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The Initial Upper Paleolithic in Central and East Asia: Blade Technology, Cultural Transmission, and Implications for Human Dispersals

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Abstract

Archaeological assemblages labeled as Initial Upper Paleolithic are often seen as possible evidence for dispersals of *Homo sapiens* populations in Eurasia, ca. 45,000 years ago. While most authors agree that the IUP can be recognized by a set of shared features, there is far less consensus on what these features are, and what they mean. Because of methodological challenges inherent to long distance comparisons, documenting and establishing a firm connection between archaeological assemblages remain difficult and often draw legitimate skepticism. There could be many reasons why Paleolithic hunter-gatherers used comparable technologies, but it usually comes down to two kinds of processes: cultural transmission or convergence. In other words, technological similarities may illustrate a cultural link between regions or may be caused by mechanisms of independent reinvention between more distantly related populations. Here, I focus on three assemblages from the Siberian Altai, Zabaikal region, and North Mongolia to address one main question: is there such thing as a united IUP in Central and East Asia, or are we looking at unrelated yet comparable adaptive processes? First, I describe the common structure of lithic blade production at the sites, with special attention to derived features relative to the regional sequence. After comparing the complexity of the production system with those of other lithic technologies, I suggest that this coherent, intricate, yet unprecedented technological pattern found across contiguous regions in Asia is better explained by transmission processes than by multiple unrelated reinventions, or local developments. The blade production system described in Siberia and Mongolia reoccur as a package, which is consistent with indirect bias and/or conformist cultural transmission processes. Overall, the results point toward close contact between individuals and hunter gatherer populations, and supports the recognition of a broad cultural unit to encapsulate Asian IUP assemblages. Considering other lines of evidence, the geographical and chronological distribution of Asian IUP lithic technology is consistent

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with a dispersal of *Homo sapiens* populations in Central and East Asia during the Marine Isotopic Stage 3, although the geographical origin of such movement is less clear.

Keywords Initial Upper Paleolithic · Asia · Cultural transmission · Lithic studies · Human dispersals

Introduction

Recent developments in paleoanthropology have convincingly shown that a single human migration across Southeast Asia is unlikely to account for the diversity of the Eurasian fossil and archaeological record. Instead, distinct events should be considered, including inland dispersals across Central and Northeast Asia (e.g. Beeton et al. 2014; Bergström et al. 2021; Dennell 2017, 2020; Dennell et al. 2020; Goebel 1999; Goebel 2015; Li et al. 2019; Reyes-Centeno et al. 2015; Rybin 2014; Zwyns 2012). Contemporaneous but not yet firmly associated with *Homo sapiens* skeletal remains, the Initial Upper Paleolithic (IUP) assemblages in Asia could represent evidence for such a long-distance population migration extending eastward from the Middle East to the Yellow River, and perhaps even beyond (Brantingham et al. 2004; Fu et al. 2014; Madsen et al. 2014; Zwyns et al. 2019). Perhaps unsurprisingly, recognizing the IUP in different regions of Eurasia remains a challenge.

The IUP was first described in connection with the earliest evidence for the Upper Paleolithic (UP) in the Levant (Marks and Ferring 1988). Together with the adoption of new forms of retouched tools, the shift from bidirectional Levallois-like core reduction to unidirectional 'volumetric' core reduction (e.g. Boker-Tachtit, layer 4) was considered as a milestone in the regional transition from Middle Paleolithic (MP) to the UP. Although stressing that transitional assemblages should not be merely studied for themselves, Marks (1990, p.71) suggests the term of Initial Upper Paleolithic (IUP) to describe an arbitrary stage within the transition continuum: "…*After all, in any continuum the breaks are arbitrary and imposed by those studying it. Where better to begin the Upper Palaeolithic than with a technology where virtually all core reduction is pointed toward blade production?...*". The definition was then broadened to include a group of Middle Eastern assemblages showing combinations of MP and UP features, such as both the Levallois method and volumetric blade production (Kuhn et al. 1999; Kuhn 2003). With a large geographic distribution involving different hominins living on the same landscape, some of the changes associated with the IUP could also be independent technological innovations by groups of individuals, or emulations between groups. In this scenario, equifinality would simultaneously drive multiple shifts in different regions from Levallois flake production toward blade production following separate but comparable pathways (Kuhn and Zwyns 2014, 2018). Hence, it is sometimes difficult to differentiate between the notion of 'transitional' assemblages and the IUP but the latter does not *necessarily* originate locally (Kuhn 2003) and could represent archaeological evidence for one (or several) population dispersal(s) (originating from a local transition apart from where some assemblages are identified).

With a definition that has changed through time and in the context of *H. sapiens* dispersal scenarios, 'analytical lumping' (Perreault 2019) may have brought unrelated assemblages under a single umbrella. Therefore, what constitutes relevant similarities (or differences) pertaining to the recognition of the IUP needs to be clarified before drawing evolutionary interpretations between assemblages. Here, I compare blade production within three lithic assemblages from the Siberian Altai, the Zabaikal region and North Mongolia. I suggest that in this case, the sudden emergence of an intricate yet unusual lithic technology in contiguous regions in Asia illustrate a cultural connection between the assemblages. Thereby, it justifies the use of a unit of analysis to consolidate assemblages sharing this specific suite of characters. In the absence of a viable regional antecedent, the direct implication is that the geographical and chronological distribution of the traits observed is consistent with a long-distance eastward migration of *H. sapiens* populations across Northern and Central Asia (Fig. 1).

Background

The comparison proposed here should not come as a surprise to most, as the sudden appearance of a blade production system with shared morphological features in Central Asia, the Altai, and in Mongolia has been known about for several decades. For example, when referencing recently discovered early blade technology in the region Okladnikov (1978: 332) wrote: "…*These are elongated-triangular blades made mostly from heavy, deeply patined flint with a thick white patina, similar to those which are characteristic of the Mousterian culture of Soviet Central Asia, including the upper layers of Teshik-Tash and Obi-Rakhmat".* Although he assigned this technology to the MP, he also notes how it contrasts with the various pebble tool traditions from the preceding period and went on to establish a link with ancient population structures. Furthermore, in this study, Okladnikov daringly proposed long-distance connections with western Eurasia: "… *It can therefore be asserted that there was a common element in the development of the most ancient population of this part of our planet, in what is now Soviet Central Asia, Mongolia, and the Altai, which persisted through hundreds of millennia. At this juncture we must mention that the Levalloisian materials of the interior of Asia are definitely related to the analogous materials of Soviet Central Asian Uzbekistan (for instance, Khodjikent grotto near Tashkent) and Tajikistan, and, via these to the Near and Middle East, especially Iran and Palestine (the caves on Mount Carmel, and Bisitun in Iran)"* (Ibid: 323). In other words, after small human groups scattered across the Asian landscape, developing their technology independently, the sudden shift toward blade technology illustrated to Okladnikov the dispersal of a new population from the west. In the early 80s, he went on to find one of the most spectacular examples of early blade technology at the site of Kara-Bom (Okladnikov 1983). Although subsequent excavations by A.P. Derevianko and V.T. Petrin led to the reassessment of the stratigraphy (showing that the original test pit crossed several cultural layers), it nevertheless confirmed the existence of early blade assemblages showing generic similarities with the underlying MP (Derevianko et al. 1998). The radiocarbon dates obtained in the early 1990s placed Kara-Bom OH5–OH6 as one of the oldest examples of the IUP (Derevianko et al. 1993; Goebel et al. 1993). The retention of MP-like features at the site was also interpreted as evidence for a local transition from the MP to the UP in the region (Brantingham et al. 2001; Derevianko et al. 2000). From then on, the idea of a local origin for the IUP in Northern Asia became more popular, at the expense of scenarios involving novel human dispersals from the west.

For the Gorny-Altai, Derevianko later proposed the existence of two distinct variants of early UP technologies, the Ust-Karakol and the Kara-Bom lithic traditions (Derevianko 2010, 2011; Derevianko and Volkov 2004). He noted similarities between assemblages belonging to the latter in the Baikal and the Selenga Basin suggesting that

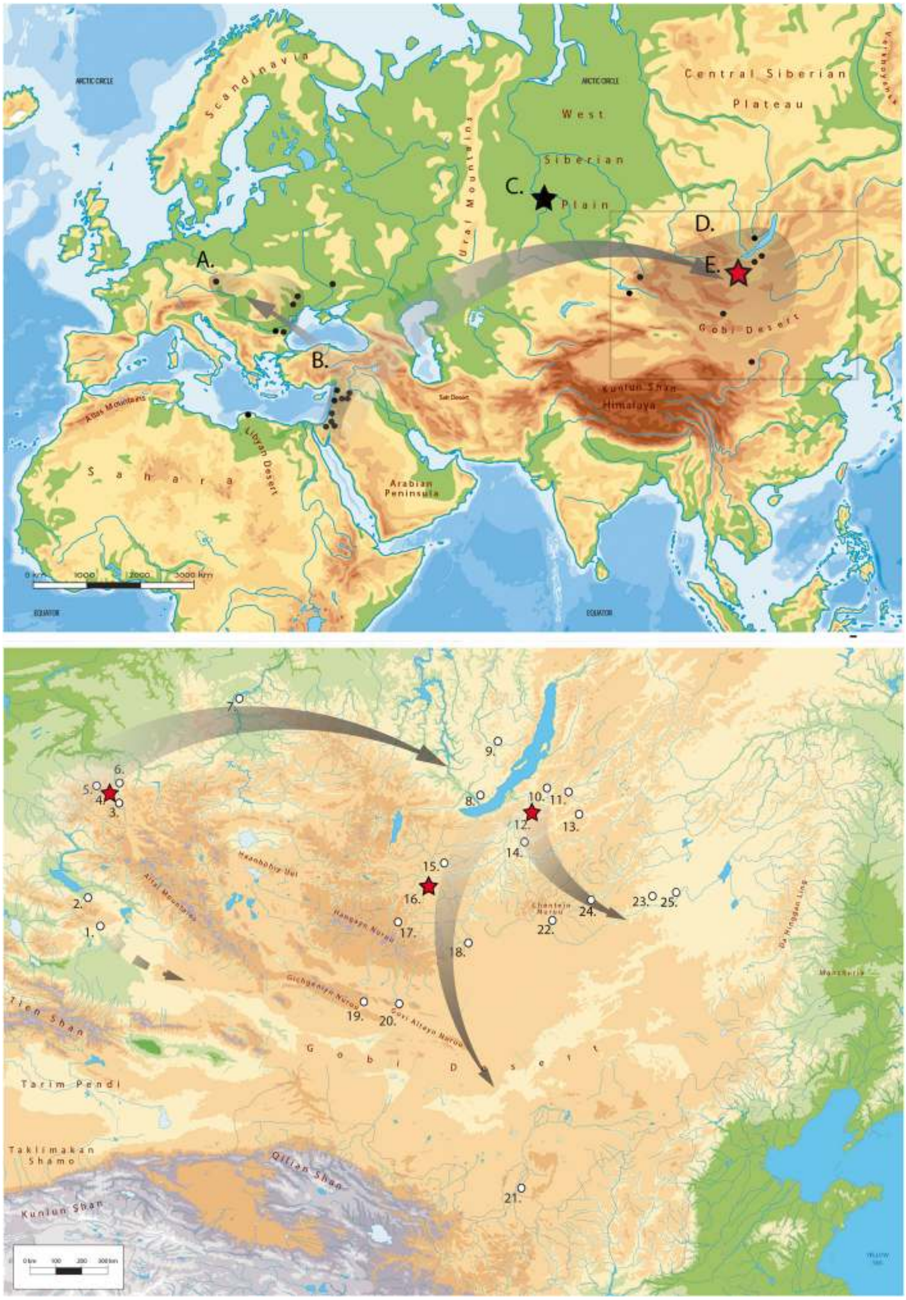

Fig. 1 Above. Map of the IUP sites showing the cluster of Bohunician assemblages (**a**), the Emiran (**b**) and the Ust-Ishim *H. sapiens* femur (**c**), and the Asian IUP (**d**). The arrows show the hypothetical dispersal of Emiran/IUP in Europe and Asia. Below. Close-up on the distribution of the potential IUP sites between the Altai and north China. 1, Luotuoshi; 2, Ush-Bulak; 3, Malo Yaloman, Cave; 4, Kara-Bom, 5, Ust-Karakol-1 and Denisova Cave; 6, Kara-Tenesh; 7, Derbina sites; 8, Arembovski; 9, Makarovo-IV; 10, Khotyk; 11, Barun-Alan sites; 12, Kamenka and Varvarina Gora; 13, Tolbaga; 14, Podzvonkaya; 15, Egiin-Gol sites (Dörölj 1–2); 16, Tolbor-16 and Tolbor-4;17, Tsatsyn Ereg; 18, Mojlt'yn-Am; 19, Chiken sites; 20, Tsagan-Agui; 21, Shuiddonggou 1; 22, Khanzat-1; 23, Khavsgayt (and Salkhit); 24, Rashaan Khad; 25, Otson Tsokhio16–18, 75–77; after Zwyns et al. (2019); Izuho et al. (2009); Odsuren et al. (2017); Gunchinsuren et al. (2017); Geo-atlas background map. The red stars show the sites discussed in the paper. The arrows show the hypothetical dispersal routes for the Asian IUP through the North, and possibly through the South (sites yet to be documented).

