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A Comparative Look at Technical Traditions in the Horn of Africa and the Nile Valley at the End of the Pleistocene

Regards croisés sur les traditions techniques dans la Corne de l'Afrique et dans la vallée du Nil à la fin du Pléistocène

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Abstract: Today, the Horn of Africa and north-eastern Africa are connected geographically by the Nile and its tributaries, several of which originate in the Horn. This connectivity evolved over the course of the Pleistocene and despite its potentially central role in the dispersal of humans within and out of Africa, the interactions between human groups of the two regions remain poorly understood. Indeed, archaeological data from these two regions are seldom compared – particularly those that concern the end of the Pleistocene between 60000 and 15000 BP (covering Marine Isotopic Stages 3 and 2).

The archaeological data from this period are generally associated with the end of the Middle Stone Age (MSA)-Middle Palaeolithic (MP) or the Late Stone Age (LSA)-Upper Palaeolithic (UP). The dynamics of the transition between these periods remain poorly defined and as broad entities, they exhibit a great deal of technical variability. Furthermore, the period was a time of great climatic variability characterised by a general tendency towards aridification (the 'Big Dry'), punctuated by irregular periods of humidity. This climatic variability and its diverse regional environmental responses across the eastern part of the African continent may have posed major adaptive challenges to human populations.

This paper aims to examine the lithic variability documented for the end of the Pleistocene in both the Horn of Africa and north-eastern Africa, with a particular focus on technological change that occurred in the context of the MSA-MP/LSA-UP-LP transition and in relation to the variability within the LSA-UP-LP. The main trends are then compared between the two regions, allowing us to evaluate the presence of possible parallel techno-cultural trajectories in both regions.
Keywords: Horn of Africa, Nile valley, Late Pleistocene, lithic technology, transition.

Résumé : La Corne de l'Afrique et l'Afrique du Nord-Est présentent de nos jours un lien géographique naturelle le long du Nil et de ses affluents, plusieurs sources du Nil étant localisées dans la Corne. Cette connectivité a évolué tout au long du Pléistocène, et ses conséquences sur les interactions possibles entre les groupes humains de ces deux régions restent mal connues, malgré le rôle central de ces régions dans les questions de dispersion humaine au sein et hors d'Afrique. En effet, les données archéologiques issues de ces deux régions sont rarement comparées, surtout pour la période de la fin du Pléistocène, entre 60000 et 15000 BP (stades isotopiques marins 3 et 2).

Les données archéologiques de cette période sont généralement attribuées à la fin du Middle Stone Age (MSA)-Paléolithique moyen (PM) ou au Later Stone Age (LSA)-Paléolithique supérieur (PS). Les modalités des transitions MSA-MP/LSA-PS restent encore peu définies, et ces deux entités incluent une grande diversité technique. En outre, cette période correspond à une grande variabilité climatique caractérisée par une tendance générale vers une aridification du climat (« the Big Dry ») ponctuée irrégulièrement de périodes

plus humides. Cette variabilité climatique se traduit par des réponses environnementales différentes d'une région à l'autre, ce qui a probablement posé des défis d'adaptation importants pour les populations humaines de cette époque.
Cet article a pour objectif d'examiner la variabilité lithique de la fin du Pléistocène au sein de la Corne de l'Afrique d'une part et de l'Afrique du Nord-Est d'autre part, en portant une attention particulière aux changements technologiques dans le cadre des transitions MSA-PM/LSA-PS et de la variabilité au sein du LSA-PS. Les principales tendances identifiées seront ensuite comparées entre les deux régions, ces « regards croisés » nous permettons d'évaluer la présence d'éventuelles trajectoires technoculturelles parallèles aux deux régions.
Mots-clés : Corne de l'Afrique, vallée du Nil, Pléistocène récent, technologie lithique, transition.

1. INTRODUCTION

While the African continent occupies an important place in research on the origins and development of *Homo sapiens* during the second part of the Middle Pleistocene and the beginning of the Upper Pleistocene, the more recent prehistory of this continent, from 70 kya, remains comparatively little studied. This period is nonetheless key in the history of human evolution, constituting a major phase in the shaping of diversity in modern humans both at the biological and cultural level (see for example Mirazón Lahr, 2016; Pagani and Crevecoeur, 2019). The ANR Big Dry project (ANR-14-CE31-0023; Bon et al., this volume) was conceived and carried out in order to compensate for the lack of data relating to this period through an emphasis on eastern Africa, which occupies a key position in the population dynamics of *Homo sapiens* both within and outside of the continent (Molinaro and Pagani, 2018). In particular, the Horn of Africa (Ethiopia, Eritrea, Somalia, Somaliland and Djibouti) and north-eastern Africa (Egypt and Sudan; particularly those regions within the Nile Valley) exhibit a natural geographical connectedness along the Nile and its tributaries, many of which originate in the Horn (fig. 1). Despite the importance of identifying this spatial relationship within the archaeological data, particularly that pertaining to the period during which *Homo sapiens* dispersed out of Africa, the field data from these regions has rarely been compared. In particular, the question remains open as to whether this geographical link, and its development alongside the pronounced climatic shifts at the end of the Pleistocene, finds echoes within the cultural production of the populations of these regions.

Indeed, the Horn has most often been lumped in with regional studies of eastern Africa, in spite of the mounting evidence that speaks against the homogeneity of data from this large region, in particular between the Horn of Africa and the Great Lakes area of the Rift Valley (Leplongeon et al., 2020b; here: fig. 1). The act of comparing the recent Pleistocene prehistory of the Horn of Africa and of the Nile Valley, as intuitive as it may seem, is not without difficulty. Indeed, different research traditions have presided over the study of these two regions and guided the collection of diverse archaeological data, thus making any direct comparisons difficult even if only by the use of differing nomenclatures.

In order to approach this challenge, the first part of this article consists of a synthesis of the archaeological documentation for each of these regions at the end of the Pleistocene and particularly for the period between 70 and 15 kya, taking into account new field data collected in the context of the ANR Big Dry project. Building on this foundation, the second part of the article aims to propose a series of comparisons related to the cultural trajectories observed in the Horn of Africa and north-eastern Africa, taking into account the strongly-contrasting paleo-environmental contexts of the two regions.

1.1. General palaeo-climatic context

The period in question stretches from the Marine Isotopic Stage (MIS) 4 to the beginning of MIS 1 (71-15 kya) and therefore overlaps significantly with the last glacial period. Although generally arid, this period is also characterised by strong climatic oscillations. MIS 4 and 3, for example, appear to have been punctuated by humid episodes, specifically at the beginning of MIS 4 and around 55-50 kya in eastern Africa, as well as around 45-35 kya in northern Africa (Blome et al., 2012). MIS 2, sometimes known as the 'Big Dry', encompasses notably the Last Glacial Maximum (LGM; ~ 23-19 kya; Waelbroeck et al., 2009). This was generally an arid period in eastern Africa, although it was straddled on both sides of the LGM – before 24 kya and after 18-16 kya – by more humid episodes (Gasse et al., 2008). The drying up of multiple East African lakes around ~ 16-17 kya, such as Lake Victoria (Stager et al., 2002) and Lake Tana (Lamb et al., 2007 and 2018) among others, had significant consequences on the flow and course of the White Nile, which almost completely dried up during parts of the year, and on the Blue Nile, which became a river with significant seasonality and a greatly-reduced flow (Williams, 2019 and 2020). These conditions contrast strongly with the environmental conditions of MIS 5, characterised by the formation of a mega-lake (> 45000 km^2) on the White Nile from 110 kya onwards (Barrows et al., 2014). Despite the prevalence of more humid conditions at the beginning of MIS 2, as witnessed by the replenishing of subterranean waters in the eastern Sahara, North-eastern Africa is characterised by an even more arid (hyper-arid) climate during MIS 2, particularly during the LGM (Pachur and Hoelzmann, 1991; Abouelmagd et al., 2014).

In contrast, the end of MIS 2 and the beginning of MIS 1 coincide with the beginning of the African Humid Period (AHP; DeMenocal et al., 2000), marked by a distinct rise in precipitation in eastern Africa that allowed

Fig. 1 – Map of the region considered in the paper, showing the geographical extension of the Nile Basin (after Williams, 2019, fig. 1) and Nubia (Auenmüller, 2019). Produced on QGIS v. 3.15 (QGIS Development Team, 2017) and Natural Earth Data. For site names, refer to figures 2 and 6 captions.

***Fig. 1 –** Carte de la région étudiée dans l'article, montrant l'extension géographique du bassin du Nil (d'après Williams, 2019, fig. 1) et de la Nubie (Auenmüller, 2019). Document créé avec QGIS v. 3.15 (QGIS Development Team, 2017) et Natural Earth Data. Pour les noms des sites, voir légendes des figures 2 et 6.*

the reconnection of the White Nile with the Lake Victoria basin (Williams et al., 2006) and led to major flooding episodes on the Nile. However, the AHP is not a uniform and synchronous entity across the continent. North-eastern Africa for example exhibited an extremely arid climate until around 12-11 kya (Kuper and Kröpelin, 2006; also see discussion in Williams, 2019, p. 105).

This brief summary underlines the significant climatic and environmental variability in both time and space for these two regions. Our comparison will therefore aim to discern the ways in which these variations affected human populations in these areas by reflecting on potential complementarities between them during certain periods and, by contrast, if these two regions witnessed the development of distinct adaptation strategies in order to deal with different environmental challenges.

1.2. General techno-cultural context

Archaeological sites dated to the period between 70 and 15 kya testify to a significant diversity in their lithic assemblages, commonly categorised as Middle Palaeolithic (MP) or Middle Stone Age (MSA) at the beginning of the period, and Upper Palaeolithic (UP), Late Palaeolithic (LP) or Late Stone Age (LSA) at its end. While Palaeolithic (LP, MP, UP) terminology is used in north-eastern Africa, Stone Age terminology (MSA, LSA) is used in the Horn. The MP-MSA is broadly characterised by the use of a variety of core reduction methods, often aimed at exploiting core surfaces (such as the Levallois and Discoidal methods) for the production of flakes, and in certain cases blades and points. The primary retouched tools are retouched or shaped points, as well as scrapers. The LSA in the Horn is most often defined by the production of blades and bladelets associated with a miniaturisation of the toolkit. Backed tools frequently occupy an important place within assemblages, occasionally forming geometric shapes (such as segments). Burins as both tools and cores are equally common. In the Nile Valley, the UP is characterised instead by volumetric blade core reduction associated with a toolkit consisting primarily of retouched blades, whereas the LP may be distinguished on the basis of its bladelet production, often transformed into backed pieces, which are often retouched into geometrics.

Whatever terminology is used (MSA-LSA or MP-UP/LP), the Horn of Africa and the Nile Valley are sites of major technological transformations during the period between 70 kya and 15 kya.

1.3. Clarification of definitions

The MSA-MP is generally considered to stretch from 300 kya to 50 kya or even as late as 30 kya and up to the Holocene (e.g. Scerri et al., 2021). The LSA-UP extends from 50-30 kya up to the Holocene. The limits (both chronological and technological) between these different phases of the Palaeolithic are sometimes blurry. This is partly due to ambiguities that arise when dealing with the transition between the MSA-MP and the LSA-UP as they are far from being abrupt or clean-cut. The starkest case is that of blade production industries at the end of the Pleistocene and the decision to consider them indicators of either the MSA-MP or the LSA-UP. This choice seems to mainly have its origins in the research histories of both regions. It is therefore pertinent to ask whether industries attributed to the MSA-MP by certain researchers would not be attributed to the LSA-UP by others and vice versa. In such a situation, it is important to go back to the definitions of core reduction methods, in particular the Levallois concept.

The Levallois concept has traditionally been seen as emblematic of the MSA-MP while displaying a wide technical diversity, notably through Levallois blade production. According to É. Boëda (1994 and 1995), Levallois core reduction is defined as a particular way of managing the volume of the core and its convexities involving hard-hammer and direct percussion, and resulting in predetermined removals of various shapes and sizes according to two broad modalities: preferential and recurrent. The Levallois concept is seen in cores composed of two opposing surfaces that are convex asymmetrical and hierarchized, with one side acting as the striking surface and the other as the production surface. The pieces are knapped along an axis parallel to the intersection of the two surfaces, making use of a striking platform whose preparation makes it perpendicular to the intersection of the surfaces. With the exception of Levallois *débordant* products linked to the management of lateral convexities, the Levallois concept as defined by É. Boëda (1994 and 1995) does not allow for the exploitation of the intersection of the core surfaces. This specification in the definition is fundamental for distinguishing between productions designed following a planimetric conception of core reduction (for example Levallois methods, planimetric in the sense of Van Peer et al., 2010) and those produced following a volumetric conception of core reduction organised around highly semi-circular geometries. This volumetric conception of core reduction is distinguished from the Levallois conception by virtue of its exploitation of a volume, implying the use of the total perimeter of the core whose production capacity is in theory equal to its volume. The so-called planimetric core reduction process (such as the Levallois) is rather limited to the productive exploitation of only one surface of the core (Boëda, 1990; Delagnes and Meignen, 2006). The distinction between these two conceptions – planimetric (or surface) and volumetric – is particularly meaningful to our perception of the evolution of lithic production between 70 kya and 15 kya, and therefore we make careful note of it in the following synthesis.

2. THE END OF THE PLEISTOCENE IN THE HORN OF AFRICA

The archaeological record in the Horn of Africa for the end of the Middle Pleistocene and Upper Pleistocene, i.e. from the MSA to the emergence of the LSA, exhibits numerous asynchronicities and local specificities in cultural expression, as well as data of varying quality. Furthermore, most known sites are concentrated primarily within the Ethiopian Rift Valley system and its immediate vicinity, leaving large areas of the Horn of Africa unexplored (fig. 2). Nevertheless, this synthesis will adopt a malleable chronological and technical framework so as to better explain the techno-cultural processes at work at the end of the Pleistocene on the basis of the most reliable data.

2.1. Emergence and decline of MSA technical traditions: transitions with permeable borders

A number of important sites in Ethiopia show that the MSA had already fully developed within the Horn of Africa before ~ 279 kya (Gademotta ETH-72-8B: Morgan and Renne, 2008) and more broadly towards the end of the Middle Pleistocene (KHS and AHS in Kibish: Shea, 2008; Kulkuletti ETH-72-1 and Gademotta ETH-72-7B: Wendorf and Schild, 1974; Garba III: Mussi et al., 2014). Although poorly studied, the oldest technologies already exhibiting basic MSA characteristics can be seen much earlier, around 500 kya (Brooks et al., 2018; Sánchez-Dehesa Galán, 2020). *Homo sapiens* remains have also been recovered from deposits dated to the end of the Middle Pleistocene, min. 233 ± 22 kya (Kibish: McDougall et al., 2005 and 2008; recently redated in Vidal et al., 2022) and ~ 160 kya (Herto: Clark et al., 2003). These were considered to be the oldest in Africa until the individuals found at Jebel Irhoud in Morocco were dated to around ~ 300 kya (Hublin et al., 2017; Richter et al., 2017). However, in addition to these early sites with typical MSA industries, other Ethiopian sites have produced Acheulean industries with quite recent dates for this period, such as at Mieso (~ 200 kya, De la Torre et al., 2014), as well as industries exhibiting a combination of Acheulean and MSA characteristics, such as at Herto (~ 160 kya, Clark et al., 2003; Sahle et al., 2019). These assemblages recall the inter-stratification of MSA (Sangoan) and Acheulean industries dated between ~ 220 et ~ 150 kya at Sai Island (site 8-B-11) in the Nile Valley (Van Peer et al., 2003 and

