Assemblages with bifacial tools in Eurasia (third part). Considerations on the bifacial phenomenon throughout Eurasia

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C. R. Palevol xxx (2016) xxx–xxx

Contents lists available at ScienceDirect

Comptes Rendus Palevol

www.sciencedirect.com

Human Palaeontology and Prehistory

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Assemblages d'outils bifaciaux en Eurasie (troisième partie). Considérations sur le phénomène bifacial à travers l'Eurasie

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ARTICLE INFO

Article history:
Received 1st June 2015
Accepted after revision 6 March 2016
Available online xxx

Handled by Amélie Vialet

Keywords:
Bifacial tools
Eurasia
Hominins
Origins
Diffusion

ABSTRACT

Eurasian bifacial series present some common features, but are chiefly characterized by wide-ranging diversity in terms of bifacial technology and blank types, whereas the heavy-duty component presents a limited number of types or categories. Heavy-duty tools are present throughout the geographical areas but the frequency of handaxes and/or cleavers is generally low, except in some regions, where they are made on flakes and/or cobbles/pebbles, on siliceous stones or other rock types. So far, it appears to be generally accepted that bifacial technology became widespread from 800 to 700 ka onwards, both for Europe and Asia, except for some earlier occurrences in the Levant and India. It would thus be reasonable to infer that bifacial technology first reached the Levant from Africa before moving toward Asia, then Europe. However, the existing data point to a much more complex reality, suggesting contemporaneous technological worlds, with or without links between them. In the state of current knowledge, and based on the methodology used for analysing lithic series, it is impossible to clearly argue in favour of either a unique phenomenon with movements of hominins or/and ideas from an African source, or to point to evidence of several onsets of bifacial technology over time on a local substratum. The palaeoanthropological background shows the difficulties involved in characterizing the few available hominin fossils and clearly relating them to bifacial technology. The current context suggests that each area should be analysed independently. Accumulative technological processes in some areas due to successive arrivals and the influence of the local substratum, and local onsets

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http://dx.doi.org/10.1016/j.crpv.2015.11.007

must be considered, as these contribute to the diversity of the strategies encountered and the varied forms of bifacial technology.

Mots clés :
Outils bifaciaux
Eurasie
Homininés
Origines
Diffusion

R É S U M É

Selon les zones géographiques et selon les séries comparées, l'Eurasie livre des séries bifaciales qui partagent des traits communs, mais, dans le temps et dans l'espace, c'est la diversité qui les caractérise. Les outils bifaciaux sont toujours présents, mais avec des fréquences réduites. Ils sont façonnés selon des stratégies variées, sur des supports et des matériaux eux-mêmes variés. Les données récentes attestent qu'ils se généralisent à partir de 800 à 700 ka à la fois en Europe et en Asie, excepté quelques témoignages plus anciens au Levant et en Inde. Il serait facile d'admettre que la technologie bifaciale a tout d'abord atteint le Levant avant l'Asie orientale et l'Europe. La réalité est plus complexe, suggérant des mondes technologiques contemporains étant ou non en relation. Les données dont nous disposons ne permettent pas à l'heure actuelle de concevoir un unique phénomène ayant abouti à la diffusion d'un Acheuléen est-africain par des mouvements de populations ou d'idées. Selon les méthodologies employées, des preuves d'émergence locale ne sont pas toujours claires selon les zones géographiques, par manque de données ou de datations. Les données paléoanthropologiques confirment la difficulté de relier des hommes aux outils bifaciaux et à les nommer. La réalité est que chaque secteur doit être étudié indépendamment, certains livrant des « outils bifaciaux », d'autres des « bifaces ». Des transformations locales ou bien issues de l'influence de nouvelles idées ou de groupes humains différents sont autant de possibilités et scénarios pour expliquer la diversité des stratégies rencontrées, démontrant la plasticité de la technologie bifaciale.

1. Introduction

The bifacial phenomenon affected vast Eurasian areas at different times. Historically, most of the series with bifacial tools were assimilated to the Acheulean, which was initially defined at the end of the 19th century in the Somme Valley, in northern France. Gabriel de Mortillet, in 1872, and later Vayson de Pradennes in the 1920s, first described the biface, which was considered for a long time as the "fossile directeur" of this technological tradition. However, the heavy-duty component is relatively diversified, and also includes cleavers and other large massive tools (for instance "rabots"). Recent studies over the past decade in East Africa indicate that the Early Acheulean is characterized by the ability to produce large flakes, some of which are subsequently used for shaping these large tools, but also by multiple new behaviours as regards subsistence strategies and raw material procurement. Many analyses point to the necessity of using the term "Acheuleans", rather than "Acheulean" to describe the different series and indicate that the sole presence of bifaces or Large Cutting Tools (LCTs, cf Kleindienst, 1961) is insufficient for defining a lithic assemblage.

Discoveries over the past decades in different Eurasian areas indicate that bifacial technology extends from 1.5 Ma to 40 ka and covers major parts of Eurasia. European Acheuleans *s.s.*, "Moustérien de type acheuléen" or the Central European Micoquian are no longer the only traditions with bifacial tools. They are contemporaneous with many other "traditions" involving bifacial technology, particularly in eastern Asia. In this final paper, our goal is to try to unravel the origins and expansion of bifacial industries in Eurasia.

2. The palaeoanthropological background: human remains *v.* bifacial tools

Palaeoanthropology relies on prehistoric archaeology to mitigate the lack of available anatomical data and reconstruct the dynamics of human populations. As for prehistory, it questions the specificity of the biological entities that crafted lithic industries throughout time. The discourse proposing a linear model of prehistoric technology, encompassing the notions of modes 1, 2, 3, and 4, is too simplistic.

In palaeoanthropology, we consider that phylogenetic patterns are established according to rules of cladistics. This school of thought is based on genealogy and the observed resemblances are considered to result from three phenomena: shared primitive characters, those representing shared derived characters and those resulting from homoplasy (reversions and convergences). Unlike the classic evolutionary systematic approach and phenetics, only derived characters are used to establish phylogenetic patterns in cladistics.

It is important to explicitly define the influence of the history of science on the names of the various taxa. Historically, the first discoveries are not necessarily the most characteristic specimens of each species and in addition, interpretations generally evolve over time, with the discovery of more complete fossils and methodological developments. Although the International Code of Zoological Nomenclature allows for such changes, the palaeoanthropological community currently does not respect this code (Zeitoun, 2015).

For the period of interest, from 1.5 Ma to around 100 ka in Asia, but focused on around 700–350 ka in Europe due to the large amount of data, considering the uncertainty surrounding the geological ages of the human fossils, it is not easy to establish a precise and consensual list of specimens to be taken into consideration. Moreover, it is important to recognize that, from a taxonomic point of view, this chronological interval historically corresponds to a "lumber room", *i.e. H. erectus sensu lato*, where certain specimens were considered as archaic *H. sapiens*, and affiliated to *H. heidelbergensis*, and subsequently to *H. antecessor* in Europe. Finally, this period also raises questions about the continuity between *H. erectus sensu stricto* and *H. sapiens* in China and the existence of *H. soloensis* in Indonesia (Zeitoun et al., 2010).

From a general point of view, it is difficult to attribute an industry to a particular taxon. In terms of potential and synchronicity, it is generally possible to associate a taxon with an industry in a geographical area during a given period, but when we look more closely, the human fossils considered here are only very rarely associated with stone tools. As we will see below, in some cases, industries with bifacial pieces occur in layers underlying and overlying layers bearing human remains, but the lithic industry is different in the human fossil-bearing layer (Table 1).

2.1. The European human background

Following the classic evolutionary systematic approach, Bermudez de Castro et al., 1997 *defined H. antecessor* on the basis of bone fragments discovered at locality TD6, Gran Dolina at Atapuerca, in Spain, and considered it to be "*the last common ancestor for Neandertals and modern humans*". More recently, an older (1.2 Ma) fragment of mandible found at Sima del Elefante, also at Atapuerca, was likewise attributed to this taxon by Carbonell et al. (2008). It should be noted that logically, the last common ancestors of *H. sapiens sapiens* and *H. sapiens neanderthalensis* are *H. sapiens*, if taxa must be monophyletic. Thus following Bermudez de Castro et al., 1997, *H. antecessor* should be equivalent to *H. sapiens*.

H. heidelbergensis was initially described on the basis of a robust mandible discovered in 1907 at Mauer in Germany (Schoetensack, 1908). This specimen was dated to 700 ka (Wagner et al., 2010), but no derived character had initially been described for this taxon. Following Rosas and Bermudez de Castro (1998), a recent anatomical study (Mounier et al., 2009) precisely diagnoses *H. heidelbergensis* using a list of mostly primitive characters and three Neandertal derived traits, leading to the same conclusion as Bermudez de Castro et al. (1997): "The species *H. heidelbergensis* is thus only acceptable in a restricted sense as a European chronospecies directly ancestor to Neandertals". Due to the lack of autapomorphy for *H. heidelbergensis*, *H. heidelbergensis* can logically be put into synonymy with *H. sapiens neanderthalensis*.

