Quaternary Science Reviews 166 (2017) 114–149

Contents lists available at ScienceDirect

Quaternary Science Reviews

journal homepage: www.elsevier.com/locate/quascirev

Fluvial deposits as an archive of early human activity: Progress during the 20 years of the Fluvial Archives Group

Parth R. Chauhan [a, b, c, *], David R. Bridgland [d], Marie-Hélène Moncel [e], Pierre Antoine [f], Jean-Jacques Bahain [g], Rebecca Briant [h], Pedro P. Cunha [i], Jackie Despriée [e], Nicole Limondin-Lozouet [f], Jean-Luc Locht [j], Antonio A. Martins [k], Danielle C. Schreve [l], Andrew D. Shaw [m], Pierre Voinchet [g], Rob Westaway [n], Mark J. White [o], Tom S. White [p]

[a] Department of Humanities and Social Sciences, Indian Institute of Science Education and Research, Sector 81, Mohali, Punjab 140 306, India
[b] Stone Age Institute, 1392 W., Dittemore Rd., Gosport, IN 47433, USA
[c] Department of Anthropology, Indiana University, Bloomington, IN, USA
[d] Department of Geography, Durham University, South Road, Durham, DH1 3LE, UK
[e] UMR 7194 CNRS, Département de Préhistoire, Muséum national d'Histoire Naturelle, Institut de Paléontologie Humaine, Paris, France
[f] Laboratoire de Géographie Physique, UMR8591 CNRS-Univ. Paris 1, 1 place A. Briand, F-92195, Meudon Cedex, France
[g] Laboratoire de Préhistoire du Muséum National d'Histoire Naturelle, Paris, France
[h] Department of Geography, Environment and Development Studies, Birbeck University of London, Malet Street, London WC1E 7HX, UK
[i] Marine and Environmental Research Centre, Department of Earth Sciences, University of Coimbra, 3030-790 Coimbra, Portugal
[j] UMR CNRS 8591 - Laboratoire de Géographie Physique, INRAP Nord-Picardie, 518, rue Saint-Fuscien, 80 000, Amiens, France
[k] Instituto de Ciências da Terra (ICT), Departamento de Geociências, Universidade de Évora, 7000-671, Évora, Portugal
[l] Centre for Quaternary Research, Department of Geography, Royal Holloway University of London, Egham, Surrey, TW20 0EX, UK
[m] Faculty of Humanities (Archaeology), University of Southampton, Southampton, SO17 1BF, UK
[n] School of Engineering, University of Glasgow, Glasgow, G12 8QQ, UK
[o] Department of Archaeology, Durham University, South Road, Durham, DH1 3LE, UK
[p] Department of Zoology, University of Cambridge, Downing Street, Cambridge, CB2 3EJ, UK

A R T I C L E I N F O

Article history:
Received 17 April 2016
Received in revised form
10 March 2017
Accepted 17 March 2017
Available online 27 April 2017

Keywords:
Fluvial archives
Hominin occupation
River terraces
Lower Palaeolithic
Middle Palaeolithic
Acheulian
Levallois

A B S T R A C T

Fluvial sedimentary archives are important repositories for Lower and Middle Palaeolithic artefacts throughout the 'Old World', especially in Europe, where the beginning of their study coincided with the realisation that early humans were of great antiquity. Now that many river terrace sequences can be reliably dated and correlated with the globally valid marine isotope record, potentially useful patterns can be recognized in the distribution of the find-spots of the artefacts that constitute the large collections that were assembled during the years of manual gravel extraction. This paper reviews the advances during the past two decades in knowledge of hominin occupation based on artefact occurrences in fluvial contexts, in Europe, Asia and Africa. As such it is an update of a comparable review in 2007, at the end of IGCP Project no. 449, which had instigated the compilation of fluvial records from around the world during 2000–2004, under the auspices of the Fluvial Archives Group. An overarching finding is the confirmation of the well-established view that in Europe there is a demarcation between handaxe making in the west and flake–core industries in the east, although on a wider scale that pattern is undermined by the increased numbers of Lower Palaeolithic bifaces now recognized in East Asia. It is also apparent that, although it seems to have appeared at different places and at different times in the later Lower Palaeolithic, the arrival of Levallois technology as a global phenomenon was similarly timed across the area occupied by Middle Pleistocene hominins, at around 0.3 Ma.

1. Introduction

Artefacts recovered from fluvial deposits, especially the Pleistocene gravels forming aggradational river terraces, have provided

* Corresponding author.
E-mail address: parthrc@iisermohali.ac.in (P.R. Chauhan).

http://dx.doi.org/10.1016/j.quascirev.2017.03.016

much of the evidence for early human occupation of regions throughout the 'Old World'. In Europe, research on this topic extends back to the days of Victorian polymaths, who combined interests in many aspects of the Earth and natural sciences, as well as human history. Of considerable influence were the visits paid by the British geologist Joseph Prestwich (1860, 1864) and archaeologist John Evans (1863, 1872), later in the company of John Lubbock, to the artefact-bearing gravels of the River Somme, in northern France, under the guidance of Jacques Boucher de Perthes (1847–1864; cf. Grayson, 1983; Bridgland, 2014). As well as sparking an awareness of the great antiquity of early humans in NW Europe, this pioneering work was a prelude to over a century of monitoring and recording of exposures in fluvial gravels, by Palaeolithic archaeologists in the main, many of them amateurs (e.g., Commont, 1909, 1910; Breuil, 1932, 1939; Breuil and Zbyszewski, 1945; Wymer, 1968; White et al., 2009). Such activity was most productive during the time before mechanical extraction of aggregates began, with huge collections of artefacts being assembled and (in part) accessioned into museums. The abovementioned mechanization led to a significant decline in the rate of new discoveries, since when attention has turned to using the existing collections as resources for study (e.g., Roe, 1968a, 1981; Wymer, 1968, 1985, 1999; Lycett and Gowlett, 2008), supplemented with data from selected (sometimes targeted) excavations and investigations of various types (e.g., Martins et al., 2010a; Santonja and Pérez-González, 2010; Harding et al., 2012; Antoine et al., 2015, 2016a).

Thus Palaeolithic archaeologists were frequent earlier instigators of research on Pleistocene river-terrace gravels. Indeed, before the development of geochronological techniques, the dating of the Palaeolithic was closely linked to artefact occurrences in the various terrace sequences of NW Europe. This approach was subsequently applied (both successfully and erroneously) to other parts of the Old World through historical/colonial impact in India, Africa and other regions. With the condensed chronostratigraphies that prevailed before the marine oxygen isotope ($\delta^{18}O$) record became the global template, however, little sense could be made of the complexities of these sequences, a problem that thwarted the prescient attempts by Roe (1968b, 1981), for example, to make progress in that respect. Great advances have now been made in terms of geochronology (see Rixhon et al., 2017), although arguably the extended 'climato-stratigraphy' provided by the $\delta^{18}O$ record (e.g. Shackleton and Opdyke, 1973; Bassinot et al., 1994; Lisiecki and Raymo, 2005) has been the most important advance. This added the additional climate cycles that allowed artefact-bearing river terraces to be correlated with glacial–interglacial climatic cyclicity, in turn allowing a climatic mechanism for terrace formation to be envisaged with confidence (e.g. Zeuner, 1945, 1959; Wymer, 1968; Bridgland, 2000).

The origins of Lower Palaeolithic archaeology in NW Europe, particularly Britain and France, was predicated by the occurrence there of handaxes of the Acheulian industry, whereas further into the heart of Europe contemporaneous tool-making had relied on smaller-sized, more impoverished raw material and thus the artefact record, flakes and cores of Clarke's (1969) 'Mode 1' technology, is less conspicuous. Handaxe industries (Clarke's 'Mode 2) also occur in Iberia, North Africa and the Levant, where their appearance was evidently earlier and perhaps part of a south-to-north spread of technology (see Schreve et al., 2015 for a recent review and source of references). In India and the wider S & E of Africa, Acheulian industries are perhaps largely separate from and of greater antiquity than those in Europe (see below), whereas the Mode 1 industries are globally more widespread and probably of the greatest longevity (e.g. Clark et al., 1994; Dennell, 2008; Barsky, 2009; Chauhan, 2010a). The advent of prepared-core (Levallois) knapping technology, 'Mode 3' of Clarke (1969), is a more recent phenomenon globally, generally appearing during the Middle Pleistocene, although 'precocious' Levallois is seen in many Acheulian assemblages before the full emergence of the former and Mode 3-type technologies are associated with Oldowan industries in Africa as early as 1.5 Ma (e.g., White et al., 2011). Indeed, the widespread appearance of Mode 3 technology at ~300–250 ka is used to define both the beginning of the Middle Palaeolithic in Europe and the Middle Stone Age (MSA) in Africa (Porat et al., 2002; Tryon, 2006; Tryon et al., 2006; White et al., 2011).

With the advent of mechanical aggregates extraction, coupled with the development of new techniques such as for geochronological dating, the attention of Lower and Middle Palaeolithic specialists turned somewhat away from fluvial contexts, in which the artefacts are often more or less abraded and secondarily derived from previously inhabited land surfaces. Some fluvial sites, nonetheless, yield primary-context archaeology, especially where hominins have accessed river-bed gravel bars to obtain raw material for stone-tool making and/or to hunt and butcher animals. For example, Devès et al. (2014) have demonstrated how the relationship between hominin landscape behaviour and herbivore distribution during the Lower Palaeolithic in the southern Levant can be revealed by documenting various edaphic factors, including soils that retain water. River-terrace sites can have another benefit; they often occur within fluvial sequences that have great value as regional templates for the terrestrial record of the Quaternary (Wymer, 1999; Bridgland, 2000, 2006; Bridgland et al., 2004, 2006; Mishra et al., 2007). For archaeologists, fluvial contexts are valuable for another reason: to ascertain the contextual integrity of Palaeolithic sites and assess fluvial sorting of lithic assemblages using various methods (e.g. Bertran et al., 2012; Byers et al., 2015). A unique benefit of secondary fluvial contexts is in pinpointing provenance or locating primary contexts upstream or nearby from where the transported material may have originated and is eroding out. In fact, pinpointing contextual integrity may now have an even larger role to play in helping to establish archaeological integrity in some cases. For example, recent behavioural studies on wild bearded capuchin monkeys in Brazil indicate that they unintentionally produce cores and sharp-edged flakes that are not utilized, but are virtually indistinguishable from classic Oldowan flakes (Proffitt et al., 2016). Using proxies to reconstruct palaeoecological conditions in association with such specimens may help confront and mitigate such interpretative challenges.

There is also a strong tradition for archaeologically motivated study of river-terrace sequences in other regions of the Old World, notably in the Levant and Turkey, where much of the work took place in the mid–late 20th Century and was instigated by western European and Russian researchers (see below, Section 5). A similar observation can be made for the history of prehistoric research in Africa (see de la Torre, 2011) and India (e.g. de Terra and Paterson, 1939), where initial surveys were along major rivers and their tributaries. In India, the focus shifted to regions between river valleys comparatively late. Nonetheless, Palaeolithic archaeologists continue to target fluvial contexts for multiple reasons: exposures of lithics and vertebrate fossils in primary context and the potential to date such contexts with new methods, especially luminescence tecniques (see Rixhon et al., 2017). In India, the earlier historical focus was on linking various lithic assemblages with corresponding fluvial terrace deposits, not only for geochronological purposes but also to understand and establish technological successions.

The FLAG organizers encouraged multi-disciplinary participation in the activities of the group from its outset; archaeologists were present at the inaugural meeting in Durham and Palaeolithic localities and assemblages have been included in many FLAG meetings (e.g., those based on Cheltenham, Clermont Ferand, Siena and Castelo Branco: see Cordier et al., 2017). In the early years of FLAG, and under the auspices of the group, those interested in longer (glacial–interglacial) timescale fluvial archives established a project within the UNESCO-sponsored International Geological Correlation Programme (later International Geocience Programme) entitled 'Global Correlation of Late Cenozoic Fluvial Deposits: Project IGCP 449, which ran for the five calendar years 2000–2004 (Bridgland et al., 2007). Throughout its life IGCP 449 included a thematic geoarchaeological subgroup, contributors to which disseminated their data at the end of the project in papers on the European (Bridgland et al., 2006) and global (Mishra et al., 2007) Lower and Middle Palaeolithic archives. The work of IGCP 449 was followed by IGCP 518 (Fluvial sequences as evidence for landscape and climatic evolution in the Late Cenozoic; 2005–2007); this continued the work of compiling fluvial archive data from around the globe but saw little Palaeolithic activity (Westaway et al., 2009). With the cessation of IGCP support in 2007 the compilation of such data has continued within the longer-timescale theme(s) of FLAG (cf. Cordier et al., 2017), with continuing geoarchaeological activity, as has been reflected in the topics covered at FLAG meetings and in special issues during the interim period. The present paper seeks to summarize the advances in the understanding of the Lower and Middle Palaeolithic during the 20-year life of FLAG, with emphasis on those made since the previous (IGCP 449) review by Mishra et al. (2007). As with its predecessor it will be organized regionally, the discussed evidence being situated in the following countries: Kenya, Zambia, Tanzania, Ethiopia, South Africa, Algeria, Egypt, Sudan, Malawi, Senegal, Mali, England, France, Portugal, Spain, Italy, Germany, Syria, Turkey, Israel, Saudi Arabia, India, China, Cambodia and Java. The general location of sites and river systems highlighted here and in the predecessor review are depicted in Fig. 1. Summary data are also provided in Table 1. In general, sites with archaeology in contexts other than fluvial have not been included in the review nor displayed on the map. This includes cave sites, rock shelters, desert sites in dune contexts, sites in colluvial fans, on bedrock exposures, in quarry contexts and so forth. It is to be noted that additional sites might have been reported in regional journals across the Old World, in languages other than English; not being easily accessible and/or translated into English, these are not included in this review.

2. Africa

Current African projects are almost all re-excavations of old sites (e.g., Olorgasailie, Olduvai, Isimila, Kalambo Falls) that have been conducted to refine chronology, stratigraphy, etc. Little has emerged to change understanding of the Acheulian since the demonstration of this industry at Konso-Gardula at ~1.75 Ma (Beyene et al., 2012). Nonetheless, several new investigations have taken place on this continent in the last decade and most recently investigated palaeoanthropological sites come from fluvial contexts and so are worthy of review here. For example, at Olduvai Gorge, Ashley et al. (2009) have demonstrated that Oldowan lithic evidence (between ~1.79 and ~1.74 Ma) did not vary at spring sites but was variable at lake-margin sites, between wet and dry periods, reflecting changing subsistence patterns during arid episodes. This work has been complemented by the collection of plant fossils from Upper Bed I and Lower Bed II (~1.85–~1.7 Ma) of Olduvai Gorge, particularly from the HWK E and MCK localities (Bamford, 2012). This helped reconstruct the Early Pleistocene ecological landscape, including fluctuations between marshes, dry grasslands and woody plants, trees and palms on the palaeolake margin, ultimately correlating it with behavioural adaptations in diverse fluvial or wetland contexts (see Stewart, 2014). Cuthbert and Ashley (2014) went a step further and highlighted the relevance of groundwater refugia to human evolution and adaptation during the driest parts of the precessional cycle at Olduvai Gorge (~1.8 Ma). They also suggested that springs might have facilitated longitudinal hominin dispersals between larger freshwater bodies or rivers during wetter periods. In a slightly older context at Olduvai Gorge, fossil tree-root stumps from ~2 Ma were documented from an interval dominated by low-viscosity mass-flow and braided-fluvial sediments. Associated with quartzite and rhyolite Oldowan artefacts, this represents wooded grasslands in association with freshwater drainage in Lower Bed I (W part of the gorge). Likewise, Archer et al. (2014) demonstrated the exploitation of aquatic fauna (catfish and turtles) by Oldowan hominins at ~1.95 Ma at FwJj20 in the Koobi Fora Formation, Lake Turkana. The archaeological material is situated 15 m below the KBS tuff (1.869 Ma) and capped by sand lenses.

The most significant recent find from fluvial contexts in Africa in recent years is that from Lomekwi 3, in the West Turkana region of Kenya, where the oldest-known stone tools have been reported (Harmand et al., 2015). These artefacts, from 3.3 Ma, are assigned to the Lomekwian industry, based on distinct typo-technological traits (different from the classic Oldowan), and come from an 80 cm horizon of indurated sandy-granular sediments within a thick bed of fine silts. The known hominin species in this region at that time is *Kenyanthropus platyops,* suggesting that a pre-*Homo* species was extensively manufacturing and utilizing stone tools. Recent research by Domalain et al. (in press) may explain the absence of stone tools in coeval deposits at Hadar, Ethiopia: *A. afarensis* did not seem to possess suitable hands to produce Lomekwian tools. Technological analysis of the assemblages, produced on basalt, phonolite and trachy-phonolite, in combination with experimental archaeology, indicates the use of passive-hammer and/bipolar techniques as well as anvils or blocks.

New palynological research has also been carried out at two sites (OGS-6a and OGS-7) at Gona (Ethiopia), the oldest-known occurrence of classic Oldowan evidence (if accepted that Lomekwian is a distinct predecessor). López-Sáez and Domínguez-Rodrigo (2009) recovered fossil pollen, amongst which *Podocarpus* cf. *gracilor* is dominant, reflecting a mosaic of open and closed habitats within a prominent wooded environment during hominin occupation. In addition to these older Mode 1 assemblages, new (classic) Oldowan sites have also been reported. From Zambia, Barham et al. (2011) used cosmogenic nuclide, palaeomagnetic and isothermal thermoluminescence methods for relative and radiometric dating of Mode 1 and Mode 3 lithic assemblages (on quartzite) to the mid-Early Pleistocene (or no older than ~1 Ma) and ~78 ka, respectively. The undiagnostic Mode 3 evidence might represent a continuing human presence into MIS 5, when other areas of south-central Africa were depopulated due to reduced rainfall. It is inferred that the Mode 1 evidence here may post-date the eastern and southern African Oldowan in general, a phenomenon documented at comparably younger Oldowan occurrences elsewhere, such as the Middle Awash in Ethiopia (Clark et al., 1994). The site of Manzi is represented by a ~4.7 m section comprising coarse–medium fluvial sands with discontinuous gravel layers containing well-rounded quartzite clasts; no Acheulian (Mode 2) artefacts were observed here. Cross bedding is visible in all sedimentary types and the gravels are interpreted to represent bars deposited by scouring during wet-season floods. Due to this high-energy fluvial context, a nearby gravel bar was systematically sampled in surface contexts to identify natural modification of clasts from exposure to high velocity floods. Although 9.6% of the 468 collected clasts were found to be modified, deep scars with clear negative bulbs of percussion were completely absent, confirming the artefactual nature of the archaeological material.

With regard to the Acheulian, several key discoveries and new interpretations have been put forward by workers in different parts

Fig. 1. Location of sites and river systems mentioned in the paper and/or in the previous review, by Mishra et al. (2007), of the data from the early years of FLAG.

of Africa. Not only have the age ranges of known Acheulian assemblages been extended, new occurrences have also yielded important palaeoanthropological information. For example, now there are five different sites with Acheulian at ~1.7 Ma in Africa: Konso Gardula and Gona in Ethiopia (see Diez-Martín et al., 2015), Kokiselei at West Turkana, Kenya (Lepre et al., 2011), the Rietputs Formation in South Africa and, added most recently, at Olduvai Gorge in Tanzania (Diez-Martín et al., 2015). The distribution of

Fig. 1. (*Continued*)

these sites suggests an older origin, yet to be discovered (Lepre et al., 2011), followed by a rapid dispersal. In the Rietputs Formation on the Vaal River in South Africa, handaxes occur throughout a lengthy sequence of coarse gravel, sand and laminated and cross-bedded fine alluvium, dated using cosmogenic nuclides (Gibbon et al., 2009). At Olduvai Gorge, Diez-Martín et al. (2015) have re-addressed the historical issue of the evolution of the Acheulian there by reporting a ~1.7 Ma Ar–Ar age for Early Acheulian handaxes in spatial and functional association with faunal remains from FLK West. The handaxes occur in a series of diverse sedimentary layers at the bottom of Bed II, including conglomerates, coarse sands, fine sands and silts. The majority of the 2120 recovered artefacts were produced on Naibor Soit quartz and also include hammerstones, battered cobbles, anvils, percussion flakes and unmodified cobbles, some of which may represent manuports. The faunal assemblage includes four cut-marked bones, 13 percussed

Table 1
Key Palaeolithic sites discussed in the text, together with summarized information.

Site	Type	Age	Context	Significance	Reference
Lomekwi, Kenya	Lomekwian	~3.3 Ma	sandy sediments within silt	Oldest known artefacts	Harmand et al., 2015
Manzi, Zambia	multiple	1 Ma; 78 ka	sands and gravels	young Oldowan	Barham et al., 2011
Kokiselei, Kenya	Acheulian	~1.7 Ma	–	among the oldest known Acheulian	Lepre et al., 2011
Rietputs Formation, SA	Acheulian	~1.7 Ma	gravel, sand, alluvium	among the oldest known Acheulian	Gibbon et al., 2009
Olduvai Gorge, Tanzania	Acheulian	~1.7 Ma	conglomerates, sands, silts	among the oldest known Acheulian	Diez-Martín et al., 2015
Garba IVD, Ethiopia	Acheulian	~1.5 Ma	sand and fine gravels	emergence of new chaine operatoire	Gallotti 2013
Garba XIII, Ethiopia	Acheulian	~1–0.8 Ma	sand and gravels	multiple behvioural attributes	Gallotti et al., 2014
Es2-Loplosi, Tanzania	Acheulian	~1.5–1.4 Ma	–	site formation reinterpreted	Diez-Martín et al., 2014a
EN1-Noolchalai, Tanzania	Acheulian	~1.5–1.4 Ma	–	fluvial erosion and redeposition	Diez-Martin et al., 2014b
Cornelia-Uitzoek, SA	Acheulian	~1 Ma	gravels & clays (Schoonspruit R.)	fossil tooth of early *Homo*	Brink et al., 2012
Mieso, Ethiopia	Acheulian	~212 Ka	multiple fluvial sediment types	among youngest African Acheulian	de la Torre et al., 2014
Kalambo Falls, Zambia	Mode 2/3	~500–300 ka	channel & floodplain deposits	–	Duller et al., 2015
Birzgane, Algeria	MP	MIS 5–4	between silt and gravels	Aterian	Djerrab et al., 2014
Site 1017, Egypt	MP	~83 ka	Nile fluvial sediments	variant of the Khormusan	Goder-Goldberger 2013
Atbara, Sudan	Acheulian –MP	~16–92 ka	gravels and sand of Atbara River	multi-aspect environmental changes	Abbate et al., 2010
Silali, Kenya	MSA	135–123 ka	medium sands	preferential and recurrent Levallois	Tryon et al., 2008
Rusinga Island, Kenya	MSA	>33–45 ka	conglomerate, silstone, sandstone	includes fossil fauna	Tryon et al., 2010
Karungu, Kenya	MSA	–	palesols and conglomerates	includes fossil fauna	Faith et al., 2015
Olduvai Gorge, Tanzania	MSA	–	–	–	Eren et al., 2014
Airport Site, Malawi	MSA	<285 Ka	multiple types in Chiwondo Beds	MSA technology is unique	Thompson et al., 2012
Putslaagte 1, SA	MSA	~60 ka	alluvial terrace of Doring River	confirms human presence during MIS 3	Mackay et al., 2014
Pinnacle Point area, SA	MSA	–	associated with yellowish red palaeosols	extensive MSA landscape	Oestmo et al., 2014
Multiple sites, Senegal	multiple	MIS 4–2	silts and gravels of Faleme Valley	diverse evidence	Chevrier et al., 2016
Multiple sites, Senegal	MSA	–	multiple; Senegal River Valley	ecological transitional zones	Scerri et al., 2016
Ounjougou, Mali	MSA	~75–30 ka	multiple sites in Yame River	30 lithic assemblages documented	Tribolo et al., 2015
Purfleet, Britain	multiple	–	multiple contexts in Thames Valley	Clactonian, Acheulian, Levallois	Bridgland et al., 2013
Swanscombe, Britain	Clactonian	MIS 11	Thames-tributary deposits		Wenban-Smith, 2014
Harnam, Britain	Acheulian	MIS 8	–	late persistence of Acheulian here	Bates et al., 2014
Dunbridge, Britain	Levallois	MIS 9b/8	gravel terraces of Test River	–	Harding et al., 2012
Warren Hill, Britain	Acheulian	MIS 9/8	Anglian gravels of Bytham River	–	Hardaker, 2012
Amiens, Rue du Manege, F	Acheulian	~550 ka	terrace deposits in Somme Basin	–	
Carriere Carpentier, F	Acheulian	~550–500 ka	associated with White Marl	oldest Acheulian in northern France	Antoine et al., 2015, 2016a
Abbeville-Rue de Paris, F	MP	MIS 8?	calcareous sands and silts; Somme	Levallois	Locht et al., 2013
Caours, F	MP	MIS 5	tufa, gravels, silts; Somme Basin	human presence during Last Interglacial	Antoine, 2006
La Celle, F	Acheulian	~400 ka	tufa association in Seine Valley	abundant fossils	Limondin-Lozouet et al., 2010
St.-Pierre-les-Elbeuf, F	Acheulian	MIS 11	sands, tufa, loess; Siene Valley	fauna present	Cliquet, 2013
Lunery, F.	Mode 1	1.1–0.93 Ma	slope deposit with blocks and clasts	located near Rosieres-Usine fossil site	Despriée et al., 2011
Pont-de-Lavaud, F.	Mode 1	~1.1 Ma	under alluvium in Creuse Valley	pollen belonging to forest taxa	Voinchet et al., 2010
La Noira, F.	Acheulian	~655 ka	top of slope deposit in Cher Valley	hominins at beginning of cold period	Despriée et al., 2010
Gievres, F.	Acheulian	~700–650 ka	within Fougeres Fm., Cher Valley	–	Despriée et al., 2010
La Morandiere, F.	Acheulian	~370 ka	in younger alluvium, Cher Valley	–	Despriée et al., 2010
Multiple sites, Portugal	Multiple	~340–75 ka	T4 and T5 of Lower Tagus	Acheulian and Middle Palaeolithic	Rosina et al., 2014; Cunha et al., 2017
Multiple sites, Spain	Multiple	–	Upper Tagus terraces & cave	Oldowan, Acheulian, MP, Mousterian	Santonja et al., 2016
Toledo area, Spain	Acheulian	~226–292 ka	Tagus sediments (2 sites)	associated with warm faunal assemblage	López-Recio et al., 2015
Two sites, Spain	Acheulian	~760 ka	Rock shelter; fluvio-lacustrine	Guadix Valley	Scott and Gibert, 2009
Barranc de la Boella, S.	Acheulian	E. Pleistocene	fluvio-deltaic; Francoli Basin	Elephant butchery site	Mosquera et al., 2015
Aridos 1, Spain	Palaeolithic	MIS 11	fluvio-lacustrine; River Jarama	includes herpetofauna	Blain et al., 2015
Notarchirico, Italy	Acheulian	~640 ka	fluvial sediments of Venosa Basin	hominin fossil site	Pereira et al., 2015
Schoningen, Germany	Acheulian	MIS 11a or 9	lacustrine deposits in tunnel valley	well preserved spears; fossil fauna	Conard et al., 2015
Homs region, Syria	Multiple	–	conglomerates; Orontes Valley	Acheulian, Levallois	Bridgland et al., 2012
Latamneh, Syria	Acheulian	~1.2–0.9 Ma	gravels and silts	associated with fauna	Bridgland et al., 2012
El Kowm, Syria	Oldowan	~1.8 Ma?	loam capped by various sediments	associated with fauna	Le Tensorer et al., 2015
Nahr el Kebir, Syria	Multiple	MIS 10-2	multiple Kebir River terraces	slope and fluvial deposits	Bridgland et al., 2008
Multiple, Turkey	Multiple	~1–0.9 Ma	gravels; Euphrates Valley	modern quarries contexts	Demir et al., 2012
Kula region, Turkey	?	~1.24–1.17 Ma	Gediz River	palaeomeander and lacustrine ponding	Maddy et al., 2015
Revadim, Israel	Acheulian	–	diverse fluvial conditions	adaptation to microhabitats	Marder et al., 2011
N.M. Outlet, Israel	MP	~65 ka	fluvio-lacustrine	most tools in Levantine Mousterian	Kalbe et al., 2015
Multiple sites, Yemen	Multiple	?	Multiple contexts including fluvial	Mixed technological traditions	Chauhan et al., 2008
Wadi Surdud, Yemen	MP	55 ka	Sand silt floodplain deposit	Local and regional characters	Delagnes et al., 2012
Dawadmi, Saudi Arabia	Acheulian	?	associated with dykes	large number of handaxes	Jennings et al., 2015a,b
Huojiadi, China	Mode 1	~1 Ma	Nihewan Basin	–	Liu et al., 2010
Xihoudou, China	Mode 1	~1.4 Ma	–	–	Kong et al., 2013
Madigou, China	Mode 1	~1.2 Ma	Nihewan Basin	wooded grassland and steppe habitat	Li et al., 2016
Cenjiawan, China	Mode 1	~1.1 Ma	Nihewan Basin		Guan et al., 2016
Danjiangkou, China	Mode 2	<800 ka	–	–	Kuman et al., 2014

(*continued on next page*)

Table 1 (*continued*)

Site	Type	Age	Context	Significance	Reference
Fengshudao, China	Mode 2	~800 ka	Bose Basin	associated with tektites	Zhang et al., 2010
Jingshuiwan, China	Mode 1?	~70 ka	silt and sand; 2nd terrace	late *H. erectus in* Changjiang Valley	Pei et al., 2010
Matar, Java	Mode 1?	–	sand and gravel terraces	associated with fossil fauna	Fauzi et al. 2016
Mekong, Cambodia	–	–	terraces of Mekong River	early human dispersal?	Forestier et al., 2014
Durkadi, India	Multiple	<100 ka	silts and gravels of Durkadi Nala	Oldowan label revises to MP and younger	Chauhan et al., 2013
Masol, India	Oldowan?	~2.56 Ma	fluvio-lacustrine sediments	includes fauna and cut-marked bones?	Dambricourt Malassé et al., 2016
Attirampakkam, India	Acheulian	~1.5–1.01 Ma	laminated clays; Kortallayar River	preserves animal footprints; multicultural	Pappu et al., 2011
Bamburi 1, India	Acheulian	~140–120 ka	clast supported cobble band	Son Valley	Haslam et al., 2011
Dhaba, India	Multiple	–	alternating sandy & silty clays	Son Valley	Haslam et al., 2012a
Hathnora. India	Multiple	>48 ka	cemented gravels	Narmada Valley	Patnaik et al., 2009
Dhansi, India	?	>780 ka	thin sandy-pebbly gravel layer	Narmada Valley	Patnaik et al., 2009
Bikor area, India	Acheulian	<780 ka	palaeo-meander cut-off	Narmada Valley	Patnaik et al., 2009
Tikoda, India	Acheulian	–	clay, gravels, silt above bedrock	extremely rich and extensive site	Ota and Deo, 2014
Jonk Valley, India	Acheulian	–	gravels and cliff surfaces	Orissa/Chattisgarh border	Padhan 2014a
Barpadar, India	Acheulian	–	–	Orissa	Behera et al., 2015
Atit, India	Acheulian	–	Urmodi River	Maharashtra	Joglekar and Deo, 2015
Toka, India	Soanian	<200 ka	uplifted post-Siwalik terrace	Tirlokpur Nadi, Siwalik Hills	Chauhan, 2007
Jwalapuram, India	MP	~77–38 ka	Jurreru Valley	associated with YTT	Petraglia et al., 2007

Abbreviations: MP: Middle Palaeolithic; F: France; S: Spain.

bones and 14 tooth-marked specimens, indicating butchery. The equally old (~1.76 Ma) Acheulian from Kenya was reported from the site of Kokiselei 4 from the Nachukui Formation at West Turkana (Lepre et al., 2011). The artefacts include pick-like tools, crude handaxes, cores and flakes (some refitting) and derive from an interbedded series of gravels, sands and muds.

Another well-known Acheulian site, Melka Kunture in the Upper Awash Basin of Ethiopia, has been re-studied and compared with previously well-dated (~1.7–1.5 Ma) assemblages (e.g. Garba IVD) in the region (Gallotti, 2013). The technological analyses demonstrate the emergence of a new chaîne opératoire at ~1.5 Ma, focused on large flake/large cutting tool production, and a large variability of small débitage modalities with systematic preparation of the striking platform. These assemblages are among the richest in East Africa and Unit D at Garba IV (the source of the abundant lithic and faunal specimens) is represented by sand and fine gravels, with dated tephra deposits in the region. One hypothesis for site formation is that the material was transported and deposited by a flood; another involves hominins exploiting a lag deposit for raw material. Gallotti et al. (2014) also reported a new Acheulian site within the same Melka Kunture complex: Garba XIII. This site is stratigraphically situated between two dated tuffs and is thus chronologically constrained to between ~1 and ~0.8 Ma. It has yielded diverse technological information such as the exploitation of large boulders for handaxe production, the use of the Kombewa method and two different raw-material procurement strategies related to different chaine operatoires. This site essentially fills a critical chrono-stratigraphical gap in the Acheulian sequence at Melka Kunture, particularly between the Early Acheulian at Garba IVD and the early Middle Acheulian at Gombore II.

At nearby Lake Natron, Tanzania, re-investigation at the known Early Acheulian site (~1.5–1.4 Ma) of Es2-Lepolosi has revealed that the material was not oriented by post-depositional fluvial processes, as previously thought (Diez-Martín et al., 2014a). This was confirmed by a statistical analysis on the orientation and tilting of 105 artefacts, as well as a re-assessment of past interpretations and unpublished data. In contrast, similar contextual investigations at the same time at nearby EN1-Noolchalai revealed a substantial effect from fluvial erosion and redeposition (Diez-Martin et al., 2014b). A somewhat younger Early Pleistocene context (~1 Ma) at Cornelia-Uitzoek, South Africa, has yielded a fossil tooth of early *Homo* (Brink et al., 2012). Unlike most hominin fossils from South Africa, which come from cave contexts, this is from a bone bed in an open-air context and is the type locality of the Cornelian Land Mammal Age. The bone bed, thought to result from accumulation by a large predator such as spotted hyaena, has also yielded Acheulian artefacts. The site represents a limited pocket of valley-fill, alluvial and colluvial fossil-rich gravels (Banded Gravel Bed) and clays (Mottled Yellow Clay), dissected and eroded by the Schoonspruit River. The artefacts recovered in the excavations include Acheulian handaxes and cleavers and biface-flakes, almost all on hornfels.

In contrast, palaeoanthropological data from the ~212 ka (Ar–Ar) Acheulian site at Mieso (Ethiopia) is rare and valuable, as most recently investigated African Acheulian occurrences are of Early Pleistocene age. This site preserves rich Late Acheulian lithic evidence (on obsidian, chert and lava) and fossil vertebrate specimens and is among the youngest East African Acheulian localities, overlapping chronologically with the regional MSA (Benito-Calvo et al., 2014; de la Torre et al., 2014). Technologically, the site preserves refits at locality Mieso 31 and standardized cleavers at Meiso 7, and the sedimentary sequence includes three distinct units comprising layers of boulder, cobble and gravel conglomerates, silty clays, sands, marls, tufas and clays with calcretes. Mieso 31 preserves a cyclic alluvial aggradation sequence, wheras at Mieso 7 the artefacts were deposited over a clay palaeo-surface; the artefact density at most of these localities suggests episodic and brief occupations, unlike East African sites with long-term high-density artefact accumulations. A comparable but historically well-known site is Kalambo Falls in northern Zambia, where Duller et al. (2015) have been re-investigating the geochronology and site formation. Here, the lithic assemblages are associated with a complexity of channel and floodplain deposits, namely four phases of punctuated deposition by the Kalambo River (~500–300, ~300–50, ~50–30 and ~1.5–0.49 ka), followed by deep incision and renewed lateral migration at a lower topographic level. The Mode 2–3 transition is dated to ~500–300 ka and the formation of the site is linked with meander dynamics as opposed to the older explanation of periodic blocking of the Kalambo River.

