makes it difficult for the reader to evaluate the possibility of partial bleaching of these samples. Ds distributions are not provided for any samples, nor are the size of the aliquots reported. The reader is therefore unable to evaluate the distributions for high skewsness, which may indicate that partial bleaching has occurred, and would therefore necessitate the use of the minimum age model for OSL age calculation. It
must be noted that the discoverers of the site, despite others’ interpretations of the find, actually suggest a variant of the early onset model, with dispersals as far as East Asia in MIS 5 followed by a subsequent dispersal associated with microblade technology (Mishra et al., 2013).

Finally, it can be noted that the early Sri Lankan microlithic assemblages, some of the earliest in South Asia, are generally non-geometric in form. At Batadomba-lena, only 25% of microlithic tools are of geometric forms (Lewis et al., 2014). At Fa Hien, two programmes of excavation have recovered just one geometric form (Deraniyagala, 1992; Perera et al., 2011).

3. The Middle Palaeolithic

A number of recent studies in southwest Asia have argued that Middle Palaeolithic lithic evidence supports particular models for the dispersal of *H. sapiens* from Africa (SOM 1; for a wider consideration of the relationship between the Middle Palaeolithic and behavioural evolution see SOM 8). Aside from making the general point that dispersal is perhaps being overused in some recent narratives, and that the possibility of independent, convergent similarities in similar environmental settings must be considered, we argue that the different models are not necessarily contradictory as our default expectation should be that there were repeated population dispersals when environmental conditions allowed it. It is unlikely that the technology of dispersing populations would have remained identical to that of the parent populations, a factor which both problematizes perceived differences between assemblages in different regions and warns against the over-interpretation of superficial similarities (SOM 9).

Before considering in detail the evidence for the dispersal of *H. sapiens* out of Africa, an important feature of the MP record is the continuation of sites down to ~30 ka or younger (Fig. 3). These sites are found across southern Africa, along the Rift Valley and in the Middle East through to India. While some of the Middle Eastern examples are known to have been produced by Neanderthals, it is unlikely that all examples, in places like southern Africa, reflect archaic hominins. If, as seems highly likely, many of these late MP sites reflect the presence of *H. sapiens*, then the notion of a dramatic and irreversible change in human behaviour ~80–50 ka should be questioned. The late persistence of the MP is congruent with a model in which microlithic/geometric technologies emerged in situ in various spatial and temporal contexts during the Late Pleistocene. The same applies to ‘Upper Palaeolithic’ variants of the Late Palaeolithic, which several Asian sites appear to clearly demonstrate emerging in situ from preceding MP assemblages. This is most clear at sites such as Boker Tachtit (Volkman, 1989), and similar arguments have been made about sites including Warwasi Cave, Iran (Tsanova, 2014).

4. The Middle Palaeolithic (Middle Stone Age) of Africa

4.1. The Middle Palaeolithic of South Africa

In recent years the description and interpretation of archaeological sites in South Africa has generated considerable scientific interest. Given that more than 5000 km separates many of these

---

`Fig. 3. Location of key dated Late Middle Palaeolithic sites.`
sites from the nearest point of Asia, South African sites are not directly relevant to understanding ‘out of Africa’ dispersals. However, this is not to say that they are not of considerable importance for understanding Late Pleistocene human behaviour. A number of publications describe the Late Pleistocene cultural sequence in southern Africa (e.g. Porraz et al., 2013; Wurz, 2013; Mackay et al., 2014a). The key point to emerge from the South African data, discussed below, is that it follows a unique cultural trajectory and differs from areas such as East Africa. For example, to Porraz et al. (2013) the long record of Diepkloof reflects local changes, with no evidence for major influxes of new populations. Wurz (2013) likewise emphasises the localised nature of cultural evolutionary trajectories in South Africa. As described in SOM 1, Clarkson has used Discriminant Function Analysis to suggest similarities between South African and South Asian Middle Palaeolithic core forms (Petraglia et al., 2007; Clarkson et al., 2012). Given the huge distance separating assemblages in these two areas, it is possible that the perceived similarities reflect convergent evolution or that further assemblages from East Africa need to be included in comparisons.

In general, in South Africa during at least the earlier to middle part of MIS 5 there seems to have been much more unidirectional/unidirectional convergent Levallois reduction, producing flakes and points, than in East Africa (e.g. Porraz et al., 2013; Wurz, 2013). This is at least the case for some of the well-known sites but, as Mackay et al. (2014a), discuss there is considerable spatial variability across South Africa, and these authors doubt the utility of technocomplex definitions across large areas given the technological heterogeneity observed. The much discussed Howiesons Poort and Still Bay technocomplexes are associated with late MIS 5 through to MIS 3 (e.g. Henshilwood, 2012). The Still Bay is typified by bifacial foliate points. While in a sense reflecting the frequent African Middle Palaeolithic focus on producing retouched points, the dominance and particular characteristics of Still Bay points distinguishes them from those of assemblages in areas such as East Africa (e.g. Villa et al., 2009).

As discussed above, the Howiesons Poort reflects another unique technocomplex, combining Middle Palaeolithic forms with other features such as backed geometries. But there is also increasing evidence for variability within the Howiesons Poort. After the Howiesons Poort, more classically Middle Palaeolithic assemblages occur in South Africa (e.g. Will et al., 2014; Mackay et al., 2014b). These late Middle Palaeolithic assemblages are technologically varied and further research is needed to understand the spatial and temporal characteristics of this variability.

