

Skhul lithic technology and the dispersal of *Homo sapiens* into Southwest Asia

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Keywords: modern humans; Levallois; stone tools; out of Africa; migration; Levant

Abstract

The Levantine sites of Skhul and Qafzeh have been interpreted as indicating an early, short and unsuccessful expansion of *Homo sapiens* out of Africa. Chronometric age estimates, however, indicate a history of prolonged occupation, and suggest that Skhul (~130-100 thousand years ago [ka]) may have been occupied earlier than Qafzeh (*beginning* ~110-90 ka). Morphologically, the Skhul individuals can be described as somewhat more primitive in comparison to the Qafzeh fossils. Though the lithic assemblages of sites such as Skhul and Qafzeh are often described as being technologically similar, as part of the ‘Tabun C’ phase/industry, limited detailed information on the Skhul lithic assemblage has been published, and little comparative work has been conducted. Here, we present an analysis of the Skhul stone tool assemblage to describe its characteristics, to evaluate the lithic results against the fossil and chronological data, and for inter-site regional comparison. Our findings indicate that the Skhul lithic assemblage differs from other Levantine Marine Isotope Stage (MIS) 5 sites, such as Qafzeh. For example, there was more of an emphasis on diverse methods of point production at Skhul, and the available samples indicate a greater emphasis on preferential rather than recurrent Levallois reduction at Skhul. The current findings suggest that neither the Levantine Middle Palaeolithic in general, nor MIS 5 assemblages in particular, were technologically homogeneous. These data are consistent with either a long occupation of the Levant by *Homo sapiens* in MIS 5, or at least two phases of occupation (early MIS 5 and mid to late MIS). Whatever the fate of the Skhul and Qafzeh population(s), their occupation of the Levant was neither short nor culturally uniform. Our findings add to the growing pool of evidence that the dispersal of our species ‘Out of Africa’ was more complex than hitherto thought. Further work on MIS 5e contexts in the Levant and elsewhere in Southwest Asia should be a research priority.

1. Introduction

As the only land connection between Africa and Eurasia (Figure 1), as well as being a more or less continuously habitable region of southwest Asia, the Levant occupies a critical position in understanding many major themes in hominin evolution (e.g. Akazawa et al., 1998; Shea, 2003; 2012; Hovers, 2009; Hovers and Belfer-Cohen, 2013). The fossil finds and the Middle Palaeolithic (MP) archaeological assemblages from Mugharet es-Skhul (hereafter Skhul) and Qafzeh Cave are often seen as evidence for an early dispersal of *Homo sapiens* out of Africa, corresponding with the environmental amelioration of the Saharo-Arabian belt in Marine Isotope Stage 5 (MIS 5, ~130-75 ka). However, the character and implications of the early presence of our species in the Levant remain elusive.

figure 1 hereabouts

Specifically, the early presence of *Homo sapiens* in the Levant is often viewed as representing a short-lived expansion of African populations into southwest Asia, perhaps faltering due to post-MIS 5 environmental deterioration and an apparent lack of sophisticated cultural features such as projectile technology among these early colonisers (Shea and Bar-Yosef, 2005; Shea, 2008a; Klein, 2009; Oppenheimer, 2012; Mellars et al., 2013). This view is supported by some interpretations of genetic data, particularly Y-chromosome and mitochondrial DNA, which suggested that earlier expansions of *Homo sapiens* left no genetic legacy in contemporary Eurasian populations (e.g. Mellars et al., 2013). On the other hand, long-term population continuity through several wet and dry climatic cycles in the Levant has also been proposed. In this view, the Skhul and Qafzeh hominins may have evolved from indigenous Middle Pleistocene populations in southwest Asia, as perhaps indicated by findings from sites such as Qesem Cave (Hershkovitz et al., 2011; Freidline et al., 2012).

A third and alternative hypothesis views the Skhul and Qafzeh populations as evidence of an early (i.e., MIS 5) onset of modern human dispersals into Eurasia that was geographically widespread

(Petraglia et al., 2007; Petraglia et al., 2010; Boivin et al., 2013; Groucutt et al., 2015a; Groucutt et al., 2015b; Reyes-Centeno et al., 2015). This view may be supported by recent fossil discoveries from Southeast and East Asia. These include teeth assigned to *Homo sapiens* from Sumatra dating to ~ 75 ka (Westaway et al., 2017) and several Chinese sites containing fossil material that has been suggested to belong to *Homo sapiens* dating to MIS 5 (Liu et al., 2010; Liu et al., 2015; Bae et al., 2014). While chronological and taxonomic ambiguities remain around such sites (Michel et al., 2016), there is clearly a growing pool of evidence for the early presence of *Homo sapiens* in East Asia. The morphological variability of these East Asian fossils suggests complex evolutionary and demographic processes (Martín-Torres et al., 2017). Consistent with these findings is the recent dating of the human colonisation of Australia to ~65 ka (Clarkson et al., 2017). A more widespread early dispersal is also supported by some genetics studies, which suggest that *Homo sapiens* may have begun to spread out of Africa much earlier than presumed (Scally and Durbin 2012; Groucutt et al., 2015a; Pagani et al., 2016, but see Mallick et al., 2016). Early dispersals of African populations into Eurasia, seemingly in the Middle Pleistocene, are also suggested by interpretations of Neanderthal DNA (Kuhlwilm et al., 2016; Posth et al., 2017). It is hoped that over the coming years the current lack of congruence between genetic, archaeological and palaeontological datasets can be overcome, and integrated models developed.

Crosscutting many of these hypotheses is the inference that the MIS 5 inhabitants of the Levant constituted a population or deme of *Homo sapiens* (e.g. Clark-Howell, 1998; Valladas et al., 1998; Holliday, 2000; Shea and Bar-Yosef, 2005; Rightmire, 2009), associated with a broadly homogeneous ‘Levantine Mousterian’ lithic industry (Clark and Lindly, 1989; Wolpoff, 1989), or at least a broadly homogeneous ‘Tabun C’ (‘phase II’) industry (e.g. Bar-Yosef, 2000). Claims for the technological homogeneity of the Levantine Middle Palaeolithic continue to be made, Kolodny and Feldman (2017, p.9). In contrast to the biological data (i.e., fossils and genetics), material culture has not played a significant role in resolving the character of the earliest known *Homo sapiens* dispersals into Eurasia, despite several assessments of its spatial and temporal variability (Hovers, 1998; 2009; Cully et al., 2013). Such recent assessments have criticised the ‘three stage’ model of the Levantine MP derived

from the Tabun Cave sequence, but little focus has specifically been devoted to intra- and inter- assemblage variation in MIS 5. Of the crucial sites of Skhul and Qafzeh, which combine lithic assemblages and *Homo sapiens* fossils in dated contexts, only Qafzeh has been subject to detailed technological analysis [Hovers, 2009, see also Copeland, 1998 on Ras el Kelb]. In contrast, the lithic assemblages from Skhul have not received the same attention, primarily because they were only briefly described (Garrod, 1937) and then subdivided and distributed to forty institutions across the globe (Garrod and Bate, 1937). As a result, studies of the Skhul lithics have focused on particular elements only, such as the retouched points (Shea, 2006; Bisson, 2001) and whole flakes (Braun, 2005). This notwithstanding, the character of the Skhul lithic assemblage remains central to claims regarding the character of the earliest dispersals of *Homo sapiens* out of Africa (Armitage et al., 2011; Richter et al., 2012; Crassard and Hilbert, 2013; Mellars et al., 2013). Therefore, while Skhul was excavated rapidly by modern standards and not all lithics were retained, its continuing prominence in these debates makes it critical to evaluate available lithic material from the site. While we acknowledge the limitations in the methodology with which Skhul was excavated and the lithic assemblage sorted and distributed, we consider the site too important to simply ignore.

We conducted an analysis of the entire sub-sample housed at the Pitt Rivers Museum (PRM), University of Oxford. We first consider the context of the MIS 5 occupation of the Levant, before describing Skhul, its human fossils, and its stone tool technology. We then compare our findings to other lithic assemblages in the region and consider these results in light of the earliest known modern human dispersals out of Africa. Our analysis aims to test the purported homogeneity of Levantine MIS 5 lithic assemblages, which offer significant insights into the demographic and behavioural character of the early occupation of the Levant by *Homo sapiens*. As well as offering the first modern analysis of lithic technology at Skhul, the findings raised in this study admit the possibility that the MIS 5 occupation of the Levant by *Homo sapiens* was long and complex, and may have involved multiple population dispersals into the area.

2. Context of the MIS 5 occupation of the Levant

Given the limited and multidisciplinary nature of the available data through which to assess the character of the earliest dispersals of *Homo sapiens* into Eurasia, it is necessary to critically evaluate the existing evidence before making further inferences. Consequently, before presenting our results from Skhul, we first detail the context of the MIS 5 occupation of the Levant from the perspective of different sources of data.

2.1 Chronology

Skhul was largely excavated to bedrock in the 1930s, and as a result it was initially difficult to obtain reliable chronometric age estimates from the site. Initial electron spin resonance (ESR) age estimates were obtained from museum samples that were not precisely provenanced, and the background dose rates were estimated from small amounts of sediment adhering to finds from the site. This dating programme produced a range of chronometric age estimates, centring on late MIS 5 (Stringer et al., 1989) or slightly younger, into MIS 4 (McDermot et al., 1993). These age estimates established the considerable antiquity of Skhul, but have been transcended by more recent results discussed below, by teams including the same authors responsible for the initial estimates. (Grün et al., 2005; Mercier et al., 1993) (summarised in Table 1). In this situation, equal weight should not be given to the initial as opposed to more recent estimates, as some studies have done (Grove et al, 2015).

table 1 hereabouts

The initial age estimates at Skhul were followed by thermoluminescence dating of the site, which was applied to six samples from layer B (Mercier et al., 1993). These gave an average of 119 ± 18 ka, consistent with MIS 5e, with most samples clustering within a few thousand years of MIS 5e. Critically, given the high internal radiation doses in the Skhul heated flints, thermoluminescence dating is argued to be less susceptible to the lack of fully reliable environmental dose rates than ESR-U series dating of the site (Mercier et al., 1993), and so we find the ~ 120 ka TL ages the most

appropriate. This estimate is also consistent with the ~140-100 ka ESR-U series dates obtained in the most recent dating study of Skhul (Grün et al., 2005). This study dated bones and teeth, including the well provenanced human fossils and directly associated faunal remains (Grün et al., 2005). If post-MIS 5 results are excluded as likely reflecting post-depositional changes, then most dates fall close to MIS 5e. Likewise, direct dates for the hominins, rather than faunal samples with imprecise provenance information, cluster around MIS 5e. If Skhul covers a short chronological range this is parsimoniously MIS 5e. If a longer time range is represented then it is possible that Skhul 9 could be older than the others at ~140-130 ka, while Skhul 2 and 5 would be around 100 ka. In summary, the clustering of TL results at around 120 ka and the most likely u-series/ESR chronology being 130-100 ka, indicate that at least the main phase of occupation at Skhul dates to MIS 5e.