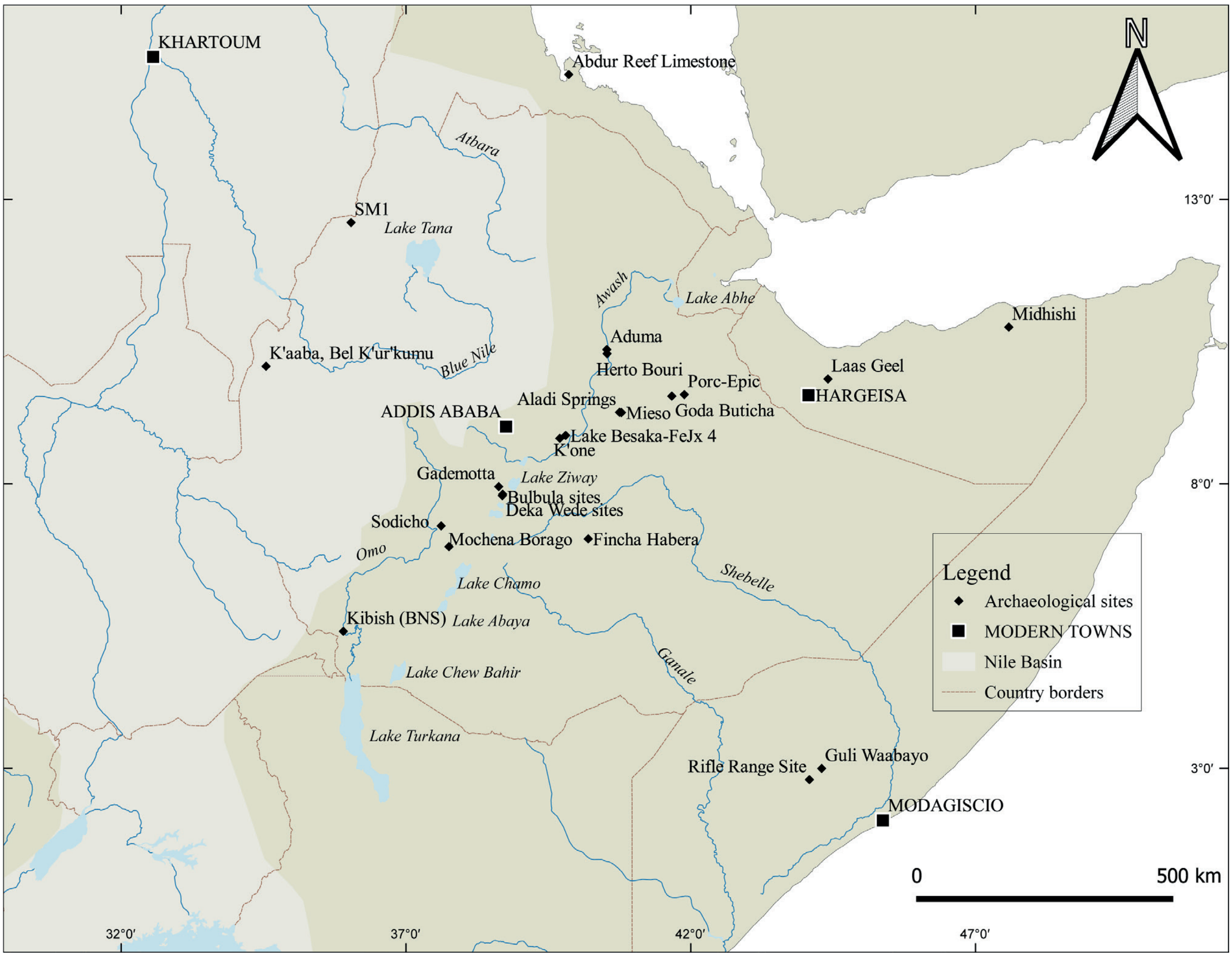

Fig. 2 – Map of the Horn of Africa (extension of the Nile Basin after Williams, 2019, fig. 1): Location of main sites mentioned in the text. Produced on QGIS v. 3.15 (QGIS Development Team, 2017) and Natural Earth Data.

***Fig. 2 –** Carte de la Corne de l'Afrique (extension géographique du bassin du Nil d'après Williams, 2019, fig. 1) : localisation des principaux sites mentionnés dans le texte. Document créé avec QGIS v. 3.15 (QGIS Development Team, 2017) et Natural Earth Data.*

2004). The beginnings of the MSA towards the end of the Middle Pleistocene cannot therefore be seen as an abrupt and widespread technical change in the Horn of Africa. Rather, it must be seen as a gradual, asynchronous and patchy emergence over nearly 150 thousand years, during a time when the Acheulean was still predominant in certain areas.

The acceleration of the climatic oscillations and the increase in their amplitude from 500 kya onwards are often arguments to explain the cognitive and biological evolution of the genus *Homo* at the Acheulean-MSA transition, and during the course of the Middle Pleistocene as they adapted their ways of life to rapid and unpredictable environmental changes (Brooks et al., 2018; Potts et al., 2018; Scerri et al., 2018). In line with these hypotheses that place an emphasis on climatic variation as a motor for change, Brandt and colleagues (2017) suggest that the particularly cold and arid conditions of MIS 4 would have triggered a restructuring of the technical sphere as well as that of mobility, communication and group organisation. It is therefore possible that during the Upper Pleistocene, marked by the last glacial period (~ 110-15 kya), we may find the beginnings of changes leading to the decline of the MSA, which by the end of the LGM had given way completely to the LSA in the Horn of Africa.

At both the beginning or end of the MSA it seems that techno-cultural changes, which themselves may or may not have been shaped by environmental conditions, were the result of gradual complex and permeable processes as opposed to clear ruptures. While the full development of LSA technologies is already evident from the beginning of MIS 1 – with industries based on the production of blades, bladelets, burins and backed pieces – it seems that they must have partially co-existed with Late MSA technical traditions particularly visible in the use of Levallois methods and the presence of points, in some cases until the Holocene. However, the mixed MSA/LSA character of several of these industries from the Late Pleistocene and Early Holocene, often described as being transitional, should be considered in light of the often-unreliable contexts in which they were recovered and that may point to stratigraphic mixing between MSA and LSA layers. Despite their recurrence, it is therefore not proven beyond a doubt that the MSA/LSA transition can be characterised by such a techno-cultural form, or at least not uniformly across the Horn of Africa.

Going back further in time, the available MIS 3 site corpus for the region may well indicate local evolutions towards the new technologies of the LSA along heterogeneous trajectories. For this reason, it is unrealistic to expect a single model for the MSA/LSA transition for the whole of the Horn of Africa. Finally, the definitions of the MSA and LSA, simultaneously static at high resolution and imprecise at a more granular resolution, present an additional difficulty in discerning the transition mechanisms at the end of the Pleistocene. It is therefore necessary here to return to the available data in order to better contextualise this question.

2.2. Chronology and technologies of the MSA between MIS 5 and MIS 3

Any account of the human techno-cultural dynamics at the end of the Pleistocene in the Horn of Africa must consider the available data since MIS 5 (~ 130-71 kya), given the considerable number of sites attributed to the Upper Pleistocene that have not been precisely dated, as well as the processes of change that seem to have occurred over the *longue durée*. In general, comparisons made at the scale of the whole of eastern Africa show that the MSA in the Upper Pleistocene (also known as the Late MSA) is marked by a diversification of assemblage compositions and by the occupation by populations occupying more contrasting environments than during MIS 5 (Basell, 2008; Tryon and Faith, 2013; Blinkhorn and Grove, 2018). As an example, the oldest MSA coastal site in the Horn of Africa, Abdur Reef Limestone in Eritrea, is also dated to the beginning of MIS 5, at 125 ± 17 kya (Bruggemann et al., 2004).

MIS 5 in Ethiopia is represented by a series of open-air sites such as BNS (Bird's Nest Site), the most recent of the Kibish Formation, dated to 104 ± 1 kya (McDougall et al., 2005; Yellen et al., 2005). F. H. Brown and colleagues (2012) propose a correlation between the Aliyo Tuff of Member II of the Kibish Formation, dated to 104 ± 1 kya, and the tuff composing Unit 15 of Gademotta that directly covers the site ETH-72-6 (Wendorf and Schild, 1974). This correlation would place ETH-72-6 in MIS 5, despite a *terminus post quem* of ~ 183 kya (Morgan and Renne, 2008). In the Middle Awash, MSA assemblages contained in the Faro Daba Beds of the Halibee Member have an age constrained between ~ 106 and ~ 96 kyr, using $U/^{230}Th$ burial dating of ostrich eggshell (OES; Niespolo et al., 2021). Uranium-Thorium dates from OES fragments at the site of SM1 in north-western Ethiopia, located along one of the main tributaries of the Blue Nile (the River Shinfa), provide an average date of around 75 kya, though the archaeological data are not yet published (Davis, 2019; Loewy et al., 2020).

A number of other sites may have an age that would place them towards the end of MIS 5 but that could equally be more recent, and are more generally considered to be Late MSA. One of these sites is A5 in the Aduma complex in the Middle Awash, which has an early date around ~ 90 kya obtained from the underlying sediments of Ardu B (Yellen et al., 2005). Another site, ETH-72-5 at Gademotta, is situated above Unit 15 already mentioned as dating to 104 ± 1 kya (Wendorf and Schild, 1974; Brown et al., 2012). The important site of Porc-Épic has provided only contradictory and unsatisfying dates, with estimations ranging between 75 and 61 kya (Michels and Marean, 1984), while other estimations place some MSA layers at the site around 50 kya (Yokoyama and Falgueres, unpublished but cited in Leplongeon, 2014) or between 40-25 kya (Assefa, 2006). This site exhibits a long sequence with MSA levels that could be attributed to either MIS 5, 4, or 3. The same goes for the site of K'one locality 5 extension, characterised by the Levallois method of Nubian type, whose date of MIS 4 was estimated purely on the basis of sedimentological arguments that correlated the silts in which the artefacts had been recovered to an arid phase of the Upper Pleistocene (Kurashina, 1978; Brandt, 1986). In the upper part of the MSA levels in the cave of Midhishi 2, in Somaliland, a piece of charcoal produced a date of > 40 kya lying beyond the limit of the radiocarbon method, and indicating a minimal age during MIS 3 but which may in fact be much older (Brandt, 1986).

Archaeological data from the region corresponding to MIS 4 are practically non-existent. The Ethiopian site of Goda Buticha is one of the only sites to have yielded an absolute date that may be related to MIS 4. The date of around 63 ± 7 kya comes from the OSL dating of sediments from layer IIf at the bottom of the long sedimentary and archaeological sequence of the site (Tribolo et al., 2017). Nevertheless, the archaeological material unearthed in this layer was grouped together with the almost identical material from layers IIe and IId, dated respectively to 43 ± 5 kya and 24.8 ± 2.6 kya. This ensemble IId-IIf can therefore be attributed to the period between ~ 63 kya and ~ 25 kya, centered primarily on MIS 3 (Leplongeon, 2013; Leplongeon et al., 2017; here: fig. 3, no. 6). Similarly, the high-altitude site of Mochena Borago, located further south in Ethiopia, has produced MIS 3 industries in the Block Excavation Area dated between > 49 kya BP and ~ 36 kya cal. BP (Brandt et al., 2017; here: fig. 3, nos. 1-5). Even further to the south, another high-altitude site located at nearly 3,500 m above sea level, known as Fincha Habera, has delivered dates between ~ 47 kya and ~ 31 kya, corresponding to the end of MIS 3 (Ossendorf et al., 2019). Similar dates have been proposed for a series of open-air sites located in the Ziway-Shala basin in central Ethiopia (Deka Wede 1, Deka Wede 4, Bulbula 1 sector 3, Bulbula 4) that lie atop a layer dating to ~ 45-43 kya cal BP, thus attributed to the end of MIS 3 (Ménard and Bon, 2023). However, the only directly-dated site is that of Deka Wede 1 (DW1), for which two charcoal have produced dates between ~ 34 kya cal BP and 31 kya cal BP (Ménard et al., 2014, Douze et al., in prep.). In the Middle Awash, assemblages contained in the Wallia beds of the Halibee members have dates comprised between ~ 31-32 kyr and are attributed to the LSA, but their characteristics are not yet fully published (Niespolo et al., 2021). Finally, in the Rift Valley in southern Ethiopia, close to the Kenyan border, renewed excavations in the Gotera zone (Chavaillon and Chavaillon, 1985) may indicate the presence of sites attributed to MIS 4-3 (E. Spinapolice, pers. comm.; Fusco et al, 2021).

From a technological point of view, with the possible exception of the LSA in the Middle Awash, all lithic assemblages recovered between MIS 5 and MIS 3 can be considered fully MSA. They exhibit characteristics that were recurrent throughout the period (and that were already present from at least MIS 8), and that were employed in a variable manner by knappers at different sites. These characteristics are the use of Levallois methods following various modalities, the occasional use of the Discoid method and, to a lesser extent, the implementation of a volumetric conception of core reduction. The objectives of the core reduction were primarily the production of flakes, but also of blades and points in various proportions and dimensions, some of which exhibit miniature dimensions (< 3 cm). Late MSA sites demonstrate the growing significance of blade production from both bidirectional opposed and unidirectional cores according either to a planimetric conception – as seen for instance at the Ziway-Shala MIS 3 sites (fig. 4) – or a volumetric conception. There is a wide range of retouched tools from the MSA in the Horn of Africa. Best represented are shaped or retouched points (unifacial, partly-bifacial or bifacial) that vary strongly in both morphology and typology (and probably function), as well as various types of scrapers made on diverse blanks, few end-scrapers, notched pieces and borers. Given that only one backed piece was discovered within the MSA levels of Goda Buticha (levels IId-IIf) as well as several fragments of backed tools at Mochena Borago (T-Group), it is difficult to draw any conclusions about the importance of this type of retouched tool in the context of MIS 3 (Brandt et al., 2017; Leplongeon et al., 2020a).

Further characteristics of these Late MSA industries are visible on a more local level. In south-eastern Ethiopia for instance, the sites of Porc-Épic and Goda Buticha exhibit almost no evidence for the production of unretouched points and instead a preponderance of retouched points of highly-diversified typologies (Perlès, 1974; Pleurdeau, 2005 and 2004; Leplongeon, 2013; Leplongeon et al., 2017; here: fig. 3, no. 6). This contrasts strongly with K'one locality 5 extension, located in the north of the Main Ethiopian Rift, where Nubian Levallois methods for the production of technological points dominate. The sites of Mochena Borago and Fincha Habera in southern Ethiopia show evidence for bipolar-on-anvil production on small obsidian blocks within the assemblages (Brandt et al., 2012 and 2017; Ossendorf et al., 2019; here: fig. 3, no. 4), a feature poorly documented in other areas. Similarly, the production of flakes of small dimensions (≤ 3 cm) at the site of Aduma 5, in the Middle Awash, is claimed to be a local variation and led to the introduction of new terminology such as "micro-Levallois" and "micro-Aduma" core types (Yellen et al., 2005). Finally, the Ziway-Shala MIS 3 sites are characterised by bidirectional opposed recurrent Levallois core reduction for blade, elongated flake and point production, showing very finely-crafted faceting of the striking platforms, as well as large pieces with convergent edges with inverse basal thinning (Ménard et al., 2014).