With regard to the Middle Stone Age (MSA), new data comes from various parts of Africa. In northern Africa, Richter et al. (2010) have reported new dates for the Ifri n'Ammar rock shelter, in the Western Maghreb region of Morocco, a site that has now extended the chronological range of Aterian technological attributes.

Thermoluminescence dates on associated heated artefacts indicate the stratigraphical presence of tanged artefacts at ~145 and ~83 ka and their absence at ~171 ka and ~130 ka, respectively (also see Bartz et al., 2015, for a ~75 ka OSL estimate from the nearby Wadi Selloum). The youngest dated context also includes personal ornaments and the site represents the oldest known occurrence of tanged Aterian artefacts. In a ~7 m section, lithic assemblages were stratigraphically associated with clayey sediments separated by layers of secondary carbonates. The entire sequence preserves a rich diversity of raw-material exploitation: flint, chert, chalcedony, quartzite and basalt. Middle Palaeolithic cave deposits elsewhere in Morocco (El Mnasra and El Harhoura 2) show discrete correspondence with periods of wetter climate and expanded grassland habitat (Jacobs et al., 2012). The investigators were also able to pinpoint gaps in occupation during MIS 5 and 4, possibly associated with drier periods with reduced vegetation cover. Although this trend of demographic responses to changing environments and/or ecologies is not reflected at the continental scale, a multi-data synthesis gives support to the hypothesis of human occupation of the Sahara during discrete humid phases at ~135, ~115 and ~105–75 ka (Blome et al., 2012). In nearby Algeria, Djerrab et al. (2014) have reported a Middle Palaeolithic Aterian site from Birzgane, using Senonian flint. The stratigraphical sequence from top to bottom includes silt capping the Aterian cultural horizon followed by cobble beds, gravels and sand. The evidence is linked with the Saharan Pluvial or the MIS 5–4 transition.

In NE Africa, the Middle Palaeolithic variant of the Khormusan from Site 1017 in the Nile Valley has been re-analyzed and compared with other regional MSA occurrences. Goder-Goldberger (2013) noted that it is situated within the Dibeira-Jer Formation, representing an aggradation stage of the Nile, now re-dated to ~83 ka and thus coinciding with sapropel S3, which reflects higher Nile flow and stronger monsoonal rainfall. Further south, in Sudan, Abbate et al. (2010) have reported new Acheulian and MSA sites from a 50 m thick Pleistocene fluvial sequence along the Atbara River. A ~10 m Early–Middle transitional sequence (Butana Bridge System) of braided stream gravel and high-sinuosity river sand yielded fossil vertebrate specimens and Acheulian artefacts. Above that, the 40 m Khashm El Girba Synthem yielded Late Acheulian and MSA artefacts from similar fluvial deposits dated to ~126–92 ka. The entire sedimentary sequence represents past changes in climate, river-network modifications from tectonic activity, and lake-level variations.

Tryon et al. (2008) have reported new sites in stratigraphical relation with the Kapedo Tuffs from the northern Kenyan Rift valley, highlighting raw-material availability as an influencing factor in the lithic variability in the region. Located in the Rift zone south of Lake Turkana, the site of Silali is situated within a context of bedded pumiceous tuffs and intercalated fluvial conglomerates. Supplementing previous geological work, the investigators also carried out comparisons of the chemical compositions of the tephra, helping to constrain the age of the associated artefacts (135–123 ka). Artefact assemblages collected and studied from five localities came largely from medium sands (Loc 1 and 4) and are produced on lava. Both preferential and recurrent Levallois techniques are evident in the represented core assemblages and large cutting tools are absent. The main artefact types that overlap between the sites here and from the nearby Baringo and Turkana Basins include unifacial and bifacial picks produced on elongated lava cobbles and diverse Levallois flakes and cores. Tryon et al. (2010) also reported MSA evidence and abundant fossil fauna, dated to >33–45 ka (radiocarbon AMS on gastropod shell) from the Wasiriya Beds of Rusinga Island (western Kenya). Multiple sources of evidence, including sediment lithology and the fossil ungulates, suggest a local fluvial system with a riparian wooded habitat and arid grasslands. Well known for its Miocene deposits, Rusinga Island has also yielded Pleistocene palaeoanthropological evidence from Wakondo, Nyamita and western Nyamsingula localities. The Wasiriya Beds are indicative of extensive cut-and-fill activity, with artefact and fossil evidence coming from conglomerate, siltstone and sandstone deposits. The diverse fauna includes one cut-marked specimen (a bovid cervical vertebra), while the lithic assemblage ($n = 176$, comprising chert, quartzite and quartz) includes Levallois cores and flakes, flake fragments and a few retouched specimens, including a small, bifacially flaked point.

A comparable MSA site was recently reported from Karungu in the nearby Lake Victoria Basin, SW Kenya, where Faith et al. (2015) addressed the palaeoenvironmental contexts using stable isotopes. The assemblages from here include points, blades and Levallois flakes and cores, all on obsidian sourced from areas near Lake Naivasha (250 km east). The archaeological evidence is ecologically contextualized within a semi-arid environment with seasonal precipitation and a dominance of C_4 grasses. There is well-preserved vertebrate evidence reflecting convergence of historically allopatric ungulates from north and south of the equator. The lithic evidence comes from palaeosols and conglomerates stratigraphically associated with the Nyamita Tuff, possibly suggesting human dispersals in association with grassland occurrence, supported by the stable-isotopic results from the fossil bovid and rodent enamel. The vertebrates include large mammals, microfauna, tortoise and unidentified reptiles, with crocodile conspicuously absent. While several localities and sections were documented, the archaeological evidence comes primarily from Kisaaka and Aringo. Radiocarbon and AMS dating of ostrich eggshell from Kisaaka and Aringo yielded ages of ~46 ka and >49 ka, respectively (minimum estimates). The maximum age-estimate is 94 ka, from U-series on tufa. Stable-isotope studies of palaeosol carbonates and fossil tooth-enamel from the Late Pleistocene (~100–45 Ma) MSA sites of Rusinga and Mfangano islands reflect riverine woodland ecosystems surrounded by extensive C_4 grassland (Garrett et al., 2015).

Investigations in the Ndutu Beds in the eastern part of Olduvai Gorge (Tanzania) yielded over 72 findspots including in situ material; hundreds of artefacts were collected along with some fauna (Eren et al., 2014). This represents some of the first systematic work on the MSA archaeology of this site and the region in general, as most work in the gorge has focused on the Early Stone Age. The investigators recovered assemblages reflecting Levallois technology on basalt, quartz and phonolite.

Further south in the East African Rift Valley, new investigations have been carried out at known MSA sites in northern Malawi, yielding lithic assemblages preserved in diverse sedimentary contexts (Thompson et al., 2012). Excavations and surveys at the Airport Site revealed a general sequence of Chiwondo Beds overlain by cobbles within a very poorly-sorted coarse sandy matrix, followed by iron pan and fining-upwards sand in some of the documented sections. The quartz-and-quartzite lithic evidence is yet to be dated and is not comparable to other MSA sites in the broader region; for example, points and backed specimens are missing here, although radial and Levallois reduction and the absence of handaxes places it within the MSA. Based on absolute dates from other MSA sites in eastern and central Africa, a lower age limit of 285 ka is provisionally assigned to this site.

In South Africa, new MSA evidence dated to MIS 3 comes from the site of Putslaagte 1 (Mackay et al., 2014) on an alluvial terrace of the Doring River in the Winter Rainfall Zone. The excavated material is dated to ~60 ka (OSL) and the majority of the 6700 recovered artefacts were produced on hornfels and quartzite cobbles and nodules. The site is situated in a back-flooding tributary mouth and represents a slackwater deposit, reflecting several large flood events. Most interestingly, the results contradict previous

Table 2
Palaeolithic projects supported by the UK Aggregates Levy Sustainability Fund.

Project	No.	Key publication
Archaeological Potential of Aggregate Deposits in the SW	3351	http://archaeologydataservice.ac.uk/archives/
Archaeological potential of cave & fissure deposits in limestone	4996	http://archaeologydataservice.ac.uk/archives/
Archaeological potential of secondary contexts	3361	http://archaeologydataservice.ac.uk/archives/
Artefacts from the Sea	3322	http://archaeologydataservice.ac.uk/archives/
BMAPA Protocol for reporting Finds of archaeological interest	3645	http://archaeologydataservice.ac.uk/archives/
Chronology of British Aggregates using AAR and degradation	3854	http://archaeologydataservice.ac.uk/archives/
Creswell Crags Limestone Heritage Area	3426	http://archaeologydataservice.ac.uk/archives/
Creswell Crags Pleistocene Archives	3502	http://archaeologydataservice.ac.uk/archives/
Happisburgh/Pakefield exposures	4600	http://archaeologydataservice.ac.uk/archives/
J J Wymer Archive	5088	http://archaeologydataservice.ac.uk/archives/
Late Quaternary Environmental & Human History of the Lower Tees Valley	4814	Mitchell et al. (2010)
Late Quaternary Landscape history of the Swale-Ure Washlands	3333	Bridgland et al. (2011)
Lower and Middle Palaeolithic of the Fenland Rivers	5266	Boreham et al. (2010)
Lynford Quarry	3253/5881	Boismier et al. (2012)
Mapping the Sub-Surface drift geology of Greater London (Lea Valley)	3282	http://archaeologydataservice.ac.uk/archives/
Medway Valley Palaeolithic Project	3836	Briant et al. (2012b)
Middle Thames Northern tributaries	3310	http://archaeologydataservice.ac.uk/archives/
Monitoring & Modelling of the Palaeolithic Resource at Chard Junction Quarry	5695	http://archaeologydataservice.ac.uk/archives/
National Ice Age Network	3790/3952	http://archaeologydataservice.ac.uk/archives/
Palaeolithic material from Dunbridge, Hampshire	5703	Harding et al. (2012)
Provenancing of Flint Nodules	3363	http://archaeologydataservice.ac.uk/archives/
Re-assessment of the archaeological potential of continental shelves	3362	http://archaeologydataservice.ac.uk/archives/.00
Seabed Prehistory R2	3876	http://archaeologydataservice.ac.uk/archives/
Seabed Prehistory: Site Evaluation Techniques (Area 240)	5684	http://archaeologydataservice.ac.uk/archives/
Somerset Aggregate Lithics Assessment	5285	http://archaeologydataservice.ac.uk/archives/
Stanton Harcourt Pleistocene material		http://archaeologydataservice.ac.uk/archives/
Stopes Palaeolithic Archive	3338	http://archaeologydataservice.ac.uk/archives/
Submerged Palaeo-Arun River: Reconstruction of Prehistoric Landscapes,	3277/3543	http://archaeologydataservice.ac.uk/archives/
Thames through Time Vol I	3263/3913	Morigi et al. (2011)
The Lower and Middle Palaeolithic occupation of the Middle & Lower Trent	3495	Bridgland et al. (2014)
The Palaeolithic Archaeology of the Sussex/Hampshire Coastal Corridor	3279	Briant et al. (2012a)
The Palaeolithic Rivers of Southwest Britain	3847	Brown et al. (2010)
The Shotton Project: A Midlands Palaeolithic Network	3388	http://archaeologydataservice.ac.uk/archives/
Valdoe Assessment Survey	4620	http://archaeologydataservice.ac.uk/archives/
Welton le Wold	3447	http://archaeologydataservice.ac.uk/archives/

interpretations of the absence of human occupation during later MIS 3, which were based primarily on rock-shelter records. This work is nicely complemented by the results of new MSA landscape-level surveys for open-air sites near Pinnacle Point caves (Oestmo et al., 2014). Much of the fresh quartzite lithic evidence is associated with yellowish red palaeosols at Vleesbai and Visbaai (although the original sedimentary context is thought to have eroded away) and the data are compared in the context of behavioural relationships between the open-air sites and the regional cave records.

Major geographic gaps have been filled by investigations in western Africa, where multiple investigations by different teams have yielded new Palaeolithic data from Senegal and Mali, respectively. In Senegal, Chevrier et al. (2016) report different lithic assemblages belonging to pre-MIS4/5, MIS 3 and MIS 2 from fine-grained (e.g. silts) and coarse-grained (gravels) contexts in the Faleme Valley. Key localities are documented from Toumboura, Missira and other surrounding sites, all of which yielded lithic industries of varying types and ages and on diverse raw materials such as quartz and silexite, including refitting specimens from Fatandi V. Scerri et al. (2016) report new MSA assemblages with high technological diversity from the Senegal River Valley, including centripetal methods of preferential and recurrent Levallois reduction. They consider Senegal as an important transitional zone between sub-Saharan and Saharan Africa, through the presence of basal lithic modification, which is equated with the process of tanging; prominent tanged assemblages are found in northern Africa in the form of the Aterian. The key sites they mention are Naye, Koungani, Dabia, Djammal Quarry, Ndiayene Pendao, Ndjideri, Djierigaye, Madina Cheikh Oumar, Ngnith Quarry and Mbane, which come from surface, gravel or quarry-spoil contexts. Another key study represents a reassessment of the typo-technological attributes of previously collected MSA lithic assemblages from a ferruginous gravel in sandy clay in the Tiemassas River valley (Niang and Ndiaye, 2016). In Mali, Tribolo et al. (2015) have interpreted OSL age estimates from Ounjougou, a large site complex preserving evidence of human occupation during MIS 3 with different technological cultures in rapid successions or technological instability. Over 30 lithic assemblages have been documented from a 16 m sedimentary sequence of the Yame River and 25 of them were bracketed between 75 and 30 ka. The MSA evidence here includes classic modes of production, such as Levallois, discoidal, unidirectional, blade and bifacial points.

3. NW Europe

There has been considerable activity during the life of FLAG in this founding region for fluvial Palaeolithic studies, particularly in southern Britain and northern France, as was highlighted, for the first half of FLAG's existence, by Bridgland et al. (2006) and Mishra et al. (2007). Progress in these countries, as well as in Europe as a whole, was reviewed in a conference in Paris in November 2014 on ‘European Acheuleans. Northern v. Southern Europe: hominins, technical behaviour, chronological and environmental contexts’. Aspects of that review of particular relevance to this present overview were published in a special issue of Journal of Quaternary Science (Schreve et al., 2015), while more technological topics in relation to handaxe form and manufacture have appeared in Quaternary International (Moncel and Schreve, 2016). Schreve et al. (2015) summarized thinking in relation to the chronology and palaeoenvironments of the European hominins associated with handaxe making, with emphasis on patterns of occupation and behaviour, offering a view of the origin and dispersal of the Acheulian, from Africa through (western) Asia to Europe. The output from the Paris conference, given its theme, is of course concentrated on the 'Atlantic side' of the separation between western Europe, with its 'Mode 2' (sensu Clarke, 1969) handaxe industries, and eastern Europe, where such forms are lacking (Mode 1). In the NW, as exemplified in Britain, there has been interaction between Modes 1 and 2, at least twice (Bridgland, 1994, 2006) with the suggestion (White and Schreve, 2000) that populations from the east brought Mode 1 technology (i.e. Clactonian) to Britain early within interglacials (MIS 11 and MIS 9), to be followed on each occasions by handaxe-makers from the south. What is less clearcut is the timing of the first appearance of the Acheulian and the extent to which it was preceded, in one or more climate cycles, by simpler Mode 1 technologies.

3.1. *Britain*

The importance of fluvial archives as repositories for Lower and Middle Palaeolithic artefacts was acknowledged in Britain by the funding, by the government agency then named English Heritage, of a substantial survey of Pleistocene fluvial sand and gravel deposits in the various river valleys and their archaeological contents, eventually summarized by Wymer (1999). This survey, which commenced in 1991, was a response to the accelerating extraction of sand and gravel in Britain for road building and construction, threatening to destroy much of the surviving Palaeolithic evidence without records being made. It comprised successive projects: the 'Southern Rivers Palaeolithic Project' (1991–94) and 'the English Rivers Palaeolithic Survey' (1994–97). Few other countries will have experienced such pressures on surviving resources, but these initiatives represent an exemplar for future consideration. The resultant exhaustive survey provided a superb archive upon which much of the research on British Pleistocene archaeology during the first two decades of the Fluvial Archives Group (FLAG) was built (e.g., Ashton and Lewis, 2002; White et al., 2006; Ashton et al., 2011; Bridgland and White, 2014, 2015); the database, which includes a gazetteer of Lower and Middle Palaeolithic fluvial-context find-spots and documentation and description of museum artefact collections, has been digitized and archived online (http://archaeologydataservice.ac.uk/archives/view/terps_eh_2009/).

Research on the Lower–Middle Palaeolithic from fluvial contexts in Britain benefitted greatly during the early years of FLAG from resources provided by the Government's 'Aggregates Levy Sustainability Fund' (ALSF). This fund, resourced from a levy on newly extracted minerals (introduced to enhance the economic viability of recycled aggregate), funded numerous projects aimed at enhancing understanding of fluvial Palaeolithic records (Table 2). Such projects ranged from studies of multiple (e.g., Palaeolithic Rivers of South West England) or single fluvial systems (e.g. the Trent and Medway Palaeolithic Projects) to detailed examination of data from single sites (e.g. Welton-le-Wold, Lincolnshire). While the levy continues to operate, the ALSF was discontinued in 2011, removing a valuable institutional and financial resource for this type of fluvial project. Nonetheless dissemination of the results of ALSF work has continued to the present day, building on, and interconnected with, other projects.

Also active during the life of FLAG has been the 'Ancient Human Occupation of Britain' (AHOB) project, funded by the Leverhulme Trust (2001–2012), which oversaw research at a number of key fluvial localities, including important new discoveries of early evidence in East Anglia, at the extreme NW extremity of hominin occupation (Parfitt et al., 2005, 2010). Earlier AHOB activity was summarized by Bridgland et al. (2006) and Mishra et al. (2007). In addition to its copious journal output (cf. http://www.ahobproject.org/AllPubs.php), the AHOB project was disseminated in a substantial research monograph (Ashton et al., 2011).

The ALSF and AHOB initiatives were undertaken against a background of a statutorily instigated developer-funding system for archaeological assessment and rescue in connection with civil engineering and building projects, which has continued to provide important information on selected sites, many of them fluvial. The location of the Thames, indisputably the most important of Britain's Lower–Middle Palaeolithic archives, at the centre of the nation's commercial activity has ensured that numerous such projects have taken place during the life of FLAG. A prime example is Purfleet, in the Lower Thames ~10 km downstream from central London, renowned for a tripartite stratigraphical sequence encompassing Modes 1, 2 and 3 of Clarke (1969): Clactonian, Acheulian and Levallois (Fig. 2). The construction of the HS1 high-speed railway between London and the Channel Tunnel engendered a substantial report (Bridgland et al., 2013) that summarized this and several other civil engineering projects to have encroached on the Purfleet locality, designated as a geological 'site of special scientific interest' for its Quaternary interglacial evidence by the British government agency 'Natural England' (Bridgland, 1994). The various developer-funded projects at Purfleet facilitated assessment of the artefacts and palaeontology from the site, as well as new analyses of stable isotopes and geochronology, all of which confirmed the veracity of the tripartite archaeological sequence and the attribution of the interglacial to MIS 9 (Bridgland et al., 2013; cf. Schreve et al., 2002). On the opposite (southern) side of the river, HS1 construction brought about the discovery of a new Clactonian (Mode 1) locality in MIS 11 south-bank Thames-tributary deposits at Southfleet Road, Swanscombe (Wenban-Smith et al., 2006), as well as further appraisal of the MIS 8–5 Ebbsfleet tributary sediments, in the vicinity of the celebrated Levallois site at Baker's Hole (Wenban-Smith, 1995, 2014; cf. Bridgland, 1994).

Important advances that have been made in the application of geochronological methodology to British Quaternary fluvial archives during the life of FLAG (Rixhon et al., 2017) are of considerable relevance to understanding the Lower–Middle Palaeolithic. The amino-acid method, previously criticized for unreliability and inconsistency (McCarroll, 2002), perhaps unfairly (cf. Bowen et al., 1989, 1995), has been overhauled and enhanced, with the highly successful application of the technique to the calcite opercula of aquatic gastropods of the genus *Bithynia* (Penkman et al., 2007, 2011, 2013). For example, use of this technique on the sequence from Harnham in Wiltshire provided evidence in support of late persistence of the Acheulian in southern Britain in an MIS 8 interstadial (Bates et al., 2014). There has also been considerable expansion of the use of luminescence dating methods for constraining the ages of British fluvial sequences, often making use of ALSF funding for dating Palaeolithic contexts: e.g., in the Solent and its tributaries (Briant et al., 2006, 2012a; Bates et al., 2010), in the south-west rivers (Brown et al., 2010), in the Medway and Thames–Medway (Briant et al., 2012b) and in the Trent (Bridgland et al., 2014). The method has been most successful for dating the younger parts of these sequences, where the quartz OSL signal is not saturated. For example, in the western Solent region the oldest reliable ages were centered on ~250 ka (Briant et al., 2006) and in the Thames–Medway ~300 ka (Briant et al., 2012b). Nonetheless, OSL dating holds further potential, with new protocols and more reliable use of feldspars likely, in the next two decades, to enable dating of older sediments and thus artefact assemblages (Rixhon et al., 2017). In an Anglo-French study, Voinchet et al. (2015) have undertaken a programme of electron-spin resonance (ESR) dating of quartz grains and/or combined ESR and U-series dating of vertebrate teeth from a number of British fluvial sites, most of them of Palaeolithic significance: Brooksby, Maidcross Hill, Warren Hill,

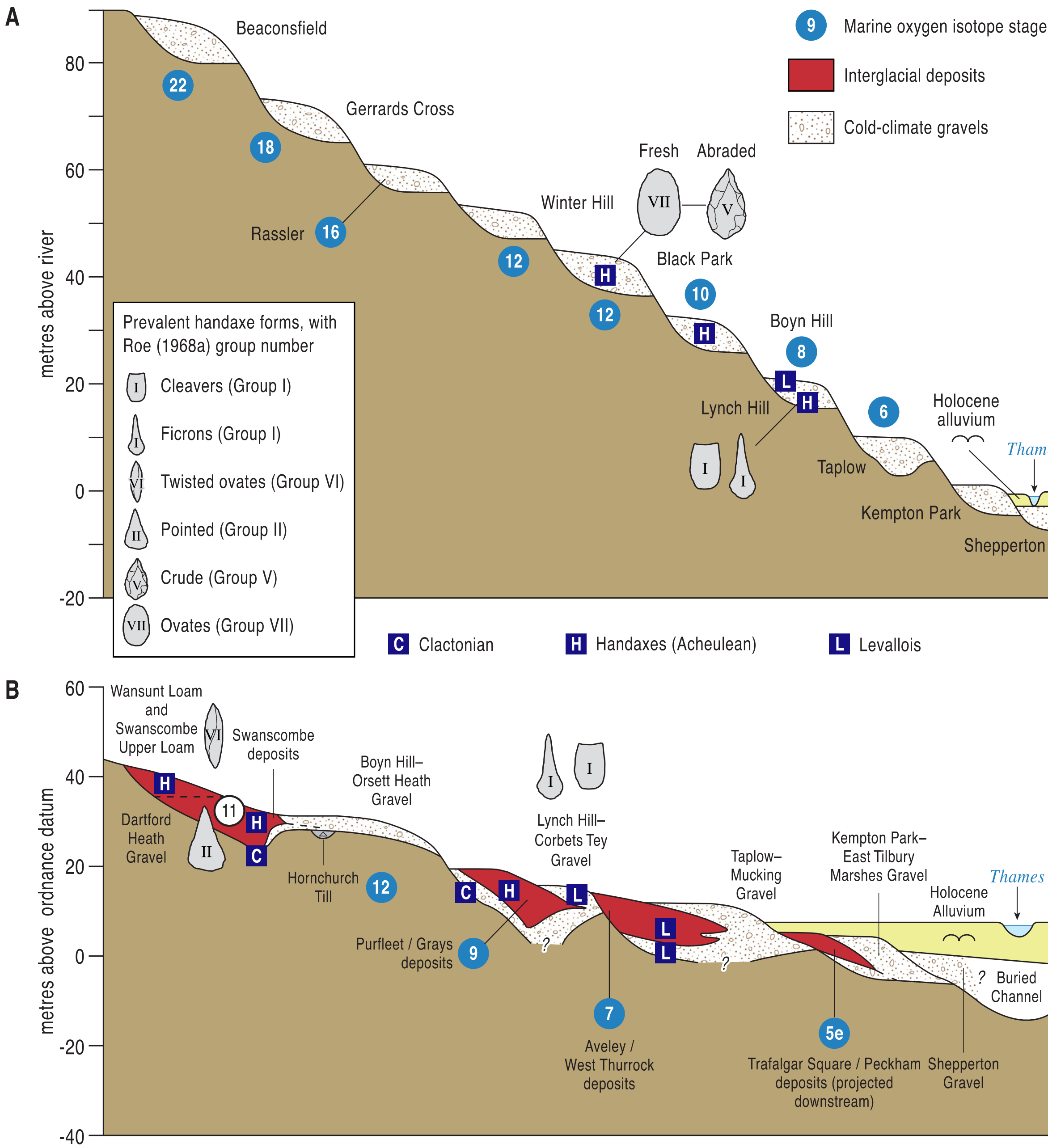


Fig. 2. The occurrence of different handaxe groups in the Thames terraces: A: Middle Thames; B: Lower Thames, downstream of London.

Beeches Pit (West Stow) and Pakefield, all in the erstwhile Bytham system (although Beeches Pit post-dates destruction of Bytham drainage), and Purfleet (see above) in the Thames. Key outcomes include support for the pre-Anglian/early Anglian fluviatile interpretation of the Warren Hill gravels, one of the richest sources of Lower Palaeolithic artefacts in Britain (cf. Wymer, 1985, 1999; Hardaker, 2012), as opposed to a younger, glacial outwash origin (cf. Gibbard et al., 2012, 2013).

Assessment of the museum archive, building on the fluvially-based English Heritage projects of the 1990s (see above) as well as the pioneering work of Roe (1968a, b), has led to the recognition of patterns of handaxe types that have potential chronological significance. This has essentially involved the updating and interpretation of Roe's (1968b) handaxe groups, as depicted in Table 3 (White, 1998, 2015; Bridgland and White, 2014, 2015, Fig. 2). Thus, in Britain at least, assemblages with significant numbers of certain characteristic handaxe types are seen to date from particular episodes within the Quaternary (Table 3). Uncertainties due to reworking and low artefact density must be taken into account when interpreting such patterns (Ashton and Hosfield, 2010), but to a large extent this is already accommodated by Roe's rigour in using only assemblages of the highest contextual integrity. The association between significant numbers of twisted ovate handaxes and MIS 11–10 (Roe's 1968b Group VI), as suggested by White (1998), was used as a potential means of age calibration for mathematical uplift/incision modelling of the erstwhile River Solent terrace sequence by Westaway et al. (2006). So too was the distribution of 'bout coupé' (flat-butted cordate) handaxes, which was taken as an

Table 3
An update of Roe's (1968b) British handaxe groups, with inferred ages after White (2015). Additions by White are in parentheses. Additions for this paper are in square brackets.

Pointed tradition			Ovate tradition		
Group I (with cleavers)	Group II (with ovates)	Group III (plano-convex)	Group V (crude, narrow)	Group VI (more pointed)	Group VII (less pointed)
MIS 9–8	MIS 11	MIS 9	MIS 15–13	MIS 11	MIS 13
Furze Platt	Swanscombe MG	Wolvercote	Fordwich	Elveden	High Lodge
Bakers Farm	Chadwell St Mary		Farnham terrace A	Bowman's Lodge	Warren Hill fresh
Cuxton	(Hoxne UI)		Warren Hill worn	Swanscombe UL	Highlands Farm (Black Park Terrace)
Stoke Newington	Dovercourt		(Kents Cavern Breccia)	(Wansunt)	Corfe Mullen
	Hitchin		[Black Park Terrace (worn)]	(Foxhall Road Grey Clay)	(Boxgrove)
	(Foxhall Road Red Gravel)			(Hoxne LI)	
				MIS 13–12	
				Caversham	
				Middle Palaeolithic	
				Shide, Pan Farm	
				Oldbury	

indicator for MIS 3. The modelling results proved to be closely comparable with those of an independent OSL-dating programme of that same terrace record by Briant et al. (2006), at least in the lower terrace gravels, where such dating was reliable. Updates of the Solent modelling and geochronology were incorporated in the dissemination of a long-term developer-funded watching brief at a gravel quarry that exploited gravel known to be a Palaeolithic resource (Harding et al., 2012). This was Kimbridge quarry, Dunbridge, which exploited two separate terrace formations of the River Test (a left-bank Solent tributary) over a period of 17 years, during which watching-brief visits were used to record and sample sections and collect artefacts (mainly from the gravel-washing plant). An ALSF-funded OSL dating programme was added at the latter stages of the work, the same resource being used to facilitate dissemination. The principal findings were that the two gravel terrace formations have probable ages in MIS 9b and MIS 8, which fits well with evidence from other sites, including those on the near Continent, for the timing of the earliest Levallois at around MIS 9, there being a small quantity of such Mode 3 material recovered from the younger of these formations. The data from the Dunbridge project demonstrate the considerable potential of watching-brief monitoring, coupled with funded analyses, of commercial quarry enterprises. Further light is shed on the timing on Levallois in the Solent region by detailed research in the Warsash area, one of the few sites in this region with good representation of Levallois technology (Hatch et al., 2017). In addition to confirming and OSL dating the suggested correlations in Harding et al. (2012), this research suggested that the Levallois may have an even younger age, given its fresh condition and stratigraphical position at the surface of Terrace 3. Meanwhile a case study from the Solent, at Foxholes, Bournemouth, has shown that caution should be exercised in using archival data. This site was previously suggested to show the earliest appearance of the Acheulian in the region (cf. Wymer, 1999) but more recent work using a wider range of contextual information has pointed to a different provenance for the artefacts, from a younger terrace gravel (Davis, 2014).

There is now evidence to suggest that there are distinctive handaxe types that can be associated with the MIS 9–8 climatic cycle, based on the patterns of occurrence of narrow 'ficron' handaxes and flat-tipped (?resharpened) 'cleavers' (Bridgland and White, 2014, 2015), as well as two different handaxe groups derived from pre-Anglian (pre-MIS 12) contexts (Table 3). The latter are a crudely made 'Early Acheulian' type (Roe's Group V) and a well-made, generally ovate group, never twisted (Roe's Group VII), to which handaxes from the well-known Boxgrove raised beach belong (cf. Roberts and Parfitt, 1999). Both occur in the recently-dated (see above) Anglian gravels of the erstwhile Bytham River at Warren Hill (Bridgland et al., 1995; Hardaker, 2012), as well as in the Anglian Black Park Gravel of the Thames; in both cases the cruder handaxes are more abraded than the Boxgrove type, suggesting that they might be older, perhaps derived from an earlier episode of (warm-climate) occupation (White et al., in press). Given the conclusions of Candy et al. (2015) that the earliest Acheulian occupation in Britain dates from MIS 13, it can perhaps be suggested, as a hypothesis to be tested, that these groups represent the two warm peaks of MIS 13. Further collaborative work is anticipated to explore the extent to which such chronologically significant handaxe occurrence patterns can also be recognized on the European continent (cf. Bridgland and White, 2015).

3.2. France

Research on fluvial deposits in NW France during the last decade has mainly focused on the Somme and Seine valleys and the Loire basin. Multidisciplinary projects studying fluvial archives have provided new data on both the chronological and the palaeoenvironmental framework for hominin occupation. These projects have been supported by the French Ministry of Culture ('Projets Collectif de Recherche', Thematic projects), the Ministry of Research (ANR) and regional institutions. The findings are summarized below and in Fig. 3.

Research undertaken during the last 20 years on the fluvial terraces and loess sequences of the Somme Basin, and on the interactions between human settlement and environmental changes, have adopted interdisciplinary approaches combining the analysis of Quaternary sequences and associated Palaeolithic settlements (Antoine et al., 2003, 2010, 2007; Bahain et al., 2007, 2010; Bridgland et al., 2006). The studies, mainly targeting fluvial formations, have highlighted the impact of cyclic climatic changes on sedimentation and river morphology, and especially the role of the 100 kyr climatic cycles since ~1 Ma, giving rise to terrace formation (Antoine et al., 2007). In this system the interglacial climatic optimum is recorded by calcareous tufa sequences, especially in the cases of MIS 11 and 5e. In the last decade several historical sites have been reinvestigated and new Acheulian and Middle Palaeolithic sites have been discovered.

The Somme basin, of course, houses the type-locality of the Acheulian, at Saint-Acheul, which is a key area. In this terrace system, at Cagny-la-Garenne, in situ Acheulian occupation was dated in the 1990s to early MIS 12, around 450 ka, but new field discoveries such as at Amiens Rue du Manège, dated around 550 ka (ESR on optically bleached quartz and terrace stratigraphy), imply a significant increase in the age of the oldest evidence for human occupation of the area (Antoine et al., 2015). In the Lower Somme basin, new interdisciplinary research has been undertaken (Antoine et al., 2016a) at the Carrière Carpentier site at Abbeville, famous for its Cromerian 'White Marl' and its chronological correspondence with former discoveries of 'Abbevillian bifaces' (handaxes) by d'Ault du Mesnil at Carrières Léon and Moulin Quignon. According to the synthesis of bio-proxies (molluscs, large vertebrates, small mammals), the 'White Marl' was deposited during the early part of an interglacial phase in a low-flow aquatic environment, as emphasized by the development of oncoliths and the presence of fishes and aquatic molluscs. The landscape was a mosaic of open-area shrubs and woodland, in which wet and grassy vegetation developed on riverbanks. On the basis of terrace stratigraphy, dating by ESR on quartz and ESR/U-series on teeth, and on biostratigraphical data, the fluvial deposits of the White Marl can be securely allocated to MIS 15 (Antoine et al., 2015; Voinchet et al., 2015). Furthermore, some Acheulian handaxes have been discovered in situ at the base of sandy slope deposits directly overlying the fluvial sequence. These artefacts are most likely coeval with the end of MIS 15 or from an early part of MIS 14, between 550 and 500 ka, and represent, together with the artefacts from Amiens Rue du Manège, the oldest in situ evidence of human occupation in Northern France. However, no unquestionable artefacts have been discovered within the White Marl or in the underlying gravel layer. In addition, new investigations on the collections from Moulin Quignon were undertaken. This celebrated site is well known for the discoveries in 1863–4 of human remains, which raised considerable controversy (Dubois, 2011). The radiocarbon dating of the human remains leaves no doubt about their modern age (Vialet et al., 2016). New work at Carrière Carpentier has shed light on the geological context, showing that the Moulin Quignon sequence overlies the same terrace step at ± 40 m above the maximum incision level of the Somme. Characteristic aquatic mollusc species (*Tanousia* cf. *stenostoma* and *Borystenia naticina*) indicate a Cromerian (Complex) age and confirm that the Moulin Quignon and Carrière Carpentier sequences are of the same age (Bahain et al., in press). There is an early collection of 12 handaxes from close to the base of the terrace sequence at Moulin Quignon and Carrière Léon (Boucher de Perthes, 1847–1864; D'Ault du Mesnil, 1896) but it will always be uncertain whether these artefacts were in situ or were introduced into the deposits by quarry workers (Moncel et al., 2016a). However, their technological features fit well with similar Acheulian series of Cromerian age.