'*Upper Paleolithic industries with similar technical and typological features developed continuously in Southern Siberia and Northern Mongolia between 60-30 ka*' (2011 p. 352). In this sense, the IUP in Siberia and Mongolia would still fit D. Clarke's definition (1978) of a technocomplex in which a low level of affinity between the smaller units (cultures, cultural groups) is explained by '*the material manifestation of cultural convergence within a common stable environmental strategy*' (Teyssandier and Zilhão 2018, p. 8 their emphasis). Regardless, the apparent unity of the earliest UP in Siberia and Mongolia was not only seen by some as the result of parallel and convergent evolutionary trends in contiguous regions, but also as evidence for the local origin of *H. sapiens* (Derevianko and Shunkov 2010; Derevianko et al. 2020).

It is increasingly clear today, however, that the IUP behavioral traits between contiguous regions in Asia are chronologically constrained. A lack of convincing antecedents (Slavinsky and Tsybankov 2020; Kuzmin and Keates 2020) combined with the perspective of social intimacy between hunter-gatherer groups (e.g., Tostevin 2003a, b, 2007) furthermore leads one to envision a broader unifying cultural entity across the region (Rybin 2000; Rybin 2014; Zwyns 2012) which possibly developed some local variations (Derevianko et al. 2013) (Fig. 2). But moving forward on these issues has proven to be difficult for various reasons, not the least because of inconsensitencies in technological definitions and lithic data sets (Kuhn and Zwyns 2014). Whether these assemblages represent the quick replacement of local populations (Goebel 1993, Goebel 1999, 2015; Zwyns 2012), multiple transitional events (e.g., Derevianko 2001, 2010, 2011), or other scenarios is therefore a question that remains up for debate.

Essentially, most authors agree on the idea that IUP can be recognized by a set of shared features but there is far less consensus on what these features are, and what they mean. Regarding the interpretative dilemma: it may be unrealistic to address the connection between two distant regions without adopting a looser definition for the IUP, which might in turn increase the risk of lumping together unrelated assemblages. Are all lithic traits equally useful for addressing such issues? How might we disentangle cultural connections between relatively distant assemblages and potentially independent, local responses to specific needs? Archaeology is not the only science with a long history of such questions that are far to be restricted to manufactured objects. When replacing the word 'assemblage' by the word 'species', it becomes evident that asking how combinations of traits relate to one another echoes the questions found within phylogeny, or cladistics (Lyman et al. 1997; O'Brien et al. 2001; Darwent and O'Brien 2006; Collard et al. 2006; Lycett 2009a, b;). This is particularly clear in the frame of dual-inheritance theory, which emphasizes a coevolution of biological and cultural traits (Boyd and Richerson 1985; Cavalli-Sforza and Feldman

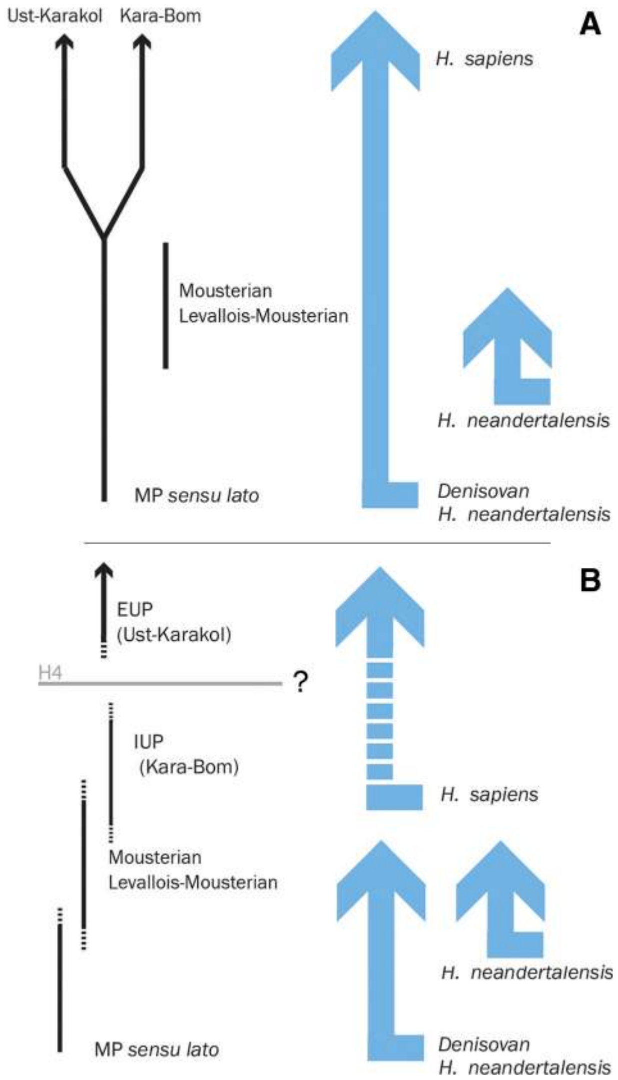

Fig. 2 Summary of the two main models for the emergence of Upper Paleolithic in the Altai. A. Cultural (in black) and biological (in blue) continuity; B. Discontinuity between the Middle and the Upper Paleolithic (whether the IUP and the EUP populations are the same is still unclear). While the interpretations of archaeological data differ, both models aim at addressing questions of cultural phylogeny

1981; Richerson and Boyd 2005; Shennan 2001). Therefore, like other products of biology and culture, the lithic record can be considered to have also been subject to evolutionary forces such as selection or drift (Bettinger and Eerkens 1999; Creanza et al. 2017a; Kolodny et al. 2015; Mesoudi 2011; Mesoudi and Aoki 2015; O'Brien et al. 2001; O'Brien and Lee Lyman 2002).

A renewed interest on issues of taxonomy (Riede et al. 2020) and convergence between stone tool assemblages (O'Brien et al. 2018; Groucutt 2020) calls for a reappraisal of what we call the IUP at a global scale (Kuhn 2019). Ultimately, this appraisal should include a multitude of assemblages covering a large geographic and temporal span, with the use of a systematic and comprehensive method (Dunnell 1976). As a first step in this direction, I try to address one main question: is there such thing as a united IUP in Central and East Asia, or are we looking at unrelated yet comparable adaptive processes? To do so, I focus on a defining feature of the IUP, blade production, using three assemblages in Siberia and Mongolia. I look for observable patterns at a macro-regional geographic scale and I try to estimate the complexity of the blade reduction system to differentiate cultural transmission from convergence. Finally, I discuss different scenarios of convergence and transmission and their relevance for human dispersal scenarios in the past.

Material and Methods

Typo-Technological Traits and Phylogeny

I distinguished between traits that belong to a group with a direct common ancestor (homologies) and the ones that emerged from separate evolutionary histories (analogies) (Lyman et al. 1997 ; Mesoudi 2011; Tostevin 2012; O'Brien et al. 2018). I consider plesiomorphic technological traits as less informative for identifying new cultural units than innovations shared by only a few assemblages (shared derived, or synapomorphy). For instance, the presence of a discoidal flaking method, or the use of hard hammer, might not be a strong argument to identify a new UP group because by then, these are chronologically and geographically widespread behaviors. Granted that the same traits can be derived relative to older ones, such shared ancestral traits are nonetheless common given the cumulative nature of the record. Without necessarily assuming that the so-called 'ratchet effect' is restricted to *H. sapiens* (Tennie et al. 2017; Kadowaki 2013), it is clear that more than any other living species, ours create technological advances using constitutive parts that individually take more than a lifetime to reinvent (Boyd and Richerson 1996, 2013; Haidle and Schlaudt 2020; Henrich and McElreath 2012; Tennie et al. 2009).

This is perhaps why in G. Clark's technological modes (1970), it is less the replacement of one technology by another that ushers a new mode (there are still flakes produced in blade assemblages) than it is the addition of a new technological solution to an already existing package of traits (e.g., Mode 3= Mode 1 + Mode 2 + Mode 3) (see also Foley and Lahr 1997; Shea 2013). Similarities could also occur in unrelated branches of an evolutionary tree especially if they are under strong and comparable selective pressure (homoplasy) (Lyman et al. 1997; Tostevin 2012; O'Brien et al. 2018) (Fig. 3). When dealing with functional units such as tools, the need often creates the organ and independent reinventions, or reversed evolutions, are frequent. For instance, Tixier (1967) identifies 'techniques' and 'methods' (*…la technique est le moyen, la methode l'esprit qui agence les moyens…*, 1967, p. 807). Here we consider as technique the tools, gestures, and movements used to knap stone, and methods as an organized pathway, involving several steps, to achieve a production goal (Tixier 1967 ; Pelegrin 1995). The former may be transmitted through education (Mauss, 1936), but with respect to issues of equifinality, they have less power than methods for reconstructing evolutionary relationships between assemblages.

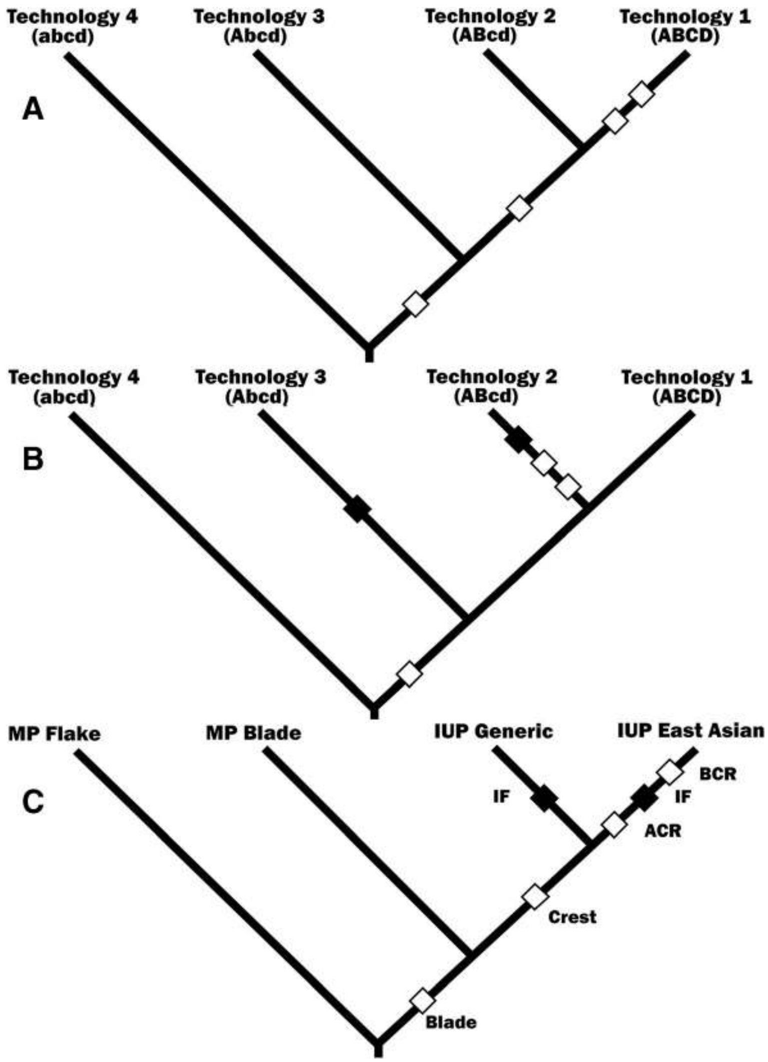

Fig. 3 Examples of evolutionary scenarios for the emergence of new cultural traits (modified after Mesoudi, 2011). Upper cases (AB) are derived features while lower cases (ab) are archaic features; black cubes are traits shared in different lineages, and white cubes are unique to a lineage. A. Parsimonious scenario with all derived features along a single lineage. B. scenario showing the independent emergence of similar traits in different lineages (homoplasy). C. An exemple (among many) of simplified scenario showing the emergence of the IUP derived features, with the package of asymmetrical core reduction (ACR) and burin-core reduction (BCR) unique to the Asian branch. Other traits, such as pyramidal cores or intentional fragmentation of blades (IF), may have been independently reinvented. while other derived features may reappear by convergence in later UP assemblages

As pointed out by Dunnell (2006), neutral traits, the most informative in measuring relatedness between assemblages, are lacking in a blade production. With different means possibly leading to a similar outcome, I consider here that a consistent choice in method is more likely to signal a choice driven by cultural norms (Sackett 1982, 1986). There is no doubt that more sophisticated models could bypass such arbitrary choices and might even consider all traits equally. Nonetheless, here I deliberately focused on technological and typological traits that did not occur in older assemblages, and that show repeated methodic choices among different options which would have served the same or similar functions.