4.2. The Middle Palaeolithic of East Africa

The oldest known fossils of H. sapiens come from East Africa (e.g. White et al., 2003; McDougall et al., 2005; Smith and Ahern, 2013; Stringer, 2014). Along with congruent biogeographical and archaeological data, this has led to suggestions that this area had an important role in the origin of our species (e.g. Basell, 2008; Shea, 2008a). The key characteristic of the East African Middle Palaeolithic in comparison to the preceding Lower Palaeolithic and to contemporaneous forms of MP assemblages is the character of Levallois methods, and particularly high frequencies of the combination of recurrent centripetal and centripetally prepared preferential methods (SOM 10) (Fig. 4). MP preferential Levallois methods in East Africa are generally focussed on the production of ovoid/rectangular Levallois flakes. Levallois methods of producing points were also used, but much less frequently. As Levallois technology occurs in certain Lower Palaeolithic contexts, it is the diversification of Levallois methods and largely the frequent use of the recurrent centripetal method which distinguishes the East African MP (e.g. Tryon, 2006). Shea (2008a, pp. 473), in a detailed analysis of East African MP technology, summarises core reduction in the studied assemblages as reflecting alternation between recurrent centripetal and preferential reduction. These specific features are lost when variability is grouped into general categories such as ‘Levallois’, or ‘prepared core technology’. For instance, ‘Levallois blade’ reduction found in areas such as South Africa appears to be absent in East Africa (Tryon and Faith, 2013). The disparate ways in which recurrent centripetal Levallois reduction has been understood (e.g. Boëda, 1994, 1995; Delagnes and Ropars, 1996; contra Usik et al., 2013), mean that for the majority of sites in East Africa its presence or absence is currently unknown (Tryon and Faith, 2013).

Examples of recurrent centripetal Levallois cores have been described in the literature as discoidal cores, asymmetric discoidal cores, disc cores, radial cores, and other terms. Given such factors and the lack of good chronological resolution we are forced to rely on a small number of dated and recently excavated sites to evaluate the character of the East African Middle Palaeolithic.

While there is variability, East African Middle Palaeolithic retouched tools are typically characterised by the dominance of three basic forms: side retouched flakes (forming ~30–60% of the retouched tools), denticulates (~10–30%) and retouched points (~10–30%) (e.g. SOM 10). Given the recurrent centripetal method, on retouched tools (sensu e.g. Scerri, 2013a; Scerri et al., 2014a), analysts are currently forced to rely on such published descriptions of whole tools. The frequencies of these forms at key sites in East Africa, and those argued to relate to dispersal from this area, are shown in SOM 11. The key point is not the exact frequency of these tool forms, but the dominance of these basic types and the rarity of others. For instance, large bifaces, end retouched flakes (‘end-scrapers’) and burins are generally rare.

Despite the limitations of available data, a number of assemblages in East Africa clearly demonstrate the presence of a similar set of typological and technological features, described above, beginning by MIS 8 and continuing through to MIS 5 and beyond (e.g. Wendorf and Schild, 1974; Clark, 1988; Tryon and McBrearty, 2003; Tryon et al., 2005; Yellen et al., 2005; McBrearty and Tryon, 2006; Onjala, 2006; Waweru, 2007; Basell, 2008; Tryon et al., 2008; Shea, 2008a; Sahle et al., 2013; Mussi et al., 2014). Previous authors have highlighted the continuity of the Middle Palaeolithic in East Africa (e.g. Wendorf and Schild, 1974, pp. 154; Shea et al., 2007; Shea, 2008a). As further sites are discovered and additional chronometric estimates become available the picture of continuity becomes even more pronounced. For example, Shea (2008a) emphasises the similarities between East African assemblages between roughly 200 ka and 80 ka. The earlier and later ends of this spectrum are represented by Gademota and Porc Epic respectively, with recent research suggesting that the former may actually date to as recently as ~40–30 ka (Assefa, 2006) and, rather more reliably given the ambiguities of the chronology of Porc Epic, the earliest site at Gademota dates to ~280–275 ka (Morgan and Renne, 2008; Sahle et al., 2014). Shea (2008a) suggests that the small differences between the Omo Kibish sites he analysed and other, similar, assemblages such as those from Aduma probably reflect raw material differences. Wurz (2013, pp. 6900) repeats the point that this evidence “may indicate that H. sapiens populations used relatively similar technological strategies throughout southern and central Ethiopia between 80 and 200 ka”. In what follows we therefore review evidence for the spatial and temporal distribution of lithic assemblages similar to those from East Africa as a possible proxy for population movements (SOM 10 discusses the presence and implications of different forms of technological packages elsewhere). This distribution of sites is shown in Fig. 5. We emphasise that we do not claim that such similarities prove the early onset model, but they are certainly consistent with it.
4.3. The Middle Palaeolithic of Northeast Africa

As discussed above, increasing evidence suggests that the industrial terms traditionally used to describe North African technological variability are obfuscating important patterns of similarity and difference. When viewed in terms of core reduction methods, the basic characteristics of retouched tools and other attributes, a number of North African assemblages demonstrate clear similarities with the East African Middle Palaeolithic. Alongside these, assemblages attributed to the Nubian Complex and Aterian could be interpreted as localised adaptations to the specific ecological conditions of North Africa, both developing from sub-Saharan backgrounds.

The technological diversity of northeast Africa (e.g. Marks, 1968a,b; Van Peer et al., 2010; Scerri, 2013a; Scerri et al., 2014a,b) is predictable given that the area is proximal to the only land route out of Africa and that dramatic environmental oscillations occurred (e.g. Blome et al., 2012; Drake et al., 2013). Recent attention has focussed on the ‘Nubian Complex’ (e.g. Van Peer, 1998; Rose et al., 2011), but the extent to which much of the archaeology of the area can meaningfully be subsumed in such a technocomplex has been debated (e.g. Kleindienst, 2006). Examples of problems with the Nubian Complex include the frequent inclusion of locations at Bir Tarfawi, one of the few localities with multiple dated sites in northeast Africa, in the ‘Nubian Complex’ (e.g. Rose et al., 2011; Wurz and Van Peer, 2012; Clarkson, 2014), despite no Nubian Levallois reduction being identified there (Wendorf et al., 1993).