Due to the affinity of the Mauer specimen with the AT-888 mandible and the SH5 skull (Mounier et al., 2009; Rosas and Bermudez de Castro, 1998), the abundant remains from Sima de Los Huesos at Atapuerca were attributed to *H. heidelbergensis*. Consequently, due to their initial description (Arsuaga et al., 1997, 2014; Bischoff et al., 1997, 2003, 2007; Parès et al., 2000) and in agreement with the dental data (Martinón-Torres et al., 2012, 2016), the specimens of Atapuerca have to be placed in the Neandertal lineage.

The fossils from Arago at Tautavel, southern France, only present rather variable Neandertal derived characters depending on the specimens (in particular the face of Arago 21 or the mandible of Arago 2) (Falguères et al., 2004, 2015; Lumley, 1976, 2015; Moigne et al., 2006). Lumley et al. (1984) attributed them to the same taxon as the Sima de Los Huesos fossils, leading Guipert et al. (2014) to consider them as *H. heidelbergensis*. Lumley (2015) attributes Arago 21 to *H. erectus tautavelensis* considered to be different from Mauer. The fossils from Sima de los Huesos and Arago are clearly associated with bifacial pieces.

In Italy, the case of the Ceprano calvarium illustrates the effects of chronological sliding on taxonomy, with an initial date of around one million years (Ascenzi et al., 1996, 2000; Clarke, 2000) and a subsequent one at 353 ± 4 ka (Nomade et al., 2011). Initially considered as a late *H. erectus* (Ascenzi et al., 1996), Manzi et al. (2001, 2010, 2011) placed it between what they call *H. erectus/ergaster* and *H. heidelbergensis* (*H. rhodesiensis*), but considering the chronology and geography of the fossil, they attribute it to *H. antecessor* (Brunner and Manzi, 2005). This originality prompted Mallegni et al. (2003) to make it the type specimen for *H. cepranensis*. Subsequent phenetical analyses showed once again the overall resemblance of this fossil to *H. heidelbergensis* (Manzi, 2004; Mounier et al., 2011), in the sense that it presents a stock of similar primitive characters with a tendency towards "neandertalisation", but does not possess Neandertal or anatomically modern human autapomorphies. The stratigraphic position of these fossils does not seem to bind them directly to bifacial lithic artefacts.

At Castel di Guido, human remains are associated with Acheulean material (Mariani-Constantini et al., 2001). The human material from surface sampling and from excavations seems to be stratigraphically consistent (Mariani-Constantini et al., 2001; Michel et al., 2001). Several archaic features inherited from *H. erectus* distinguish these bones from those of Neandertals, but others link them to anatomically modern humans (Mallegni et al., 1983). In addition, the CdG5 parietal fragment fits onto the CdG6 temporal (Mallegni and Radmilli, 1988), which presents Neandertal derived traits according to Elyaqtine (1995).

Fontana Ranuccio yielded a first lower incisor of *Homo* sp. indet. and a dental root of uncertain attribution (around 450 ka?) (Muttoni et al., 2009; Segre and Ascenzi, 1984), as well as two additional molars with Neandertal characters according to Ascenzi and Segre (1996). However, the strict association of bifacial pieces, fauna and the human remains transported by fluvial deposits, cannot be taken for granted.

For the site of Pofi, the only available anthropological information concerns the tibia Pofi 2, found at Cava Pompi,

Table 1
Eurasian Human remains in their chronological and archaeological context.
Tableau 1
Restes humains eurasiens dans leur contexte chronologique et archéologique.

Site	Human remains	Taxonomical references	Dating	Dating references	Association with stone artefacts	Bifacial pieces
Sima de Los Huesos (Spain)			> 320 ka	Bischoff et al., 1997	**Strict association**	**Yes**
Homo heidelbergensis	Skull		> 200 ka	Parès et al., 2000		Isolated piece
Neandertal lineage	Mandible	Arsuaga et al., 1997	400 to 500 ka	Bischoff et al., 2003		
	Postcranial remains	Martinon-Torres et al., 2016	600 ka	Bischoff et al., 2007		
Arago (France)			450 ka	Yokoyama and Nguyen 1981	**Strict association**	**Yes**
	Skull	Guipert et al., 2014	450 ka	De Lumley et al., 1984		
Homo heidelbergensis	Mandible		450 ka	Moigne et al., 2006		
Neandertal lineage	Postcranial		> 350 ka	Falguères et al., 2004		
Ceprano (Italy)					No association	Yes
Late Homo erectus	Skull	Ascenzi et al., 1996, Clarke, 2000	1 Ma	Ascenzi et al., 1996, 2000		
between Homo erectus, ergaster and Homo heidelbergnsis		Manzi et al 2001	> 700 ka	Ascenzi and Segre, 1997		
Homo cepranensis		Mallegni et al., 2003	450+50–100	Muttoni et al., 2009		
Homo heidelbergensis		Manzi, 2004	430 to 385 ka	Manzi et al., 2010		
		Bruner and Manzi, 2005 Mounier et al., 2011	353 ± 4 ka	Nomade et al., 2011		
Castel di Guido (Italy)			300 ka	Mallegni et al., 1983	**Strict association?**	**Yes**
non Neandertal lineage	Femur, occipital	Mallegni et al., 1983	Stade 9	Mariani-Constantini et al., 2001		
Neandertal lineage	Temporal, parietal	Mallegni and Radmilli, 1988 Elyaqtine, 1995	442 ± 7 ka to 250–170 ka	Michel et al., 2001		
Fontana Ranuccio (Italy)			458 ± 5.7 ka	Biddittu et al. 1979	Uncertainty	Yes
Neandertal lineage	Incisive	Segrè and Ascenzi 1984				
Neandertal lineage	Molar	Ascenzi and Segrè 1996				
Pofi (Italy)			400 ka	Biddittu et al. 1979	No strict association	Yes
	Ulna		400 to 350 ka	Biddittu and Celletti, 2001		
Neandertal linneage?	Skull vault		MIS 13 to 11	Manzi et al., 2011		
	Tibia	Stringer et al., 1998	Stade 11 10	Nomade et al., 2011		
Venosa Notarchirico (Italy)			359 ka+154/–97	Lefevre et al., 1994	No strict association	?
Homo sp.	Femur	Piperno, 1999				
Visogliano (Italy)						
no Neandertal lineage	Mandibula	Cattani et al., 1991	390 ka	Falguères et al., 2008	Uncertainty	?
no Neandertal lineage	Teeth	Mallegni et al., 2002				
Mala Balanica (Serbia)			> 113+72/–43 ka	Roksandic et al., 2011	No association	–
archaic Homo sp. no Neandertal lineage	Partial mandibula	Roksandic et al., 2011	525 to 397 ka	Rink et al., 2013		

Table 1 (*Continued*)

Site	Human remains	Taxonomical references	Dating	Dating references	Association with stone artefacts	Bifacial pieces
Vertesszöllös (Hungary)						
no Neandertal lineage	Occipital	Thoma, 1966	185 ± 25 ka	Schwarcz and Latham, 1984	Strict association	No
Homo erectus		Wolpoff, 1977				
no Homo erectus no Neandertal		Hublin, 1988				
Apidima (Greece)	Two skulls		400 to 105 ka	Harvati et al., 2011	No association	–
Neandertal lineage	Skull 2	Harvati and Delson, 1999				
between Homo heidelbergensis and Homo neanderthalensis	Skull 2	Harvati et al., 2009				
Petralona (Greece)					No association	Yes
Homo rodhesiensis	Cranium	Stringer, 1974	650 ± 280 to $127 \pm 35/198 \pm 50$ ka	Hennig et al., 1981		
Homo heidelbergensis		Hublin, 1985	250 to 150 ka	Grün, 1996		
Neandertal lineage		De Bonis and Melentis 1982	> 780 ka	Poulianos, 1981, 2005		
		Harvati et al., 2010				
Bilzingsleben (Germany)					Unknown	Unknown
no Neandrtal lineage	Molar, frontal, parietal, occipital	Hublin, 1988	414 ± 45 to 280 ka	Schwarcz et al., 1988		
Homo erectus cf Homo pekinensis	Mandibula	Vlcek 2000	< 350 ka	Mallick and Franck 2002		
Boxgrove (Great Britain)					No strict association	
archaic Homo	Tibia	Stringer et al., 1998	Stade 13	Roberts et al., 1994		Yes
Neandertal		Stringer et al., 1998				
Homo heidelbergensis	Incisors	Hillson et al., 2010				
Swanscombe (Great Britain)		Stewart, 1964	MIS 12-11	Bridgland et al. 2013	Unclear	No
Neandertalian	Two parietal and one occipital	Santa Luca, 1978				
		Hublin, 1998				
Kocabas (Turkey)			1.11 ± 0.11 Ma	Engin et al., 1999	No association	–
Homo erectus	Skull cap	Vialet et al., 2012	510 ± 5 to 330 ± 0.13 ka	Kappelman et al., 2008		
			1.3 to 1.1 Ma	Lebatard et al., 2014		
Nadaouiyeh Aïn Askar (Syria)					**Strict association**	**Yes**
Homo erectus	Parietal	Schmid et al., 1997	450 ka	Schmid et al., 1997		
Ubeidiya (Palestine) layer K-30K-29					No strict association	Yes
Homo sp. indet.	Teeth and cranial gragments	Bar-Yosef and Goren-Inbar, 1993				
Ubeidiya (Palestine) layer I-26a					**Strict association**	**Yes**
Homo cf ergaster	Incisor	Belmaker et al., 2002	1.2 Ma	Rink et al., 2007		
Gesher Benot Ya'aqov (Palestine)					**Strict association**	**Yes**
Homo erectus	Fragment of femur	Geraads and Tchernov, 1983	900 ± 150 ka	Goren-Inbar et al., 1992		

