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Levallois and non-Levallois blade production at Shuidonggou in Ningxia, North China

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ABSTRACT

The Shuidonggou site is one of the most important for prehistoric research in China, yielding evidence of ancient human colonisations in North China during the Late Upper Pleistocene. Situated in the Ordos desert, it was first discovered and excavated by Teilhard de Chardin during the first half of the 20th century. He noted the originality of the lithic assemblages produced on blades and flakes, comparable to the Upper Palaeolithic in Western Europe. This open-air site in loess context dates from ca. 17,000 to 25,000 BP and may be earlier than 30,000 BP. The principal objective of this paper is to present the technical aspects of the Shuidonggou lithic assemblages using a technological approach based on the dynamic analysis of blanks and cores in a global overview of the *chaîne opératoire* concept. The goal is to understand the knapping strategies used: were both Levallois and non Levallois methods used? The importance of Shuidonggou is thus linked with the question of the use of the Levallois method.

1. Introduction

The presence of Levallois reduction associated with blade products in this region of the world around 17–25,000 BP underlies several problems in which anthropological, geographic and technological aspects are intermingled. The latter has a more significant role, as technology serves as the basis for discussions about the origins of modern behavior (Kuhn et al., 2004).

In reality, technological data is quite poorly identified and is often caricatured. It serves quite often as the pretext for one argument or another, without the technological value being truly identified, as if the abstraction were sufficient.

The site of Shuidonggou is a kind of illustration of such problems of identification of production modes and their objectives. The association of Levallois reduction and blades fatally evokes (Brantingham et al., 2004) industries called "Early Upper Paleolithic" or "Lepto-Levalloisian" with all of the underlying anthropological implications.

For this reason it seems preferable, before beginning this kind of discussion, to understand the technological and "techno-logical" significance of the lithic assemblage. Although Levallois reduction is clearly present, the first question to ask is whether it is technically capable of meeting this new demand for blades. In other words, does an entirely blade-producing Levallois method exist or, in contrast, is blade production the result of a new mode of production that is "entirely blade non-Levallois"? Depending on the response, several anthropological scenarios are thus possible, with very different implications. So, before discussing in more detail the techniques, this paper first schematically addresses the different possible scenarios and their implications.

Considering a change from Levallois reduction to blade production involves scenarios of local change with adaptation of a new technological concept, essentially local or borrowed via external contact. As Levallois reduction is not structurally capable of responding to this new entirely blade concept, two scenarios can be proposed: local development or a migratory phenomenon. For the first, this would be local invention and the fact of retaining Levallois reduction is due to the need to maintain a more diversified production. For the second, the laminar phenomenon is evidence of the presence of new populations. Persistence of Levallois reduction is thus interpreted as a sign of "transition". Although such a concept

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of diffusion is a reality in Europe, is it applicable to all continents? Is blade production at Shuidonggou one of the proofs of diffusion?

Several problems are intermingled, where on the basis of improperly identified facts, hypotheses are constructed, or even real paradigms such as Out of Africa. Insidiously, a sort of bio-cultural correlation is then suggested between a hominid type (modern humans) and a technological fact (blade production), that is poorly identified, leading to discussion of modern behaviors. Similarly, most of the time, Neandertals are still exclusively associated with the Levalloiso-Mousterian phenomenon, despite work in the Near East since the 1980s that has shown that this correlation is false. The Levalloiso-Mousterian "culture" is common to both Neandertals and modern humans (Vandermeersch, 1981, 1982; Schwarcz et al., 1988; Valladas et al., 1988; Stringer et al., 1989; Mercier, 1992; Mercier et al., 1993; Grün and Stringer, 2000, 2005).

By contrast, blade production after 40,000 BP is clearly associated in Europe and the Near East with modern humans (Bailey et al., 2009). However, a more precise examination of the data demonstrates that this correlation has no bio-cultural validity; it is simply historical. As much in Western Europe as in the Near East, many blade industries are known from as early as MIS 8 (Garrod and Bate, 1937; Rust, 1950; Hours, 1982; Jelinek, 1982, 1990; de Heinzelin and Haesaerts, 1983; Delagnes, 2000; Gopher et al., 2005; Meignen, 2007, 2011). In Europe from MIS 7 and during MIS 5 and 4, sporadic and highly localized appearances of blade industries associated or not with Levallois reduction occur. The makers, although fossil remains are not associated, are quite likely to have been Neandertals. The "laminar" tools produced are very different from one site to another, and unlike the typological classifications for the Upper Paleolithic. It is only with the Uluzzian in Italy and the Chatelperronian in France that blade production becomes the dominant reduction strategy, now with an entirely new range of tools. The determination of the makers of these industries – Neandertals (*Homo neanderthalensis* and *Homo sapiens neanderthalensis*) or modern humans – is the subject of debate (d'Errico et al., 1998; Mellars, 1999; Zilhão and d'Errico, 1999), with two opposing views: local invention by Neandertals or a technological concept transported by modern humans.

In the Near East, the laminar history is quite different. True blade industries appear after the Acheulean and the Yabrudian in MIS 8, well before the Levallois phenomenon. These are two successive strictly laminar industries: the Amudian (Garrod and Bate, 1937) and the Hummalian (Hours, 1982). The makers are not yet identified, but *Homo sapiens* was already present in the Near East 280,000 years ago (Zuttiyeh) (Vandermeersch, 1982; Zeitoun, 2001), followed soon after by Neandertals (Tabun C1) (Mercier et al., 1995; Millard and Pike, 1999; Mercier and Valladas, 2003). Blade tools, and in particular hose of the Hummalian are original and different from those found150,000 years later with the Ahmarian and the Aurignacian.

The reality of technological data in the circum-Mediterranean region thus requires attention to bio-cultural correlation, but also dissociation of the laminar phenomenon from tools that are made on blades. The laminar phenomenon exists since MIS 8 with different makers – modern humans and Neandertals. This phenomenon reappears around 45/30,000 BP, this time with modern humans as the principal actor. However, while this phenomenon reappears, the tools associated with it are different from those previously produced, with specificities, as in the Near East, where some of the tools (endscrapers and burins) already have a non-trivial presence during the Mousterian phase. The difference lies in the fact that they are considered as tools. However, when each tool is deconstructed into a transformative part and a grasping part (Lepot, 1993; Boëda, 1997), it is the transformative part that changes with the adoption of blade production (Boëda, 2005). The transformative parts of endscrapers and burins are made on a new kind of blank: the blade. Obviously the hafting methods would change as well as the range of movements and energies employed.

Many anthropological scenarios apply the technological fact without investigation proper to it. Yet, confronted with these challenges, it is fundamental to know what is being discussed and even more so in Eastern Asia where the presence of Levallois reduction in northern China at Shuidonggou and Jinsitaï (Wang et al., 2010) naturally suggests a geographic extension between Western and Eastern Asia via the Altai and Mongolia. From this comes the idea of a sort of continuity of a Levallois "world" from the Atlantic to the Pacific, with the underlying anthropological dimension and the same questions as for the circum-Mediterranean region, that is, to determine the hominids responsible: Neandertal, a new recently identified regional species (Krause et al., 2007, 2010), modern humans (Kuzmin et al., 2009; Bailey and Liu, 2010; Liu et al., 2010), or a local sub-species of *H. sapiens* (Zeitoun et al., 2010; Curnoe et al., 2012). Laminar reduction is also present, even if it is less clearly documented. Data are known only in China at Shuidonggou and in Korea at Kumgul and Suyanggae (Lee and Kong, 2001; Kong and Lee, 2004). Is this truly a specific form of reduction of local invention or, conversely, evidence of "contact" with the West?

Addressing these questions needs a different analytic perspective of technology, more inductive, aiming not to attach a given even to a pre-written history, but taking the facts as they are presented, demonstrating where or not a phenomenon of much greater complexity than previously expected existed. Such complexity is often obscured to the benefit of a single history, refusing to identify others, with their differences. This returns to the problem of perception of facts and the resulting data. From this, the persistent question of how to collect data and what meaning can be given them with respect to the hominids responsible is again raised. Moreover, to disconnect human productions from their makers would be otherwise be a more radical solution that avoids the anthropological question without resolving it.