The early MP in northeast Africa is poorly understood. Hawkins et al. (2001) report a site (REF–4) at Kharga Oasis in Egypt dating to ~220 ka. Likewise, the earliest MP at Bir Tarfawi is not well characterised (Wendorf et al., 1993). A clearer picture emerges from sites dating to MIS 6 at ~175 ka, such as E–87–1, E–86–1 and E–87–4 (Wendorf et al., 1993). This MIS 6 expansion correlates with a phase of increased humidity (see e.g. Drake et al., 2013). These sites are technologically similar to those from East Africa, suggesting northwards expansions correlating with environmental amelioration.

A number of northeast African MIS 5 sites continue to demonstrate similarities with the East African MP. Key examples come from the MIS 5 Bir Tarfawi and Bir Sahara palaeolakes of...
southwestern Egypt (Fig. 6). As described and illustrated in considerable detail by Wendorf et al. (1993), these assemblages feature a combination of preferential and recurrent Levallois methods and retouch focussed on producing side retouched flakes, denticulates and variable frequencies of points. It is important to note that compared to the MP of East Africa, there is already a considerable reduction in the frequency of points, and this helps contextualise the rarity of retouched points in areas such as the Levant. Some of this change in the specifics of retouched flake typology may reflect the raw material available in areas such as Bir Tarfawi/Bir Sahara, consisting of coarse quartzitic sandstone. Aside from the influence of raw material on variability, these sites also serve as important reminders of the need to carefully consider mobility and settlement patterns when comparing lithic assemblages. At Bir Tarfawi/Bir Sahara cores were generally initially prepared elsewhere and subsequently transported close to these lakeside sites, where further knapping was conducted. Following this, many cores, Levallois flakes and retouched tools were removed, giving these assemblages distinctive characteristics such as low frequencies of cores.

Other, more or less undated, assemblages in northeast Africa are also similar to the East African MP. Examples include the site of Station One (1013) in northern Sudan, which features a quartz assemblage rather different to most nearby sites, and exhibits both the core reduction strategies and the retouched tool forms typical of East Africa (Fig. 7). Rose (2004) who analysed the assemblage likewise saw it as evidence for the northwards expansion of an East African population.

The Khormusan industry was discovered at several excavated sites in northern Sudan (Marks, 1968b). As well as large lithic assemblages (Fig. 7), these sites produced other finds including ochre and bone tools. Unfortunately the age of the Khormusan assemblages is unclear, but Goder-Goldberger (2013) argues that they begin in late MIS 5. In terms of the technological characteristics of the Khormusan, both preferential and recurrent centripetal Levallois methods occur at high frequencies alongside other methods such as the reduction of simple single platform cores (Goder-Goldberger, 2013). Both the debitage and retouched tools are likewise similar to the East African MP. Such factors led Goder-Goldberger (2013) to describe the Khormusan as an ‘MSA East African industry in Nubia’. The younger Khormusan sites demonstrate a process of localisation, with, for example, side retouched flakes largely being replaced by burins. Sites such as 1035 (Fig. 7) may represent a variant of the Khormusan located somewhat further from the Nile (Goder-Goldberger, 2013). Further south in Sudan, ongoing research is revealing lithic assemblages similar to both the Khormusan and the East African MP (Osypinski et al., 2011; Osypinski, 2012).
A final northeast African site of interest is that of Haua Fteah, Libya. Ongoing work is clarifying the nature of the lithic assemblages at the site, but published illustrations appear to show lithics with the same basic features we highlight as characterising the East African MP (e.g. McBurney, 1967, pp. 116, 122, 124). Reynolds (2013) suggests similarities of the Haua Fteah lithics to assemblages in the Levant and northeast Africa, rather than North African technocomplexes such as the Aterian or the Nubian Complex, matching Scerri’s (2013a) observation of the distinctiveness of Haua Fteah compared to the other sampled sites. Available evidence suggests the absence of the type fossils of the Aterian and Nubian Complex from Haua Fteah. Douka et al. (2013) report a multi-technique dating programme of the site, showing that the MP at the site is present by MIS 5 and extends through to MIS 3.

4.4. Northwest Africa

As our focus here is on dispersal out of Africa, space prevents a thorough discussion of the northwest African record. Most research in this area has addressed the Aterian technocomplex (e.g. Bouzouggar and Barton, 2012; Scerri, 2013a; Scerri et al., 2014a). Traditional attention has focussed on the typology of retouched artefacts (e.g. Tixier, 1967), particularly tanged tools, with recent interest extending to bifacial foliates. Relatively little information is available on the core reduction strategies at most Aterian sites. Likewise, little information is available on the technology of pre-Aterian MP sites such as Jebel Irhoud. We acknowledge that it is quite possible that the Maghreb played an important role in the background to dispersal out of Africa, but it is hard to evaluate this with available data.

Fig. 6. Examples of lithics from several phases of occupation at Bir Tarfawi, Egypt. Preferential Levallois flakes with centripetal preparation (A,B,G,H,M), side retouched flakes (C, I), retouched points (D, J,N,O) and Levallois cores (E,F,K,L,P,Q) including many showing a recurrent centripetal method (illustrations modified from Wendorf et al., 1993).
One of the few sites where good information is available is that of Ifri N’Ammar, which has been described in a detailed monograph (Nami and Moser, 2010). The earlier Middle Palaeolithic at the site dates to MIS 6, and may reflect dispersal across the Sahara during wet periods of this generally arid phase. Core reduction is heavily Levallois and appears similar to that of East Africa, with both preferential and recurrent centripetal methods being well represented. Moving beyond a traditional type fossil approach, it must be emphasised that ‘Mousterian points’ are far more abundant than tanged points at Ifri N’Ammar, and that the latter can be seen as a

sub-type of a wider category of retouched points. Similar reduction and retouch characteristics also seem to characterise other Maghrebian sites such as Contrabandiers (e.g. Dibble et al., 2013a). Given these technological similarities, it can be argued that the Aterian represents a regional variant of a technological package first seen in East Africa. Tanging can be seen as a particular form of hafting modification (Scerri, 2013b), developing within an existing pool of knowledge and techniques rooted in sub-Saharan Africa.