This mosaic of technological specificities draws on a common source and seems to exhibit local cultural adaptations of the MSA that can be identified in geographically-distinct zones dispersed across the Horn of Africa at both individual sites and in local groupings. Despite the difficulty of assessing the chronological relations between sites in certain cases, the idea that environmental conditions played a role in these local expressions finds an echo in the "kaleidoscope of palaeoenvironments"

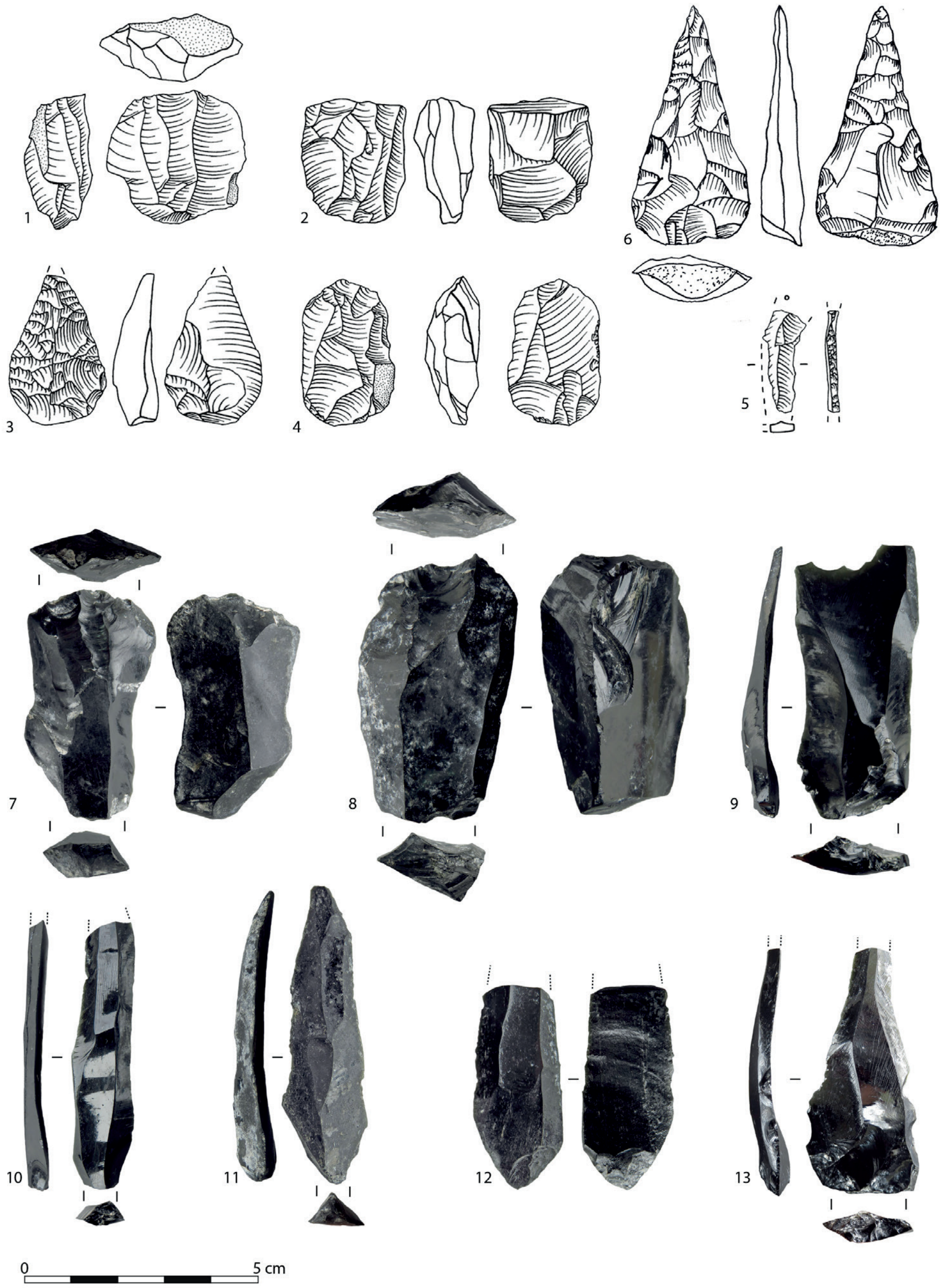

Fig. 3 – Examples of artifacts from MIS 3 sites from the Horn of Africa. 1: Double platform core, Mochena Borago, Goup-S (drawing and terminology after Brandt et al., 2012); 2: Multiplatform core, Mochena Borago, Group-T (drawing and terminology after Brandt et al., 2012); 3: Partly-bifacial point, Mochena Borago, Group-T (drawing and terminology after Brandt et al., 2012); 4: Bipolar core, Mochena Borago, Group-S (drawing and terminology after Brandt et al., 2012); 5: Backed piece, Mochena Borago, Group-T (drawing and terminology after Brandt et al., 2012); 6: Bifacial point, Goda Buticha, layers IId IIf (drawing A. Leplongeon); 7-8: Bidirectional cores on flake, Deka Wede 4 (photos K. Douze); 9: Bidirectional elongated flake, Deka Wede 4 (photo K. Douze); 10-11: Blades, Deka Wede 4 (photos K. Douze); 12: Retouched tool with basal thinning, Deka Wede 4 (photo K. Douze); 13: Convergent bidirectional flake, Deka Wede 4 (photo K. Douze). All in obsidian except no. 6 in flint.

***Fig. 3 –** Exemples d'artefacts découverts dans des sites MIS 3 de la Corne de l'Afrique. 1 : Nucléus à double plan de frappe, Mochena Borago, Goup-S (dessin et terminologie d'après Brandt* et al., *2012) ; 2 : nucléus à multiples plans de frappe, Mochena Borago, Group-T (dessin et terminologie d'après Brandt* et al., *2012) ; 3 : pointe parti-bifaciale, Mochena Borago, Group-T (dessin et terminologie d'après Brandt* et al., *2012) ; 4 : nucléus bipolaire sur enclume, Mochena Borago, Group-S (dessin et terminologie d'après Brandt* et al., *2012) ; 5 : pièce à dos, Mochena Borago, Group-T (dessin et terminologie d'après Brandt* et al., *2012) ; 6 : pointe bifaciale, Goda Buticha couches IId IIf (dessin A. Leplongeon) ; 7-8 : nucléus bidirectionnels sur éclat, Deka Wede 4 (clichés K. Douze) ; 9 : éclat allongé bidirectionnel, Deka Wede 4 (cliché K. Douze) ; 10-11 : lames, Deka Wede 4 (clichés K. Douze) ; 12 : outil retouché à amincissement basal, Deka Wede 4 (cliché K. Douze) ; 13 : éclat convergent bidirectionnel, Deka Wede 4 (cliché K. Douze).*
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described by M. Pickford (2009) to characterise the eastern African Rift and its surrounding area. Over the course of the Upper Pleistocene, given the relentless degradation of climatic conditions – in particular from MIS 4 onwards – the Horn would have offered a diversity of habitats in limited spaces that may have encouraged local adaptations. In this context, the range of geological zones occupied (Asrat et al., 2008), from the Rift floor shaped by intense volcanic activity (the sites of Ziway-Shala) to the Jurassic limestone cliffs at the junction of the Somalian plateau and the Afar (Goda Buticha, Porc-Épic) and to the silicic mountains of the rift escarpments (Mochena Borago, Fincha Habera), is without doubt partly responsible for the diversity of technical behaviours observed, in addition to the various locally available and dominant raw materials (for example Pleurdeau, 2005; Ossendorf et al., 2019; Fusco et al., 2021).

Whereas all MSA sites dating to the end of the Middle Pleistocene, and certainly most of those from MIS 5, are open-air settlements, numerous sites dating to MIS 4/3 and MIS 3 are cave and shelter occupations, occasionally located in high-altitude zones (> 2000 m). These latter sites offer a range of vertically-distributed ecozones favourable to occupation by small groups of hunter-gatherers, and do not require seasonal movements over long distances (Vogelsang and Wendt, 2018; Ossendorf et al., 2019). In the same way, lakeshores also functioned as "magnets for occupation" during the MSA. It was the case in the endorheic basin of Ziway-Shala, which despite its low water level during MIS 3 nonetheless experienced a period of landscape stabilisation with occupations concentrated on the basin floor, riverbanks or on canyon slopes (Bon et al., 2013; Ménard et al., 2014). While the Horn of Africa – and in particular the Rift Valley – may be perceived as a favourable context for human expansion, the archaeological record in the area as it appears now, suggests a series of isolated occupations over long periods of time.

2.3. MIS 2 and the question of MSA/LSA transitional industries

The MIS 2, as recorded for example in the lake sediments of Chew Bahir in Ethiopia, contained periods of (hyper-)aridity and perhaps more importantly episodes of rapid and relatively abrupt arid-humid oscillation (Trauth et al., 2019). The impact of these particular MIS 2 climatic and environmental conditions on human populations remains difficult to evaluate due to the lack of archaeological data from this period. Furthermore, several site sequences are characterised by a sedimentary hiatus corresponding to this period (Goda Buticha and Mochena Borago: Pleurdeau et al., 2014; Brandt et al., 2017; Tribolo et al., 2017). The hypothesis in which the mountainous plateaux of south-western Ethiopia acted as a refuge for human populations during this period (Brandt et al., 2012; Foerster et al., 2015, p. 337) has recently been the subject of renewed attention. On the one hand, the stratigraphic sequence of Mochena Borago (situated around 2,200 m a.s.l on Mount Damota) does

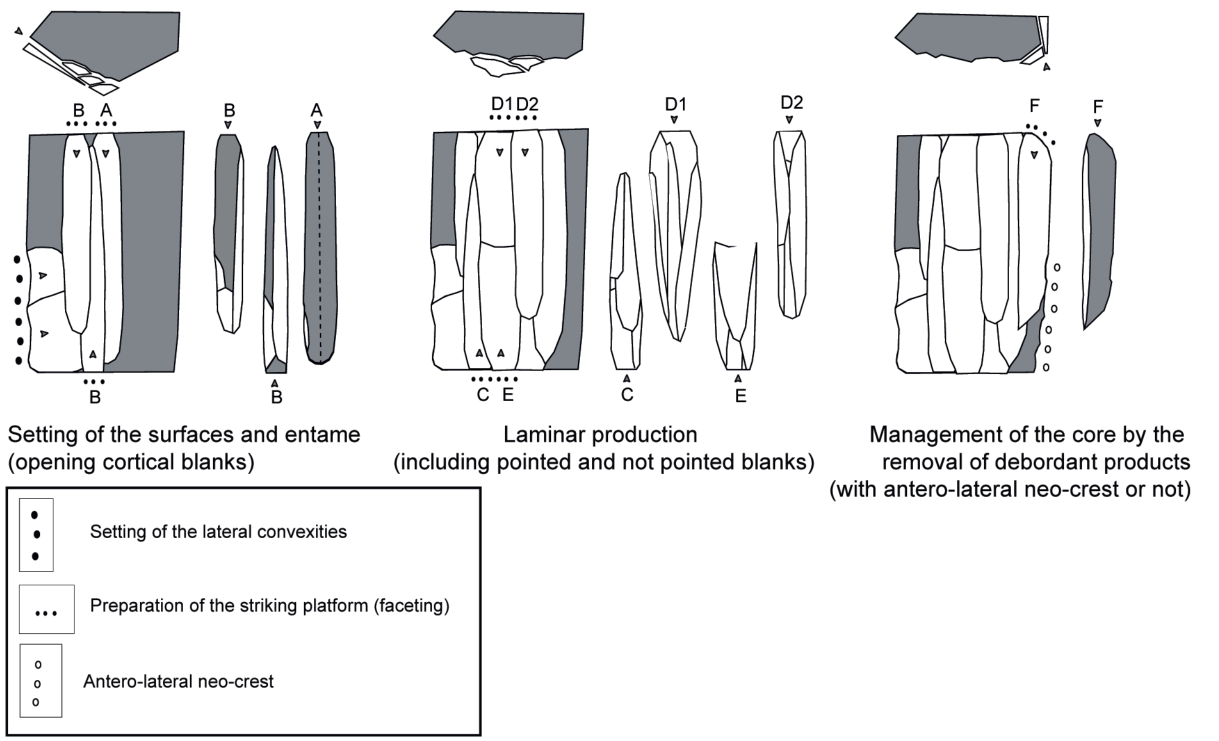

Fig. 4 – Operation scheme for blade production at the MIS 3 sites of B1s3 et DW1, Ziway-Shala basin (Ménard et al., 2014; CAD C. Ménard).

***Fig. 4** – Schéma opératoire de production luminaire à B1s3 et DW1, sites MIS 3 du bassin de Ziway-Shala (Ménard* et al., *2014 ; DAO C. Ménard).*

not exhibit any MIS 2 level (Brandt et al., 2017). On the other hand, Sodicho Rock Shelter located around 40 km from Mochena Borago at 1,900 m altitude a.s.l. exhibits a long stratigraphic sequence dating to MIS 2 and associated with human occupations, from which the material is currently in the process of being published (Hensel et al., 2019 and 2021). The sedimentary data from the site of Sodicho suggests an occupation of the site when arid conditions are documented in the region, supporting the environmental refugium hypothesis during MIS 2 for at least one part of the mountainous plateaux of south-western Ethiopia. In contrast, the sedimentary sequence at the site from 17 kya cal. BP testifies to more humid conditions that could be correlated to the AHP, and which correspond largely with sterile archaeological units, suggesting an abandonment of the site by humans.

Between the industries that come before and after MIS 2 there are significant technical changes. The underlying question is the one of the emergence of the LSA in the Horn of Africa, which seems to occur relatively late (during the MIS 2) in this region. It is therefore important to identify if the changes linked to this emergence, particularly technical ones, appear in rupture or in continuity with the MSA. From the mid-twentieth century, it was considered that a transitional period between the MSA and LSA was apparent in the Horn of Africa, given repeated discoveries of assemblages with both MSA and LSA characteristics, with Levallois and Discoidal products as well as shaped or retouched points occurring alongside large backed tools, microliths, and significant (often predominant) blade productions. This association of elements led J. D. Clark to propose a distinct regional nomenclature for these assemblages that he considered as markers of the end of the Upper Pleistocene, between the MSA and the LSA, during an arid period (Clark, 1954, p. 158). These included the Hargeisan in northern Somalia, which he considered to be a distinct variant of the Magosian of southern Somalia and the Ogaden – due to differences in the types of angle burins and end-scrapers in particular – and as a successor to the Stillbay, which according to the author was the last MSA culture. Given the scarcity of sites relating to this Hargeisan "culture" – an issue acknowledged by J. D. Clark – the use of the term "Hargeisan" as a cultural-historical entity was little by little abandoned despite occasionally still being used (Brandt and Gresham, 1990; Gutherz et al., 2014). Since then, many of these assemblages with transitional characteristics have been re-studied and others revealed, though with questionable sedimentary contexts that do not always allow their transitional nature to be confirmed.

The review of the few sites in the Horn of Africa with assemblages composed of both MSA and LSA elements – and therefore potentially transitional – reveals that they most often occurred during MIS 2, and have often uncertain chrono-stratigraphic contexts. In Somaliland, assemblages attributed to the Hargeisan were recovered from Unit CSUb at Midhishi 2 dated to around 1890 ± 340 BP (Brandt, 1986), as well as at Laas Geel Shelter 7, where layers SU709-SU7011 provided conflicting dates between the 13th millennium cal BP and 40 kya BP (Gutherz et al., 2014). In Ethiopia, the site of Aladi Springs delivered an assemblage associating typical MSA and LSA artefacts, which was already described as unreliable by J. D. and K. D. Williamson (1984) and whose age is uncertain though possibly a little older than ~ 17-12 kya BP, according to the date obtained for the clayey layers directly above (Gossa et al., 2012). The lower horizon at site FeJx4 from Lake Besaka was considered to be MIS 2, with dates between 27120-21850 cal. BP (Brandt, 1986), placing it among the oldest expressions of the LSA in Ethiopia (also see Gasse and Street, 1978). A new date produced in the context of the ANR Big Dry indicates a minimum age of around ~ 13.6-13.4 kya cal. BP, which leaves open the hypothesis that the context is potentially younger (Habte, 2020).

It is clear that the corpus of sites with so-called transitional industries as well as absolute dates within MIS 2 are rather unconvincing (see also Leplongeon et al., 2020b). As mentioned earlier, it is only recently that two new sites with contexts reliably-dated to MIS 2 were discovered, which are currently in the process of being published. These include the site of Sodicho, located in south-western Ethiopia (Hensel et al., 2019and 2021), the Oulen Dorwa assemblages in the Middle Awash (Niespolo et al., 2021) and the side of Aga Dima S2 (ADS2) in the Ziway-Shala Basin.

The material from the site of Sodicho is in the process of being published, but a preliminary description of the lithic assemblage from part of the lower levels of the sequence, dated between ~ 27-13.5 kya cal. BP, shows dominant bladelet production. No retouched tools were identified in the studied sample (Hensel et al., 2021, p. 12; here: fig. 5, nos. 1-3). Similarly, the material from the Oulen Dorwa assemblages in the Middle Awash is in the process of being analysed. It is attributed to the LSA and is associated with numerous OES fragments, ^{14}C dated to between 23.9 and 21.4 kya cal. BP (Niespolo et al., 2021). The characteristics of the lithic assemblages appear at first sight broadly similar to the ones of Sodicho (bladelet production from pyramidal cores, with few retouched tools), but both assemblages need to be further characterised before they can be included in comparative analyses.