As a result, a three-step approach has been developed: techniques sensu stricto, "techno-logical" and technological, leaning historical taking into account interactions between humans, their techniques and places of occupation.

The techniques phase is that of demonstrating the epi-phylogenetic memory included in each object, in other words, the memory of the objectives and means to achieve them that are reflected by a demonstration of knowledge and know-how.

The "techno-logical" phase addresses the meaning of the development of techniques via a structural analysis of the objects over the long term. The long duration shows that the processes of production as well as tools evolve toward greater complexity, regardless of the place that produced them, as if there was an underlying logic to the technology. Using methods able to restore the memory to objects considered "dead", the aim is to determine the lineages of objects – cores and tools – and to identify the place of each in their own lineage. This approach is heuristic because, by no longer defining the object by what it is at a given moment, but by the place it occupies in its lineage, it allows understanding of the preceding and succeeding stages of each object. Forming a kind of evolutionary value scale, this basis addresses the anthropological reasons (or not) of these successive states.

The technology phase is the historical analysis of technical facts based on observations made during the first two analytic phases. It takes into consideration the historical meaning of change. This anthropological aspect is addressed by different axes: geographical, societal, economic and symbolic. Although this aspect is the final objective, to achieve it requires knowing what is under discussion.

While showing differences is a necessity, the information can come only from the meaning given to these differences, and thus the importance of the identity of the differences.

2. Historical and geographical context of Shuidonggou

The Shuidonggou site is located in the Ningxia Hui Autonomous Region in Northern China, about 10 km east of the Yellow River, on the margins of the Ordos Desert (38°17′ 55.0′ N, 106°30′ 6.2′ E; 1220 m above sea level) (Fig. 1). The site was first excavated in 1923 by Licent and Teilhard de Chardin (1925) and subsequently re-excavated by Chinese teams in the early 1960s and again in 1980 (Boule et al., 1928; Jia et al., 1964; Ningxia Museum, 1987).

Shuidonggou occupies an ecotonal boundary dividing the semiarid desert steppe, associated with the Yellow River and foothills of the Helan Mountains, from the arid Ordos Desert. The site is scattered along the banks of the small Biangou River which runs southeast to northwest to the Yellow River. The region is dominated by a thick (10–40 cm) sandy-loess platform that is increasingly intercalated with alluvial sediments near the Yellow River. Sandy-loess deposits in the direct vicinity of Shuidonggou appear to correspond to the Late Pleistocene early Malan loess. At Shuidonggou the Border River has dissected the sandy-loess platform, producing channel cuts with steep 10–20 m deep exposures. Four main major archaeological localities occur at Shuidonggou (Madsen et al., 2001). Localities 1 and 2 (Fig. 2), which face one another across the small channel of the Border River, have yielded archaeological materials.

3. Stratigraphy and dating

Licent and Teilhard de Chardin (1925) considered Shuidonggou to be an evolved Mousterian with Upper Palaeolithic features, a classification supported by Bordes (1968), while others placed the site within the Chinese Upper Paleolithic (Jia et al., 1964; Lin, 1996). The present state of research requires caution in the use of the terms Upper Paleolithic or Early Upper Paleolithic, and even Lepto-Levalloisian (Brantingham et al., 2004) because this terminology is inherited from periods when Western prehistory was the only reference. Although these terms are still used in Western Europe, they should be applied with extreme caution in the East, in China or in Asia in general. At present, it is preferable to think in terms of alterity, where the other exists via its differences and modes of appearance. In addition, perhaps the Upper Paleolithic and Mousterian do not even exist here (Gao, 1999).

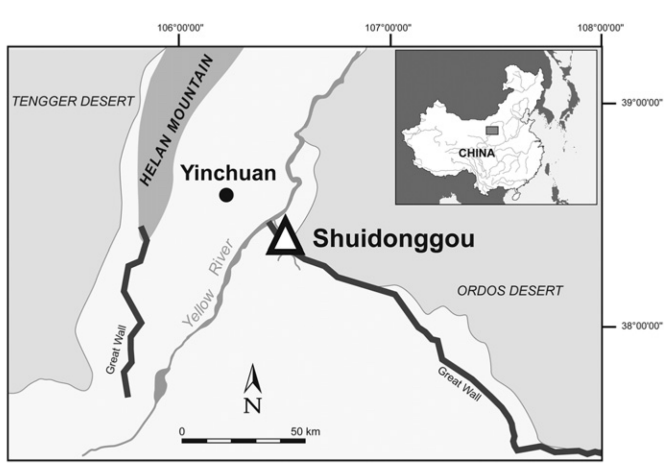

Fig. 1. Location of the site of Shuidonggou, North China.

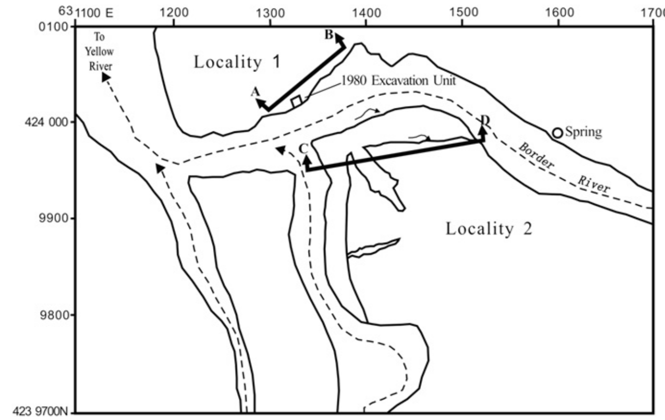

Fig. 2. Detail position of Shuidonggou locality 1 and 2, measurement are given as UTM coordinates in 100-m intervals (re-edited after Madsen et al., 2001, p. 708).

Shuidonggou represents a large area with ten "prehistoric stations" defined as sites where human occupations date from the end of the Pleistocene to the Holocene. The most important in terms of lithic frequencies is Locality 1. The raw material of stratum 7 and 8 of Locality 1 is primarily quartzite, but there are also rare products made of chert.

3.1. Stratigraphy of locality 1

Shuidonggou Locality 1 was discovered in a cutbank of the right bank of the Biangou River, its profile 15 m thick. The deposit includes continuous strata from the Oligocene to Early Holocene. Late Pleistocene sediments at Locality 1 occur within a fluvial cut-and-fill sequence (Chen et al., 1984; Madsen et al., 2001; Liu et al., 2010):

Stratum 8c sediments consist of fluvial, finely bedded medium sand containing no carbonates. This stratum sits on Plio-Pleistocene red clay.

Stratum 8b overlying the bedded sands is a structureless fine silt with abundant carbonates. This stratum is the primary archaeological unit. A non-conformity marks the transition to unit 8a.

Stratum 8a represents a sequence of channel gravels and cross bedded medium sands of fluvial, or possibly mixed fluvial and eolian origin. Strata 5–7 represent a continuation of fluvial sedimentation with interbedded gravels and medium sands. The archaeological items from these strata are likely redeposited. A non-conformity marks the transition to Holocene sediments, represented by low energy waterlain silts and sands with abundant organic materials. Stratum 4 is the lowest Holocene unit, dated with two radiocarbon assays on pond organic matter of 5940 ± 100 BP and 6505 ± 95 BP (Geng and Dan, 1992).

The Shuidonggou stone industry derives primarily from Stratum 8b. Similar archaeological materials found in strata 6 and 7 may be redeposited (Madsen et al., 2001).