Fig. 8. Lithics associated with a possible MIS 6 expansion of Homo sapiens into the Levant. All lithics from Nesher Ramla except B (Hayonim, Upper E). A,B: Levallois cores, C: Levallois flake, D: side retouched flake, E,F: retouched points (illustrations modified from Meignen, 1998; Zaidner et al., 2014).
Sites along possible routes between East and northwest Africa, such as Adrar Bous in Niger, demonstrate a similar constellation of lithic traits. The Adrar Bous MP assemblages combine recurrent centripetal and preferential Levallois reduction methods, with retouch focussing on points and side retouched flakes (Clark et al., 2008).

5. The Middle Palaeolithic of southern Asia

5.1. The Middle Palaeolithic of the Levant

Most of our knowledge on prehistory in Southwest Asia currently comes from the Levant, which has a diverse MP record (e.g. Shea, 2003, 2013; Hovers, 2009; Groucutt, 2014), suggesting that researchers should stop referring to different phases of the Levantine MP as having “the same type of Middle Palaeolithic assemblage” (Dennell and Porr, 2014, pp. 5). On the whole the early Levantine MP is not well understood, and fossil evidence to identify its manufacturers is weak. The Middle (or ‘interglacial’) Levantine Middle Palaeolithic is particularly associated with MIS 5, but also with MIS 6, and demonstrates technology similar to the East African MP, and is found exclusively with fossils of H. sapiens. After MIS 5 the Levantine Late Middle Palaeolithic is only found with Neanderthal fossils, and appears to reflect the arrival of new populations from the north, which were both biologically and culturally different from the MIS 5 occupants. We see the Levantine Late Middle Palaeolithic as a regional manifestation of what we label the Southern Neanderthal Dispersal (SOM 10). An example of a site attributed to this is that of Tor Faraj, Jordan (Henry, 2003; Groucutt, 2014).

Zaidner et al. (2014) report an important new site (Nesher Ramla) from the Levant. The site appears to span MIS 6 to late MIS 5, although as the artefact bearing sediments at the site have been deposited through processes such as slope wash there is a risk of partial bleaching of grains and age overestimation. While more information on the site is needed, some basic patterns are of importance. In terms of Levallois flaking, the early assemblages are dominated by centripetal Levallois, while the younger assemblages are dominated by unidirectional-convergent flaking. Along with similar chronologies and perhaps technologies from sites such as Tabun and Hayonim Upper E (Mercier et al., 2007), the Nesher Ramla evidence may suggest an earlier (MIS 6) onset to the
technological traits classically regarded as characterising MIS 5 in the Levant (Fig. 8). The chronology of these sites matches the MIS 6 wet phase that saw northwards expansions of populations in Africa (e.g. Wendorf et al., 1993; Drake et al., 2013).

Several Levantine assemblages dating to MIS 5 resemble the East African MP, including some associated with *H. sapiens* fossils. Key sites include Qafzeh, Skhul, Naame, Tabun, Hayonim, Ras el Kelb, Dourara, and Umm el Tel (e.g. Shea, 2003, 2013; Hovers, 2009). The site of S-20 (the ‘Split Rock Site’) from the Sinai Peninsula appears to provide a land connection between similar African and Levantine assemblages (Kobusiewicz, 1999; Kobusiewicz et al., 2001). The site is rarely discussed in the literature, but from the perspective of the present paper is possibly a very important locality. As elsewhere, its similarities with other sites are obscured by variable nomenclatures. For instance, ‘discoidal’ cores are very common at the site. But from the illustrations in Kobusiewicz (1999) it is clear that at least some of them can actually be described as Levallois cores. Forms of Levallois reduction present include recurrent centripetal and preferential with centripetal preparation (Fig. 9). Likewise, ‘perforators’ at the site can alternatively be seen as retouched points. Clearly more research is needed on the site and the assemblage, but it is certainly consistent with the hypothesis proposed in this paper (Fig. 9). The buried lithics, with horizons dated to ~60 ka and ~80 ka (Kobusiewicz et al., 2001), had been redeposited down slope after the occupation so an MIS 5 age at Qafzeh Cave; 1) the frequency of side retouched flakes (‘sidescrapers’) decreases, 2) the frequency of retouched points decreases and 3) the frequency of notches/denticulates increases. The earlier assemblages at Qafzeh are therefore more similar to the East African MP than the later ones are. An important transition point seems to be around layer XIV/XV. This is when notches/ denticulates generally become dominant over side retouched flakes. Layer XV is also of interest as this is very unusual for Qafzeh in having a large number of Levallois points, the frequency of which rapidly increases and then rapidly decreases. This phase of point production may correlate with an arid phase (cf. Shea, 1998) that resulted in demographic changes affecting lithic technology, as well as numerous other factors indicating changes in how the site was used (Hovers, 2009, pp. 36–37). The technological changes largely relate to retouched tool typology, and in terms of core reduction strategies there appears to be basic continuity. This suggests that retouched typology may be more sensitive to local adaptation or drift (Scerri et al., 2014a), as indicated above in terms of the increase in the frequency of burins in northeast Africa, and the decrease in the frequency of retouched points away from East Africa, while core technology stays more constant.

Qafzeh Cave, with its famous *H. sapiens* fossils, has been published in considerable detail (Hovers, 2009) and so will form the basis of our discussion, while noting the basic similarity of lithics from the site with many others from the area. Qafzeh dates to mid (electron spin resonance dates) to later (thermoluminescence dates) MIS 5 (Millard, 2008). With multiple layers, Qafzeh is a rare example allowing the study of the nuances of change through time in a southwest Asian example of an assemblage similar to the East African MP (Figs. 10 and 11).