For Qafzeh, a total of 53 age estimates obtained through various chronometric methods are available (Table 2). The ages suggest that occupation of the lower part of the sequence containing the human fossils, layers XV and below, dates to ~115-90 ka (Schwarcz et al., 1988; Valladas et al., 1988; Grün and Stringer, 1991; Yokoyama et al., 1997), and probably towards the younger end of that range. In summary, perhaps the most reliable chronometric age estimates for Qafzeh come from TL dating, giving an average of 92 ± 5 ka. It can be observed that only three of the nineteen TL estimates were older than 100 ka, with most clustering around 90 ka. ESR estimates are very scattered, with early uptake giving an average of 115 ka and late uptake an average of 96 ka. The early uptake ESR results are influenced by MIS 6 outliers. The authors of the ESR dating study emphasise that the correct age is probably given by the late uptake model (Schwarcz et al, 1988), therefore suggesting a late MIS 5 chronology consistent with the TL results. The age of the younger undated layers at Qafzeh remains uncertain and may represent a considerable span of time. Hovers (2009) suggests that these younger layers may date to MIS 5a. In any case, it appears likely that the onset of the Qafzeh sequence postdates the occupation of Skhul and it has been argued that the populations from these two sites may have been separate (Millard, 2008), despite assumptions to the contrary and the common combination/conflation of Skhul and Qafzeh. The noisy chronometric data mean that it is possible that

the Skhul and Qafzeh occupations overlap in time, but there are strong indications that Skhul is of a greater age than Qafzeh.

Table 2 hereabouts

Other sites in the Levant have produced chronometric age estimates relevant for understanding MIS 5 occupations, although these too are subject to re-interpretation. For Tabun Cave, age estimates for layer C vary from (averaging) MIS 6, to the MIS 6-5 transition, to MIS 5e (Grün and Stringer, 2000; Mercier and Valladas, 2003). The stratigraphic complexity and dating controversies of Tabun make understanding the significance of hominin fossils from the site difficult, and we will not consider them in the present paper. In Lebanon, the Central Gallery of Nahr Ibrahim has produced purportedly similar lithics (Solecki, 1975) and age estimates of 78 ± 24 and 89 ± 29 ka (Porat and Schwarcz, 1991). Naamé has also produced broadly similar lithics, i.e. with a dominance of centripetal Levallois reduction (Fleisch, 1970) but the suggested date of ~ 90 ka (Leroi-Gourhan, 1980), needs re-evaluation using modern chronometric techniques. Other sites described as having similar lithic affinities have produced younger dates, but these have problems including the use of unusual techniques such as ESR dating of burnt flints (Porat and Schwarcz, 1991). Douara has produced age estimates of 77 ± 9 ka (ESR, EU) or $\sim 57\pm15$ ka (LU), or 59.7 ± 9.3 ka by nuclear track dating (Kai et al., 1987; Miki et al., 1988). In all cases, these young age estimates are possibly problematic, and need re-evaluation. As a result, the younger end of the MIS 5 occupation of the Levant by *Homo sapiens* is currently difficult to determine, although it is often cited as being around 75 ka, or at the end of MIS 5 (e.g. Shea, 2003; 2008a). Recent chronometric age estimates from Nesher Ramla in southern Israel suggest that the sequence dates to between 176 ± 52 ka and 94 ± 18 ka (Zaidner et al., 2014). Lithics in the earlier part of the Nesher Ramla sequence are dominated by centripetal Levallois reduction. Assuming that these ages are not exaggerated due to partial bleaching of grains as a result of the colluvial and sheetwash formation processes, the chronology suggests an onset of technology most commonly associated in the Levant with MIS 5 somewhat earlier, during MIS 6, at around 170 ka.

This estimate corresponds with age estimates from other sites, such as Hayonim Upper E (Mercier et al., 2007), and may indicate an early presence of *Homo sapiens* in the Levant, or may have been made by another hominin species. This can be tested by the future recovery of MIS 6 hominin fossil material in the area.

2.2 MIS 5 Lithic Technology

Aside from Skhul and Qafzeh, several sites in the Levant assigned to MIS 5 have produced important lithic assemblages. Key examples include Tabun Cave level C (Garrod and Bate, 1937; Jelinek et al., 1973; Jelinek, 1982a; Jelinek, 1982b), Ras el Kelb (Copeland, 1998), Douara Cave unit III (Hanihara and Akazawa, 1979), Hayonim Cave upper E (Meignen, 1998), Nahr Ibrahim central gallery (Solecki, 1975), Naamé (Fleisch, 1970) and Hummal (Hauck, 2011). Other sites less securely fitting into this group include Ar Rasfa (Ahmad and Shea, 2009), and the rarely cited locality of S-20 in the Sinai, which includes MIS 5 age estimates and at least broadly similar technological characteristics (Kobusiewicz, 1999; Kobusiewicz et al., 1999). Examples of MIS 5 lithics from Qafzeh and Ras el Kelb are shown in figure 2. Such assemblages are traditionally assigned to a ‘Tabun C’ or ‘Phase II’ stage of the Levantine MP, but a homogenising approach premised on industrial nomenclatures - rather than assemblage level variability - has recently been widely criticised (e.g. Hovers, 1998; Shea, 2014; Scerri et al., 2014a).

figure 2 hereabouts

Diverse views have been expressed about the technology of the Levantine MIS 5 assemblages. A number of investigators emphasise a purportedly time and species transgressive ‘Levantine Mousterian’, although different researchers highlight different qualities of this purported entity. Some stress the presence of ‘Nahr Ibrahim’ (or ‘truncated-faceted’) pieces (e.g. Jelinek et al., 1973) and a strong tendency towards unidirectional reduction often associated with a laminarity of blanks and the production of (particularly Levallois) points (Shea, 2003; Crew, 1969; Marks, 2009; Wurz and Van

Peer, 2012). It has also been argued that the ‘Levantine Mousterian’ is characterised by low levels of retouch (Dibble and Holdaway, 1993). Alternatively, MIS 5 assemblages can be seen as being distinct from both early and late Levantine MP assemblages. For example, technological descriptions of MIS 5 assemblages emphasise the centripetal, with smaller levels of bidirectional, character of Levallois preparation (e.g. Shea, 2003; 2012; Bar-Yosef, 2000). The nature of Levallois removals is not generally detailed, but Shea (2012) indicates that they are usually preferential. The rarity of ‘Upper Palaeolithic elements’ and points has often been noted (Copeland, 1965; Crew, 1975).

This notwithstanding, there has been considerable ambiguity in the definition of Levantine MIS 5 technology, and whether this can be described as a coherent ‘Tabun-C’ phase/industry. To Bar-Yosef (Bar-Yosef, 2000, p.116), Skhul and Qafzeh are technologically “similar”. Crew (2009), however, felt that Qafzeh had too many points to be included in his group analogous to the Tabun-C phase. Shea (2003, p. 336) views Skhul as being “intermediate” between Tabun C and B phases. Others have suggested that Tabun C and B should be combined into a single variable entity (Ronen, 1979; Marks, 1992; Culley et al., 2013). Meignen (1995) classified Skhul alongside both early and late Levantine MP sites as an example of an assemblage apparently dominated by Levallois recurrent unidirectional methods. Therefore, while textbooks and reviews frequently present the tripartite Levantine MP division in simple terms, the reality is much less clear and is heavily debated. In the case of Skhul, various attributions have been made, but are often not based on detailed analyses of the assemblage. Detailed technological data are only available for a small number of Levantine MIS 5 sites, and of these, only Qafzeh is securely associated with *Homo sapiens* skeletal material. We therefore outline this key site, which has been published in considerable detail by Hovers (2009). This comprehensive analysis of the Qafzeh assemblages demonstrated a “remarkably homogeneous technical system, primarily employing recurrent centripetal Levallois flaking” (Hovers, 2009, p. 52). Late in reduction there was sometimes a switch to a preferential method, which is also more frequent earlier in the cave’s sequence (Hovers, 2009 p. 105). Residual cores at Qafzeh are normally 50-40 mm in length and width, 25-20 mm thick and weigh ~60 g (Hovers, 2009, p. 53). The mean angle on cores between

striking platforms and Levallois removals is 79-75°. With respect to Levallois flake dimensions at Qafzeh, average lengths for most layers are around 50-40 mm, widths are typically 30 mm and thickness 8-6 mm (Hovers, 2009; p. 81). These Levallois flakes generally have centripetal preparation, but this varies considerably through the sequence. Most of the retouched forms at Qafzeh consist of 'scrapers' and 'notches/denticulates'. No bifaces/handaxes are reported, and retouched points are rare.

While there are many technological commonalities through the Qafzeh sequence, there are also significant technological differences (Figure 3) (Hovers, 2009; Groucutt et al., 2015b). For example, layer XV demonstrates a relatively large component of unidirectional-convergent Levallois reduction. As figure 3 shows, in basic technological features such as dorsal scar patterns and aspects of retouch, there is considerable temporal variability at Qafzeh. Differences also relate to how the site was used, with much more flaking debris in the upper part of the sequence (Hovers, 2009), probably demonstrating variability in the extent of on-site knapping. These analyses suggest that there are temporal differences characterising the human occupations at Qafzeh, which, as shall be seen, feature differences to the technology of Skhul.

figure 3 hereabouts

While it is beyond the scope of this paper to comprehensively review the detailed studies from Levantine sites not associated with skeletal material, it should be noted that the possibility of significant differences between Skhul and Qafzeh should not be viewed as particularly controversial. For example, at Ras el-Kelb in Lebanon, reduction was also primarily centripetal Levallois in character, with an emphasis on the recurrent centripetal method (Copeland, 1999). However, the site also features differences compared to Qafzeh, such as the rarity of Levallois points throughout the sequence and high rates of retouch, with between 15 and 33% of the products retouched in different

units (Copeland, 1998). While Copeland (Copeland, 1998; 1999) presents useful information on Ras el Kelb, complete study was curtailed by the Lebanese civil war.

3. Skhul and Qafzeh hominin fossils

The Skhul and Qafzeh fossil series have been extensively described and discussed. From the late 1970's onwards they have frequently been grouped together in analyses (Stringer, 1978; Stringer and Trinkaus, 1981; Trinkaus, 1981; 1984; Vandermeersch, 1981). However, any assumptions of demic homogeneity made by such groupings are belied by the high internal variability of these samples (Stringer, 1996). Furthermore, the antiquity of the samples and the controversial nature of their 'modern' affinities (e.g. Schwartz and Tattersall, 2010) or noted primitive features, emphasises the need for caution with respect to conclusions about their population-level taxonomy.