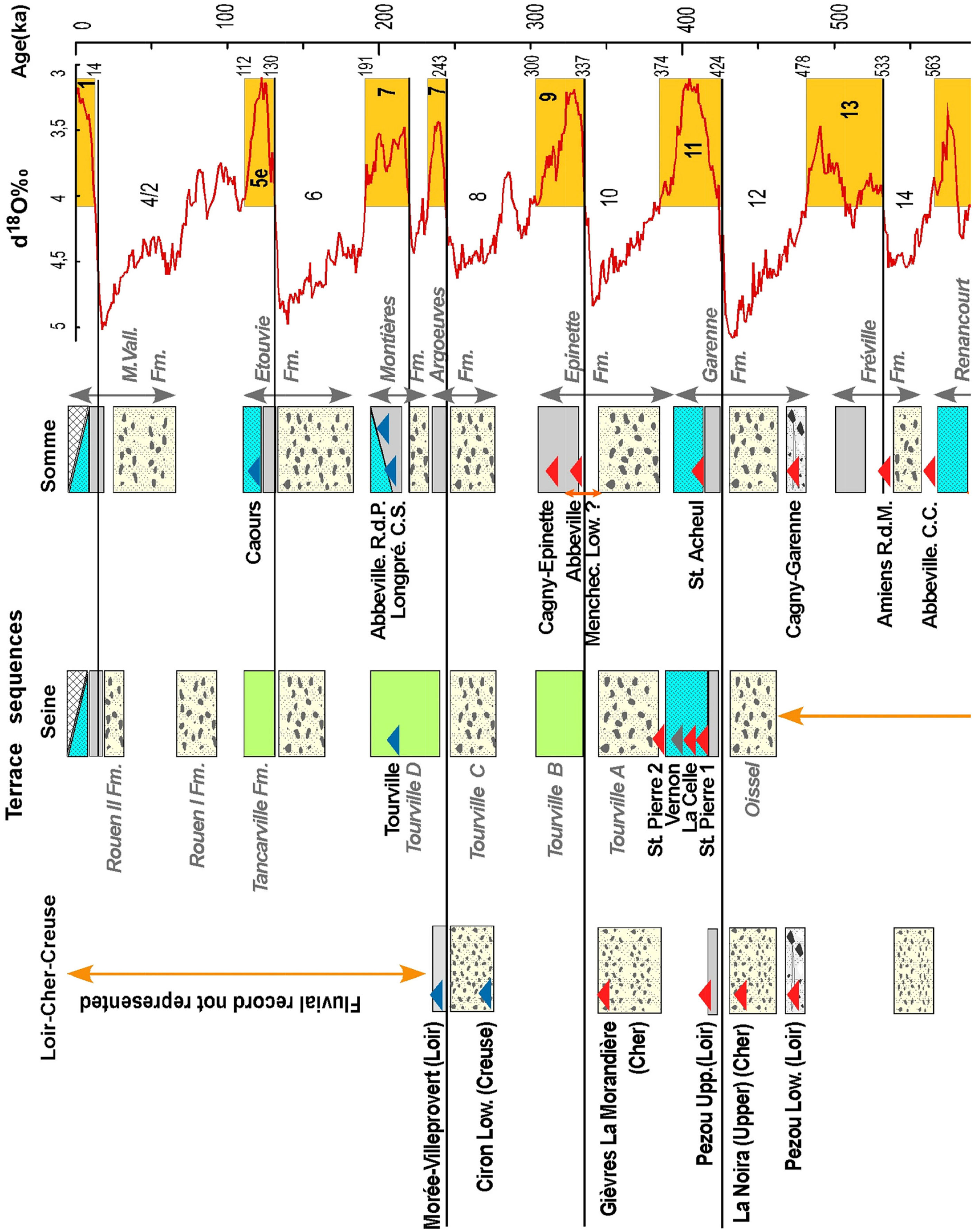
At Abbeville-Rue de Paris, an in situ Middle Palaeolithic Levallois flint industry has been recovered from fluvial calcareous sands and silts located at the top of a terrace sequence (Locht et al., 2013). According to its location within the terrace system, the basal gravels of this sequence can be correlated with Alluvial Formation III of the Somme, at ~15 m above the maximum incision of the valley, on which basis they would be allocated to MIS 8. However the first attempts at ESR dating of optically bleached quartz from these deposits seem to provide overestimated results, perhaps a result of poor initial bleaching (Voinchet et al., 2015).

The Caours tufa sequence has yielded evidence of human occupation at the beginning of MIS 5 (White et al., 2017), establishing human occupation during this period of time that had previously been considered as unfavourable (Antoine et al.,, 2006; Bahain et al., 2010; Dabkowski et al., 2010, 2011, 2015). The tufa sequence is separated from the underlying periglacial alluvial gravels by fluvial calcareous silts. Both tufa and fluvial silts have provided abundant malacological faunas, describing a climatic evolution contemporaneous of the initial phases of an interglacial, followed by a climatic optimum and then declining temperatures (Limondin-Lozouet et al., 2015). Within these horizons, several Palaeolithic layers have been discovered in situ, in association with interglacial large mammal remains showing evidence of human modification. Taking into account its relative position within the Somme terraces system, the U-series ages (average ± 120 ka BP), OSL and ESR/U-series dates and the results of the various bioclimatic studies, the Caours sequence clearly represents the first record of the Eemian interglacial in the Somme basin. In addition, the archaeological levels discovered at Caours are a unique example of human occupation during the Last Interglacial in Northern France.

Moving to the Upper Seine valley, the artefact-bearing tufa deposit at La Celle, known for more than a century for extensive collections of shells and leaf impressions, has been subject to new studies. These have been undertaken in order to reappraise the palaeontological potential of the site and to improve its dating (Limondin-Lozouet et al., 2010). Recent investigations show that the tufa accumulated under interglacial conditions and demonstrate the progressive development of forest biotopes, culminating in the climatic optimum. In the upper levels the reopening of the landscape is registered in the molluscan communities. The tufa at La Celle has been correlated with MIS 11, based on the geomorphological context of the site, together with the occurrence of the '*Lyrodiscus* fauna', a malacological assemblage characteristic of tufa deposits of this period in NW (Limondin-Lozouet and Antoine, 2006). This correlation is supported by radiometric dating (U-series and ESR/U-series) which have produced a mean age of 400 ka (Bahain et al., 2010). Mammalian remains include *Macaca* and *Hippopotamus*, associated with flint artefacts that indicate human occupation during the interglacial optimum (Limondin-Lozouet et al., 2010; Dabkowski et al., 2011). The La Celle tufa provides the longest malacological succession from MIS 11 and allows a detailed reconstruction of the development of the forest cover during that stage. These data were used to reconstruct a precise environmental and chronological framework within which Acheulian occupations dating from MIS 11 can be set (Limondin-Lozouet et al., 2015).

New fieldwork at Saint-Pierre-lès-Elbeuf has provided supplementary data on the chronology of the sequence at this important Seine locality (Cliquet , 2013; Cliquet et al., 2009; Leroyer and Cliquet, 2010), where four loess layers are interspersed with four interglacial soils, from Elbeuf IV to Elbeuf I (Eemian). The oldest soil (Elbeuf IV) is immediately overlain by white alluvial sands with faunal and lithic remains in secondary position. It is also covered by a calcareous tufa which includes faunal remains, occasional flint artefacts and an interglacial molluscan *Lyrodiscus* fauna attributed to MIS 11 (Limondin-Lozouet et al., 2010), this age being confirmed by ESR and ESR/U-series dates (Voinchet et al., 2015). The recent fieldwork has investigated the white sands and tufa overlying the Elbeuf IV palaeosol. One area of 45 m^2 yielded in situ Acheulian artefacts and faunal remains (Cliquet et al., 2009), while rolled artefacts and bones in secondary context were recovered from another area at the same level. Above the tufa is a loess attributed to MIS 10. Handaxes and flake-tools where found at the very base of this loess, a few centimetres above the tufa contact. From the old and new collections, two occupation phases have been identified within and above the tufa. The flint raw material is derived from nearby fluvial gravels and both phases of occupation indicate the manufacture of handaxes. The lower assemblage is mainly composed of large pointed elongated handaxes with thin, well-worked tips. Handaxes from the higher assemblage are varied in size and form.

The open-air site of Tourville-la-Rivière in the Lower Seine Valley was discovered in 1967 in a gravel quarry, where excavations have yielded Early and Middle Palaeolithic faunal and lithic assemblages (Vallin, 1991; Cliquet et al., 2010; Faivre et al., 2014). The archaeological sequence lies on the lower terrace of the Seine. The majority of the sequence was deposited during the Saalian (MIS 8–6). The lowermost deposits are composed of coarse periglacial gravels and sands (layer C), overlain by fine-grained alluvial sediments (sands and silts), which are subdivided into three layers (D1, D2 and D3). The upper-part of the sequence contains laminated



Terrace sequences
Loir-Cher-Creuse
Seine
Somme
d18O‰
Age(ka)
Fluvial record not represented
Morée-Villeprovert (Loir)
Ciron Low. (Creuse)
Gièvres La Morandière (Cher)
Pezou Upp.(Loir)
La Noira (Upper) (Cher)
Pezou Low. (Loir)
Rouen II Fm.
Rouen I Fm.
Tancarville Fm.
Tourville
Tourville D
Tourville C
Tourville B
Tourville A
St. Pierre 2
Vernon
La Celle
St. Pierre 1
Oissel
Caours
Abbeville. R.d.P.
Longpré. C.S.
Cagny-Epinette
Abbeville
Menchec. Low. ?
St. Acheul
Cagny-Garenne
Amiens R.d.M.
Abbeville. C.C.
M.Vall. Fm.
Etouvie Fm.
Montières Fm.
Argoeuves Fm.
Epinette Fm.
Garenne Fm.
Fréville Fm.
Renancourt

Fig. 3.

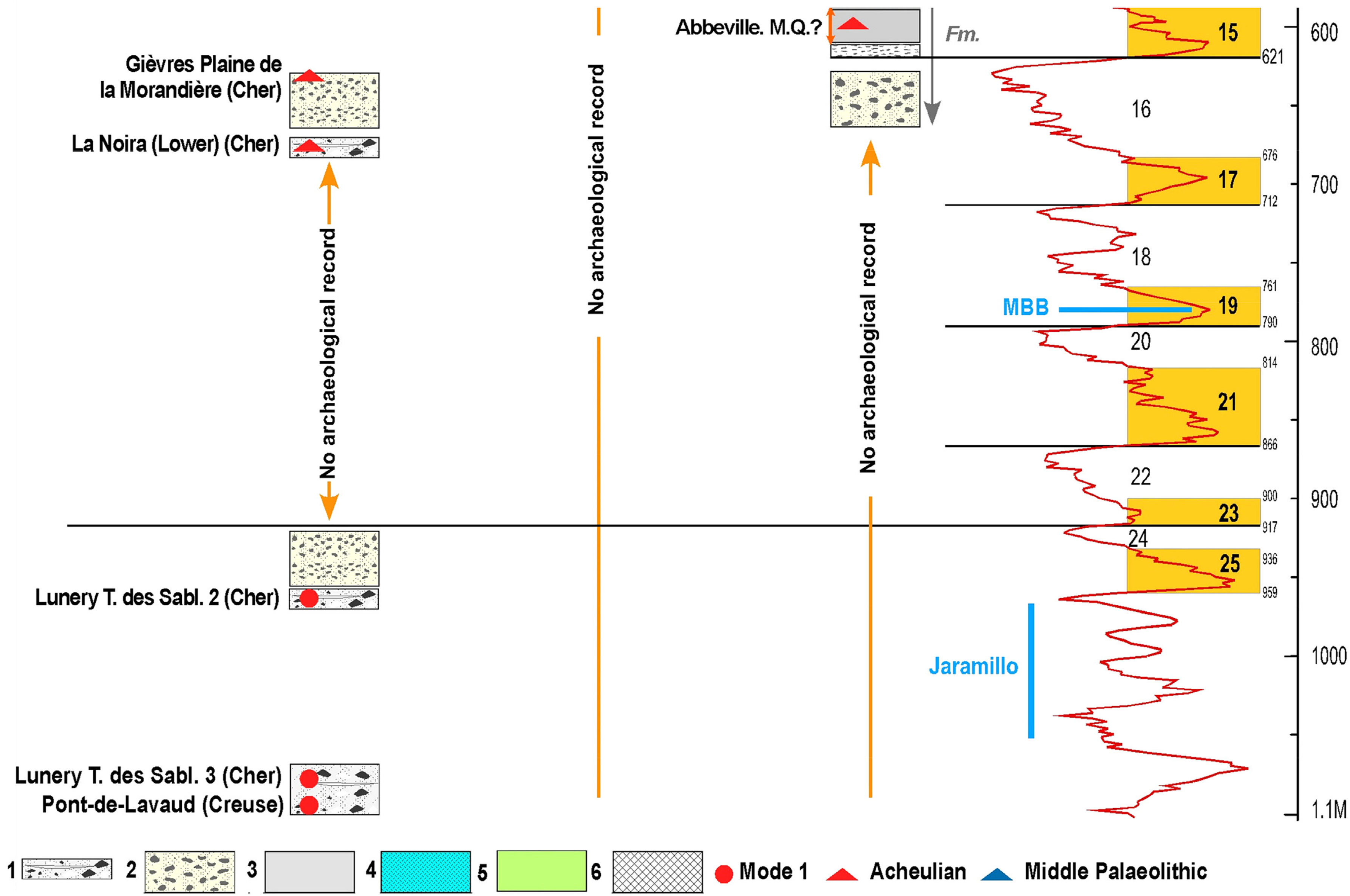


Fig. 3. Updated summary of the French Lower and Middle Palaeolithic. Legend: 1 - Heterogeneous coarse slope deposits, including weakly reworked blocks (chalk and flint), only preserved at the margin of alluvial formations, close to junction between alluvial plains and slopes (early-glacial climatic conditions); 2 - Heterogeneous coarse gravels, including sand lenses (generally braided river systems and periglacial environments; full glacial climatic conditions); 3 - Homogeneous to finely laminated silts or sandy silts, forming the upper unit of alluvial formations (systematically calcareous in the Somme River; late-glacial to early interglacial climatic contexts); 4 - Calcareous freshwater tufa deposits (including oncoliths, porous tufa and stromatoliths; fully interglacial climatic contexts; 5 - Estuarine silts (Lower Seine River; interglacial climatic contexts; 6 - Humic soil and soil complexes (Weichselian early-glacial). Figure by P. Antoine, J. Despriée, J-J. Bahain, and P. Voinchet.

sands (layer E) topped by periglacial deposits (layers F–K) composed of slope deposits and aeolian sands. The assemblage comprises core-management flakes, rare non-Levallois cores, retouched tools or finished products (notably Levallois blanks and non-Levallois blades). The corpus provides evidence of fragmentation of the reduction sequence and importation of Levallois products to the site. Human remains discovered in layer D2 have been attributed to the Neanderthal lineage (Faivre et al., 2014). ESR/U-series dates performed on layer D2 teeth provide an age between 226 and 183 ka.

In the middle Creuse, Cher and Loir River valleys, within the Middle Loire Basin, the observed fluvial aggradations correspond to systems of 9–10 river terraces, interpreted as the response of the fluvial system to Pleistocene climatic cyclicity. Work during the last two decades has improved the chronological and archaeological frameworks for these three systems (Despriée et al., 2004, 2011; Voinchet et al., 2010). In the Sables-de-Rosières Formation of the Cher, the site of Lunery was discovered close to the Early Pleistocene palaeontological site of Rosières-Usine (Despriée et al., 2011). At Lunery, three fluvial terraces are stacked on the western side of the current valley. The lowest unit (3) yielded a periglacial heterogeneous slope deposit including large blocks, cobbles and pebbles embedded in an unsorted matrix, resting on the bedrock slope. These blocks are derived from older coarse fluvial deposits located upslope and are overlain by cross-bedded alluvial sands, dated by ESR on quartz to 1.1 ± 0.12 Ma, reflecting both periglacial conditions and deposition at the front of a fluvial bar during the Early Pleistocene. Three archaeological horizons including a core–flake industry have been recovered within unit 3. The overlying unit 2 is composed of horizontal beds of coarse fluvial sands, which yielded an ESR age of 930 ± 68 ka. Some artefacts (cores and choppers) have been discovered in coarse gravels deposited on the bedrock.

In the Creuse valley, Early Palaeolithic archaeological remains (Mode 1) have been found at the Pont-de-Lavaud site (Eguzon-Chantôme, Indre) under the basal alluvial deposit of Aggradation sheet I of the Creuse system, dated to around 1.1 Ma (Voinchet et al., 2010). The site clearly shows several episodes of hominin presence. The main record is of river-side occupation, directly on the bedrock or at the top of a coarse diamicton composed of pebbles and rolled blocks, spreading across the micaschist river-bank following fluvial incision during a periglacial episode. Pollen and phytolith analyses carried out of the overlying archaeological sediments have revealed the prevalence of forest taxa, including Tertiary relics, related to a warm and wet climate (Marquer et al., 2011; Messager et al., 2011).

In the Cher valley, there has been regular work between 2003 and 2014 at the la Noira Acheulian site (Despriée et al., 2011; Moncel et al., 2013). The artefacts here were recovered at the top of a basal coarse slope deposit (stratum b), constituted by an accumulation of local 'millstone', a rock formed as slabs by diagenetic silicification within Oligocene lacustrine limestone, with no trace of any fluvial transport. The position of the artefacts, deposited after the slope materials and before phases of gelifluction and cryoturbation, would suggest that hominins were present after the period of river incision at the beginning of a cold climatic stage. This has been correlated with the beginning of MIS 16 (Despriée et al., 2011) on the basis of ESR dates of 655 ± 55 ka on overlying fluvial sands (Moncel et al., 2013; Voinchet et al., 2015). The assemblage recovered from stratum b consists of cores, flakes and bifacial tools considered as early evidence of the Acheulian (Moncel et al., 2013, 2016b). Other sites discovered in the same (Fougères) formation of the Cher include Gièvres, at la Plaine-de-la-Morandière, dated to 700–650 ka. At the same locality, a younger alluvial formation (370 ka) yielded handaxes (at the site of la Morandière).

These new data from fluvial contexts enrich the debate about the earliest European industries, with or without bifacial technology, and the onset of hominin occupation. Current data indicate possible arrivals of new hominin groups or new traditions with handaxes and other large tools as early as 900–500 ka, before a large dispersal in Western Europe following the severe MIS 12 glacial stage. The Southern Caune de l'Arago record is one example among the earliest evidence for bifacial technology, albeit in a cave context (Barsky and Lumley, 2010; Falguères et al., 2015). New fieldwork and research projects on Menez-Dregan, La Grande Vallée, Terra Amata, Aldène, Prince Cave and Lazaret, among others, in addition to the sites in fluvial contexts, have further enriched the post-MIS 12 corpus (De Lumley, 2009; Herisson et al., 2012; Moncel et al., 2012, 2015, 2016c; Baena et al., 2014; Ravon et al., 2015; Rossoni-Notter et al., 2015; Schreve et al., 2015; Viallet, 2015; Voinchet et al., 2015). Between MIS 11 and 9, new appearances suggest the imminent onset of behavioural changes that are seen to have occurred between MIS 9 and 7 (Early Middle Palaeolithic) with, for example, new core technologies such as Levallois, and new subsistence strategies and land-use patterns (Herisson et al., 2016; Moigne et al., 2015). After MIS 7, according to areal variation, regional traditions were established, with continuous (southern areas) or discontinuous (northern areas) occupation represented by many well-dated Middle Palaeolithic sites but mainly preserved in loess–palaeosol records (Locht et al., 2010; Goval et al., 2015; Antoine et al., 2016b).

4. Southern Europe

4.1. Iberia

In Iberia, activity in relation to the Palaeolithic during the currency of IGCP 449 was documented by Bridgland et al. (2006) and Mishra et al. (2007). Subsequently the SW corner of the peninsula was the venue for the FLAG 2010 meeting, when sites and museum collections in the Portuguese reach of the Tagus were visited (Stokes et al., 2012). As part of the dissemination of that meeting, Cunha et al. (2012) discussed the dating of the Tagus terraces in Portugal and Palaeolithic sites associated with these. Modern work here has used improved geomorphological mapping of the terraces and integration of several types of absolute dating: C^{14}, U-series, ESR and OSL. In the case of the last, quartz-OSL dating of detrital grains or rocky surfaces has allowed finite ages to be obtained only for Late Pleistocene deposits (Sohbati et al., 2012), whereas infrared-stimulated luminescence (IRSL), using K-feldspar as dosimeter, has been able to date the three lower terraces in the sequence, going back to ~ 300 ka, limited by the high sediment dose rates (Cunha et al., 2008, 2017; Martins et al., 2009, 2010a, b; Oosterbeck et al., 2010). The same approach has been used, but with the more recent pIR-IRSL dating method, in other Portuguese coastal and fluvial staircases containing Lower to Upper Palaeolithic industries (in the Minho, Douro, Mondego and Guadiana rivers; e.g. Ramos et al., 2012; Carvalhido et al., 2014).

In the Lower Tagus six terrace levels (T1 to T6) have been recognized along the valley, with details as follows: T6 at +7–10 m (above river level), 64–32 ka, with Late Middle Palaeolithic (late Mousterian); T5 at +18–26 m, 136–75 ka, with Middle Palaeolithic industries and Mousterian knapping (Levallois); T4 at +34–48 m, ~340–160 ka, with Lower Palaeolithic (Early to Late Acheulian) to early Middle Palaeolithic; T3, T2 and T1 do not contain archaeological materials and only T3 (+43–78 m) and T1 (+84–164 m) have been dated (ESR; Rosina et al., 2014). Thus it has been shown that most of the previous TL ages used to date Lower to Middle Palaeolithic industries (in Portugal and Spain) were minimum ages (luminescence signal in saturation). For example, the Acheulian archaeological levels that occur within fine-grained organic sediments (with palaeosos) in the T4 terrace at Alpiarça, previously dated by Mozzi et al. (2000) as Late Pleistocene (Last Interglacial), were later re-dated by pIR-IRSL to 340–160 ka (Martins et al., 2014; Cunha et al., 2017). This is of potential significance in connection with the new ideas about the chronological significance of handaxe patterns, as the assemblages from here include types that in Britain would be suggestive of an age in MIS 9–8 (Bridgland and White, 2014).

Further upstream in the Spanish reach of the (upper) Tagus, as well as of the neighbouring (upper) Duero and Guadiana systems and the Miño and Guadalquivir beyond these, lithic artefacts are common, as exemplified in recent reviews by Santonja and Pérez-González (2010) and Santonja et al. (2016). According to these authors the Acheulian is typically well represented in terraces ~30 m above their respective rivers, with a mix of Acheulian and Middle Palaeolithic artefacts in contexts dating from after MIS 9. An earlier group of assemblages, dated to the Early Pleistocene (~1.3–1.2 Ma) and defined as Oldowan or Mode 1, is mainly from cave sites; it should be noted that a higher degree of technological complexity compared with the African Oldowan cannot be eliminated on the basis of the presently available evidence (Santonja and Pérez-González, 2010). In more detail, in the upper Tagus and upper Duero drainage basins a maximum of 17–16 'true' river terraces (not considering fan-head trench terraces) were identified and dated by combining absolute ages and palaeomagnetic data. The first Palaeolithic materials here are represented by isolated large flint flakes of apparent Early Acheulian affinity, associated with the +100–107 m to +80–85 m terraces (with ages ~1.4–1.2 Ma). Acheulian sites have been found in terraces ranging from +70–78 m (~1.1–1.0 Ma) to +18–22 m (~135–74 ka), this later terrace having upper stratigraphical levels containing Middle Palaeolithic (Mousterian) artefacts; Mousterian sites were found in terraces between +13 and 15 m and +8–10 m (~60–28 ka) (e.g. Santonja and Pérez-González, 2010; Pérez-González et al., 2013; Panera et al., 2014; López-Recio et al., 2015; Roquero et al., 2015a, 2015b; Rubio-Jara et al., 2016). In both the Upper and Lower Tagus, Upper Palaeolithic materials are usually found associated with colluvium and aeolian sands (~30–12 ka; e.g. Martins et al., 2010a; López-Recio et al., 2015). The largest artefact collections associated with a warm faunal assemblage were found in the Acheulian sites of Pinedo and Cien Fanegas (Tagus, near Toledo) in the +25–30 m terrace, its upper deposits dated to 226 ± 37 ka (AAR) and its basal deposits >280 ka and 292 ± 17 ka (pIR-IRSL) (López-Recio et al., 2015).

On the southern periphery of the Iberian peninsula are two sites of considerable renown as potentially representative of the earliest handaxe making in Europe: La Solana del Zamborino and Cueva Negra del Estrecho del Río Quípar (Scott and Gibert, 2009). While the latter is a rock shelter, the former site is associated with a fluvio-lacustrine sequence, >150 m thick, in the valley of the Guadix, a western tributary flowing from the Sierra Nevada into the internally draining Baza Basin. The archaeology here was previously thought to date from the late Middle Pleistocene, based on its typology, but analysis of the sequence suggests that the Matuyama–Bruhnes palaeo-magnetic reversal occurs just below the artefact-bearing horizons, which are now given an age of ~760 ka (Scott and Gibert, 2009), although this has been questioned by Jiménez-Arenas et al. (2011).

A further site in the NE of the peninsula, again near the coast, is Barranc de la Boella (Catalonia, Spain), where deposits of the lower River Francolí system have yielded artefacts and animal bones (Vallverdú et al., 2014). Work here was summarized for the November 2014 Paris conference (see above) by Mosquera et al. (2015), describing a late Early Pleistocene elephant-butchery site from a fluvio-deltaic context, incised below the 60 m terrace of the Francolí and formed at a height of ~50 m above modern sea level. A butchered adult *Mammuthus meridionalis* was excavated here, together with other faunal remains and 125 lithic artefacts, including retouched flakes and a large, well-fashioned schist pick, as well as smaller refitting material. Spatial analysis of zooarchaeological and taphonomic evidence, together with technical and use–wear analyses, confirm that the butchery of the mammoth carcass was the rationale for the occupation. Geochronology using palaeomagnetic and cosmogenic analyses, as well as micro- and macro-faunal biostratigraphy (notable occurrences being *Mimomys savini* and *Mammuthus meridionalis* itself), conform with the late Early Pleistocene attribution, within the late Matuyama chron (Mosquera et al., 2015). The authors claim, from the various evidence obtained, that this is the oldest known Early Acheulian butchery site in Europe.

Also presented as part of the dissemination of the Paris 'Acheulean' conference (see above), Blain et al. (2015) have reported on new palaeo-environmental data derived from herpetofaunal evidence from three important Spanish Palaeolithic contexts dating from MIS 11; these include cave deposits from Atapuerca but also fluvial overbank deposits from Áridos-1, on the left valley-side of the River Jarama, SE of Madrid, and fluvio-lacustrine sediments at Ambrona, NE of the Spanish capital. The MIS 11 interglacial was an important period for hominin occupation in Europe and also is seen as the best analogue amongst the late Middle Pleistocene interglacials for the Holocene, without the anthropogenic influences that affect the records from the second half of the latter. Herpetofauna, which include numerous taxa of high environmental and climatic sensitivity, are able to provide valuable climatic indicators; thus the work on these three Spanish sites has provided valuable information about the environmental context for occupation of Iberia at this time using mutual climatic range analysis (cf. Martínez-Solano and Sanchiz, 2005). This shows mean annual temperatures varying from ~2.7 to ~0.3 °C and mean annual precipitation between ~311.7 and ~74.4 mm, also showing a progressive decrease in temperature and rainfall from the climatic warm peak of the early MIS 11 interglacial to the end of the stage.

4.2. Italy

An Italian fluvial site of early Middle Pleistocene affinity at Notarchirico, Basilicata, also features in the output from the Paris 'Acheulean' conference, in a contribution by Pereira et al. (2015). This is the well-known hominin fossil and Acheulian site at Notarchirico, near Venosa (Mallegni et al., 1991; Lefèvre et al., 1994). The archaeological and hominin site is within fluvial sediments ~7 m thick that form part of the fill of the Venosa Basin, a tectonic depression that formed a drainage route directed south-eastwards towards the Bradano River (Raynal et al., 1998; Lefèvre et al., 2010). Within this sequence have been found artefacts at various levels, including numerous handaxes, and a femur of *Homo heidelbergensis*. Much of the sediment is derived from the nearby Monte Vulture stratovolcano and consists of ash and volcanoclastic material that had previously been dated by the K/Ar and thermoluminescence methods and with reference to the tephrostratigraphy of the local volcanism, giving an age of ~640 ka, within MIS 16 (Lefèvre et al., 2010). Pereira et al. (2015) have provided new combined Ar/Ar and ESR dates that have strengthened the geochronology of this site, placing both the archaeological assemblage and the hominin fossil securely within MIS 16 and thus confirming this as one of the oldest Acheulian contexts in Europe and the oldest hominin fossil locality in Italy. Schreve et al. (2015) suggested, given the paucity of evidence for hominin presence during this severe glacial further north, that the Italian peninsula might have served as a refugium for human populations at that time, from which more northerly parts of Europe were recolonization subsequently.

5. Central and Eastern Europe

Mishra et al. (2007) reported on a number of sites in the area lying east of the zone within which Acheulian industries are characteristic of the Middle Pleistocene: Germany and the former Warsaw Pact countries. They noted the prevalence of Mode 1 industries in this area, with artefacts that are dominantly small and made from glacially-transported clasts of flint and other suitable raw material, belonging to the 'Lower Palaeolithic Microlithic Tradition' (LPMT; e.g. Burdukiewicz and Ronen, 2003). Indeed, Kozlowski (2003) had identified a 'demarcation line', approximately running along the Rhine and the Alps, between the area to the south and west where 'Mode 2' (handaxe) industries are widespread and that further east and north where the Acheulian is absent and only 'Mode 1' pebble and flake industries occur. Lithic assemblages from fluvial contexts in Central Europe belonging to the LPMT Mode 1 tradition, described in the IGCP 449 reviews (Bridgland et al., 2006; Mishra et al., 2007), include those from Bilzingsleben II, Ehringsdorf and Taubach, in Germany, Vértesszölös, Hungary (cf. Fluck and McNabb, 2007), and Racinĕves, Czech Republic (Tyrácek et al., 2001, 2004).

The complex fluvio-lacustrine site at Schöningen is another that has yielded lithic artefacts conforming to the LPMT tradition. Two substantial recent publications have provided much new information about this site: an edited volume (Behre, 2012) and a special issue in the Journal of Human Evolution (Conard et al., 2015). The geological context for the complex site at Schöningen is now interpreted as a series of largely lacustrine deposits formed within a former Elsterian glacial tunnel valley (Lang et al., 2012, 2015; Stahlschmidt et al., 2015). In the 2015 compendium the consensus view of the age of the main archaeological levels, representing the Reinsdorf Interglacial deposits (Schöningen II) with their famous multiple wooden spears (Thieme, 1997), holds that this represents MIS 9, based on U-series dating of organic sediment (Sierralta et al., 2012) and TL dating of burnt flints (Richter and Krbetschek, 2015). This interpretation fits well with the 'short-chronology' view that sees the Esterian as equivalent to MIS 10 (Eissmann, 2002; Geyh and Müller, 2005, 2006), although that idea is not widely accepted (cf. Kukla, 2003; Desprat et al., 2005; Scourse, 2006; Preece et al., 2007; Penkman et al., 2011, 2013) and differs from earlier ascription of the Reinsdorf deposits to MIS 11 (Mania, 2006, 2007). The nature of the mammalian fauna, which includes the extinct giant beaver *Trogontherium cuvieri* and certain rare and exotic taxa, such as *Homotherium latidens* and *Bubalus murrensis* (Serangeli et al., 2015; Van Kolfschoten et al., 2015), has affinity with assemblages attributed to MIS 11 (Schreve, 2001, 2012). Furthermore, although the proponents of the MIS 9 interpretation do not claim that the thermal maximum is represented by Schöningen II, the palaeo-climatic evidence (Urban and Bigga, 2015) would appear to have more in common with the lenthy and cooler MIS 11 interglacial, particularly its later warm substage 11a (such as is represented in the Thames at Swanscome: White et al., 2013), than with the shorter, warmer MIS 9(e) event, thought to be represented by the Purfleet Thames locality (see above). Whether Schöningen II dates from MIS 11a or MIS 9, the claim that its has yielded "the oldest spears in human history" can be refuted, given that the yew-wood spear-tip from the Thames–Medway site at Clacton-on-Sea, SE England (McNabb, 1989; Allington-Jones, 2015), unequivocally dates from the early interglacial subtsage of MIS 11 (Bridgland, 1994, 2006; White et al., 2013).

6. Western Asia: the Levant, Turkey and the Arabian Peninsula

Fluvial deposits in the northern Levant and Turkey have yielded Palaeolithic material in varying quantities, much of what is known resulting from extensive research in the late 20th Century (e.g., Van Liere, 1961; De Heinzelin, 1965, 1967; Ponikarov et al., 1967; Besançon and Sanlaville, 1981; Besançon and Geyer, 2003; Sanlaville, 2004). Access to much of the area is currently impossible because of war in Syria, but significant new work was undertaken on the Euphrates, Orontes and Kebir river systems in Syria prior to the onset of hostilities, while the Euphrates was studied further upstream, in southern Turkey, and the Orontes, which flows northwards, further downstream, in its lowest reach through Hatay Province, Turkey. A review of the fluvial stratigraphy in these systems is provided elsewhere in this issue (Bridgland et al., 2017), showing that they are more variable than the earlier (20th Century) workers supposed (see Oguchi et al. (2008) for information on late Quaternary fluvial deposits in relation to archaeological sites and Schrøder et al. (2012) on spring deposits as proxies for interstadials at the Palaeolithic site of Yabroud in Syria). The Lower and Middle Palaeolithic archaeological records of these regions have also been reassessed in detail (Shaw, 2012); a brief summary of the repercussions of this new work for the Palaeolithic archives is provided below. Much further west in Turkey, a new artefact discovery has been reported from the River Gediz (Maddy et al., 2015; see below), location of the FLAG plenary meeting of 2006 (Cordier et al., 2017), whereas further south, in the Arabian Peninsula, well-dated Lower and Middle Palaeolithic archaeological assemblages have recently been recovered from sites in Saudi Arabia, Yemen, Oman and the United Arab Emirates (see below).

6.1. New age model for the river Orontes terrace sequence in Syria

Cemented river terrace deposits were identified in the higher Syrian reaches of the Orontes, above Homs, as a result of work carried out from 2001 as part of an archaeological survey of the Homs region (Bridgland et al., 2003, 2012; Philip et al., 2005). Field walking as part of that survey recovered 283 Lower and Middle Palaeolithic artefacts, made from a variety of cherts and flint, including 72 Levallois cores, 15 Levallois products and 27 handaxes. Sporadic exposures showed that the upper parts of the conglomeratic deposits were subject to carbonate solution at the base of the soil, potentially liberating artefacts from the gravel bodies into the soil; whether such material could realistically be differentiated from surface archaeology other than by condition and/or typo-technology is doubtful. The original dating model for the underlying widespread terraces was based on uplift modelling (cf. Westaway, 2002; Westaway et al., 2002, 2006), calibrated with reference to the previously known sequence in the Middle Orontes, where the important fossil- and (Lower Palaeolithic) artefact-bearing sequence at Latemneh (Hooijer, 1961; Clark, 1966a, b; Van Liere, 1966; De Heinzelin, 1966, 1968; Copeland and Hours, 1993) was taken to date from the mid-Middle Pleistocene (Bridgland et al., 2003). A subsequent adjustment was required when U-series dating of the lowest (+10 m) Arjun terrace gave an age within MIS 6, older than the modelling had previously suggested (Bridgland et al., 2012).