Levallois reduction dominates the Qafzeh Cave assemblages. Levallois cores are technologically and morphologically similar to cores from East Africa (Fig. 10). Recurrent and preferential cores at Qafzeh are similar in basic size and shape features, indicating that the differences between them do not relate to reduction intensity (Hovers, 2009). As shown in Fig. 11 some interesting changes in retouched tool technology and morphology occurred over time at Qafzeh. While there is some fluctuation due in part to variable sample sizes, three important trends can be seen with decreasing age at Qafzeh Cave; 1) the frequency of side retouched flakes (‘sidescrapers’) decreases, 2) the frequency of retouched points decreases and 3) the frequency of notches/denticulates increases. The technological changes largely relate to retouched tool typology, and in terms of core reduction strategies there appears to be basic continuity. This suggests that retouched typology may be more sensitive to local adaptation or drift (Scerri et al., 2014a), as indicated above in terms of the increase in the frequency of burins in northeast Africa, and the decrease in the frequency of retouched points away from East Africa, while core technology stays more constant.

A final point to be made in regards to the Levantine MIS 5 evidence relates to the geographical distribution of sites (Fig. 5). It is commonly implied that *H. sapiens* in the Levant dispersed from Africa by the shortest possible straight line (see e.g. Stewart and Stringer, 2012). While not an unreasonable hypothesis, this pattern
is not supported by the fact that ‘Tabun C’ or ‘Middle (MIS 5) Middle Palaeolithic’ sites — i.e. those in the present paper which are described as being similar to those from East Africa — are relatively common in the northern and central, but apparently rare in the southern, Levant. Likewise the presence of East African MP-like assemblages in Syria at sites such as Douara, Hummal and Umm el Tlel may suggest a connection of the Levantine occupation to the Tigris—Euphrates river system. This may indicate that populations leaving Africa primarily moved initially eastwards through Arabia, before moving northwards to the Levant along the Tigris—Euphrates river system. Given the persistence of arid areas even during peak interglacials (Jennings et al., in this volume) such riverine corridors may have been crucial corridors through the Saharo-Arabian belt (Drake et al., 2011; Scerri et al., 2014a; Breeze et al., 2015).

5.2. The Middle Palaeolithic of Arabia

The rapid acceleration of research in Arabia allows this area to now be factored into accounts of dispersal out of Africa (e.g. Groucutt and Petraglia, 2012, 2014; Scerri et al., 2014b). The first phase of recent developments focussed on the southern and eastern extremities of the Peninsula. These revealed assemblages interpreted as either autochthonous developments (Armitage et al., 2011; Delagnes et al., 2012), or as being broadly similar to the African MSA (Armitage et al., 2011), or to the ‘Nubian Complex’ (Usik et al., 2013). Research in Saudi Arabia being conducted by the Palaeodeserts Project is revealing a number of assemblages, dating to MIS 5 where they have been dated, which demonstrate similarities with the East African MP (Fig. 12).

The assemblages at Jebel Barakah in the western UAE appear from published illustrations to include high frequencies of recurrent centripetal Levallois reduction and other features common in East African MP assemblages (Fig. 12) (McBrearty, 1993; Wahida et al., 2009). Similar assemblages are known from other surface contexts in the eastern UAE (Scott-Jackson et al., 2009), and perhaps from the excavations at Jebel Faya. In the case of Jebel Faya, the recent paper by Bretzke et al. (2014) supplements earlier descriptions of lithic technology at the site (Armitage et al., 2011) and allows for a more robust consideration of the site within the model proposed here. Bretzke et al. (2014) report a series of six assemblages. The oldest, VI (n = 477), was deposited in MIS 5 and is characterised by centripetal Levallois reduction along with a bifacial reduction strategy. Illustrations show both recurrent centripetal and preferential with centripetal preparation core forms. Such reduction methods, dating to MIS 5, are clearly congruent with the hypothesis of East African population expansion proposed here, but
the significance of the bifacial component requires further clarification. The younger (post-MIS 5) assemblages at Jebel Faya show a diversity of typo-technological features, congruent with population fragmentation and complex demographic processes.

In Saudi Arabia, knowledge on vast areas is limited to rapid reconnaissance surveys conducted during the 1970's. The reports of these surveys hint at East African-like assemblages across Saudi Arabia, as suggested by many of the illustrations of these surveys published in the journal Atfal. In particular, Zarins et al.'s (1979) survey of central Saudi Arabia revealed assemblages dominated by what they referred to as the ‘discoidal core with flat back’. Many of these appear to be recurrent centripetal Levallois cores (Fig. 12).

Some assemblages from Jubbah in the Nefud desert of northern Saudi Arabia likewise resemble the East African MP (Petraglia et al., 2011, 2012a). Several assemblages have been identified here which display considerable differences between each other, even within a small geographic area (Scerri et al., 2014b). The most important assemblage for our present discussion is the site of Jebel Qattar-1. Here a small assemblage of only 114 lithics is associated with a calcarete/incipient palaeosol dating to ~75 ka (Petraglia et al., 2011, 2012a). Core forms reflect centripetal reduction, including recurrent centripetal Levallois, while retouched types include a retouched point and side retouched/denticulated flakes (Fig. 12). Preferential Levallois flakes are centripetally prepared and ovoid/rectangular in shape.

Many of the other sites at Jubbah relate mostly to raw material procurement, so have broadly unidirectional cores and few retouched tools, making understanding their background difficult. Sites in this category include JFK-1 and JFK-12. These can be seen as rather different to most East African assemblages, but whether this reflects cultural factors or represents raw material procurement and only an early stage of reduction remains to be fully understood. Scerri et al. (2014b) compared assemblages from Jubbah to assemblages from the Nile Valley using a suite of multivariate statistics. Their results demonstrate that the North African and Arabian sites do not neatly separate into their respective geographical areas. This result indicates that lithic variability within the Sahara-Arabian belt does not match modern political structures, and is congruent with a northeast African background of the makers of at least some of the Jubbah assemblages. The site of JSKM-1 is rather different to the other sites at Jubbah included in this study, and along with QJ-1, provides the closest parallels to the East African MP (Petraglia et al., 2011, 2012a; Scerri et al., 2014b).