Various analyses have supported the view that the combined Skhul-Qafzeh sample represents an early form of *Homo sapiens sensu stricto*, albeit with robust or primitive features (e.g. Howells, 1989; Stringer, 1992; Trinkaus, 1995; Vandermeersch, 1996; Holiday, 2000; Schwartz and Tattersall, 2003; 2010; Franciscus and Holiday, 2013). Overall in terms of cranial morphology they are globular, with a high frontal bone, long and arched parietal, a rounded occipital profile and upper parietal expansion. While Skhul 5 could be considered primitive in its thin but continuous supraorbital torus, seemingly matched in the less complete Skhul 2 and 4 brows (Schwartz and Tattersall, 2003; 2010), all the preserved faces are relatively short and transversely flat, with a retracted infraorbital region and variable degrees of canine fossa formation. However, Skhul 5 does have distinctly more total facial prognathism than Qafzeh 6 or 9 or (probably) Skhul 4.

Both samples show 'modern' crown morphology, anterior dental size reduction and less anterior dental wear overall than Neanderthals, though some individuals (e.g. Qafzeh 9) retain a large posterior dentition (Trinkaus, 1995; Bailey and Hublin, 2013). While the mandibles are relatively short with anterior mental protuberances, Schwartz and Tattersall (2003; 2010) argued that none of the Skhul

fossils display the inverted “T” mental trigone configuration with lateral tubercles and mental fossae which they consider characterises *Homo sapiens*. These ‘modern’ traits are also absent in Qafzeh 4 and 7, but are present in the Qafzeh 9 and 11 mandibles. Additionally, the Skhul 4, 5, and 6 mandibles arguably or actually show Neanderthal-like retromolar spaces, whereas Skhul 7 and Qafzeh 9 do not (Schwartz and Tattersall, 2003; 2010; Franciscus and Trinkaus, 1995).

However, looking at the individual adult cranial material from Skhul (5 and 9) and Qafzeh (6 and 9), using data from one of us (CS) we can compare their measurements after size standardisation to examine similarities and contrasts within and between the samples. These suggest that the Skhul crania are relatively larger in glabello-occipital length, parietal breadth, biauricular breadth, biasterionic breadth and facial height, but lower in basion-nasion length and basion-bregma height than Qafzeh, while in individual terms, Skhul 9 has the shortest parietal chord and subtense values. With the exception of the larger parietal breadth and smaller basion-nasion length, these features of Skhul could be considered more primitive. However, with respect to cranial angles, Qafzeh 6 appears somewhat more primitive or Neanderthal-like in its higher bregma angle and lower nasion-bregma angle than Qafzeh 9 and Skhul 5 (values cannot be calculated for Skhul 9). And the much less complete cranial remains of Qafzeh 3 are reminiscent of Skhul 9 in combining a more modern-looking frontal profile with relatively low parietal curvature and a projecting and angulated occipital profile.

Analyses of postcranial features of the Skhul and Qafzeh hominins overall demonstrate the presence of warm-adapted body proportions (with the exception of Skhul 5), and derived traits shared with other examples of *Homo sapiens*. These include hand morphology (Niewoehner, 2001), pelvic shape (Trinkaus, 1995), flatter rib shafts of the upper thorax compared to Neanderthals (Franciscus and Churchill, 2003; Vandermeersch, 2008) shorter clavicles, and the radial tuberosity having a more anteromedial orientation (Trinkaus, 19995; Franciscus and Holliday, 2013).

So while the Skhul and Qafzeh series show clear derived traits in cranial and postcranial anatomy shared with recent humans, they also display considerable variation, and differ in aspects of cranial shape and morphology, both within and between the samples. Thus the stratigraphically oldest specimen in the Qafzeh sample (Qafzeh 11) has some of the smallest posterior teeth in the entire MP, while the later specimen Qafzeh 9 has some of the largest. In several aspects, the Skhul material could be considered the more primitive in features of cranial vault shape, the less well developed mental trigone on the mandibles, the supraorbital morphology of Skhul 2, 4, 5 (though seemingly matched by Qafzeh 6) and the parietal and pubic ramus shape of Skhul 9. The data are therefore consistent with a hypothesis in which the individuals from Skhul and Qafzeh could be drawn from different, temporally separate, populations.

4. The site of Mugharet es-Skhul

Mugharet es-Skhul (Cave of the Kids [juvenile goats]) remains one of the key sites in our understanding of human occupation history of the Levant. Skhul is located at 34.97 N, 32.67 E (~44 masl) in the appropriately named Wadi el-Mughara (Valley of the Caves, also known as Nahal Me'arot), on the western side of Mount Carmel, 3 km east of the current Mediterranean shoreline, and 20 km south of the city of Haifa. As part of Dorothy Garrod's ambitious research programme in the Middle East, the site of Skhul was excavated by the American student Theodore McCown for two months in 1931 and for three months in 1932 (McCown, 1937; Davies et al., 1999; Petraglia and Potts, 2004). The main part of the site is now virtually devoid of sediments.

Skhul consists of a small cave/rockshelter and, primarily, the area immediately in front of this. By modern archaeological standards the excavation led by the inexperienced McCown proceeded rapidly, with limited spatial recording and screening for small finds. The recorded stratigraphy indicated the presence of three layers: A, B and C. Layer A was a superficial and mixed humic soil horizon. Layer B varied in thickness, from ca. 40 cm in places to ca. 150-200 cm across most of the excavation (McCown, 1937). Midway through excavation, Layer B was subdivided into upper (B1) and lower

(B2) sub-layers, and although they did not show a sharp distinction, they were sub-divided on the basis of the hardness of the sediments. It is possible that the stratigraphic differences between B1 and B2 are due to post-depositional processes, as Layer B becomes increasingly indurated with depth. Lithic artefacts from B1 are described as being generally patinated, while those from B2 were generally unpatinated. Stone tools and animal fossils were found “scattered in an even manner” in layer B (McCown, 1937, p. 96). Finally, Layer C consists of a thin lens of yellow-brown sands overlying bedrock, with stone tools but apparently lacking in fauna.

Aside from the stone tool assemblage and fauna, non-utilitarian or ‘symbolic’ material culture was also discovered at the site. *Nassarius gibbosulus* shells from Skhul have been interpreted as beads (Vanhaeren and d’Errico et al., 2006; D’Errico and Vanhaeren, 2007) and widely cited as key evidence for the presence of ‘modern human behaviour’. Skhul may well represent the oldest known such example yet identified. While much of the relevant material was not sieved or retained during excavation, analysis of archived material also demonstrates the presence of pigments from Skhul (D’Errico et al., 2013). Furthermore, evidence indicates that the pigments were transported to the site and modified by heating (Salomon et al., 2012). Whether used for symbolic or functional purposes, the import of pigments from distances exceeding 10 km (Hovers and Belfer-Cohen, 2013) and their subsequent modification (e.g. heating changed the colour of some from yellow to red) provides insights into complex mobility patterns and behaviours.

Further signs of ‘symbolic behaviour’ have been inferred from the human burials. In the Skhul 5 burial, the arms of the skeleton seemingly clasp a wild boar mandible, interpreted as a grave good (McCown, 1937; Belfer-Cohen et al., 1992). The boar mandible is apparently by far the best preserved fossil of a large mammal from Skhul (Grün et al., 2005), consistent with it having been rapidly interred. At least four, but possibly as many as seven of the Skhul humans (1, 2, 4, 5, 6, 7, and 9) are interpreted as deliberate burials (McCown, 1937; Belfer-Cohen and Hovers, 1992; Hovers et al., 1995). The relatively close spatial positioning of the Skhul burials may suggest that they were

buried close to each other in time, although individual 9 may be older than the others (Grün et al., 2005).

5. Previous analyses of the Skhul lithic assemblage

Garrod (1937) provides the only existing description of the Skhul lithic assemblage, before it was divided and sent to 40 different institutions, consisting of just four published pages plus illustrations. Garrod's description focuses on the retouched artefacts, and to a lesser extent the cores, and little is detailed about the unretouched and non-Levallois flakes. Table 3 summarises the data tabulated by Garrod (1937), showing both total frequencies and frequencies of retouched artefacts and Levallois flakes only. Examples of lithics depicted by Garrod (1937) are shown in figure 4. While the nature of excavation and subsequent sorting of lithics do not follow modern standards, we consider them appropriate for an overall characterisation of the assemblage. We also note the presence of many broken and cortical flakes, and consider it unlikely that these would have been retained if the assemblage was so sorted as to be meaningless.

figure 4 hereabouts

table 3 hereabouts

Garrod (1937) stated that the Skhul assemblage “closely resembles that of Tabun-C”, yet she also noted a number of differences between the assemblages. For instance, scrapers retouched on both lateral margins were described as being much less abundant than in Tabun C. The data from Garrod (1937) allow us to calculate that, at Tabun C, these double-sided scrapers as she defined them constitute 11.6% of the sample of retouched and Levallois pieces, while at Skhul they form 5.1% of B1 and 3.7% of B2.

A key feature of the Skhul assemblage described by Garrod (1937) is the presence of large numbers of retouched points. The retouched points consist of approximately equal frequencies of retouched

Levallois points and ‘leaf shaped’ points (67 to 55 in layer B1, 25 to 24 in B2). It was also noted that some points were retouched on the ventral surface, an aspect to which we will return. Garrod (1937) also describes a small number of handaxes as coming from Skhul. These are intriguing, but may represent hominin scavenging of nearby sites such as Tabun Cave, where eroding sediments would have revealed handaxes at the time Skhul was inhabited. Alternatively, the handaxes from Skhul may have been found close to bedrock, predating the MP deposits. It is also possible that they were actually a part of the MIS 5 inhabitant’s technological repertoire, but this is difficult to evaluate with available data.

Garrod (1937) argued that there are no essential differences between the lithics of B1 and B2, but that implements are generally slightly smaller in the former and also have a higher ratio of unprepared striking platforms. Garrod (1937) described the lithics from layer B1 as being generally between 90 and 50 mm in length. Cores are described as predominantly Levallois, “the great majority for broad flakes” (Garrod, 1937, p. 110). These are described as varying in size, but with one group of small cores being “remarkably uniform and very neatly made”. Levallois flakes were generally ‘broad flakes’ (i.e. not points), and were mostly thin and ‘medium’ sized. Cores and Levallois flakes in B2 are described as being similar, although the latter were generally smaller in size (Garrod, 1937, p. 111). Layer C is thin and only produced a small lithic assemblage, but Garrod (1937) emphasised the high frequency of triangular Levallois flakes (i.e. Levallois points) in this layer. She stated that of the cores, 16 are Levallois and 50% of these are for triangular flakes (points) (Garrod, 1937). Of the Levallois flakes, 35 are described as being of broad form, and 63 are triangular. A further 14 are described as being the proximal ends of Levallois flakes.