Later work further downstream, with the support of the Syrian National Earthquake Center (Bridgland et al., 2012), led to reconsideration of the ages of the Middle Orontes sequence in the Hama–Latemneh area, building on a detailed reappraisal of the artefact collections and site archives from the latter site by Shaw (2012). The Latamneh locality incorporates a number of separate gravel quarries dating from the latter half of the 20th and into the present century, although there is no reason to suppose that same sequence of mammal-bearing fluvial deposits was not exposed in all of them (Bridgland et al., 2012; Shaw, 2012). Surviving exposures observed during the first decade of the 21st Century revealed a thick gravel sequence extending from ~260 m to ~280 m above sea level (a.s.l.), the top being ~55 m above the level of the modern river Orontes, although there is a further ~10 m of silt above the gravel (Bridgland et al., 2012). The mammal-bearing levels are the 'lower gravels' within the thick aggradational succession here (cf. Shaw, 2012), although faunal remains have also been observed in fine-grained ?floodloam deposits within this lower part of the sequence (Bridgland et al., 2012).

The Latamneh fauna includes *Crocuta crocuta*, *Hippopotamus* cf. *behemoth*, *Camelus* cf. *dromedarius*, *Giraffa camelopardalis*, *Praemegaceros verticornis*, *Bos primigenius*, *Bison priscus*, *Bovidae* 'de type antilope', gen. et sp. indet., cf. *Pontoceros* (?), *Equus* cf. *altidens*, *Stephanorhinus hemitoechus*, *Mammuthus trogontherii*, *Stegodon* cf. *trigonocephalus*, *Dama* cf. *mesopotamica* and *Gazella* (?) *soemmering* (Guérin and Faure, 1988; Guérin et al., 1993). It was thought by Bridgland et al. (2003) to be of Middle Pleistocene affinity, combining mammoth and giant deer species that are unknown in Europe after the Elsterian with a rhinoceros (*S. hemitoechus*) unknown before that glacial. Their interpretation, which placed the Latamneh deposits at ~ MIS 12, owed much to the occurrence of *S. hemitoechus* and is now regarded as untenable. Bar-Yosef and Belmaker (2010), in their review of Early and Middle Pleistocene faunas and archaeological evidence from the wider region, grouped Latamneh with sites dating from 1.2–1.0 Ma, being influenced by the small-mammal assemblage (cf. Mein and Besançon, 1993), which includes the pre-Middle Pleistocene *Lagurodon arankae* (cf. Markova, 2007). Bar-Yosef and Belmaker (2010) positioned Latamneh between the Israeli sites of 'Ubeidiya (von Koenigswald et al., 1992) and Gesher Benot Yaaqov (Goren-Inbar et al., 2000) in a sequence of descending age, but all within the Early Pleistocene. Bridgland et al. (2012) also took account of a further faunal record from Sharia, near Hama: a mandible, with teeth, of *Mammuthus meridionalis* (Van Liere and Hooijer, 1961), an elephant that is regarded as an evolutionary precursor of the *M. trogontherii* at Latamneh. This occurred in gravel, ≤10 m thick, aggraded to ~40 m above the modern Orontes and thus within the height range of the sequence at Latamneh, 25 km further downstream. Bridgland et al. (2012, 2017) therefore reinterpreted the age of the sequence at Latamneh, and thus of its Acheulian assemblage, as ~1.2–0.9 Ma (Fig. 4A).

6.2. Early Palaeolitic material from the Euphrates

Of direct relevance to the new interpretation of Latamneh is the Palaeolithic record from the River Euphrates. The terrace archives of the Syrian reach of this river have been studied from the mid-20th Century, with considerable collections made of Lower and Middle Palaeolithic artefacts from fluvial contexts (Van Liere, 1961; De Heinzelin, 1965, 1967; Ponikarov et al., 1967; Besançon and Sanlaville, 1981; Copeland, 2004; Sanlaville, 2004). Understanding of the record from this reach, particularly that part between Raqqa and Deir ez-Zor, has been enhanced following recent resurvey of the terrace outcrops and new dating of interbedded basalt lavas (Demir et al., 2007a, b; Bridgland and Westaway, 2014). An important outcome is that much of the sequence is now regarded as significantly older than previously supposed. Meanwhile the Palaeolithic record from the Syrian Euphrates has been reviewed and updated, incorporating the above-mentioned geological findings (Shaw, 2012). Just as earlier French workers extended their research on the Euphrates upstream into Turkey (e.g., Minzoni-Déroche, 1987; Minzoni-Déroche and Sanlaville, 1988), so the recent studies of this river have also included the reach extending ~100 km upstream of the Syrian border (Demir et al., 2008, 2012). As part of this work, numerous abraded artefacts, included handaxes, have been recovered ex situ from quarries at Birecik exploiting the thick Bayındır gravel, interpreted as the infill of a deep incision by the Euphrates, to within ~10 m of its present level (Demir et al., 2008; Bridgland et al. (2017; Fig. 4B). The Bayındır gravel aggradation, which took the river to a level ~55 m above the modern river, is dated 1.2–1.0 Ma, with the handaxes from Birecik seemingly occurring near the base of the sequence. The dating is by uplift modelling (cf. Westaway, 2002) calibrated with reference to dated volcanicity within the Syrian reach of the Euphrates (Demir et al., 2007a, b). In that reach there are numerous handaxe sites (e.g., Ain Abu Jemaa, near Deir ez-Zor; Fig. 4C) associated with deposits that can be considered equivalent to the upper part of the Bayındır Gravel at Birecik area, and can thus be dated to ~1.0–0.9 Ma. In the Syrian reach the lower part of this aggradation is below the modern river-level and thus inaccessible. Further upstream in the Turkish reach, around Karaba bridge (on the Şanliurfa to Adiyaman road), the upstream equivalent of the Bayındır Gravel has been termed the Kavşut Gravel (Demir et al., 2012). Handaxes have been recovered from the quarries here, of generally similar techno-typology and in comparable condition to those from Birecik, but it is uncertain whether they are from the Kavşut Gravel or from later (Middle Pleistocene) terrace deposits that have been inset into the older much thicker deposit. Demir et al. (2008) considered that there were older artefact-bearing deposits in the Euphrates, notably the Tilmağara gravels (separate upper and lower terraces) of southern Turkey, disposed up to ~80 m above the modern river and which they tentatively dated to ~1.8 Ma (Fig. 4B).

A unique occurrence of a substantial Lower Palaeolithic core and flake (Mode 1) assemblage in Syria is reported from El Kowm (or Ain al Fill), where the artefacts and fauna come from a detrital loam horizon capped by multiple layers of carbonate-rich sediments, sand, gravels, clayey beds and loam (Le Tensorer et al., 2015). The evidence (790 artefacts) was estimated to be ~1.8 ma in age, based on geological, tectonic, palaeomagnetic and associated faunal data.

6.3. New understanding of the lower and Middle Palaeolithic of the Orontes and Euphrates

The new field investigations, described above, in combination with reassessment of extant artefact collections (Shaw, 2012), have greatly enhanced understanding of the Lower and Middle Palaeolithic archaeological record from the Orontes and Euphrates valleys. Key findings are:

1. There is evidence for a regional hominin presence dating back to at least 1 Ma. This early occupation is associated with handaxes, the lack of which, from some small collections, is probably a reflection of assemblage size and not of itself a chronological indication.
2. Lower and early Middle Pleistocene assemblages are technologically similar, being characterized by handaxes and simple ad hoc core working. There are occasional examples of 'simple-prepared' cores (cf. White and Ashton, 2003), but these are sporadic, fortuitous occurrences (the earliest examples are from gravels at Ain Abu Jemaa on the Euphrates in Syria, probably older than MIS 22; see Fig. 4C). They certainly do not reflect the lasting adoption of prepared-core working strategies.
3. Latamneh, now assigned to ~ MIS 22 (Fig. 4A) is unique in the Orontes and Euphrates valleys in having significant numbers of trihedral 'large cutting tools', although they occur sporadically at other localities. Often regarded as chronologically significant

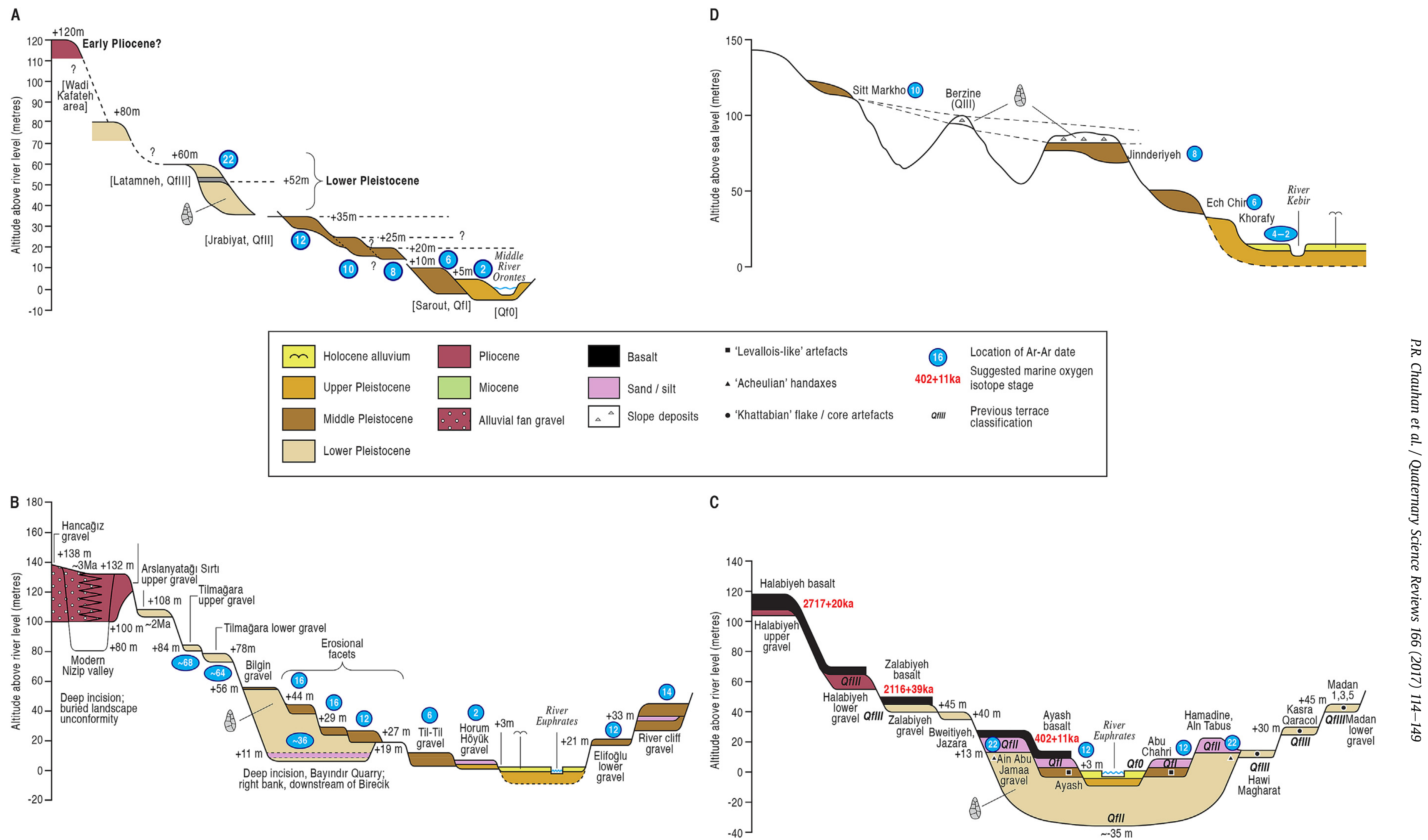


Fig. 4. Artefact-bearing river systems in Syria and Turkey. A–C modified from Bridgland and Westaway (2014). The main handaxe-bearing deposits are indicated in each case. A – The Middle Orontes, showing new suggested MIS correlations. B – The Euphrates reach at Birecik. C – The Euphrates reach between Raqqa and Deir ez-Zor, showing Ar–Ar dating of basalts. D – The Nahr el Kebir, showing the concentration of handaxes in slope deposits.

(e.g. Copeland, 2004), their prevalence here can be argued to be contextually specific and reflects hard-hammer flaking of locally available tabular flint blanks, without recourse to extensive thinning. Euphrates deposits regarded as broadly contemporary or earlier in age have produced fairly refined ovate bifacial handaxes and few trihedrals.

4. Large concentrations of late lower/Middle Palaeolithic stone tools are found on the surface and within colluvial deposits in valley-side locations; these are situated on sources of lithic raw material: relict terrace gravels and bedrock.
5. Assemblages from these late Lower/Middle Palaeolithic localities reflect cyclical, logistical use of these places and of the wider landscape. Many (particularly in the Orontes) display evidence of both handaxes and Levallois core working; this may imply a late Lower/early Middle Palaeolithic age.
6. Collections containing fewer Middle Palaeolithic artefacts, and which reflect more ephemeral activity, are associated with fine-grained sediment bodies within what were, at the time of occupation, active floodplains.

6.4. *The Palaeolithic of the Nahr el-Kebir*

The Nahr el Kebir ash Shamali, which enters the Mediterranean near Latakia and is Syria's third largest river, has a valuable sequence of river terraces from which significant assemblages of artefacts have been recovered (e.g., Hours, 1981, 1994; Besançon et al., 1988; Sanlaville, 1977, 1979; Besancon and Sanlaville, 1981, 1984, 1993). Research here between 2004 and 2009 has led to re-evaluation of the terrace record (Bridgland et al., 2008, 2017). Prior to this recent work the accepted template for the sequence was that of Sanlaville (1979), who recognized four Kebir river terraces that he correlated with the four Alpine Pleistocene cold stages (glacials), noting their interdigitation near the coast with a staircase of interglacial raised beaches. Whereas Sanlaville reconstructed his four terraces with longitudinal profiles that diverge downstream, the revised interpretation envisages four broadly parallel terraces, all significantly steeper than the modern floodplain. Furthermore, the second highest of Sanlaville's terraces and one of the most important in terms of artefact content, the Jabal Berzine Formation, has not been confirmed as a fluviatile formation; it has been shown instead to consist of erosional remnants of slope deposits capping isolated hills, although what is probably the same suite of slope deposits, again rich in artefacts, has also been observed capping the next terrace in the sequence (Fig. 4D). The newly recognized sequence has four terraces because an additional formation has been identified just above the modern Kebir floodplain, from quarry workings ~15 km upstream of Latakia (Bridgland et al., 2008). It is suggested that this terrace system is much younger than was supposed by Sanlaville (1979), having formed in synchrony with the last four 100 kyr (glacial–interglacial) climatic cycles in an area of relatively rapid uplift (Bridgland and Westaway, 2014; cf. Bridgland et al., 2012, 2017), thus representing MIS 10, 8, 6 and 4–2 (Fig. 4D).

The Palaeolithic assemblages from the Kebir, divided into four separate industrial traditions by the earlier workers (Copeland and Hours, 1978, 1993; Copeland, 2004), are now seen to be largely, although not entirely, derived from slope deposits rather than from the fluvial gravels. The very clear fluvial abrasion of many of them suggest derivation from older, higher-level Kebir terraces that have been lost to erosion, although some may come from the Sitt Marko Formation, which could not be found in exposure during the recent surveys. Reanalysis of the extant artefact collections has demonstrated that they are broadly technologically homogenous, regardless of their previous terrace attribution; handaxe assemblages that were suggested to show subtle, chronologically distinct differences (Copeland and Hours, 1978) in fact exhibit uniform characteristics. Detailed appraisal of this work, and of the new terrace stratigraphical evidence from this valley, must await future publication. The implications for understanding are clear, however, given that Copeland and Hours (1978) regarded the artefact record from this system as the most complete expression of an evolutionary framework for a coastal facies of the Levantine Acheulian. Neither the geological framework nor the stone-tools assemblages support this claim for a regionally distinctive 'cultural' evolution. These differences might now be explicable in terms of differences in age, since the more slowly uplifting areas drained by those inland rivers have artefact-bearing terraces considerably older than anything preserved in the Kebir (see Fig. 4).

6.5. *Fluvial archives of the Palaeolithic in Israel*

There are many important karstic Palaeolithic sites in Israel (Tabun, Qafzeh, Qesem, etc.) but significant fluvial examples are relatively rare. The earliest Palaeolithic evidence from Israel is found within the thick lacustrine and fluvial deposits of the 'Ubeidiya Formation in the central Jordon Valley, dated to ~1.4–1.2 Ma. Over 30 archaeological horizons have been identified here, the oldest of which has yielded only Mode 1 chopper assemblages (Bar Yosef and Goren-Inbar, 1993; Bar-Yosef, 1998). Handaxes and other large cutting tools appear in small numbers in the fourth oldest archaeological horizon, Level II-26, but it is not until level K-30 that they are found in larger numbers and become more persistent. Mode 1 is also found at Bizat Ruhama, Israel (Ronen et al., 1998), dated to ~1.0–0.8 Ma, comparable with the similarly dated Mode 1 site at Dursunlu, Turkey (Kuhn, 2002). At Gesher Benot Ya'aqov, dated to ~750 ka, a rich assemblage of handaxes, cleavers, other large cutting tools, together with a form of Mode 3 technology on huge boulders, has been recovered from fluvial deposits of the River Jordon (Goren-Inbar et al., 2000). Goren-Inbar and colleagues have suggested that the technology at Gesher Benot Ya'aqov indicates African affinities (Goren-Inbar and Saragusti, 1996; Goren-Inbar et al., 2000; see Mischke et al. (2014) regarding the use of ostracods in understanding the environmental impact on Palaeolake Hula during Acheulian occupation here), perhaps recording a wider dispersal event involving handaxe-making hominins around this time, which would fit with the appearance of handaxes in Europe ~650ka. In situ signatures at Gesher Benot Ya'aqov also show the persistent use of fire (Goren-Inbar et al., 2004) and nut-cracking on anvils (Goren Inbar et al., 2002), while lithic scatters containing handaxe thinning flakes but no handaxes show the transport of large cutting tools materials away from the site (Goren Inbar and Sharon, 2006). At Revadim, Marder et al. (2011) used multi-proxy data to demonstrate that the Acheulian assemblages accumulated in an active fluvial environment that included channelling, overbank flooding and episodic inundation. Essentially, hominin populations were attracted to this location by favourable microhabitats.

Less than 1 km NE of Gesher Benot Ya'aqov is a Middle Palaeolithic (Mousterian) site within a fluvio-lacustrine context in the Jordan valley as it extends through the Hula Basin. This is the site at Nahal Mahanayeem Outlet, on the eastern bank of the River Jordan at its southern exit from the Hula Valley, although when the main occupation level was active (~65 ka: OSL) this was a short-term hunting location at the shore of the palaeo-Lake Hula, according to the interpretation of recent research there (Kalbe et al., 2014, 2015; Sharon and Oron, 2014). The site has yielded a small assemblage of flint artefacts along with well-preserved animal bones and other fossils. Although the assemblage is small (~1000 artefacts) it has the highest percentage of tools of any Levantine

Mousterian site and appears to represent a non-Levallois blade-core knapping technology (Sharon and Oron, 2014).

6.6. New artefact discovery from the Gediz, Turkey

The recovery of a quartzitic worked flake from Lower Pleistocene fluvial deposits of the River Gediz in the volcanically active Kula region of western Turkey has extended the known extent of early Quaternary hominin occupation of western Asia (Maddy et al., 2015). The periodic Quaternary basaltic volcanism of this region has provided a means for geochronological constraint of the Gediz fluvial archives here, making use of Ka–Ar and Ar–Ar methodologies to data the lavas flows. Emplacement of these lavas has sometimes disrupted the evolution of the river, forming temporary lacustrine ponded reaches, and has also protected some of the unconsolidated Quaternary fluvial sediments from erosion. Indeed, 'mesa'-like uplands capped with lava have been shown to preserve, beneath the volcanic capping, staircases of weakly separated gravel terraces that are attributable to 41 ka climatic cycles in the Early Pleistocene (Maddy et al., 2005, 2012, 2017).

The worked flake is the only artefact discovered during the lengthy period of research in this system by the Maddy team. Its preservation probably owes much to the fact that it was in silty alluvial (overbank) deposits within the infill of a meander loop that existed temporarily between different eruptions from a nearby volcanic neck. The palaeo-meander was incised through a pre-existing staircase of eleven Early Pleistocene Gediz terraces and lined with gravel and finer-grained fluvial sediments before being inundated by a lake that is attributed to the damming of the river by a further eruption. The artefact occurred in the uppermost fluvial deposits. Maddy et al. inferred that its age lies between that of the lava capping the terrace staircase and that which they suppose ponded the lake in the meander, leading to its eventual abandonment. These dates, ~1.24 and ~1.17 Ma, respectively, provide maximum and minimum ages for the occupation of the region, allowing for the incision of the meander at the older boundary and the possibility that the lake was ponded by an earlier eruption than that dated.

6.7. New knowledge of Lower–Middle Palaeolithic occupation of fluvial environments in the Arabian Peninsula

In recent years the Arabian Peninsula (primarily Saudi Arabia, Oman, Yemen and the United Arab Emirates) has emerged as an important region for research into low-latitude Quaternary environmental change and hominin demography (e.g. Rose and Petraglia, 2009; Groucutt and Petraglia, 2012). Expansion of human populations into and through the interior of Arabia is widely accepted to have occurred on more than one occasion and to have been linked to humid climatic phases during the Pleistocene, when savanna-type landscapes prevailed in what are now hyper-arid regions (Vaks et al., 2007; Rosenberg et al., 2011, 2013; Breeze et al., 2015; Jennings et al., 2015a; Parton et al., 2015a). However, the highly fragmentary nature of Arabian terrestrial sequences, coupled with the fact that most Palaeolithic sites consist of mixed lithic scatters from surface contexts, has hampered the construction of chronological and palaeoenvironmental frameworks with which to understand the Lower and Middle Palaeolithic record.

A further problem for regional understanding of the Arabian Palaeolithic is the lack of perennial fluvial systems, the evidence for which consists largely of poorly-dated gravels and alluvial deposits (for recent reviews, see Breeze et al., 2015, 2016). The principal drainage across central Arabia consists of several eastward-flowing wadis that presently carry water only seasonally. It is likely that these systems were repeatedly activated during humid periods in the Pleistocene and early Holocene (Powers et al., 1966; Chapman, 1971; Anton, 1984; Edgell, 1989, 2006), although some are now choked in places by dunes (Holm, 1960), suggesting that they have been inactive as continuous systems for a considerable period of time. At a smaller scale, more localized alluvial fans have formed around the bases of steep-sided jebels and dykes, from which intermittent streams flowed during wet phases (e.g. Parton et al., 2010, 2015b; Jennings et al., 2015b). It has been suggested that most of the trans-Arabian wadi systems were incised in their current configurations by the early Quaternary, based on relationships between basal gravel deposits and dated lava flows (Al-Sayari and Zötl, 1978; Anton, 1984). Younger terraces have also been dated using radiocarbon (e.g. Jado and Zötl, 1984) but, given the unreliability of early radiocarbon methods, these ages require verification. More recent dating programmes have applied OSL and Uranium–Thorium techniques to fluvial deposits in south-central Arabia (e.g. Maizels, 1987, 1990; Blechschmidt et al., 2009; Mclaren et al., 2009; Parton et al., 2010, 2013; Rose et al., 2011; Sitzia et al., 2012; Atkinson et al., 2013), contributing to an increasingly detailed chronology for the Late Pleistocene and Early Holocene. However, the general absence of substantial fluvial archives in Arabia is reinforced by the fact that the most significant stratified archaeological assemblages reported in recent years have been found in association with either lacustrine sequences, representing a source of fresh water, or raw materials suitable for stone tool production (e.g. Armitage et al., 2011; Delagnes et al., 2013; Groucutt et al., 2015; Jennings et al., 2015b; Scerri et al., 2015).

In Saudi Arabia, most Lower and Middle Palaeolithic sites have been found on the deflated landscapes of central Arabia or on the shores of palaeolakes that formed at various times within interdunal basins in the major sand seas (the Nefud and Rub al' Khali deserts). The shifting nature of such dune fields has meant that these basins are seldom stable enough to record more than one episode of lake formation, although examples of multiple lake phases preserved in superposition have now been recorded; luminescence dating has shown that lake formation coincided with peak interglacial conditions during MIS 13, 11, 9, 7, 5e and 5c, and possibly during MIS 3 (Mclaren et al., 2009; Petraglia et al., 2011; Parton et al., 2013; Rosenberg et al., 2013; Groucutt et al., 2015). Archaeological assemblages have now been found in association with all but the earliest of these dated sequences, suggesting that hominin populations were able to occupy Arabia repeatedly during times of climatic and environmental amelioration. The Acheulian landscape surrounding Dawadmi, located on the central Nejd plateau of the Arabian shield, occupies a region largely free of Quaternary sediments (Jennings et al., 2015b). Thousands of handaxes are preserved here on a well-developed desert pavement, in close proximity to prominent intrusive dykes of relatively recent igneous rock. These are the source of many of the fine-grained raw materials used for handaxe manufacture, but also provided sufficient relief for ephemeral wadis to form during periods of wet climate, which incised shallow valleys into the bedrock surface. The precise of age of these assemblages remains to be ascertained, however (Shipton et al., 2014; Jennings et al., 2015b). Assemblages recovered from lacustrine contexts in northern Saudi Arabia are better constrained, with Acheulian assemblages recorded from the late Middle Pleistocene (MIS 11 and 9), superseded by Levallois-dominated assemblages from MIS 7 onwards (e.g. Crassard et al., 2013; Scerri et al., 2015; Groucutt et al., 2016), further extending a chronological pattern of occurrence that was first established in Europe. Possible palaeohydrological connections between north Africa, the Levant and north-western Arabia during MIS 7 and 5e have been explored by Breeze et al. (2016), highlighting the potential for a 'northern route' out of Africa and into Arabia at various times in the late Middle and Late Pleistocene. Bailey et al. (2015)

have demonstrated the need for integrating submerged coastal records with terrestrial records in southwestern Saudi Arabia. In terms of inland fluvial contexts, they documented two stratified lithic occurrences in fluvial sediments in the Jizan area: in channel deposits at Wadi Sabiya and in fine-grained floodplain sediments underlying a lava flow at Wadi Jizan. In the Tihama region of SW Yemen, Chauhan et al. (2008) located several Lower and Middle Palaeolithic open-air find-spots and surface scatters in association with fluvial gravels and on top of terrace deposits. However, the contextual integrity of some of these occurrences may be questionable if they have had multiple cycles of exposure and burial in an arid coastal setting. Nearby, at Wadi Surdud, Delagnes et al. (2012) excavated a 55 ka Middle Palaeolithic site within an alluvial sedimentary basin in the hills between the Yemeni highlands and the Tihama coastal plain. The recovered assemblages include pointed blades, pointed flakes and Levallois-like flakes with long unmodified cutting edges, produced from local rhyolite. The invetigators infer broad cultural connections with other sites in the region but also highlight the distinctivness of the assemblages, possibly reflecting local innovations.

7. India

There has been a recent surge of palaeoanthropological research in India, addressing a wide range of topics and problems; thus the last decade has witnessed numerous publications (journal articles and edited volumes spanning the disciplines of Palaeolithic and Mesolithic archaeology) describing the results of new surveys, excavations and laboratory-based work. India has a lengthy history of the study of prehistoric occurrences in various fluvial contexts (e.g. de Terra and Paterson, 1939) including silts, sands and conglomerates. Indeed, numerous surveys over the decades, combined with new methodological approaches such as GIS (e.g. Field et al., 2007), suggest that river valleys and associated environments such as floodplains were frequently exploited in the past as corridors for mobility as well as for various resources. Thus, due to this contextual attention, the majority of palaeoanthropological sites in India have come from fluvial contexts. Research into the Lower and Middle Palaeolithic since the review by Mishra et al. (2007) includes not only a diverse range of sites and evidence but also addresses fundamental research issues and existing gaps in knowledge. The most relevant data and publications are outlined below, from the oldest to the youngest in age.

With the possible exceptions of Riwat and the Pabbi Hills in the Pakistan Siwaliks, no unequivocal or well proven evidence currently exists for the presence of Oldowan-like or pre-Acheulian technology in the entire Indian subcontinent (Chauhan, 2009a). For example, one re-investigated claim of an Oldowan to Acheulian transition, made in the 1970s, at Durkadi in the central Narmada basin, turned out to preserve a much younger sequence: Middle Palaeolithic to Mesolithic (Chauhan et al., 2013). The revised Durkadi sequence appeared to preserve an alternating series of silt and sandy–pebbly gravels, the majority of which preserve lithic artefacts on fine-grained material such as chert, chalcedony and quartz. One major reason for this techno-chronological 'absence' (of the Oldowan in South Asia) may be the low profile of preserved and/or exposed Early Pleistocene sedimentary contexts in the sub-Siwalik zone (i.e. central and peninsular India). The most recent claim is ~2.6 Ma evidence of pre-Acheulian hominin activity, again from the Siwalik Hills, which preserve a continuous sequence of fluvio-lacustrine sediments from about 18 Ma onwards and extend from Pakistan to NE India (Flynn et al., 2016). This new claim from Masol (near Chandigarh, northern India) has been made by an Indo-French team which has published a series of 10 multidisciplinary papers in *Comptes Rendus Palevol*. The finds include a large number of lithics (Gaillard et al., 2016), fossil fauna (Moigne et al., 2016) and alleged stone-tool cut-marked fossils (Dambricourt Malasse et al., 2016). The remaining papers are on geology and geomorphology, stratigraphy and litho-stratigraphy, palaeomagnetic dating, and palaeoenvironments. Except for a few specimens, the majority of the lithics and all of the vertebrate fossils come from surface contexts. In addition, there are key methodological and interpretative issues regarding the alleged cut-marks, both with the original specimens as well as the experimental butchery used as a comparative analogy. The lithics, although not classified as Oldowan, have been interpreted to be techno-morphologically different from the regional Soanian evidence (which is abundant), as the quartzite choppers are 'simple' instead of 'classic'. The associated stratigraphical sequence is dominated by alternating strata of sand, silt, clay and sandstone. However, if it turns out to be a legitimate find, this would revolutionize our understanding of the temporal, behavioural and environmental contexts of early-human dispersals from Africa. For instance, if scientifically legitimate, it would collectively situate expert butchery behaviour, meat eating and associated hominin dispersal from Africa prior to the appearance of the Oldowan (~2.6 Ma) and soon after the emergence of the earliest *Homo* (~2.8 Ma) in East Africa. This new discovery also has other empirical issues: currently no lithic evidence is known between 3.3 and 2.6 Ma in Africa and no Mode 1 sites older than 1.8 Ma have been recovered outside Africa (and more specifically between India and Africa). In short, new and more secure evidence is needed from both Masol and elsewhere to support these claims. While it is not impossible that Mode 1 technology was innovated more than once within and outside Africa, there is currently neither evidence nor a reliable methodological approach to confirm it.

Regarding the Indian Acheulian, the site of Attirampakkam has been investigated since the late nineteenth century. In fact, this region is historically famous in the Indian Palaeolithic for yielding the first known handaxes, discovered by R.B. Foote (Pappu, 2007). Multiple researchers have excavated or studied the prehistoric evidence in this region, with different results and interpretations, but most recently (since the early 1990s) S. Pappu and her colleagues have been studying the evidence at Attirampakkam using a comprehensive and multidisciplinary approach. Their efforts have revealed that the lowermost Acheulian is dated to ~1.5 Ma, using palaeomagnetic and cosmogenic nuclide dating (Pappu et al., 2011), making it the oldest unequivocal Palaeolithic evidence from the subcontinent. This multicultural site also preserves post-Acheulian Palaeolithic assemblages and Mesolithic evidence. More intriguingly, the sedimentary context of the site represents one of the lengthiest stratigraphical sequences known in South Asia (>6 m) and has even preserved Pleistocene mammalian footprints. The Early Acheulian evidence is predominantly found in alternating layers of silt and clay without palaeosols, which represent low-velocity laminar overbank stream-flow. The Late Acheulian and Middle Palaeolithic evidence is found in association with a disconformable upward-fining sequence of coarse lateritic gravels, clay-rich silts, and finer lateritic gravels. The team has also published on clay mineralogy (Sreedhar et al., 2008) and rock magnetic properties as these relate to palaeoenvironmental and palaeoclimatic records of Pleistocene rainfall (Warrier et al., 2011). The age of the Early Acheulian at Attirampakkam has significant palaeoanthropological implications (see Dennell, 2013), representing the oldest known Acheulian evidence outside of Africa.

Following their reinvestigations of known sites in the middle Son Valley (see Jones and Pal, 2009), Haslam et al. (2011) reported Late Acheulian assemblages from Patpara and Bamburi 1. These have been dated to the MIS 6–5e transition or between 140 and 120 ka (Sihawal lower member), using the single-grain OSL method, and represent some of the youngest known Late Acheulian evidence in the Indian subcontinent and possibly the world (discounting the Middle Palaeolithic diminutive bifaces that survived until 60 ka in some parts of India). At Bamburi 1, the handaxes and large flake tools come from a clast-supported angular cobble band and at Patpara the lithics come from a clast-supported pebble conglomerate. The assemblages have been associated with archaic *Homo* populations and the study includes a comparison of lithic specimens from multiple sites and sedimentary contexts. This work suggests that bifacial reduction had become refined and symmetrical by at least 200 ka and potentially much earlier. What is required now is the recovery of similar Late Acheulian assemblages and associated absolute dates to understand the spread and development of the Acheulian within India. It is possible that the entire South Asian Late Acheulian record represents regional cultural groups (e.g., Ruebens, 2013) and techno-morphological diversity that is yet to be properly recognized and characterized. The recovery of such assemblages will also shed light on the appearance and evolution of the subsequent South Asian Middle Palaeolithic, understanding of which remains incomplete. The study of the terminal Acheulian and prepared-core technologies in India can also reveal why specific techniques and tool types are not widespread in the subcontinent (e.g., preferential Levallois; projectile points). In the same region, a multi-cultural sequence in a fluvial context has been reported from Dhaba (Haslam et al., 2012a), where a 13 m composite section has revealed lithic industries within alternating strata of sandy silt and clay rich silt with rhizoliths and carbonate nodules above a conglomerate/breccia. It is also viewed as the only known extensive Middle Palaeolithic flake-dominated occurrence without handaxes in the Middle Son Valley.