Ongoing work at the Mundafan Palaeolake in southwestern Saudi Arabia is revealing an abundant Middle Palaeolithic record. An initial visit reported by Crassard et al. (2013) identified MP assemblages characterised by both recurrent centripetal and preferential centripetal Levallois reduction (Fig. 12). Rosenberg et al. (2011) dated lake formation, with which the MP sites are associated, to MIS 5. Additional recent discoveries at Mundafan resulting from a longer period of fieldwork are currently being analysed and written up, and strengthen the case for similarities with the East African MP.

Finally, as discussed by Scerri et al. (in this volume), Middle Palaeolithic sites in the western Nefud desert also feature characteristics analogous to the East African MP. A particularly important example is found at the site of KAM-1, which was previously dated to MIS 5 by Rosenberg et al. (2013). The lithic assemblage at this site, while again small, is dominated by the key forms also found in the East African MP.

Other forms of the Middle Palaeolithic in Arabia represent distinctive phenomena, with unclear cultural ancestry (e.g. Armitage et al., 2011; Delagnes et al., 2012; Bretzke et al., 2014). Whether the ‘Nubian Complex’ sites of Arabia, which are essentially undated other than one minimum age estimate for redeposited lithics at one site (Rose et al., 2011), represent dispersal or are a convergent local development remains to be tested. The rich, but undated, archaeological record of the Huqf area of Oman presents another distinctive variant of the Arabian Palaeolithic (Jagher, 2009). The fast changing picture of the Arabian Middle Palaeolithic (Groucutt and Petraglia, 2012, 2014) therefore suggests repeated dispersals into the Peninsula, with subsequent aridification and contraction to refugia leading to distinctive forms of technology. Within this pattern we emphasise the evidence for East African MP-like technology, found in southwest, central and northern Arabia. Its apparent absence from southeast Arabia may reflect the fact that increasing evidence suggests the amelioration of Arabia occurred due to the incursion of the African rather than Indian Ocean Monsoon (Jennings et al., in this volume). As a result, southeast Arabia may have remained generally arid, with population movement focussed on the west to east trending rivers of central Arabia.

5.3. The Middle Palaeolithic of Iran

The Middle Palaeolithic of Iran remains poorly understood, but is another area of great importance where research is accelerating (e.g. Otte et al., 2009; Vahdati-Nasab, 2011; Vahdati-Nasab et al., 2013; Heydari-Guran, 2014; Speth, 2014). Changing conceptions of the MP of Iran include the recognition that some assemblages include Levallois technology (Dibble, 1984; contra Skinner, 1965). The increasing knowledge of the Iranian MP is being matched by its increasing diversity. This diversity makes it unlikely that the whole of the MP of Iran was produced by Neanderthals, as has traditionally been suggested (e.g. Smith, 1986). We consider a more parsimonious explanation to be that the considerable Middle Palaeolithic technological diversity in Iran reflects, at least in part, a complex demographic history. Until recently, little was known about the MP outside the Zagros Mountains, and here analyses were focussed on a Bordesian approach. Not much progress was made on clarifying either the variability within Iran, or how this related to surrounding regions.

The sites of the more southern Zagros area, such as Kunji Cave, demonstrate technological traits similar to the East African MP (Fig. 13). Core technology is dominated by recurrent centripetal Levallois cores, while the presence of large ovoid preferential Levallois flakes demonstrates preferential Levallois reduction. Around two-thirds of Levallois flakes exhibit centripetal scar patterns (Baumler and Speth, 1993). The dominant retouched component consists of sidescrapers, notches/denticulates and retouched points (Baumler and Speth, 1993). Other sites such as Houmian (Bewley, 1984) and Bistun Cave (Dibble, 1984) may reflect a similar technological package. Others, such as Shanidar in closely neighbouring northern Iraq (Solecki and Solecki, 1993) and Warwasi Cave, Iran (Dibble and Holdaway, 1993; Groucutt, in preparation) appear to demonstrate a rather different form of technology, attributed here to the Southern Neanderthal Dispersal (SOM10). The heavily retouched character of the Zagros Middle Palaeolithic has tended to dominate discussions, but considerable differences can be seen in terms of factors such as core reduction strategies. In this sense technology at Warwasi is primarily characterised by a combination of largely unidirectional reduction in the early phase followed by the reduction of discoidal cores and cores on flakes. The centripetal Levallois cores that dominate the Kunji assemblage are all but absent from Warwasi. Understanding the character of this emerging technological variability in Iran is currently limited by the paucity of chronometric age estimates for Palaeolithic sites.

5.4. The Middle Palaeolithic of South Asia

South Asia has a long history of Palaeolithic research resulting in the identification of a large number of surface Middle Palaeolithic
sites (e.g. Misra, 2001; James and Petraglia, 2005). Due to the limited number of excavated sites, the chronology of the South Asian MP remains poorly resolved. The recently excavated site of Katoati (Blinkhorn et al., 2013) presents the oldest dated Middle Palaeolithic assemblage at ca. 96 ka, with further MIS 5 to MIS 3 occupations evident at this site. Continued presence of Middle Palaeolithic assemblages from MIS 5 and into MIS 3 is also observed at Jwalapuram (Clarkson et al., 2012; Petraglia et al., 2012b) and at a number of sites in the Thar Desert (Blinkhorn et al., 2013; Blinkhorn, 2014). At these sites, Middle Palaeolithic assemblages combine Levallois and discoidal debitage schemes with a wide range of retouch strategies and a focus on higher quality raw materials that appear in smaller clast sizes than those exploited by Late Acheulean populations. The variability of point production methods is particularly notable, including both debitage (various Levallois methods) and façonnage (uni- and bifacial retouching, 

shouldering and tanging) approaches. As Blinkhorn et al. (in this volume) discuss, point technology is abundant in the Thar Desert, and this arguably parallels aspects of technology associated with *H. sapiens* to the west. Some forms of point core technologies in the Thar Desert exhibit preparation of flaking surfaces similar to Nubian Levallois technology as defined to the west (Blinkhorn et al., 2013; Blinkhorn, 2014). The differences may reflect the use of lower quality raw materials in the Thar Desert. Although the number of well dated sites currently prohibits an analysis of spatial diversity within the Middle Palaeolithic of South Asia, evidence of diachronic trends, such as the emergence of blade production, are evident (e.g. Misra, 1982) particularly in MIS 3 dated contexts (Blinkhorn, 2014).