The lithic artefact data summarised in tables 3 and 4 show that in some cases there appears to be directional change through time, i.e. retouched points become somewhat more common (1.6%, 4.7%, 7.5% from youngest to oldest layers). In other layers, there are ‘reversions’, such as in the decline of burins (3.3%, 0.7%, 2.1% respectively). Levallois flakes in the main (B) layers are roughly equal in

their representation of 'broad' (40.3%, 46.3%) and triangular (16.2%, 17.7%) forms, while layer C has much higher frequencies of triangular Levallois points (51.6% compared to 28.7% for broad forms). A total of 11.5% of the layer C 'tools' were reported as being the bulbar ends of Levallois flakes, a form not reported in other layers. On the whole, all layers can be characterised as having points, 'scrapers' (side retouched flakes, particularly retouched on one lateral), and Levallois flakes.

In the later twentieth century, some of the seminal lithic analyses of the MP of southwest Asia included samples from Skhul (Skinner, 1965; Crew, 1975). Skinner's (1965) Skhul sample focussed on retouched tools, of which he sampled several hundred, but also 139 cores (which he described as 109 Levallois, 21 discoidal, 6 prismatic, and 3 informal). He viewed the Skhul assemblages as similar to other sites of his 'C group', which was found throughout the Levant, and characterised by features such as high levels of Levallois technology and the relatively frequent retouch of blanks. Crew (1975) emphasised the emergence of technological analysis, rather than purely typological approaches, to lithic studies. His analysis of dorsal scar patterns on Levallois flakes from Skhul showed a tendency toward centripetal preparation, but with relatively limited preparatory removals from the lateral margins.

Some more recent studies have focussed on question driven approaches to particular topics rather than focussing on attempting to define 'industrial' groups. Elements of the Skhul lithic assemblage have been included in such studies. Bisson (2001; 2007) demonstrated previously unexplored aspects of the Skhul assemblage, such as basal retouch, possibly as a hafting modification. Studies on point technology, and debate on whether MP examples functioned as projectile armatures or the tips of thrusting spears (see also Scerri, 2013 for a perspective from neighbouring North Africa), have included samples from Skhul (Shea, 2006; Shea and Sisk, 2010; but see Newman and Moore, 2013). Braun (2005) included a sample (n=181) from Skhul in his comparison of Levantine and Zagros Middle Palaeolithic flake production.

6. Methods

The PRM sample, consisting of 270 artefacts (Finlayson, 2013), was analysed using an established methodology for recording both qualitative and quantitative aspects of lithic technology. This combined analysis allows us to both describe the Skhul assemblage and to compare it to published data for other sites in the wider region. The definitions of measurements and attribute states are described in detail elsewhere (Scerri et al., 2014a; 2014b; Groucutt et al., 2015c; 2015d). The selected attributes have been tested in an experimental context to demonstrate their suitability for describing the variability in Levallois reduction (Scerri et al., 2016).

For cores, we recorded dimensions in mm (lengths [both maximum and technological]), widths [maximum and technological] and thickness [maximum]), percentage cortex, the number of scars, weight (g), dimensions of final/dominant scars, the angle of the dominant striking platform and dorsal scar patterns, for both preparation (bidirectional, centripetal, unidirectional-convergent, indeterminate) and exploitation (bidirectional, centripetal, perpendicular, unidirectional, indeterminate/unstruck). By crosscutting techno-morphological aspects (e.g. core form; Levallois, discoidal, etc.) with aspects of shape, particularly indices derived from the metrical data, such as elongation (length/width) and convergence (medial width/distal width) we are able to describe core morphology and technology, and how these change with reduction.

For flakes, similar metric and attribute data were gathered, namely weight, length, width, thickness, length of perimeter (using a comb scale), the number of dorsal scars, percentage cortex and the angle of the striking platform. These metrics were used to calculate measures of shape such as volume (length x width x thickness), elongation, flattening and convergence. For striking platforms width and thickness were measured, allowing the calculation of the platform indices of area (width x thickness) and flattening (width/thickness). Attribute data included the morphology of the striking platform (cortical, plain, dihedral, faceted). Crosscutting the morpho-technological data with attribute states

allows us to describe and interpret the debitage, both in terms of aspects of size and shape and in typological terms (such as different forms of Levallois product).

Finally, for retouched flakes the same full set of measurements taken for flakes was also made. In addition, a basic typology was constructed emphasising the position (e.g. lateral, distal) and character (e.g., ‘normal retouch’, notching) of retouching, allowing us to describe pieces using classifications such as ‘side notched flakes’ or ‘double side retouched flakes’. Additional quantitative measures of retouch were recorded using standard procedures, namely the Geometric Index of Unifacial Retouch (Kuhn, 1990), the Index of Invasiveness (Clarkson, 2002) and the percentage of the margins retouched.

The completeness of all lithics was recorded, and averages for particular categories only generated where the appropriate measurement was available, i.e. a proximal fragment of flake can be used to calculate platform features, but not the length of the flake.

7. Results

7.1. Overview of the PRM collection

The PRM collection consists of 56 cores, 85 Levallois flakes, 47 non-Levallois flakes, 81 retouched tools and 1 hammerstone. While the sample of non-Levallois flakes is rather small, sample sizes for other forms allow a thorough description of the assemblage. Many published comparative studies include sample sizes for individual sites smaller than those in our sample for cores, Levallois flakes and retouched flakes. As was common practice in the 1930’s many ‘waste’ flakes and other pieces which were felt to be of limited importance were discarded before analysis. As we explore further below, the PRM collection represents a good sample of the assemblage analysed by Garrod (1937). As Scerri and colleagues (2016) quantitatively demonstrated, sampled assemblages can produce similar results to complete assemblages, and we recognise the limitations of the Skhul assemblage by

focussing on broad typo-technological features rather than addressing aspects which may be more problematic given the nature of the sample (for instance, ratios of cores to flakes, patterns of flake breakage, etc.).

With respect to the stratigraphic context of the sample, 78 are labelled as being from layer B, 111 as being from the subdivision B1, and 81 from B2. Given the subsequent small samples for particular types within these subdivided groups, we analysed the material as one group, which is consistent with Garrod's (1937) observation that the assemblages were not distinct entities. Given the lack of detailed geomorphological study of the site, the stratigraphic distinction between B1 and B2 remains unclear. In addition, many of the artefacts are not labelled with assignments to B1 or B2. With, for example, the cores in the Pitt Rivers sample, 58.9% are from B1, 33.9% are not assigned to a sub-layer on B, and just 7.1% are from B2. Our analysis therefore focuses on the overall sample from layer B, while we acknowledge that future studies may fruitfully attempt to look at additional samples from the site and evaluate diachronic changes in material culture as far as the coarse stratigraphic information allows.

All lithics in the PRM collection are made from high quality chert raw material. Limited information is available on the raw material sources used by the Skhul inhabitants, but high quality raw materials are located in very close proximity to the site. The relatively high levels of cortex in the assemblage (discussed below) indicates that they have not been extensively reduced and that the earlier stages of reduction are represented in the assemblage. The original package sizes are hard to determine from the material studied. The largest core is 101 mm in length, while the average is 51.2 mm. The longest flake is 122.52 mm, while the average is 60.6 mm. These dimensions may indicate something on raw material package size, but given the nature of the sample, this is unclear.

The lithics are generally in excellent condition, although often with patches of breccia adhering to their surfaces, with 93% having low levels of weathering and the remaining 7% being moderately

563 weathered. Patination levels are more varied, with 46.5% showing low patination, 38.3% showing
564 moderate patination, and 15.2% showing considerable patination. There are some differences in the
565 frequency of levels of patination by stratigraphic unit, as previously noted (Grün et al., 2005). For B1,
566 43.2% of the PRM collection have little patination, 36.9% medium and 19.8% considerable. For the
567 deeper B2 layer, 74.1% have little patination, 21.0% medium and 4.9% considerable. While there is
568 therefore a tendency for lithics from B2 to be less patinated, this is not an absolute distinction.
569 Caution should therefore be taken in assuming that the lithics used for the TL analysis were from B2
570 as they were unpatinated (Grün et al., 2005, p. 331).

571
572 All the cores are complete, as are 95% of the Levallois flakes, 81% of the non-Levallois debitage and
573 85% of the retouched pieces. Nevertheless, the fact that broken lithics are a frequent part of the
574 collection indicates that while the sample is to some extent selective, it is not selective to the point of
575 being uninformative. We consider it unlikely, for instance, that broken flakes would have been
576 preferentially retained while certain forms of Levallois core were not. While we know that McCown
577 and Garrod did not retain all lithics from Skhul, such factors indicate that the available sample is still
578 highly informative.

579
580 The similarity of the PRM sample to the larger assemblage described by Garrod (1937) is evident in
581 both broad and specific terms. In broad terms, the collections feature the same basic technological
582 characteristics, i.e. a predominance of preferential Levallois cores, and retouched tools focussing on
583 side retouched flakes and points. More specifically, figure 5 compares the frequencies of key forms in
584 Garrod's total assemblage to the PRM sample. The tabulated data exclude rare forms, i.e. those with
585 less than ten examples in the complete assemblage, and does not include flakes which are not
586 Levallois or retouched, due to their relative rarity in the PRM sample. It is evident from figure 5 that
587 the PRM sub-sample closely matches Garrod's assemblage. Where there are minor differences
588 between the samples this is, in part, due to differences in methodology and nomenclature. As our
589 recording focuses on constituent features (attributes) rather than simply on typological designations,

we describe, for instance, pieces retouched on two edges as double side retouched flakes, whereas to Garrod a double sided-scraper was a specific typological entity. Such considerations explain some of the minor variation between the samples, which is outweighed by the basic similarity between them.