Please cite this article in press as:Moncel, M.-H., et al., Assemblages with bifacial tools in Eurasia (third part). Considerations on the bifacial phenomenon throughout Eurasia. C. R. Palevol (2016), http://dx.doi.org/10.1016/j.crpv.2015.11.007

Table 1 (*Continued*)

Site	Human remains	Taxonomical references	Dating	Dating references	Association with stone artefacts	Bifacial pieces
Tabùn (Palestine) layer E			350 ± 30 to 330 ± 30 ka	Mercier et al., 1995	**Strict association**	**Yes**
Homo sp. indet	Fragment of femur	McCown and Keith, 1939	200 ka	Grün et al., 1991		
			200 ka	Grün and Stringer, 2000		
Zuttiyeh (Palestine)		Hublin, 1976	Stade 8 to 6	Bar-Yosef, 1988	**Strict association**	**Yes**
archaic Homo sapiens	Frontal and zygomatic bone	Vandermeersch, 1981	250 to 200 ka	Bar-Yosef and Vandermeersch, 1993		
Modern human		Bar-Yosef and Vandermersch 1991 Zeitoun, 2001				
Hathnora (India)					No strict association	Yes
Homo erectus narmadaensis	Half calvarium	Sonakia, 1985	< 162 ± 8 ka	Patnaik et al., 2009		
Homo erectus		Lumley and Sonakia, 1985	< 407 ± 21 ka	Patnaik et al., 2009		
Homo sapiens		Zeitoun, 2000 Cameron et al., 2004				
Homo sp. indet.	Clavicula	Sankhyan, 1997				
Zhoukoudian Layer 10 (China)					No strict association	No
Sinanthropus pekinensis	1 calvarium	Black, 1927	460 ka	Liu, 1983		
Homo pekinensis		Groves, 1989	600 ka	Shen et al., 2001		
		Tattersall and Schwartz 2000				
Zhoukoudian Layer 8-9 (China)					No strict assocation	No
Sinanthropus pekinensis	Sevral calvarium teeth and	Black, 1927	420 ka	Liu, 1983		
Homo pekinensis	Postcranial remains	Groves, 1989	500 » 60 ka	Shen et al., 2001		
		Tattersall and Schwartz 2000 Zeitoun, 2000				
Homo sapiens pekinensis						
Gongwangling Layer 6 (China)		Etler, 1996	1.15 Ma	Wu and Poirier, 1995	No association	–
Homo erectus	Partial cranium		1.54 to 1.65 Ma	Zhu et al., 2015		
Tangshan (China)			350 ka	Chen et al., 1996	No association	–
Homo erectus cf Zhoukoudian	1 tooth, cranial fragments	Liu et al 2005	620 ka	Zhao et al., 2001		
Xuetangliangzi Layer 3 (China)			581 ± 93 ka	Chen et al. 1997	Strict association	No
Homo sapiens	Two skull	Li and Etler, 1992	936 ka	Lumley et al., 2008		
Chenjiayao (China)			500 ka	Wu et al., 1989		
Homo sapiens cf Modern lineage	Fragment of mandible		650 ka	An et al., 1990		
Longtangdong (China)		Wu and Dong, 1982	200 ka	Huang et al., 1981	No association	–
Homo erectus	Parial skull	Kidder and Durband, 2004	195+6/−16 ka	Li and Mei, 1983		
		Wu et al., 2006	270 to 150 ka	Chen et al., 1987		
Homo erectus cf Zhoukoudian			300 ka	Huang et al., 1995		
			412+6/−25	Grün et al., 1998		

Table 1 (*Continued*)

Site	Human remains	Taxonomical references	Dating	Dating references	Association with stone artefacts	Bifacial pieces
Dali Layer 3 (China)		Zhou and Wang 1982	Stade 6 to 7	Wang, 1985	Strict association	No
Homo sapiens daliensis	Skull	Lumley and Sonakia, 1985	230 to 190 ka	Wu, 1991		
Homo erectus		Braüer and Mbua, 1992				
archaic Homo sapiens cf Modern		Zeitoun, 2000				
Xujiayao (China)	Several cranial pieces, mandibula and teeth	Braüer and Mbua, 1992	125 to 104 ka	Chen et al., 1984	Strict association	No
Archaic Homo sapiens						
Jinniushan Layer 7 (China)	Calvarium and postcranial	Braüer and Mbua, 1992	280 ka	Lu, 1989	No association	–
archaic Homo sapiens						
Chaoxian (Chaohu) (China)						
Homo sapiens	Occipital	Xu et al., 1984	200 to 160 ka	Chen et al., 1987	No association	–
Homo sapiens	Maxilla	Xu et al., 1986				
Maba (China)						
Homo sapiens cf Modern	Incomplete calvarium	Zhou and Wang 1982	130 ka	Wu, 1991	No association	–
		Wu, 1983	135 to 129 ka			
archaic Homo sapiens		Braüer and Mbua, 1992	135 to 129 ka	Yuan et al., 1986		
Zhirendong Layer 2 (China)			113 to 100 ka	Liu et al., 2010	No strict association	–
Homo sapiens sapiens	Incomplet mandibula	Liu et al., 2010				
Liujiang (China)			73 to 62 ka » 227 to 110 ka	Yuan et al., 1986	No association	–
Homo sapiens sapiens	Calvarium	Woo, 1959	139 to 113 ka	Shen et al., 2002		
			153 ka	Shen and Michel, 2007		
Tubo (China)		Li et al., 1984	220 to 94 ka	Shen et al., 2001	No association	–
Homo sapiens sapiens	Isolated teeth		139 to 85 ka	Shen and Michel, 2007		
Huanglong (China)			93.13 to 76.6 ka	Wu et al., 2007 in Shen et al., 2013	Strict association	No
Homo sapiens sapiens	Isolated teeth	Liu et al., 2010b	103.7 1.6 to 103.1 1.3	Liu et al., 2010		
		Wu et al., 2006	101 to 81 ka	Shen et al., 2013		
Sangiran Ngebung2 (Indonesia)			0.97 to 0.73	Sémah et al., 1992	**Strict association**	**Yes**
Ngebung ensemble A	Tooth		0.88 to 0.86	Falguères and Yokohama, 2001		
Homo erectus		Sémah et al., 1992				

but it was not found in stratigraphic context. Stringer et al. (1998) are the only researchers to relate it to a Neandertal sample. At Notarchirico, a femur fragment was found in the upper alpha layer without bifacial tools (Piperno, 1999).

Some human remains were found at Visogliano (Cattani et al., 1991), where the lithic assemblage only includes two core-like proto-bifaces (Falguères et al., 2008). According to Mallegni et al. (2002), the absence of derived Neandertal characters implies that these fossils are archaic *H. sapiens*.

At Mala Balanica in Serbia (Rink et al., 2013), the absence of a retro-molar space on the mandible, a mental foramen below the P4 and a *prominentia lateralis* in a fore position, are dissimilar to the derived characters found on Mauer or on Neandertals in general. These traits lead Roksandic et al. (2011) to consider it as an archaic *Homo* sp., but no artefact is associated with this specimen.

At Vertesszöllös in Hungary, in a layer yielding a microlithic industry and attributed to MIS 9 (Schwarcz and Latham, 1984), an adult occipital is considered not to bear Neandertal characters. Thoma (1966) and Wolpoff (1977) affiliated it to *H. erectus*. Hublin (1988) distinguished it from both Asian *H. erectus* and Neandertals.

In Greece, two human craniums were found at cave A of Apidima. The second skull was relatively more complete and was described as showing Neandertal facial characters (Harvati and Delson, 1999). However, in a more recent study, Harvati et al. (2009) placed it between *H. neanderthalensis* and *H. heidelbergensis* (s.l.). The stone industry at this site is not directly associated with the human remains.

The stratigraphic origin of the cranium from Petralona is disputed. It was found isolated on the cave floor, but according to Poulianos (1981, 2005), the skull was uncovered in layer 11, which includes most of the stone tools. Stringer (1974) attributed it to *H. rhodesiensis*, but Hublin (1985) includes it in a regional definition of *H. heidelbergensis*. The specimen shows some archaic *H. sapiens* characters, such as those observed on the Kabwe skull (*H. sapiens rhodesiensis*), but it also presents a set of facial traits linking it to the European Neandertal lineage (De Bonis and Melentis, 1982; Harvati et al., 2010, 2011; Hennig et al., 1981).

The human remains found at Bilzingsleben (around 400 ka), in the centre of Germany (Mania et al., 1994), display no Neandertal derived characters but are comparable to their anatomical counterparts from Vertesszöllös and Petralona, according to Hublin (1988). The fragment of a mandible from a third individual presenting neither Neandertal nor anatomically modern human derived characters was described by Vlcek et al. (2000). It was said to be closer to the Chinese specimens from Zhoukoudian than to the Arago specimens. The lithic industry has not yet been described.