The site of ADS2 is a sedimentary trap whose lower layers (b to d) are reliable and dated between ~ 31-26 kya cal. BP, at the MIS 3-MIS 2 boundary (Habte, 2020; Douze et al., in prep.). The lower part of the sequence of ADS2 is probably both contemporaneous (level d) with and successive (levels c and b) to the sites dated to the end of MIS 3 in the Ziway-Shala Basin (DW1, DW4, B1s3, B4) located a few kilometers away and below. Elevated slightly above its surroundings, Aga Dima may have been occupied during the minor lake transgression recorded in the Deka Wede and related to the turning point between MIS 3-MIS 2, a phase during which the MIS 3 sites situated by the river were submerged. The question is whether this slight temporal stagger is enough to explain how a technical industry so strongly anchored in the know-

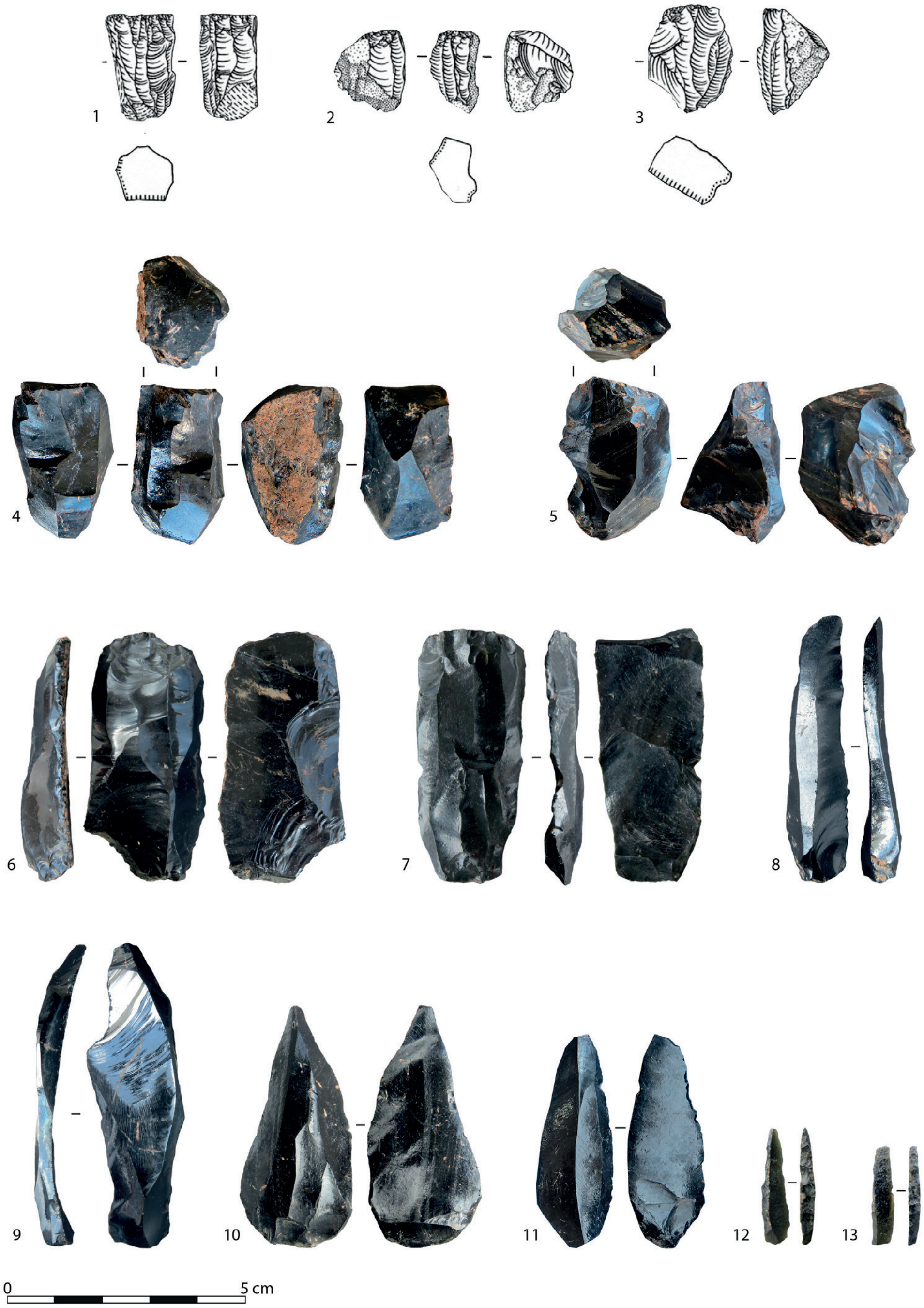

Fig. 5. Examples of artifacts from MIS 2 sites from the Horn of Africa. 1-3: Bladelet cores, Sodicho, Late Pleistocene (drawings and terminology after Hensel et al., 2021); 4-5: Volumetric small elongated flake cores, Aga Dima S2, Level c (photos K. Douze); 6: Bidirectional core on flake, Aga Dima S2, Level d (photo K. Douze); 7: Bidirectional core on flake, Aga Dima S2, Level c (photo K. Douze); 8: Elongated bidirectional flake, Aga Dima S2, Level c (photo K. Douze); 9: Blade, Aga Dima S2, Level c (photo K. Douze); 10: Bidirectional point with basal thinning, Aga Dima S2, Level d (photo K. Douze); 11: Elongated flake with basal thinning, Aga Dima S2, Level c (photo K. Douze); 12: Backed bladelet, Aga Dima S2, Level d (photos K. Douze); 13: Backed bladelet, Aga Dima S2, Level c (photos K. Douze). All in obsidian.

***Fig. 5** – Exemples d'artefacts de sites MIS 2 de la Corne de l'Afrique. 1-3 : Nucléus à lamelles, Sodicho, Pléistocène final (dessins et terminologie d'après Hensel* et al.*, 2021) ; 4-5 : petits nucléus volumétriques à éclats allongés, Aga Dima S2, niveau 6 (clichés K. Douze) ; 6 : nucléus bidirectionnel sur éclat, Aga Dima S2, couche d (cliché K. Douze); 7 : nucléus bidirectionnel sur éclat, Aga Dima S2, couche c (cliché K. Douze) ; 8 : éclat bidirectionnel allongé, Aga Dima S2, couche c (cliché K. Douze); 9 : lame, Aga Dima S2, couche c (cliché K. Douze) ; 10 : pointe bidirectionnelle à amincissement basal, Aga Dima S2, couche d (cliché K. Douze) ; 11 : éclat allongé à amincissement basal, Aga Dima S2, couche c (cliché K. Douze) ; 12 : lamelle à dos, Aga Dima S2, couche d (cliché K. Douze) ; 13 : lamelle à dos, Aga Dima S2, couche c (cliché K. Douze). Tous en obsidienne.*

hows of the MSA could be subsequently accompanied by a new, typically LSA component at ADS2.

At ADS2, the blade character of the industry – already present during MIS 3 at the neighboring sites on the lacustrine plain (DW1, DW4, B1s3, B4) – is further reinforced by the presence of blades and bladelets that are more centered and straight, resulting from more volumetric core reductions (fig. 3, nos. 10 and 11; fig. 5, no. 8). The presence of tools with basal thinning as well as unifacial and partly-bifacial points that form the third most important group of tools at ADS2 testify to a strong similarity with the MIS 3 sites of the lacustrine plain (fig. 3, no. 12; fig. 5, nos. 10 and 11). However, the backing process, i.e. for the manufacture of backed tools and truncated pieces, is represented in the assemblages of ADS2 while being completely absent from older sites in the same area (fig. 5, nos. 12 and 13). The backing process was nonetheless carried out just as much on large blanks of the same type as those produced at the end of the MSA, as on bladelets, with the latter present only in small quantities sometimes reaching small dimensions (≤ 3 cm long). The use of flakes or blades as blanks for cores is a common feature across all sites, although at ADS2 removals are also concentrated on the edges of these core blanks for the production of bladelets on the narrow surface, aside from real burins that also appear for the first time (11% of all tools). The blades are more robust and narrow than those obtained from the planimetric conception of core reduction. The bidirectional exploitation, which is common to all the sites of the Ziway-Shala basin (fig. 3, nos 7 and 8; fig. 5, nos. 6 and 7) is also implemented through a volumetric conception of core reduction at ADS2. The half-crest blades are also more numerous. Together, these elements suggest a gradual technological and typological shift that introduces, for the first time in the Ziway-Shala area, elements that are undoubtedly characteristic of the LSA (volumetric debitage, significant production of burins and backed pieces; Ménard, 2015; Habte, 2020). The association of these techno-typological characteristics makes attributing this site to either the MSA or LSA quite difficult, though it is tempting to see it as Early LSA with a Late MSA technical persistence. The stratigraphic truncation of the sediments after 26 kya cal BP at ADS2, as well as the absence of published lithic data for the period between 26 and 15 kya here or elsewhere in the Horn of Africa (beyond the brief description of Sodicho, Hensel et al., 2021) prevents us from evaluating whether the later LSA industries are in cultural continuity with the LSA components of the ADS2 industries, both being chronologically separated by more than 10 millennia, even at a local scale.

Given the poor resolution of the archaeological documentation for MIS 2, it is difficult to know whether the extreme aridity of MIS 2 rendered human occupation in the Horn of Africa invisible, or if it caused populations to abandon the region. The recently published data from Sodicho (Hensel et al., 2021) attest to a retreat of populations towards refuge zones, more of which may be identified in the future. In any case, our understanding of the processes of decline of MSA technical traditions and the subsequent rise of LSA technical systems during this isotopic stage has been strongly impacted by these climatic changes and yet the processes of this shift are difficult to grasp. The site of ADS2 nonetheless shows that before the LGM, at least locally, certain techniques that were to become characteristic of the LSA were already present, whereas later in the same area, no techno-typological similarity with the MSA is observed after the LGM, during MIS 1 (Ménard et al., 2014). As for Sodicho, although the authors do not propose a taxonomical attribution for the assemblages of MIS 2, it is nonetheless clear that these assemblages, which remain to be described, will deliver precious information regarding this issue.

2.4. Synthesis of the contribution of the Big Dry project to the question of the MSA-LSA transition in the Horn of Africa

Our studies, together with the other available data, allow a new look at the MSA-LSA transition by questioning the meaning of the presence and/or absence of certain elements considered as techno-cultural markers, such as 1) backed pieces and microlithism, 2) blade production, and 3) Levallois core reduction and points.

In general, backed pieces occur very occasionally in pre-MIS 1 contexts (Leplongeon et al., 2020a). The only sites where backed pieces have been found in contexts securely dated to MIS 3 are Mochena Borago, where they appear in the form of tool fragments (Brandt et al., 2012 and 2017; here: fig. 3, no. 5), and Goda Buticha IId-IIf (N = 1; Leplongeon, 2014; Leplongeon et al., 2017), where such pieces may be the result of intrusions from LSA layers immediately above. In contrast, the site of ADS2, dated to the beginning of MIS 2, has provided a small number of backed pieces (n = 18/385 retouched pieces) made on varied blank types and of varying dimensions (fig. 5, nos. 12 and 13). These backed pieces are made either on blanks that are very similar to those produced at MSA sites from the end of MIS 3 in the area, namely on large elongated pieces resulting from bidirectional opposed core reduction, or on bladelets from which one of the cutting edges has been modified by abrupt retouch. These data seem to indicate that the emergence of this type of modification occurs towards the end of the Pleistocene in the Horn of Africa, possibly associated with the emergence of LSA technical systems. However, and this is an important fact, it can be dissociated from the emergence of what has been traditionally named "microlithism" (Leplongeon, 2014).

Indeed, the miniature dimensions (≤ 3 cm) of a significant proportion of the artefacts from certain assemblages is a common feature at several Late MSA sites for the production of flakes and bladelets (for example Aduma A5, Porc-Épic, Mochena Borago, Goda Buticha) and is already apparent during the Early MSA for flake productions (for example Kibish, Gademotta ETH-72-8B, Garba III). The production of tools of very small dimensions in some industries seems to be an adaptive behavior in the context of peculiar functional or economic situations that occurred during different phases of the Palaeolithic, and is therefore not in itself a techno-cultural criteria distinctive of the LSA (for example: Douze, 2012; Pargeter and Shea, 2019; Gallotti et al., 2020; Spinapolice, 2020). In addition, the oldest LSA sites dated to the Terminal Pleistocene, such as B1s1 in the Ziway-Shala basin (Ménard et al., 2014; Ménard, 2015), as well as Macho Hill (Humphreys, 1978) and the lower layer FeJx4 at Lake Besaka (Brandt, 1982), also exhibit industries with non-miniaturised backed pieces, though made on more standardised blanks than at ADS2. In other words, the act of producing blanks of small dimensions and/or manufacturing backed pieces, must be dissociated from the emergence of a "microlithic industry" understood as the strict expression of industries with a dominant bladelet component associated with the manufacture of geometric microliths (such as segments) – criteria to which the LSA *sensu stricto* was often reduced.

Another major aspect here is the importance of blade production as a criterion for the distinction between the MSA and the LSA. It seems that the blade component of certain Late MSA industries is quite similar to that of the earliest LSA industries, as seen in those MIS 3 industries from the Ziway-Shala basin that are characterised by a predominant blade production. However, the technical systems that produced these blades are clearly different with respect to the LSA due to the almost exclusive use of planimetric conceptions in the form of Levallois blade core reduction at MIS 3 sites, which contrasts starkly with blade production on semi-conical, or at least volumetric cores at LSA sites dating to MIS 1 (Ménard et al., 2014). However, as the identification of the MIS 3 local "identities" described above might lead to a biased view of the evolutionary dynamics at play in the Horn, it should be qualified that outside the example of Ziway-Shala, studies have shown an elongation of the products from the MIS 3 to the Early Holocene (Leplongeon et al., 2017). Blade production seems well represented within assemblages everywhere from MIS 3 onwards and is the result of planimetric conceptions (among which Levallois) and occasional volumetric conceptions of core reduction, or a combination of both, according to the site (Leplongeon et al., 2017). The blade criterion is therefore not decisive on its own for distinguishing between the MSA and the LSA at the end of the Pleistocene. It seems that across our studies, the assemblages in which blade production is dominant, independently of the methods used to obtain the blades, are dated to the end of the MIS 3 and to MIS 2, peaking during MIS 1, rather than in the Holocene (flake and bladelet industries) or to periods before MIS 3 (flake, point, and occasional blade industries).

Finally, the use of Levallois methods and the production of points, generally considered to be key indicators of the MSA, have been recovered from several assemblages dating to the Holocene (Goda Buticha level IIc: Leplongeon et al., 2017; K'aaba upper levels and Bel K'urk'umu: Fernández et al., 2007), in association with flake and bladelet industries more typical of the Holocene. At these sites, the question remains open as to whether these Levallois methods were reinvented or if they persisted until the Holocene as these sites exhibit a stratigraphic hiatus between the MIS 3 and Holocene levels (Goda Buticha), a chronological hiatus between the MSA and LSA assemblages (K'aaba) or an absence of MSA layers at the site (Bel K'urk'umu). For now, regarding Levallois core reduction, the use of non-standardized descriptive vocabulary hampers our understanding of this technological convergence. It is becoming more and more critical to reach a better common assessment of the Levallois concept and the meaning of its diversity based on MSA and LSA lithic material, particularly in order to draw a distinction between flake productions from cores with hierarchized surfaces and true Levallois productions (according to Boëda, 1994). As for points, their occurrence within LSA layers takes varied forms, including primarily unifacial points of small dimensions (< 4 cm long) with bilateral retouch at Goda Buticha (level IIc) or those of K'aaba. Their recurrence over the course of prehistory no longer needs to be demonstrated, putting into question their status as latent MSA indicators, especially in situations where they are not dominant.

Taking into account all of these parameters, the MSA-LSA transition appears to have been a gradual, multi-facetted process without a stark rupture between the MSA and the LSA, and whose roots may be found during the Late MSA or perhaps even as early as MIS 4. In the context of the Horn of Africa, according to the available data, the production of backed tools could be an indicative feature of the progressive replacement of MSA technical traditions by those of the LSA prior to the predominance of volumetric blade production within assemblages. In turn, the latter may signal the emergence of the LSA *stricto sensu,* with or without latent MSA features. However, the hiatus in the archaeological record between 25-15 kya in the Horn of Africa counters all attempts to observe the dynamics of change during this crucial period of full development of the LSA as described in this volume (Ménard et al., this volume). This is true for the Ziway-Shala basin but also for the sites of Goda Buticha and Mochena Borago, which also exhibit a chronological and sedimentary hiatus during MIS 2 within their long stratigraphic sequences (Pleurdeau et al*.,* 2014; Ménard and Bon, 2015; Brandt et al., 2017; Tribolo et al*.,* 2017). For these reasons, it is important to consider work carried out in the Nile Valley where MIS 2 occupations are particularly well-represented.