Bisson (2007) likewise demonstrated how another (smaller) sample of the Skhul assemblage, at McGill University, appeared to offer a representative sample of the total assemblage. Braun (2005) also concluded, based on factors such as the percentage of cortical and retouched flakes in the Harvard collection, that the sample was sufficient to be representative of the total assemblage. It appears that Garrod selected representative samples to send to the different institutions. With this evaluation at hand, we consider the Skhul lithic collection used here to be an appropriate sample with which to characterise lithic technology from Layer B of the site. While the Skhul excavation was not conducted according to modern standards, and future studies may be able to refine our understanding of the site, we argue that the PRM collection offers a valuable baseline on the fundamental characteristics of the assemblage, and that Skhul lithic technology should not be downplayed in modern syntheses. Given that the character of Skhul lithic technology does play a significant role in many papers, we consider it better that this role is based on an actual analysis of the assemblage rather than superficial impressions, while recognising the imperfect nature of the sample.

figure 5 hereabouts

7.2. Core Technology

The Skhul cores in the PRM collection (figure 6) can be classed as Levallois (n=48), Levallois preform (n=3), blade (n=1), discoidal (n=1), multiplatform (n=1), irregular (amorphous) (n=1), and indeterminate (n=1). The Levallois cores dominate the assemblage, and the specifics of Levallois preparation and exploitation are described below. The other core forms demonstrate the existence of a diversity of approaches to reduction, whether driven by factors such as clast morphology and/or a desire for certain forms of blanks.

figure 6 hereabouts

The morphology and technology of cores is provided in table 4, allowing the consideration of factors such as dorsal surface preparation in terms of the intensity of reduction. Many of the Skhul cores are of broadly similar size and shape, with most being between 65 and 45 mm in maximum dimension, 60 to 40 mm in maximum width and 30 and 15 mm in maximum thickness (table 4). Likewise factors such as the angle between the dominant scar and the striking platform display a narrow range of variability, with most being 65 and 75°.

table 4 hereabouts

In terms of shape variability, the Skhul cores are generally broadly similar. The core convergence index (measured as medial width divided by distal width), has an average value of 1.7, indicating somewhat convergently shaped cores, with 50% falling between 1.2 and 1.9 (standard deviation or σ 0.8). With respect to flattening (width divided by thickness) the range of values is narrow (50% fall between 1.7 and 2.6), with a mean of 2.1 (the lower the number, the less flat the artefact). The size and shape data indicate relative homogeneity in the size and shape of cores.

Table 5 summarises the preparation and exploitation of the Levallois cores, showing a dominance of centripetal preparation and unidirectional (preferential) exploitation. Recurrent centripetal Levallois cores are present in small numbers (less than 6% of the Levallois cores) (figure 6c), and only a single recurrent bidirectional Levallois core was identified (figure 6e). Within the centripetally prepared and unidirectionally exploited preferential Levallois cores there is a gradient between: 1) those which are more elongate and have preferential scars of a basically pointed shape (figure 6a), and 2) rounder cores with highly centripetal preparation and oval preferential scars (figure 6f). While the latter are ‘classic’ Levallois cores, the former represent a category with something of a tendency to beaked

(‘Nubian’) Levallois-like dorsal surface convexity (e.g. figure 5a). The Levallois cores producing more pointed forms usually have one elongated, débordant removal from distal (e.g. figure 6a,b), with convexity otherwise being formed by centripetal removals. The cores also often have small subsidiary scars at the distal end, perhaps emphasising convexity at this point to ensure the removal of a pointed flake.

table 5 hereabouts

While only five Levallois cores show recurrent exploitation, all after centripetal preparation, it is interesting to consider these against the dominant preferential cores to determine the different reduction trajectories in the assemblage. Compared to the unidirectionally exploited preferential cores (n=40), the recurrent cores are typically lighter on average (49.1g, σ 15.2), rather than the 60.4 g average (σ 61.4) of preferential cores. Likewise, whereas the average cortical cover for the preferential cores is 20.1%, four of the five recurrent cores have 0% cortex. The average maximum linear dimensions for the core forms are, however, similar at 55.4 mm (σ 14.2) for the recurrent and 56.8 mm (σ 8.9) for the preferential cores. These data may indicate that reduction at Skhul was dominated by preferential methods until the cores became difficult to work, after which, in some cases, a few further removals were made if the convexities were suitable. This interpretation is supported by a reading of the scar patterns on the cores. It is commonly the case that cores with recurrent removals are characterised by an initial Levallois removal which has failed to cover much of the debitage surface (e.g. figure 6e). These removals then created a convexity that allowed the core to be rotated and further removals made, giving the core a recurrent character.

The size and shape of the final/dominant scars provides information on the final phase of predetermined flake production. As shown in table 5, the Skhul cores display a generally fairly narrow range of variability. In both the length and widths of these scars, the majority fall within a range of less than 15 mm. Likewise, with both elongation and convergence, most last/dominant scars exhibit a

limited range of variability. Most of the examples from Skhul are only slightly longer than wide, and non-convergent in shape. Hence, while there are cores showing the production of pointed debitage, in most cases (e.g., figure 6d and f), the removals were broadly oval shaped.

7.3. Levallois debitage

A total of 85 pieces were classified as Levallois products, 81 of which are whole. As Levallois removals provide insights into a greater proportion of the reduction sequence than the cores, they offer important information on lithic technology at Skhul. Of the 81 complete Levallois products, four can be described as Levallois blades, 43 as Levallois flakes (i.e. broad and non-convergent) (figure 7), and 34 as Levallois points (figure 8).

figure 7 hereabouts

figure 8 hereabouts

Basic morpho-technological data on complete Skhul Levallois flakes are shown in table 6. Most of the Levallois flakes are fairly thin, have finely faceted platforms, and 75% weigh less than 30 g. In terms of widths, lengths and thicknesses, the Skhul Levallois flakes demonstrate a fairly low degree of variation. This is also the case for the length of the perimeter. In addition to homogeneity of size, most of the Levallois flakes have between 5 and 7 dorsal scars. The Levallois flakes display more variation with respect to volume and the shape indices shown in table 6. Consideration of elongation shows that the flakes are more elongate than are the final scars on the cores (Table 7), suggestive of a move towards squatter (less-elongate) removals late in reduction. The flakes display high flattening indices, showing that they are relatively thin. The Levallois flakes have a wide range of values for convergence, with both oval/rectangular (e.g. figure 7) and triangular/convergent (figure 8) both being found at Skhul. The high mean convergence, at more than 5, highlights the importance of the latter category, again in contrast to the evidence from the cores.

699

700 *table 6 hereabouts*

701

702 *table 7 hereabouts*

703

704 In terms of Levallois flake striking platforms, 87% are faceted, 5% dihedral, 2% plain and 4%
705 indeterminate. Measurements and indices of the striking platforms are shown in table 8. On the whole,
706 the platforms show higher rates of flattening and generally quite consistent striking platform angles
707 (~80-90°).

708

709 *table 8 hereabouts*

710

711 With respect to the complete Levallois flakes (n=81), the dorsal scar patterns can be described as
712 unidirectional (12.3%), unidirectional convergent (28.4%), bidirectional (32.1%), perpendicular
713 (3.7%), weakly centripetal (14.8%) and centripetal (8.6%). The relatively low frequency of centripetal
714 preparation is notable, as is the diversity of dorsal scar patterns. These centripetal forms are much less
715 common than variants of unidirectional (including convergent) and bidirectional preparation (which
716 cumulatively form 72.8% of the sample). In order to explore these frequencies further, Figure 8 shows
717 percentages of scar patterns by flakes/blades and points. Figure 8 indicates that there are differences
718 in dorsal scar patterns between these two form categories, as might be expected. These differences
719 also extend to weight: flakes/blades weigh an average of 24.0g, compared to 19.0g for the points.
720 Comparisons can be made between the forms of scar pattern against other morpho-technological
721 features of the Levallois flakes. Levallois flakes with unidirectional (25.1 g, σ 12.2) and bidirectional
722 (27.7 g, σ 15.3) scar patterns have greater average weights than the other scar patterns: unidirectional
723 convergent (16.7 g, σ 8.4), perpendicular (17.7 g, σ 8.0), weakly centripetal (18.3 g, σ 8.7) and
724 centripetal (20.5 g, σ 11.2), although they are also more variable. A similar pattern is found with
725 length, which is again largest on average for flakes classed as unidirectional (63.1 mm, σ 10.5) and

bidirectional (63.0 mm, σ 18.5) compared to unidirectional-convergent (54.5 mm, σ 9.0), perpendicular (44.1 mm, σ 15.1), weakly centripetal (57.6 g, σ 10.6) and centripetal (52.4 g, σ 13.1). In other attributes, such as platform preparation, scar patterns are not associated with clear morpho-technological differences. External platform angle, for instance, has a limited range. Aside from the very small sample for perpendicular scar patterns (79.8°), Levallois flakes with all scar patterns have average platforms angles that fall between 83° and 89° (table 8). For platform flattening (thickness/width), the average mean values for all scar patterns fall between 0.22 and 0.29, indicating that all products are highly flattened. We will consider the significance for this along with the core data subsequently, in order to understand the influence of reduction intensity on morpho-technological variation.

7.4. Non-Levallois débitage

A total of 47 pieces (29%) were either non-Levallois or indeterminate, consisting of five blades, five débordant flakes, and 37 other flakes. The débordant flakes vary in length between 104.1 and 74.8 mm in length (mean 84.4 mm) and weigh on average 34 g. Three of the five débordant flakes have bidirectional scar patterns. Of the remaining two, one débordant flake features a unidirectional scar pattern and the other a weakly centripetal scar pattern.

Of the 42 other flakes, 81% are complete. Most of these have no cortex, but a small number have cortical cover, including one with 100% cover. The scar patterns on the 34 complete pieces can be summarised as unidirectional (26.5%), unidirectional convergent (2.9%), bidirectional (35.3%), perpendicular (2.9%), weakly centripetal (17.6%), and centripetal (5.9%) and other (indeterminate, cortical) (8.8%). Compared to the Levallois flakes, these reflect higher levels of unidirectional flaking and broadly similar frequencies to other categories aside from having lower levels of unidirectional convergent patterns. The average weight of these pieces is 34.4 g, ranging from 4.3 g to 188.7 g with a standard deviation of 37.3. In terms of their index of convergence, they have a mean of 2.9, and a

range from 0.7 to 15.2 (σ 3.7). Compared to the Levallois flakes, the non-Levallois flakes are more varied in weight, and are typically much less convergent in shape, consisting of preparation flakes, of both platform and debitage surfaces.