Cultural Transmission and Convergence

Similarities between IUP assemblages in Central and East Asia have been described either as the result of a transmission of knowledge between individuals/groups dispersing eastward across the region, or of independent reinvention by local populations. But cultural transmission and convergence are not mutually exclusive processes. For example, for objects that involve combinations of traits, the idea of a product might well be the result of contact between peoples, whereas its production in different regional contexts may involve reinventions or idiosyncratic behaviors. Here, I follow a two-step approach.

First, I use the simplifying assumption that similarities between lithic assemblages are either the result of cultural transmission *or* an independent reinvention. I use the work of Byrne (2007) with chimpanzees to forward this line of thinking. Byrne posits that the more complex a technology is (intricate complexity), the less likely it is to be reinvented independently (e.g., guided learning, asocial learning, stimulus enhancement, or general low fidelity social learning). Lucas and colleagues (2020) show that, in an experimental context, tool types efficiency increases across generations while teaching only provides an advantage for the more complex tools. While the simple tools tend to converge on a common design, the more complex tools maintained a diversity of designs. For example, a discoidal flaking method is relatively straight forward and therefore, more likely to be reinvented than a specific blade production system under certain conditions and by distantly related individuals. In addition, Byrne suggests that cultural transmission is best indicated by observed behaviors shared between contiguous regions (regional ubiquity). I add here a notion of time-depth that might not be as essential for observing extent primates than it is for archaeology (chronological ubiquity). As shown by Stout et al. (2010), Byrne's approach can be helpful to discuss variation (or the lack thereof) in lithic technology with the caveat that quantifying behavioral complexity is a challenge on its own.

Table 1 Different modes of cultural transmission and convergence (from Eerkens et al. 2006; Mesoudi 2011; McGhee 2018)

Cultural transmission	Guided variation	Trait transmitted from a social convention to an individual who will experiment to optimize the state/attribute
	Conformism	Trait composed of a state/attribute picked up by an individual based on its high frequency in the social pool
	Indirect bias	Trait composed of a state/attribute picked up as part of a package of different traits from the social pool
Convergence	Nonparallel	Independent emergence of a trait that derives from a single inherited archaic trait
	Parallel	Independent emergence of a trait that derives from several inherited variants
	Reverse evolution	A derived trait that reverses back to an anterior state

Second, I discuss specific some modes of transmission with different degrees of individual innovations (Table 1). Broadly, transmission means that the traits observed are influenced by contact between people in a familial context (vertical transmission, from parents to offspring) or between more distantly related individuals that happen to be in contact (horizontal transmission, outside of the nuclear family) (Lipo et al. 2006 ; Mesoudi 2011). Transmission can occur when individuals adopt either the most common variant in their social landscape (conformist transmission) or from a specialist (prestige bias) trait by trait. The borrowers may also seek to improve the efficiency of a trait by experimenting (guided variation); thereby involving both transmission and individual innovations in lithic technological knowledge acquisition. Alternatively, a hunter may deliberately borrow a whole package of traits at once (indirect bias) from a specialist or a social norm, to increase their chances to have a successful hunt (Boyd and Richerson 1985; Yeh et al. 2019). Indirect bias happens when only one trait (or a few) in the package improve the success of the individual, but the whole package is copied due to uncertainty about the identity of the trait in question by the copier at the time. From an empirical point of view, the modes are expected to differ in terms of traits standardization. Indirect bias leads to less emergent variability than trait by trait transmission, especially in cases of guided variation (Bettinger and Eerkens 1999).

Convergence happens when two (or more) individuals/groups invented and maintain the same technology independently through stochastic or adaptive processes (for more see O'Brien et al. 2018). Well-known cases of such convergent evolution, e.g., the invention of ceramics, or the domestication of animals and plants, show the importance of a context (or 'evolutionary landscape') that will favor a specific technological leap among multiple possibilities (Kolodny et al. 2015). Overall, one may expect more variations to emerge over time in the process of production than among the objects themselves, but within certain limits. Moore (2011) suggests that different reduction sequences can converge to produce specific types of blanks within the constraints of a few physical laws (in a 'design-space'). Reducing a method to the accumulation of short sequences ('cells'), he questions the recognition of 'high-order' planning in the empirical record of fossil human species. This approach posits that the morphology of the blanks drives the process of production (and thereby exhibit intentionality or the lack thereof). Overall, convergence often implies that a substantial environmental pressure triggered similar and independent behavioral responses. In biology, it may be a less parsimonious model to explain the emergence of similar traits than a straightforward connection between individuals, or groups (Mesoudi 2011; Tostevin 2007). In terms of culture, however, evolutionary changes are frequent and the simplest tree is not necessarily the most likely (McElreath 1997 cited after Eerkens et al. 2006; Perreault 2019).

How Complex is Complex?

Regardless of the definition used (see Hoffecker 2017), there seems to be no perfect way evaluate the degree of complexity of a technology in the archaeological record. Oswalt (1976) measured complexity of tools by counting their constituent parts, or 'technounits'. For example, a spear with stone tip, a wooden shaft, and a binder to hold them together would equal three technounits. Compared to a wooden spear (1 technounit), the former would be considered as more complex. Although comprehensive and helpful for studying composite tools, Oswalt's approach does not address the manufacturing steps for the individual units which are considered by default as equally complex. In other words, it places more emphasis on 'instruments' than on the 'tools' that they are made of (Mauss, 1967). For example, a knife manufactured from a piece of chert is considered as single unit, because 'it is manufactured in the most basic sense' (Oswalt, 1976, p.39) even if it took less effort and steps of production than a 1 technounit wooden spear. Hence, at the assemblage level, all kinds of technounits are counted once (e.g., different types of points such as Clovis and Levallois are grouped and counted equally as one unit).

To study lithic assemblages, complexity needs to also be evaluated within a technounit by considering the production steps before being compared with other existing units. Perreault et al. (2013) proposed a solution for lithic technology by breaking down reduction sequences into procedural units. The total number of procedural units is considered representative of complexity when defined as *'the minimum amount of information that is needed to manufacture a product*' (Oswalt, 1976, p. 398). Because it is difficult to identify independent variables, or specific behaviors (e.g. use of soft hammer), Perreault et al. use a conservative list of procedural units alongside an extended version of the same list. Granted that complexity is a relative notion and procedural units alone are too general to capture some fine scale lithic technological details (Kuhn and Zwyns 2018), they do allow for informative comparisons between IUP assemblages and other well-known technologies such as the Oldowan, Acheulean, Middle Stone Age, MP and UP.

Another way to approach this problem is to look at the number of levels or sublevels within a system to describe its hierarchical complexity (Simon 1962), which in terms of technology means to look at the suite of hierarchical steps involved in a reduction system (Haidle 2010, 2014). Such qualitative description of a reduction sequence leads to the construction of a cognigram that illustrates the hierarchical depth of the given system (Lombard et al. 2019; Stolarczyk and Schmidt 2018). Every step illustrates the technical and/or cognitive challenge (*subfoci*) that was met to achieve a primary goal. The number of steps can also be quantified to fuel comparative analyses such as the one described above. Based on a detailed set of experimental data, Muller et al. (2017) measure and compare the complexity of lithic technologies such as bipolar, discoidal and bifacial flaking, Levallois and blade technology. A distinction is made between the number of phases per sequence of knapping (hierarchical depth), and the number of *subfoci* per phases of core reduction (hierarchical breadth) in order to estimate the amount of planning and decision-making involved in a sequence. The more complex the technology, the higher the number of sequences and *subfoci*. Here I used Muller et al.'s (2017) extensive experimental referential to compare with the IUP material—essentially a specific case of bidirectional blade reduction with the use of crest.

The Sites and the Context

The degree of ubiquity described by Byrne (2007) is easier to assess from the archaeological record than complexity. Granted that the resolution of the record is low, the goal is not to demonstrate that people who lived at the three sites studied here physically met during their lifetimes. Instead, the data should show that a connection by way of a common cultural lineage is likely if not wholly within the realm of possibilities. Moreover, it should show that the assemblages are comparable (Tostevin 2007). The focus of the study is the region delimited by the Northwest Siberian Altai, the Eastern shore of the Lake Baikal and the Northern part of Mongolia (Fig. 1). Mountain lowlands and open steppe provide opportunities for grazers and human groups to circulate roughly along latitude lines, with the main geographical obstacle being high-altitude peaks and perhaps, bodies of water. Most of the material from these sites has been extensively published elsewhere and here I only briefly summarize the background.

Kara-Bom (N 50′430″; E 85′420″) is in the Yelo Basin, (Derevianko et al. 2000) in between mountains ranging around 2300 m above sea level. Lying on the foothills of a schist cliff, Kara-Bom today is located adjacent to a freshwater spring. About 700 m from the site stands a natural amphitheater and a low pass to the neighboring valley. The material selected here is known as OH5–OH6 and dates to ca. 45 ka, (Derevianko et al. 1993; Goebel et al. 1993) and based on refits is described as belonging to a single level (Belousova and Rybin 2016).

Kamenka (N 51°44′ 51.95″; E 108°17′30.91″) is in the Transbaikal region, circa 60 km from the capital of the Republic of Buryatia, Ulan-Ude (Lbova 1991; Germonpré and Lbova 1996; Zwyns and Lbova 2019). The region is mountainous and hilly with valleys shaped by the Selenga River drainage system. The site lies on the colluvial slopes of the Kamenka Mountain, circa 2 km from the current banks of the Brianka River. The assemblage considered here is known as Kamenka A–C. Although it is in the process of being redated (Higham and Lbova 2018), it has yielded dates close to 45 ka (and much younger ones) (Lbova 2000; Orlova et al. 2005; Hughes et al. 2006).

Tolbor-16 (N 49° 13′ 621″; E 102° 55′ 381″) is approximately 300 km northwest of Ulaanbaatar, in the Northern Hangai Mountains, along the western flank of the Tolbor River valley, 13 km south of the confluence with the Selenga River (Fig. 4). It lies on the left bank of a deep rill, at the junction between a rocky canyon coming down from the Shar Khad Mountain and the Valley open grassland where the site is located. The material considered here derives from the lowermost archaeological horizon (AH6) in Pits 1 and 4 and is dated ca 45 ka (Zwyns et al. 2019). Details about the stratigraphy and the lithic assemblage have been published elsewhere and are summarized in Table 2 below.

Overall, the three sites are located at comparable elevations and in a broadly similar ecological setting. The fauna associated with the human occupation shows differences

Fig. 4 Mountain and valley landscapes from North Mongolia. View on the Tolbor-16 site from the West

Table 2 Basic description of the sites presented here (for more see Derevianko et al. 2000; Lbova 2000; Zwyns et al. 2019)

Site	Kara-Bom	Kamenka	Tolbor-16
Layer	OH5–OH6	Complex A–C	AH6
Elevation	ca. 1100 m asl	ca. 600 m asl	1169 m asl
Landscape	Mountain lowlands, steppe-taiga	Mountain lowlands, mosaic	Mountain lowlands, steppe-taiga
Main raw material	Large size, effusive rock	Unknown size, silicified tuff	Large size, effusive rock
Distance from main raw material source	Local within daily foraging range, 1–2 km	Mostly beyond daily foraging range, ca. 30 km (?)	Local - within daily foraging range 1–2 km
Blade reduction	ACR, IF, BCR, Bidirectional reduction	ACR, IF, BCR, bidirectional	ACR, IF, BCR, bidirectional
Dominant fauna	Equus sp, Bos sp.	*Procapra guturosa*, Equus sp.	Bos sp., Caprinae sp. and Equus sp.
Other technologies	Pendants, Ochre, fire (?)	Bone tools, pendants, engraved bones, fire (?)	Ochre? fire?

though, and there is a clear lack of zooarchaeological studies (but for Kamenka see Germonpré and Lbova 1996; Turner et al. 2013) mostly due to poor bone preservation in the layers considered here. Although equids occur in the three fauna inventories, caprid are more present in the Altai, gazelle in the Baikal, and Bos sp. in Mongolia. Carnivores seem to have a secondary access to the bone assemblages (Wrinn 2010; Turner et al. 2013; Zwyns et al. 2019). In Kamenka, the earliest stages of blade core reductions are poorly documented, and Tolbor-16, some blades may have been exported, but overall, the three sites yield evidence for blade production on site. A major relevant difference is the raw material access: the Tolbor-16 site is in the direct vicinity of the primary and secondary sources, whereas Kara-Bom is located a few kilometers away, though within the daily foraging radius. The Kamenka raw material is said to originate over 20 km away within the same drainage system. It also lacks the oversized blades found at the two other locations, and the cores are extremely reduced. In these conditions, the size and shape of the nodules used at Kamenka are difficult to assess.