An isolated tibial diaphysis was found in locality Q1/B at Boxgrove (MIS 13) in Great Britain (Roberts et al., 1994). This bone may be attributed to archaic *Homo*, especially *H. heidelbergensis*, due to temporal and geographical proximity, but its robustness recalls that of Neandertals (Stringer et al., 1998). More recently, two isolated incisors presenting robust spatulate crowns were found and were provisionally attributed to *H. heidelbergensis* by Hillson et al. (2010). Nevertheless, although Acheulean artefacts are predominantly concentrated in one level of the site (Roberts and Parfitt, 1999), their strict connection with the human remains cannot be taken for granted. An occipital and two parietal bones at Swanscombe were previously considered to belong to a last common ancestor of anatomically modern humans and Neandertals (Sergi, 1953; Stewart, 1964). However, it was later considered to be a Neandertal (Santa Luca, 1978).

2.2. The Near East pivot

In western Turkey, an incomplete calvarium dated to more than 1.1 Ma was found at Kocabaş (Engin et al., 1999; Kappelman et al., 2008; Lebatard et al., 2014). Initially interpreted as a *H. erectus* by Vialet et al. (2012), the specimen is more precisely considered to be closer to both African fossils OH9 and Daka (Vialet et al., 2014), which are considered to be at the bottom of the *H. rhodesiensis*–*H. sapiens* lineage. Due to the lack of derived traits, the Kocabaş specimen could also be considered as an archaic *H. sapiens*, according to our cladistic viewpoint. No stone artefacts were described in association with this specimen.

A left human parietal bone was found in unit VII A at Nadaouiyeh Aïn Askar, in Syria (Jagher et al., 1997; Le Tensorer et al., 1997, 2007; Schmid et al., 1997), with Acheulean artefacts. The shape of the parietal bone corresponds to a rather low cranial vault and even though it is thick, these features tend to distance it from the Neandertal lineage and affiliate it more closely to *H. erectus*.

At Ubeidiya in Israel, at 1.4–1.2 Ma, bifaces were found in layers K-30 and K-29 (Bar-Yosef and Goren-Inbar, 1993; Sagi, 2005). Several human cranial fragments and isolated teeth were initially attributed to *Homo* sp. (Tobias, 1966) and an isolated incisor found in layer I-26a was more recently attributed to *H. cf. ergaster* (Belmaker et al., 2002).

At Gesher Benot Ya'aqov (800 ka), two femur fragments were attributed to *H. erectus* (Geraads and Tchernov, 1983; Goren-Inbar et al., 1992).

A *Homo* sp. femoral fragment was found in layer E of Tabùn Cave (MIS 8) (Grün and Stringer, 2000; Grün et al., 1991; McCown and Keith, 1939; Mercier and Valladas, 2003; Mercier et al., 1995) and was associated with an Acheulo-Yabrudian lithic assemblage (Gardner and Bate, 1937).

In Galilee, the Zuttiyeh fossil (MIS 8 or 6) was originally considered to be a Neandertal (Keith, 1927), then an archaic *H. sapiens* (Hublin, 1976). A phenetic study (Sohn and Wolpoff, 1993) moved it closer to the Chinese series of Zhoukoudian. Its face distinguishes it from Neandertals, according to Hublin and Tillier (1991), but some of these characters are considered to be primitive by Stringer (1984). Finally a cladistic analysis (Zeitoun, 2001) confirmed its former presumed attribution to *H. sapiens sapiens* by Vandermeersch (1981). Its age is disputed but Bar-Yosef and Gisis (1974) indicate that it was discovered at the bottom of a Yabroudian–Acheulean layer.

2.3. The Indian subcontinent

At Hathnora in central India, a human half calvarium is considered to be an "evolved" *H. erectus* by Lumley and Sonakia (1985) and Sonakia (1985), and is attributed to Neandertal by Cameron et al. (2004), but a cladistic analysis places this specimen closer to *H. sapiens* than to *H. erectus*, at the base of the *H. sapiens* lineage (Zeitoun, 2000). An isolated clavicle uncovered in a horizon of the Boulder Conglomerate at Hathnora does not allow any specific attribution according to Sankhyan (1997), but the illustrations he provides do not convincingly demonstrate that the fossil bone belongs to any human taxon (Patnaik et al., 2009).

2.4. China

From 1.5 Ma to 90 ka, numerous human fossils exist but in most cases, they do not present any strict association with lithic artefacts (An et al., 1990; Chen et al., 1984, 1987, 1996; Etler, 1996; Grün et al., 1998; Huang et al., 1995; Li and Mei, 1983; Lu, 1989; Norton and Braun, 2010; Vialet et al., 2010; Wang, 1985; Wu and Dong, 1982; Wu et al., 1989; Xu et al., 1986; Yuan et al., 1986; Zhao et al., 2001; Zhu et al., 2015).

No bifacial pieces were uncovered at Zhoukoudian in northern China (Liu, 1983; Shen et al., 2001), but it is nonetheless necessary to expose some of the anthropological elements of this site as the definition of Chinese *H. erectus* was established on the basis of this series

(Wu, 1991). The Zhoukoudian specimens were initially described as *Sinanthropus pekinensis* by Black (1927). This taxonomic name was later changed into *H. erectus pekinensis* (cf Campbell, 1963). However, the name *H. pekinensis* was also recognized by Groves (1989) and Schwartz and Tattersall (2002). It should also be noted that a cladistic analysis reports a different phylogenetic position for the specimen belonging to the older layer and those from the more recent layers (Zeitoun, 2000). In this analysis, these specimens are considered to belong to an "archaic" *H. sapiens*.

At Gongwangling, in north-western China, a partial human fossil was uncovered in the archaeological layer 6. On account of extensive alterations due to postmortem erosion and breakage (Woo, 1966), it is difficult to determine its taxonomic affiliation, but it is generally attributed to *H. erectus* (Rightmire, 2013). A lithic industry without bifacial pieces was found at the bottom of the underlying layer 8 and a handaxe was uncovered on the surface (Wu and Poirier, 1995). Two fragmentary human crania and a tooth were found in a cave near Tangshan near Nanjing, eastern China (Wu and Poirier, 1995). The facial characters described by Liu et al. (2005) for the specimen of Nanjing n° 1 are close to those observable on the Zhoukoudian series. No tool was found with these fossils. In the site of Yunxian (Xuetangliangzi), two human skulls were found in layer 3 with lithic artefacts (Etler and Li, 1994; Vialet et al., 2010). In spite of postmortem taphonomic deformation, it is possible to observe the presence of a canine fossa and other features which relate these specimens more to early *H. sapiens* and the anatomically modern human lineage than to the Neandertal lineage (Li and Etler, 1992). According to Feng (2008), the lithic assemblage consists mainly of choppers, some picks and poor quality bifacial pieces, but only one bifacial piece comes from the layer underlying the human fossil-bearing layer, and other bifaces were uncovered on the surface.

An incomplete human mandible was found at Chenjiayao, in eastern China. The presence of a mental trigone could relate this specimen to early anatomically modern humans. Only one crude scraper and three flakes in quartz were found with this fossil (Wu and Poirier, 1995). A fragmentary and deformed cranium was found at Longtandong, in southern China (Huang et al., 1981), presenting morphological similarities to the Zhoukoudian *H. erectus* (Day, 1986; Wu and Dong, 1982). Nevertheless, some "progressive" features were also observed after comparison with the Zhoukoudian series according to Wu and Dong (1985). No lithic industry is associated with these human remains but large flakes made of rhinoceros enamel were observed by Olsen and Miller-Antonio (1992). In the province of Shaanxi, the Dali calvarium was found at the bottom of a late Middle Pleistocene (Li, 1983) layer. It is a transitional form between *H. erectus* and *H. sapiens* according to Wu (1983), but cladistic analysis affiliates it to *H. sapiens* (Zeitoun, 2000). Some human fossils were found at Xujiayao, in northern China (Wu, 1980). Recent analyses of the remains point to a complex mosaic of primitive and derived features, including traits classically identified in Eurasian Neandertals, Early and Middle Pleistocene hominins, and even Late Pleistocene anatomically modern human from Asia (Bar-Yosef, 1988; Bar-Yosef and Vandermeersch, 1993; Kidder and Durband, 2004; Wu and Trinkaus, 2014). A dental study confirms this mosaic of primitive and derived features (Xing et al., 2015). Several thousand lithic pieces associated with bone tools were uncovered at the site, but no bifacial pieces were noted (Jia et al., 1979).