7.5. Retouched Tools

The PRM sample contains 81 retouched tools, of which 69 (85.2%) are complete. The typological breakdown of the retouched forms is shown in table 9, while examples of retouched forms are shown in Figures 9 and 10. Here we combine typological descriptions (e.g. ‘normal/regular’ retouch, notching) with the position of retouch. This classificatory system offers an approximate comparison with Garrod’s typology, sufficiently enough to highlight the representativeness of the PRM sample (figure 5). Table 9 shows that the most common form of retouched tool represented are side-retouched flakes (traditionally described as ‘sidescrapers’), retouched on one lateral margin, making up almost half of the sample. Other combinations of side-retouch with retouch either on the opposed lateral and/or the distal portion also make up a considerable portion of the sample. Notched and denticulated flakes are present, but occur in small numbers. Retouched points also occur at a fairly high frequency, at over 10% of the sample. Only two pieces do not fit within the above categories, one that has basal retouch (truncation) but is not otherwise retouched, and one which is a bifacially retouched piece.

table 9 hereabouts

Morphological information on complete retouched flakes is shown in table 10. The degree of morphological diversity varies for the different measures, with some, such as length, width and thickness displaying relatively little variation (most falling within a relatively narrow range). These figures also demonstrate how extreme values can have a strong effect. For instance, the mean average for the convergence of retouched flakes is higher than the 75th percentile, showing the influence of a relatively small number of highly convergent pieces.

table 10 hereabouts

While the nature of the sample makes the issue of blank selection difficult to address, the features of blanks chosen for retouch can be described. Most (77.7%) retouched flakes do not have any cortex, and only three examples have more than 40% cortex. The scar patterns on the complete retouched flakes can be described as: unidirectional (24.6%), unidirectional convergent (10.1%), bidirectional (43.5%), perpendicular (5.8%), weakly centripetal (10.1%), centripetal (5.8%). These are broadly similar values to those recorded for Levallois flakes, aside from having somewhat less unidirectional convergent patterns and somewhat more bidirectional patterns. For 35.8 % of retouched tools, the blanks were Levallois flakes, while in 32.1% they were not. In 32.1% of cases it was not possible to tell whether blanks were Levallois or not. The dimensions of the striking platforms are fairly similar to those of Levallois flakes, as are the external platform angles (table 11). The striking platforms on the complete retouched flakes can be described as plain (17.4%), dihedral (7.2%), faceted (58.0%), indeterminate (e.g. crushed or retouched) (17.4%).

table 11 hereabouts

Retouch is generally limited to the dorsal surface (59 of 69, 85.5%), while 4.3% are only retouched on the ventral surface, 8.7% are retouched on both surfaces and 1.4% are retouched 'on edge'. The retouch is generally continuous (92.8%), rather than clustered (7.2%). The angle of the retouch is most commonly semi-abrupt (55.2%), while 22.4% is abrupt, 17.9% is flat, and 4.5% is steep. Not many pieces display notches, which, where present, are 5 to 15 mm across and normally 1.5 to 4 mm deep. The most common form of retouch is 'scraper-like', and covers most of the length of either one or both lateral margins.

Various measures have been proposed to quantify the intensity or invasiveness of retouch, and offer a useful alternative to more subjective typological categories. Table 12 shows summary statistics for the Geometric Index of Unifacial Retouch (GIUR, Kuhn, 1990), the Index of Invasiveness (I of I,

Clarkson, 2002) and the percentage of the perimeter retouched. These measures emphasise different, but complementary, aspects of retouch, with the GIUR offering a more ‘vertical’ perspective (also a proxy for the steepness of retouch), while I of I offers a more ‘horizontal’ perspective. Table 12 illustrates that the retouched tools from Skhul have much higher GIUR than I of I scores. This suggests relatively steep retouch, which is not found over much of the edges and surfaces of the pieces. On average less than 40% of the perimeter was retouched.

table 12 hereabouts

Two particular features worthy of comment are the evidence for basal modification and the presence of retouched points. Confirming the earlier observation of Bisson (2001; 2007), seven examples of basal modification on the ventral surface of Skhul retouched flakes were identified in the PRM collection. Five of these are from B2, with one from B1 and one from an unknown part of B. A further four examples may feature basal modification, but were classed as indeterminate. The basally modified pieces vary considerably with respect to factors such as size and shape, as well as technological aspects such as dorsal scar patterns. The form of retouch was classified as shouldering (n=1), basal thinning (n=2) and truncation (n=4). The prominence of retouched points in the Skhul assemblage is an interesting technological feature given their apparent rarity at sites such as Qafzeh. As shown in figure 9, retouching was used to both produce pointed shapes and to modify the base of the tool. The retouched points feature unidirectional (n=3), unidirectional convergent (n=2) and bidirectional (n=3) dorsal scar patterns. In all but one case they are only retouched on the dorsal surface. Other examples of retouched flakes from Skhul are shown in figure 10.

figure 9 hereabouts

figure 10 hereabouts

8. Inter-Site Comparisons

The technological features of the Skhul lithic assemblage can be placed into a comparative regional and inter-regional framework. We initially focus on selected sites from northeast Africa and southwest Asia as these have detailed data, gathered using comparable methods. The sites offer representative examples of particular geographic and temporal contexts; Qafzeh being a MIS 5 Levantine site, Tor Faraj a MIS 3 Levantine site, Warwasi a Zagros MP site, Jebel Qatar 1 (JQ-1), Jebel Katefeh-1 (JKF-1), 123-b, and Mundafan Al-Buhayrah (MDF-61) being Arabian Late Pleistocene sites, 1010-8 a northeast African site, and Porc Epic an East African Late Pleistocene site (Hovers, 2009; Groucutt, 2014; Scerri, 2014; Scerri et al., 2014a; 2014b; Groucutt et al., 2015c; Groucutt et al., 2015d). As many sites are published in either broad or strictly typological terms, very specific comparisons cannot be conducted. Consequently, we begin with the initial more detailed comparisons of a quantified nature, leading to broader comparisons across a larger area with an emphasis on fundamental technological aspects. As it is beyond the scope of this paper to offer systematic comparison, we highlight key salient observations as a basis for testable hypotheses.

8.1. Cores

In basic aspects of size, the values obtained for cores from Skhul are similar to cores from Qafzeh. They are likewise similar to those from the MIS 5 Arabian site of MDF-61, where preferential Levallois cores (n=29) have a mean maximum dimension of 52.1 mm, maximum width of 44.5 mm and maximum thickness of 18.1 mm. For the recurrent centripetal cores (n=37), the values are 56.9 mm, 49.1 mm and 18.0 mm. The cores from MDF-61 are however, typically somewhat lighter than those from the Skhul sample. The latter have a mean weight of 74.3 g, while cores are generally lighter at Mundafan, e.g. preferential Levallois cores have a mean weight of 52.1 g and recurrent centripetal of 56.9 g. At other MP sites cores are typically slightly larger, such as JKF-1, while some are generally somewhat smaller, such as Tor Faraj. These data suggest that cores from Skhul are of medium size and reduction intensity, and can therefore be fruitfully compared to sites such as Qafzeh

and MDF-61 in a way which will genuinely highlight technological differences, and not pragmatic factors such as differential reduction intensity. Critically, these sites feature a greater emphasis on recurrent rather than preferential Levallois reduction, in clear contrast to Skhul.

8.2. Levallois debitage

The Skhul Levallois flakes are slightly longer and wider than those from Qafzeh, while having a similar thickness. The sample of 84 Levallois flakes from MDF-61 in Arabia provides another important comparative sample. These have an average weight of 29.0 g, slightly heavier than those from Skhul. In other factors, both in terms of size and factors such as the number of scars, the Skhul Levallois flakes are similar to those from MDF-61. The exception to this is that Skhul Levallois flakes are typically much more convergent than those from MDF-61 (means of 5.3 and 1.6 respectively). The size of the striking platforms is very similar to that from MDF-61 (mean of 259.9 mm²). However, platforms there are much less flattened than those from Skhul (3.2 versus 4.7). The characteristics of Levallois products reveal interesting patterns of similarities and differences. In some basic aspects of shape and size, the Skhul Levallois flakes are similar to those from MDF-61 and Qafzeh. In other regards, however, they are clearly quite different. In factors such as their frequently convergent shape, the Skhul examples differ from MDF-61 and Qafzeh.

8.4. Retouched Tools

In terms of factors such as weight and dimensions, Skhul retouched pieces are medium sized, larger on average than those from sites such as Porc Epic, Tor Faraj and Warwasi (all having means of less than 20 g), but much smaller than those from sites such as 1010-8 and 123-b, which have average weights of over 60 g. The same pattern is found for other factors such as length and width. With respect to retouch intensity, MDF-61 features retouched flakes which have an average GIUR score of 0.69, showing vertically invasive retouch, which is much higher than Skhul (mean of 0.43). In other words, more than 75% of retouched tools from Mundafan Al-Buhayrah have higher GIUR

scores than the 75th percentile of the Skhul sample. The Skhul GIUR scores are similar to those from Porc Epic and 1010-8, with much greater values recorded at sites such as Tor Faraj and Warwasi. These factors reflect the cross-cutting drivers of the methods of tool manufacture and the position of the sites in the landscape in relation to raw material sources. The I of I scores are low compared to other sampled sites, reflecting the emphasis at Skhul on the retouching of one edge and not in an invasive manner. The retouched tools at Skhul are therefore both of moderate size and reduction intensity, and feature a clear suite of characteristics. For instance, the relative abundance of retouched points differentiates them from other sites such Qafzeh.

8.5. Wider comparisons

With the preceding brief comparative discussion in mind, we can consider the comparative dimension of the Skhul lithic assemblage with a focus on technological aspects.

Though Skhul is often described as being technologically similar to Qafzeh and other ‘Tabun-C’ assemblages, the current analysis demonstrates a number of differences. While it is possibly some of these may have been influenced by the nature of the excavation and subsequent sorting, we consider it unlikely that this is the main factor determining the character of the PRM assemblage. Firstly, although the centripetal and bidirectional preparation of the Skhul cores falls within the classic descriptions of ‘Tabun-C’ lithic assemblages, a much higher emphasis on preferential rather than recurrent Levallois reduction is evident. Levallois flakes also demonstrate both diverse scar patterns, and a relatively low frequency of centripetal scar patterns. The Skhul assemblage is, in this way, clearly differentiated from sites such Qafzeh and Ras el-Kelb. Where recurrent methods were used at Skhul they seem to represent a basically ‘opportunistic’ approach, where preferential removals have not covered much of the debitage surface. This is the opposite pattern to sites such as Qafzeh, where recurrent methods were used for the bulk of the reduction process with the addition of preferential reduction late in the process. Technological differences between Skhul and Qafzeh are summarised in

table 13. These also apply to Arabian sites such as MDF-61, indicating that some broad cultural processes in the Levant are to an extent replicated across a much wider area of southwest Asia.

table 13 hereabouts

Another important aspect of core reduction at Skhul concerns the presence of point production. Where Levallois points are present at Qafzeh (particularly layer XV), they are technologically different to those from Skhul. At Qafzeh, where present, almost all points were produced by unidirectional-convergent preparation (Hovers, 2009) (e.g. figure 2t,u), whereas at Skhul they were produced by more diverse dorsal surface preparation, with the production of points by retouch also demonstrating a broader interest in the production of convergent forms. Some of the Levallois points and cores at Skhul display some similarity to technology often described as ‘Nubian’ Levallois (e.g. figures 6a, 9c,d), but described here, following the original terminology of Seligman (1921), as ‘beaked’ Levallois (Groucutt et al., 2015a). Instead of viewing the presence of such features as a direct consequence of population dispersal, there is the distinct possibility that such forms at Skhul represent independent, convergent evolution of similar reduction methods as found elsewhere (Blinkhorn et al., 2013; Will et al., 2015). The forms at Skhul are present within a context of preferential Levallois reduction with bidirectional and centripetal preparation. Beaked Levallois technology has been occasionally noted in the Levant (Vermeersch, 2001; Hussain et al., 2015; Goder-Goldberger et al., 2016), but not in contexts with chronological control. The presence of these beaked Levallois forms in the Levant is important given recent debates on the meaning of this technology in Arabia. In particular, the claim has been made that beaked Levallois core forms in Arabia must represent dispersal out of Africa since southwest Asia has no non-African progenitor of a similar type (Crassard and Hilbert, 2013). While not identical to most examples previously described as ‘Nubian’, several specimens from Skhul demonstrate similar technological features, and it is possible to imagine how the former could ‘evolve’ to, or from, purportedly ‘classic’ examples of the latter. Elsewhere in the

Levant, the clear presence of undated beaked-Levallois technology firmly shows the presence of this technology in the area (Golder-Goldberger et al., 2016).