3. THE END OF THE PLEISTOCENE IN THE NILE VALLEY

The end of the Pleistocene in north-eastern Africa is distinguished from other regions of the continent by an archaeological record attributed to different chrono-cultural complexes, such as Middle Palaeolithic

(MP), Middle Stone Age (MSA), Upper Palaeolithic (UP) and Late Palaeolithic (LP). This terminological soup has probably contributed at least in part to the artificial isolation of north-eastern Africa with respect to neighbouring regions (see for example Van Peer, 2016). In this section, we will consider this terminological problem before reviewing the archaeological record from the Nile Valley at the end of the Pleistocene (fig. 6).

3.1. The archaeology of the Nile Valley at the end of the Pleistocene: between European and Africanist research traditions

Historically, European terminology has held a privileged position, particularly in the use of the terms "Middle Palaeolithic" and "Mousterian". This is related in part to the colonial history of northern Africa and therefore to the research traditions of the researchers involved. However, these denominations have tended to be replaced by the term "Middle Stone Age" for both north-eastern (Van Peer, 2004; Van Peer and Vermeersch, 2007; Wurz and Van Peer, 2012) and northern Africa (Dibble et al., 2013; Campmas, 2017), in a deliberate bid to reconcile the prehistory of the north of the continent with that of the regions south of the Sahara (see also Garcea, 2004).

While there is consensus around the use of MSA, and despite the increased use of LSA in northern Africa for later periods, the term "Upper Palaeolithic" remains predominant in the Nile Valley due to interpretations of certain characteristics of the material as exhibiting closer links to the Levant than to the rest of the continent (for example Wurz and Van Peer, 2012). It is nonetheless interesting to note that the term "Later Stone Age" is also used for the industries of the western Egyptian desert and in Sudan (Svoboda et al., 2013; Garcea, 2020; Kleindienst et al., 2020). The term "Late Palaeolithic", whose use is widespread thanks to research undertaken in the wake of the construction of the Aswan dam (the Nubian campaign), is used only in the Nile Valley and refers specifically to industries dated to the period between 25-15 kya. For more recent periods, the terms "Epipalaeolithic" (a term used mainly in the Levant) or "Mesolithic" (a European term) and later "Neolithic" are still used despite being recognised as somewhat problematic (for example Garcea, 2004).

In this article, with regards to the Nile Valley, we will default to those terms that remain the most widely-used, namely MSA for industries up to around 50 kya, UP for industries from the period between 50-25 kya and LP for industries dated to the period between 25-15 kya.

3.2. The end of the Middle Stone Age and the beginning of the Upper Palaeolithic: fragmentary data and specialised contexts

One of the main problems facing the study of prehistory in this region is the scarcity of stratified sites and the lack of an absolute chronology, with most remains of MSA occupation having been found in surface contexts.

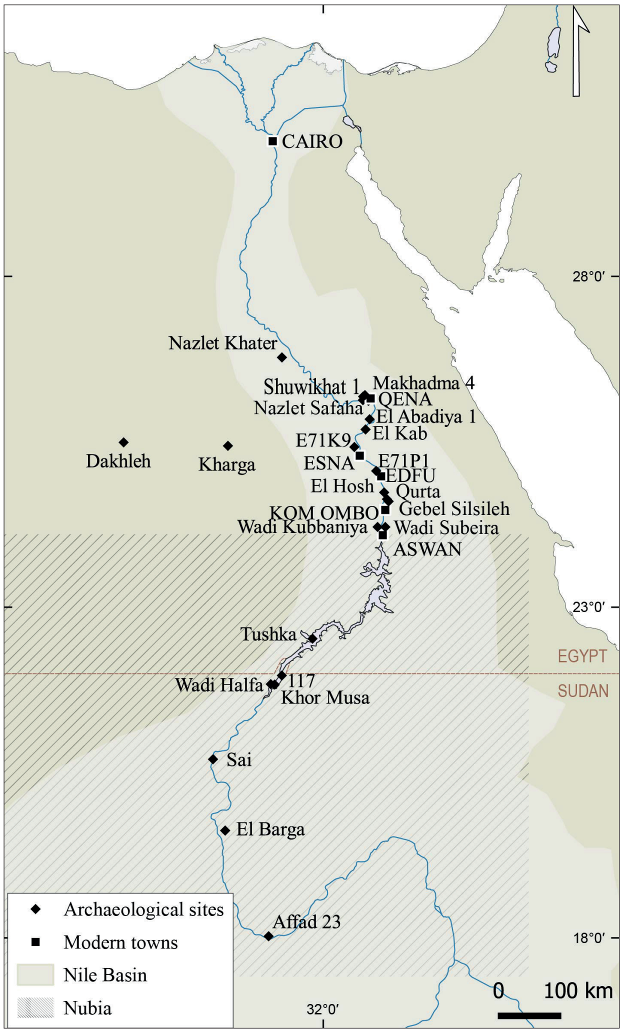

Fig. 6 – Map of the Nile Valley with the location of the main sites mentioned in the text. Geographical extension of the Nile Basin (after Williams, 2019, fig. 1) and of Nubia (after Auenmüller, 2019). Produced on QGIS v. 3.15 (QGIS Development Team, 2017) and Natural Earth Data.

***Fig. 6 –** Carte de la vallée du Nil indiquant la localisation des principaux sites mentionnés dans le texte. Extension géographique du bassin du Nil (d'après Williams, 2019, fig. 1) et de la Nubie (d'après Auenmüller, 2019). Document créé avec QGIS v. 3.15 (QGIS Development Team, 2017) et Natural Earth Data.*

Despite these limitations, this section attempts to reconstitute in a chronological manner the processes at play in the Nile Valley between the end of the MSA and the beginning of the UP.

Three phases may be distinguished in the MSA of north-eastern Africa. One pre-MIS 5 phase sometimes associated with Sangoan/Lupembian appears to be solidly anchored in the African MSA (for example Van Peer et al., 2003; Van Peer, 2016). Only a very few sites are dated to this early stage of the MSA. They are located in the Sudanese part of the Nile basin (for example Van Peer et al., 2003 and 2004; Spinapolice et al., 2018; Masojć et al., 2019 and 2021), and in the western Egyptian desert, namely in the Kharga Oasis (Caton-Thompson, 1952;

Kleindienst et al., 2008), and at Bir Sahara and Bir Tarfawi (Wendorf et al., 1993).

The second phase corresponds to MIS 5 and includes sites attributed to the Nubian complex, bringing together assemblages that have often been characterised by the production of points according to the Nubian Levallois method (for definitions of this variant of the Levallois see Guichard and Guichard, 1965; Usik et al., 2013; here: fig. 7, nos. 1 and 3). Some industries not included in the Nubian Complex are also associated with this second phase of the MSA, such as the Denticulate Mousterian (Marks, 1968c) or the Upper Levalloisian (Caton-Thompson, 1952; Kleindienst et al., 2008).

The Nubian Complex is generally associated with MIS 5 (Van Peer, 1998 and 2016; Vermeersch, 2020), even if only a few absolute dates are associated with sites of this complex whose chronological boundaries remain blurry. Outside north-eastern Africa, other assemblages exhibit the presence of the Nubian Levallois, particularly in the Horn of Africa at the site of K'one locality 5 extension (Kurashina, 1978), at Gademotta ETH-72-6 (Wendorf and Schild, 1974; Douze, 2012), in eastern Africa at Rusinga (Tryon and Faith, 2013), in Arabia (Rose et al., 2011; Crassard and Hilbert, 2013; Usik et al., 2013) or in the Levant (Goder-Goldberger et al., 2016 and 2017). Some of these assemblages have been attributed to the Nubian Complex and interpreted as related to human dispersals that took place during MIS 5 (Van Peer, 1998 and 2016; Usik et al., 2013; Rose and Marks, 2014; Goder-Goldberger et al., 2016), though this subject is strongly debated (Groucutt et al., 2015; Will et al., 2015; Scerri and Spinapolice, 2019; Groucutt, 2020; Hallinan and Shaw, 2020). The late Nubian Complex is characterised in north-eastern Africa by its great lithic variability, grouping together assemblages attributed to diverse chrono-cultural entities such as the Nubian Mousterian, the Khormusan, the N Group, and the Aterian (Van Peer, 1998 and 2016). While the Aterian (a techno-complex dating between ~ 130 kya and 40-30 kya in northern Africa) is well-represented in Egyptian oases (Dakhleh and Kharga: Kleindienst, 2001; Hawkins, 2012), the question of its geographic extension to the Nile Valley is debated (Kleindienst, 2001; Scerri, 2013 and 2017; but see also Carlson, 2015; Garcea, 2020a and 2020b).

The third phase of the MSA – corresponding to MIS 4 and 3 – produced only a few sites. In Egypt, these function as sites for the extraction of raw materials in the Nile Valley (Nazlet Safaha and Taramsa 1: Van Peer et al., 2010; Van Peer, 2016). In Sudan, the sites belonging to the Khormusan were generally considered to date to the period between 60-40 kya (Wendorf, 2001), but have recently been correlated to MIS 5a or MIS 4 on the basis of stratigraphy (Goder-Goldberger, 2013). A re-evaluation of the dates and the correlation of Khormusan sites with the base of the Late Middle Palaeolithic Aggradation led R. Schild and colleagues to propose that the Khormusan be correlated with MIS 4 (Schild et al., 2020). Despite the small number of sites, MIS 4 can be characterised in north-eastern Africa by its great technological variability, seen in various well-defined industries: the Safahan (Van Peer, 1991b and 1992; here: fig. 7, nos. 4 and 5), the Khormusan (Marks, 1968b) and the Taramsian (Van Peer et al., 2010) – the latter testifying to the beginning of a technological transition away from the MSA towards volumetric blade debitage (fig. 7, nos. 6 and 7). These assemblages may represent local developments (for example the sequence at Taramsa 1, Van Peer et al., 2010), even if similarities with the East African MSA have been noted for the Khormusan (Goder-Goldberger, 2013).

As with MIS 4, only a few MSA sites have been dated to MIS 3 in north-eastern Africa. In Sudan, only the complex of sites in the Affad basin, perhaps representing a series of dry-season hunting camps – particularly the site of Affad 23 – and recently dated to around 55 kya can be attributed to MIS 3 (Osypińska and Osypiński, 2016; Osypiński and Osypińska, 2016; Osypińska et al., 2020; Osypiński, 2020). The only sites in the Egyptian Nile Valley that have produced absolute dates within MIS 3 are the Upper Palaeolithic sites of Nazlet Khater 4 (NK4), ~ 44-38 kya cal BP (Vermeersch et al., 2002a; Leplongeon and Pleurdeau, 2011) and Phase VI at the site of Taramsa 1 ~ 45-40 kya cal BP (Van Peer et al., 2010). The site of Shuwikhat 1 (with a minimum date of 25 kya BP) has produced a blade industry dating to the end of the Upper Palaeolithic (the Shuwikhatian) and can be dated to MIS 3 (Vermeersch et al., 2000b; Vermeersch, 2020; here: fig. 7, nos. 8 and 10). A similar chronological context may be proposed for the assemblages of El Abadiya 1, also attributed to the Shuwikhatian and E71K9, though having been first associated with the non-Levallois Edfouan and only later re-attributed by means of typo-technological similarities with the Shuwikhatian (Schild and Wendorf, 2010, p. 111).

The question of human presence in the western Egyptian desert between MIS 4 and 2, a period during which the Sahara is considered to have been hyper-arid, is widely debated. Deposits of travertine and riparian marlstone containing molluscs and mammal teeth in the Dakhleh and Kharga oases have been subject to ESR dating (Electron Spin Resonance) and suggest the presence of water sources throughout this arid period, in opposition to hypotheses of an "uninhabitable" desert (Kleindienst et al., 2016 and 2020; Blackwell et al., 2017). Numerous surface assemblages are attributed to the Khargan (Caton-Thompson, 1952), whose characteristics (namely small core dimensions and Levallois flakes, as well as flake segmentation) drove those teams working in the oases to attribute them to a late phase of the MSA, and to correlate them with dates indicating the presence of water sources during MIS 3 (McDonald et al., 2016; Kleindienst et al., 2016 and 2020). However, in the absence of directly dated material associated with lithics, the chronological attribution of these industries, as well as their possible association with stone structures (site J, Kharga), remains the subject of some debate (see discussions in Vermeersch, 2009; McDonald et al., 2016; Kleindienst, 2020; Kleindienst et al., 2020).

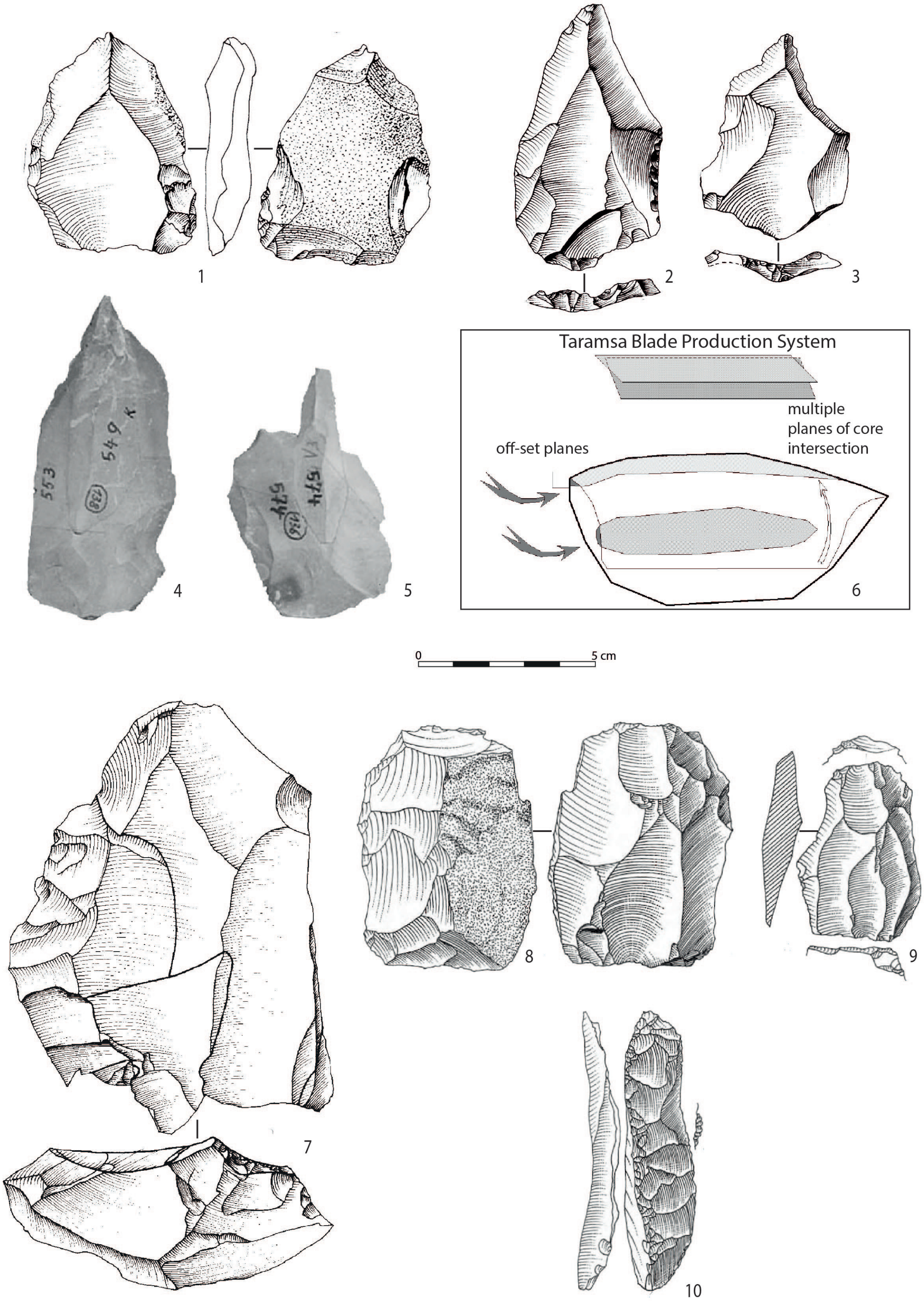

Fig. 7. Examples of Middle Stone Age and Upper Palaeolithic artifacts from the Nile Valley. 1: Nubian cores (Vermeersch et al., 2002b); 2-3: Nubian points from Nazlet Khater 1 (Vermeersch et al., 2002b); 4-5: Refits of Levallois Safahan artefacts from Nazlet Safaha 1 (Van Peer et al., 2002); 6: Schematic representation of the laminar production system at Taramsa (after Van Peer et al., 2010); 7: Blade core at Taramsa, Taramsa 1 Phase VI (Van Peer et al., 2010); 8-9: Blade cores with opposed knapping platforms (Vermeersch et al., 2000b); 10: Crested blade from Shuwikhat 1 (Vermeersch et al., 2000b).