Blade Technology

Summarized below are the shared-derived technological features related to the production of IUP blades in the sample studied. There are three parts to the system: first the production of large blades (asymmetrical), then the intentional breakage of some blades, and finally the production of smaller blades/bladelet from those broken blade blanks (burin-core). Given the recursion and interdependence of the different parts, they can be considered as multiple traits within a broader technical system, or package. For the sake of clarity, however, I treat the three parts as distinct methods as detailed below. More details about the quantitative data behind this technological model and its representative parts have been published elsewhere (see Zwyns 2012; Zwyns and Lbova 2019; Zwyns et al. 2019).

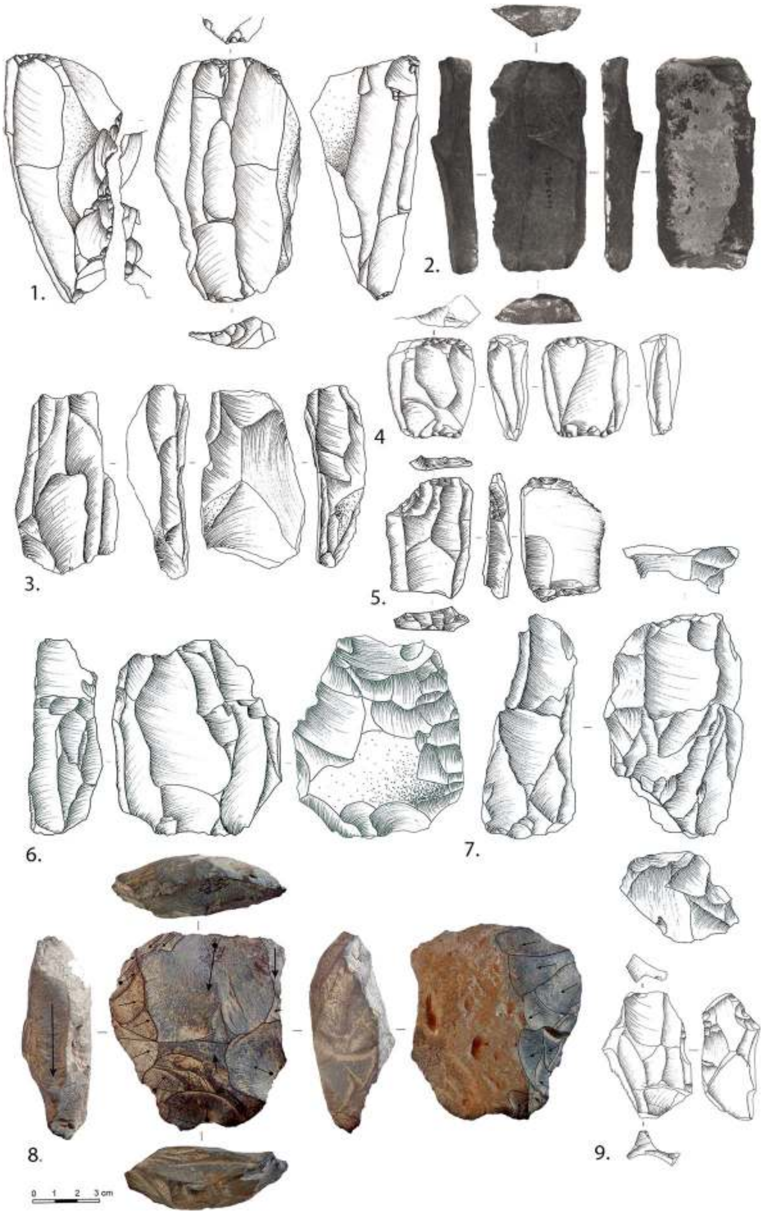

Fig. 5 Cores. 1, 2 Tolbor-16; 3, 5–7 Kara-Bom; 4, 8, 9 Kamenka. 1, 3, 6–9 Asymmetrical cores in various stages of reduction. 2, 4, 5 Truncated-facetted.

Shared-Derived Technological Features

1. Asymmetrical core reduction (ACR) is a specific yet recurring method oriented toward the production of large/medium size blades of various contours (convergent, subparallel or parallel) (Fig. 5). Although poorly documented, the initial core reduction shows the preparation of a crest at the intersection between the narrow

and the broad face of a tabular nodule of raw material. With rare median crests, the geometric set-up indicates an oblique axis of core reduction. The back of the core is often flat, either cortical or prepared. The latter treatment indicates that the flat back is not only a contingency of raw material shape. Just like for the flaking surface, median crests at the back of the cores are rare and instead, a lateral crest at the back is prepared by postero- or anterolateral flaking. This preparation is often located at the opposite end of the core relative to the flaking surface. Hence, a flat back clearly indicates that the reduction will take place at the intersection between two surfaces. Such reduction pattern gives to the core an asymmetrical cross-section. Blades are removed in this way from and between the narrow and the broad face. The broadest flaking surface is reduced using frequent shifts between two opposed platforms, leading to a production that includes elongated convergent blades, sometimes slightly *debordant*. The active narrow face plays a role in the reshaping

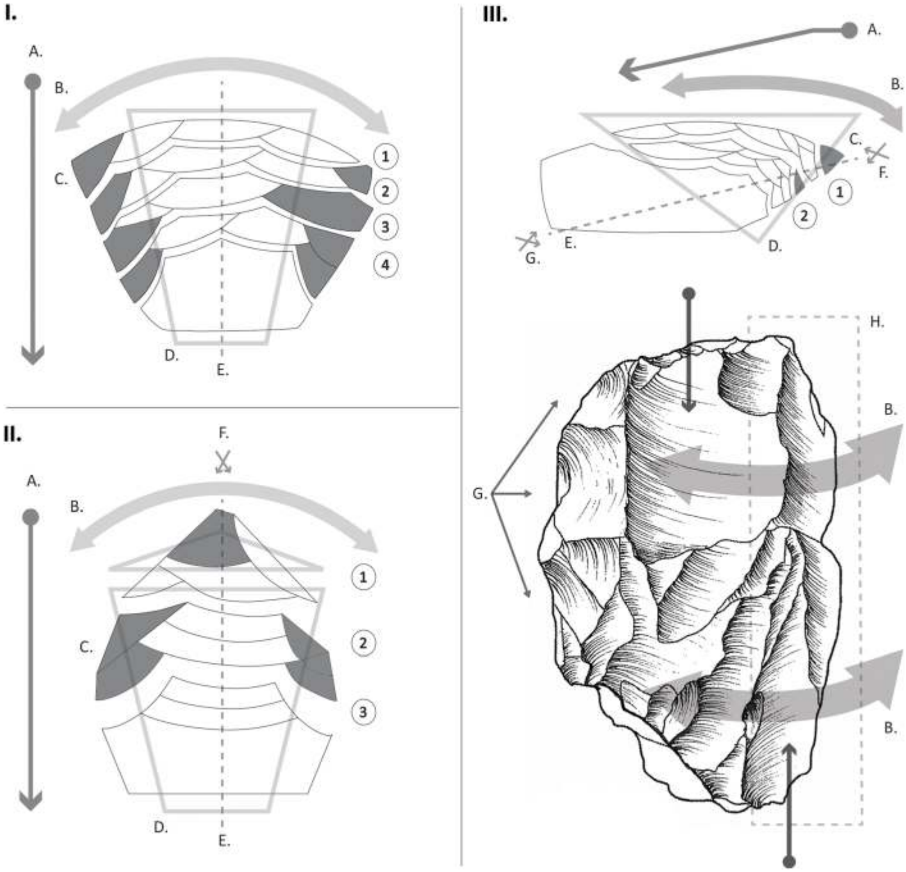

Fig. 6 Simplified core reduction methods (modified after Boëda 1990; and Škrdla 2013). Middle Paleolithic blade reduction—Levallois conception, with surface reduction and debordant removals. II. Bohunician blade reduction—Initialization with crest. III. ACR from the Asian IUP (Boëda's *Roc-de-Combe type*), blades are removed between two surfaces. (A, E) Axis of core reduction. (B) Motion around the flaking surface. (C) Technical flakes (*debordant*) for the management of lateral convexities. (D) Core geometry. (F) Crest. (G) Posterior crest. (H) Intersection between two surfaces

of the core convexity with the frequent removal of thick, naturally backed blades often with parallel edges (Fig. 6). The opposite narrow face remains untouched or shows negatives of orthogonal removals further enhancing the lateral convexity. In some variants, it is possible to distinguish a primary from a secondary platform, but the dorsal face of associated blades within assemblages usually supports the idea of frequent switching between platforms (as opposed to two successive and long-lasting unidirectional reduction phases). Platform preparation of cores included marginal faceting that isolated a plain, dihedral, or facetted platform. Pecking or heavy abrasion modified the external platform edge and reinforced the platform to sustain the compression force of a violent impact. This behavior is probably linked with a technique but it is worth mentioning since it reoccurs in numerous IUP sites in Siberia and beyond (for more, see Slavinsky et al. 2017; Zwyns 2012; Zwyns and Lbova 2019). The platforms largely show consistency with the use of a mineral hammer percussion technique, but the use of other material cannot be excluded. Exhausted cores can show a different morphology although the method does not change it too dramatically. The core is usually abandoned when the broad face became flat. With a lack of lateral convexity, blade production on the broad face or core management on the narrow face is no longer possible. A second possibility is that the thickness of the core is reduced more intensively than the length with the last products still being blades. If on the contrary the length of the core decreases faster than the thickness, it ends as a flake core.

2. Some of the thickest blades are intentionally fragmented (IF), or snapped, using direct percussion, passive or active anvil systems with the resulting segment subsequently being turned into a core (see Step 3). Usually above 10 mm thick, blades that are IF are selected from are among the most robust produced by ACR—namely the numerous side blades, crests, and neocrests involved in core management. The process is not yet fully understood with individual cases reported in Kamenka (Zwyns and Lbova 2019) and Tolbor-16 and backed up by refits and experiments at Kara-Bom (Slavinsky et al. 2019). Although quantitative methods have been proposed to distinguish accidental from intentional fragmentation (Kuhn 2019), here the blades snapped are among the thickest leaving little doubt on the anthropogenic nature of the break. How much it affects the assemblage is unclear, and here I only identify its presence/absence. With a selective collection of raw material (thick blades), and a processing phase using specific techniques to achieve a specific goal (that may but does not necessarily leads to Step 3), I consider it here as a technology on its own.