3.2. Dating and environmental data

At Locality 1, there are two finite radiocarbon dates of 17,250 ± 210 BP and 25,450 ± 800 BP, from Stratum 8b, the Late Pleistocene stratum containing Upper Palaeolithic materials (CQRC, 1987). The first of these is a collagen date from what is likely a re-deposited bone, while the second is on a carbonate nodule. These dates are more cautiously assumed to be minimum ages due to potential problems with radiocarbon assays of bone collagen and carbonate (Pendall et al., 1994). Chen et al. (1984)

report bone-derived U–Th ages from the "Lower Cultural Level" at Shuidonggou ranging from 40,000 to 32,000 a. U–Th dating of bone should be treated with extreme caution because of the uncertainty surrounding the mechanisms of uranium uptake and loss from bone tissues. In contrast, according to palynological evidence suggesting that the Late Pleistocene deposits at Shuidonggou accumulated under generally cold and dry conditions, Zhou and Hu (1988) favour a literal interpretation of the younger radiocarbon dates, more precisely to the Last Glacial Maximum about 20,000 BP. During the last decade, exposed loess profiles along the Border River bisecting Shuidonggou were examined in order to detect hearths containing both datable material and associated artifacts, in attempt to resolve this chronological confusion.

Recent surveys conducted by a Chinese and American team in 1999 and 2000 (Gao et al., 2002, 2006, 2008) confirm the importance of Locality 1 and others, including for example Locality 2. The Chinese researchers confirmed the early dating for Locality 1 (SDG1) with stratum 7 dated to ca. 35,000 a at the base of the stratigraphy (Liu et al., 2009). In the same paper, early dates of 72,000 a and 64,000 a for Layer 17 of Shuidonggou Locality 2 (SDG2) were also reported.

Faunal remains are apparently quite rare in the Late Pleistocene deposits at Shuidonggou. The larger mammalian fossil species include *Coelodonta antiqutatis*, *Equus przewalskyi*, *Equus hemonius*, and *Spiroceros kiahktensis Gazella* (Zhong et al., 1987; Madsen et al., 2001). These species are common to the palaeoarctic faunal complex distributed widely across northern Eurasia during the Late Pleistocene (Madsen et al., 2001). They are broadly similar to the species represented in the Upper Salawusu formation (Miller-Antonio, 1992; Madsen et al., 2001) dated to the early part of MIS 3 (55–30 ka).

4. Technological reconsideration of the Shuidonggou lithic assemblages

The approach is qualitative because the first objective is to determine the operatory schemes applied throughout the assemblages which cannot be achieved only by quantitative methods. The explanation of this methodological choice is simple: what is being done and what is being quantified? As the artifacts were identified by morphology alone as produced by Levallois blade production by the authors cited above, the objective is to confirm or refute these data by technologically analyzing the volumetric constructions of all of the cores and their modes of management in order to determine the real functional intentions.

In other words, unlike what is found by technological analyses that are limited to the reconstruction of core preparation and production phases, which confound the ends and the means, the question is reversed, in an attempt to explain the technological consequences of each predetermining removal in order to identify their techno-functional role for subsequent predetermined removals, desired and sought by the prehistoric knappers. To do so, it is necessary to apply a methodology capable of taking into account the technological correspondence between the objectives and means of production utilized. This requires determining the functional intentions during the production phase. However, this methodology must be structural in order to take into consideration the developmental stage of each object by placing each in a lineage. This approach involves a techno-logic. So, the understanding of an object must be done "… à partir des critères de la genèse pour définir l'individualité et la spécificité de l'objet technique: l'objet technique individuel n'est pas telle ou telle chose donnée hic et nunc, mais ce dont il y a genèse" (Simondon, 1958). This objectifies each artifact by the place where it occupies in a lineage. All of the artifacts in a single lineage are as much new forms of equilibrium, calling for their replacement and their transformation.

It is of no use to identify an object by what can be seen. Its technological meaning is provided only by the position that it occupies in its lineage. The laminar phenomenon at Shuidonggou is therefore addressed in its evolutionary framework by determining its technological stage as well as the specificity of Levallois reduction in relation to it.

5. The laminar lineage

To better understand the laminar lineage, return to the concept of laminar reduction. This concept refers to many different technical realities that can be grouped into two groups: the first including necessarily mixed productions that include blade removals, such as Levallois reduction and the second containing exclusively laminar productions, thus called blade production. Levallois reduction produces laminar products within recurrent series that are not themselves laminar. The latter modes of production do not have specific terms, but are found under very different names which include the words blade or laminar. Semantically, Levallois reduction is not qualified by another term signifying the specificity of its production because it produces a range of different kinds of products. Developmentally, all of the exclusively blade production systems are included within a single lineage, termed laminar.

Regardless of the developmental stage of these structural modalities, they all must have a certain number of technical traits capable of providing blades "on demand". To produce a blade requires:

- a volume with sufficient mass to absorb and retransmit the fracture shocks, and to provide the number of blades sought;
- a flaking surface adapted to the percussion processes, internal or tangential;
- a reduction volume, termed useful volume, capable of qualitatively and quantitatively producing the intended blanks.

Depending on the lateral and distal convexities established, one can produce a blade of a given length and/or width and/or section and/or contour and/or profile, etc., producing a single blade or many. This would then be a recurrent series. This concept of recurrence is thus differentiated from a simple series of removals, where the technical consequences of each removal do not affect the following removal. This implies that the flaking surfaces of each of these two methods, successive with and without recurrence, are not the same. For simple succession, after removals, the flaking surface shows almost no criteria of predetermination, the detachment of each removal affects the success of the subsequent removal, without control of its technical characteristics, while for recurrence, the flaking surface (or the volume to be reduced) presents a series of criteria of predetermination anticipating all of the production and the kinds of removals intended and made possible by the choice of recurrent methods.

The concept of recurrence means that each technical criterion of predetermination used is replaced by another. That is, a predetermined laminar removal leaves a scar on the flaking surface with technological consequences that can be exploited for the control of the next removal, etc. One of these consequences is the creation of a ridge playing the role of guide for the development of the fracture wave of the following removal. It is quite obvious that such recurrence is directly dependent on the volumetric shaping of the core. Some forms allow the production of only a small number of blades, limited to the volume to be knapped, which is only part of the whole block. Other volumetric forms offer a nearly unlimited production of blades, where the volume is nearly equal to the useful volume, itself equal to the whole block which was selected among others found in the environment.

The concept of recurrence thus introduces a need to remain in the series produced in order to maintain an acceptable rate of success for each removal in the series. Within a single series, it will or will not be possible to alter the technical traits of recurrent removals, depending on the rules to be respected. In other words, one cannot do whatever one wants at any given moment.

Experimental knapping reproductions based on observation of all kinds of predetermined cores suggest that aberrant behaviors did not exist. One succeeds or fails depending on experience, but in general one always follows the technical rules learned to achieve the intended results. Only rarely can phenomena of technological deviance be seen. These rules enable achievement of the objectives once the know-how is acquired.

The laminar nature of a removal is thus the result of utilization of a series of criteria created on the volume to be knapped. This volume is the equivalent of a structure, composed of elements, interactive or not, governed by rules of management. The organization of the elements is linked to the qualitative and quantitative objectives sought. However, the chronology of technological systems shows that they are not found randomly at any time, but rather that a techno-logic exists. That is, the structural organizations follow an evolution within a single lineage.

Since the first stratigraphic sequences yielded archaeological sequences, terms of archaic techniques preceding more evolved techniques have appeared (considered as such by the analyst), such as those of proto- and para-debitage foreshadowing true debitage, which is more evolved. A sort of "naïve", but quite real, order was thus discussed reflecting a more or less "effective" diagnosis. So, for all time periods regardless of the technological cultures, one observes an evolution evidencing an increasingly developed technicity. The terms progress or perfecting were used to explain such changes. However, while perfecting is a perception of the one who benefits from it, it is no longer useful to define what took place "within" the object. A core does not exist as the result of perfecting. By contrast, it is experienced by the person who creates it as a stage of perfecting. This is why the term "integration" is used rather than perfecting to define the structural evolution of a core. It is in this sense that technological development is reflected by an increasingly and unstopping integration of technical elements that compose each object, culminating in other objects where it is no longer possible to modify the least structural element without risking rendering the object non-functional. Such structural evolution will also affect both objectives and the modes of production enabling such objectives to be achieved. The productional evolution is in this an implacable response to the functional evolution of tools. However, there is no automatic link between these two parallel trends, because other acting operatory modalities exist, such as retouch or methods of surface management, which could also act as modalities of response to the need for change, before structural and final change is made to the core.