Fig. 7. *Exemples d'artefacts du Middle Stone Age et du Paléolithique supérieur de la vallée du Nil. 1 : Nucléus nubien (Vermeersch* et al., *2002b) ; 2-3 : pointes nubiennes de Nazlet Khater 1 (Vermeersch* et al., *2002b) ; 4-5 : remontages d'artefacts Levallois Safahan de Nazlet Safaha 1 (Van Peer* et al., *2002) ; 6 : représentation schématique du système de production laminaire de Taramsa (Van Peer* et al., *2010) ; 7 : nucleus laminaire de Taramsa de la phase VI de Taramsa 1 (Van Peer* et al., *2010) ; 8-9 : nucléus laminaires à plans de frappe opposés (Vermeersch* et al., *2000b) ; 10 : lame à crête de Shuwikhat 1 (Vermeersch* et al., *2000b).*

The scarcity of sites dated to MIS 4-3 may indicate a low population density in the Nile Valley, perhaps due to the hyper-arid climate of this period. However, sites like Taramsa, Nazlet Safaha and NK4 suggest a particularly intensive exploitation of raw materials and may instead indicate a significant demographic pressure (Van Peer et al., 2010; Van Peer, 2016). In addition, geomorphological factors linked to a research bias may contribute to this state of affairs.

The sites of the Egyptian Nile Valley belonging to MIS 4 and 3 are thus primarily sites for the extraction of raw materials, with the possible exception of those sites attributed to the Shuwikhatian, if one accepts their chronological attribution to MIS 3. Comparisons with adjacent desert sites, as well as with those of the Sudanese Nile Valley, are somewhat difficult and reinforce, perhaps artificially, the impression that the Egyptian Nile Valley was isolated from its neighbouring regions at the end of the Pleistocene.

3.3. The Late Palaeolithic: occupation of the Nile Valley during MIS 2

3.3.1. General context

In contrast to the preceding period, numerous sites dated to MIS 2 are known in the Nile Valley, corresponding principally with two occupation phases: 23-20 kya cal. BP and 16-14 kya cal. BP, separated by a period with fewer sites (Vermeersch and Van Neer, 2015; Leplongeon, 2021). This important archaeological record from MIS 2 may well be correlated with a rise in population density in the Nile Valley, or at least in certain parts of the Nile Valley during MIS 2, suggesting that it acted as an environmental refuge during this hyper-arid period in the Sahara. The analysis of available dates for this period should nonetheless be treated with care, especially when interpreting them as proof of demographic changes. It is likely that this density reflects at least in part the intensity of research in certain areas and is therefore probably not representative of known archaeological data, with half of the available dates coming for example from the sites of Wadi Kubbaniya (see discussion in Leplongeon, 2021).

Only a few sites correspond to the beginning of MIS 1, between 14 and 11 kya in the Nile Valley. It is only from the beginning of the Holocene that sites become more numerous, with Mesolithic sites around Kerma, Sudan, dating to around 11 kya cal. BP (Honegger, 2019) and the Epipalaeolithic site of El-Kab in Egypt dating to 9 kya cal. BP (Vermeersch, 1978; Vermeersch and Van Neer, 2015). One exception may be Site 117 at Jebel Sahaba in Sudan (Wendorf, 1968), where dates were produced with a wide spread between 18 and 11 kya (also see Crevecoeur et al., 2021 and this volume). While it may be acceptable to consider numbers of known sites as a proxy for population density, the fluctuations observed over the course of MIS 2 and the geographic distribution of sites may be partly correlated – tentatively in the absence of further data – with the documented climatic and environmental fluctuations during this period.

The Nile has three principal tributaries: the White Nile, the Blue Nile, and the Atbara (fig. 6). While the flow of the Nile depends primarily on waters brought by the Blue Nile and the Atbara during humid seasons, it depends almost exclusively on those of the White Nile during the dry season (Williams, 2019). The drying out of east African lakes at the end of the Pleistocene, in particular Lake Victoria, the primary source of the White Nile, around ~ 17-16 kya (Johnson et al., 1996; Talbot et al., 2000; Williams et al., 2006 and 2015) would have had important consequences for the perennial character of the Nile (Williams, 2019 and 2020). These consequences are however debated. Two main models have been proposed for the behaviour of the Nile during MIS 2 and the LMG in particular, but no consensus has yet been reached by the scientific community. The first model, developed by F. Wendorf and R. Schild (Schild and Wendorf, 1989 and 2010; Wendorf and Schild, 1989) proposes that the Nile would have taken the form of a braided river during the LMG. Nile would have therefore been at this point a seasonal river with a slower flow, similar to the Atbara today.

P. Vermeersch (2006), followed by P. Vermeersch and W. Van Neer (2015), propose instead a model according to which the Nile would have been blocked at multiple points by sand dunes, creating lakes propitious to the survival of animals and also to human occupation. This hypothesis seems to be supported by a reinterpretation of stratigraphic data from the site of Makhadma 4 (Vermeersch et al., 2000a; Vermeersch, 2006; Vermeersch and Van Neer, 2015), as well as data from fish otoliths (Dufour et al., 2018). The authors propose that this model is applicable to several areas of the Nile Valley, namely near Aswan and Gebel Silsileh as well as Esna (Vermeersch and Van Neer, 2015, p. 160 and 163), despite its rejection by R. Schild and F. Wendorf (2010) on the basis of an absence of typically riparian deposits such as calcareous mars or diatomites. Only new geological work in these areas is likely to shed more light on these two hypotheses.

Whatever the model, paleo-environmental data and the presence of archaeological sites dated to this period seem to indicate that the Egyptian Nile Valley may have served as an environmental refuge during MIS 2 and particularly the LGM. Prevailing hyper-arid conditions in the adjacent desert areas exclude its role as a “corridor” with neighbouring regions (also see Leplongeon, 2021). It should be noted that there are no known sites dated to MIS 2 in the north of Egypt. Although this may reflect in part a research bias, it also seems to be due to the fact that MIS 2 is correlated with a significant drop in the water level of the Mediterranean. This drop induced a hollowing of the Nile river bed from the area of Qena onwards, with human occupations to the north of Qena probably being washed away or buried under metres of sediment deposited by the Nile following the rise in sea level in the Holocene (Sandford and Arkell, 1929; Wendorf and Schild, 1989).

Furthermore, the rise in precipitation in eastern Africa at the beginning of MIS 1 and the subsequent reconnection of Nile tributaries with various East African riparian basins led to significant flooding events (the "wild Nile"; Butzer, 1980), the environmental consequences of which likely deeply disturbed ecosystems and human populations in the Nile Valley. These environmental changes may explain in part the significant level of interpersonal violence documented for this period at the cemetery at Jebel Sahaba (Kuper and Kröpelin, 2006; Vermeersch and Van Neer, 2015; Crevecoeur et al., 2021).

In fact, MIS 2 sites in the Egyptian Nile Valley and in Nubia are generally interpreted as evidence for seasonal occupation with subsistence economies based largely on fishing (Tilapia and Catfish) and to a lesser extent on large mammal hunting (primarily Aurochs, Hartebeests, Dorcas Gazelles, and occasionally hippopotamuses or donkeys; see syntheses and discussions in Van Neer and Gautier, 1989; Van Neer et al., 2000; Schild and Wendorf, 2010; Coudert, 2013; Yeshurun, 2018), as well as on the exploitation of wild plants, notably at Wadi Kubbaniya (Hillman et al., 1989). Rock-art panels at Qurta, El Hosh and in Wadi Subeira, located close to sites from the Late Palaeolithic, are also related to this period (Huyge, 2009; Huyge et al., 2011; Kelany, 2012; Kelany et al., 2015). These bear representations of animals (mainly aurochs) and some human figures ("headless women") in a very homogenous style. OSL dating of sediments covering one rock-art panel at one site, Qurta II, provided a *terminus ante quem* of 15 kya for these occupations (Huyge et al., 2011).

In terms of technical behaviour, MIS 2 sites in the Egyptian Nile Valley testify to a great diversity in lithic assemblages, distributed across numerous industries and taxonomic entities (Schild and Wendorf, 2010, table 1). The industries of the LP are frequently characterised by the production of elongated products of small sizes, produced from cores with opposed striking platforms, with both planimetric and volumetric conceptions (fig. 8, nos. 3 and 5). These blanks were transformed into backed pieces, whose variability is distinct from one industry to the next (see Close, 1989). However, a certain number of industries exhibit flake production instead, or an association between flake and blade production. Flake production in these industries is frequently carried out on a core, often of small dimensions, identified as being Levallois (Kubbaniyan industry) or else recalling the Levallois method (Halfan method, Marks, 1968a; here: fig. 8, nos. 1 and 2).

3.3.2. Variability in the Late Palaeolithic of the Nile Valley

The great diversity of technical facets documented over a relatively short period and in a limited geographical area (Upper Egypt and Nubia) has been the subject of much debate (for example by Schild and Wendorf, 2010, p. 110). The majority of the available LP data come from excavations carried out in the context of the Nubian Campaign and from those that continued directly afterwards until the end of the 1980s. The majority of these sites have since disappeared, having either been "drowned" by the Aswan Lake following the construction of the dam or destroyed by the continued expansion of irrigation systems. Despite the impressive quantity of accumulated data, in the absence of any recent excavations, only the systematic re-evaluation of contexts and materials with modern tools can reveal new patterns.

In this way, multiple factors of technical variability may be identified. However, it is necessary to point out that many of these factors are associated only with a few absolute dates, which were often obtained using material with a sometimes questionable association with the industry (Leplongeon, 2021). This complicates the interpretation of those lithic characteristics that seem atypical for assemblages attributed to the UP or LP. The discussion in the article by E. Paulissen and P. Vermeersch (1987) demonstrates this difficulty. This is particularly evident for the Halfan, the Sebilian, and the Levallois Edfouan (table 1), although the authors do stress that the stratigraphic positioning of the sites of these industries seems to be related to the aggradation of the Nile at the end of the Pleistocene, and that they do not have any other arguments in favour of proposing an older date for these industries. It appears however that in the absence of a solid chrono-stratigraphical context for some of these characteristics, it is impossible to reject completely the hypothesis according to which the technological variability witnessed during MIS 2 in the Nile Valley can be partly explained through the erroneous chronological attribution of some of these industries. However, even with those industries with unreliable attribution removed, there are still numerous documented industries for this period.

A second factor for this variability may be linked to the geographical distribution of the sites, with some industries being found only in Nubia between the first cataract (at the Aswan Dam) and the second (Wadi Halfa), whereas others are found only in Upper Egypt and in Egyptian Nubia between the first cataract and Dishna (Schild and Wendorf, 2010, here: table 1). The chronological distribution of sites within each of these areas is difficult to establish. Indeed, as we have noted, the available dates (numerous old radiocarbon dates, often not corrected for reservoir effects) prevent the establishment of a detailed chronology for these industries as well as any potential chronological succession, as has been evidenced at the micro-regional scale in the Levant, for example for the chrono-cultural sequences in the Negev Desert, and in the eastern and southern Levant (Goring-Morris, 1995; Maher et al., 2012; Garrard and Byrd, 2013; Enzel and Bar-Yosef, 2017). Because of this, it is only possible to speculate that variability in these industries either echoes complex social interactions as proposed for the Levant, or is linked to a certain fragmentation of populations along the Nile Valley in line with the environmental lake model proposed by P. Vermeersch and W. Van Neer (2015).

Industry and chronological range*	Geograph. distrib.**	Lithic characteristics***	Other characteristic finds
Idfuan/Shuwikhatian Min. age 25 ka	A	Technology: blade production using opposed platform cores and crested products; toolkit: denticulates, burins, endscrapers and burins1	
Fakhurian 23-25.6 ka cal BP	A	Technology: non-Levallois blade and bladelet production, single and opposed platform cores; toolkit: backed bladelets largely dominant, retouched pieces and perforators	
Levallois Idfuan	A	Levallois variant of the Idfuan? Technology: blade production using opposed platform cores, use of Levallois and Halfa methods; toolkit: notches and denticulates are dominant	
Gemaian Undated	B	Technology: Levallois, Halfan and Nubian-like cores; toolkit: denti-culates and notches	Bone tool (N = 1)
Halfan 19-24 ka cal BP	B	Use of small Nile pebbles giving a microlithic aspect; technology: Halfan and Levallois cores; toolkit: Ouchtata and backed bladelets	
Kubbaniyan 19.3-23.5 ka cal BP	A	Technology: flake and bladelet production, use of single and opposed platform cores, occasional use of Levallois and Halfa methods; toolkit: Ouchtata and backed bladelets, burins. Egyptian variant of the Halfan?	Grinding imple-ments, bone tools and ostrich eggshell beads
Ballanan-Silsilian 16.3-20.8 ka cal BP	A, B	Sometimes includes the use of exotic raw materials; Technology: mainly oriented towards the production of short elongated blanks (blade/let) with single and opposed platform cores; toolkit: backed pieces, truncations, proximally retouched blade(let)s and notched tools, occasional use of the microburin technique2	
Qadan 12-20.2 ka cal BP	Mostly B, one site in A (Wadi Kubba-niya)	Small dimensions of the artefacts; technology: mainly oriented towards flake production with single and opposed platform cores, several cores reminiscent of the Levallois methods for Qadan point production, bladelet production documented in some but not all sites; toolkit: Qadan points, burins, small scrapers and backed pieces (the latter only at some sites)3	Rare bone tools, grinding imple-ments
Afian 14-16.8 ka cal BP	A	Technology: mainly oriented towards the production of wide and small elongated products, planimetric conception of debitage with high frequencies of faceted platforms; toolkit: truncations, backed bladelets and geometrics4	Grinding stones (Kom Ombo area) and if Makhadma 4 is included in the Afian, bone tools
Sebilian 12.6-16.9 ka cal BP	A, B	'very particular association of lithics'; technology: Discoidal and Levallois cores for the production of flakes; toolkit: truncated and backed flakes, use of the microburin technique	
Isnan 13.2-16.6 ka cal BP	A	Technology: production of flakes and rare blades from single and opposed platform cores; toolkit: high percentage of endscrapers, followed by notches and denticulates, rare backed pieces	Grinding imple-ments
Arkinian (excluding el Adam variant) 11.9-12.8 ka cal BP	B	Bladelet and flake production from single and opposed platform cores, presence of bipolar reduction, stone anvils; numerous backed pieces and endscrapers	Grinding imple-ments, bone spatula

Table 1 – Characteristics of the Late Palaeolithic cultural entities in the Nile Valley (*: after Leplongeon, 2021; **: after Schild and Wendorf, 2010, A = southern Egypt between Sohag and the first cataract, B = Egyptian and Sudanese Nubia between the first and the second cataract; ***: after Schild and Wendorf, 2010 except when mentioned otherwise – [1]characteristics after Vermeersch, 2020 [these characteristics, associated with minimal ages around 25 ka led to an attribution to the later Upper Palaeolithic, rather than the Late Palaeolithic], [2]characteristics after Smith, 1966 and Leplongeon, 2017, [3]characteristics after Usai, 2020, [4]characteristics after Leplongeon, 2017 [note that in this reference the attribution of Makhadma 4 to the Afian is questioned]).