In the case of India, Middle Palaeolithic sites are abundant, but have seen little chronometric dating, environmental contextualization or comparative lithic analyses. Important sites include Jwalapuram 22 (JWP 22) (Haslam et al., 2012). This has produced a reasonably large lithic assemblage securely stratified beneath the ~74 ka tephra of the Youngest Toba Tuff (Fig. 14). Along with OSL estimates clustering around 85 ka from the archaeological layer itself, the occupation is well dated to MIS 5a. The technology at this site is similar to the East African MP, with core types such as recurrent centripetal Levallois cores being frequent (Clarkson et al., 2012). Other types, such as single platform cores, are the largest core type at the site but may merely represent cores that were not extensively reduced (Haslam et al., 2012), rather than representing particular reduction methods as such. Discoidal cores at JWP 22 appear to represent heavily reduced cores. Retouched types at JWP 22 are dominated by side retouched/denticulated flakes, and several retouched points are present (Haslam et al., 2012). None of the features found in assemblages associated with either the Southern Neanderthal Dispersal or the Northern Neanderthal Dispersal (SOM 10) are found in Indian Middle Palaeolithic sites, suggesting that populations dispersed eastwards in a basically longitudinal manner. The current lack of evidence for Neanderthals in monsoonal regions may, hypothetically, reflect the fact that the lighter build of *H. sapiens* may have been advantageous in hot and humid settings.

The available evidence suggests a tendency away from East African-like features to more localised forms of technology, which as discussed above, gave rise to the Late Palaeolithic of South Asia (e.g. James and Petraglia, 2005; Jones and Pal, 2009; Clarkson et al., 2012). This occurred after MIS 5, and the basic pattern of technological continuity before and after the Toba eruption has been described in several publications (Petraglia et al., 2007; Jones and Pal, 2009; Haslam et al., 2012; Clarkson et al., 2012; Jones, 2012). At Jwalapuram “virtually identical” recurrent centripetal Levallois cores are found at JWP 22 (below Toba ash) and JWP 3b and JWP 20 (post Toba) (Clarkson et al., 2012, 170).
6. Discussion and conclusions

In this paper we have conducted the first detailed review of lithic evidence relating to two of the major models for the dispersal of *H. sapiens* out of Africa. Available evidence suggests that there is no lithic ‘smoking gun’ for dispersal out of Africa. There are, however, patterns which can be used to construct hypotheses to be tested by interdisciplinary studies. The identification of similarities between lithic assemblages does not provide automatic evidence for dispersal, given the diverse factors which influence lithic technology and morphology. Likewise, colonisation events are often marked by radical changes in technology, so the detection of differences does not necessarily disprove demographic or cultural connections.

Available evidence suggests that geometric and microlithic technologies repeatedly developed independently. Beyond superficial similarities, differences are found in all aspects of microlithic/geometric technology from the core reduction methods employed to the character of the retouched component, as well as the chronology of when these technologies emerged. Both East Africa and South Asia present strong evidence for the in situ emergence of the Late Palaeolithic. In the case of South Asia, for instance, blade technology appears in the Middle Palaeolithic contexts. The earliest South Asian microliths are non-geometric in form. One must ask, why, if there was a dispersal of microlith-using people from Africa, they apparently stopped making geometric microliths on their microblades for the first few thousand years of their occupation of South Asia. Problematically, the lithic methodology of Mellars et al. (2013) appears to be largely based on the superficial comparison of one component of retouched tool forms, in contrast to the dominant trajectory in lithic analysis over the last 30 years. For example, their analysis is based on literature review and the comparison of selected lithic illustrations, with the broadly similar shapes of the selected artefacts regarded as self-evidently demonstrating demographic or cultural connectivity. Such an approach ignores not only recent research in areas such as South Africa and South Asia almost entirely, but also the large literature on microlithic technologies in particular (e.g. Elston and Kuhn, 2002; Hiscock et al., 2011; Leplongeon, 2014). The hypothesis of technological convergence (analogy) rather than dispersal/cultural diffusion (homology) for the distribution of geometric and microlithic assemblages is testable, both by further fieldwork to recover excavated and dated assemblages and by detailed comparative studies.

Mellars et al. (2013) claim that key evidence in favour of their model is underwater on now flooded coastal shelves. In Arabia and South Asia hominins were living inland at the time cited by Mellars et al. (2013), and interior areas were therefore demonstrably habitable (Groucutt and Petraglia, 2012; Parton et al., 2013). Likewise, once people reached Sahul they rapidly expanded to a diversity of landscapes from mountains to deserts (e.g. Clarkson, 2014, pp. 83). Similarly, *H. sapiens* were far inland in Laos by ~60–50 ka (Demeter et al., 2012). Given these findings, even if future discoveries suggest the dispersal of populations carrying microlithic and geometric technologies out of Africa ~60–50 ka this is unlikely to reflect the initial colonisation of southern Asia by *H. sapiens*. Even if evidence is found to support such dispersals, they are likely to merely represent one phase of repeated dispersals out of Africa, which we contend began by MIS 5. Likewise, if evidence is found supporting coastal occupation, this will in no way be contradictory with the use of interior environments. When we turn to the Middle Palaeolithic it is evident that there is a need to move beyond purely typological foci and the reduction of variability to ‘industries’ defined by type fossils (e.g. Shea, 2014; Scerri et al., 2014a,b). Likewise, the notion that the Middle Palaeolithic is a broadly homogenous entity (Mellars et al., 2013), where variability is primarily driven by raw material variation, finds little support in comparative studies. Focussing on lithic attributes—the actual units of Middle Palaeolithic variability—reveals spatially and temporally patterned variability, that offers great scope for clarifying patterns such as adaptation and dispersal.