In the framework of the development of productional structures in the laminar lineage, cores at the start of the evolutionary cycle are distinguished as type C2 and then D2 reduction, which uses a single part of the block to be knapped: the useful volume prepared is thus limited to part of the original block. Other cores require specific preparation that structures the block as a whole to be knapped to produce a volume of blades equivalent to the volume of the core, itself also equal to the volume of the original block. These cores are called type E2, then F2 cores, corresponding to a final phase in the evolution of the laminar lineage. Another means to obtain laminar removals is Levallois reduction (type F1).

The development of modes of production from reduction in laminar lineages creates certain volumetric constructions capable of being exploited by several methods, both for initialization and production. During reduction, two essential phases must be distinguished: initialization consisting of preparing a core (i.e., the useful volume) which has the technical constraints required to obtain given kinds of removals, and production of these removals, the second of which is too often given more importance over the first in analyses. In general, methods of initialization and production of most of the laminar volumetric structures (D2 and F2) knapped are relatively few, the most common being the unipolar method. During the evolution of techniques, Levallois reduction (F1) appears, which presents an exception to the number of methods of initialization and exploitation. More than a dozen can be inventoried: recurrent or preferential, parallel unipolar, convergent unipolar, parallel bipolar, orthogonal, centripetal, all with or without débordant removals, etc. Such diversity is linked to the volumetric structure of a Levallois core, which will be discussed in more detail below. There is thus a structural link on this structure and its capacity to produce all kinds of predetermined removals with the forms of the future tools. This specificity is unique in the history of techniques. Discoidal reduction (E1) or pyramidal reduction (E2) offers a range of products, but nothing comparable to the variability of products made by Levallois methods (F1).

Levallois reduction is thus reduction in which the diversity of products is the cause itself of its existence in terms of complexity and singularity with respect to other kinds of reduction. In other words, Levallois reduction is a technological structure which, in

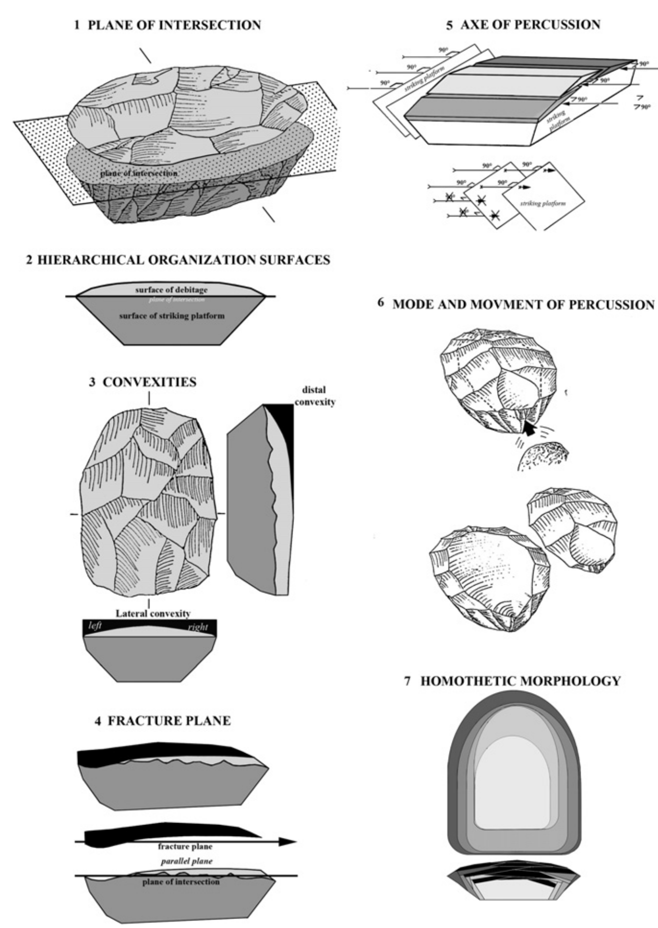

Fig. 3. Seven criteria of the Levallois method.

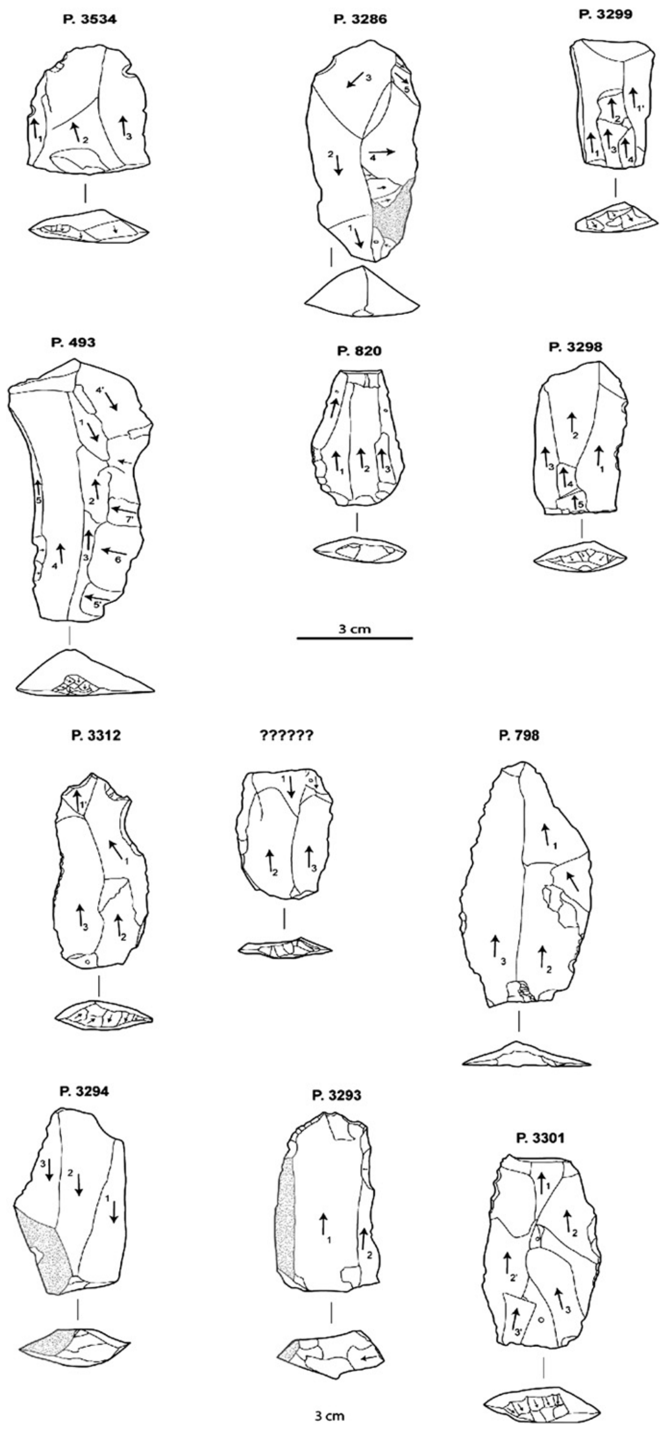

Fig. 4. Levallois products.

order to be operational, must produce such diversity. Experimentation reproducing most of the combinations of methods of initialization and production indicate that in all recurrent series, it is nearly impossible to reproduce twice in a row the same kinds of products, because the technical criteria created on the flaking surface change after each removal. This inability to repeatedly produce the same kind of removal perhaps explains the existence of a group of methods called preferential, in which a series of successive flaking surfaces can be created on a Levallois volumetric construction, each time identical, but each producing a single removal per useful volume.

What does such instability to produce identical removals mean in the context of a recurrent series for certain products such as laminar removals? Imagine that one needs a quantity of laminar products. Is Levallois reduction the best technical strategy to obtain them? Quite clearly, not: unless one also needs a few triangular or quadrangular flakes, in which case Levallois would be the best response since it can follow one or another method to facilitate the mixed range of intended products.

How can one thus meet an exclusive need for laminar removals? The history of techniques in the circum-Mediterranean region, and more specifically in the Near East, demonstrates a very singular orientation toward volumetric constructions adapted to the exclusive production of laminar removals like those found in the Amudian and Hummalian.