***Tabl. 1** – Caractéristiques des entités culturelles du Paléolithique récent de la Vallée du Nil (* : d'après Leplongeon, 2021 ; ** : d'après Schild et Wendorf, 2010, A = sud de l'Égypte entre Sohag et la première cataracte, B = Nubie égyptienne et soudanaise entre la première et la deuxième cataracte ; *** : d'après Schild et Wendorf, 2010 sauf mentions contraires – [1]caractéristiques d'après Vermeersch, 2020 [ces caractéristiques, associées à un âge minimal autour de 25 ka, ont mené à une attribution de l'assemblage au Paléolithique supérieur récent plutôt qu'au Paléolithique récent], [2]caractéristiques d'après Smith, 1966 et Leplongeon, 2017, [3]caractéristiques d'après Usai, 2020, [4]caractéristiques d'après Leplongeon, 2017 [dans cet article, l'attribution de Makhadma 4 à l'Afien est remise en cause]).*

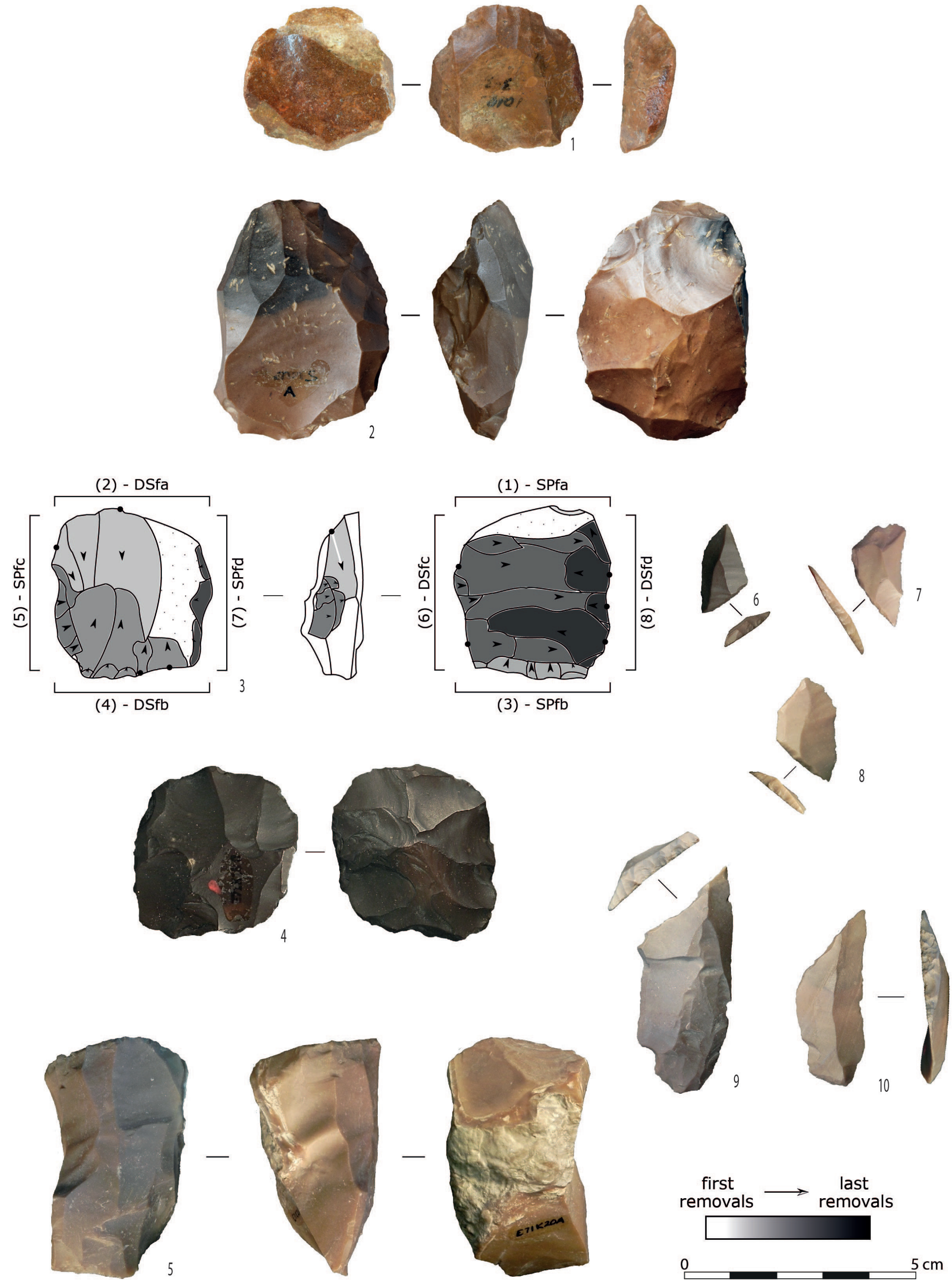

Fig. 8 – Examples of Late Palaeolithic artifacts from the Nile valley. 1: Halfian core from Halfian site 1018; 2: Halfian cores from Levallois Edfouen site E71P1A; 3-4: Orthogonal cores from Alfian site E71K18; 5: Cores with opposed knapping platforms from Silsilian site E71K20; 6-8: Proximal truncations from site E71K18C; 9: Proximal truncation from site E71K20; 10: Backed blade from site E71K20 (photos A. Leplongeon, taken courtesy of the Trustees of the British Museum; 3-10: Leplongeon, 2017).

Fig. 8 *– Exemples d'artefacts du Paléolithique récent de la vallée du Nil. 1 : Nucléus halfien du site halfien 1018 ; 2 : nucléus halfien du site Edfouen à Levallois E71P1A ; 3-4 : nucleus orthogonaux du site Afien E71K18 ; 5 : nucleus à plans de frappe opposés du site silsilien E71K20 ; 6-8 : troncatures proximales du site E71K18C ; 9 : troncature proximale du site E71K20 ; 10 : lame à dos abattu du site E71K20 (clichés A. Leplongeon, avec l'aimable autorisation du British Museum ; 3-10 : Leplongeon, 2017).*

Finally, a third factor for this variability may be linked to the functions of the sites or indeed to their season of occupation (for example Lubell, 1976). However, and in contrast with preceding periods, all sites seem to testify to the presence of similar faunal assemblages, while nevertheless indicating different seasons of occupation (see also Coudert, 2013).

3.4. From the Middle Stone Age to the Late Palaeolithic in the Nile Valley: ruptures and continuity

From the beginning of MIS 3 until the end of the LGM, archaeological data from the Nile Valley can be divided into multiple phases – corresponding to the final phase of the MSA, the UP and the LP – each separated by chronological intervals without any archaeological data, whether due to research biases, to variable conservation conditions or an actual absence of human occupations in the area. The resolution of the available data does not allow us to distinguish between these different hypotheses, and therefore it remains to evaluate the similarities and differences that can be observed in the lithic record during this period. In order to do this, we will rely on elements generally emphasised in attributing an assemblage to the MP-MSA and UP-LP-LSA: the presence of Levallois methods *versus* volumetric blade-bladelet technologies and the emergence of backed pieces.

3.4.1. The Levallois from MIS 3 to the end of the LGM in the Nile Valley: continuity, reinvention, experimentation?

The Levallois and the transition to the Upper Palaeolithic (~ 60-50 kya)

The end of the MSA in the Nile Valley is marked by great variability in Levallois methods (Van Peer, 1991a and 1992), which are often oriented towards producing elongated blanks through bi-directional methods and which frequently involve the minute facetting of the striking platform (high proportions of convex shaped butts or *chapeaux de gendarme*).

The site of Taramsa 1 (Van Peer et al., 2010) is particularly interesting regarding the question of Levallois variability. The site is characterised by multiple trenches dug out of an ancient wadi terrace for the extraction of blocks of chert. It was exploited over a long period that produced an extremely complex stratigraphy. Six main "phases of activity" have been identified, each characterised by multiple lithic assemblages within which numerous refittings were carried out, allowing for a precise analysis of the core reduction methods (Van Peer et al., 2010). Phase I (207 kya) was attributed to the Lupembian, Phase II (dated between 117 ± 10.5 et 88.8 ± 9.5 kya) to an early phase of the Nubian Complex, Phase III – to which is attributed a child burial – to the Nubian Complex (mean age 78.5 ± 5.6 kya), Phase IV (mean age 56.2 ± 5.5 kya) to the Taramsan, Phase V (mean age 40.9 ± 4.5 kya) to the Safahan and finally Phase VI (40.7-45.4 kya cal. BP) to the UP. In particular, the Taramsan is characterised by a specific core reduction method with distinct Levallois characteristics, but deviates from it by the presence of a somewhat peculiar distal striking platform, with more pronounced lateral convexities, and an exploitation plane slightly offset with respect to the intersection plane of the core (fig. 7, nos. 6 and 7). These characteristics, resembling volumetric debitage methods, led to the interpretation that the assemblages of Activity Phase IV and the Taramsan may represent a transition between Levallois production and the volumetric blade production of the Upper Palaeolithic (Van Peer et al., 2010, p. 241). However, it is likely that several "transitional" trajectories existed in parallel, with P. Van Peer et al. (2010, p. 241) suggesting that the production methods in activity Phase V at Taramsa are documenting a distinct transitional trajectory parallel to that seen in Phase IV. A successional relationship is suggested with the Nubian Levallois method for Phase IV and the Safahan Levallois method for Phase V.

Although these data all come from a single site, they seem to indicate that the tendency towards the use of volumetric blade technologies in the Nile Valley was in place from the beginning of MIS 3.

The Levallois in the Upper Palaeolithic (~ 50-25 kya)

The UP in Egypt was seen for a long time as characterised strictly by blade assemblages and the absence of Levallois methods. However, the publication of new sites and new analyses of assemblages attributed to the UP have allowed a certain nuancing of this vision. The characteristics of these assemblages are summarised below.

As already mentioned, the UP in the Nile Valley is represented by a very limited number of sites (Taramsa, Activity Phase VI, NK4, Shuwikhat, E71K9 and El-Abadiya Central Sector, the latter three grouped under the term "Idfuan-Shuwikhatian"). Phase VI at Taramsa 1 is characterised by a blade production method similar to that of the Taramsan (Phase IV), although its volumetric blade character is even more pronounced. This production is associated with the production of Nubian Levallois points (Van Peer et al., 2010, p. 181-182). Nazlet Khater 4 has produced an assemblage that is characterised primarily by volumetric blade production, leading to it being considered as an abrupt rupture with previous industries (Vermeersch et al., 2002a). It is nonetheless interesting to note that certain characteristics less frequent in the assemblage at NK4 are reminiscent of the MSA, such as the presence of flake production using the core surface and the presence of bifacial components (Leplongeon and Pleurdeau, 2011; Vermeersch, 2020). Of the sites attributed to the Shuwikhatian, only Shuwikhat 1 and El Abadiya have been subject to detailed analyses (Vermeersch et al., 2000b). They are characterised primarily by volumetric blade production on cores with opposed striking platforms. While Levallois methods are absent, certain characteristics such as the maintenance of core convexities, the somewhat planar character of the surfaces of exploitation of cores as well as the treatment of the striking platforms (by faceting) is perhaps indicative of a Levallois lineage (Vermeersch et al., 2000b, p. 156,180; here: fig. 7, nos. 8 to 10). However, the blade components of the assemblage, associated with few retouched tools but dominated by end-scrapers, burins and backed pieces have been considered sufficient for attribution of the assemblage to the UP (Vermeersch et al., 2000b; Vermeersch, 2020).

This short synthesis of several assemblages attributed to the UP in the Nile Valley shows that despite the lack of data for MIS 3 and their partial contradiction with the earliest published data on the Egyptian UP, the available archaeological record speaks for a hypothesis of gradual local transitions from Levallois core reduction methods towards volumetric blade core reduction. While their attribution to the UP seems justified by the predominance of blade productions frequently exhibiting a volumetric conception, in our opinion the technological characteristics that appear to be inherited from the Levallois deserve to be underlined.

The Levallois in the Late Palaeolithic (~ 25-15 kya)

One of the interpretations linked to the LP in the Nile Valley seeks to explain the presence (persistence?) of Levallois technologies up until this period (see discussion in Paulissen and Vermeersch, 1987). Faced with new data from the end of the MSA and the UP in the Nile Valley described above, and considering certain elements in continuity with the MSA, this late flourishing of Levallois methods in the Nile Valley should no longer be a surprise, though it nonetheless deserves re-evaluation. Indeed, while we accept that a certain Levallois heritage can be identified within the assemblages of the UP, clearly-defined Levallois methods are indeed much rarer or even absent in certain assemblages. Although many of the industries of the LP in the Nile Valley incorporate Levallois methods in their definition, a critical review of these industries will allow us to nuance this view.

Among the Levallois industries of the LP, only the Kubbaniyan has provided absolute dates and carefully-documented contexts – it is also interesting to note that the Levallois flakes and cores are present in smaller proportions in these assemblages – whereas for the Sebilian and the Gemaian, the stratigraphic integrity of the assemblages has been questioned (for example, Paulissen and Vermeersch, 1987). Sites with clear stratigraphic contexts will be essential in order to consider these industries as definitive parts of the LP.

Other industries exhibiting Levallois core reduction (the Levallois Idfuan and Halfan, see table 1) are characterised by a specific method: the Halfan. “Classic” Levallois debitage is present only in meagre proportions (see also Van Peer, 1991a). The Halfan method was defined by A. Marks (1968a) as a core reduction method for pre-determined flakes, based upon the bi-directional preparation of the core and involving the meticulous crafting of a faceted convex striking platform in addition to the preparation of distal convexities of the core by removing bladelets or elongated flakes (fig. 8, nos. 1 and 2). These steps give the core “the appearance of a Levallois core” (Marks, 1968a, p. 394) and the Halfan method is generally considered to be one of the Levallois methods used in the Nile Valley (Van Peer, 1991a and 1992). The abundance of Halfan cores associated with backed bladelets at certain sites located between the first and second cataracts has led to the definition of the Halfan as a distinct industry (Marks, 1968a). The Halfan method is also documented in other industries from the LP (for example in the Levallois Edfouan). The status of the Halfan method and its place within other Levallois methods are important factors to consider in the debate regarding the persistence of the Levallois into the LP. Indeed, it seems to be the most common method affiliated with the Levallois among LP industries. Determining if and by what means this method derives from other Levallois methods from the MP is critical to evaluate its role within a scenario of the continued existence (and therefore continuity) of the Levallois in the LP.

4. COMPARATIVE LOOK AT THE HORN OF AFRICA AND THE NILE VALLEY

Here, we comparatively evaluate techno-cultural dynamics at the end of the Pleistocene in both the Horn of Africa and the Nile Valley, two regions geographically connected by the Nile basin but whose archaeologies have yet to be interrogated in relation to one another. These dynamics take place in the context of the climatic deterioration of the Last Glacial period, culminating with the LGM, which profoundly affected the landscapes of these areas and exacerbated existing contrasts. In this context, the trajectories that lead to the decline of the MSA and the advent of LSA/UP-LP technical traditions are certainly distinct, though several convergences can also be noted and force us to attempt to interpret the value of this information. Before beginning with this task however, it is worth recalling that the archaeological records of these two regions are chronologically and contextually very disparate.

4.1. Two distinct regions: research bias or age-old reality?

The Horn of Africa and the Nile Valley can be fairly strongly distinguished with regards to the available data for the period between MIS 3 and the end of MIS 2. There are only a few contemporaneous sites in the two regions. A relatively large number of sites are attributed to MIS 3 in the Horn of Africa – or at least they are more numerous than in the Nile Valley – and by contrast very few sites are dated to MIS 2, whereas many sites are known for this period in the Nile Valley (table 2).

This differential chronological distribution of occupations in each of the regions could be seen as reflecting a true complementarity between them, with human populations having favoured one or the other according to the circumstances. However, archaeological data are far from being able to prove such a scenario, and if it is necessary to defend a model, it would undoubtedly be that of the entrenchment of populations within different areas of the Horn of Africa during MIS 3, with its limited zones of mobility (for example limited vertical mobility in mountain habitats). Furthermore, the archaeological record of the Nile Valley speaks for the occupation of sites with very specialised functions (for example for the extraction of raw materials), producing data that are difficult to compare with the Horn of Africa. Finally, the systematic sedimentary and chronological hiatus which covers the period of the LGM in the Horn of Africa (for example at Goda Buticha, Mochena Borago, ADS2 and without a doubt, at other sites interpreted formerly as transitional) presents a major research bias for assessing past reality regarding the differential population of these two regions. Was the Horn really depopulated while the Nile Valley was more densely populated during the LGM? The question remains open for the moment.

Other exacerbating factors demarcating the two regions include the types of known sites for the period, which vary widely from shelters, caves, lake-shore or at high altitude occupations in the Horn, whereas in the Nile Valley they are almost exclusively open air and near water sources.