As for the last chronological range of the occurrence of bifacial pieces in China, *i.e.* 110 to 80 ka, this period could include many sites with anatomically modern human fossils although their dating is still disputed and no bifacial lithic artefact is strictly associated with these remains. At Jinniushan, a cranium is attributed to archaic *H. sapiens* by Bräuer and Mbua (1992). At Chaoxian, human fossils are attributed to early *H. sapiens* by Xu et al. (1984) and the Maba calvarium is also considered to be an early *H. sapiens* (Wu, 1983; Zhou et al., 1982). No lithic artefacts are associated with the human remains at these three sites. Isolated teeth and a mandible fragment bearing a mental trigon were unearthed in layer n° 2 of Zhirendong Cave, in southern China (Liu et al., 2010). This specimen, as well as the remains of Liujiang Man discovered in Tongtianyan (Woo, 1959), are considered to be the oldest anatomically modern human remains in China (Shen et al., 2002) but their strict stratigraphic context is unknown.

At Longdon Cave, *H. sapiens* remains were found in both disturbed and undisturbed cave deposits. One hundred and seventy-one stone artefacts collected from Locality 54100 and other sites in the vicinity of this cave were studied but no bifacial pieces were observed (Olsen and Miller-Antonio, 1992). In the deposits of Ganqian Cave, several isolated human teeth were uncovered and attributed to *H. sapiens* (Shen and Michel, 2007) but with no associated lithic artefacts (Li et al., 1984; Wang et al., 1999). The seven-hominin teeth from Huanglong Cave were assigned to *H. sapiens* by Liu et al. (2010). These remains are associated with a lithic industry presenting transitional features between the archaeological cultures of southern and northern China (Wu et al., 2006).

2.5. The Indonesian cradle of mankind

Two interpretations are currently applied to regional chronology in Indonesia: a long chronology and a short chronology, *i.e.* Sémah (2001) *versus* Larick et al. (2001) for the Sangiran sites, as well as for Trinil or Perning. This presents the additional difficulty of choosing the range of human fossils to take into account. Nevertheless, for these sites, in the different localities and stratigraphic levels, all the fossils are attributed to *H. erectus* (Zeitoun et al., 2010). In Indonesia, lithic pieces compatible with Acheulean traditions were found out of stratigraphic context in southern Sumatra or at the bottom of the Kabuh Formation at Ngebung 2 in Sangiran (Semah et al., 1992). At Ngebung, a human femur was found in the Grenzbank conglomeratic layer at the base of the stratigraphy (Grimaud-Hervé et al., 1994), as well as a human right molar strictly associated with lithic artefacts in layer A. The occupation layer yielded typical cleavers with flakes, choppers, hammerstones, polyhedrons and bolas (Sémah, 2001; Sémah et al., 2003).

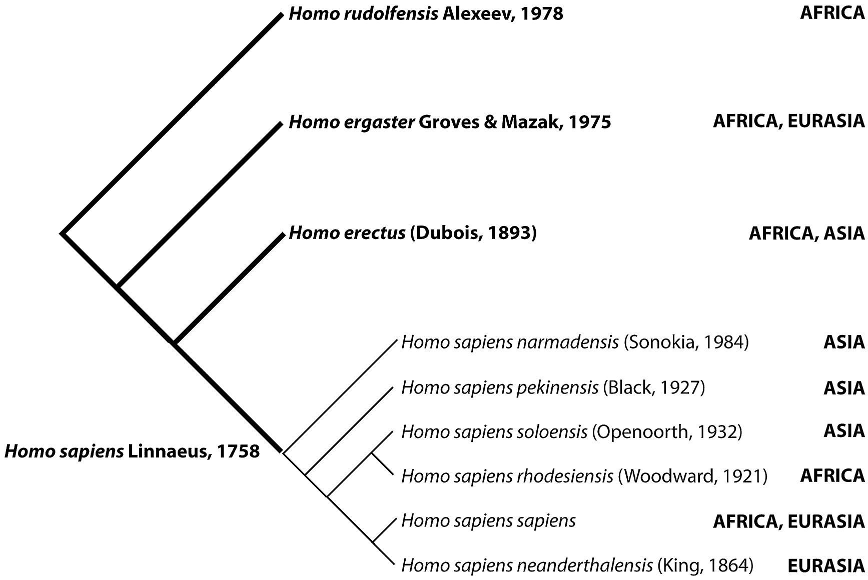

Fig. 1. Anthropological phylogeny according to V. Zeitoun (2000), modified.
Fig. 1. Phylogénie anthropologique, selon Zeitoun (2000), modifié.

2.6. *Conclusion regarding Eurasian palaeoanthropology*

By applying the logical argumentation developed by Vandermeersch (1989), based on the postulate that it is not biologically conceivable that speciation occurs in several places, except in the case of multiple convergence, the available data indicate that *H. sapiens* is not the direct descendant of *H. erectus* but its sister-group. On this basis, *H. sapiens* should also appear as a very old taxon with several regional subtaxa, in keeping with the recommendations of Bonde (1989). Based on cladistics, Zeitoun (2000) demonstrated both former hypotheses and showed that, apart from the African Knmwt 15000 specimen, the *H. erectus* clade includes the whole Trinil-Sangiran series while other so-called *H. erectus sensu largo* should be attributed to several *H. sapiens* subtaxa. This interpretation reconciles the "multiregional" and "Out of Africa" models and explains the significant polymorphism observed, particularly in Europe (Zeitoun, 2004). Our anthropological assessment highlights general synchronicity between humans and artefacts, as far as bifacial industries are concerned. For the Near East, *H. erectus* or archaic *H. sapiens* are the craftsmen of such industries while, in Europe, these artisans are archaic *H. sapiens* related to the Neandertal lineage. In Indonesia, only *H. erectus* seems to be related to bifacial industries but in China, we suggest that only "archaic *H. sapiens*" and "anatomically modern human" lineages are involved (Fig. 1).

3. Chronological and technological considerations

3.1. *In Europe*

In western Europe, bifacial technology appears from 1 to 0.9 Ma (La Boella, Spain, Vallverdu et al., 2014), but the scarcity of bifacial tools and partial tool shaping may indicate a local onset at that time. The French site of la Noira (700 ka), with its diversified and elaborate bifacial tool kit, provides the most convincing evidence of arrivals so far (Moncel et al., 2013). The sporadic archaeological evidence between 800 and 500 ka raises questions as to the significance of the assemblages using this technology: do they only represent episodic arrivals of new hominin groups with this technology (as suggested by the elaborate bifaces at la Noira), an influx of new ideas or needs, or local origins (despite the lack of dates to assess that)? It also calls into question the use and definition of the term Acheulean. "Acheuleans" would be more relevant to describe the observed diversity. Bifaces and cleavers always occur in very low frequencies and these tools appear to be a marginal component of tool kits. From 500 ka onwards in Western and Southern Europe, assemblages with bifacial technology cover both southern and northern latitudes with some degree of regional standardization in keeping with site functions (bifaces *v.* bifacial tools). Filiations over time are not well evidenced by current data. Raw material components are very different in the North and the South, with mainly flint in the form of nodules in the North, and various rock types available as large stone blocks in the South. This may account for the presence of some tool types, such as cleavers on flakes, with no links with the Large Flake Assemblages (LFA) described in the Levant (Sharon, 2007). Traditions with bifacial technology appear to have first continuously occupied northern latitudes from 500 ka onwards.

Technological diversity would thus be due:

- to repeated waves of hominin expansion from 700 ka onwards (yielding an impression of technological stasis), then to regional histories or evolution after MIS 12, with innovations and/or stability;
- to a local onset in rare and so far poorly demonstrated cases;

• to varied activities or traditions accounting for the absence of unessential bifaces (Ashton et al., 1992; Monnier et al., 2001).

Obviously, the significance of assemblages with bifaces will be somewhat elucidated when the function of these tools, the role of activities and raw materials will be better known, since their technological and morphological variability does not seem to have chronological or geographical connotations.

3.2. Regarding South Asia

In South Asia (India), the early Acheulean assemblages, dated to 1.5 Ma, are similar to the African Acheulean due to the large flake component (cf. Large Flake Assemblage tradition [LFA], Sharon, 2007). However, this typical component is not systematically produced. Very often, large cutting tools are made from other types of blanks, like slabs or cobbles, especially if the latter are readily available in the local environment. Local raw materials are used in priority and are of diverse quality and shape (quartzite, basalt, silicified limestone). It is important to mention the presence of cleavers on flakes (LCTs) in most of the series, in addition to spheroids and polyhedrons. The biface ratio is low; between 1 and 2%. Bifacial technology is often crude, with few removals forming pointed and symmetrical tools.

This is also the case for the Chinese sites of Bose, South China, or elsewhere, where both bifaces and unifaces (pointed or with a transversal tip) are often made on cobbles. Ratios of bifaces or bifacial tools are low (less than 5%). Most of the series are composed of thick heavy-duty tools on pebbles and cobbles (choppers and chopping-tools, picks, spheroids). In China, the earliest evidence occurs as early as 1.5 Ma, then at around 800 ka and continues until 90 ka. This technology suggests more bifacial tools than "Acheulean" tools, as described in Europe. However, some assemblages share common features with the African technology (Hao and Kuman, 2016). Debates are still heated in recent papers, opposing researchers considering the Chinese finds as Acheulean and others attributing them to a local onset (Kuman et al., 2014; Wang and Bae, 2014; Wang et al., 2014). The Indian series would be the farthest discoveries of "Acheulean"-type artefacts from East Africa and the Levant.