While it is widely claimed that bifacial *façonnage* technology was not part of the Levantine MP technological repertoire (e.g. Armitage et al., 2011; Richter et al., 2012), the paucity of studied early MIS 5 sites in the Levant makes this a difficult claim to evaluate. Their possible presence at Skhul, and definite presence at Jebel Faya in eastern Arabia (Armitage et al., 2011), suggest that they may have been part of early MIS 5 toolkits in this area. MIS 7 to early MIS 5 lithic assemblages in East Africa contain occasional bifaces, while bifaces appear to be essentially absent in later MIS 5 and younger assemblages (Wendorf and Schild, 1974; Walter et al., 2000; Clark et al., 2003; Yellen et al., 2005; Shea, 2008b). However, the presence of rare bifaces may reflect stratigraphic complexities and/or hominin scavenging of bifaces from older Acheulean sites, rather than being part of a standard MSA/MP technological repertoire. Likewise, in the case of Giv'at Rabbi East (Lower Galilee), bifaces were recently found in sediments dating to late MIS 6 and MIS 5 (Yaroshevich et al., 2017). In this case, the excavators discuss several possible scenarios to explain the presence of Acheulian-like bifaces in assemblages of MP age. Their favoured model is one in which MP hominins scavenged the bifaces from a nearby Lower Palaeolithic site, perhaps using them in quarrying activities. (Yaroshevich et al., 2017). Such situations demonstrate the need for the excavation of more early MIS 5 contexts in the area. In Arabia, Jebel Faya (early MIS 5) features bifaces, while they are absent in late and post-MIS 5 assemblages, such as MDF-61, JQ-1 and SD-1.

Perhaps more securely, emerging evidence indicates temporal changes in Levallois reduction methods, such as an apparent focus on preferential Levallois technology in MIS 5e Southwest Asia, at sites such as Skhul and (seemingly) Jebel Faya (Bretzke et al. 2014), and a later MIS 5 emphasis on recurrent centripetal Levallois technology, as at Qafzeh, MDF-61 and JQ-1 (Hovers, 2009; Petraglia et al., 2012; Groucutt et al., 2015c). These patterns suggest that while the data from Skhul complicate

our understanding of the Levantine MP, the new and emerging picture provides a better articulation of the Levant with surrounding regions.

9. Discussion

The integrated evaluation of the Skhul and Qafzeh hominin palaeontological and chronometric data with the technological analyses presented here indicates that a simple demographic scenario of a single, short-lived African population dispersal and subsequent extirpation is unlikely, or at least not proven. These data are instead consistent with a longer and more complex occupation of the Levant than commonly envisaged. While several alternative possibilities are consistent with the available records, on the basis of the current data, we favour a model in which the *Homo sapiens* from these sites were drawn from distinct, temporally discrete, populations. This interpretation is consistent with the growing evidence from surrounding regions and palaeoenvironmental archives for repeated humid phases facilitating population movements within and between Africa and southwest Asia (Blome et al., 2012; Drake et al. 2013; Scerri et al., 2014a; Parton et al., 2015; Breeze et al., 2016; Scerri, 2017). Between these humid episodes, periods of intense aridity can be hypothesised to have led to repeated localised extinctions (Shea, 2008a). For instance, the Levant in MIS 5, including the end of MIS 5e, witnessed periods of marked aridity (e.g. Neugebauer et al., 2016; Palchan et al., 2017; Kiro et al., 2017). The available chronological data suggest that the human occupation of Skhul dates to ~120 ka, and the older part of the Qafzeh sequence to ~95 ka, while other sites in southwest Asia include MDF-61 in Saudi Arabia, dating to ~85 ka. Further research is needed to explore whether there was long term population continuity in the Levant, or – as hinted at by the archaeological, palaeontological and palaeoenvironmental data we have discussed – there was population turnover of the area even during periods such as MIS 5, and multiple dispersals into the area.

It might be expected that changes in southwest Asian lithic technology should mirror the palaeontological, chronological and palaeoenvironmental pattern. Despite the general recognition of sites such as Skhul representing dispersal from northeast Africa, several authors have asserted that

Levantine MP assemblages display no evidence for compelling similarities with northeast African assemblages (e.g. Marks, 1992; Vandermeersch, 2001; Klein, 2009, p. 606). The apparent lack of similarities includes the purported absence of bifacial *façonnage* and beaked ('Nubian') Levallois-like technology in the Levant. These apparent absences have been used to support particular dispersal models, such as those invoking a crossing of the Red Sea at the Bab al Mandab, between the Horn of Africa and southern Arabia (Armitage et al., 2011).

As we have shown, the Skhul lithic assemblage has a particular technological character, which differs in some regards from other sites to which it is often compared, such as Qafzeh (Table 13). This can be interpreted in different ways. While some differences in lithic technology reflect pragmatic influences such as different access to, or quality of, raw materials, recent studies demonstrate that the influence of raw material variation has been overstated. For instance, Scerri and colleagues (2014a) found that MP variation across North Africa reflected geographical/environmental factors and did not correlate with raw material factors (see also Eren et al., 2014). Likewise, variability in reduction intensity plays an important role in determining the character of lithic assemblages. For instance, it is possible that the relative prevalence of retouched points at Skhul may reflect the resharpening of points produced by debitage, indicating high reduction intensity. But given the fact that raw materials were available nearby, and that the overall characteristics of the assemblage do not demonstrate high levels of reduction intensity, we do not think that factors such as mobility strategies or the stage of reduction are exerting a fundamental influence on the assemblage. While we do not suggest that variation in lithic technology purely reflects cultural transfer, as both 'branching' and 'blending', we do argue that cultural factors are one of the most important factors in structuring the regional MIS 5 archaeological record. Alongside other categories of evidence, lithic technology can therefore provide valuable insights into demography and behavioural change.

The Skhul cores, relatively homogeneous in both morphology and technology, demonstrate preferential Levallois exploitation following centripetal preparation. While this may be exaggerated

by the selective discard of non-Levallois, and non-preferential Levallois cores given early twentieth century definitions of Levallois technology, this is unlikely to have fundamentally influenced the character of the available assemblage. The preferential products range in shape from rectangular to pointed. Characteristics of the Levallois flakes and points correspond with the core observations, though the flakes display some differences to the scars of preferential removals on the cores, indicating changes through the reduction process. These differences include greater elongation and convergence of the products themselves, than of those inferred from cores. The flakes also demonstrate less of a centripetal focus to those produced early in the reduction process, highlighting the need to study different aspects of lithic assemblages in order to gain a full understanding. The retouched component is dominated by side-retouched flakes, but the presence of retouched points is a key features of the assemblage, as side retouched flakes are found in most MP assemblages.

From our analysis of the Skhul assemblage, it is clear that it differs from sites such as Qafzeh in several ways. More widely, notions of a relatively homogeneous time transgressive ‘Levantine Mousterian’ (e.g. Wolpoff, 1989; Clark, 1992) find little support when detailed technological observations are made on the lithic assemblages. The features of the ‘Levantine Mousterian’ have been suggested to include the production of Levallois points and low levels of retouch; yet, to choose just one example, the large assemblages from Ras el Kelb have hardly any Levallois points and have high levels of retouch (Copeland, 1998). Perceptions of a homogeneous Levantine MP reflect, in part, variable research traditions towards lithic assemblages. As Hovers (1998) pointed out, the application of a Bordesian typological approach would render all Levantine MP assemblages as ‘typical Mousterian’. However, our analysis shows that even assemblages belonging to a single phase or group of the Levantine MP, in fact, embody considerable variability. We are not, however, suggesting that there is no inter-assemblage structure to the Levantine MP, merely that this structure is more variable and complicated than previously observed. This variability is also not being captured by traditional industrial nomenclatures. While the Skhul assemblage features some similarities to other Levantine assemblages assigned to MIS 5, such as frequent centripetal Levallois reduction, we have shown that in other regards it differs considerably.

1052
1053 Various factors influence the character of lithic assemblages, and several contributions have
1054 emphasised the importance of organizational approaches to understanding the Levantine MP (Jelinek,
1055 1992; Hovers, 2009). At Qafzeh, for instance, cores were imported to the site, while at Ras el Kelb the
1056 rarity of cores and the high rates of retouch instead indicate a focus on the introduction of Levallois
1057 flakes and retouched tools. Such differences indicate that technological variation must be
1058 contextualised in terms of factors such as mobility and lithic provisioning strategies. Such factors
1059 mean that we have only partial insights into the mobility and technological strategies of MIS 5
1060 Levantine hominins, and that more sites from a variety of landscape settings are needed to make
1061 robust conclusions.

1062
1063 The prevalence of point production at Skhul is a noteworthy characteristic. Lithics demonstrating
1064 beaked Levallois-like reduction are present at Skhul in seemingly small numbers, yet that they are
1065 present at all is key, as descendant populations could have increased the frequency with which they
1066 were made. Likewise, MIS 6 and 5 assemblages at Giv'at Rabbi East feature frequent bidirectional
1067 preparation of Levallois debitage surfaces (Yaroshevich et al., 2017), which might also offer a
1068 precursor to beaked Levallois technology. This is not to say that beaked Levallois technology in
1069 Arabia did not result directly from dispersal out of Africa, but that such an automatic assumption
1070 based on relatively superficial similarities of a single core reduction type is as yet premature. The
1071 demonstration that the MIS 5 archaeological record features significant temporal differences must be
1072 factored into future comparative studies. Our findings offer a broad articulation between the African
1073 and southwest Asian records, and highlight the continued relevance of northern (trans-Sinai) dispersal
1074 out of Africa, via the Levant (see e.g. Breeze et al., 2016). While our data suggest that crossing the
1075 Bab al Mandab is not necessary to explain observed patterns in palaeontological and archaeological
1076 data, it is possible that this 'southern' route also played a role.