Furthermore, the available remains for the Horn at the beginning of MIS 1 are primarily lithic artefacts, as many sites show very random – and more often no – preservation of organic remains. In the Nile Valley by contrast, for example in MIS 2, the preservation of organic remains (faunal and plant remains; e.g. traces of rhizome crushing at Wadi Kubbaniya: Hillman et al., 1989) as well as the spatial organisation of sites with the presence of structures (post holes interpreted as fish-smoking structures at Makhadma 4 Kubbaniya: Vermeersch et al., 2000a), enables the relatively extensive reconstruction of human-environment relations in this region. These differences in the nature of the preservation of remains, in addition to limiting the evaluation of behavioural convergences between the two areas, has led to research questions that are necessarily different from one region to the other.

Finally, and perhaps more insidiously, these regions are distinguished from one another by their research traditions, with research in the Horn of Africa following the models of the MSA and LSA developed in and for Africa, while research in the Nile Valley has oscillated between research questions that are distinctly Africanist and those that are turned towards the Near East and Europe, particularly regarding the origins of the UP. The Palaeolithic of the Nile Valley also benefitted from numerous research projects from the 1960s to 1980s, often initiated in the context of the Nubian Campaign and its numerous and ambitious archaeological and geomorphological projects. This contrasts with the scarcity of recent studies in the region, in particular concerning the LP. Inversely, the Horn of Africa has seen a resurgence of research since the 1990s, notably on questions related to the end of the MSA and the beginning of the LSA, a period that is at present neglected in the Nile Valley.

The different research traditions and questions have led to the use of terminologies that are hardly comparable, both in the naming of the industries and for the description of their components. The objective of this comparative overview is not to question the use of a particular nomenclature, but rather to surpass the oftentimes paralyzing obstacles created by divergent terminologies by instead describing the lithic variability at the end of the Upper Pleistocene in the two regions as well as their respective techno-cultural trajectories (table 2).

4.2. Confronting the two regions: trajectories towards new production systems?

Our approach here is to summarise the available data for both regions by chronological phase and by confronting data from both simultaneously, in order to comprehend the processes of change, whether they occurred following ruptures or in continuity.

4.2.1. MIS 5 (~ 130-70 kya)

The MSA at the beginning of the Upper Pleistocene in the Horn of Africa is characterised by the production of flakes, points, and elongated products, essentially by Levallois methods. There is a significant variability of the Levallois methods used, such as the Nubian core reduction at K'one and at ETH-72-6 (if one accepts the attribution of these sites to the beginning of the Upper Pleistocene), the micro-Levallois and micro-Aduma at Aduma, and more generally an implementation of multiple modalities and management types in the Levallois operative schemes within assemblages. Volumetric blade production is also known but remains sporadic, as is the case from the beginning of the MSA.

In parallel, the MSA in the Nile Valley at the beginning of the Upper Pleistocene, and more specifically at the end of MIS 5, corresponds mainly to the Nubian Complex, although the exact chronological extent and technical variability within the latter remain poorly known. It is characterised by the use of Nubian Levallois methods for the production of points, alongside other Levallois methods, namely of recurrent modality and centripetal core management types. The Nubian Complex covers a wide diversity of industries.

4.2.2. MIS 4-beginning of MIS 3 (~ 70-35 kya)

No site in the Horn of Africa has produced absolute dates clearly relating to MIS 4. The beginning of MIS 3 is in contrast increasingly represented, particularly in recent excavations (Goda Buticha, Mochena Borago, Fincha Habera). The MSA here is characterised by significant variability in debitage methods, which are mainly

	MIS 5		MIS 4		MIS 3		MIS 2		Early MIS 1 (15-12ka)	
	NV	HoA	NV	HoA	NV	HoA	NV	HoA	NV	HoA
General Classification	MSA	MSA	MSA	MSA	UP	MSA	LP	MSA / LSA	ND	LSA
Relative density of known sites	+	+	Δ	–	Δ	+	+	Δ	-	+
Flake production from platform cores	+	+	+	ND	Δ	+	+	Δ	ND	Δ
Elongated blank production from platform cores	Δ	Δ	Δ	ND	Δ	Δ	+	+	ND	+
Elongated blank production from volumetric cores	Δ	Δ	+	ND	+	Δ	+	+	ND	+
Bipolar-on-anvil core reduction	-	–	-	ND	-	Δ	Δ	–	ND	-
Levallois core reduction	+	+	+	ND	-	+	Δ	-	ND	-
Technological points	+	+	-	ND	-	+	Δ	+	ND	Δ
Retouched or shaped points	Δ	+	Δ	ND	Δ	+	-	Δ	ND	-
Backed pieces (all dimensions)	-	–	-	ND	Δ	Δ	+	Δ	ND	Δ

These elements may be absent (-), sporadically present/rare (Δ), present/numerous (+), or no data is available (ND).

Table 2 – Table comparing the presence of typo-technological elements discussed in the text between the Nile Valley (NV) and the Horn of Africa (HoA).
Tabl. 2 – *Tableau comparant la présence des éléments typo-technologiques discutés dans le texte entre la vallée du Nil (NV) et la Corne de l'Afrique (HoA).*

planimetric, both Levallois and non-Levallois, with some occurrences of volumetric blade production and bipolar-on-anvil core reduction. Each site has distinct technological characteristics, in which Levallois is not clearly dominant. The production of elongated blanks is more significant than in preceding periods but is still mainly conditioned by planimetric conceptions of core reduction. Backed pieces seem to be present for the first time in the Horn in two MIS 3 sites, though in very small quantities and quite varied forms, and are not necessarily associated with blade industries (Mochena Borago). Retouched and shaped points remain predominant.

In the Nile Valley, the rare data available for MIS 4 and the beginning of MIS 3 in Egypt cover sites that demonstrate a very specific function of raw material extraction, and where technological manifestations of Levallois conceptions verging on volumetric blade production seem to have taken place (Taramsan, Safahan). It is in this respect that these industries are no longer considered as fully integrated into the technical world of the MSA but rather as precursors of a transition towards the UP. Indeed, one of the key sites from this period, NK4, is fully assigned to the UP by the presence of a volumetric approach to core reduction, despite some characteristics reminiscent of a planimetric approach more typical of the MSA, notably in the management of convexities. Similarly, Phase VI at Taramsa is attributed to the Upper Palaeolithic, despite certain characteristics that recall the MSA. The attribution of NK4 or Taramsa (Phase VI) to the UP is based almost exclusively on technological arguments, as the function of these sites (the extraction of raw materials) has led to a very low representation and uncharacteristic toolkits, except for the adzes of NK4. By contrast, in Sudan, the only site dated to the beginning of MIS 3, Affad 23 (~ 55 kya; Osypinska et al*.*, 2020; Osypinski, 2020; Osypinski et al., 2021), is considered as fully MSA, with a very clear use of Levallois methods.

4.2.3. End of MIS 3-MIS 2 pre-LGM (~ 35-25 kya)

Sites in the Horn of Africa that can securely be related to the very end of MIS 3 are DW1, DW4, B1s3 and B4 in the Ziway-Shala basin. These sites have provided blade industries produced following a planimetric approach to core reduction, most often through a bi-directional Levallois method, and the products of which show carefully faceted platforms (fig. 4). Since cores are all cores-on-flakes and therefore quite flat, the management of the lateral convexities was achieved by *débordant* removals, often highly inclined, having laterally taken away the intersection plane between the two surfaces. This type of management cannot be mistaken for a volumetric conception of core reduction, and moreover, no backed pieces have been recovered from these sites. In contrast, the site of Aga Dima S2, also in the Ziway-Shala basin and dated to the very beginning of MIS 2 has provided an assemblage characterised by similar types of productions, although this time with the introduction of strongly curved geometries on some of the cores. Alongside a volumetric management of the cores, the site has produced a toolkit composed of points associated with backed pieces of diverse morpho-dimensional characteristics, as well as burins.

In the Nile Valley, only a few sites have been dated to the end of MIS 3 and the beginning of MIS 2. With minimum ages around 25 kya, the Shuwikhatian-Edfouan industry, represented principally by three sites, belongs to this period, namely Shuwikhat 1, El Abadiya 1 and E71K9. Volumetric blade schemes are dominant here, though they include additional characteristics that recall planimetric conceptions and Levallois core reduction methods (management of convexities and preparation of striking platforms). These assemblages have produced a few backed pieces, but in relatively small quantities, and their manufacture is described as quite irregular.

4.2.4. The second part of MIS 2 (~ 25-15 kya)

In the Horn of Africa, only the site of Sodicho, whose material is currently in the process of being published, can be attributed to this period (Hensel et al., 2021). It is therefore necessary to jump forward several millennia to the beginning of MIS 1 in order to identify occupations again, at least in the Ziway-Shala basin and perhaps at Besaka (Habte, 2020). These latter areas have produced industries that are, this time, fully LSA with volumetric blade-bladelet productions, backed pieces and burins, with no Levallois core reduction, but which also occasionally provide a few flake cores (notably at Besaka). This is followed during the Holocene by highly diversified LSA technologies accompanied by equally disparate subsistence modes.

On the contrary, numerous sites attributed to the LP are documented and divided into multiple industries in the Nile Valley (table 1). These sites are characterised by highly diverse productions, generally blade-bladelet productions, with debitage methods that are both volumetric and planimetric. Volumetric blade productions are occasionally associated with Levallois core reduction methods (Kubbaniyan) or with methods that seem to derive from the Levallois (Halfan), whose descent from former production systems is not evident due to the poor chronological resolution. Backed pieces are abundant and tend to dominate the toolkit. They exhibit a significant variability and are often not highly standardised, even if the retouch type appears to be more regular than for MIS 3 sites. It is possible that the micro-burin technique is represented, though with a very limited or even purely accidental usage (Leplongeon, 2017; Leplongeon and Goring-Morris, 2018). The evolution of these industries is unknown given the poor archaeological data from the end of MIS 2 and the beginning of MIS 1 in the Nile Valley (with the possible exception of Jebel Sahaba; see discussions in Vermeersch and Van Neer, 2015; Crèvecœur et al., 2021; Leplongeon, 2021).

In the end, while stark contrasts remain in the archaeological records of these two regions, the above synthesis of data allows us to go beyond the incompatibility of comparisons between them, and instead to propose avenues of convergences between their cultural trajectories as well as to sketch more precisely the technological and chronological evidences defining their divergences.

4.3. Similarities between the two regions: parallel but asynchronous processes?

Beyond the marked differences in the archaeological records of the two regions characterised by gaps during which few or no sites are known, it is possible to identify parallel processes, at least regarding the development of industries with technical principles typical of the LSA or of the UP-LP.

At the beginning of the Upper Pleistocene, the MSA of the two regions can be characterised by a dominance of Levallois conceptions, which are resolutely central to the lithic productions and exhibit a wide range of variability. This diversity of Levallois productions leads to a mosaic representation of industries with distinct characteristics, centering around a common conception of the geometry of core reduction (opposed hierarchized surfaces, removals parallel to the intersection plane, and the importance of the preparation of the surfaces).

The conceptions of core reduction in the two regions become increasingly varied as Levallois methods decrease in importance at most sites. Industries with elongated blanks become more common, and from the end of MIS 4 the Nile Valley sees a move towards resolutely laminar and volumetric industries. The strong contrasts between industries within each of these regions reinforces the image of a mosaic of technical practices. The practices in some regions demonstrate important changes from a conceptual point of view regarding the production modes as well as in the toolkit, with the introduction of the concept of backing during MIS 3. This change however does not represent a stark technical rupture since, in both regions, the first volumetric blade industries also retain some characteristics that seem to have been inherited from the Levallois (ADS2, Shuwikhat 1).

This common trend of local developments leading to the replacement of the Levallois which was dominated by volumetric conceptions in both regions, follows a gradual though asynchronous pattern in both regions (MIS 4-3 in the Nile Valley, end of MIS 3-beginning of MIS 2 in the Horn). The fact that these changes were gradual has contributed to the adoption of different terminologies in the respective regions, depending on whether the interpretations emphasised the evidence for continuity (maintaining the assignment of the industries to the MSA in the Horn) or evidence that marks a break with previous technical traditions (attribution of the industries to the UP in the Nile Valley). It is possible that gradual trajectories towards new conceptions of core reduction and of the toolkit as a whole are rooted in the diversification of industries marking the end of the MSA, which is itself perhaps linked to the climatic conditions of the Last Glacial period. This diversification may indeed be seen as reflecting a strong adaptive dynamic in which technical systems had to rapidly be reinvented while remaining flexible in order to deal with increasingly unstable environmental situations. One can envision that the climate-related pressures that occurred asynchronously and in different ways in each region also led to techno-cultural changes taking place at different moments.

This asynchrony in the trajectories of change, despite some convergence in their processes, is again encountered at the time of the emergence of the LSA and the LP, during or after the LGM in both regions. However, the more pronounced discrepancies, and even the more significant break between the very end of the MSA and the early LSA sites, are exacerbated in the Horn of Africa due to the absence of archaeological data for the LGM period, corresponding to a hiatus of nearly 10,000 years. In the Horn, just after the LGM, Ethiopian sites of the Late Glacial – final Pleistocene – demonstrate the emergence of clearly laminar industries, with backed pieces and burins, and without any Levallois (Ménard et al., this volume). These were once grouped under the term of "Ethiopian Blade Tradition" (Clark and Williams, 1978) and are considered discontinuous with the varied industries of the Holocene LSA that follows (Ménard and Bon, 2015).

The Nile Valley during MIS 2 shows the development of original industries with a significant variability for a restricted chronological period and in a limited area. The question of their continuity with previous industries – the MSA in particular, based on the presence of Levallois conceptions during MIS 2 – remains open and difficult to resolve given the small number of known sites for the end of MIS 3. However, the evidence of profound conceptual changes towards blade and volumetric core reduction processes as early as MIS 4 in the Nile Valley do not allow us to reject the hypothesis of a sporadic reinvention of Levallois methods or at least methods recalling the Levallois during MIS 2 (Halfan). Several authors have suggested exterior influences on the development of the variability observed in MIS 2 in the Nile Valley through contacts with Northwestern Africa (Phillips, 1972 and 1973; Close, 1978 and 2002) or the Levant (Schmidt, 1996). In this respect, a recent genetic study based on ancient DNA from individuals from Taforalt (~ 15 kya), Morocco, indicates the presence of genetic interactions between the populations of northern Africa and those of the Levant at the end of the Pleistocene as well as a Western, Central, and Southern African ancestry for individuals from Taforalt (Van de Loosdrecht et al., 2018). These results suggest interactions along the Mediterranean at the end of the Pleistocene, while the role of the Nile Valley in these interactions remains to be clarified. Systematic comparisons of archaeological data between these regions are still rare (Leplongeon and Goring-Morris, 2018) and in the absence of ancient DNA from human remains in the Nile Valley, the question remains open. It is interesting to note that LSA sites documented at the beginning of the Holocene in the Horn of Africa (Ménard et al., 2014; Khalidi et al., 2020) also show the development of highly varied industries, close in both chronology and geography, and which present, as in the Nile Valley, highly contrasting modes of subsistence (also see Coudert, 2013).

It is tempting to draw parallels between the processes of change occurring in the two regions, even if they proceed according to significantly different timings. In each case, local developments within the MSA towards volumetric blade production, occasionally associated with a toolkit including backed pieces, are followed by distinctive changes marked by a growing diversification of industries. And it is only once this process was completed at the extreme end of the Pleistocene for the Horn – and perhaps as early as the beginning of MIS 2 in the Nile Valley – that we observe that the technical and behavioural universes of the MSA are definitively over. What comes out of this synthesis, is that despite each region presenting unique technical developments, there are similarities in the processes of change at the conceptual level regarding the lithic productions and through the lens of their evolution in the long-term. From this perspective, it is not so much a question of estimating whether ruptures occurred at exactly the same time, but rather whether they describe a similar dynamic of change. As a result, it appears that, without being able to assert the exact mechanisms of the influence of the "Big Dry" on the behaviour of prehistoric populations, it is nonetheless clear that in its broad chronological acceptance, this climatic phenomenon accompanied and undoubtedly amplified the restructuring of their technical worlds, as early as its beginning at the end of the MSA. And while these two regions have different archaeological records and signatures, it is clear from their comparison that their general trajectories can be brought closer to one another, not in the rhythm of change strictly speaking but in the direction of the processes of technological changes over time.

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