Our review of Middle Palaeolithic variation in Africa and southern Asia has identified the early origin of a particular combination of technological features in East Africa. These can be distinguished from other forms of Middle Palaeolithic, such as the more unidirectional reduction associated with the ‘Southern Neanderthal Dispersal’ (SND) and the emphasis on small bifacial tools in the ‘Northern Neanderthal Dispersal’ (NND) (Som 10). In distinguishing such spatial—temporal entities we must rely on the dominant technological trends, rather than presence—absence of an individual feature which may occur at extremely low frequencies. The basic stability of the East African MP, from ~MIS 8 to 3, stands in stark contrast to other areas, such as South Africa (e.g. Porraz et al., 2013; Will et al., 2014; Mackay et al., 2014a), West Africa (e.g. Soriano et al., 2010), the Nile Valley (e.g. Marks, 1968a; Van Peer, 1998; Van Peer et al., 2010; Scerri, 2013a), the Levant (e.g. Shea, 2003, 2013; Hovers, 2009) and the Arabian Peninsula (Armitage et al., 2011; Groucutt and Petraglia, 2012; Bretzke et al., 2014). Even so, all of these areas there is a significant diversity of Middle Palaeolithic technologies through time. While we acknowledge that there is some variability in the East African MP (Tryon and Faith, 2013), the evidence for dated sites suggests to us that it is relatively limited, particularly for the pre ~50 ka period.

The reasons for the character of the East African Middle Palaeolithic, and the similar technological features found in many sites across the Saharo-Arabian belt and into India by MIS 5, are topics in need of further research (see also e.g. Wallace and Shea, 2006; Meignen et al., 2009; Delagnes and Rendu, 2011; Eren and Lyckett, 2012). In part, the continuity presumably reflects demographic factors and population continuity in the varied environments of East Africa, in contrast to other regions which saw repeated extinctions (e.g. Shea, 2008b). It is possible that the similarities in basic technological features we have identified partly reflect convergent solutions to similar subsistence practices or some other ‘practical’ factor. This, however, seems unlikely to be entirely the case, as the ‘East African-like’ technological package is found on a diversity of raw materials, in different ecological situations and in different biomes.

By MIS 5 lithic assemblages similar to those of East Africa were found across the Saharo-Arabian belt and into India. We hypothesise that the similarities highlighted in this paper corresponds with the dispersal of *H. sapiens* into Asia, while recognising that several mechanisms can produce similarities between lithic assemblages. This hypothesis, which clearly demonstrates that alternatives are possible to the model of Mellars et al. (2013), needs to be tested by the types of attribute analyses, which are proving useful elsewhere (e.g. Tostevin, 2012; Scerri, 2013a; Scerri et al., 2014a,b).

In parallel with evidence for dispersal, the archaeological record reveals evidence for significant changes in behaviour. From MIS 5 East African sites cease to be tightly tethered to rivers and lakes (Basell, 2008), perhaps indicating improved dispersal abilities (e.g. McBrearty and Brooks, 2000). After MIS 5, populations in many areas appear to have contracted until MIS 3 in the face of climatic deterioration. The Late Middle Palaeolithic is characterised by a diversification of technologies (Groucutt and Scerri, 2014), and this provides the background to the various ‘Late Palaeolithic’ industries that developed in MIS 3. The rapidly fluctuating climate of MIS 3 also provided renewed windows of opportunity for interregional dispersal.

In conclusion, we find little evidence from lithic technology that the successful dispersal of *H. sapiens* occurred as a single event
–60–50 ka, nor that it was only associated with geometric and microlithic technologies. We therefore cannot agree to the presence of any similarities which are “effectively beyond dispute” (Mellars et al., 2013, pp. 10702). We highlight MIS 5 as a critical period for the early dispersals of H. sapiens. This is fully congruent with subsequent dispersals taking place, perhaps including the frequently invoked hypothesis of dispersals from northeast Africa to the Levant in MIS 3. Eliciting the nature of hominin demography in Africa and southern Asia necessitates the continued development of interdisciplinary research, of which we have shown variability in lithic technology is an important aspect.

Acknowledgements

This research was supported by a grant from the European Research Council (ERC) to M.D. Petraglia (Advanced Grant 295719 ‘PALAEODESERTS: Climate Change and Hominin Evolution in the Arabian Desert: Life and Death on the Cross-roads of the Old World’). J. Blinkhorn acknowledges the support of the McDonald Institute for Archaeological Research (University of Cambridge) and the Fondation Fyssen. E.M.L. Scerri acknowledges the support of the Fondation Fyssen and the British Academy. We acknowledge funding from the Arts and Humanities Research Council (H. Groucutt, L. Lewis) and the Wenner-Gren Foundation (L. Lewis). We would particularly like to thank Chris Clarkson, Rémy Crassard and Ceri Shipton for previous discussions about lithic technology.

Appendix A. Supplementary data

Supplementary data related to this article can be found at http://dx.doi.org/10.1016/j.quaint.2015.01.039.

References

Clarkson, C., Jones, S., Harris, C., 2012. Continuity and change in the lithic industries of the Jerruera Valley, India, before and after the Toba eruption. Quaternary International 258, 105–120.


Sneath, J.D., 2014. The importance of Iran’s Paleolithic record for unravelling key issues in human evolution. International Journal of the Society of Iranian Ar-
chaeologists 1, 10–26.