Central India must have acted as an important corridor of movement and exchange for technologies, ideas, culture, behaviours, and genes throughout the Pleistocene. Along with NW India and Pakistan, this region should theoretically preserve a highly diverse record of archaeological evidence spanning the Palaeolithic and Mesolithic periods, comparable with other parts of the subcontinent. The Narmada Basin Paleoanthropology Project (NBPP) has been involved in revealing the nature of Palaeolithic and palaeontological occurrences in the central Narmada Basin, building on contributions by numerous previous scholars (Chauhan and Patnaik, 2008). Using the work of Tiwari and Bhai (1997) as a geological foundation for the multidisciplinary research, NBPP project members initially worked at the site of Hathnora, the only known pre-modern hominin fossil site in the subcontinent (Athreya, 2010). Patnaik and colleagues have clarified and interpreted the Quaternary geology of this region using multidisciplinary methods including new absolute dates. The deposits in which the hominin fossil(s) were recovered are secondary in nature, based on stratigraphical observations of specific sedimentary contexts such as cemented gravels, mixing of lithic and fossil materials of different ages, and preliminary ESR dates (Patnaik et al., 2009). The NBPP has also clarified the temporal context of other important finds in the valley. For example, using a new luminescence dating approach, which shows potential for further refinement and widespread application, Morthekai et al. (2015) have indirectly and broadly confirmed the Early Pleistocene age of deposits at Dhansi (Rao et al., 1997), which have yielded undiagnostic lithics: mostly flakes on various raw materials and two amorphous cores. The Dhansi lithics come from a thin sandy-pebbley gravel horizon at the base of a 15 m section representing both the Surajkund and Dhansi Formation; the lithological context of the Matuyama–Brunhes transition is not preserved here however. The gravel is overlain and underlain by alternating horizons of sand and clay, with carbonate nodules. Elsewhere in this river basin study area, Early and Late Acheulian sites are found in diverse ecological contexts: older assemblages close to the Vindhyan Hills and presumably younger and more refined bifaces in the ancient fluvial deposits of the Narmada and its ancient tributaries. Isolated and stratified findspots of fresh bifaces come from Surajkund (between cemented sandy-pebbley gravels and clay-rich palaeosols) and throughout the entire Narmada palaeochannel (i.e. palaeomeander cut-off) nearby; the latter also preserves fresh flakes and debitage representing shaping, trimming and resharpening. These palaeochannel sediments belong to the upper part of the Dhansi Formation, which has yielded a normal polarity here (Rao et al., 1997), unlike at Dhansi; thus the Acheulian evidence in the palaeochannel is < 780 ka. Additional investigations of the Central Indian Acheulian were carried out on an exceptionally rich Acheulian occurrence at Tikoda in the Raisen District north of the Narmada Basin. Here, ongoing excavations by Ota and Deo (2014) of the multiple Acheulian clusters have revealed 8 m thick stratified contexts, including clay, ferrigunous gravels and sandy silt above Vindhyan bedrock. A 4.4 m trial trench at the TKD-II locality yielded a sedimentary sequence of (from top) mottled fissured clay, a ferruginous sandy gravel and a thin layer of soft haematite pellets that yielded artefacts and broken slabs of quartzite. The artefact horizon caps a sterile brown-yellow clay deposit and overlies a second artefact-bearing gravel at a depth of 3.88 m from the surface. Multidisciplinary scientific studies, including geochronological applications, are being applied, the results of which should shed light on its behavioural significance and temporal context within the Indian Acheulian.

In eastern India, Padhan (2014a) carried out extensive Palaeolithic surveys in the Jonk river basin of western Orissa and eastern Chattisgarh, which yielded 15 new Acheulian localities and also four Middle Palaeolithic occurrences (Padhan, 2014b). Although most of the evidence was found in the foothills, some collections were made from fluvial gravels of river sections and on cliff surfaces. Additional reports of Acheulian occurrences in fluvial settings have come from Barpadar in the Upper Jira River basin of Odisha (Behera et al., 2015) and from Atit near the Urmodi River in Maharashtra (Joglekar and Deo, 2015). From a contextual pan-Indian perspective, a number of Palaeolithic sites have yielded fossil fauna in fluvial contexts from various river valleys in northern, central and peninsular India (Chauhan, 2008a), the majority of which are Middle Palaeolithic. These mutual occurrences in fluvial contexts include the valleys of Hunsgi, Kukdi, Pravara, Paimer, Kortallyar, Godavari, Narmada, Tungabhudra, Mula, Ganga, Mahanadi, Bhima, Parvati, Sagileru and Ghod. Most of these fossil–lithic associations have been documented from sandy–pebbly gravels (occasionally cemented), suggesting mixing and secondary deposition. Thus far, no convincing evidence of Palaeolithic butchery activity or bone modification is evident from any of these known occurrences. Alleged stone-tool cut marks have been reported from Kurnool Caves in a Late Quaternary context and recently from Masol, in the Siwalik zone (discussed earlier). In short, the Indian Acheulian, at ~1.5 Ma, is currently the oldest outside Africa and comprises a rich and diverse history of technological progression, radiation within South Asia and the terminal bifacial evidence is among the youngest in the Old World. Almost all Indian Acheulian sites contain varying ratios of handaxes to cleavers and extensive comparative studies are required to explain the uneven typological patterns across the Old World (e.g. marginal cleaver presence in Europe; marginal biface sites in East Asia). Detailed geological studies on Indian fluvial contexts may also help explain the relative dearth of hominin fossils and butchery sites in India in comparison with other regions. Based on current evidence, the Indian subcontinent is viewed by some as the easternmost occurrence of classic Acheulian evidence or the eastern end of the Movius Line, a geographic boundary named after H. Movius, who first noticed a typo-technological dichotomy between Mode 1 and Mode 2 assemblages (Schick, 1994; also see Lycett and Bae, 2010 and references therein). Essentially, Mode 1 assemblages dominated the eastern side of this boundary while Mode 2 dominated the western side during the Lower Palaeolithic. In recent years, new Mode 2 sites have been reported from eastern Asia, a few of which are mentioned below.

The Soanian industry has been well known since the 1930s, when de Terra and Paterson (1939) first reported this evidence from northern Pakistan. For the next several decades, their work was used as a benchmark in Indian prehistory when interpreting lithic assemblages from river-terrace deposits. However, work by the British Archaeological Mission to Pakistan (e.g., Dennell, 1989) subsequently demonstrated that there was no correlation between the terrace sequences and technological change within the Soanian. Another long-pending issue was the 'chrono-cultural' relationship between the Soanian and the regional Acheulian. Today Soanian and Soanian-like assemblages are known throughout the entire Siwalik Hills or Sub-Himalayan region, from Pakistan to northeast India including Nepal; the evolution of this technology may represent an ecological adaptation to constraints of raw material (exclusive dominance of rounded cobbles and pebbles) deposited as conglomerate fans from the Himalaya. From evidence found at Toka and comparable Soanian sites, Chauhan (e.g. 2007) has further demonstrated and confirmed that most of the Soanian evidence appears to post-date the regional Acheulian and this adaptation of using rounded (i.e., river-worn) clasts continued until the regional Neolithic and Chalcolithic times (e.g. Soni and Soni, 2010). Despite this progress since the 1990s, many key questions and issues remain, such as whether there are any convincing Lower Palaeolithic Soanian assemblages in the Sub-Himalayan zone. If there are, what techno-cultural relationship was there with the contemporaneous Acheulian evidence? Lower Palaeolithic Soanian assemblages are expected because the associated raw material was available in many parts of the Siwalik Hills. Thus far, no Soanian site has been found in primary geological context and thus none dated, including the younger evidence. If Lower Palaeolithic Soanian occupation is ultimately found to be absent, the associated factors and reasons need to be identified. The post-Acheulian age for most Soanian assemblages is tentatively and collectively based on typology—the presence of Levallois or prepared-core attributes, the absence of Acheulian bifaces in Soanian assemblages, and the stratigraphical contexts within the regional geological formations. Most Soanian and Soanian-like assemblages occur in surface contexts on sediments of all known Siwalik formations (ranging from the Miocene to the Pleistocene). Some assemblages, however, appear to be chrono-stratigraphically associated with post-Siwalik fluvial terraces (situated horizontally above tilted Siwalik sediments) deformed by ongoing tectonic activity (e.g. Chauhan, 2008b). These uplifted terraces generally comprise fluvial silt and/or pebbly-cobbly gravel deposits and are considered to be younger than 600 ka in the Indian Siwalik zone, although younger post-Siwalik deposits (i.e. <200 ka) are more abundant and probably suggest the maximum age for most known Soanian assemblages.

The classic (i.e. flake-dominated) Middle Palaeolithic of the Indian Subcontinent has received considerable attention in recent years, particularly in relation to the dispersal of archaic and modern human groups and associated prepared-core or Levallois technologies (e.g. Groucutt et al., 2015). Recent debates have been dominated by attempts to associate modern humans with the Indian Middle Palaeolithic (in the absence of fossil evidence) and on the ecological and the impact of the Toba volcanic eruption on existing hominin populations at ~74 ka (Williams, 2012a, b). The Toba volcano is located in Sumatra and, today, the YTT isochronous marker, which is known to occur across central and peninsular India, represents the largest terrestrial source of Toba ash deposits. Tephra deposits at Indian Acheulian sites, such as Morgaon and Bori, are assumed to belong to the Older Toba Tephra (Mishra et al., 2005; Gaillard et al., 2010) but these deposits have recently yielded very young ages (Biswas et al., 2013) and most probably represent reworked deposits of the YTT. There are two opposing sides on the question of the ecological and biological impacts of the YTT, and several diverse hypotheses have developed. For example, Ambrose (1998) has argued that the eruption probably had major impacts on global climate and ecology at 74 ka and, consequently, on the behavioural and biological evolution and migrations of hominin groups, including effects from population bottlenecks. A study by Petraglia et al. (2007), and subsequent investigations by this team (Haslam et al., 2010a, 2010b; 2012b; Blinkhorn et al., 2012; Clarkson et al., 2012), attempted to challenge such claims based on the recovery of Middle Palaeolithic assemblages in stratigraphical association with the YTT at Jwalapuram in the Jurreru Valley in southern India. Blinkhorn et al. (2012) have documented 60 individual locations with primary tephra deposits in the Jurreru Valley, where stable isotope and phytolith analyses indicated that the ratio of C_3 to C_4 plants varies with regard to changes in topographic height in the landscape of up to ~5 m. This group of investigators recovered Middle Palaeolithic stone tools (without bifaces) from below *and* above the YTT at multiple localities on limestone, quartzite and chert. As an example of the nature of the tephra occurrence, more than 7.5 m of sediments were documented at Jwalapuram locality 3, including a 2.55-m-thick deposit of ash. Petraglia et al. (2007) have stated that the tephra initially accumulated here on a wet-clay substrate, probably in a lacustrine environment. Based on the overall multidisciplinary evidence, they have argued that (1) the Jwalapuram artefacts statistically cluster with those made by modern humans in southern Africa, thus modern humans must have reached South Asia prior to 74 ka, and (2) the super-eruption had rather minimal impact on these populations. Ultimately several problems have arisen with the dating method and results, artefact contexts, and interpretations in Petraglia and colleagues' study (Balter, 2010; Petraglia et al., 2012). Based on re-dating of some of these contexts, it is interesting to observe that the Middle Palaeolithic in this region continues up to 38 ka, whereas microlithic technology was already existing by 48 ka in other parts of India. In short, there is still no known, securely dated, palaeoanthropological site in South Asia with a primary YTT deposit, in association with Palaeolithic artefacts, above and below the ash, in an undisturbed context. As a consequence, it is still unclear how the eruption affected regional ecologies, hominin populations, or their technologies (see Williams, 2012b). Observations made by Jones (2010, 2012) suggest that the YTT probably had variable impacts across the entire subcontinent and so a single widespread, homogeneous effect should not be expected. Not all archaeologists are convinced that the Jwalapuram artefacts were produced by modern humans (Mellars et al., 2013) and there may be other explanations possible for typo-morphological overlap with specific African assemblages. For example, the Jwalapuram artefacts may represent parallel technological trajectories rather than a dispersal event from elsewhere; perhaps the tools were manufactured by a non-modern hominin species. Nonetheless, the Jurreru Valley research program has archaeologically addressed the Toba issue for the first time and opened up many interesting questions regarding hominin populations and ecological changes in South Asia.

8. China and east Asia

Palaeoanthropological research in China has yielded many new Lower Palaeolithic sites, as well as re-investigations and re-dating of known sites, including Mode 1 and an increasing number of

Mode 2 or biface sites, thus challenging the concept of the Movius Line. The Mode 1 evidence includes the ~1 Ma Huojiadi site, dated by magnetostratigraphy (Liu et al., 2010), the ~1.4 Ma Xihoudu site, dated using cosmogenic nuclides (Kong et al., 2013), and the ~1.2 Ma Madigou site in the Nihewan Basin, indicating occupation of lightly-wooded grassland and sparse step habitat (Li et al., 2016). Another site in the Nihewan Basin to preserve extensive lacustrine and fluvial deposits is Cenjiawan, on the fourth river terrace, which has yielded 1625 artefacts, including refitting specimens; it is dated ~1.1 Ma from magnetostratigraphy (Guan et al., 2016). Mode 2 or Lower Palaeolithic biface (handaxe) evidence has been reported from multiple locations: in a terrace context from the Danjiangkou Reservoir Region in central China, dated to between 800 ka and the Late Pleistocene (Kuman et al., 2014), while ~800 kyr old handaxes have been reported from Fengshudao in the Bose Basin (Zhang et al., 2010). Pei et al. (2010) have discussed the lithic technology from the ~70 ka (OSL) old Jingshuiwan site from silt and sand of the second terrace of the Changjiang River in the Three Gorges region. The recovered artefacts include retouched examples, cores, flakes, flake fragments, stone hammers and 'chunks', all produced on a wide range of raw materials such as silicarenite, quartzite, intrusive and extrusive rocks and volcanic breccia. The typo-technology has prompted the investigators to suggest late survival of *Homo erectus* in southern China during MIS 4. In SE Asia, renewed palaeoanthropological investigations were recently initiated at the Pleistocene locality of Matar (near Ngandong, East Java), where fossils and lithics were documented in alluvial terraces of poorly consolidated sand and gravels (Fauzi et al., 2016). Core and flake tools on chalcedony, chert and jasper were found in association with fossils of various vertebrate taxa, including *Stegodon trigonocephalus, Bubalus paleokarabau, Bibos paleosondaicus* and *Hexaprotodon sivalensis*. Similarly, Forestier et al. (2014) have re-visited and highlighted the technological relevance of the lithic assemblages from the terraces of the Mekong River in Cambodia, in relation to early human dispersals.

9. Discussion and conclusions

Since the last review of such data, published in 2007, Palaeolithic research in fluvial contexts has taken place at numerous sites in Africa, Europe and Asia, reflecting key palaeoanthropological milestones. In Africa, the majority of the work continues to come from East Africa, although new regions in northern, western and southern Africa are being increasingly explored for their palaeoanthropological potential and geographic significance. There has also been a growing focus of studies related to hominin adaptations to diverse water sources, including rivers, floodplains, springs, groundwater and wetlands. For instance, not only has the age of the earliest stone tools been extended to 3.3 Ma (Lomekwi 3, Kenya) but multiple Acheulian sites have now been dated to ~1.7 Ma (Konso Gardula and Gona in Ethiopia, Olduvai Gorge in Tanzania and Kokiselei in Kenya). Nonetheless, it is critical to survey for and locate Palaeolithic sites dated between 3.3 Ma and 2.6 Ma in Africa, to understand the transitional relationship (if any) between the Lomekwian and the Oldowan. The Olduvai Gorge evidence suggests a longer co-existence of the Early Acheulian and the Oldowan, suggesting different hominin behaviours and site functions and possibly highlighting climatic change (as seen from the aridity and landscape openness in lowermost Bed II at Olduvai Gorge and the Omo Basin and Busidima Formation in Ethiopia) as a catalyst for technological innovation at this time. Some of the youngest Acheulian in Africa was reported from Mieso (Ethiopia) and new MSA sites indicate a diverse set of technological adaptations in varying geographic and ecological contexts. This evidence includes an extension of the lower age bracket for the Aterian in northern Africa and technological similarities between the 100–35 year old MSA records from Rusinga Island, Mfangano Island and Karungu and the areas to the east and north of Lake Victoria, which have yielded a history of contractions, expansions and grassland fluctuations. Some research on the MSA in Senegal stands apart, as it was carried out exclusively by regional archaeologists, whereas most palaeoanthropological research in Africa has traditionally been undertaken by Western scientists. Except for a few exceptions, most of the Africa MSA sites have yielded very little fossil vertebrate evidence and all are generally interpreted as being associated with modern humans. However, there is a need for caution when interpreting MSA technologies younger than 200 ka, as most of these sites do not preserve hominin fossil evidence.

In Europe, the majority of the Palaeolithic research in fluvial contexts is reported from Britian, France, Spain, Italy, Germany and parts of eastern Europe and includes the discovery of new sites, the dating or re-dating of known sites and high-resolution palaeoenvironmental reconstruction of select locations. In fact, the new European data appears to have utilized more ESR and U-series dates, whereas sites in India and other regions have relied more on OSL dates. A large part of the new British evidence occurred under the auspices of the 'Ancient Human Occupaton of Britian' project or was carried out in the context of salvage archaeology in relation to infrastructure development. In addition to the location of new Mode 1 and 2 Palaeolithic localities (e.g. Clactonian evidence in Thames-tributary deposits), older evidence was chronologically revised (e.g. the Solent Acheulian and Levallois) and studied with multidisciplinary methods (e.g. Purfleet) including the successful application of the amino-acid method. Revised chronologies have led to identifying some of the youngest Acheulian (from an MIS 8 interstadial?) in southern Britain as well as changing contextual interpretations (e.g. Warren Hill gravels). Most significantly, research on lithics from fluvial contexts has revealed a chronological patterning of handaxe types associated with the MIS 9–8 climatic cycle. It would be interesting to see if this trend originated from France (or nearby regions) or is specific to Britian. It is also intriguing that the Clactonian remains regionally unique by being the only Lower Palaeolithic Mode 1 technology that exploited large flakes, unlike its other Mode 1 counterparts across the Old World.

New French research comes primarily from the Somme and Seine valleys and the Loire basin and includes a focus on the 100 kyr cyclicity within the last million years and the discovery of new Acheulian and Middle Palaeolithic sites. At least two sites have yielded Mode 1 assemblages slightly older and slightly younger than 1 Ma (although one is in a high-energy depositional environment). The majority of the studied sites in this region were of Middle Pleistocene age and several occurrences were found to be associated with different sediments such as loess, as well as calcareous tufa deposits, and with vertebrate fossils that accumulated under interglacial conditions. Some of the known historically-significant sites (e.g. Cagny-la-Garenne) were proved to be slightly older than previously thought through new discoveries in the region and other studies have indicated contemporaneity (e.g. Moulin Quignon and Carrière Carpentier). At some sites, specific contextual issues need to be resolved (e.g. Carrière Léon) and numerous known occurrences require more reliable absolute dates (e.g. Abbeville-Rue de Paris). The French evidence also collectively suggests major behavioural changes between MIS 9 and 7, including new technologies, subsistence and landuse patterns, with regional patterning increasing after MIS 7.

Parallel research in Portugal indicates the use of multidisciplinary geochronological methods to study sites in terrace contexts (e.g. Tagus), thus chronologically correlating many Acheulian assemblages with other European occurrences. Similar contexts were also studied in Spain in association with Acheulian sites, whereas the Early Pleistocene Mode 1 sites here come largely from cave contexts. It is also now apparent that some of the earliest European Acheulian is in Spain (~760 ka) and Early Pleistocene elephant butchery evidence (e.g. Barranc de ka Boella, claimed to be the oldest European Acheulian butchery evidence) complements the earlier known Middle Pleistocene evidence from Torralba and Ambrona. This evidence is further supplemented by Acheulian lithics and hominin fossil material in the Venosa Basin of Italy. A cultural boundary is now known to straddle parts of Central and Eastern Europe (e.g. Germany, Hungary and Czech Republic), indicating a geographic dichotomy between Mode 1 and Mode 2 occurrences. New data and publications have also come from one of the best-preserved Middle Pleistocene palaeoanthropological occurrences in Europe: Schöningen, Germany, in fluvio-lacustrine contexts.

The West Asian evidence also collectively highlights techno-cultural diversity during the Early and Middle Pleistocene, particularly in the Levant, and also appears to have accommodated more Early Pleistocene hominin populations than previously thought. Growing evidence from Turkey (e.g. Gediz River Valley) and Syria reflects rich Palaeolithic records in various river terrace and floodplain contexts, with the new Orontes data supplementing the long-known Acheulian evidence from Latemneh in Syria. Due to the absence of absolute dates, biostratigraphy is the main method used to place these occurrences in the early Middle Pleistocene or late Early Pleistocene (MIS 22) by different researchers, although uplift/incision mapping has also been found useful. One of the key features of this regional record is the isolated occurrences of trihedral picks or large cutting tools, rare at most Acheulian sites. In contrast to the West Asian Acheulian, which comes from terrace deposits (e.g. the Nahr el-Kebir), new Middle Palaeolithic evidence is reported from palaeo-floodplain contexts. In Israel, most of the well-known Palaeolithic sites are associated with cave or karstic contexts, although new research has increased the number of known occurrences in fluvial settings (e.g. Revadim; Nahal Mahanayeem Outlet) including a non-Levallois blade-core technology. New Palaeolithic data from the Arabian peninsula clearly indicates the past environmental contrast during hominin occupation in comparison to today's extreme desert ecology. This region has yielded both Acheulian and Middle Palaeolithic sites in inland terrestrial zones as well as coastal/littoral zones, including submerged records in the Red Sea. Some technologies (e.g. Nubian in Oman) reflect discrete technological dispersals eastwards from Africa. The inland Palaeolithic sites show adaptations to past humid climatic phases and palaeo-grassland settings but most occurrences come from lacustrine or bedrock-surface contexts rather than fluvial. Middle Palaeolithic hominins appear to have been more prolific in the region and Acheulian sites (albeit rich) are comparatively more geographically restricted/isolated.

Fluvial records and Palaeolithic evidence from other parts of Asia is dominated by new Chinese investigations. Here chronologies of old sites are being constantly revised and new sites steadily discovered, particularly in eastern and southeastern China. Mode 1 or Oldowan-like evidence continues to come from the Nihewan Basin. The new Acheulian-like sites represent an increase in biface occurrences from what was previously known but it is still being debated whether they represent Acheulian cultural transmission or parallel (independent) technological evolution (e.g. Lycett and Bae, 2010; Li et al., in press; Moncel et al., in press). The latter possibility is strongly supported by key techno-morpho-typological differences between biface sites east and west of the Movius Line (however see Brumm and Moore, 2012; Dennell, 2015, for arguments against the Movius Line). However, one major geographic gap in our knowledge continues to be the lack of research/evidence in western and central China, which would critically link the West and East Asian palaeoanthropological records as well as revealing evidence of Acheulian technologies dispersing eastwards. Until this gap is filled with new data, debate will continue regarding the route(s) of Oldowan and Acheulian dispersals from Africa to East and Southeast Asia (Central Asia vs. Indian Subcontinent). Also, while biface or Acheulian-like sites are increasing in number in East Asia (particularly China), Mode 3 or Levallois sites continue to be of marginal presence east of the Movius Line *sensu lato* (e.g. Lycett, 2007). This is a conundrum, as it is assumed that Mode 3 producing populations were substantial and well established inside and along the Movius Line.

In India, new discoveries and reinvestigations at known sites include the possible presence of pre-Acheulian hominin activity (i.e. lithics and cut-marked bones from the Siwalik Hills of northern India), the earliest-known Acheulian (Attirampakkam) and the youngest known dimuntive bifaces outside Africa, with diverse Middle Palaeolithic evidence in various contexts, including stratigraphical associations with Younger Toba Tephra (YTT) deposits. The oldest unequivocal evidence is represented by ~1.5 myr old Acheulian from southern India and late Early Pleistocene lithic assemblages from central India. The Attirampakkam evidence suggests a need for more surveys and excavations at known and new Early Acheulian sites to understand their pan-Indian distribution, possible demographic implications, and potential relationships (if any) with East Asian bifacial assemblages. Additional Acheulian assemblages have been previously reported to be older than the Matuyama–Brunhes boundary, based primarily on associated palaeogmagnetic dating attempts (Sangode et al., 2007; Gaillard et al., 2010). While some of these interpretations may represent genuine Early Pleistocene Acheulian occurrences, others require more rigorous site-specific geochronological applications, including absolute methods (Chauhan, 2010b). Despite this progress, the Indian Subcontinent has not yet yielded pre-*Homo* fossils since the early 1980s, which has been a major hindrance in identifying the various species occupying the region during the last 2 to 1.5 million years. Middle Palaeolithic technology appears to have evolved across the Old World at various times and, thus, archaeologists need not always invoke techno-cultural influence from Africa or elsewhere. This is provisionally supported by the fact that the South Asian Middle Palaeolithic, in general, lacks widespread projectile technology, as is commonly known from Middle Palaeolithic and MSA sites elsewhere. In fact, there is marked increase in the typo-morphological diversity of Indian lithic assemblages from 100 ka onwards, reasons for which are probably related to differing ecologies but are not well studied. Examples include the contemporaneous occurrence of flake-dominated (i.e. Middle Palaeolithic), blade-dominated (i.e. Upper Palaeolithic) and microlithic technologies at 45 ka across the Subcontinent (Chauhan et al., 2015), many of which have stratigraphic or transitional gaps at multi-cultural sites (Chauhan, 2009b). Much more research is required before any conclusive or reliable statements can be made about the true short- or long-term impacts of Toba. For example, Blinkhorn et al. (2014) have reported new YTT deposits in Sagileru Valley, where further multidisciplinary work can be carried out and where the methodological and interpretive errors made at Jwalapuram can be avoided. Unfortunately, virtually no Palaeolithic research has taken place in the other South Asian countries such as Nepal, Pakistan, Bangladesh, Bhutan and Sri Lanka; the majority of prehistoric research in these regions has centered on the Mesolithic and Neolithic evidence. Indeed, it also cannot be ruled out that the South-Asian Late Acheulian and Middle Palaeolithic may represent a mixture of both introduced and regionally innovated technologies. A major problem in separating archaeological evidence of dispersals from indigenous developments is the high techno-morphological diversity of Late Quaternary lithic assemblages across South Asia, probably related to ecological differences, raw material variations, and other related factors. Similarly, the general global trend visible (besides hominin activity near diverse fluvial contexts) is that both Mode 1 and Mode 2 assemblages also overlap considerably in both time and space in various parts of the Old World, particularly during the Early to Middle Pleistocene transition zone. Another problem is that the Indian subcontinent preserves an inverse dichotomy of Pleistocene contexts: the Siwalik Hills preserve extensive Early Pleistocene sediments, whereas the rest of the Subcontinent preserves abundant Middle and Upper Pleistocene deposits, thus making it challenging to recognize and recover early Oldowan evidence.

In global context, Lower Palaeolithic occupation of caves remains marginal and in many regions almost completely absent. In many regions outside Europe, the resolution and frequency of scientific studies needs to increase to address the correlations between fluvial terraces and the regional archaeology. The available palaeoanthropological data continues to highlight the fact that almost all technological dispersals from Africa throughout the Quaternary first took place eastwards rather than northwards (i.e. longitudinal vs. latitudinal trends), a fact that may also be reflected in select mammalian dispersals. The exception is the difference between Upper Palaeolithic and microlithic dispersals soon after 60–55 ka: the former first reaches Europe while the latter first reaches India. There is also a broad trend where the frequency of symbolic behaviour also becomes more sporadic in Asia, compared with its European and African counterparts.

Future research on Palaeolithic evidence from fluvial contexts needs to address a number of research questions, empirical gaps and methodological issues. First and foremost, the large amount of data that has been collected over the decades requires global access, preferably as an online database. This will facilitate a comprehensive repository of data for research, comparative and research purposes. It will also allow researchers to quantify their data in terms of artefact and site densities in specific river valleys and time periods. Another priority is the protection of key type-sites and rare Quaternary contexts, especially given the rapid rate of global development and population increase. Regarding research targets in the field, key geographic gaps need to be filled (e.g. central Africa, central and eastern Europe, central Asia, Afghanistan and surrounding regions, southern Russia, northeastern India, western China, mainland southeast Asia and Australia) by locating new sites and new fluvial sequences through systematic surveys and multidisciplinary applications. This approach is also needed in regions that do not preserve any palaeoanthropological data to explain the absence of hominin occupation or specimen preservation. Moreover, such approaches will enable scientists to distinguish between the absence of hominin occupation and the absence of specific hominin behaviours in a given region. The burgeoning amount of Palaeolithic data in fluvial contexts can also help guide students and researchers to more problem-oriented projects, such as hominin adaptative strategies to seasonality and the shifting of water resources in the past (due to fluvial dynamics, tectonic activity, droughts and so forth). Some Palaeolithic records might document such behaviors but the question arises of how they could be recognized. For example, a hominin population that had relied primarily on springs might have shifted their preference to riverine contexts due to explicit and drastic environmental regimes. Technological questions also remain unanswered: e.g. why cleavers are only marginally present in Europe compared with other regions of the Old World. From a methodological perspective, the fluvial archives data is globally inconsistent and requires more effort at specific sites through geochronological refinement, micro-geomorphology, sedimentology, palaeoenvironmental reconstructions and minute comparisons and correlations with surrounding non-fluvial data. This might, for example, resolve issues such as the environmental impact of annual monsoon patterns on hominin mobility and technological adaptations.

References

Abbate, E., Albianelli, A., Awad, A., Billi, P., Bruni, P., Delfino, M., Ferretti, M.P., Filippi, O., Gallai, G., Ghinassi, M., Lauritzen, S.-E., Vetro, D.L., Martínez-Navarro, B., Martini, F., Napoleone, G., Bedri, O., Papini, M., Rook, L., Sagri, M., 2010. Pleistocene environments and human presence in the middle Atbara valley (Khashm El Girba, Eastern Sudan). Palaeogeogr. Palaeoclimatol. Palaeoecol. 292, 12–34.

Allington-Jones, L., 2015. The Clacton spear: the last one hundred years. Archaeol. J. 172, 273–296.

Al-Sayari, S.S., Zötl, J. (Eds.), 1978. Quaternary Period in Saudi Arabia, Vol. 1. Sedimentological, Hydrogeological, Hydrochemical, Geomorphological, and Climatological Investigations in Central and Eastern Saudi Arabia. Springer, New York.

Ambrose, S.H., 1998. Late Pleistocene human population bottlenecks, volcanic winter, and differentiation of modern humans. J. Hum. Evol. 34, 623–651.

Antoine, P., Limondin-Lozouet, N., Auguste, P., Locht, J.L., Ghaleb, B., Reyss, J.L., Escudé, E., Carbonel, P., Mercier, N., Bahain, J.J., Falguères, C., Voinchet, P., 2006. Le Tuf de Caours (Somme, France): mise en évidence d'une séquence éemienne et d'un site paléolithique associé. Quaternaire 17, 281–320.

Antoine, P., Auguste, P., Bahain, J.-J., Coudret, P., Depaepe, P., Fagnart, J.-P., Falguères, C., Fontugne, M., Frechen, M., Hatté, C., Lamotte, A., Laurent, M., Limondin-Lozouet, N., Locht, J.-L., Mercier, N., Moigne, A.-M., Munaut, A.-V., Ponel, P., Rousseau, D.-D., 2003. Paléoenvironnements pléistocènes et peuplements paléolithiques dans le bassin de la Somme (nord de la France). Bull. Soc. Préhist. Fr. 100, 5–29.

Antoine, P., Auguste, P., Bahain, J.-J., Chaussé, C., Falguères, C., Ghaleb, B., Limondin-Lozouet, N., Locht, J.-L., Voinchet, P., 2010. Chronostratigraphy and palaeoenvironments of acheulean occupations in northern France (Somme, Seine and Yonne valleys). Quat. Int. 223–224, 456–461.

Antoine, P., Moncel, M.-H., Limondin-Lozouet, N., Locht, J.-L., Bahain, J.-J., Moreno, D., Voinchet, P., Auguste, P., Stoetzel, E., Dabkowski, J., Bello, S.M., Parfitt, S.A., Tombret, O., Hardy, B., 2016a. Palaeoenvironment and dating of the early acheulean localities from the somme river basin (Northern France): new discoveries from the High Terrace at Abbeville-Carrière Carpentier. Quat. Sci. Rev. 149, 338–371.

Antoine, P., Coutard, S., Guerin, G., Deschodt, L., Goval, E., Locht, J.-L., Paris, C., 2016b. Upper Pleistocene loess-palaeosol records from northern France in the European context: environmental background and dating of the Middle Palaeolithic. Quat. Int. 411, 4–24. http://dx.doi.org/10.1016/j.quaint.2015.11.036.

Antoine, P., Limondin-Lozouet, N., Chaussé, C., Lautridou, J.P., Pastre, J.F., Auguste, P., Bahain, J.J., Falguères, C., Galehb, B., 2007. Pleistocene fluvial terraces from northern France (Seine, Yonne, Somme): synthesis and new results. Quat. Sci. Rev. 26, 2701–2723.

Antoine, P., Moncel, M.-H., Locht, J.-L., Limondin-Lozouet, N., Auguste, P., Stoetzel, E., Dabkowski, J., Voinchet, P., Bahain, J.-J., Falgueres, C., 2015. Dating the earliest human occupation of Western Europe: new evidence from the fluvial terrace system of the Somme basin (Northern France). Quat. Int. 370, 77–99. http://dx.doi.org/10.1016/j.quaint.2014.08.012.

Anton, D., 1984. Aspects of geomorphological evolution; palaeosols and dunes in Saudi Arabia. In: Jado, A., Zotl, J. (Eds.), Quaternary Period in Saudi Arabia, Vol. 2: Sedimentological, Hydrogeological, Hydrochemical, Geomorphological, and Climatological Investigations in Western Saudi Arabia. Springer, New York, pp. 275–296.

Archer, W., Braun, D.R., Harris, J.W.K., McCoy, J.T., Richmond, B.G., 2014. Early Pleistocene aquatic resource use in the Turkana Basin. J. Hum. Evol. 77, 74–87.

Armitage, S.J., Jasim, S., Marks, A., Parker, A.G., Usik, V.I., Uerpmann, H., 2011. The Southern route "Out of Africa": evidence for an early expansion of modern humans into Arabia. Science 331, 453–456.

Ashley, G.M., Tactikos, J.C., Owen, R.B., 2009. Hominin use of springs and wetlands: paleoclimate and archaeological records from Olduvai Gorge (~1.79–1.74 Ma). Palaeogeogr. Palaeoclimatol. Palaeoecol. 272, 1–16.

Ashton, N., Hosfield, R., 2010. Mapping the human record in the British early Palaeolithic: evidence from the Solent River system. J. Quat. Sci. 25, 737–753.

Ashton, N.M., Lewis, S.G., 2002. Deserted Britain: declining populations in the British late Middle Pleistocene. Antiquity 76, 388–396.

Ashton, N.M., Lewis, S.G., Stringer, C.B. (Eds.), 2011. The Ancient Human Occupation of Britain. Elsevier, Amsterdam.

Athreya, S., 2010. South Asia as a geographic crossroad: patterns and predictions of hominin morphology in Pleistocene India. In: Norton, C.J., Braun, D.R. (Eds.), Asian Paleoanthropology: From Africa to China and Beyond, Vertebrate Paleobiology and Paleoanthropology 2010, pp. 129–141.

Atkinson, O.A.C., Thomas, D.S.G., Parker, A.G., Goudie, A.S., 2013. Late Quaternary humidity and aridity dynamics in the northeast Rub' al-Khali, United Arab Emirates: implications for early human dispersal and occupation of eastern Arabia. Quat. Int. 300, 292–301.

Baena, J., Moncel, M.-H., Cuartero, F., Navarro, M.G.C., Rubio, D., 2014. Late Middle Pleistocene genesis of Neanderthal technology in western Europe: the case of Payre site (south-east France). Quat. Int. http://dx.doi.org/10.1016/j.quaint.2014.08.031.