It is important to bear in mind that the production of large flakes requires suitable forms of raw materials, such as outcrops or very large blocks. If these are not available, craftsmen will settle for cobbles or slabs. Conversely, if cobbles or slabs are lacking in the environment, large flakes have to be produced from outcrops. These environmental constraints induce technical habits and skills that may lead knappers to prefer specific raw materials, even when a full range of possibilities becomes available.

3.3. Regarding East Asia

As we have aimed to demonstrate through the selection of sites, in East Asia, several analytic aspects must be considered before any attempts at interpretation. The first aspect concerns the representation of the bifacial tool within the different assemblages. This representation can vary from more than 80% at many sites in the Near East (Boëda et al., 2004; Jagher, 2011; Le Tensorer and Muhesen, 1995), to less than 5% in East Asia (Bodin, 2011; Hao Li and Kuman, 2016; Hou and Li, 2007; Li, 2011; Li, 2015; Li and Sun, 2013; Li et al., 2014; Norton et al., 2006; Wang and Bae, 2014; Wang et al., 2008, 2014). In an assemblage where bifaces represent the majority of the tools, it is logical to suppose that they act as blanks for different kinds of working edges and are not simply the repetition of the same tool type. The biface thus acts as a "matrix", which requires functional technical traits for its transformative (prepared area) and prehensile parts. The active edges are arranged on this matrix according to the intended function.

The East Asian examples clearly illustrate the need to take into account the assemblage as a whole. The contradictory debates regarding the famous Movius line provide a good example of this (Dennell, 2016; Gamble and Marshall, 2001; Hao Li et al., in press, Lycett and Bae, 2010; Norton et al., 2006; Wang and Bae, 2014). In the sites selected to represent East Asia between 800 and 90 ka, bifaces are extremely rare, and appear to represent specific tools, rather than multi-purpose tools.

Let us first consider the raw materials. The main common denominator for most lithic raw materials used in East Asia, regardless of petrographic determination, is the form in which they were used: the cobble. In this, Movius (1948) was correct in underlining this attribute.

Let us now consider simple knapping principles. When a block of stone is knapped, "predetermined" removals are produced, some of which correspond to intended end products, which are immediately useable or require secondary processing (for instance retouch). The sought-after criteria may require specific preparation of the block of stone to create the necessary conditions for producing these end products or may already be naturally present due to the selection of appropriate forms. Some cobbles bear the flat/convex surfaces required to produce one to three successive removals. The sites of Liangshan Longgangsi and Houfang show this pattern of predetermined removals, termed type C (Boëda, 2013; Bodin, 2011; Li et al., 2014). However, it is common to see this type of artefact classified in the indeterminate category of "core/tools".

When a tool is made, regardless of type, the technological purpose is oriented towards its functionalization, requiring the preparation of a prehensile part, a transformative part and a working edge. When shaping is the chosen technical solution, there are two possibilities: using the natural part of the block or preparation of the transformative part by flaking. As a result, when a cobble is used, the prehensile part is held naturally. Preparation mainly concerns the transformative part.

Shaping can affect one or both faces of the tool. At the site of Bose, most of the tools are unifaces. Why so many unifaces? Is this a single tool type or a continuously produced chopper? The technological analysis of these tools indicates three phases. The first entails selecting a cobble with a natural prehensile part suitable for holding and

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with a flat surface that will be one of the two faces of the edge of the transformative part. The second phase shapes the transformative part made by the intersection of two surfaces, one of which is flat and natural. The final phase is the preparation of the working edge. Such construction enables the production of different kinds of tools (transformative part and working edge). Why then reduce all the worked cobbles into the simplistic concepts of choppers or chopping-tools?

At Bose, is the choice to shape cobbles imposed by the quality of the raw material? After availing of the opportunity to test this raw material ourselves, we can refute this hypothesis.

The choice of cobbles for tool production across East Asia thus appears to structure all the reduction schemes. Such behavior persists throughout the Pleistocene in both East and Southeast Asia, in some cases until the Holocene, as seen with the Hoabinhian. This behavior corresponds to a specific technical option with its own constraints and ergonomic and evolutionary consequences. The technological world of this region is thus not the same as that of the Mediterranean periphery. The forms and contours of tools and the associated techniques are different.

As a result, we are confronted with:

- a range of diversified tools around the Mediterranean during the same periods, but for which artificial categories are minimized;
- the preferential exploitation of cobbles using different methods in East Asia: unifacial, bifacial and trihedral shaping and knapping of all kinds.

While neither of these features, considered individually, is unique to East Asia, their widespread presence throughout this region and over several hundred millennia is truly specific to this area.

If we return to the concept of the convergent bifacial tool, termed biface, which triggered the construction of a global culture called the Acheulean, we are correct in refuting this proposal for East Asia. In actual fact, this assertion is based on the presence of artefacts with identical contours. This single morphological criterion is not sufficient for such a cultural generalization. However, the evidence clearly shows that the biface also exists in East Asia. Two hypotheses can be formulated to explain its presence. The first is the technological convergence of a single "idea". This involves producing an entirely standardized form, through shaping. This would explain why we find this technological concept in such far-flung places and time periods. But it is important not to reduce this contour and form to a single tool type. Technological analyses demonstrate that most often these pieces represent different specific tool types. The second hypothesis is that the concept of this standardized form and contour is borrowed and transmitted from one person to another, but made according to local traditions.

Contrary to common belief, these different methods of manufacture and varied forms and contours in East Asia take into account the assimilation of a technological concept, which may subsequently be altered through borrowing. One could use the neologism "Asianification" of an idea to reflect this phenomenon, rather than the result of the settlement of a territory by more cognitively evolved human groups.

Whether the concept of the convergent tool created by shaping was introduced by inter-community contacts or was the result of technological convergence, it is experienced differently because it becomes part of a set of practices, which are themselves different. To underline this point, we could introduce several reflections regarding the absence of cleavers in East Asia (although it is largely represented on the Indian subcontinent) and the maintenance of a degree of "technical primitiveness" throughout the history of these pieces in East Asia.

The existence of cleavers in East Asia is closely linked to a commonly held idea for the Acheulean. When we speak of bifaces and therefore of the Acheulean, it is assumed that we should inevitably also find cleavers. Some objects could possibly be considered to present the contour of a cleaver, but these are very rare and in most cases caution should be applied. In contrast, there is another type of artefact often interpreted as a cleaver based on a vague shape resemblance. This is sometimes called a "*couperet*" (Fig. 2). A good example comes from Zhoukoudian (locality 15 RP39029) (Li, 2011), where someone searching for cleavers would present this piece lengthwise. Yet techno-functional analysis by several of us has shown that all of the use-wear formed by shocks is found on the edge opposite a bifacially retouched back.

The "archaic" nature of the bifacial industries in East Asia is striking. How can this phenomenon be explained? There are two percussion methods for shaping; either via direct impact on the edge of the artefact (peripheral percussion) or internal contact a few millimeters from the edge (internal percussion). Hammerstones are adapted to the impact mode. It is clear that the aim, rather than the means, is important here: the technological results of the detachment of the flakes. In general, we observe a shift from internal to peripheral percussion at different times from one continent to another. For East Asia, this transition does not appear to have occurred, with rare exceptions, which require more detailed analyses. Raw materials and their morphology are immediately eliminated as causes for this evolutionary halt. One of the explanations that can be proposed among others is that the bifacial phenomenon never became dominant. However characteristic they may be, the number of bifaces discovered is minimal in comparison with other tools. We can thus assume that this tool required little technological investment (apart from its function), unlike the abundant flake tools. Indirectly, this indicates a lack of circulation of the concept, which remained confined to very specific geographic zones. The most recent extremely abundant and geographically grouped Korean data (from MIS 4-3) (Lumley et al., 2011) confirm this evolutionary "blockage". Does this also hold true for India? Technological data are too sparse to detect changes in production methods. However, these observations seem to be similar to those in Southeast Asia.

In conclusion, it appears preferable not to use the linguistic terminology applied to the Mediterranean periphery and Africa to describe the observed occurrences in East Asia.

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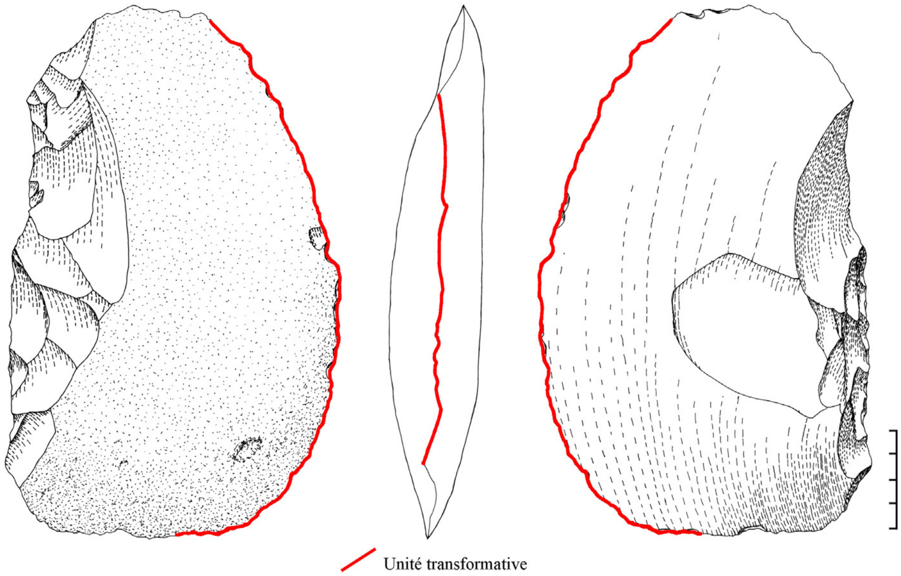

Fig. 2. Couperet, Zhoukoudian (locality 15 RP39029). Traces of use are located on the edge parallel to the maximum artefact length.
Fig. 2. Couperet, Zhoukoudian (localité RP39029). Traces d'usure sur le bord parallèle à la longueur maximum de l'artéfact.