So, to understand the interactions between the different modes of production, it is fundamental to distinguish between volumetric structures capable of producing only laminar removals – C2, D2, E2 and F2 – termed blades, and volumetric structures, such as Levallois – F1 – capable of producing a few laminar removals associated with convergent flakes or not of all types. This differentiation indicates that the production systems are not all based on the same volumetric construction. In reality, there are different technological lineages. Exclusive blade production constitutes a lineage that has its own evolution, but which encounters the history of Levallois. In a similar scenario, Levallois reduction does not belong to the laminar lineage and its presence or absence is independent of any evolutionary phenomenon with respect to the laminar lineage, as in the Near East where "entirely blade" reduction appears well before Levallois reduction. The history shows that this is intercalated between two significant laminar episodes, of which the second reappears during the "transition" phase or the Early Upper Paleolithic, which is not the case in Western Europe where the phenomenon is reversed, Levallois reduction always preceding blade production, which is inserted into the history from time to time.

Exclusive blade production is thus a technological reality that crosses the history of Levallois. There is quite clearly no direct evolution between the laminar lineage and Levallois reduction. Each contains structurally in itself the technological solutions and responses to needs. Each is a response adapted to the techno-functional needs unique to each culture. In the framework of the laminar lineage, there is a productional response that develops due to cultural and probably also spatial "pressure". Levallois reduction is a response to other cultural pressures having selected different technological options.

In the context of the site of Shuidonggou, it is therefore of interest to identify the techno-functional intentions of Levallois reduction and to identify the developmental stage of the complementary laminar structure, if it does exist. If so, based on its developmental stage, its historical significance will be different.

At Shuidonggou, it is clear that two broad categories of removals appear to have been the intended products: blades, flakes and triangular flakes. Subsequently, depending on intended function, each tool class has a specific form of retouch.

Several types of tools made on blades and also on flakes can thus be found in the same assemblage (strata 7 and 8). Two categories can be distinguished: Levallois and non-Levallois.

Analysis of the removal scars on all flaking surfaces on the cores clearly shows that for Levallois cores, objectives are multiple and consist in obtaining elongated products and flakes and triangular flakes while the other cores focus only on blade production. At Shuidonggou, two distinct core types are present, both of which produce elongated blanks, but only one of which – Levallois – also produced flakes. By changing the analytic perspective, the latter shows "mixed" production and in the former only a single uniform production with the technical objective being the blade.

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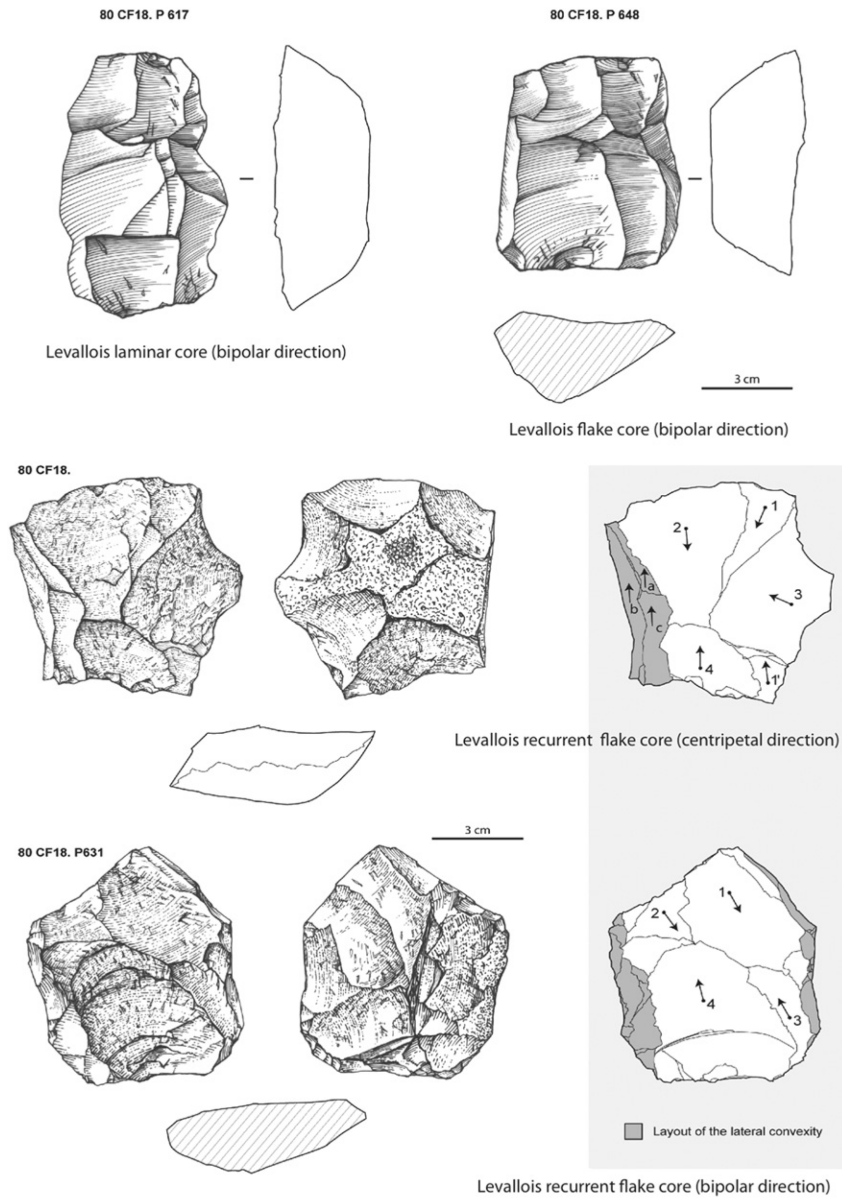


Fig. 5. Levallois core.

6. Distinction of two reduction concepts to product blades

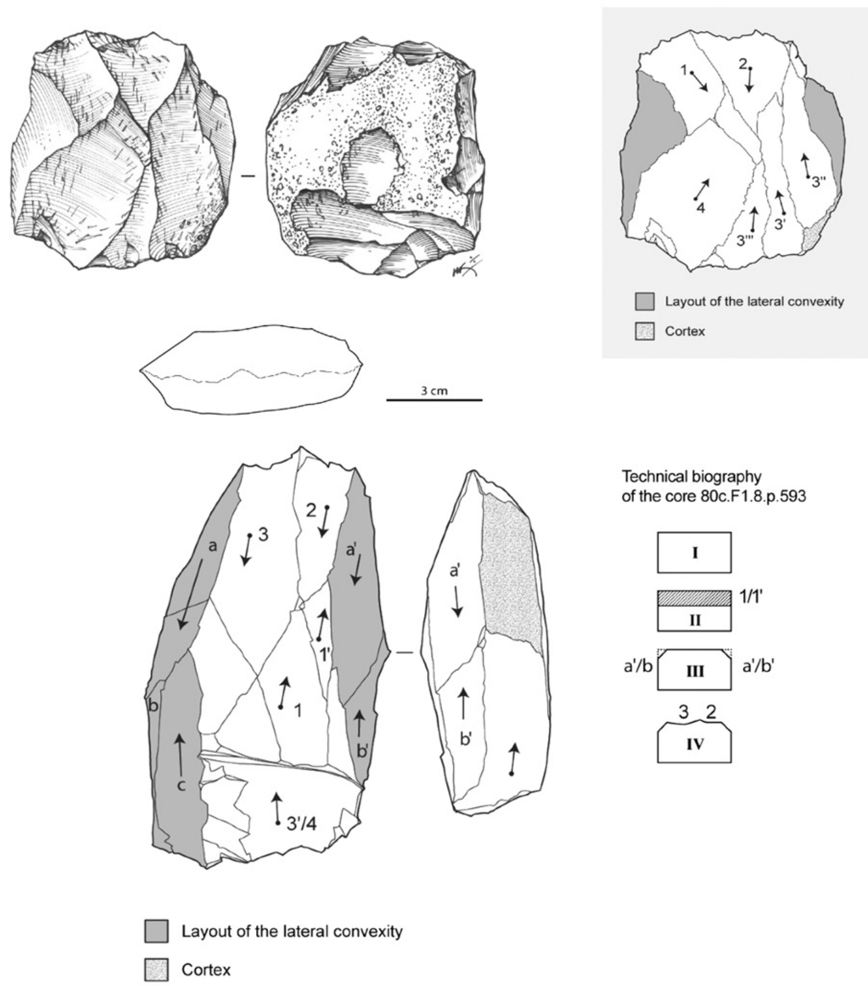
At Shuidonggou, the use of two reduction methods to produce blade blanks can be demonstrated, which also sometimes produced flakes as well.