Bahain, J.-J., Falguères, C., Laurent, M., Voinchet, P., Dolo, J.-M., Antoine, P., Tuffreau, A., 2007. ESR chronology of the Somme River Terrace system and first human settlements in Northern France. Quat. Geochronol. 2, 356–362.
Bahain, J.-J., Falguères, C., Dolo, J.-M., Antoine, P., Auguste, P., Limondin-Lozouet, N., Locht, J.-L., Tuffreau, A., Tissoux, H., Farkh, S., 2010. ESR/U-series dating of teeth recovered from well-stratigraphically age-controlled sequences from Northern France. Quat. Geochronol 5, 371–375. http://dx.doi.org/10.1016/j.quageo.2009.02.007.
Bahain, J.-J., Limondin-Lozouet, N., Antoine, P., Voinchet, P., 2017. Réexamen du context géologique, chrono- et biostratigraphique du site de Moulin Quignon à Abbeville (Vallée de la Somme, France). L'Anthropologie. http://dx.doi.org/10.1016/j.anthr.2016.05.006 (in press).
Bailey, G.N., Deves, M.H., Inglis, R.H., Meredith-Wiliams, M.G., Momber, G., Sakellariou, D., Sinclair, A.G.M., Rousakis, G., Al Ghamdi, S., Alsharekh, A.M., 2015. Blue Arabia: Palaeolithic and underwater survey in SW Saudi Arabia and the role of coasts in Pleistocene dispersals. Quat. Int. 382, 42–57.
Balter, M., 2010. Of two minds about Toba's impact. Science 327, 1187–1188.
Bamford, M.K., 2012. Fossil sedges, macroplants, and roots from Olduvai Gorge, Tanzania. J. Hum. Evol. 63, 351–363.
Barham, L., Phillips, W.M., Maher, B.A., Karloukovski, V., Duller, G.A.T., Jain, M., Wintle, A.G., 2011. The dating and interpretation of a Mode 1 site in the Luangwa Valley, Zambia. J. Hum. Evol. 60, 549–570.
Barsky, D., 2009. An overview of some African and Eurasian Oldowan sites: evaluation of hominin cognition levels, technological advancement and adaptive skills. In: Hovers, E., Braun, D. (Eds.), Interdisciplinary Approaches to the Oldowan. Springer, Dordrecht, pp. 39–47.
Barsky, D., de Lumley, H., 2010. Early European Mode 2 and the Stone Industry from the Caune de l'Arago's Archeostratigraphical Levels "P." Spec. Issue. Hum. Expans. Eurasia 223, 71–86.
Bartz, M., Klasen, N., Zander, A., Brill, D., Rixhon, G., Seeliger, M., Eiwanger, J., Weniger, G.-C., Mikdad, A., Brückner, H., 2015. Luminescence dating of ephemeral stream deposits around the Palaeolithic site of Ifri n'Ammar (Morocco). Quat. Geochronol. 30, 460–465.
Bar-Yosef, O., 1998. Early colonizations and cultural continuities in the lower Palaeolithic of western Asia. In: Petraglia, M.D., Korisettar, R. (Eds.), Early Human Behaviour in Global Context: The Rise and diversity of the Lower Palaeolithic record. Routledge, London, pp. 221–279.
Bar-Yosef, O., Belmaker, M., 2010. Early and Middle Pleistocene faunal and hominin dispersals through southwestern Asia. Quat. Sci. Rev. 30, 1318–1337.
Bar-Yosef, O., Goren-Inbar, N., 1993. The Lithic Assemblages of 'Ubeidiya, a Lower Paleolithic Site in the Jordan Valley. The Institute of Archaeology, The Hebrew University of Jerusalem, Jerusalem.
Bassinot, F.C., Labeyrie, L.D., Vincent, E., Quidelleur, X., Shackleton, N.J., Lancelot, Y., 1994. The astronomical theory of climate and the age of the Brunhes–Matuyama magnetic reversal. Earth Planet. Sci. Lett. 126, 91–108.
Bates, M.R., Briant, R.M., Rhodes, E.J., Schwenninger, J.-L., Whittaker, J.E., 2010. A new chronological framework for Middle and upper Pleistocene landscape evolution in the Sussex/Hampshire coastal corridor. Proc. Geol. Assoc. 121, 369–392.
Bates, M.R., Wenban-Smith, F.F., Bello, S.M., Bridgland, D.R., Buck, L.T., Collins, M.J., Keen, D.H., Leary, J., Parfitt, S.A., Penkman, K.E.H., Rhodes, E.J., Ryssaert, C., Whittaker, J.E., 2014. Late persistence of the Acheulian in southern Britain in an MIS 8 interstadial: evidence from Harnham, Wiltshire. Quat. Sci. Rev. 101, 159–176.
Behera, P.K., Sinha, P., Thakur, N., 2015. Barpadar: an Acheulian Site in the Upper Jira River, District Baragarh, Odisha. Man and Environment XL (1).
Behre, K.-E. (Ed.), 2012. Die chronologische Einordnung der paläolithischen Fundstellen von Schöningen. The chronological setting of the Palaeolithic sites of Schöningen. Forschungen zur Urgeschichte im Tagebau von Schöningen 1. RGZM, Mainz.
Benito-Calvo, A., Barfod, D.N., McHenry, L.J., de la Torre, I., 2014. The geology and chronology of the Acheulean deposits in the Mieso area (East-Central Ethiopia). J. Hum. Evol. 76, 26–38.
Bertran, P., Lenoble, A., Todisco, D., Desrosiers, P.M., Sorensen, M., 2012. Particle size distribution of lithic assemblages and taphonomy of Palaeolithic sites. J. Archaeol. Sci. 39, 3148–3166.
Besançon, J., Geyer, B., 2003. La géomorphologie de la basse vallée de l'Euphrate Syrien: contribution à l'étude des changements de l'environnement géographique au Quaternaire. In: Geyer, B., Montchambert, J.-Y. (Eds.), La Basse Vallée de l'Euphrate Syrien du Néolithique a l'avenement de l'Islam. Vol. 1: text. Mission Archéologique de Mari, vol. 6. Institut Francais du Proche Orient, Beirut, Lebanon, pp. 7–59.
Besançon, J., Sanlaville, P., 1981. Aperçu géomorphologique sur la vallée de l'Euphrate Syrien. Paléorient 7, 5–18.
Besançon, J., Sanlaville, P., 1984. Terrasses fluviatiles au Proche-Orient. Bulletin de l'Association Française pour l'Etude du Quaternaire, pp. 186–191.
Besançon, J., Sanlaville, P., 1993. La vallée de l'Oronte entre Rastane et Aacharné. In: Sanlaville, P., Besançon, J., Copeland, L., Muhesen, S. (Eds.), Le Paléolithique de la vallée moyenne de l'Oronte (Syrie): Peuplement et environnement, vol. 587. British Archaeological Reports, International Series, pp. 13–39.
Besançon, J., Copeland, L., Sanlaville, P., 1988. Réflexions sur les prospections géopréhistoriques au Proche-Orient. Paléorient 14, 31–39.
Beyene, Y., Katoh, S., WoldeGabriel, G., Hart, W.K., Uto, K., Sudo, M., Kondo, M., Hyodo, M., Renne, P.R., Suwa, G., Asfaw, B., 2012. The characteristics and chronology of the earliest Acheulean at Konso, Ethiopia. PNAS 110 (5), 1584–1591.
Biswas, R.H., Williams, M.A.J., Raj, R., Juyal, N., Singhvi, A.K., 2013. Methodological studies on luminescencedating of volcanic ashes. Quat. Geochronol. 17, 14–25.
Blain, H.-A., Lozano-Fernandez, I., Olle, A., Rodríguez, J., Santonja, M., Pérez-González, A., 2015. The continental record of Marine isotope stage 11 (Middle Pleistocene) on the Iberian Peninsula characterized by herpetofaunal assemblages. J. Quat. Sci. 30, 667–678.
Blechschmidt, I., Matter, A., Preusser, F., Rieke-zapp, D., 2009. Monsoon triggered formation of Quaternary alluvial megafans in the interior of Oman. Geomorphology 110, 128–139.
Blinkhorn, J., Parker, A.G., Ditchfield, P., Haslam, M., Petraglia, M.D., 2012. Uncovering a landscape buriedby the super-eruption of Toba, 74,000 years ago: a multi-proxy environmental reconstruction oflandscape heterogeneity in the Jurreru Valley, South India. Quat. Int. 258, 135–147.
Blinkhorn, J., Smith, V.C., Achyuthan, H., Shipton, C., Jones, S.C., Ditchfield, P., Petraglia, M.D., 2014. Discovery of youngest Toba tuff localities in the Sagileru Valley, south India, in association with Palaeolithic industries. Quat. Sci. Rev. 105, 239–243.
Blome, M.W., Cohen, A.S., Tryon, C.A., Brooks, A.S., Russell, J., 2012. The environmental context for the origins of modern human diversity: a synthesis of regional variability in African climate 150,000-30,000 years ago. J. Hum. Evol. 62, 563–592.
Boismier, W.A., Gamble, C., Coward, F. (Eds.), 2012. Neanderthals among mammoths. Excavations at Lynford Quarry, Norfolk. English Heritage, London.
Boreham, S., White, T.S., Bridgland, D.R., Howard, A.J., White, M.J., 2010. The Quaternary history of the Wash fluvial network, UK. Proc. Geol. Assoc. 121, 393–409.
Boucher de Perthes, J., 1847–1864. Antiquités celtiques et antédiluviennes: Mémoire sur l'industrie primitive et les arts à leur origine. Three volumes: 1847, 1857, 1864. Treuttel et Wurtz, Paris.
Bowen, D.Q., Hughes, S.A., Sykes, G.A., Miller, G.H., 1989. Land–sea correlations in the Pleistocene based on isoleucine epimerisation in non-marine molluscs. Nature 340, 49–51.
Bowen, D.Q., Sykes, G.A., Maddy, D., Bridgland, D.R., Lewis, S.G., 1995. Aminostratigraphy and amino acid geochronology of English lowland valleys: the Lower Thames in context. In: Bridgland, D.R., Allen, P., Haggart, B.A. (Eds.), The Quaternary of the Lower Reaches of the Thames. Field Guide. Quaternary Research Association, Durham, pp. 61–63.
Breeze, P.S., Drake, N.A., Groucutt, H.S., Parton, A., Jennings, R.P., White, T.S., Clark-Balzan, L., Shipton, C., Scerri, E.M., Stimpson, C.M., Crassard, R., 2015. Remote sensing and GIS techniques for reconstructing Arabian palaeohydrology and identifying archaeological sites. Quat. Int. 382, 98–119.
Breeze, P.S., Groucutt, H.S., Drake, N.A., White, T.S., Jennings, R.P., Petraglia, M.D., 2016. Palaeohydrological corridors for hominin dispersals in the Middle East ~250–70,000 years ago. Quat. Sci. Rev. 144, 155–185.
Breuil, H., 1932. Le Paléolithique ancien en Europe occidentale et sa chronologie. Bull. Soc. Préhist. Fr. 29, 570–578.
Breuil, H., 1939. The Pleistocene succession in the Somme valley. Proc. Prehist. Soc. 5, 33–38.
Breuil, H., Zbyszewski, G., 1945. Contribution à l'étude des industries Paléolithiques du Portugal et de leurs rapports avec la géologie du Quaternaire. Les principaux gisements des plages quaternaires du littoral d'Estremadura et des terrasses fluviales de la basse vallée du Tage, XXVI. Comunicações Serviços Geológicos de Portugal, Lisboa, p. 662.
Briant, R.M., Bates, M.R., Schwenninger, J.-L., Wenban-Smith, F.F., 2006. A long optically-stimulated luminescence dated Middle to Late Pleistocene fluvial sequence from the western Solent Basin, southern England. J. Quat. Sci. 21, 507–523.
Briant, R.M., Bates, M.R., Schwenninger, J.-L., Wenban-Smith, F.F., 2012a. Terrace reconstruction and long profile projection: a case study from the Solent river system near Southampton, England. Proc. Geol. Assoc. 123, 438–449.
Briant, R.M., Keen, D.H., Kilfeather, A.A., Parfitt, S., Penkman, K.E.H., Preece, R.C., Roe, H.M., Schwenninger, J.-L., Wenban-Smith, F.F., 2012b. Integrated chronological control on an archaeologically significant Pleistocene river terrace sequence: the Thames-Medway, eastern Essex, England. Proc. Geol. Assoc. 123, 87–108.
Bridgland, D.R., 1994. Quaternary of the Thames. Geological Conservation Review Series, vol. 7. Chapman and Hall, London.
Bridgland, D.R., 2000. River terrace systems in north-west Europe: an archive of environmental change, uplift and early human occupation. Quat. Sci. Rev. 19, 1293–1303.
Bridgland, D.R., 2006. The Middle and Upper Pleistocene sequence in the Lower Thames: a record of Milankovitch climatic fluctuation and early human occupation of southern Britain. Proc. Geol. Assoc. 117, 281–305.
Bridgland, D.R., 2014. John Lubbock's early contribution to the understanding of river terraces and their importance to geography, archaeology and Earth science. Notes Rec. R. Soc. J. Hist. Sci. 68, 49–63.
Bridgland, D.R., Westaway, R., 2014. Quaternary fluvial archives and landscape evolution: a global synthesis. Proc. Geol. Assoc. 125, 600–629.
Bridgland, D.R., White, M.J., 2014. Fluvial archives as a framework for the Lower and Middle Palaeolithic: patterns of British artefact distribution and potential chronological implications. Boreas 43, 543–555.
Bridgland, D.R., White, M.J., 2015. Chronological variations in handaxes: patterns detected from fluvial archives in NW Europe. J. Quat. Sci. 30, 623–638.
Bridgland, D.R., Lewis, S.G., Wymer, J.J., 1995. Middle Pleistocene stratigraphy and

archaeology around Mildenhall and Icklingham, Suffolk: report on the geologists' association field Meeting, 27 June, 1992. Proc. Geol. Assoc. 106, 57–69.
Bridgland, D.R., Philip, G., Westaway, R., White, M., 2003. A long Quaternary terrace sequence in the Orontes River valley, Syria: a record of uplift and of human occupation. Curr. Sci. (New Delhi) 84, 1080–1089.
Bridgland, D.R., Maddy, D., Bates, M., 2004. River terrace sequences: templates for Quaternary geochronology and marine-terrestrial correlation. J. Quat. Sci. 19, 203–218.
Bridgland, D.R., Antoine, P., Limondin-Lozouet, N., Santisteban, J.I., Westaway, R., White, M.J., 2006. The Palaeolithic occupation of Europe as revealed by evidence from the rivers: data from IGCP 449. J. Quat. Sci. 21, 437–455.
Bridgland, D.R., Keen, D.H., Westaway, R., 2007. Global correlation of Late Cenozoic fluvial deposits: a synthesis of data from IGCP 449. Quat. Sci. Rev. 26, 2694–2700.
Bridgland, D.R., Westaway, R., Daoud, M., Yassminh, R., Abou Romieh, M., 2008. River Terraces of the Nahr el Kebir, NW Syria, and their Palaeolithic record. CBRL Bull. 3, 36–41.
Bridgland, D.R., Innes, J.B., Long, A.J., Mitchell, W.A., 2011. Late Quaternary Landscape Evolution of the Swale–Ure Washlands, North Yorkshire. Oxbow Books, Oxford.
Bridgland, D.R., Westaway, R., Abou Romieh, M., Candy, I., Daoud, M., Demir, T., Galiatsatos, N., Schreve, D.C., Seyrek, A., Shaw, A., White, T.S., Whittaker, J., 2012. The River Orontes in Syria and Turkey: downstream variation of fluvial archives in different crustal blocks. Geomorphology 165–166, 25–49.
Bridgland, D.R., Harding, P., Allen, P., Candy, I., Cherry, C., George, W., Horne, D., Keen, D.H., Penkman, K.E.H., Preece, R.C., Rhodes, E.J., Scaife, R., Schreve, D.C., Schwenninger, J.-L., Slipper, I., Ward, G., White, M.J., White, T.S., Whittaker, J.E., 2013. An enhanced record of MIS 9 geoarchaeology: data from construction of the High Speed 1 (London – channel Tunnel) rail-link and other recent investigations at Purfleet, Essex, UK. Proc. Geol. Assoc. 124, 417–476.
Bridgland, D.R., Howard, A.J., White, M.J., White, T.S., 2014. The Quaternary of the Trent. Oxbow Books, Oxford 406.
Bridgland, D.R., Demir, T., Seyrek, A., Daoud, M., Abou Romieh, M., Westaway, R., 2017. River terrace development in the NE Mediterranean region (Syria and Turkey): patterns in relation to crustal type. Quat. Sci. Rev. 166, 307–323.
Brink, J.S., Herries, A.I.R., Moggi-Cecchi, J., Gowlett, J.A.J., Bousman, C.B., Hancox, J.P., Grün, R., Eisenmann, V., Adams, J.W., Rossouw, L., 2012. First hominine remains from a ~1.0 million year old bone bed at Cornelia-Uitzoek, Free State Province, South Africa. J. Hum. Evol. 63, 527–535.
Brown, A.G., Basell, L.S., Toms, P.S., Bennett, J., Hosfield, R.T., Scrivener, R.C., 2010. Late pleistocene evolution of the exe valley: a chronstratigraphic model of terrace formation and its implications for Palaeolithic archaeology. Quat. Sci. Rev. 29, 897–912.
Brumm, A., Moore, M.W., 2012. Biface distributions and the Movius line: a southeast Asian perspective. Aust. Archaeol. 74, 32–46.
Burdukiewicz, J.M., Ronen, A., 2003. Research problems of the Lower and Middle Palaeolithic small tool assemblages. In: Burdukiewicz, J.M., Ronen, A. (Eds.), Lower Palaeolithic Small Tools in Europe and the Levant, vol. 1115. British Archaeological Reports, International Series, pp. 235–238.
Byers, D.A., Hargiss, E., Finley, J.B., 2015. Flake morphology, fluvial dynamics, and debitage transport potential. Geoarchaeol. Int. J. 30, 379–392.
Candy, I., Schreve, D.C., White, T.S., 2015. MIS 13–12 in Britain and the North Atlantic: understanding the palaeoclimatic context of the earliest Acheulean. J. Quat. Sci. 30, 593–609.
Carvalhido, R.P., Pereira, D.I., Cunha, P.P., Buylaert, J.-P., Murray, A.S., 2014. Characterization and dating of coastal deposits of NW Portugal (Minho–Neiva area): a record of climate, eustasy and crustal uplift during the Quaternary. Quat. Int. 328–329, 94–106.
Chapman, R.W., 1971. Climatic changes and the evolution of landforms in the Eastern Province of Saudi Arabia. Geol. Soc. Am. Bull. 82, 2713–2728.
Chauhan, P.R., 2007. Soanian cores and core-tools from Toka, northern India: towards a new typotechnologicalorganization. J. Anthropol. Archaeol. 26, 412–441.
Chauhan, P.R., 2008a. Large mammal fossil occurrences and associated archaeological evidence in Pleistocene contexts of peninsular India and Sri Lanka. Quat. Int. 192, 20–42.
Chauhan, P.R., 2008b. Soanian lithic occurrences and raw material exploitation in the Siwalik Frontal Zone, northern India: a geoarchaeological perspective. J. Hum. Evol. 54, 591–614.
Chauhan, P.R., 2009a. Was there an Oldowan occupation in the Indian subcontinent? A critical appraisal of the earliest paleoanthropological evidence. In: Schick, K., Toth, N. (Eds.), The cutting edge: new approaches to the archaeology of human origins. Stone Age Institute Press, Gosport, pp. 33–54.
Chauhan, P.R., 2009b. The South Asian Paleolithic record and its potential for transitions studies. In: Camps, M., Chauhan, P.R. (Eds.), Sourcebook of Paleolithic transitions: methods, theories and interpretations. Springer, New York, pp. 121–139.
Chauhan, P.R., 2010a. Core-and-flake assemblages of central & Peninsular India. In: Norton, C.J., Braun, D. (Eds.), Asian Paleoanthropology: From Africa to China and Beyond. Paleobiology and Paleoanthropology Series. Springer Press, pp. 113–128.
Chauhan, P.R., 2010b. Comment on 'Lower and Early Middle Pleistocene Acheulian in the Indian sub-continent' by Gaillard et al. (2009) (Quat. Int.). Quat. Int 223–224, 248–259.
Chauhan, P.R., Patnaik, R., 2008. The Narmada Basin Paleoanthropology Project (Central India). Antiquity Project Gallery. http://www.antiquity.ac.uk/projgall/chauhan317/ (Accessed 28 October 2015).
Chauhan, P.R., Ali Othman, S., Al-Mikhlafi, A., Al-Ma'ammary, A., 2008. The Bab al-Mandab Paleoanthropology Project in Yemen. Online Project Gallery in Antiquity (December issue). http://www.antiquity.ac.uk/projgall/chauhan318/.
Chauhan, P.R., Ozarkar, S., Kulkarni, S., 2015. Genes, stone tools and modern human dispersals in center of the Old World. In: Kaifu, Y., Goebel, T. (Eds.), Proceedings of the Symposium on the Emergence and Diversity of Modern Human Behavior in Palaeolithic Asia. November 29-December 1. Texas A&M University Press, Tokyo, Japan, pp. 94–113.
Chauhan, P.R., Sathe, V., Shaik, S., 2013. A short note on prehistoric reinvestigations at Durkadi, centralIndia. Indian J. Phys. Anthropol. Hum. Genet. 32, 185–193.
Chevrier, B., Rasse, M., Lespez, L., Tribolo, C., Hajdas, I., Fígols, M.G., Lebrun, B., Leplongeon, A., Camara, A., Huysecom, E., 2016. West African Palaeolithic history: new archaeological and chronostratigraphic data from the Faleme valley, eastern Senegal. Quat. Int. 408, 33–52.
Clark, J.D., 1966a. The Middle acheulean occupation site at Latamne northern Syria. Ann. Archéol. Arab. Syr. 16, 31–74.
Clark, J.D., 1966b. Further excavations (1965) at the Middle acheulean occupation site at Latamne northern Syria: general results, definitions and interpretations. Ann. Archéol. Arab. Syr. 16, 75–120.
Clark, J., de Heinzelin, J., Schick, K., Hart, W., White, T., WoldeGabriel, G., Walter, R., Suwa, G., Asfaw, B., Vrba, E., et al., 1994. African *Homo erectus*: old radiometric ages and young Oldowan assemblages in the middle Awash Valley, Ethiopia. Science 264 (5167), 1907–1909.
Clarke, G., 1969. World prehistory: a new outline. Cambridge University Press, Cambridge.
Clarkson, C., Jones, S., Harris, C., 2012. Continuity and change in the lithic industries of the Jurreru Valley, India, before and after the Toba eruption. Quat. Int. 258, 165–179.
Cliquet, D., 2013. Les occupations paléolithiques en Normandie dans leur contexte chronostratigraphique: "bribes archaeologiques". Quaternaire 24, 315–359.
Cliquet, D., Lautridou, J.-P., Antoine, P., Lamotte, A., Leroyer, M., Limondin-Lozouet, N., Mercier, N., 2009. La séquence loessique de Saint-Pierre-lès-Elbeuf (Normandie, France): nouvelles données archéologiques, géochronologiques et paléontologiques. Quaternaire 20, 321343.
Commont, V., 1909. Saint-Acheul et Montières. Notes de Géologie, de Paléontologie et de –Préhistoire. Mémoire de la Société Géologique du Nord, VI, mém III, 68.
Commont, V., 1910. Note préliminaire sur les Terrasses fluviatiles de la Vallée de la Somme. Epoque de l'apparition de l'homme quaternaire. Ann. Soc. Géol. Nord 39, 185–248.
Conard, N.J., Serangeli, J., Böhner, U., Starkovich, B.M., Miller, C.E., Urban, B., van Kolfschoten, Th, 2015. Excavations at Schöningen and paradigm shifts in human evolution. J. Hum. Evol. 89, 1–17.
Copeland, L., 2004. The Palaeolithic of the Euphrates valley in Syria. In: Aurenche, O., Le Mière, M., Sanlaville, P. (Eds.), From the River to the Sea-The Palaeolithic and the Neolithic on the Euphrates and in the Northern Levant-Studies in honour of Lorraine Copeland, vol. 1263. British Archaeological Reports, International Series, pp. 19–61.
Copeland, L., Hours, F., 1978. La séquence Acheuléenne du Nahr el Kebir, région septentrionale du littoral Syrien. Paléorient 4, 5–31.
Copeland, L., Hours, F., 1993. The Middle Orontes Palaeolithic flint industries. In: Sanlaville, P., Besançon, J., Copeland, L., Muhesen, S. (Eds.), Le Paléolithique de la valléemoyenne de l'Oronte (Syrie): Peuplement et environnement, vol. 587. British Archaeological Reports, International Series, pp. 63–144.
Cordier, S., Briant, B., Bridgland, D., Herget, J., Maddy, D., Mather, A., Vandenberghe, J., 2017. The Fluvial Archives Group: 20 years of research connecting fluvial geomorphology and (palaeo)environments. Quat. Sci. Rev. 166, 1–9.
Crassard, R., Petraglia, M.D., Drake, N.A., Breeze, P., Gratuze, B., Alsharekh, A., Arbach, M., Groucutt, H.S., Khalidi, L., Michelsen, N., Robin, C.J., 2013. Middle Palaeolithic and Neolithic occupations around Mundafan palaeolake, Saudi Arabia: implications for climate change and human dispersals. PLoS One 8, e69665.
Cunha, P.P., Martins, A.A., Huot, S., Murray, A.S., Raposo, L., 2008. Dating the Tejo River lower terraces in the Ródão area (Portugal) to assess the role of tectonics and uplift. Geomorphology 102, 43–54.
Cunha, P.C., Almeida, N.A.C., Aubry, T., Martins, A.A., Murray, A.S., Buylaert, J.-P., Sohbati, R., Raposo, L., Rocha, L., 2012. Records of human occupation from Pleistocene river terrace and aeolian sediments in the Arneiro depression (Lower Tejo River, central eastern Portugal). Geomorphology 165–166, 78–90.
Cunha, P.P., Martins, A., Buylaert, Jan-Pieter, Murray, A.S., Raposo, L., Mozzi, P., Stokes, M., 2017. New data on the chronology of the Vale do Forno sedimentary sequence (Lower Tejo River terrace staircase) and its relevance as a fluvial archive of the Middle Pleistocene in western Iberia. Quat. Sci. Rev. 166, 204–226.
Cuthbert, M.O., Ashley, G.M., 2014. A spring forward for hominin evolution in East Africa. PLoS One 9 (9), e107358. http://dx.doi.org/10.1371/journal.pone.0107358.
Dabkowski, J., Antoine, P., Limondin-Lozouet, N., Chaussé, C., Carbonell, P., 2010. Les microfaciès du tuf calcaire éemien (SIM 5e) de caours (Somme, France): éléments d'analyse paléoécologique du dernier interglaciaire. Quaternaire 21, 127–137.
Dabkowski, J., Royle, S.H., Antoine, P., Marca-Bell, A., Andrews, J.E., 2015. High-resolution δ18O seasonality record in a French Eemian tufa stromatolite (caours,

Somme Basin). Palaeogeogr. Palaeoclimatol. Palaeoecol. 438, 277–284. http://dx.doi.org/10.1016/j.palaeo.2015.08.017.
Dabkowski, J., Limondin-Lozouet, N., Antoine, P., Marca-Bell, A., Andrews, J., 2011. Enregistrement des variations climatiques au cours des interglaciaires d'après l'étude des isotopes stables de la calcite des tufs calcaires pleistocènes du nord de la France: exemples des séquences de Caours (SIM 5e; Somme) et de LaC elle-sur-Seine (SIM). Quaternaire 22, 275–285.
Dambricourt Malassé, A., Moigne, A.-M., Singh, M., Calligaro, T., Karir, B., Gaillard, C., Kaur, A., Bhardwaj, V., Pal, S., Abdessadok, S., Sao, C.C., Gargani, J., Tudryn, A., Sanz, M.G., 2016. Intentional cut marks on bovid from the Quranwala zone, 2.6 Ma, Siwalik frontal range, northwestern India. ComptesRendusPalevol 15, 317–339.
D'Ault du Mesnil, G., 1896. Dents de rhinocéros. Bull. Soc. d'anthropologie Paris 7, 37–48.
Davis, R.J., 2014. Concerning the earliest Acheulean occupation of Britain: the geological context of a handaxe assemblage from Foxholes, Bournemouth, southern England. Lithics 35, 33–39.
De Heinzelin, J., 1965. Observations sur les terrasses du Moyen-Euphrate. Bull. Soc. Géol. Fr. 7, 37–44.
De Heinzelin, J., 1966. Geological observations near Latamne. Ann. Archéol. Arab. Syr. 16, 115–120.
De Heinzelin, J., 1967. Supplement a: investigations on the terraces of the Middle Euphrates. In: Van Loon, M.N. (Ed.), The Tabqa Reservoir Survey 1964. Direction Général des Antiquities et des Museums, Damascus, pp. 22–26.
De Heinzelin, J., 1968. Geological observations near Latamne. Quaternaria 10, 3–8.
Delagnes, A., Crassard, R., Bertran, P., Sitzia, L., 2013. Cultural and human dynamics in southern Arabia at the end of the Middle Paleolithic. Quat. Int. 300, 234–243.
Delagnes, A., Tribolo, C., Bertran, P., Brenet, M., Crassard, R., Jaubert, J., Khalidi, L., Mercier, N., Nomade, S., Peigné, S., Sitzia, L., Tournepiche, J.F., Al-Halibi, M., Al-Mosabi, A., Macchiarelli, R., 2012. Inland human settlement in southern Arabia 55,000 years ago. New evidence from the Wadi Surdud Middle Paleolithic site complex, western Yemen. J. Hum. Evol. 63, 452–474.
de la Torre, I., 2011. The origins of stone tool technology in Africa: a historical perspective. Philos. Trans. R. Soc. B Biol. Sci. 366, 1028–1037.
de la Torre, I., Mora, R., Arroyo, A., Benito-Calvo, A., 2014. Acheulean technological behaviour in the Middle Pleistocene landscape of Mieso (East-Central Ethiopia). J. Hum. Evol. 76, 1–25.
De Lumley, H., 2009. Terra Amata, Nice, Alpes-Maritime. Des campements acheuléens datés de 400 000 à 380 000 ans. CNRS Editions.
de Terra, H., Paterson, T.T., 1939. Studies on the ice age in India and associated human cultures. Carnegie Institution of Washington, Washington (DC).
Demir, T., Westaway, R., Seyrek, A., Bridgland, D., 2007a. Terrace staircases of the River Euphrates in southeast Turkey, northern Syria and western Iraq: evidence for regional surface uplift. Quat. Sci. Rev. 26, 2844–2863.
Demir, T., Westaway, R., Bridgland, D., Pringle, M., Yurtmen, S., Beck, A., Rowbotham, G., 2007b. Ar–Ar dating of Late Cenozoic basaltic volcanism in northern Syria: implications for the history of incision by the River Euphrates and uplift of the northern Arabian Platform. Tectonics 26. http://dx.doi.org/10.1029/2006TC001959.
Demir, T., Seyrek, A., Westaway, R., Bridgland, D., Beck, A., 2008. Late Cenozoic surface uplift revealed by incision by the River Euphrates at Birecik, southeast Turkey. Quat. Int. 186, 132–163.
Demir, T., Seyrek, A., Westaway, R., Guillou, H., Scaillet, S., Beck, A., Bridgland, D.R., 2012. Late Cenozoic regional uplift and localised crustal deformation within the northern Arabian Platform in southeast Turkey: investigation of the Euphrates terrace staircase using multidisciplinary techniques. Geomorphology 165–166, 7–24.
Dennell, R.W., 1989. Report of the British archaeological Mission to Pakistan 1980–1989. Man Environ. 14, 129–131.
Dennell, R.W., 2008. The Palaeolithic Settlement of Asia. Cambridge University Press (Cambridge World Archaeology Series).
Dennell, R.W., 2013. The Nihewan Basin of north China in the Early Pleistocene: continuous and flourishing, or discontinuous, infrequent and ephemeral occupation? Quat. Int. 295, 223–236.
Dennell, R.W., 2015. Life without the Movius line: the structure of the east and southeast Asian early Palaeolithic. Quat. Int. 400, 14–22.
Desprat, S., Sánchez Gonõ, M.F., Turon, J.-L., McManus, J.F., Loutre, M.F., Duprat, J., Malaizé, B., Peyron, O., Peypouquet, J.-P., 2005. Is vegetation responsible for glacial inception during periods of muted insolation changes? Quat. Sci. Rev. 24, 1361–1374.
Despriée, J., Gageonnet, R., Voinchet, P., Bahain, J.J., Falguères, C., Duvialard, J., Varache, F., 2004. Pleistocene fluvial systems of the Creuse river (Middle Loire Basin – Centre Region, France). Quaternaire 15 (1–2), 45–56.
Despriée, J., Voinchet, P., Tissoux, H., Moncel, M.-H., Arzarello, M., Robin, S., Bahain, J.-J., Falguères, C., Courcimault, G., Dépont, J., Gageonnet, R., Marquer, L., Messager, E., Abdessadok, S., Puaud, S., 2010. Lower and Middle Pleistocene human settlements in the middle loire River basin, Centre region, France. Quat. Int. 223–224, 345–359.
Despriée, J., Voinchet, P., Tissoux, H., Bahain, J.-J., Falguères, C., Courcimault, G., Dépont, J., Moncel, M.-H., Robin, S., Arzarello, M., Sala, R., Marquer, R., Messager, E., Puaud, S., Abdessadok, S., 2011. Lower and Middle Pleistocene human settlements recorded in fluvial deposits of the middle Loire River Basin, centre region, France. Quat. Sci. Rev. Spec. Issue Hum.n Occup. Paleoarctic 30, 1474–1485.
Devès, M., Sturdy, D., Godet, N., King, G.C.P., Bailey, G.N., 2014. Hominin reactions to herbivore distribution in the lower Palaeolithic of the southern Levant. Quat. Sci. Rev. 96, 140–160.
Diez-Martín, F., Yustos, P.S., de la Rúa, D.G., González, J.A.G., de Luque, L., Barba, R., 2014a. Early acheulean technology at Es2-Lepolosi (ancient MHS-Bayasi) in Peninj (Lake Natron, Tanzania). Quat. Int. 322–323, 209–236.
Diez- Martín, F., Yustos, P.S., González, J.A.G., Luque, L., de la Rúa, D.G., Domínguez-Rodrigo, M., 2014b. Reassessment of the early acheulean at EN1-Noolchalai (ancient RHS-Mugulud) in Peninj (Lake Natron, Tanzania). Quat. Int. 322–323, 237–263.
Diez-Martín, F., Yustos, P.S., Uribelarrea, D., Baquedano, E., Mark, D.F., Mabulla, A., Fraile, C., Duque, J., Díaz, I., Pérez-González, A., Yravedra, J., Egeland, C.P., Organista, E., Domínguez-Rodrigo, M., 2015. The origin of the acheulean: the 1.7 million-year-old site of FLK west, Olduvai Gorge (Tanzania). Nature 5, 17839. http://dx.doi.org/10.1038/srep17839.
Djerrab, A., Spassov, S., Defaflia, N., Hus, J., Abdessadok, S., Ruault-Djerrab, M., Bahra, N., Ech-Chakrouni, S., 2014. The Middle Palaeolithic site of Birzgane (Tebessa, Algeria): rock magnetic property characterisation and past rainfall reconstruction. Quat. Int. 320, 63–74.
Domalain, M., Bertin, A., Daver, G., 2017. Was *Australopithecus afarensis* able to make the Lomekwian stone tools? Towards a realistic biomechanical simulation of hand force capability in fossil hominins and new insights on the role of the fifth digit. C.R. Palevol. http://dx.doi.org/10.1016/j.crpv.2016.09.003 in press.
Duller, G.A.T., Tooth, S., Barham, L., Tsukamoto, S., 2015. New investigations at Kalambo Falls, Zambia: luminescence chronology, site formation, and archaeological significance. J. Hum. Evol. 85, 111–125.
Edgell, H.S., 1989. Evolution of the Rub' al Khali desert. J. King Abdulaziz Univ. Earth Sci. 3, 109–126.
Edgell, H.S., 2006. Arabian Deserts; Nature, origin and evolution. Springer, Dordrecht.
Eissmann, L., 2002. Quaternary geology of eastern Germany (Saxony, Saxon-Anhalt, south Brandenburg, Thüringia), type area of the Elsterian and Saalian stages in Europe. Quat. Sci. Rev. 21, 1275–1346.
Eren, M.I., Durant, A.J., Prendergast, M., Audax, Z.P., Mabulla, E., 2014. Middle stone age archaeology at Olduvai Gorge, Tanzania. Quat. Int. 322–323, 292–313.
Evans, J., 1863. Account of some further discoveries of flint implements in the Drift on the Continent and in England. Archaeologia 39, 57–84.
Evans, J., 1872. The Ancient Stone Implements, Weapons and Ornaments of Great Britain. Longman, London.
Faith, J.T., Tryon, C.A., Peppe, D.J., Beverly, E.J., Blegen, N., Blumenthal, S., Chritz, K.L., Driese, S.G., Patterson, D., 2015. Paleoenvironmental context of the Middle stone age record from Karungu, Lake Victoria Basin, Kenya, and its implications for human and faunal dispersals in East Africa. J. Hum. Evol. 83, 28–45.
Faivre, J.-P., Maureille, B., Bayle, P., Crevecoeur, I., Duval, M., Grün, R., Bemilli, C., Bonilauri, S., Coutard, S., Bessou, M., 2014. Middle Pleistocene Human Remains from Tourville-la-Rivière (Normandy, France) and Their Archaeological Context. PLoS One 9, e104111.
Falguères, C., Shao, Q., Han, F., Bahain, J.J., Richard, M., Perrenoud, C., Moigne, A.M., De, H.L., 2015. New ESR and U-series dating at Caune de l'Arago, France: a key-site for European Middle Pleistocene. Quat. Geochronol. 30, 547–553.
Fauzi, M.R., Ansyori, M.M., Prastiningtyas, D., Intan, M.F.S., Wibowo, U.P., Walandari Rahmanendra, H., Widianto, H., Simanjuntak, T., 2016. Matar: a forgotten but promising Pleistocene locality in East Java. Quat. Int. 416, 183–192.
Field, J.S., Petraglia, M.D., Lahr, M.M., 2007. The southern dispersal hypothesis and the South Asian archaeological record: examination of dispersal routes through GIS analysis. J. Anthropol. Archaeol. 26, 88–108.
Fluck, H.L., McNabb, J., 2007. Raw material exploitation at the Middle Pleistocene site of Vértesszölös. Hung. Lithics 28, 50–65.
Flynn, L.J., Pilbeam, D., Barry, J.C., Morgan, M.E., Raza, S.M., 2016. Siwalik synopsis: a long stratigraphic sequence for the later Cenozoic of south Asia. ComptesRendusPalevol 15, 877–887.
Forestier, H., Sophady, H., Puaud, S., Mourer, R., Billault, L., Philippe, M., Zeitoun, V., 2014. New evidence of old stone tools from the Mekong terraces, Cambodia. C.R. Palevol 13, 109–120.
Gaillard, C., Mishra, S., Singh, M., Deo, S., Abbas, R., 2010. Lower and early Middle Pleistocene Acheuleanin the Indian sub-continent. Quat. Int. 223–224, 234–241.
Gaillard, C., Singh, M., DambricourtMalassé, A., Bhardwaj, V., Karir, B., Kaur, A., Pal, S., Moigne, A.-M., Sao, C.C., Abdessadok, S., Gargani, J., Tudryn, A., 2016. The lithic industries on the fossiliferous outcrops of the Late Pliocene Masol Formation, Siwalik Frontal Range, northwestern India (Punjab) Les industries lithiques sur les affleurementsfossilifères fin Pliocène de la formation de Masol, chaînefrontale des Siwaliks, Nord-Ouest de l'Inde (Pendjab). ComptesRendusPalevo l15, 341–357.
Gallotti, R., 2013. An older origin for the acheulean at Melka Kunture (upper Awash, Ethiopia): techno-economic behaviours at Garba IVD. J. Hum. Evol. 65, 594–620.
Gallotti, R., Raynal, J.-P., Geraads, D., Mussi, M., 2014. Garba XIII (Melka Kunture, upper Awash, Ethiopia): a new acheulean site of the late lower Pleistocene. Quat. Int. 343, 17–27.
Garrett, N.D., Fox, D.L., McNulty, K.P., Faith, J.T., Peppe, D.J., Plantinga, A.V., Tryon, C.A., 2015. Stable isotope paleoecology of late Pleistocene Middle stone age humans from the Lake Victoria basin, Kenya. J. Hum. Evol. 82, 1–14.
Geyh, M.A., Müller, H., 2005. Numerical ^{230}Th/U dating and a palynological review of the Holsteinian/Hoxnian Interglacial. Quat. Sci. Rev. 24, 1861–1872.
Geyh, M.A., Müller, H., 2006. Missing evidence for two Holstein-like Interglacials.