3.4. *Regarding West Asia*

West Asia and the Arabian Peninsula are often described as vital buffer zones connecting Africa, Europe and East Asia. Recent research (Chevrier, 2012b) on a series of East African and Near Eastern sites has clearly demonstrated that the different evolutionary stages of this phenomenon are present and equivalent from one region to the next.

Bifacial technology is at present undeniably African in origin (Beyene et al., 2013; Lepre et al., 2011; Roche et al., 2003), with the invention of bifacial shaping around 1.7 Ma. The Near Eastern equivalent is found at the site of 'Ubeidiya, dated between 1.4 and 1.2 Ma (Bar-Yosef and Goren-Inbar, 1993; Belmaker, 2006). The latter site is more recent (800 ka), but bifacial volumetric forms are highly similar, and both correspond to an evolutionary stage that can be considered as the initial, or almost initial stage (Boëda, 2005). In both cases, earlier technocomplexes occur, providing evidence of a potential purely local link.

The sites of Gesher Benot Ya'aqov, Nadaouiyeh Aïn Askar and El Meirah show all of the technological evolutionary stages seen in Africa, albeit with a certain time lapse, as in Europe, but without an evolutionary rupture. Such evolutionary similarity from one continent to another with a permanent time lag supports the hypothesis of parallel evolution transmitting and developing the same bifacial technological concept. If the concept of bifaces comes from Africa, as suggested by its chronology, it is surprising to find it at 'Ubeidiya several hundred thousand years later with a similar technological level. Although there is a significant time lapse between these occurrences, the similarity in technological levels, both of which are in the first evolutionary stage, clearly supports the diffusion of a technological concept from one group to the next or a phenomenon of convergence, as in East Asia.

We can also compare the more or less contemporaneous material from El Meirah (Syria) with Isenya (Kenya) (Roche et al., 1988; Texier and Roche, 1995). Technologically, the Isenya bifaces reflect a technical level indicating peripheral percussion, while at El Meirah percussion is still internal, giving it an archaic character. This evolutionary difference is another argument in favor of evolution in each macro-region transmitting and developing the same technological concept: that of a standardized blank from the first stages of production in order to support one or more tools. Actually we should dissociate the evolution of technological stages of fabrication and the use of bifacial pieces from the history of these changes, which are both independent of their geographic location, in order to discern these two levels of observation – the details of technological change and the temporality of these changes. One is at the level of identification of change while the other concerns the chronology of changes, rhythmicity, causes, etc.

Another important point concerns the expansion, or rather the limits, of the eastern bifacial phenomenon. To the north, the phenomenon does not extend beyond Georgia and Azerbaijan. To the east, the Zagros Mountains form a border limiting expansion. Southern Iraq and most of Iran do not have true bifacial industries. The phenomenon is thus found within a limited, trapezoidal-shaped area of the Near East, including a coastal zone, a continental zone in contact with the Syrian and Jordanian steppe and the watersheds of the Tigris and Euphrates. Contrary to previous records, Central Asia as a whole and the Iranian Plateau to Pakistan, the Gulf of Oman and the Persian Gulf have no bifaces (Davis and Ranov, 1999). It is only on the terraces of the Indus that they reappear. The Near East is thus a cul-de-sac for the bifacial phenomenon, in which we observe all of the technological evolutionary stages and a range of methods and styles that reflect local populations rooted in their regions.

Except for a few stratified sites such as Saffaqah (site excavated but not dated; Saudi Arabia) (Whalen, 2003; Whalen et al., 1984), we have no stratigraphic sequence that could serve as a chronological framework for the Arabian Peninsula. The general data indicate that this entire territory was occupied, from the interior desert zones to the mountainous and coastal zones (Petraglia, 2003). Nonetheless, for the southern part of the Arabian Peninsula, the data collected show that most of the territory occupied in the southern part of this region is mountainous or coastal, situated along the Red Sea, the Oman Sea and the Gulf of Oman to the Strait of Ormuz (Amirkhanov, 1994; Groucutt and Petraglia, 2012; Petraglia, 2003; Petraglia et al., 2009; Rose and Hilbert, 2014; Whalen, 2003; Whalen and Pease, 1991; Whalen and Schatte, 1997; Whalen et al., 2002). Such technological similarities show that the same technological concept was used there. The latest discoveries in the United Arab Emirates are of much interest because they are the easternmost bifaces known to date near the Gulf of Oman. It is obviously very tempting to cross this channel and establish contact with Iran, Pakistan, India and East Asia. However the maritime border of Iran has not yet yielded a single biface. The westernmost bifaces in Pakistan come from the Indus region, associated with typical cleavers. Cleavers, in the current state of discoveries, do not appear to be present in Oman or the UAR. Such absences are difficult to interpret. Hence, we must ask the following question. Did contemporaneous non-bifacial industries exist, and are as of yet unidentified, or were there truly empty zones without occupation during this period? As long as we cannot answer this question, it is difficult to propose a scenario for this part of the world.

In conclusion, we can only say that the standardized bifacial concept for tools is not a universal technological concept. The bifacial concept is one of a standardized tool and not of a single tool type. It includes abundant expressions of form, volume and use of its edges, allowing each human group adopting it to express it differently.

3.5. Regarding Southeast Asia (Mainland and archipelagos)

Currently available data for bifacial technology in Southeast Asia, bordered by the Indian and Chinese areas, go back to around 800 ka. The diversity of the assemblages indicates that this area was a technological melting pot during the Early Palaeolithic, which is highly probable given the unrivalled mosaic of fossil hominin populations, variability and bio-environmental and behavioural traits in the area (including the *H. erectus* groups who reached Java more than 1.5 Ma ago).

Eastwards of ancestral African roots, we observe that the spatial distribution of series with bifacial technology becomes unclear, especially towards East Asia (China) and Southeast Asia. The presence of handaxes, pebble tools, cleavers and large cutting tools elsewhere in the world before the Middle Pleistocene clearly deconstructs the linear "Out of Africa" diffusionist model (Norton and Braun, 2010).

Southeast Asia is above all characterized by its geographical disparity. This "angle of Asia", as it was called by Mus (1977), does not just represent one world but a juxtaposition of contrasted worlds (continental, peninsular and more recently insular) extending over about 4 million km^2. Half of Southeast Asia is covered by one of the largest archipelagos in the world (Indonesia) and by the Philippines, making any attempt to identify common denominators highly unrealistic.

Some undeniable geographical determinism must be added to cognitive factors, such as the varied quality, accessibility and density of raw materials in the environments of the different sites. It is therefore difficult to undertake large scale typological and morphological comparisons of tools without taking into account the spatial discontinuity of Palaeolithic sites, environmental changes over time, subsistence modes and the multiple solutions applied to raw material flaking.

India and maritime Southeast Asia yield more similar "bifacial evidence" to that described in Europe or Africa.

South-eastern bifacial tools are generally poorly shaped, apart from some specific large pieces (> 20 cm long), for instance from South Sumatra, made on large flint nodules, indicating well-mastered shaping. Overall, however, they are partial, cortical, thick and poorly standardized tools. The cutting edges are often irregular with cortical zones or breakages due to accidents. Partial shaping is one of the main characteristics of the bifacial tools in tropical areas. The blank (flake, block or pebble) presents little modification. Reduction sequences are short, made by hard hammers with three or four series or removals, resulting in poorly balanced tool surfaces. Cross-sections are rarely symmetrical and are often triangular or trapezoidal. Tools present cortical zones and non-invasive removals. They do not display the same investment as in Europe, despite common features such as elongation, extension and symmetry of the cutting edge.

China represents a separate world to Southeast Asia, India or Africa as far as both raw materials and tool morphology are concerned (many unifacial heavy-duty tools made on pebbles and cobbles). The Chinese lithic assemblages form a heterogeneous entity of lithic industries, very different to the Indian Acheulean tools, which emerged around 1.5 Ma. They are mostly made on pebbles, with handaxes and abundant pebble tools (unifaces, picks, choppers, chopping-tools) (Hou et al., 2000; Lumley et al., 2008; Wang and Bae, 2014; Wang et al., 2014).

We can however see some similarities between China, the early sites of the North of Thailand, such as Sao Din or the Lampang sites with large sandstone and quartzite pebble tools. The Ban Don Mun (Lampang) pebble tools are clearly typologically closer to the Lower-Middle Pleistocene Chinese assemblages on pebbles than the Indian series. Apart from the dimensional factor, these massive unifaces are also close to the Bose assemblage in South China. These pebble tool assemblages from the Southeast Asian Mainland would thus mark continuity with the Chinese world and a rupture with Maritime Southeast Asia.