6.1. First mode production: Levallois reduction

The Levallois concept (Boëda, 1994) is a specific volumetric construction enabling the successive production of removals with diversified morpho-technical traits from successive useful volumes that can be reinitialized at will. Creating such useful volumes is done by the complete reorganization of the block of raw material in order to include in a single synergy of effect all of the future technical traits intended on the predetermined removals. Such necessary synergy culminates in a highly recognizable and typical volume because it is invariant; this invariance being one of the conditions to preserve the same ends with the same means.

The recognition of the Levallois concept in the Shuidonggou assemblage makes it necessary to recall the Levallois core and its technical characteristics. The core is characterized by the interaction of seven technical criteria (Fig. 3):

1 The volume of the core is conceived in the form of two asymmetrical convex secant surfaces. The delimitation of these surfaces bounds a plane.
2 The two surfaces are hierarchically related: one produces predetermined defined and varied blanks, the other is a striking platform surface for the production of such predetermined blanks. In the course of a single production sequence of predetermined blanks, the role of the planes cannot be reversed.
3 The flaking surface is maintained in such a fashion that the products obtained off will be predetermined. The technical characters of predetermination consist in the maintenance of the lateral and distal convexities that serve to guide the shock wave of each predetermined blank.



Levallois blade core (bipolar direction)

Fig. 6. Levallois core.

4 The fracture plane of the predetermined blanks is parallel to the plane of intersection of the two surfaces.
5 The surface for the preparation of striking platforms is maintained in such a fashion that the predetermining and maintenance of this surface depends on the method chosen for the detachment of predetermined blanks, but such platforms always share one characteristic: the surface of striking platforms which is to receive the percussion for the removal of predetermined blanks must always be oriented in relation to the flaking surface such that the line created by the intersection of these two surfaces is perpendicular to the flaking axis of the predetermined blanks. This line created at the intersection of the planes is called the hinge.
6 Only one technique of flaking is used with the Levallois operational scheme: direct percussion with a stone hammer. The percussion takes place a few millimeters from the hinge on the surface of striking platforms and not on the hinge. The consequence of this characteristic is that the axis of percussion must be perpendicular to the hinge. A non-perpendicular axis does not allow for the control of the force of percussion.
7 The volumetric construction is a structural response that aims toward "a kind of auto-regulation or of auto-adaptation and a kind also of auto-correlation". The conception of the Levallois core represents a cognitive capacity to respond to a large number of problems arising during core reduction or during a change of objective.

The Levallois method is a kind of internal adaptation to outside circumstances. Levallois is defined as an auto-correlation (global internal coherence) of the technical system with integrated predetermination criteria.

This method creates hierarchical surfaces. Such hierarchical organization is made to keep the constant operational character for all the surfaces at any time. In an informal way, this trait is reflected in the specific morphology of the core which is always flat: it allows arrangement of a good angle between both surfaces at any time.

At Shuidonggou, different kinds of Levallois cores are present to produce typically Levallois blades, flakes and triangular flakes (Fig. 4): Levallois cores with elongated removals with bipolar direction of the removals (Figs. 5–7), Levallois recurrent flake cores with bipolar or centripetal direction of the removals (Fig. 6).

6.2. *Second concept: non-Levallois reduction or "type D2" reduction*

The global conception of the volume produced by this core is completely different from that of the Levallois concept (Boëda, 1997, 2005). Here, when the block is ready to be knapped, there are two parts within the global volume: a structured or

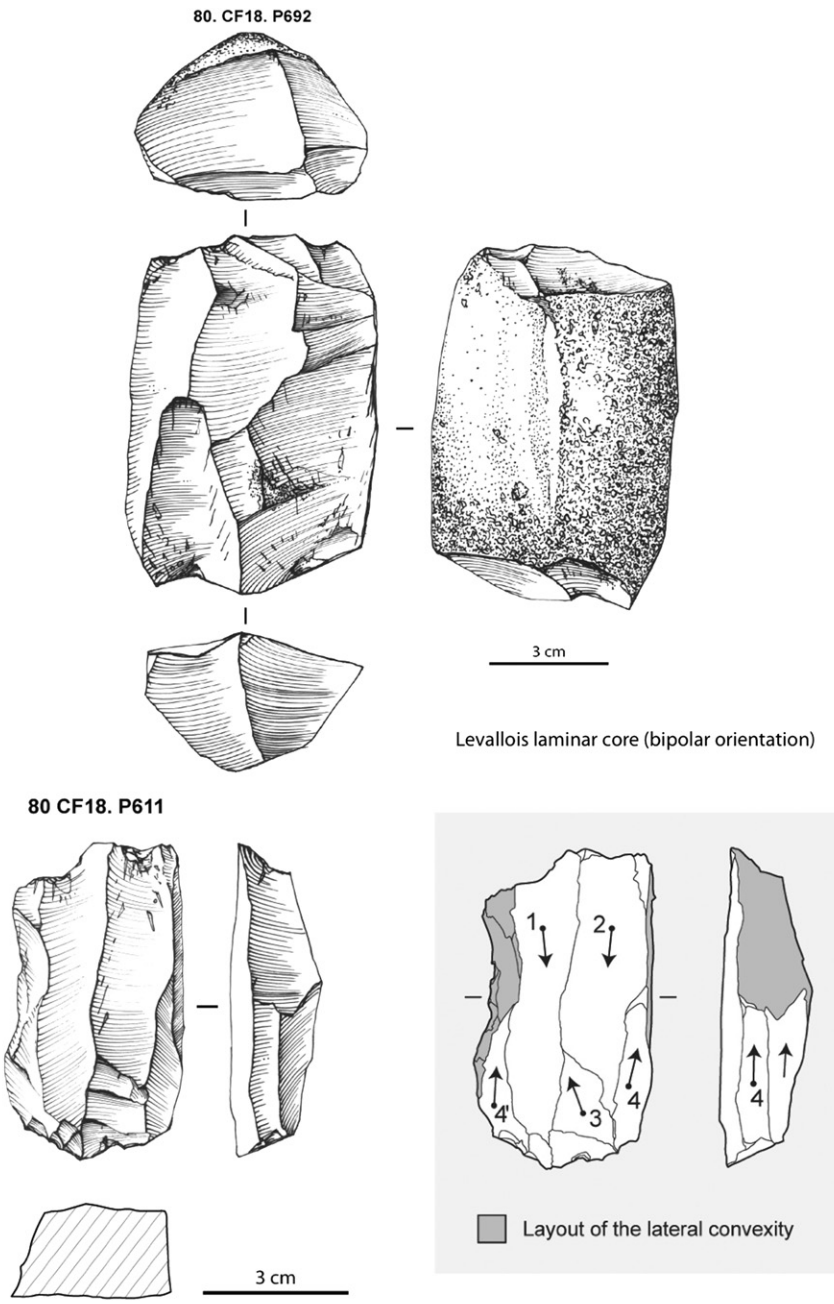


Fig. 7. Levallois core.

"active" volume which corresponds to the core sensu stricto, that is, a form with removal scars present and another "passive" volume lacking such scars (Fig. 8). Only one part (the "active" one) of the block is thus truly worked with an obligatory "initialization" phase before knapping to obtain the intended blanks: blades.

In the case of "type D2-core morphology" (Fig. 9), the volume of the core was exploited after very short series of removals and the exploitation of the volume halted abruptly in the *chaîne opératoire*. The global configuration of the core has not here integrated a possible solution to continue the reduction session as a sort of "optional reset": the core is stopped or sometimes, the core is reworked by using another natural part of the block, or more rarely, by restarting the former original flaking surface which retains some technical traits.