3. Burin-core reduction (BCR) refers to a way to produce small blades or bladelets from an IF thick blade, or a laminar flake, using the technological length as a flaking surface (Zwyns et al. 2012) (Fig. 7). Although the opposite is not true, the BCR is directly dependent on the production of thick blades. The platforms are adjusted on the snapped surfaces by frontal or lateral removals (truncation), and blanks are removed along the edge of the blade. The removals are often bidirectional at the end of the exploitation. Variants of BCs distinguished by the number of platforms and flaking surfaces are likely a reflection of different reduction stages; the simplest variant has one platform and one flaking surface and the heavily reduced one has bidirectional removals along both edges (coffin-shaped)

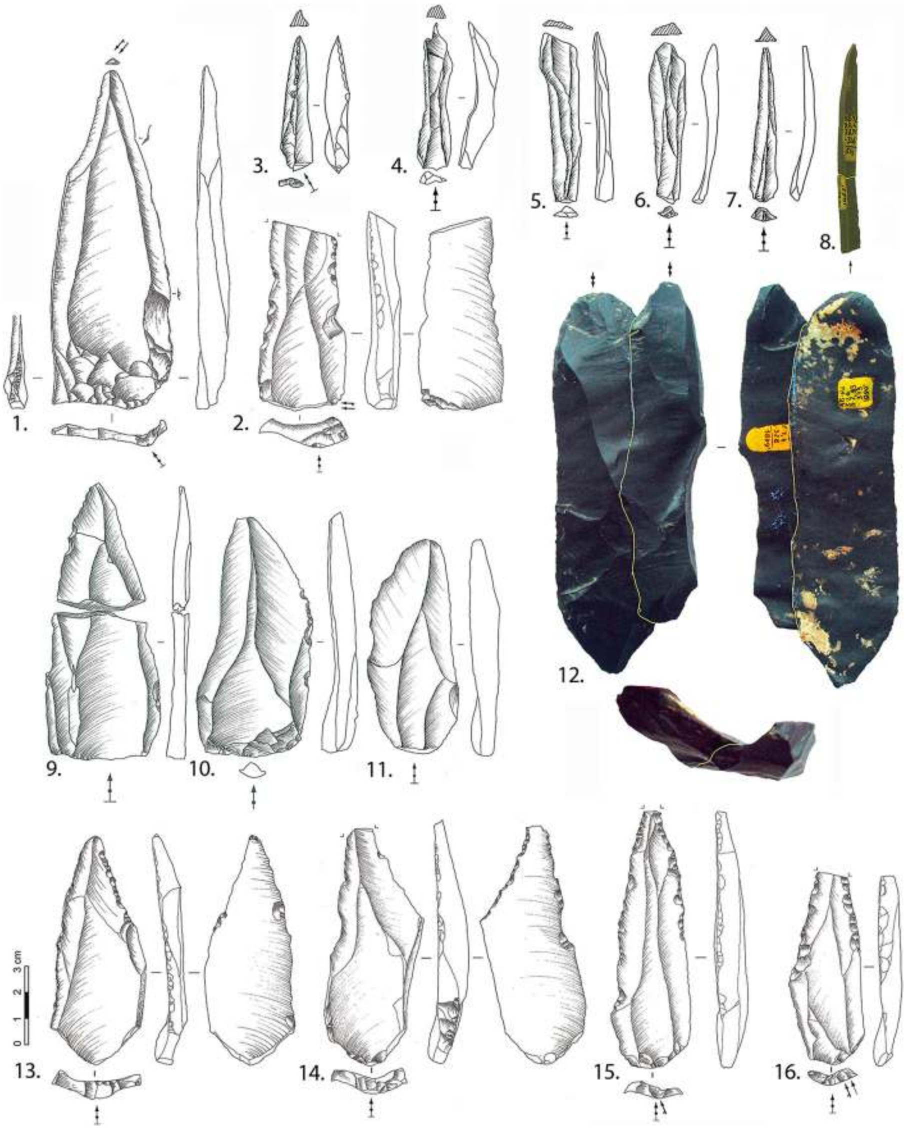

Fig. 7 Blades. 1–2 Tolbor-16; 3–12 Kara-Bom; 13–16 Kamenka. 1, 2, 9–11, 13–16 convergent blades, 3–7 Burin-core productions (secondary spalls/*recoupes*), 8 refitted fragments of the mesio-distal end of a long first spall, 12, refitted blades from the intersection between broad a narrow face of a blade core (the first removal is *debordant*)

(Fig. 8). The variants can fall into different tool types and subtypes, starting with a *burin d'angle sur cassure/troncature* (Tixier 1963) and evolving toward dihedral and polyhedral forms, or toward a truncated-facetted morphology. Quantifying such phenomenon, however, is not easy. The first problem is that variance in burin-core sizes is related to the ACR reduction process (Fig. 9). The second problem is that snapping events can happen several times during the BCR reduction thereby intensifying the reduction in burin-core length. Finally, certain variant seems to

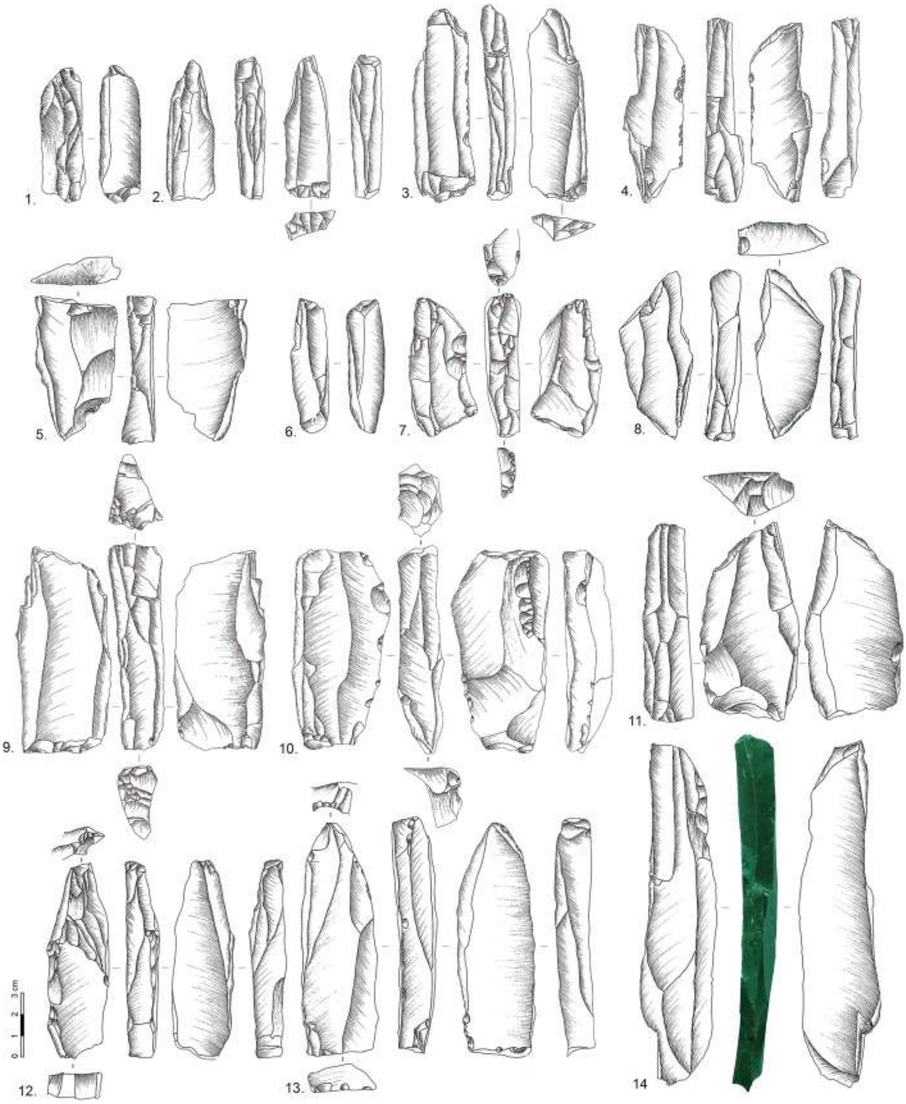

Fig. 8 Burin-cores. 1–6, 8, 11, 14 Kara-Bom; 7, 9, 10, Tolbor-16, 12–13; Kamenka

indicate 'telescopic' conceptions such 'as a blade turned into a core produces a blade that is turned into a core, which will produce blades'. Although the BCs could potentially produce thin blades, a flaking surface ca. 10 mm thick means that most of the blanks are naturally backed and/or irregular. In fact, BCR does not seem optimal as a system to produce bladelets. Based on width measurements, the blanks show a continuity of reduction that transgresses the usual arbitrary technological cutoff between blade and bladelet (<12 mm), and they usually remain unretouched. Blank platforms are either plain or facetted, with little to no abrasion. The use of a small size mineral hammer is consistent with the number of hinged fractures (and the lack of overshot), without ruling out the use of bipolar technique

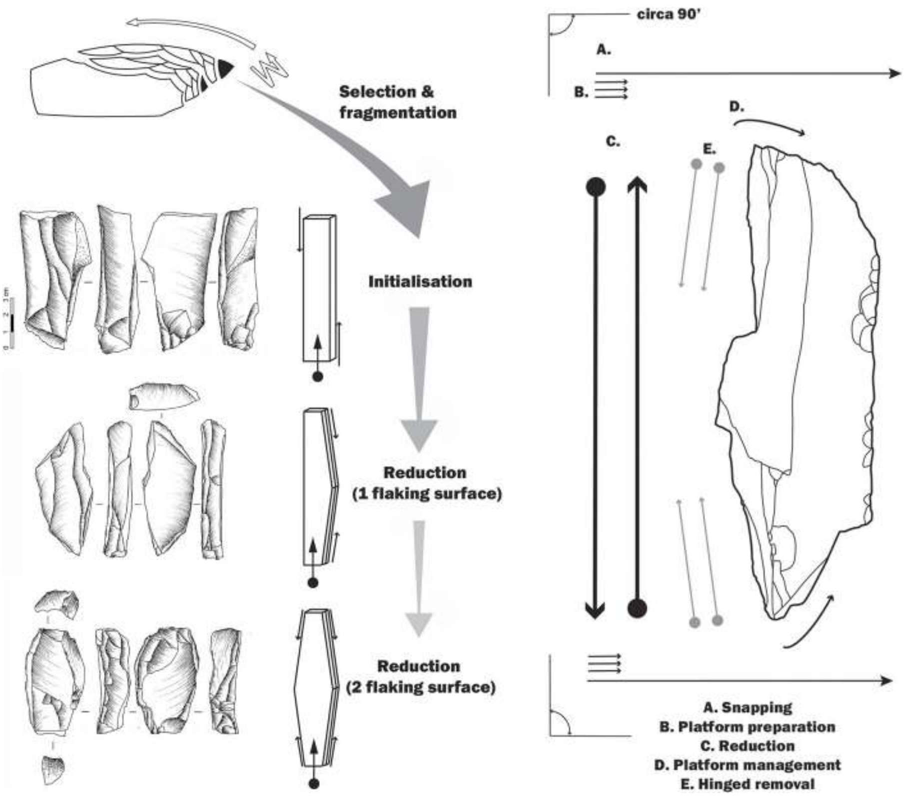

Fig. 9 Simplified core reduction methods for Burin Cores. Left. Start with the selection of thick technical blanks, the IF, and then the reduction that generate typological variations (step 1: angle burin on breakage, or truncation, angle dihedral burin; step 2: straight dihedral, polyhedral or multiple burin; step 3: multiple dihedral or polyhedral). Right. Close up on the reduction method (multiple angle dihedral burin; bidirectional along the longitudinal axis of the blade)

in the last stages, or a recycling of BCs as tools (e.g., chisel). Exhausted cores are various in size, but they usually show a damaged platform either with an acute EPA or on the contrary, close to 90°. Variants include truncated facetted cores, or burin-cores for which the flaking surface extends toward the broad face (similar to ACR but on a blade). The latter form of cores is known in the regional Middle Paleolithic, but here, it is produced on an Upper Paleolithic blank (Fig. 5).