The "Movius Line" model (Movius, 1944, 1948, 1949), opposing "handaxe cultures" on the western side of India to "chopper-chopping-tool cultures" on the eastern side seems to be substantiated for China and for Mainland Southeast Asia (Thailand and Cambodia). However, it appears questionable for the Indonesian industries, owing to their originality and variability.

Occurrences of handaxes or cleavers no longer appear to be a relevant criterion for discussing the presence/absence of the Acheulean in Europe or in East Africa. These two tool types are rare or absent from all sites in East or Southeast Asia. Other evidence seems more relevant, such as the prevalence of abundant pebbles in a vast area of about 12 million km^2 (China and continental Southeast Asia) where shaping is predominantly unifacial on small or large blanks.

Unifacial shaping would have been adopted in various ways over this vast geographical area one million years ago. This technology persisted during the Late Upper Pleistocene and the beginning of the Holocene in Mainland Southeast Asia with the Hoabinhian, interpreted as a sort of "pebble-culture conservatism" (Forestier, 2000; Gorman, 1972; Heekeren et al., 1967; Heider, 1958; Higham, 2014; Marwick, 2007; Matthews, 1964; Moser, 2001; Schoocongdej, 2006; Zeitoun et al., 2008).

4. Conclusion

The bifacial phenomenon can be interpreted in many different ways depending on the researcher. The aim of this extensive analysis was to bring together researchers using various methodologies and terminologies, and to apply several experiences to specific Eurasian areas. This results in sections with personal points of view for each of the three papers, which are parts of a broader overview. These different degrees of analysis provide a new vision of assemblages with bifacial technology and enhance the debate on the origin and diffusion of this technology, as well as possible connections between the different areas.

The earliest currently known bifaces are found in East Africa. Africa is consequently the possible source of this technology at that time since the earliest dates in Eurasia are a little younger (see India at 1.5 Ma, new data in China at 1.5 Ma and the Levant at 1.4 Ma). Our purpose was not to debate the African data, as this is beyond the scope of these papers. We have rather focused on Eurasia and attempted to untangle the numerous hypotheses concerning these industries.

While the existence of bifacially shaped tools is a reality, should we necessarily assimilate the presence of such tools with a cultural phenomenon of global magnitude? Particularly when the abundant ethnological data show that tools can be invented in different places with no contact between them. Such independent invention is known as technological convergence (Leroi-Gourhan, 1973). Paradoxically, prehistorians are more inclined to use the concept of arrows linking artefacts that are *a priori* similar (Chevrier, 2012a). These "liaisons" are then interpreted from an anthropological viewpoint as evidence of migratory movements. This challenging situation implies that the material realities that we uncover are often shrouded in problems of perception.

The term "Acheulean" has at times been discarded for describing the earliest assemblages with bifaces outside Europe (from the Levant to the Far East), and replaced with terms such as "assemblages with bifaces", "with bifacial tools" or "pieces shaped by a partial bifacial retouch", although series with some bifaces and cleavers on flakes also occur in Europe. The hypothesis of a linear dispersal of the "Acheulean" is thus increasingly cast aside in favour of hypotheses such as convergence, replacement or reinvention.

A combination of shared and diversified features characterizes the bifacial component in Eurasia. The diversity of bifacial technology and blank types represents the main trend throughout time and space whereas the heavy-duty component exists in a limited number of types of forms or categories. Heavy-duty tools occur in all geographical areas but the frequency of handaxes and/or cleavers is generally low, apart from in some regions (Levant), and they can be made on flakes and/or cobbles/pebbles, siliceous stones or other materials, depending on the area. It seems to be widely accepted that bifacial technology became widespread from 800 to 700 ka, both for Europe and Asia, with some earlier occurrences in the Levant, China and India. It would be relatively simple to presume that bifacial technology first reached the Levant from Africa, before moving towards Asia, then Europe. However, the current record points to a much more complex situation, suggesting the presence of contemporaneous technological worlds with or without links between them, where some bifaces represent the addition of diverse functional areas and others are managed as a whole volume.

4.1. How to interpret the available data?

Must we consider that raw material diversity (quality, shape and size) and its careful selection could account for the observed diversity through adaptations of basic strategies?

This could explain the presence of more unifacial and crude heavy-duty tools in some areas and the capacity or opportunity to produce and use large flakes in others. That could also explain the occurrence of some bifacial bone tools and scrapers in some Italian sites (MIS 9), where similar reduction sequences to pebbles were applied. The use of bones for specific actions is suggested by Zutovski and Barkai (in press).

Must we consider that the diversity of the hominins associated with bifacial tools could explain the diverse technological strategies and morphological results?

According to some analyses, hominin diversity could account for the observed diversity. In the earliest Levantine sites, we observe *H. erectus* remains, followed by archaic *H. sapiens*, whereas in Europe, *H. heidelbergensis* precedes the Neandertal lineage. *H. antecessor* would thus be an archaic *H. sapiens*, the last common ancestor of *H. sapiens sapiens* and *H. sapiens neandertalensis*.

Must we consider that each area records a different history due to local influences, accessibility and possible connections with other areas in relation to fluctuating climates and sea levels?

This would explain the fact that bifaces are absent from some areas and that other areas reveal isolated histories (Zwyns et al., 2014 for Mongolia; Smith, 1986 and Bar-Yosef, 1994 for Iran; Vishnyatsky, 1999 for central Asia). Eurasia encompasses a wide range of topographic and climatic contexts (Bailey et al., 2011). These contexts were modified over time due to climatic variations, leading to sea level variations, and thus to new potential routes of migration or isolated geographical entities.

The occupation of India is considered to have occurred by coastal routes from the west, and could thus be considered to be within the sphere of Levantine bifacial technology (Pappu et al., 2011). This would not have been the case for China, which is more isolated from the rest of Eurasia or unattained by this technology. For the Indonesian archipelagos, sea level variations would have enabled successive waves of *H. erectus* to join new territories across land bridges, resulting in *in situ* technological evolution when isolated from the Mainland. The situation would have been much the same in China with technology based above all on thick heavy-duty tools on cobbles.

Must we consider that accumulative behavioural processes influenced by local backgrounds due to slow dispersals of populations or ideas through Europe or Asia could explain the specific nature of Chinese heavy-duty tools and the systematically low frequencies of bifaces and cleavers in the European series?

For Europe, the hypothesis of direct arrivals through the Levant or Gibraltar is still under discussion. The lack of data pointing to a local origin and the lack of elaborate bifaces for the earliest evidence suggest an introduction on a local core-and-flake industry (Mode 1) substratum. Various scenarios can be proposed for Southern and Northern Europe, whereas central Europe is a case apart (see Carbonell et al., in press). Slow dispersals of hominins or “know-how” could have come from the exterior, at times, due to favorable conditions (land bridges between the British Isles and the continent, changes in the herbivore guild or climatic cycles). These factors could explain the characteristics of the European lithic series, influenced by the Levant, where some traditions would have evolved on a local substratum, regardless of their origin (local or allochthonous). New discoveries in Greece (Galadinou et al., 2013) indicate a possible route along the Mediterranean coast, linking the Levant and Europe.

For the time being, data concerning latitudinal dispersals from Asia (and China) to Europe remain sparse, in spite of the description of some shared anatomical features by certain authors (Bermudez de Castro and Martinon-Torres, 2013). However, we have to keep in mind particular biface features, for instance at Bose, where “lingulate”-type tools could be considered as a micro-regional trait.

Current data show the variability of the bifacial phenomenon throughout Eurasia. Can we clearly infer from these data either a unique phenomenon with dispersals from an African source, or evidence of several onsets at different periods on a local substratum?

The palaeoanthropological background confirms the difficulties involved in describing and naming the rare hominin fossils and unequivocally relating specific taxa to bifacial technology.

In light of the current situation, each area must be analysed independently for the time being and new sites are required to enlarge the corpus. Apart from local onsets or dispersals of bifacial technology from one or several sources, many other phenomena could have occurred in Eurasia. Accumulative technological processes in some areas with gradual external influences on a local substratum could also, among others, explain the diversity of the strategies encountered in some areas. For instance, current data on early *H. sapiens* in Asia seem to show that certain features are related to the “tropical” belt, with the widespread use of plant materials. Perhaps we could consider that early hominin adaptation to a tropical world could have led to a decrease in technological complexity or choices and the adoption of other technical skills to produce the heavy-duty stone tool component?

It is thus impossible to emit a general conclusion and propose a single model, due to the small number of sites with reliable data, the paucity of bifacial tools at most sites, the diversity of situations (types of sites, raw material availability), and the scarcity of data relating to on-site activities, especially for the Asian corpus.

Acknowledgements

These analyses were carried out as part of an “Action thématique du Muséum” (ATM), Paris, France, focusing on “Acheulean” behaviours. The English version was edited by Louise Byrne, official translator.

We would like to thank the three reviewers and Amélie Vialet, the editor, for their relevant and constructive comments, which helped us to improve the papers.

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