The potential variability of this D2 volume is used to produce a range of removals, including blades, flakes and triangular flakes. The volumes to produce flakes are identified as "type D1", "type D2" for blades only and "type D3" for triangular flake production only (Boëda, 1997).

The D2 core-type consists of exclusive production of blanks which are twice as long as wide, called blades. Initialization of the core is classical: it consists of shaping the natural side convexity of the block by laminar and cortical removals or the use of previous/posterior crested blades and finally, by a good striking platform surface with such technical specificities which depend on the modality of percussion (internal or marginal).

D2 reduction produces a homogeneous set of blades. Nevertheless, such blade production is constrained by the limited part of the block used by the knapper. Increase in production would be

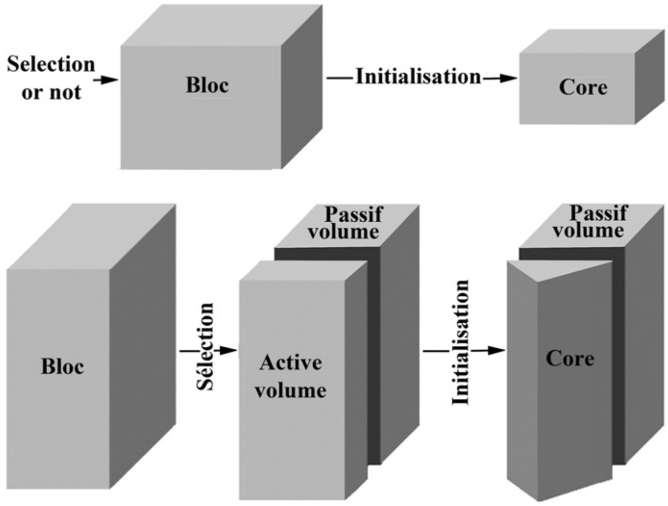


Fig. 8. Dynamic sketch of type "D2" reduction (bottom) and a Levallois strategy (above).

made by changing the conception of the core morphology with regard to the initial natural volume of the block.

One example shows a variant in the modality of initialization (Fig. 9). The flaking surface is directly cortical. In reality, initialization consists in selection of the future volume to be knapped regardless of whether it is necessary to prepare it, apart from the surfaces for the striking platform. Developmentally, such reduction is called C2 and corresponds to a preceding technological stage. In some cases, however, it is found associated with type D2, which is dominant. By contrast, in other cases, such as European laminar reduction in MIS 4, it represents the only technological solution.

7. Discussion

At Shuidonggou Locality 1, strata 7 and 8, two knapping methods were used to produce different tools on blades and flakes. These two methods are complementary to obtain blanks for making stone tools. Here the particularity of the Levallois method is to produce around 20% of blades, 60% of flakes and 20% of chunks (knapping accidents): these products were retouched to create different tools, including end-scrapers and denticulates on blades, when there are no broken or convergent tools like scrapers on flakes (Fig. 10). The D2 method presents a single knapping strategy oriented to the production of blades and elongated flakes, subsequently transformed into burins, scrapers, notches, etc., or directly used unretouched (Fig. 11).

Such technological data confirm the presence of two contemporaneous methods for obtaining elongated blanks such as blades: the Levallois method with classical core preparation and another less complicated method termed Type D2 reduction. Both Levallois and non-Levallois methods are thus clearly present at Shuidonggou at the end of the Late Pleistocene, just prior to widespread adoption of laminar reduction. These data also support the hypothesis of the extension of the Levallois method in North-east Asia, where it is possible to find evidence of this method in Mongolian and Altai-Siberian sites at the same period (Brantingham et al., 2001; Derevianko, 2005, 2009).

A question remains unresolved regarding Levallois expansion and geographic context: why is the Levallois method found only in the desert, dry and loessic regions of North Asia (North China, Mongolia, Siberia-Altai) and not to the south where the climate and the raw material with a good quality of chert exist.

The laminar production of Shuidonggou from strata 7 and 8 in Locality 1 resulted in many tools made on laminar products (blades and elongated flakes), including burins, endscrapers, backed blades, scrapers, etc. In stratigraphic context, these tools are situated below another stratum which is very rich in laminar products, but without Levallois reduction. Levallois reduction is present only in strata 7 and 8 at Shuidonggou.

Strata 7 and 8 date to ca. 35,000 BP (Liu et al., 2009) and include numerous quadrangular and triangular flakes retouched as classical Mousterian types of tools: scrapers and convergent tools with continuous retouch.

Thus, at Shuidonggou there are tools on Levallois blanks associated with Upper Palaeolithic tools made on laminar and non-Levallois reduction called type D2. Such technological association appears to be a "transition phenomenon" from the Middle to the Upper Palaeolithic. This transition phenomenon is well-known in the Middle East, in Central Asia and in Mongolian but is not homogeneous and coherently overlapping.

Considering the contemporaneity of these two reduction modes as two distinct technical solutions, mastered and complementary within a single area by a single human group, it appears logical to examine the evolutionary nature of each one in terms of one with respect to the other: their origin, emergence, lineage. In this, the developmental nature of type D2 is important because it stipulates the presence of an evolutionary phenomenon of its first stages at 17/20,000 BP.

The sites of Gobi (Chikhen Agui) and Tasagan Agui, dated between 30 and 20,000 BP (Derevianko et al., 2004) seem to propose the same association between non-Levallois of type D2 and Levallois (type F1). Further, in the Altai, the sites considered to be the Early Upper Paleolithic of Siberia, dated to around 38,000 BP (Goebel, 2004) have yielded laminar productions that appear to be of types C2 and D2, based on published descriptions. Several

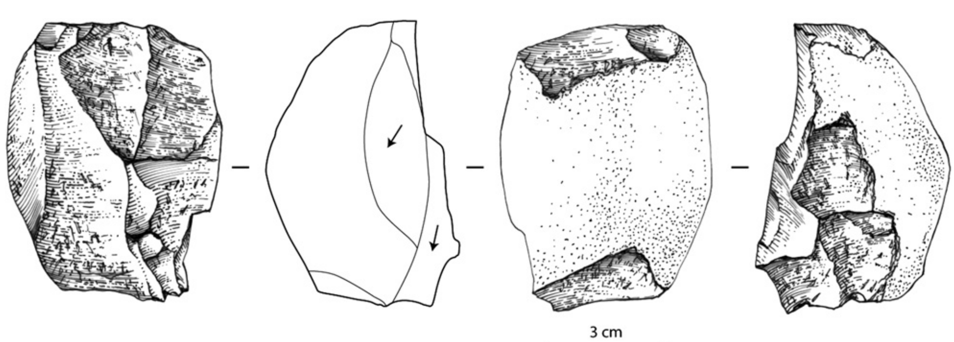


Fig. 9. Type D2 blade core.