Retouched Tools and Plesiomorphic Features

Derived tool forms consist of various types of retouched blades (convergent, backed knife, with proximal thinning, etc.), endscrapers, rare burins, wedges, and perforators (Fig. 10). In fact, these types are not equally distributed between assemblages and they may represent one of the clearest geographical differences observed. Some spectacular forms are restricted to a few regions, or even sometimes a single site. For example,

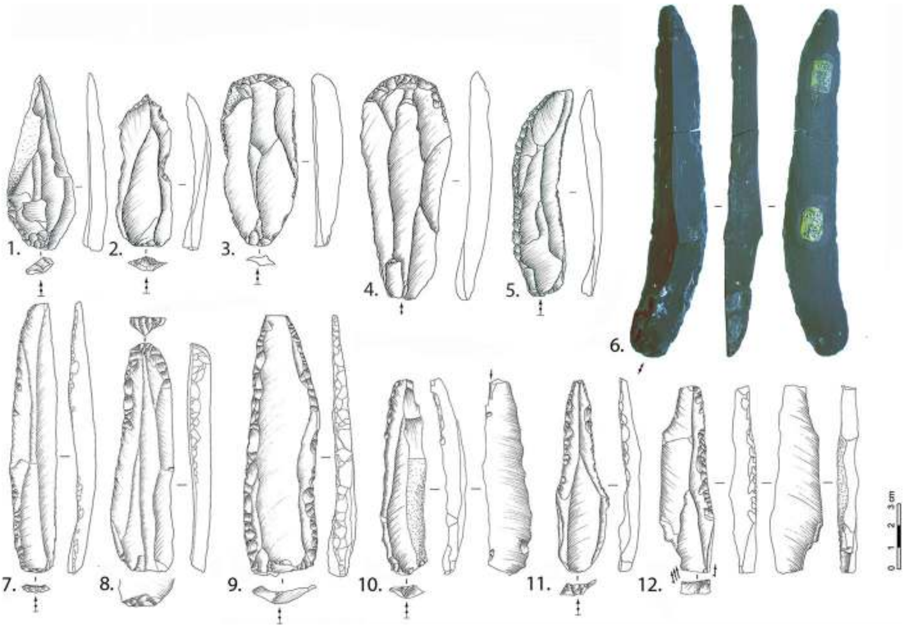

Fig. 10 Tools. 1–6; Kara-Bom; 7–12, Kamenka. 1, point with proximal direct retouch; 2, perforator/notch; 3, 4, endscraper on blade; 5, 6, curved retouched blades; 7–12 sub-parallel retouched blades (8, endscraper on blade; 11, pointed blade; 12, burin/BC-preform or retouched blade)

blades/flakes with proximal thinning and pointed tip with bilateral retouch are known in Kara-Bom, and other sites in the Altai, but also in Makarovo IV, along the Lena (Rybin 2000, 2014; Zwyns 2012). Such artifacts are rare (if present at all) in Mongolia. Kara-Bom also include curved retouched blades, bifacial pieces, and leaf points (Belousova et al. 2019) that are rare or unknown further east. Broad typological studies already exists (e.g., Rybin 2014) and this aspect falls outside of the scope of the paper.

Variability attributed to the IUP may also come from problems of definition, or from the typological approach adopted by the observer. Keeping in mind some of the core types may be representing exhausted specimens of the technologies listed above (Dibble et al. 2017), discoidal, and Levallois-like cores do occur at IUP sites but in small numbers. Contrary to MP and later UP assemblages, there is no evidence for a standardized production of flakes at the scale of the assemblage in the three sites studied. Hence, just like retouched tool types known from earlier periods, such as notches or denticulate, plesiomorphic traits seem more likely to represent opportunistic episodes of expedient production. Overall, issues of typology and plesiomorphic technological features represent a significant part of the variability observed within and between IUP assemblages, while the blade technology is derived and much more conservative.

Complexity

The procedural units (PU thereafter) are too general to fully capture the qualitative signatures of a technology, but they allow for a comparison with well-known systems

Table 3 Procedural units from the three sites presented compared with examples of UP, MP and MSA assemblages (data from Perreault et al. 2013)

Site	Assemblage	Age	Period	PU conservative	PU nonconservative
Üçağızlı	Layers B, B1–3, C	35–32 ka	UP	9	15
Kara-Bom	OH5–OH6	47–45 ka	UP	13	20
Kamenka	A–C	ca. 45 ka	UP	13	20
Tolbor-16	AH6	45 ka	UP	15	21
Amud	Layer B4–B1	68–55 ka	MP	11	23
Klasies RM	Howeison Poort stage	62–58 ka	MSA	9	22
Qafzeh	layer XXIV-III	ca. 92 ka	MP	10	19
Klasies RM	Klasies stage	115–100 ka	MSA	9	19

analyzed by Perrault and colleagues (Perreault et al. 2013) (S1). The values obtained for the three sites range between 13 and 15 with a conservative count, and 20–21 for an extended list of units. Compared with the 13 sites listed in that study, the IUP extended scores among the highest values, with the Middle Stone Age assemblages from Klasies River Mouth dated of ca. 115–80 ka (KRM stage, PU=19) and 62–58 ka (Howieson Poort stage; PU=22); or the Middle Paleolithic of Qafzeh and Amud dated ca. 92 ka (layer XXIV-III; PU=19) and 68–55 ka (B4-B1, PU=23), respectively. It is higher than the Early Upper Paleolithic of Üçağızlı Cave (Ahmarian layers B, B1–3, C PU=15) dated ca. 35–32 ka (Table 3). The conservative PU score of the IUP sites considered here is higher than any of the examples listed in the previous studies. In addition, Muller et al. (2017) compare results from replicative experiment on different technologies such as basic flaking, discoidal, Acheulean handaxe, Levallois, uni- and bidirectional blade productions. Their results show that Levallois preferential and recurrent reduction has the greatest number of sequence phases and it is therefore the most complex. It has twice as much hierarchical depth and breadth than blade production. Not surprisingly, the later showed more intricate complexity than bipolar, or discoidal flaking and about the same as a biface production.

The three technological steps described for the IUP, however, show a one-way dependent relationship. Taking it backward, to produce small blades using the BCR method, implies that thick blades from another reduction sequence have been successfully snapped following yet another method (IF); hence, the 3 derived parts of the IUP system together can be described as branching or ramified (*sensu* Mathias and Bourguignon 2020). Although ACR is necessary for the next steps, it also seems oriented toward its own production goals apart from the further reduction of blades through IF and BCR. Hence the number of *subfoci* should be equal to the sum of the three steps or seen as branching events in a single reduction continuum. Assuming that ACR and BCR are comparable to the bidirectional blade production described by Muller et al. (2017), it would seem that the repetition of a complete IUP sequence required considerable planning and concentration (Fig. 11).

To summarize, the blade reduction found at the three sites under scrutiny is relatively complex compared with other common Paleolithic flaking technologies. But the methods

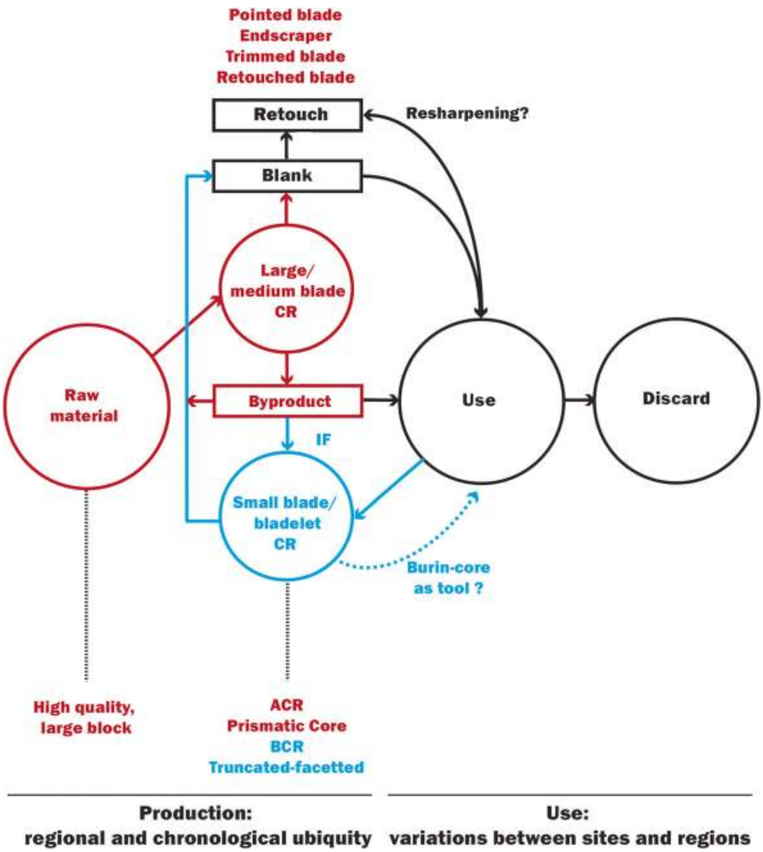

Fig. 11 Theoretical reconstruction of the blade production. There are two distinct pathways to produce large/ medium (red) and small (blue) blades. The byproducts of the large blade production are essential and play a central role in the system. The production/maintenance is the focus of the present analysis and seems stable between sites. The use of the material is expected to be more variable depending on the site or the region

used to estimate this complexity have their limitations. For example, the high PU scores from a conservative approach may account for a bias between observers. Also, the blade reduction system described here may not be exactly the same as the bidirectional blade reproduced by the two experimental knappers used by Muller et al. (2017). Nevertheless, the goal here is not to obtain definitive measure of the IUP complexity. Instead the description and the two approaches used to evaluate complexity confirmed that the package described above, when either broken down in procedural units or into attributes, is a demanding system as complex and cohesive, if not more so, than other Upper Paleolithic technologies.

Discussion

The Parts, the Sum, and the Whole

The set of shared derived features ACR-IF-BCR occur during a relatively short period in contiguous regions. It shows a pattern with settlements located in the lowlands or dry steppe of Central and East Asia where robust/straight blades are part of a broader subsistence strategy. It is possible that blades are advantageous in such an environment, but does the environment predict the way blades are produced? Below, I list some examples where parts of the system known from the IUP occur in other regional or chronological contexts. When we breakdown these examples and look at their constituent parts 'trait-by-trait' it becomes easier to find potential instances of convergence, yet a specific causal link to environmental variables still remains to be seen.

The asymmetrical core morphology described here is usually described as 'subprismatic' in Siberia, and it is also well known in other regions. In fact, it was first described as part of a reduction system by E. Boëda (1990) in a Châtelperronian context, in South-West Europe. Tagged as the '*debitage of Roc-de-Combe type*', it is distinct from the Levallois concept with a production of blades at the intersection of a broad and a narrow face, thereby increasing the number of naturally backed blades. Adjusted by abrupt retouch, these backed blades may be typed as Châtelperronian knives/points. Another major difference would be that Châtelperronian reduction is mostly unidirectional, apart from the distal management of the core flaking surface operated from an opposed striking platform. The same author describes a comparable core geometry in the Hummalian assemblages from Syria (Boëda 1995). In other examples known from early Solutrean contexts in France (Renard 2010), the Middle Paleolithic of Crimea (Cabaj and Sitlivy 1994), the Lincombian-Raniszian-Jerzmanowician in the British Isles (Flas 2008, 2011), the Maisierian in Belgium (Touzé 2018), and the late Middle Paleolithic assemblages from East European Plain (Hoffecker et al. 2019; Nehoroshev 2004; Nehoroshev and Vishnyatsky 2000), it is not always clear if the asymmetrical cross section of the core represents a feature of a broader reduction process (e.g., organized around a broad flaking surface) or a strategy on its own.

Although not often documented, the intentional breakage of blades might suffer from a lack of visibility in the literature. The most prominent examples of the transformation of broken blades into cores indicates a wide chronological and geographical distribution of this general core reduction strategy, including the Middle Stone Age of South-Africa (Soriano et al. 2007), the Epipaleolithic in the Magreb (Tixier 1963), the Mesolithic in Europe (Brezillon 1968; Inizan et al. 1995), and the Neolithic of the Middle-East (Braidwood 1961; Nishiaki 1996; Vardi and Gilead 2011). These examples are steps toward the production and curation of artifacts that are so far unknown from IUP contexts (segments and geometric microliths, and sickle blades, respectively). BCR is known in the Middle Paleolithic of Northern France and is associated with the appearance of a blade technology during the MIS5 (Revillon 1995; Slimak 2006) (Fig. 6-I). The latter leans toward the volumetric core geometry distinct from the ACR, hence producing the *debordant* blade turned into cores (Otte 1994; Revillon 1995). The BCR are also part of the complex set of technological solutions displayed in Gravettian contexts, with various types of polyhedral burins (Klaric 2006). Notable is that, just as for the IUP, the Gravettian examples not only occur far from the raw material site, but close to extraction sites as well. Hence, their presence is not merely a question of raw material availability.

This nonexhaustive list of examples is informative at several levels. First, it shows that taken independently the elements that constitute the system described in the Central and East Asian IUP occur in a vast array of geographical and chronological contexts, suggesting they have been reinvented independently at least once. What mechanisms drive the selection of these traits and whether they are an example of parallel convergence or not (Table 1) are issues that remain to be addressed. At first glance, the empirical record seems irreconcilable with a one-to-one traits-environment correlation, or with a straightforward cultural connection with the IUP. Second, none of the examples listed show a repetition of the *whole* IUP system observed in Asia. Hence, it suggests that hierarchical complexity matters. Even if blank production is considered within a limited 'design space' (Moore 2011), the repetition of a systemic behavior (such as branching core reduction methods) and the scarcity of simpler technological alternatives to produce large or small blades, are factors that increases the power of the comparison between these Asian IUP assemblages.