Reply to the comments by J.D. Scourse on: numerical ^{230}Th/U dating and a palynological review of the Holsteinian/Hoxnian Interglacial. Quat. Sci. Rev. 25, 3072–3075.
Gibbard, P.L., Boreham, S., West, R.G., Rolfe, C., 2012. Late Middle Pleistocene ice-marginal sedimentation in East Anglia. England. Boreas 41, 319–336.
Gibbard, P.L., Turner, C., West, R.G., 2013. The Bytham River reconsidered. Quat. Int. 292, 15–32.
Gibbon, R.J., Granger, D.E., Kuman, K., Partridge, T.C., 2009. Early Acheulean technology in the Rietputs Formation, South Africa, dated with cosmogenic nuclides. J. Hum. Evol. 56, 152–160.
Goder-Goldberger, M., 2013. The Khormusan: evidence for an MSA East African industry in Nubia. Quat. Int. 300, 182–194.
Goren-Inbar, N., Saragusti, I., 1996. An Acheulian biface assemblage from Gesher Benot Ya'aqov, Israel: indications of African affinities. J. Field Archaeol. 23, 15–30.
Goren-Inbar, N., Sharon, G., 2006. Invisible handaxes and visible Acheulian biface technology at Gesher Benot Ya'aqov, Israel. In: Goren-Inbar, N., Sharon, G. (Eds.), Axe Age: Acheulian Toolmaking from Quarry to Discard. Equinox, London, pp. 111–135.
Goren-Inbar, N., Feibel, C.S., Verosub, K.L., Melamed, Y., Kislev, M.E., Tchernov, E., Saragusti, I., 2000. Pleistocene milestones on the out-of-Africa corridor at Gesher Benot Ya'aqov, Israel. Science 289, 944–948.
Goren-Inbar, N., Sharon, G., Melamed, Y., Kislev, M.E., 2002. Nuts, nut cracking, and pitted stones at Gesher Benot Ya'aqov, Israel. Proc. Natl. Assoc. Sci. (USA) 99, 2455–2460.
Goren-Inbar, N., Alperson, N., Kislev, M.E., Simchoni, O., Melamed, Y., Ben-Nun, A., Werker, E., 2004. Evidence of hominin control of fire at Gesher Benot Ya'aqov, Israel. Science 304, 725–727.
Goval, E., Hérisson, D., Locht, J.-L., Coudenneau, A., 2015. Levallois points and triangular flakes during the Middle Palaeolithic in northwestern Europe: considerations on the status of these pieces in the Neanderthal hunting toolkit in northern France. Quat. Int. http://dx.doi.org/10.1016/j.quaint.2015.04.039.
Grayson, D.K., 1983. The Establishment of Human Antiquity. Academic Press, New York.
Groucutt, H.S., Petraglia, M.D., 2012. The prehistory of the Arabian peninsula: deserts, dispersals, and demography. Evol. Anthropol. Issues, News, Rev. 21, 113–125.
Groucutt, H.S., White, T.S., Clark-Balzan, L., Parton, A., Crassard, R., Shipton, C., Jennings, R.P., Parker, A.G., Breeze, P.S., Scerri, E.M., Alsharekh, A., 2015. Human occupation of the Arabian empty quarter during MIS 5: evidence from Mundafan Al-Buhayrah, Saudi Arabia. Quat. Sci. Rev. 119, 116–135.
Groucutt, H.S., Breeze, P., Drake, N.A., Jennings, R., Parton, A., White, T.S., Shipton, C., Clark-Balzan, L., Al-Omari, A., Cuthbertson, P., Wedage, O.M., Bernal, M.A., Alsharekh, A., Petraglia, M.D., 2016. The Middle Palaeolithic of the Nejd, Saudi Arabia. J. Field Archaeol.
Guan, Y., Wang, F.-G., Xie, F., Pei, S.-W., Zhou, Z.-Y., Gao, X., 2016. Flint knapping strategies at Cenjiawan, an early Paleolithic site in the Nihewan Basin, north China. Quat. Int. 400, 86–92.
Guérin, C., Faure, M., 1988. Biostratigraphie comparée des grands mammifères du Pléistocène en Europe Occidentales et au Moyen Orient. Paléorient 14, 50–56.
Guérin, C., Eisenmann, V., Faure, M., 1993. Les grands mammifères du gisement PléistocèneMoyen de Latamné (vallée de l'Oronte, Syrie). In: Sanlaville, P., Besançon, J., Copeland, L., Muhesen, S. (Eds.), Le Paléolithique de la vallée moyenne de l'Oronte (Syrie): Peuplement et environnement, vol. 587. British Archaeological Reports, International Series, pp. 169–178.
Hardaker, T., 2012. The artefacts from the present land surface at the Palaeolithic site of Warren Hill, Suffolk, England. Proc. Geol. Assoc. 123, 692–713.
Harding, P., Bridgland, D.R., Allen, P., Bradley, P., Grant, M.J., Peat, D., Schwenninger, J.-L., Scott, R., Westaway, R., White, T., 2012. Chronology of the lower and Middle Palaeolithic in NW Europe: developer-funded investigations at Dunbridge, Hampshire, southern England. Proc. Geol. Assoc. 123, 584–607.
Harmand, S., Lewis, J.E., Feibel, C.S., Lepre, C.J., Prat, S., Lenoble, A., Boe, X., Quinn, R.L., Brenet, M., Arroyo, A., Taylor, N., Clement, S., Daver, G., Brugal, J.-P., Leakey, L., Mortlock, R.A., Wright, J.D., Lokorodi, S., Kirwa, C., Kent, D.V., Roche, H., 2015. 3.3-million-year-old stone tools from Lomekwi 3, West Turkana, Kenya. Nature 521, 310–315.
Haslam, M., Clarkson, C., Petraglia, M.D., Korisettar, R., Jones, S., …, Ambrose, S.H., 2010a. The 74 ka Tobasuper-eruption and southern Indian hominins: archaeology, lithic technology and environments atJwalapuram Locality 3. J. Archaeol. Sci. 37, 3370–3384.
Haslam, M., Clarkson, C., Petraglia, M., Korisettar, R., Boivin, N., …, Mackay, A., 2010b. Indian lithic technology prior to the 74,000 BP Toba super-eruption: searching for an early modern human signature. In: Boyle, K.V., Gamble, C., Bar-Yosef, O., Barrett, J. (Eds.), The Upper Palaeolithic Revolution in Global perspective: papers in honour of Sir Paul Mellars. McDonald Institute for Archaeological Research, Cambridge, pp. 73–84.
Haslam, M., Roberts, R.G., Shipton, C., Pal, J.N., Fenwick, J.L., …, Petraglia, M.D., 2011. Late Acheulean hominins at the Marine Isotope Stage 6/5e transition in north-central India. Quat. Res. 75, 670–682.
Haslam, M., Harris, C., Clarkson, C., Pal, J.N., Shipton, C., …, Petraglia, M.D., 2012a. Dhaba: an initial report on an Acheulean, Middle Palaeolithic and microlithic locality in the middle Son Valley, north-central India. Quat. Int. 258, 191–199.
Haslam, M., Clarkson, C., Roberts, R.G., Bora, J., Korisettar, R., …, Petraglia, M.D., 2012b. A southern Indian Middle Palaeolithic occupation surface sealed by the 74 ka Toba eruption: further evidence from Jwalapuram Locality 22. Quat. Int. 258, 148–164.
Hatch, M., Davis, R.J., Lewis, S.G., Ashton, N., Briant, R.M., Lukas, S., 2017. The stratigraphy and chronology of the fluvial sediments at Warsash, UK: implications for the Palaeolithic archaeology of the River Test. Proc. Geol. Assoc. http://dx.doi.org/10.1016/j.pgeola.2016.12.001.
Herisson, D., Airvaux, J., Lenoble, A., Richter, D., Claud, E., Primault, J., 2012. Le gisement acheuléen de La Grande vallée à Colombiers (Vienne, France): stratigraphie, processus de formation, datations préliminaires et industries lithiques. PALEO 23, 1–18.
Herisson, D., Coutard, S., Goval, E., Locht, J.-L., Antoine, P., Chantreau, Y., Debenham, N., 2016. A new key-site for the end of the Lower Palaeolithic and the onset of the Middle Palaeolithic at Etricourt-Manancourt (Somme, France). Quat. Int. 409, 73–91.
Holm, D., 1960. Desert Geomorphology in the Arabian Peninsula. Science 132, 1369–1379.
Hooijer, D.A., 1961. Middle Pleistocene mammals from Latamne, Orontes Valley, Syria. Ann. Archéol. Syr. 11, 117–132.
Hours, F., 1981. Le Paléolithique inférieur de la Syrie et du Liban. Le Point de la question en 1980. In: Cauvin, J., Sanlaville, P. (Eds.), Préhistoire du Levant: Chronologie et organisation de l'espace depuis les origines jusqu'au VIe millénaire. Colloques Internationaux du Centre National de la Recherche Scientifique 598. Centre National de la Recherche Scientifique, Lyon, pp. 165–183.
Hours, F., 1994. Western Asia in the period of *Homo habilis* and *Homo erectus*. In: History of humanity: prehistory and the beginnings of civilization. UNESCO, pp. 62–77.
Jacobs, Z., Roberts, R.G., Nespoulet, R., El Hajraoui, M.A., Debénath, A., 2012. Single-grain OSL chronologies for Middle Palaeolithic deposits at El Mnasra and El Harhoura 2, Morocco: Implications for Late Pleistocene humane environment interactions along the Atlantic coast of northwest Africa. J. Hum. Evol. 62, 377–394.
Jado, R.A., Zötl, J. (Eds.), 1984. Quaternary Period in Saudi Arabia, Vol. 2. Sedimentological, Hydrogeological, Hydrochemical, Geomorphological, Geochronological and Climatological Investigations in Western Saudi Arabia. Springer-Verlag, New York.
Jennings, R.P., Singarayer, J., Stone, E.J., Krebs-Kanzow, U., Khon, V., Nisancioglu, K.H., Pfeiffer, M., Zhang, X., Parker, A., Parton, A., Groucutt, H.S., 2015a. The greening of Arabia: multiple opportunities for human occupation of the Arabian Peninsula during the Late Pleistocene inferred from an ensemble of climate model simulations. Quat. Int. 382, 181–199.
Jennings, R.P., Shipton, C., Breeze, P., Cuthbertson, P., Bernal, M.A., Wedage, W.O., Drake, N.A., White, T.S., Groucutt, H.S., Parton, A., Clark-Balzan, L., 2015b. Multi-scale Acheulean landscape survey in the Arabian Desert. Quat. Int. 382, 58–81.
Jiménez-Arenas, J.M., Santonja, M., Botella, M., Palmqvist, P., 2011. The oldest handaxes in Europe: fact or artefact? J. Archaeol. Sci. 38, 3340–3349.
Joglekar, J., Deo, S.G., 2015. Newly discovered Acheulian site at Atit on Urmodi River, Satara District, Maharashtra. Man Environ. XL 1.
Jones, S.C., 2010. Palaeoenvironmental response to the ~74 ka Toba ash-fall in the Jurreru and middle Son valleys in southern and north-central India. Quat. Res. 73, 336–350.
Jones, S.C., 2012. Local- and regional-scale impacts of the c. 74 ka Toba supervolcanic eruption on hominin populations and habitats in India. Quat. Int. 258, 100–118.
Jones, S.C., Pal, J.N., 2009. The Palaeolithic of the middle Son Valley, north-central India: Changes in hominin lithic technology and behaviour during the Upper Pleistocene. J. Anthropol. Archaeol. 28, 323–341.
Kalbe, J., Sharon, G., Porat, N., Zhang, C., Mischke, S., 2014. Geological setting and age of the Middle Paleolithic site of Nahal Mahanayeem Outlet (Upper Jordan Valley, Israel). Quat. Int. 331, 139–148.
Kalbe, J., Mischke, S., Dulski, P., Sharon, G., 2015. The Middle Palaeolithic Nahal Mahanayeem Outlet site, Israel: reconstructing the environment of Late Pleistocene wetlands in the eastern Mediterranean from ostracods. J. Archaeol. Sci. 54, 385–395.
Kong, P., Jia, J., Zheng, Y., 2013. Cosmogenic 26Al/10Be burial dating of the Paleolithic at Xihoudu, North China. J. Hum. Evol. 64, 466–470.
Kozlowski, J.K., 2003. From bifaces to leaf points. In: Soressi, M., Dibble, H.L. (Eds.), Multiple Approaches to the Study of Bifacial Technologies. University of Pennsylvania Museum of Archaeology and Anthropology, Philadelphia, pp. 149–164.
Kuhn, S.L., 2002. Paleolithic Archaeology in Turkey. Evol. Anthropol. 11, 198–210.
Kukla, G., 2003. Continental records of MIS 11. Earth's climate and orbital eccentricity: the Marine Isotope Stage 11 question. Geophys. Monogr. Ser. 137, 207–211.
Kuman, K., Li, C., Li, H., 2014. Large cutting tools in the Danjiangkou Reservoir Region, central China. J. Hum. Evol. 76, 129–153.
Lang, J., Winsemann, J., Steinmetz, D., Polom, U., Pollok, L., Böhner, U., Serangeli, J., Brandes, C., Hampel, A., Winghart, S., 2012. The Pleistocene of Schöningen, Germany: a complex tunnel valley fill revealed from 3D subsurface modelling and shear wave seismics. Quatern. Sci. Rev. 39, 86–105.
Lang, J., Böhner, U., Polom, U., Serangeli, J., Winsemann, J., 2015. The Middle Pleistocene tunnel valley at Schöningen as a Paleolithic archive. J. Hum. Evol. 89, 18–26.
Lefèvre, D., Raynal, J.P., Vernet, G., Pilleyre, Th, Piperno, M., Sanzelle, S., Fain, S., Miallier, D., Montret, M., 1994. Sedimentation, volcanisme et présence humaine dans le bassin de Venosa (Basilicata, Italie) au Pléistocène moyen: exemple du site de Notarchirico. Bull. Soc. Préhist. Fr. 91, 103–112.
Lefèvre, D., Raynal, J.P., Vernet, G., Kieffer, G., Piperno, M., 2010. Tephro-stratigraphy

and the age of ancient Southern Italian Acheulean settlements: The sites of Loreto and Notarchirico (Venosa, Basilicata, Italy). Quat. Int. 223–224, 360–368.
Lepre, C.J., Roche, H., Kent, D., Harmand, S., Quinn, R.L., Brugal, J.-P., Texier, P.-J., Lonoble, A., Feibel, C.S., 2011. An earlier origin for the Acheulian. Nature 477, 82–85.
Leroyer, M., Cliquet, D., 2010. Continuity or discontinuity of the "acheulean tradition" through the middle Pleistocene? The exemple of the Mont-Enot site at Saint-Pierre-lès-Elbeuf, Seine-Maritime, France. Spec. Issue, Hum. Expans. Eurasia 223–224, 462–464.
Le Tensorer, J.-M., Le Tensorer, H., Martini, P., von Falkenstein, V., Schmid, P., Villalain, J.J., 2015. The Oldowan site Ain al Fil (El Kowm, Syria) and the first humans of the Syrian Desert. L' anthropologie 119, 581–594.
Li, H., Kuman, K., Li, C., 2017. What is currently (un)known about the Chinese Acheulean, with implications for hypotheses on the earlier dispersal of hominids. C. R. Palevol 2016. http://dx.doi.org/10.1016/j.crpv.2015.09.008 (in press).
Li, X., Pei, S., Jia, Z., Guan, Y., Niu, D., Ao, H., 2016. Paleoenvironmental conditions at Madigou (MDG), a newly discovered Early Paleolithic site in the Nihewan Basin, North China. Quat. Int. 400, 100–110.
Limondin-Lozouet, N., Antoine, P., 2006. A new *Lyrodiscus* (Mollusca, Gastropoda) assemblage at saint-acheul (Somme Valley): reappraisal of stage 11 malacofaunas from northern France. Boreas 35, 622–633.
Limondin-Lozouet, N., Antoine, P., Bahain, J.-J., Cliquet, D., Coutard, S., Dabkowski, J., Ghaleb, B., Locht, J.-L., Nicoud, E., Voinchet, P., 2015. North-West European MIS 11 malacological successions: a framework for the timing of Acheulean settlements. J. Quat. Sci. 30, 702–712. http://dx.doi.org/10.1002/jqs.2798.
Limondin-Lozouet, N., Nicoud, E., Antoine, P., Auguste, P., Bahain, J.-J., Dabkowski, J., Dupéron, J., Dupéron, M., Falguères, C., Ghaleb, B., Jolly-Saad, M.-C., Mercier, N., 2010. Oldest evidence of Acheulean occupation in the Upper Seine valley (France) from an MIS 11 tufa at La Celle. Quat. Int. 223–224, 299–311.
Lisiecki, L.E., Raymo, M.E., 2005. A Pliocene–Pleistocene stack of 57 globally distributed benthic δ^{18}O records. Paleoceanography 20, PA1003. http://dx.doi.org/10.1029/2004PA001071.
Liu, P., Deng, C., Li, S., Zhu, R., 2010. Magnetostratigraphic dating of the Huojiadi Paleolithic site in the Nihewan Basin, North China. Palaeogeogr. Palaeoclimatol. Palaeoecol. 298, 399–408.
Locht, J.-L., Goval, E., Antoine, P., 2010. Reconstructing Middle Palaeolithic hominid behaviour during OIS 5 in northern France. In: Conard, N.J., Delagnes, A. (Eds.), Settlement Dynamics of the Middle Paleolithic and Middle Stone Age. Kerns Verlag, pp. 329–357.
Locht, J.-L., Coutard, S., Antoine, P., Sellier, N., Ducrocq, T., Paris, C., Guerlin, O., Klefer, D., Defaux, F., Limondin-Lozouet, N., Deschodt, L., 2013. Données inédites sur le Quaternaire et le Paléolithique du Nord de la France. Rev. Archéol. Picardie 3/4, 5–70.
López-Recio, M., Silva, P.G., Roquero, E., Cunha, P.P., Tapias, F., Alcaraz-Castaño, M., Baena, J., Cuartero, F., Morín, J., Torres, T., Ortiz, J.E., Murray, A.S., Buylaert, J.P., 2015. Geocrolología de los yacimientos achelenses de Pinedo y Cien Fanegas (Valle del Tajo) e implicaciones en la evolución fluvial en el entorno de Toledo (España). Estud. Geol. 71, 1–19.
López-Sáez, J.-A., Domínguez-Rodrigo, M., 2009. Palynology of OGS-6a and OGS-7, two new 2.6 Ma archaeological sites from Gona, Afar, Ethiopia: Insights on aspects of Late Pliocene habitats and the beginnings of stone-tool use. Geobios 42, 503–511.
Lycett, S.J., 2007. Why is there a lack of Mode 3 Levallois technologies in East Asia? A phylogenetic test of the Movius-Schick hypothesis. J. Anthropol. Archaeol. 26, 541–575.
Lycett, S.J., Bae, C.J., 2010. The Movius Line controversy: the state of the debate. World Archaeol. 42, 521–544.
Lycett, S.J., Gowlett, J.A.J., 2008. On questions surrounding the Acheulean 'tradition'. World Archaeol. 40, 295–315.
McCarroll, D., 2002. Amino-acid geochronology and the British Pleistocene: secure stratigraphical framework or a case of circular reasoning? J. Quat. Sci. 17, 647–651.
Mackay, A., Sumner, A., Jacobs, Z., Marwick, B., Bluff, K., Shaw, M., 2014. Putslaagte 1 (PL1), the Doring River, and the later Middle Stone Age in southern Africa's Winter Rainfall Zone. Quat. Int. 350, 43–58.
Mclaren, S.J., Al-Juaidi, F., Bateman, M.D., Millington, A.C., 2009. First evidence for episodic flooding events in the arid interior of central Saudi Arabia over the last 60 ka. J. Quat. Sci. 24, 198–207.
McNabb, J., 1989. Sticks and stones: a possible experimental solution to the question of how the Clacton spear point was made. Proc. Prehist. Soc. 55, 171–251.
Maddy, D., Demir, T., Bridgland, D., Veldkamp, A., Stemerdink, C., van der Schriek, T., Westaway, R., 2005. An obliquity-controlled Early Pleistocene river terrace record from Western Turkey? Quat. Res. 63, 339–346.
Maddy, D., Demir, T., Veldkamp, A., Bridgland, D., Stemerdink, C., van der Schriek, T., Schreve, D., 2012. The obliquity-controlled early Pleistocene terrace sequence of the Gediz River, western Turkey: a revised correlation and chronology. J. Geol. Soc. Lond. 169, 67–82.
Maddy, D., Schreve, D., Demir, T., Veldkamp, A., Wijbrans, J.R., van Gorp, W., van Hinsbergen, D.J.J., Dekkers, M.J., Scaife, R., Schoorl, J.M., Stemerdink, C., van der Schriek, T., 2015. The earliest securely-dated hominin artefact in Anatolia? Quat. Sci. Rev. 109, 68–75.
Maddy, D., Veldkamp, A., Demir, T., van Gorp, W., Wijbrans, J.R., van Hinsbergen, D.J.J., Dekkers, M.J., Schreve, D., Schoorl, J.M., Scaife, R., Stemerdink, C., van der Schriek, T., Bridgland, D.R., Aytaç, A.S., 2017. The Gediz River fluvial archive: a benchmark for Quaternary research in Western Anatolia. Quat. Sci. Rev. 166, 289–306.
Maizels, J.K., 1987. Plio-Pleistocene raised channel systems of the western Sharqiya (Wahiba), Oman. In: Frostick, L., Reid, I. (Eds.), Desert Sediments: Ancient and Modern. Geological Society, London, Special Publication No 35. Blackwell Scientific Publications, Oxford, pp. 31–50.
Maizels, J., 1990. Raised channel systems as indicators of palaeohydrologic change: a case study from Oman. Palaeogeogr. Palaeoclimatol. Palaeoecol. 76, 241–277.
Mallegni, F., Segre, A.G., Segre-Naldini, E., 1991. Découverte d'un femur acheuléen à Notarchirico (Venosa, Basilicate). Anthropologie 95, 47–88.
Mania, D., 2006. Stratigraphie, Klima- und Umweltentwicklung der letzten 400 000 Jahre im Saalegebiet und Harzvorland (Forschungsstand 2006). Hercynia N. F. 39, 155–194.
Mania, D., 2007. Das Eiszeitalter und seine Spuren im Tagebau Schöningen. In: Thieme, H. (Ed.), Die Schöninger Speere: Mensch und Jagd vor 400 000 Jahren. Theiss, Stuttgart, pp. 35–61.
Marder, O., Malinsky-Buller, A., Shahack-Gross, R., Ackermann, O., Ayalon, A., Bar-Matthews, M., Goldsmith, Y., Inbar, M., Rabinovich, R., Hovers, E., 2011. Archaeological horizons and fluvial processes at the Lower Paleolithic open-air site of Revadim (Israel). J. Hum. Evol. 60, 508–522.
Markova, A., 2007. Pleistocene chronostratigraphic subdivisions and stratigraphic boundaries in the mammal record. Quat. Int. 160, 100–111.
Marquer, L., Messager, E., Renault-Miskovsky, J., Despriee, J., Gageonnet, R., Voinchet, P., Bahain, J.-J., Falguères, C., 2011. Paléoovégétation du site à hominidés de Pont-de-Lavaud, Pléistocène inférieur, région Centre, France. Quaternaire 22, 187–200.
Martínez-Solano, I., Sanchiz, B., 2005. In: Santonja, M., Pérez-González, A. (Eds.), Anfibios y Reptiles del Pleistoceno medio de Ambrona. In Los Yacimientos Paleolíticos de Ambrona y Torralba (Soria), Un Siglo de Investigaciones Arqueológicas, vol. 5. Zona Arqueológica: Alcala de Henares, pp. 233–239.
Martins, A.A., Cunha, P.P., Huot, S., Murray, A.S., Buylaert, J.-P., 2009. Geomorphological correlation of the tectonically displaced Tejo River terraces (Gavião–Chamusca area, central Portugal) supported by luminescence dating. Quat. Int. 199, 75–91.
Martins, A.A., Cunha, P.P., Rosina, P., Osterbeek, L., Cura, S., Grimaldi, S., Gomes, J., Buylaert, J.-P., Murray, A.S., Matos, J., 2010a. Geoarchaeology of Pleistocene open-air sites in the Vila Nova da Barquinha-Santa Cita area (Lower Tejo River basin, central Portugal). Proc. Geol. Assoc. 121, 128–140.
Martins, A.A., Cunha, P.P., Buylaert, J.-P., Huot, S., Murray, A.S., Dinis, P., Stokes, M., 2010b. K-Feldspar IRSL dating of a Pleistocene river terrace staircase sequence of the Lower Tejo River (Portugal, western Iberia). Quat. Geochronol. 5, 176–180.
Martins, A.A., Cunha, P.P., Buylaert, J.-P., Murray, A.S., Raposo, L., Mozzi, P., Stokes, M., 2014. Chronology of the Vale do Forno fluvial sequence and its relevance to Lower Palaeolithic in W Iberia. In: Fluvial Archives Group 2014 Beinnial Meeting, Abstracts, p. 20.
Mein, P., Besançon, J., 1993. Micromammifères du Pléistocène Moyen de Letamné. In: Sanlaville, P., Besançon, J., Copeland, L., Muhesen, S. (Eds.), Le Paléolithique de la vallée moyenne de l'Oronte (Syrie): Peuplement et environnement, vol. 587. British Archaeological Reports, International Series, pp. 179–182.
Mellars, P., Gori, K.C., Carr, M., Soares, P.A., Richards, M.P., 2013. Genetic and archaeological perspectiveson the initial modern human colonization of southern Asia. PNAS 110, 10699–10704.
Messager, E., Lebreton, V., Marquer, L., Russo-Ermolli, E., Orain, R., Renault-Miskovsky, J., Lordkipanidze, D., Despriée, J., Peretto, C., Arzarello, M., 2011. Palaeoenvironments of early hominins in temperate and Mediterranean Eurasia: new palaeobotanical data from Palaeolithic key-sites and synchronous natural sequences. Quat. Sci. Rev. 30, 1439–1447.
Minzoni-Déroche, A., 1987. Étude de l'industrie lithique. In: Minzoni-Déroche, A. (Ed.), Le Paléolithique du Basin du Nizip: Rapport Préliminaire. Institute d'Études Anatoliennes, Istanbul, pp. 71–114.
Minzoni-Déroche, A., Sanlaville, P., 1988. Le Paléolithique Inférieur de la région de Gaziantep. Paléorient 14, 87–98.
Mischke, S., Ashkenazi, S., Almogi-Labin, A., Goren-Inbar, N., 2014. Ostracod evidence for the Acheulian environment of the ancient Hula Lake (Levant) during the early-mid Pleistocene transition. Palaeogeogr. Palaeoclimatol. Palaeoecol. 412, 148–159.
Mishra, S., Deo, S., Sangode, S., Chen, C.H., Abbas, R., Naik, S., 2005. Hominid response to the catastrophicOTT eruption at Bori and Morgaon in western India. In: Paper presented at the InternationalSymposium on Migration and Evolution of early Humans in the Old World. Bose, GuangxiZhuang Autonomous Region, China.
Mishra, S., White, M.J., Beaumont, P., Antoine, P., Bridgland, D.R., Howard, A.J., Limondin-Lozouet, N., Santisteban, J.I., Schreve, D.C., Shaw, A.D., Wenban-Smith, F.F., Westaway, R.W.C., White, T., 2007. Fluvial deposits as an archive of early human activity. Quat. Sci. Rev. 26, 2996–3016.
Mitchell, W.A., Bridgland, D.R., Innes, J.B., 2010. Late Quaternary Evolution of the Tees–Swale Interfluve East of the Pennines: The role of glaciation in the development of River systems in northern England. Proc. Geol. Assoc. 121, 410–422.
Moigne, A.-M., Valensi, P., Auguste, P., García-Solano, J., Tuffreau, A., Lamotte, A., Barroso, C., Moncel, M.-H., 2015. Bone retouchers from Lower Palaeolithic sites: Terra Amata, Orgnac 3, Cagny-l'Epinette and Cueva del Angel. Quat. Int. http://dx.doi.org/10.1016/j.quaint.2015.06.059.
Moigne, A.-M., Dambricourt Malassé, A., Singh, M., Bhardwaj, V., Gaillard, C., Kaur, S., Karir, B., Pal, S., Abdessadok, S., Chapon Sao, C., Gargani, J., Tudryn, A.,