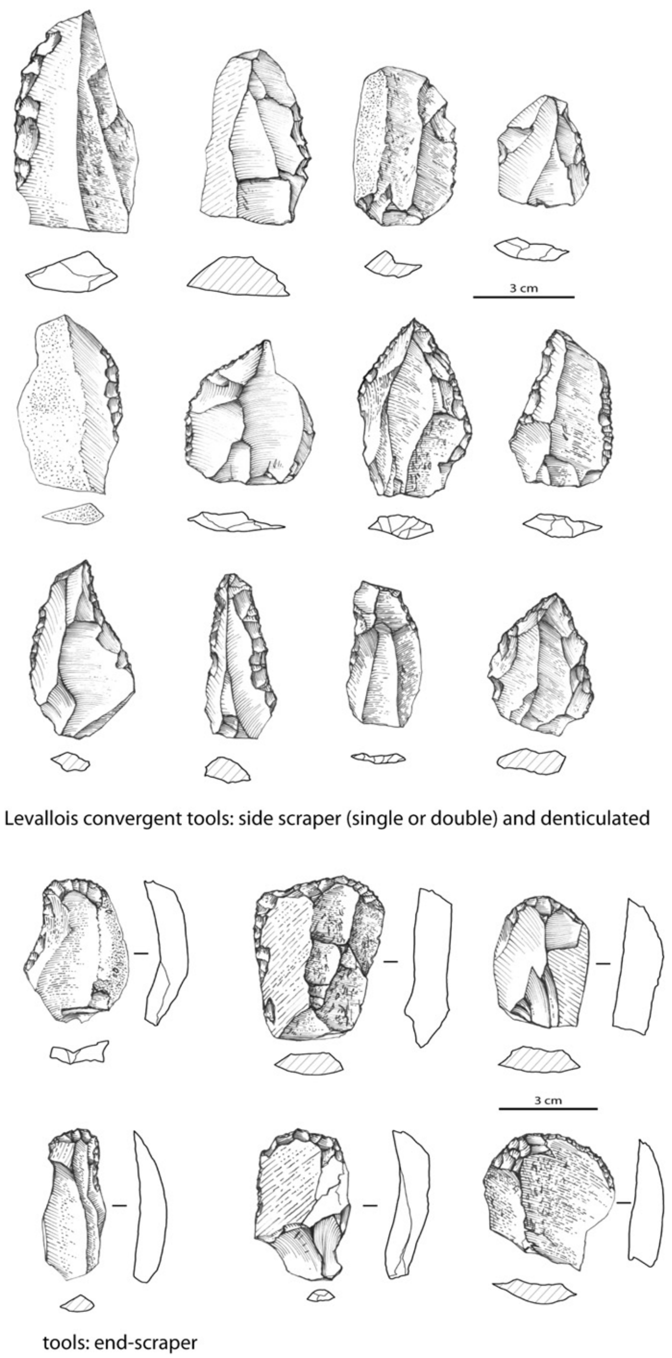


Fig. 10. Levallois tools.

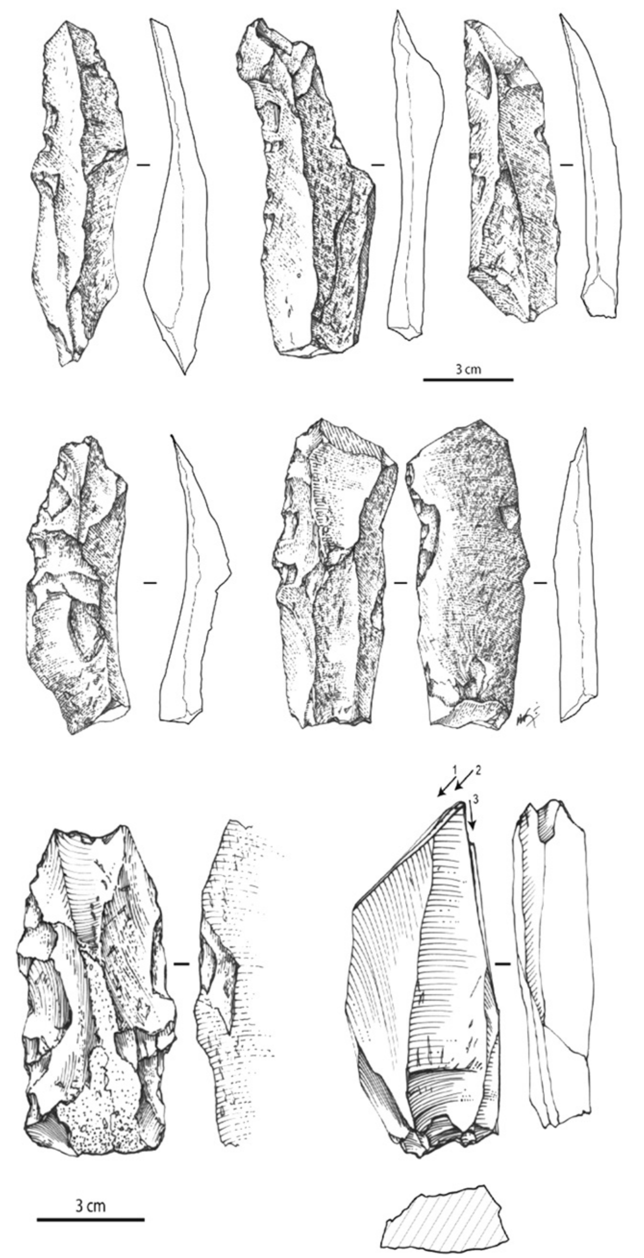


Fig. 11. Tools obtained from D2 reduction.

conclusions can be inferred from these observations. The first is that when blade production appears, it is in its initial C2 or D2 form. This fact is techno-logical and signifies the beginning of the laminar lineage. The second, more unusual, indicates that regardless of age, between 38,000 and 17,000 BP, there is no perceptible change. A third observation indicates that in each region, there are local particularities, although adopting the same new technological norm. All of these observations support the adoption of a new technological idea that necessitates the production of laminar blanks with new transformative parts. This hypothesis is quite certainly linked to the possibilities of standardized hafting offered by blades and as a result, opening the way to new ways of using the tools. The diversity in technological facies is due to the fact that this idea takes form in the memory of different groups who adopt it by perpetuating and/or inventing a new technological system of production to better respond to this new idea. The fact that this new system corresponds to the first developmental stage of the laminar lineage indicates local invention, which is adopted at different times by different groups which had little contact between them, explaining why it is found from 38,000/40,000 to 17,000 BP. The presence of absence of Levallois reduction is perhaps indicative of the maintenance of a non-laminar production associated with the more specific blade production or to the maintenance of a Levallois tradition; this would explain why in some cases the development of Levallois methods that attempt to better respond to these new objectives occurred, without really achieving them technically, but sufficient in terms of need.

Broadening observations to Western Asia shows exactly the same diversity of production schemes, the same developmental stages and the same new kinds of tools. Thus it appears to confirm that around 30,000/40,000 BP, a new idea spread around the Mediterranean, but also to Eastern Asia via the Altai. The same initial developmental stage throughout these different geographic areas indicates that a phenomenon of borrowing by local populations, requiring technological changes in production and the short-term disappearance of Levallois reduction. There is thus no reason to rely on any cognitive determinism of a migrating human group.

While the laminar blank becomes the main predetermined product in the *chaîne opératoire*, significant differences exist in its modality of production. There is exclusively non-Levallois laminar production, mixed laminar production with both Levallois and non-Levallois methods, or in some cases, strictly Levallois. In addition, the term "Levallois" masks realities very different from one site to another with a high degree of variability in products: elongated triangular blanks, quadrangular flakes and/or typical laminar blanks.

The association or not of laminar debitage also fluctuates from one site to another. Such variability does not seem to be either associated with a specific region, a particular cultural area, or even a precise chronological period. On the other hand, from the Oriental Mediterranean to the South of Mongolia between 45,000 and 30,000 BP, there was an important change in tool blanks with a high frequency of Upper Palaeolithic tools. The "Levallois flake" as privileged blank in the *chaine opératoire* disappears, suggesting that the transition phenomenon is not a single phenomenon in the etymological sense, but rather a real cultural path to the beginning of the Upper Palaeolithic.

Intersite variability in different areas and their chronology indicates that the variability in lithic production is more a sort of witness of the appropriation of a new technical idea. Depending on the technical tradition, this new technical idea would progressively expand through space and time by assimilation in different human groups. This would explain the high degree of variability between lithic assemblages and a very strong cultural otherness.

This otherness can be considered as a serious "technical response" which demonstrates that ideas spread more than the human gene, as is often advanced in the classical paradigm of human evolution. The observed change is evidence of the borrowing of a technical idea – laminar – which will become established as a real technical system.

This "laminar" phenomenon is not the same exclusive step of this temporality, because essentially laminar industries are well-known in the Middle East and Africa around 200,000 years ago. Nevertheless, in the framework of this rediscovery of laminar reduction, the presences of new tools and especially their adoption independent of geographic and cultural otherness is observed.

What is called "transition" is only the beginning of a technical standardization and duration spread on a geographic scale not yet fully understood by archaeologists. Shuidonggou strata 7 and 8 at Locality 1 show this way of thinking: a wave of a technical idea which seems to have reached its southernmost extension, and possibly to Eastern Asia.

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