Complexity and Modes of Transmission

The technological system described is relatively complex, and although building blocks exist elsewhere, it is geographically and chronologically constrained. The three sites presented are in regions where UP sites are numerous and in fact, dozens of additional examples could potentially belong to the IUP as defined here (for an exhaustive list, see Rybin 2014). Following Byrne (2007), such intricate complexity, and regional (and chronological) ubiquity indicates that the similarities observed in the Sibero-Mongol IUP are more likely to reflect a common cultural background than multiple independent (re)inventions. With the evidence presented here and the methods used, it is not possible to invalidate such alternative hypothesis. However, it shifts the likelihood (Perreault 2019) from convergence toward processes of cultural transmission. So, what kind of transmission could explain the pattern observed? As pointed out by multiple authors, any forms of transmission within a group is likely to reduce variations relative to individual learning (Boyd and Richerson 1985; Eerkens and Lipo 2007; Mesoudi and O'Brien 2008). This question would require in-depth consideration and I acknowledge here the limitations of the brief discussion that follows. It is not granted that using variations or attribute correlations will help in identifying a definite mode of transmission. Realistically, one can also expect that individuals were changing modes of transmission depending on their needs and opportunities (Eerkens and Lipo 2007; Mesoudi and O'Brien 2008).

Considering that a system and its structural hierarchy are passed along between individual and groups points toward a scenario of indirect bias. Individuals would select a model in their social environment based on a few desirable traits among the most successful individuals and borrow the whole package that comes with it (Boyd and Richerson 1985 ; Bettinger and Eerkens 1999 ; Eerkens and Lipo 2007; Yeh et al, 2019). It is difficult to firmly identify a specific 'goal' to the system beyond the general idea of producing large and small blades. Although it remains unclear which traits were attractive, one may expect that the latter would occur in relatively high frequency. In the regional IUP, large, massive blades are far more common than the BCR and the small blades/bladelets. In fact, BCR do not always coexist with large blades in IUP assemblages, and it is often represented in small frequencies. Large blades are also the most curated objects of the system, whereas smaller blades are rarely retouched. Hence the production of large blades following a specific procedure could be generalized by way of frequency-based bias (such as conservatism), and sometimes lead to the transmission of a larger package (by indirect bias). Occasionally, by learning the production of (sometime unnecessarily) spectacular large blades from a specialist, individuals may also learn a ramification of the process to produce small ones following a specific pathway. In sum, there are many reasons why blades, large or small, should be borrowed and conformist transmission 'trait by trait' should not be excluded from models of knowledge transmission. In case of the most massive examples, one could also consider possible indicators of prestige and other runaway processes (Boyd and Richerson 1985). The scarcity of simpler ways to produce bladelets from IUP sites may in some cases indicate low levels of individual experimentation, or a secondary role to the production of small blanks unnecessary in certain contexts. Meanwhile, some individuals could have received through indirect bias a larger package that includes BCR.

Technocomplexes, Culture Groups, and Populations

Given all the potential confounding variables inherent to long-distance comparison (e.g., landscape, site function, settlement patterns among others), variations are expected and likely to be more pronounced as the sample size and the geographical scope of the study grows larger. For example, more classic forms of volumetric cores or short convergent blanks (sometimes Levallois types) occur in relatively high frequency. It raises questions on how to characterize the geometric conception of cores, more often described as flat-faced than asymmetrical. For example, Sitlivy et al. (1997) consider that asymmetrical forms (then called 'sub-volumetric') are the end of a reduction process during which the core was mostly flat. Blades with proximal thinning found in the Altai are rare in the Baikal region and in Mongolia (Rybin 2000, 2014), and in North China, blade intentional breakage and BCR are rare (Kuhn 2019; Li et al. 2020). Another way to look at variations would be to consider that innovation, and the transmission of cultural information is tightly linked with demography. A dynamic, relatively small population (Henrich 2004; Kline and Boyd 2010; Kobayashi and Aoki 2012; Shennan 2001), could be consistent with the recurring character of the IUP technology whereas a network of interconnected populations (Creanza et al. 2017b; Greenbaum et al. 2019), or a palimpsest of occupations by different populations (Coco et al. 2020) could account for the 'transitional' features. These angles could explain some the patterns observed, but they will remain speculative until we clarify which part of an archaeological assemblages (if any) is indicative of population size and density (Collard et al. 2016; Dogandžić and McPherron 2013; Vaesen et al. 2016).

It is understood that blades are not such a 'big deal' (Bar-Yosef and Kuhn 1999) and focusing on stone tools means that there is a high risk of underestimating how complex the IUP technology actually is. Body ornament from Kara-Bom and in Kamenka shows substantial variations (Lbova 2011; Rybin 2014), while bone tools suffer preservation biases and are more common in the Baikal region (Derevianko and Rybin 2003; Lbova 2011; Lbova et al. 2010). This all suggests that while using lithics as a proxy may help drawing the contours of vast entities, other categories of artifacts may complicate the picture. Such a situation can be observed elsewhere, with cultural units such as the Aurignacian, or the Gravettian (but see Reynolds and Riede 2019) first defined based on lithic material but for which genetic data indicates correspondence with populations in only the broadest sense (Fu et al. 2016). Based on body ornaments, the same assemblages show even greater variability that could reflect a complex population structure, smaller units closer to ethno-linguistic groups (Vanhaeren and D'Errico 2006), or even the number of crafters within groups (Rigaud et al., 2018). Let it be clear: the idea here is not to use lithics to argue for a cognitive advantage, a specific anatomy or the recognition of an ethnographic group; but does variation between assemblages invalidate a possible movement of population or cultural lineage?

According to the simulations produced by Eerkens and colleagues (2006), modes of transmission do not all yield a detectable phylogenetic signal, but indirectly biased transmission is the most likely to do so. Although it is certainly not the only way of transmitting information in the Paleolithic, it accounts for some of the patterns observed in the archaeological record (Mesoudi and O'Brien 2008). In the present case, it means that using a technological package is closer to what Perreault (2019) may have called a 'smoking gun' and provides more ground than individual traits for analytical lumping. The Asian IUP appears as complex as the European UP, African MSA or Levantine MP counterparts, while the regional and chronological ubiquity satisfy *the needs for unity and discreteness* of a technocomplex as defined by Clarke (1978) (emphasized by Teyssandier and Zilhão 2018: 8). But matching the empirical record with Clarke's taxonomy of 'culture', 'culture group' and 'technocomplex', is not easy and perhaps unnecessary. When the technological package is described as a '*polythetic set of specific and comprehensive artifact types* (1978, p. 246), it indicates a cultural proximity that is in disconnect with the wide geographic distribution of the traits described here. Assemblages in a culture group, and the broader unit of technocomplex have less in common than within a culture. Their degree of relatedness is described in terms of artifact families, which does not fully account for the manufacture process of different artifacts.

Another problem is that Clarke explains the similarities that define a technocomplex as the result of interactions between hunter-gatherer behaviors and their environment. It may not be incompatible with the hypothesis of indirect biased transmission, but it sets adaptive behavior as a default condition to explain shared cultural traits, and thereby favors the idea of convergent evolution. Although I opposed transmission to convergence for the sake of clarity, there is no point downplaying the role of environment, and thereby natural selection, in the formation and transmission of the IUP technology. As Boyd and Richerson point out (1985, p.175), '*...A model of cultural evolution which involves bias forces alone cannot account for the origins of an adaptation unless an explanation can be provided for why the bias themselves arose...*'. For example, one may consider the Central and East Asian IUP assemblages as a series of independent traits, some of which were being selected as components for an object beneficial in an open environment (e.g., type of composite hunting weapons). While selection must have played a role, we do not know enough about the function of the objects and the environment in which they were used to describe such mechanism. For the lack of better word, the term *technocomplex* may be appropriate to characterize the IUP in Central and East-Asia, but within a broader definition than the one proposed by Clarke, closer to the generic entry from the Oxford Online Dictionary: *An otherwise disparate group of cultures considered to share certain general similarities in technology and artifact type* (Technocomplex 2020).

To summarize, the IUP in the generic sense remains an arbitrary analytical unit that mark the beginning of the Upper Paleolithic in a continuum of changes (Marks and

Ferring 1988) happening regionally or not (Kuhn 2003). It brings together assemblages sharing basic features that leave open the possibility of technological convergences, but the combination of specific derived features in lithic technology (such as the ACR-BCR package) with other aspects of material culture may also help identifying cultural lineages.

Implications for the Peopling Scenarios

In the context of hunter-gatherer societies, the transmission of a technological package means face-to-face encounters, and/or a close connection between the different groups involved. Yet, the Altai IUP sites are separated from the Transbaikal and the Tolbor Valley by a bird fly distance of ca. 1500 km and 1200 km respectively. The two latter regions are ca. 450 km apart, overall drawing 3000 km long triangular perimeter and covering an area of 230 000 km^2. In fact, the IUP as described here extends far beyond the limits of the present study, from East Kazakhstan to the Yellow River Basin and it lacks plausible antecedent in most of these regions. For these reasons alone, the distribution of basic archaeological traits seems best explained by some form of demic diffusion (e.g., Ammerman and Cavalli-Sforza 1984).

Between mountains and along river systems (e.g., Kondo et al. 2018; Li et al. 2019), hunter-gatherers could reach the Southern shores of the Lake Baikal from the Altai, passing above the Sayan Range northward from the Tuva region and through the drainage systems of major rivers such as the Yenissei, or the Lena rivers. By following Selenga River southward, they could have crossed the Eastern Sayan and the Yablonoi Mountains toward the steppes of Mongolia and the Gobi Desert, reaching the Yellow River following a string of ephemeral lakes. The most reliable age estimates for the IUP are between 47–45 ka cal BP in the Altai (Belousova et al. 2018; Derevianko et al. 1993; Goebel et al. 1993), 45 ka cal BP in the Baikal (Goebel and Aksenov 1995; Higham and Lbova 2018; Lbova 2011) and in Mongolia (Zwyns et al. 2019) and closer to the 42–40 ka cal BP when moving southeast (Li et al. 2013). In Tolbor-16, it occurs in layers for which sedimentological data identify a climatic event tentatively correlated with the Greenland Interstadial (GI) 12 (Zwyns et al. 2019). The IUP is not exactly the same age everywhere and it seems slightly younger in East Asia than in the Altai, although with a chronological resolution too low to infer a directional population movement (Fitzsimmons et al. 2017),

Certain aspects of Paleolithic material culture may have their own evolutionary history (Hussain and Will 2020), the identification of a widespread cultural package is not trivial when it happens to overlap in time and space with long-distance human dispersals (Bar-Yosef and Belfer-Cohen 2013; Fu et al. 2014, 2016; Hoffecker 2017; Hublin 2012). Recently, dental and osseaous remains associated with IUP material in Europe confirmed that populations of *H. sapiens* were on the move by 45 ka cal BP (Fewlass et al. 2020; Hublin et al. 2020). In Asia, the IUP overlaps in age with the femur from Ust-Ishim, the earliest *H. sapiens* skeletal remains known in Siberia; a coincidence that cannot be ignored (Fu et al. 2014; Viola and Zwyns 2015). The Ust-Ishim individual has no known descendant, but extent human populations show evidence of gene flow between Denisovans and *H. sapiens* that may date back to ca. 43 ka (Zhang et al., 2020). This is important because it places both taxa and the IUP in the same landscape at the same time. Unseen in the Ust-Ishim individual genome, introgression could have happened eastward with movements of populations taking place between the GI12 and the GI8 (ca. 40 ka cal BP) (Devièse et al. 2019; Fu et al. 2013, 2014, 2016, Massilani et al. 2020). More complicated are the alternative scenarios in which the IUP was made by local populations, such as Denisovans, or the multiple possibilities of acculturation/transculturation (Douka et al. 2019; Hublin et al. 1996; Le Brun-Ricalens 2019; Roussel et al. 2016). Difficult to falsify, they remain less parsimonious and leave important questions open such as: Where is the archaeology of modern humans?