2016. The faunal assemblage of the paleonto-archeological localities of masol formation, late pliocene quranwala zone, NW India. In: Human Origins on the Indian Sub-continent. Comptes Rendus Palevol, vol. 15, pp. 359–378.
Moncel, M.-H., Schreve, D., 2016. The Acheulean in Europe: Origins, evolution and dispersal. Quat. Int. 411, 1–8.
Moncel, M.-H., Ashton, N., Lamotte, A., Tuffreau, A., Cliquet, D., Despriée, J., 2015. The Early Acheulian of north-western Europe. J. Anthropol. Archaeol. 40, 302–331. http://dx.doi.org/10.1016/j.jaa.2015.09.005.
Moncel, M.-H., Despriée, J., Voinchet, P., Tissoux, H., Moreno, D., Bahain, J.-J., Courcimault, G., Falguères, C., 2013. Early Evidence of Acheulean Settlement in Northwestern Europe-La Noira Site, a 700 000 Year-Old Occupation in the Center of France. PlosOne One 8, e75529.
Moncel, M.-H., Moigne, A.-M., Combier, J., 2012. Towards the middle palaeolithic in western europe: the case of orgnac 3 (southeastern France). J. Hum. Evol. 63, 653–666.
Moncel, M.-H., Orliac, R., Auguste, P., Vercoutère, C., 2016a. La séquence de Moulin Quignon est-elle une séquence archéologique ? L'Anthropologie 120 (5), 369–388. Paris.
Moncel, M.-H., Despriée, J., Voinchet, P., Courcimault, G., Hardy, B., Bahain, J.-J., Puaud, S., Gallet, X., Falguères, C., 2016b. The Acheulean workshop of la Noira (France, 650 ka) in the European technological context. Special issue First European peopling Quat. Int. 393, 112–136.
Moncel, M.-H., Arzarello, M., Peretto, C., 2016c. Editorial. The holstainian eldorado. Quat. Int. 409, 1–8.
Moncel, M.-H., Arzarello, M., Boëda, E., Bonilauri, T., Chevrier, B., Gaillard, C., Forestier, H., Yinghua, L., Sémah, F., Zeitoun, V., 2017. Assemblages with bifacial tools in Eurasia (second part). What is going on in the East? Data from India, Eastern Asia and Southeast Asia. C. R. Palevol 2016. http://dx.doi.org/10.1016/j.crpv.2015.09.010 (in press).
Morigi, T., Schreve, D., White, M., Hey, G., 2011. In: Thames through Time: The Archaeology of the Gravel Terraces of the Upper and Middle Thames. The Formation and Changing Environment of the Thames Valley and Early Human Occupation to 1500 BC. Oxford Archaeology, Oxford.
Morthekai, P., Chauhan, P.R., Jain, M., Shukla, A.D., Rajapara, H.M., Singhvi, A.K., 2015. Thermally re-distributed IRSL (RD-IRSL): a new possibility of dating sediments near B/M boundary. Quat. Geochronol. 30 (Part B), 154–160.
Mosquera, M., Saladie, P., Olle, A., Cáceres, I., Huguet, R., Villalaín, J.J., Carrancho, A., Bourlès, D., Braucher, R., Vallverdú, J., 2015. Barranc de la Boella (Catalonia, Spain): an Acheulean elephant butchering site from the European late Early Pleistocene. J. Quat. Sci. 30, 651–666.
Mozzi, P., Azevedo, T., Nunes, E., Raposo, L., 2000. Middle terrace deposits of the Tagus river in Alpiarça. Portugal, in relation to early human occupation. Quat. Res. 54, 359–371.
Niang, K., Ndiaye, M., 2016. The Middle Palaeolithic of West Africa: Lithic techno-typological analyses of the site of Tiemassas, Senegal. Quat. Int. 408, 4–15.
Oestmo, S., Schoville, B.J., Wilkins, J., Marean, C.W., 2014. A Middle Stone Age Paleoscape near the Pinnacle Point caves, Vleesbaai, South Africa. Quat. Int. 350, 147–168.
Oguchi, T., Hori, K., Oguchi, C.T., 2008. Paleohydrological implications of late Quaternary fluvial deposits in and around archaeological sites in Syria. Geomorphology 101, 33–43.
Oosterbeck, L., Grimaldi, S., Rosina, P., Cura, S., Cunha, P.P., Martins, A.A., 2010. The earliest Pleistocene archaeological sites in western Iberia: present evidences and research prospects. Quat. Int. 223–224, 399–407.
Ota, S.B., Deo, S.G., 2014. Investigation of Acheulean localities TKD-I and TKD -II at Tikoda, District Raisen, Madhya Pradesh (2010–2012). In: Paddayya, K., Deo, S.G. (Eds.), Recent advances in Acheulean culture studies in India. ISPQS Monograph No. 6. Deccan College, Pune, pp. 57–66.
Padhan, T., 2014a. The Acheulian Phase in Odisha with special reference to recent research in the Jonk Basin. In: Paddayya, K., Deo, S.G. (Eds.), Recent Advances in Acheulian Culture Studies in India. ISPQS Monograph No. 6, pp. 67–84.
Padhan, T., 2014b. Stone Age archaeology of Jonk River Basin in Western Odisha and Eastern Chattisgarh. Herit. J. Multidiscip. Stud. Archaeol. 2, 405–420.
Panera, J., Rubio-Jara, S., Yravedra, J., Hugues-Alexandre, B., Sesé, C., Pérez-González, A., 2014. Manzanares Valley (Madrid, Spain): a good country for Proboscideans and Neanderthals. Quat. Int. 326–327, 329–343.
Pappu, S., 2007. Changing trends in the study of a Palaeolithic site in India: a century of research atAttirampakkam. In: Petraglia, M.D., Allchin, B. (Eds.), The evolution and history of human populationsin South Asia. Interdisciplinary Studies in Archaeology, Biological Anthropology, Linguisticsand Genetics Series. Springer, New York, pp. 121–137.
Pappu, S., Gunnell, Y., Akhilesh, K., Bracuher, R., Taieb, M., …, Thouveny, N., 2011. Early Pleistocene presence of Acheulean hominins in South India. Science 331, 1596–1599.
Parfitt, S.A., Barendregt, R.W., Breda, M., Candy, I., Collins, M.J., Coope, G.R., Durbridge, P., Field, M.H., Lee, J.R., Lister, A.M., Mutch, R., Pemkman, K.E.H., Preece, R.C., Rose, J., Stringer, C.B., Symmons, R., Whittaker, J.E., Wymer, J.J., Stuart, A.J., 2005. The earliest humans in northern Europe: artefacts from the Cromer Forest-bed formation at Pakefield, Suffolk, U.K. Nature 438, 1008–1012.
Parfitt, S.A., Ashton, N.M., Lewis, S.G., Abel, R.L., Coope, G.R., Field, M.H., Gale, R., Hoare, P.G., Larkin, N.R., Lewis, M.D., Karloukovski, V., Maher, B.A., Peglar, S.M., Preece, R.C., Whittaker, J.E., Stringer, C.B., 2010. Pleistocene human occupation at the edge of the boreal zone in northwest Europe. Nature 466, 229–233.
Parton, A., Parker, A.G., Farrant, A.R., Leng, M.J., Uerpmann, H.-P., Schwenninger, J.-L., Galleti, C., Wells, J., 2010. An early MIS3 wet phase at palaeolake Aqabah; preliminary interpretation of the multi-proxy record. Proc. Semin. Arab. Stud. 40, 267–276.
Parton, A., Farrant, A.R., Leng, M.J., Schwenninger, J.L., Rose, J.I., Uerpmann, H.P., Parker, A.G., 2013. An early MIS 3 pluvial phase in Southeast Arabia: climatic and archaeological implications. Quat. Int. 300, 62–74.
Parton, A., White, T.S., Parker, A.G., Breeze, P.S., Jennings, R., Groucutt, H.S., Petraglia, M.D., 2015a. Orbital-scale climate variability in Arabia as a potential motor for human dispersals. Quat. Int. 382, 82–97.
Parton, A., Farrant, A.R., Leng, M.J., Telfer, M.W., Groucutt, H.S., Petraglia, M.D., Parker, A.G., 2015b. Alluvial fan records from southeast Arabia reveal multiple windows for human dispersal. Geology 43, 295–298.
Patnaik, R., Chauhan, P.R., Rao, M.R., Blackwell, B.A.B., Skinner, A.R., Khan, H.S., 2009. New geochronological, palaeoclimatological and palaeolithic data from the Narmada Valley hominin locality, centralIndia. J. Hum. Evol. 56, 114–133.
Pei, S., Gao, X., Feng, X., Chen, F., Dennell, R.W., 2010. Lithic assemblage from the Jingshuiwan Paleolithic site of the early Late Pleistocene in the Three Gorges, China. Quat. Int. 211, 66–74.
Penkman, K.E.H., Preece, R.C., Keen, D.H., Maddy, D., Schreve, D.C., Collins, M.J., 2007. Testing the aminostratigraphy of fluvial archives: the evidence from intra-crystalline proteins within freshwater shells. Quat. Sci. Rev. 26, 2958–2969.
Penkman, K.E.H., Preece, R.C., Bridgland, D.R., Keen, D.H., Meijer, T., Parfitt, S.A., White, T.S., Collins, M.J., 2011. A chronological framework for the British Quaternary based on *Bithynia* opercula. Nature 476, 446–449.
Penkman, K.E.H., Preece, R.C., Bridgland, D.R., Keen, D.H., Meijer, T., Parfitt, S.A., White, T.S., Collins, M.J., 2013. An aminostratigraphy for the British Quaternary based on *Bithynia* opercula. Quat. Sci. Rev. 61, 111–134.
Pereira, A., Nomade, S., Voinchet, P., Bahain, J.J., Falguères, C., Garon, H., Lefèvre, D., Raynal, J.P., Scao, V., Piperno, M., 2015. The earliest securely dated hominin fossil in Italy and evidence of Acheulian occupation during glacial MIS 16 at Notarchirico (Venosa, Basilicata, Italy). J. Quat. Sci. 30, 639–650.
Pérez-González, A., Gallardo-Millán, J.L., Uribelarrea del Val, D., Panera, J., Rubio-Jara, S., 2013. La inversión Matuyama-Brunhes en la secuencia de terrazas del río Jarama entre Velilla de San Antonio y Altos de la Mejorada, al SE de Madrid (España). Estud. Geol. 69, 35–46.
Petraglia, M.D., Korisettar, R., Boivin, N., Clarkson, C., Ditchfield, P., …, White, K., 2007. Middle Paleolithicassemblages from the Indian subcontinent before and after the Toba super-eruption. Science 317, 114–116.
Petraglia, M.D., Alsharekh, A.M., Crassard, R., Drake, N.A., Groucutt, H., Parker, A.G., Roberts, R.G., 2011. Middle Paleolithic occupation on a marine isotope stage 5 lakeshore in the Nefud Desert, Saudi Arabia. Quat. Sci. Rev. 30, 1555–1559.
Petraglia, M.D., Ditchfield, P., Jones, S., Korisettar, R., Pal, J.N., 2012. The Toba volcanic super-eruption, environmental change, and hominin occupation history in India over the last 140,000 years. Quat. Int. 258, 119–134.
Philip, G., Abdulkarim, M., Newson, P., Beck, A., Bridgland, D., Bshesh, M., Shaw, A., Westaway, R., Wilkinson, K., 2005. Settlement and landscape development in the Homs region, Syria: report on work undertaken during 2001–2003. Levant 37, 21–42.
Ponikarov, V.P., Kazmin, V.G., Mikhailov, I.A., Razvaliayev, A.V., Krasheninnikov, V.A., Kozlov, V.V., Soulidi-Kondratiyev, E.D., Mikhailov, K.Y., Kulakov, V.A., Faradzhev, V.A., Mirzayev, K.M., 1967. The Geology of Syria, Explanatory notes on the geological map of Syria, Scale 1:500,000. Part I: Stratigraphy, Igneous rocks and Tectonics. Syrian Arab Republic, Ministry of Industry, Department of Geological and Mineral Research, Damascus.
Porat, N., Chazan, M., Schwarcz, H., Horwitz, L.K., 2002. Timing of the Lower toMiddle Paleolithic boundary: new dates from the Levant. J. Hum. Evol. 43, 107–122.
Powers, R., Ramirez, L., Redmond, C., Elberg, E., 1966. Geology of the Arabian Peninsula. Sedimentary Geology of Saudi Arabia Geology of Saudi Arabia. USGS Professional paper 560-D, Washington.
Preece, R.C., Parfitt, S.A., Bridgland, D.R., Lewis, S.G., Rowe, P.J., Atkinson, T.C., Candy, I., Debenham, N.C., Penkman, K.E.H., Rhodes, E.J., Schwenninger, J.-L., Griffiths, H.I., Whittaker, J.E., Gleed-Owen, C., 2007. Terrestrial environments during MIS 11: evidence from the Palaeolithic site at West Stow, Suffolk, UK. Quat. Sci. Rev. 26, 1236–1300.
Prestwich, J., 1860. On the occurrence of flint-implements, associated with the remains of animals of extinct species in beds of a late geological period, in France at Amiens and Abbeville, and in England at Hoxne. Philos. Trans. R. Soc. Lond. 150, 277–317.
Prestwich, J., 1864. Theoretical considerations on the conditions under which the (drift) deposits containing the remains of extinct mammalia and flint implements were accumulated, and on their geological age. Philos. Trans. R. Soc. Lond. 154, 247–309.
Proffitt, T., Luncz, L.V., Falótico, T., Ottoni, E.B., de la Torre, I., Haslam, M., 2016. Wild monkeys flake stone tools. Nature 539, 85–88.
Ramos, A., Cunha, P.P., Cunha, L., Gomes, A., Lopes, F.C., Buylaert, J.-P., Murray, A.S., 2012. The River Mondego terraces at the Figueira da Foz coastal area (western central Portugal): geomorphological and sedimentological characterization of a terrace staircase affected by differential uplift and glacio-eustasy. Geomorphology 165–166, 107–123.
Rao, K.V., Chakrabarti, S., Rao, K.J., Ramani, M.S.V., Marathe, S.D., Borkar, B.T., 1997. Magneto-stratigraphyof the Quaternary fluvial sediments and Tephra of Narmada Valley, Central India. In: Tiwari, M.P., Bhai, H.Y. (Eds.), Quaternary Geology of the Narmada Valley. Geological Survey ofIndia Special Publication No. 46, Calcutta, pp. 65–78.

Ravon, A.-L., Monnier, J.-L., Laforge, M., 2015. Menez-Dregan I, layer 4: a transitional layer between the Lower and Middle Palaeolithic in Brittany. Quat. Int. http://dx.doi.org/10.1016/j.quaint.2015.07.066.
Richter, D., Krbetschek, M., 2015. The age of the Lower Palaeolithic occupation at Schöningen. J. Hum. Evol. 89, 46–56.
Richter, D., Moser, J., Nami, M., Eiwanger, J., Mikdad, A., 2010. New chronometric data from Ifri n'Ammar (Morocco) and the chronostratigraphy of the Middle Palaeolithic in the Western Maghreb. J. Hum. Evol. 59, 672–679.
Rixhon, G., Briant, R., Cordier, S., Duval, M., Jones, A., Scholz, D., 2017. Revealing the pace of river landscape evolution during the Quaternary: recent developments in numerical dating methods. Quat. Sci. Rev. 166, 91–113.
Roberts, M.B., Parfitt, S.A., 1999. Boxgrove. A Middle Pleistocene hominid site at Eartham Quarry, Boxgrove, West Sussex. Archaeological Report 17. English Heritage, London, p. 456.
Roe, D.A., 1968a. A Gazeteer of British Lower and Middle Palaeolithic Sites. Council for British Archaeology, Research Report No 8, London.
Roe, D.A., 1968b. British Lower and Middle Palaeolithic hand axe groups. Proc. Prehist. Soc. 34, 1–82.
Roe, D.A., 1981. The Lower and Middle Palaeolithic Periods in Britain. Routledge and Kegan Paul, London.
Ronen, A., Burdukiewicz, J.M., Laukhin, S.A., Winter, Y., Tsatskin, A., Dayan, T., Kulikov, O.A., Vlasov, V.K., Semenov, V.V., 1998. The Lower Paleolithic site Bitzat Ruhama in the northern Negev. Archaeol. Korresp. 28, 163–173.
Roquero, E., Silva, P.G., Zazo, C., Goy, J.L., Masana, J., 2015a. Soil evolution indices in fluvial 896 terrace chronosequences of Central Spain (Tagus and Duero fluvial basins). Quat. Int. 376, 101–113.
Roquero, E., Silva, P.G., López Recio, M., Tapias, F., Cunha, P.P., Morín, J., Alcaraz-Castaño, M., Carrobles, J., Murray, A.S., Buylaert, J.P., 2015b. Geocronología de las terrazas de Pleistoceno Medio y Superior del valle del Tajo en Toledo (España). In: Galve, J.P., Azañon, J.M., Pérez Peña, J.V., Ruano, P. (Eds.), Una vision global del Cuaternario. El hombre como condicionante de processos geológicos. XIV Reunión Nacional de Cuaternario, Granada, pp. 8–12.
Rose, J.I., Petraglia, M.D., 2009. Tracking the origin and evolution of human populations in Arabia. In: Petraglia, M.D., Rose, J.I. (Eds.), The Evolution of Human Populations in Arabia. Springer, Dordrecht, pp. 1–12.
Rose, J.I., Usik, V.I., Marks, A.E., Hilbert, Y.H., Galletti, C.S., Parton, A., Geiling, J.M., Černý, V., Morley, M.W., Roberts, R.G., 2011. The Nubian Complex of Dhofar, Oman: An African Middle Stone Age Industry in Southern Arabia. PLoS One 6, e28239.
Rosenberg, T.M., Preusser, F., Fleitmann, D., Schwalb, A., Penkman, K., Schmid, T.W., Al-Shanti, M.A., Kadi, K., Matter, A., 2011. Humid periods in southern Arabia: windows of opportunity for modern human dispersal. Geology 39, 1115–1118.
Rosenberg, T.M., Preusser, F., Risberg, J., Plikk, A., Kadi, K.A., Matter, A., Fleitmann, D., 2013. Middle and Late Pleistocene humid periods recorded in palaeolake deposits of the Nafud desert, Saudi Arabia. Quat. Sci. Rev. vol. 70, 109–123.
Rosina, P., Voinchet, P., Bahain, J.-J., Cristováo, J., Falguéres, C., 2014. Dating the onset of Lower Tagus River terrace formation using electron spin resonance. J. Quat. Sci. vol. 29, 153–162.
Rossoni-Notter, E., Notter, O., Simone, S., Simon, P., 2015. Acheulean technical behaviors in Aldène cave (Cesseras, Hérault, France). Quat. Int. http://dx.doi.org/10.1016/j.quaint.2015.11.016.
Rubio-Jara, S., Panera, J., Rodríguez de Tembleque, J., Santonja, M., Pérez-González, A., 2016. Large flake Acheulean in the middle of Tagus basin (Spain): Middle stretch of the river Tagus valley and lower stretches of the rivers Jarama and Manzanares valleys. Quat. Int. http://dx.doi.org/10.1016/j.quaint.2015.12.023.
Ruebens, K., 2013. Regional behaviour among late Neanderthal groups in western Europe: a comparativeassessment of late Middle Palaeolithic bifacial tool variability. J. Hum. Evol. 65, 341–362.
Sangode, S.J., Mishra, S., Naik, S., Deo, S., 2007. Magnetostratigraphy of the Quaternary sediments associated with some Toba Tephra and Acheulian artefact bearing localities in the Western and Central India. Gondwana Magazine special volume 10, pp. 111–121.
Sanlaville, P., 1977. Etude géomorphologique de la region littorale du Liban, 2 vol.. Université Libanaise, Beyrouth, p. 859.
Sanlaville, P., 1979. Étude géomorphologique de la basse-vallée du Nahr el Kébir. In: Sanlaville, P. (Ed.), Quaternaire et préhistoire du Nahr el Kébir septentrional. Les débuts de l'occupation humaine dans la Syrie du nord et au Levant. Collection de la Maison de l'Orient Méditerranéan no. 9, Série Géographique et Préhistorique no. 1. CNRS, Paris, pp. 7–28.
Sanlaville, P., 2004. Les terraces Pléistocènes de la vallée de l'Euphrate en Syrie et dans l'extrême sud de la Turquie. In: Aurenche, O., Le Mière, M., Sanlaville, P. (Eds.), From the River to the Sea-the Palaeolithic and the Neolithic on the Euphrates and in the Northern Levant- Studies in Honour of Lorraine Copeland, vol. 1263. British Archaeological Reports, International Series, pp. 115–133.
Santonja, M., Pérez-González, A., 2010. Mid-Pleistocene Acheulian industrial complex in the Iberian Peninsula. Quat. Int. 223–224, 154–161.
Santonja, M., Pérez-González, A., Panera, J., Rubio-Jara, S., Méndez-Quintas, E., 2016. The coexistence of Acheulean and Ancient Middle Palaeolithic technocomplexes in the Middle Pleistocene of the Iberian Peninsula. Quat. Int http://dx.doi.org/10.1016/j.quaint.2015.04.056. Published online in 2015.
Scerri, E.M., Breeze, P.S., Parton, A., Groucutt, H.S., White, T.S., Stimpson, C., Clark-Balzan, L., Jennings, R., Alsharekh, A., Petraglia, M.D., 2015. Middle to Late Pleistocene human habitation in the western Nefud desert, Saudi Arabia. Quat. Int. 382, 200–214.
Scerri, E.M.L., Blinkhorn, J., Groucutt, H.S., Niang, K., 2016. The Middle Stone archaeology of the Senegal River Valley. Quat. Int. 408, 16–32.
Schick, K.D., 1994. The Movius Line reconsidered: Perspectives on the earlier Paleolithic of eastern Asia. In: Corruccini, R.S., Ciochon, R.L. (Eds.), Integrative Paths to the Past: Palaeoanthropological Advances in Honor of F. Clark Howell. Paramount Communications, New Jersey, pp. 569–596.
Schreve, D.C., 2001. Differentiation of the British late Middle Pleistocene interglacials: the evidence from mammalian biostratigraphy. Quat. Sci. Rev. 20, 1693–1705.
Schreve, D.C., 2012. The Reinsdorf Interglacial (Schöningen II) mammalian assemblage in its European context. In: Behre, K.-E. (Ed.), Die chronologische Einordnung der paläolithischen Fundstellen von Schöningen. The chronological setting of the Palaeolithic sites of Schöningen. Forschungen zur Urgeschichte im Tagebau von Schöningen 1. RGZM, Mainz, pp. 129–142.
Schreve, D.C., Bridgland, D.R., Allen, P., Blackford, J.J., Gleed-Owen, C.P., Griffiths, H.I., Keen, D.H., White, M.J., 2002. Sedimentology, palaeontology and archaeology of late Middle Pleistocene River Thames terrace deposits at Purfleet, Essex, UK. Quat. Sci. Rev. 21, 1423–1464.
Schreve, D.C., Moncel, M.-H., Bridgland, D.R., 2015. Editorial: Chronology, palaeoenvironments and subsistence in the Acheulean of western Europe. J. Quat. Sci. 30, 585–592.
Schrøder, N., Jensen, G.M., Limborg, M., 2012. Groundwater spring deposits as proxy for interstadials in the Levant: the chronology and climate history of the Palaeolithic cultures from Yabroud (Syria). Quat. Int. 257, 27–33.
Scott, G.R., Gibert, L., 2009. The oldest hand-axes in Europe. Nature 461, 82–85.
Scourse, J., 2006. Comment on: Numerical ^{230}Th/U dating and a palynological review of the Holsteinian/Hoxnian Interglacial by Geyh and Müller. Quat. Sci. Rev. 25, 3070–3071.
Serangeli, J., van Kolfschoten, T., Starkovich, B.M., Verheijen, I., 2015. The European Saber-toothed cat (*Homotherium latidens*) found in the "Spear Horizon" at Schöningen (Germany). J. Hum. Evol. 89, 172–180.
Shackleton, N.J., Opdyke, N.D., 1973. Oxygen isotope and palaeomagnetic stratigraphy of equatorial Pacific core V28-238: oxygen isotope temperatures and ice volume on a 10^5 and 10^6 year scale. Quat. Res. 3, 39–55.
Sharon, G., Oron, M., 2014. A lithic tool arsenal of Mousterian hunters. Quat. Int. 331, 167–185.
Shaw, A.D., 2012. The Earlier Palaeolithic of Syria. Reinvestigating the evidence from the Orontes and Euphrates valleys. Br. Archaeol. Rep. Int. Ser. 2341.
Shipton, C., Parton, A., Breeze, P., Jennings, R., Groucutt, H.S., White, T.S., Drake, N., Crassard, R., Alsharekh, A., Petraglia, M.D., 2014. Large Flake Acheulean in the Nefud Desert of Northern Arabia. PaleoAnthropology 2014, 446–462.
Sierralta, M., Frechen, M., Urban, B., 2012. ^{230}Th/U dating results from opencast mine Sch€oningen. In: Behre, K.-E. (Ed.), Die chronologische Einordnung der paläolithischen Fundstellen von Schöningen. The chronological setting of the Palaeolithic sites of Sch€oningen. Forschungen zur Urgeschichte im Tagebau von Schöningen 1. RGZM, Mainz, pp. 143–154.
Sitzia, L., Bertran, P., Boulogne, S., Brenet, M., Crassard, R., Delagnes, A., Frouin, M., Hatté, C., Jaubert, J., Khalidi, L., Messager, E., Mercier, N., Meunier, A., Peigné, S., Queffelec, A., Tribolo, C., Macchiarelli, R., 2012. The Paleoenvironment and Lithic Taphonomy of Shi'Bat Dihya 1, a Middle Paleolithic Site in Wadi Surdud, Yemen. Geoarchaeology 27, 471–491.
Sohbati, R., Murray, A., Buylaert, J.-P., Almeida, N., Cunha, P.P., 2012. Optically stimulated luminescence (OSL) dating of quartzite cobbles from the Tapada do Montinho archaeological site (east-central Portugal). Boreas 41, 452–462.
Soni, V.S., Soni, A.S., 2010. Large size cleaver-like flakes and Hoabinhoidal elements from terminal Pleistocene to mid-Holocene epoch sites. Quat. Int. 223–224, 242–244.
Sreedhar, A.K., Balakrishnan, S., Pappu, S., Kumar, A., 2008. Clay mineralogical studies of sediments and strontium isotope analyses on calcretes at the prehistoric site of Attirampakkam, Tamil Nadu. Curr. Sci. 94, 779–786.
Stahlschmidt, M.C., Miller, C.E., Ligouis, B., Goldberg, P., Berna, F., Urban, B., Conard, N.J., 2015. The depositional environments of Schöningen 13 II-4 and their archaeological implications. J. Hum. Evol. 89, 71–91.
Stewart, K.M., 2014. Environmental change and hominin exploitation of C4-based resources in wetland/savanna mosaics. J. Hum. Evol. 77, 1–16.
Stokes, M., Cunha, P.P., Martins, A.A., 2012. Techniques for analysing Late Cenozoic river terrace sequences. Geomorphology vols. 165–166, 1–6.
Thieme, H., 1997. Lower Palaeolithic hunting spears from Germany. Nature 385, 807–810.
Thompson, J.C., Mackay, A., Wright, D.K., Welling, M., Greaves, A., Gomani-Chindebvu, E., Simengwa, D., 2012. Renewed investigations into the Middle Stone Age of northern Malawi. Quat. Int. 270, 129–139.
Tiwari, M.P., Bhai, H.Y., 1997. Quaternary stratigraphy of the Narmada Valley, 46. Geological Survey of India Special Publication, pp. 33–63.
Tribolo, C., Rasse, M., Soriano, S., Huysecom, E., 2015. Defining a chronological framework for the Middle Stone Age in West Africa: Comparison of methods and models for OSL ages at Ounjougou (Mali). Quat. Geochronol. 29 (2015), 80–96.
Tryon, C.A., 2006. Early Middle Stone Age Lithic Technology of the Kapthurin Formation (Kenya). Curr. Anthropol. 47, 367–375.
Tryon, C.A., McBrearty, S., Texier, P.-J., 2006. Levallois lithic technology from the Kapthurin Formation, Kenya: Acheulean origin and Middle Stone Age Diversity. Afr. Archaeol. Rev. 22, 199–229.
Tryon, C.A., Roach, N.T., Logan, A.V.M., 2008. The Middle Stone Age of the northern Kenyan Rift: age and context of new archaeological sites from the Kapedo Tuffs.

J. Hum. Evol. 55, 652–664.
Tryon, C.A., Faith, J.T., Peppe, D.J., Fox, D.L., McNulty, K.P., Jenkins, K., Dunsworth, H., Harcourt-Smith, W., 2010. The Pleistocene archaeology and environments of the Wasiriya Beds, Rusinga Island, Kenya. J. Hum. Evol. 59, 657–671.
Tyrácek, J., Fejfar, O., Fridrich, J., Kovanda, J., Smolíková, L., Sýkorová, J., 2001. Racineves—a new Middle Pleistocene interglacial in the Czech Republic. Bull. Czech Geol. Surv. 76, 127–139.
Tyrácek, J., Westaway, R., Bridgland, D.R., 2004. River terraces of the Vltava and Labe (Elbe) system, Czech Republic, and their implications for the uplift history of the Bohemian Massif. Proc. Geol. Assoc. 115, 101–124.
Urban, B., Bigga, G., 2015. Environmental reconstruction and biostratigraphy of Upper Middle Pleistocene lakeshore deposits at Sch€oningen. J. Hum. Evol. 89, 57–70.
Vaks, A., Bar-Matthews, M., Ayalon, A., Matthews, A., Halicz, L., Frumkin, A., 2007. Desert speleothems reveal climatic window for African exodus of early modern humans. Geology 35, 831–834.
Vallin, L., 1991. Un site de boucherie probable dans le Pléistocène moyen de Tourville-la-Rivière (Seine-Maritime). In: Actes du Symposium 11–17 November 1986. Clermont-Ferrand.
Vallverdú, J., Saladié, P., Rosas, A., Huguet, R., Cáceres, I., Mosquera, M., Garcia-Tabernero, A., Estalrrich, A., Lozano-Fernández, I., Pineda-Alcalá, A., Carrancho, A., Villalaín, J.J., Bourlès, D., Braucher, R., Lebatard, A., Vilalta, J., Esteban-Nadal, M., Lluc Bennàsar, M., Bastir, M., López-Polín, L., Ollé, A., Vergés, J.M., Ros-Montoya, S., Martínez-Navarro, B., García, A., Martinell, J., Expósito, I., Burjachs, F., Agustí, J., Carbonell, E., 2014. Age and date for early arrival of the Acheulian in Europe (Barranc de la Boella, la Canonja, Spain). PLoS One 9, e103634.
Van Kolfschoten, T., Buhrs, E., Verheijen, I., 2015. The larger mammal fauna from the Lower Paleolithic Schöningen Spear site and its contribution to hominin subsistence. J. Hum. Evol. 89, 138–153.
Van Liere, W.J., 1961. Observations on the Quaternary of Syria. Berichten van de Rijksdienst voor het Oudheidkundig Bodemondezoek, vol. 5, pp. 7–69.
Van Liere, W.J., 1966. The Pleistocene and Stone Age of the Orontes River (Syria). Ann. Archéol. Arab. Syr. 16, 7–30.
Van Liere, W.J., Hooijer, D.A., 1961. A paleo-Orontes level with *Archidiskodon meridionalis* (Nesti) at Hama. Ann. Archéol. Syr. 11, 165–172.
Vialet, A., Favin Lévêque, J.-C., Lebon, M., Zazzo, A., Vercoutère, C., Froment, A., Charlier, P., 2016. Nouvel examen des ossements humains de Moulin-Quignon (Somme, France). Étude anthropologique, taphonomique et première datation par le radiocarbone. L'Anthropologie 120, 389–427.
Viallet, C., 2015. Bifaces used for percussion? Experimental approach to percussion marks and functional analysis of the bifaces from Terra Amata (Nice, France). Quat. Int. http://dx.doi.org/10.1016/j.quaint.2015.08.068.
Voinchet, P., Despriée, J., Tissoux, H., Falguères, C., Bahain, J.-J., Gageonnet, R., Dépont, J., Dolob, J.-M., 2010. ESR chronology of alluvial deposits and first human settlements of the Middle Loire Basin (Region Centre, France). Quat. Geochronol. 5, 381–384.
Voinchet, P., Moreno, D., Bahain, J.-J., Tissoux, H., Tombret, O., Falguères, C., Moncel, M.-H., Schreve, D., Candy, I., Antoine, P., Ashton, N., Beamish, M., Cliquet, D., Despriée, J., Lewis, S., Limondin-Lozouet, N., Locht, J.-L., Parfitt, S., Pope, M., 2015. New chronological data (ESR and ESR/U-series) for the earliest Acheulian sites of north-western Europe. J. Quat. Sci. 30, 610–622.
von Koenigswald, W., Fejfar, O., Tchernov, E., 1992. Revision einiger alt- und mittelpleistozaner arvicoliden (Rodentia, Mammalia) aus dem östlichen Mittelmeergebiet ('Ubeidiya, Jerusalem und Kalymnos–Xi). Neues Jahrb. Geol. Paläontologie, Abh. 184, 1–23.
Wenban-Smith, F.F., 1995. The Ebbsfleet Valley, Northfleet (Baker's Hole). In: Bridgland, D.R., Allen, P., Haggart, B.A. (Eds.), The Quaternary of the Lower Reaches of the Thames. Field Guide. Quaternary Research Association, Durham, pp. 147–164.
Warrier, A.K., Sandeep, K., Harshavardhana, B.G., Shankar, R., Pappu, S., Akhilesh, K., Prabhu, C.N., Gunnell, Y., 2011. A rock magnetic record of Pleistocene rainfall variations at the palaeolithic site of Attirampakkam, Southeastern India. J. Archaeol. Sci. 38, 3681–3693.
Wenban-Smith, F.F., 2014. Baker's Hole, Ebbsfleet (TL 615742) Areas B and F: Burchell's Ebbsfleet Channel site (TQ 561240) & Temperate Bed (TQ 174050). In: Bridgland, D.R., Allen, P., White, T.S. (Eds.), The Quaternary of the Lower Thames and eastern Essex. Field Guide. Quaternary Research Association, London, pp. 189–198.
Wenban-Smith, F.F., Allen, P., Bates, M.R., Parfitt, S.A., Preece, R.C., Stewart, J.R., Turner, C., Whittaker, J.E., 2006. The Clactonian elephant butchery site at Southfleet Road, Ebbsfleet, UK. J. Quat. Sci. 21, 471–483.
Westaway, R., 2002. The Quaternary evolution of the Gulf of Corinth, central Greece: coupling between surface processes and flow in the lower continental crust. Tectonophysics 348, 269–318.
Westaway, R., Maddy, D., Bridgland, D., 2002. Flow in the lower continental crust as a mechanism for the Quaternary uplift of south-east England: constraints from the Thames terrace record. Quat. Sci. Rev. 21, 559–603.
Westaway, R., Bridgland, D., White, M.J., 2006. The Quaternary uplift history of central southern England: evidence from the terraces of the Solent River system and nearby raised beaches. Quat. Sci. Rev. 21, 2212–2250.
Westaway, R., Bridgland, D.R., Sinha, R., Demir, T., 2009. Fluvial sequences as evidence for landscape and climatic evolution in the Late Cenozoic: a synthesis of data from IGCP 518. Glob. Planet. Change 68, 237–253.
White, M.J., 1998. On the significance of Acheulean biface variability in Southern Britain. Proc. Prehist. Soc. 64, 15–44.
White, M.J., 2015. Dancing to the Rhythms of the Biotidal Zone': Settlement History and Culture History in Middle Pleistocene Britain. In: Coward, F., Hosfield, R., Pope, M., Wenban-Smith, F. (Eds.), Settlement, Society and Cognition in Human Evolution: Landscapes in the Mind. Cambridge University Press, Cambridge, pp. 154–173.
White, M.J., Ashton, N.M., 2003. Lower Palaeolithic core technology and the origins of the Levallois method in North-Western Europe. Curr. Anthropol. 44, 598–609.
White, M.J., Schreve, D.C., 2000. Island Britain - Peninsular Britain: Palaeogeography, colonisation and the Earlier Palaeolithic settlement of the British Isles. Proc. Prehist. Soc. 66, 1–28.
White, M.J., Ashton, N., Scott, B., 2011. The Emergence, Diversity and Significance of Mode 3 (Prepared Core) Technologies. In: Ashton, N.M., Lewis, S.G., Stringer, C.B. (Eds.), The Ancient Human Occupation of Britain. Elsevier, Amsterdam, pp. 53–63.
White, M.J., Bridgland, D.R., Schreve, D.C., White, T.S., Penkman, K.E.H., 2017a. Well-dated fluvial sequences as templates for patterns of handaxe distribution: understanding the record of Acheulean activity in the Thames and its correlatives. Quat. Int. (in press).
White, T.S., White, M.J., Bridgland, D.R., Howard, A.J., 2009. Palaeolithic and Quaternary research in the Trent Valley (UK): contributions by early collectors. Proc. Geol. Assoc. 120, 223–232.
White, T.S., Preece, R.C., Whittaker, J.E., 2013. Molluscan and ostracod successions from Dierden's Pit, Swanscombe: insights into the fluvial history, sea-level record and human occupation of the Hoxnian Thames. Quat. Sci. Rev. 70, 73–90.
White, T.S., Bridgland, D.R., Limondin-Lozouet, N., Schreve, D.C., 2017b. Fossils from Quaternary fluvial archives: sources of biostratigraphical, biogeographical and palaeoclimatic evidence. Quat. Sci. Rev. 166, 150–176.
Williams, M.A.J., 2012a. The ~73 ka Toba super-eruption and its impact: history of a debate. Quat. Int. 258, 19–29.
Williams, M.A.J., 2012b. Did the 73 ka Toba super-eruption have an enduring effect? Insights from genetics, prehistoric archaeology, pollen analysis, stable isotope geochemistry, geomorphology, icecores, and climate models. Quat. Int. 269, 87–93.
Wymer, J., 1968. Lower Palaeolithic archaeology in Britain, ss represented by the Thames Valley. John Baker, London.
Wymer, J., 1985. Palaeolithic Sites of East Anglia. Geo Books, Norwich, p. 440.
Wymer, J.J., 1999. The Lower Palaeolithic Occupation of Britain. Wessex Archaeology and English Heritage, Salisbury.
Zeuner, F.E., 1945. The Pleistocene Period: Its Climate, Chronology and Faunal Succession. Ray Society Publication No. 130, London.
Zeuner, F.E., 1959. The Pleistocene Period: Its Climate, Chronology and Faunal Succession, second ed. Hutchinson,, London.
Zhang, P., Huang, W., Wang, W., 2010. Acheulean handaxes from Fengshudao, Bose sites of South China. Quat. Int. 223–224, 440–443.