1077

The emerging complexity within the Levantine MP identified in the technological analysis of the Skhul sample is also supported by the human palaeontology. Contrary to the commonly held assumption that the Skhul and Qafzeh samples are unequivocally part of the same MIS 5 population, it is equally possible that they represent two distinct populations, separated by many millennia. Determining whether the shared ‘modern’ traits signify a common population or a common evolutionary heritage is difficult. We currently lack a good sample of comparably complete fossils from Africa in MIS 6, particularly in the postcranial skeleton. If the shared ‘modern’ traits of Skhul and Qafzeh were already present in their African ancestral population(s) then those traits could have been independently transmitted to distinct descendant groups represented by Skhul and Qafzeh. This may be indicated by the propensity towards more archaic features such in the Skhul individuals.

While our conclusions are based on a synthetic assessment of the available chronometric, environmental, palaeontological, genetic, and archaeological data, we recognise that the Skhul lithic sample has certain limitations. As was common at the time of excavation, the site was dug rapidly and not all material from the excavation was retained. This imposes certain constraints on the kinds of questions which can be posed and addressed. Nevertheless, the frequent inclusion of Skhul in hypotheses of *Homo sapiens* dispersal into southwest Asia warrants the consideration of Skhul lithic technology. Our focus has therefore been on describing the PRM sample and its broad technological features. For instance, selective curation by McCown and Garrod does not negate the fact that point production is prominent at Skhul in contrast to Qafzeh. Likewise, while it is certainly possible that Levallois cores were preferentially retained over non-Levallois cores, for instance, it seems unlikely that such a strong selection against recurrent and for preferential Levallois cores would have been made. Likewise, it seems unlikely that Levallois flakes with centripetal scar patterns would have been preferentially discarded. The presence of many lithics with ancient breaks in the collection also suggests that it is not selective to the point of being uninformative; it seems unlikely that broken flakes would have been seen as being more important to keep than recurrent Levallois cores. Likewise, while some of the homogeneity of various aspects of size and shape of Skhul lithics may have been exaggerated by selection, this is unlikely to apply to aspects such as angle of striking

platforms and the number of scars, which demonstrate some consistent patterning. In summary, we therefore acknowledge that the Skhul lithic assemblage is not ideal from the perspective of contemporary standards, but we also highlight that all archaeological sites and subsequent interpretations are subject to numerous biases, both geological and human. While recognising the limitations of the Skhul lithic assemblage, we wish to emphasise the importance of the site, owing to its significant occupation history. We have attempted to use the available data to formulate an interpretation of the site and its regional context, and hope that future research will further develop and refine our understanding.

10. Conclusion

Levantine archaeological and palaeontological records have played crucial roles in understanding hominin evolution and dispersals out of Africa in the Late Pleistocene. In the debate on the origin and spread of *Homo sapiens*, Levantine fossils and archaeological findings have been cited as evidence supporting directly opposing models. A fast-body of evidence from areas such as Arabia allows the Levant to be situated in a wider southwest Asian context (Groucutt and Petraglia, 2012), while the increased application of chronometric dating techniques in the Middle East provides improved temporal resolution.

Available chronometric age estimates for Levantine sites such as Skhul and Qafzeh, along with the analysis of the Skhul lithic assemblage presented here, indicate that the MIS 5 occupation of the Levant was neither short nor behaviourally homogeneous. Within the Qafzeh sequence various temporal changes can be seen (Hovers, 2009), involving lithic technology, as well as other aspects including the presence of human burials and ochre in the lower but not the upper part of the sequence. This impression of complexity and change is also clear when the technological characteristics of sites such as Skhul and Qafzeh are compared.

The best age estimates for Skhul suggest a chronology of ~130-100 ka, and perhaps slightly older at the base. In contrast, the lower levels of Qafzeh date to ~100-90 ka, with most of the layers of the site being younger than this. Parsimoniously, these data suggest that Skhul may have been occupied during MIS 5e and Qafzeh during MIS 5c (and perhaps extending to MIS 5a). These results suggest that either *Homo sapiens* was in the Levant for tens of thousands of years in MIS 5, and/or that there were multiple dispersals into the area. The latter appears more likely to us, yet the former cannot be rejected given available evidence. The evidence for extreme aridity in the Levant between the occupations of Skhul and Qafzeh may suggest a mechanism for population turnover in the area (e.g. Kiro et al., 2017). Therefore, even if one thinks that the nature of the Skhul lithic assemblage is too problematic for modern comparative studies due to selective curation, the chronological information alone indicates that Skhul represents an earlier phase of occupation of the Levant than sites such as Qafzeh.

If the Skhul lithic assemblage is too problematic to be meaningful, then existing claims such as the homogeneity of the Tabun-C phase should also be rejected. We consider it better to discuss available data and acknowledge its caveats than to continue to ignore the details of the Skhul lithic assemblage. If the Skhul lithic assemblage is as uninformative as some reviewers of this paper argued, then we should not accept the claim by Mellars and colleagues (2013, p. s15) that it “bears no resemblance whatever to the very different” Middle Palaeolithic sites of Arabia, nor the suggestion by Armitage and colleagues (2011, p. s5), that assemblage C of Jebel Faya shows “none of the technological traits” found at Skhul. These claims flow from the general recognition that the Skhul lithic assemblage was not excavated and curated to modern standards, and the conclusion from this that the assemblage can therefore be described in a somewhat superficial manner. Given that claims are being made on major issues in human evolution based on vague impressions of the Skhul assemblage, it is incumbent upon scholars to test these ideas with the data at our disposal.

The particular characteristics of the Skhul lithic assemblage, described in detail here for the first time, complicate narratives for population dispersal, and emphasise the need for the detailed analysis of spatially and temporally representative samples. In the case of the Levant and elsewhere in southwest Asia, the targeting of Last Interglacial (MIS 5e) contexts for excavation according to modern standards should be a research priority (see recently e.g. Galili et al., 2017). In conclusion, accumulating multidisciplinary data, including the analysis of the PRM Skhul lithic assemblage we have presented, increasingly suggest that there were multiple dispersals of *Homo sapiens* out of Africa in MIS 5, corresponding with humid phases, and alternating with phases of aridity. We have described the Skhul lithic assemblage, acknowledging its limitations in terms of excavation methods and so on, and formulated hypotheses that can be tested by multidisciplinary analyses of new sites.

Acknowledgements

For funding, we acknowledge the British Academy (HG, EMLS), the European Research Council (grant no. 295719, MDP) and the Calleva Foundation and the Human Origins Research Fund (CS). We thank the Pitt Rivers Museum, University of Oxford, and particularly Madeline Ding, for facilitating access to the Skhul collection. We than the editors and three anonymous reviewers for their useful suggestions on how to improve the paper.

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Figure captions

Figure 1. Location of Skhul and other key sites mentioned in the text. 1. Abdur Reef, 2. Aduma, 3. Bir Tarfawi/Bir Sahara, 4. Dhofar sites, 5. Gademotta/Kulkuletti, 6. Haua Fteah, 7. Hummal, 8. Jebel Faya, 9. Jubbah sites, 10. Mundafan, 11. Naamé, 12. Nesher Ramla, 13. Omo Kibish, 14. Porc Epic, 15. Qafzeh, 16. Ras el Kelb, 17. S-20, 18. Sai Island, 19. Shi'bat Dihya 1, 20. Sodmein Cave, 21. Taramsa, 22. Tor Faraj, 23. Warwasi.

Figure 2. Examples of Levantine MIS 5 lithics from Ras el Kelb (A-M) and Qafzeh Cave (N-Y). A-D, N-P: Levallois cores, E-H, Q-U: Levallois flakes, I-M, V-Y: retouched tools. While there are many similarities between the lithic assemblages, there are also differences such as much higher rates of retouch at Ras el Kelb and the presence of Levallois points in some units at Qafzeh. Modified from Hovers (2009) and Copeland (1998).

Fig 3. Examples of temporal variability in lithic technology at Qafzeh cave. A.) variation in dorsal scar patterns on Levallois flakes, b.) variation in the face(s) retouched. Produced with data from Hovers (2009). Temporal variation of these forms shows that even within a single site assigned to the 'Tabun-C' phase, there is considerable technological variability.

Fig 4. Previously published illustrations of Skhul lithics. 1-3: points, 4-14: retouched flakes ('scrapers'), 15-20: cores, 21: handaxe/biface. Previously published descriptions and illustrations establish the importance of Levallois reduction at Skhul and show that the retouched toolkit is dominated by side retouched flakes and retouched points. Modified from Garrod 1937; Bisson 2001; Shea, 2006.

Fig 5. Comparison of the percentage of key lithic types between the complete Skhul assemblage and the Pitt Rivers Museum sample showing the basic similarity in composition. Figure excludes non-Levallois flakes, unclear categories, and those with less than 10 pieces in the complete sample.

Fig 6. Illustrations of Skhul cores, showing preferential (A,B,D,F,G) and recurrent (C,E) methods and diversity of preparation. Darker greys show later removals. Squares at start of arrows indicate removed interpreted as being Levallois (i.e. predetermined). The core forms show variation in patterns of dorsal preparation, from ‘classic’ highly centripetal preparation (F) to forms producing pointed flakes which share similarities with beaked-Levallois technologies (A)

Fig 7. Illustrations of Skhul Levallois flakes with centripetal and bidirectional dorsal scar patterns. Darker greys show later removals. Centripetally and bidirectionally prepared ovoid to rectangular shaped Levallois flakes are characteristic elements of MIS 5 Levantine assemblages.

Fig 8. Comparison of dorsal scar patterns for A) Levallois flakes/blades, B) Levallois points at Skhul. While points typically feature unidirectional convergent and bidirectional preparation, flakes/blades tend to have centripetal or unidirectional preparation.

Fig 9. Illustrations of Skhul points, produced by both dorsal surface shaping (A-F) and retouch (G-I). Darker greys show later removals. Black shows retouched areas. While points with unidirectional/convergent scar patterns are present (A, B), a key feature of Skhul is the diversity of forms of preparation. Several examples feature distal preparation reminiscent of beaked Levallois technology.

1619 **Fig 10. Examples of other retouched forms from Skhul.** Black shows retouched areas. The
1620 dominant form of retouched tool at Skhul consists of side retouched flake ('scrapers'), retouched on
1621 one or both margins.

1622