Moving Forward

As the hypothesis of a concomitant dispersal of IUP and *H. sapiens* is slowly taking shape, legitimate concerns remain on the pitfalls of using archaeology 'to draw arrows on maps' (see for example Reynolds and Riede 2019a, b; Shea 2011, 2014, 2019). Accepting that not all lithic assemblages are equally informative means that it is difficult to find a one-size-fits-all solution to these problems. As emphasized by Shea (2019), lithic specialists rely on myriads of different approaches to analyze the material record. Moving forward, simplified comparable data sets would be essential to test hypotheses at a macro-scale. This could be achieved via simple standardized attribute lists (presence/absence of traits), and hopefully by computing attributes without a costly distinction between derived and retained features. For the IUP, a draft of such list exists since 2014, thanks to a group of experts on early Upper Paleolithic assemblages from Eurasia who convened at the Max Planck Institute in Leipzig (Kuhn and Zwyns 2018) to find a middle ground between oversimplification and irrelevant details (the list of attributes for the three sites discussed here is in S2).

The Asian IUP is assumed to originate in the West (but see Otte 2019), and it is tempting to revisit Okladnikov's idea and seek possible comparisons in the Levant, with the steppe belt as a possible corridor. For example, broad similarities exist between the Central and East Asian IUP and the Bohunician (Hoffecker 2009; Hublin 2012, 2015; Svoboda 2004) or the Bachokirian (Fewlass et al. 2020; Hublin et al. 2020) from Central and Eastern Europe. More detailed studies reveal, however, significant differences in the blade core reduction or the absence of BCR (Škrdla 2013) (Fig. 6-II). For example, Demidenko et al. (2020) support the idea that the IUP in Europe would find its origins in the Emiran of the Middle East (Tostevin 2003a, 2003b), while noting the lack of genuine bladelet production. Moreover, different IUP variants have been described in a relatively small area where it may have originated (Goring-Morris and Belfer-Cohen 2020). Western Asia nevertheless appears as a cultural hub with relevant comparisons for the Central and Eastern Asian record; from the Negev (although layers 1 and 2 at Boker Tachtit show more affinities with the material described here than the layer 4 originally used to coin the term IUP) to Yemen (Shi'bat Dihya 1) (Delagnes et al. 2012; Marks and Ferring 1988; Marks and Volkman 1983).

With the current lack of IUP sites between the Altai and the Levant, the connection remains hypothetical but directional long-distance movements are plausible. Morphological, genetic and archaeological data convincingly show that Neanderthals moved from Europe to as far as the Altai several times during the Late Pleistocene (Kolobova et al. 2020; Mafessoni et al. 2020; Viola et al. 2012). Hence, it is reasonable to consider a similar movement for *H. sapiens* during a temperate episode, perhaps with an Asian branch quickly isolated from Central Europe after leaving western Asia. Finally, while the simplicity of a dispersal model may seem unrealistic, or a caricature to some, it has the advantage to set clear archaeological expectations. With a growing body of evidence suggesting that IUP is contemporaneous with major population movements, to consider such a model seems like a legitimate course of action. Would it be falsified; negative results will still be informative regarding other major evolutionary processes which may have influenced technological change in Central and East Asia, such as convergence.

Conclusion

I presented here specific technological features of the blade production shared by three lithic assemblages from the Altai, the Transbaikal, and North Mongolia dated of approximatively 45 ka cal BP. The traits are relatively consistent despite the distance between the sites, the differential access to raw material, and other possible confounding factors. Different from what precedes and what follows in the regional sequences, the system is no less complex and repetitive in its composition and organization than other broad cultural units of Eurasia or Africa. Some of the traits are part of a package that occurs repeatedly in an ever growing list of coeval assemblages, within and between these regions, and represent a plausible case for frequency-based bias and indirectly biased transmissions. I suggest that in conjunction with other source material (ornament, bone tools), the blade technology is helpful to recognize and trace the distribution of a cultural unit between Siberia and North China. For the lack of a better word, the latter can be referred to as a technocomplex. Together with fossil and genetic evidence, this research adds to a growing body of data in support of an eastern *H. sapiens* dispersal across the steppe belt during the first half of the OIS 3. Although many questions remain regarding the origin, the nature, and the magnitude of this population movement, lithic analyses can still bring a valuable contribution to identify assemblages relevant to these issues.

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Data Availability Most of the data used here has been published elsewhere and/or are included in the supplementary material.

Declarations

Conflict of Interest The author declares no conflict of interest.

References

Ammerman, A. J., & Cavalli-Sforza, L. L. (1984). *The Neolithic transition and the genetics of populations in Europe, Princeton Univ*. Princeton: Press.

Bar-Yosef, O., & Belfer-Cohen, A. (2013). Following Pleistocene road signs of human dispersals across Eurasia. *Quaternary International, 285*, 30–43. https://doi.org/10.1016/j.quaint.2011.07.043.

Bar-Yosef, O., & Kuhn, S. L. (1999). The big deal about blades: Laminar technologies and human evolution. *American Anthropologist, 101*(2), 322–338.

Beeton, T. A., Glantz, M. M., Trainer, A. K., Temirbekov, S. S., & Reich, R. M. (2014). The fundamental hominin niche in late Pleistocene Central Asia: A preliminary refugium model. *Journal of Biogeography, 41*(1), 95–110. https://doi.org/10.1111/jbi.12183.

Belousova, N. E., & Rybin, E. P. (2016). The technology of pimary stone splitting of the Early Upper Paleolithic industry of the UP1 cultural layer at the Kara-Bom site (Russian Altai). *Theoria y praktika archaeologycheskyi isslodevanyii, 4*(16), 7–22 (in Russian).

Belousova, N. E., Rybin, E. P., Fedorchenko, A. Y., & Anoykin, A. A. (2018). Kara-Bom: New investigations of a Palaeolithic site in the Gorny Altai, Russia. *Antiquity, 92*(361). https://doi.org/10.15184/aqy.2018.4.

Belousova, N. E., Rybin, E. P., Fedorchenko, A. Y., & Kulik, N. A. (2019). Initial Upper Paleolithic leaf-shaped biface from the Kara-Bom site: Technology, function, and context. In *Problems of Archaeology, Ethnography, Anthropology of Siberia and Neighboring Territories* (Vol. XXV, pp. 36–43) (in Russian).

Bergström, A., Stringer, C., Hajdinjak, M., Scerri, E. M., & Skoglund, P. (2021). Origins of modern human ancestry. *Nature, 590*(7845), 229–237.

Bettinger, R. L., & Eerkens, J. (1999). Point typologies, cultural transmission, and the spread of bow-and-arrow technology in the Prehistoric Great Basin. *American Antiquity, 64*(2), 231–242. https://doi.org/10.2307/2694276.

Boëda, E. (1990). De la surface au volume, analyse des conceptions, des débitages Levallois et laminaire. Paléolithique moyen et Paléolithique supérieur ancian en Europe. *Memóires du Musée de Prehistoire dÎle de France, 3*, 63–68.

Boëda, E. (1995). Levallois: a volumetric construction, methods, a technique. In H. L. Dibble & O. Bar-Yosef (Eds.), *The definition and interpretation of Levallois technology* (pp. 41–65). Prehistory Press Madison.

Boyd, R., & Richerson, P. (1985). *Culture and the evolutionary process*. Chicago: University of Chicago Press.

Boyd, R., & Richerson, P. J. (1996). Why culture is common, but cultural evolution is rare. *Proceedings of the British Academy, 88*, 77–93.

Boyd, R., & Richerson, P. J. (2013). The cultural evolution of technology. In P. J. Richerson, H. Christiansen, & Morten (Eds.), *Cultural evolution: Society, tecnology, language, religion* (pp. 119–142). MIT Press.

Braidwood, R. J. (1961). The general appearance of obsidian in Southwestern Asia and the microlithic side-blow blade-flake in obsidian. In G. Bersu (Ed.), *Bericht über den V. Internationalen Kongress für Vor und Frühgeschichte, 1958*. *Hamburg*: Mann.

Brantingham, P. J., Gao, X., Madsen, D. B., Bettinger, R. L., & Elston, R. G. (2004). The initial Upper Paleolithic at Shuidonggou, northwestern China. In *The Early Upper Paleolithic beyond Western Europe* (pp. 223–241). *Berkeley*: *University of California Press*.

Brantingham, P. J., Krivoshapkin, A. I., Jinzeng, L., & Tserendagva, Y. (2001). The Initial Upper Paleolithic in Northeast Asia. *Current Anthropology, 42*(5), 735–746.

Brezillon, M. (1968). *La dénomination des objets en pierre taillée. Paris*: *Fac. Lettres et Scien. Humain. ed. CNRS Paris*.

Byrne, R. W. (2007). Culture in great apes: Using intricate complexity in feeding skills to trace the evolutionary origin of human technical prowess. *Philosophical Transactions of the Royal Society B: Biological Sciences, 362*, 577–585.

Cabaj, V., & Sitlivy, V. (1994). The blade component in the Middle Palaeolithic of Ukraine: Origin and evolution. *Révillion, S. & Tuffreau, A.(eds), Les industries ….*

Cavalli-Sforza, L., & Feldman, M. (1981). *Cultural transmission and evolution: A quantitative approach (Monographs.)*. Princeton University Press.

Clark, G. (1970). *Aspects of prehistory* (Vol. 116). Univ of California Press.

Clarke, D. L. (1978). *Analytical archaeology* (second ed.). London.

Coco, E., Holdaway, S., & Iovita, R. (2020). The effects of secondary recycling on the technological character of lithic assemblages. *Journal of Paleolithic Archaeology*, 1–22.

Collard, M., Shennan, S. J., & Tehrani, J. J. (2006). Branching, blending, and the evolution of cultural similarities and differences among human populations. *Evolution and Human Behavior, 27*(3), 169–184. https://doi.org/10.1016/j.evolhumbehav.2005.07.003.

Collard, M., Vaesen, K., Cosgrove, R., & Roebroeks, W. (2016). The empirical case against the 'demographic turn' in palaeolithic archaeology. *Philosophical Transactions of the Royal Society B: Biological Sciences.* https://doi.org/10.1098/rstb.2015.0242.

Creanza, N., Kolodny, O., & Feldman, M. W. (2017a). Greater than the sum of its parts? Modelling population contact and interaction of cultural repertoires. *Journal of the Royal Society Interface, 14*(130). https://doi.org/10.1098/rsif.2017.0171.

Creanza, N., Kolodny, O., & Feldman, M. W. (2017b). Cultural evolutionary theory: How culture evolves and why it matters. *Proceedings of the National Academy of Sciences of the United States of America, 114*(30), 7782–7789. https://doi.org/10.1073/pnas.1620732114.

Darwent, J. O'Brien, M.J. (2006) Using cladistics to construct lineages of projectile points from Northeastern Missouri. In CP Lipo, MJ O'Brien, M. Collard & SJ Shennan (Eds) *Mapping our ancestors: Phylogenetic methods in anthropology and prehistory*, 185-209.

Delagnes, A., Tribolo, C., Bertran, P., Brenet, M., Crassard, R., Jaubert, J., et al. (2012). Inland human settlement in southern Arabia 55,000 years ago. New evidence from the Wadi Surdud Middle Paleolithic site complex, western Yemen. *Journal of Human Evolution, 63*(3), 452–474. https://doi.org/10.1016/j.jhevol.2012.03.008.

Demidenko, Y. E., Škrdla, P., & Rychtaříková, T. (2020). Initial Upper Paleolithic bladelet production: Bladelets in Moravian Bohunician. *Přehled výzkumů, 61*(1), 21–29.

Dennell, R. (2017). Human colonization of Asia in the late pleistocene the history of an invasive species. *Current Anthropology, 58*, S383–S396. https://doi.org/10.1086/694174.

Dennell, R. (2020). *From Arabia to the Pacific: How our species colonised Asia*. Routledge.

Dennell, R., Martinón-Torres, M., de Castro, J. M. B., & Xing, G. (2020). A demographic history of late Pleistocene China. *Quaternary International.* (In press).

Derevianko, A. (2001). The middle to upper Paleolithic transition in the Altai (Mongolia and Siberia). *Archaeology, Ethnology and Anthropology of Eurasia, 2*, 70–103.

Derevianko, A. P. (2010). Three scenarios for the Middle to Upper Paleolithic transition: Scenario 1: The Middle to Upper Paleolithic transition in Northern Asia. *Archaeology, 3*, 2–32. https://doi.org/10.1016/j.aeae.2010.10.002.

Derevianko, A. P. (2011). The origin of anatomically modern humans and their behavior in africa and eurasia. *Archaeology, Ethnology and Anthropology of Eurasia, 39*(3), 2–31. https://doi.org/10.1016/j.aeae.2011.09.001.

Derevianko, A. P., Nikolayev, S. V., & Petrin, V. T. (1993). The dating of the Paleolithic Kara-Bom site with physical methods (C14 and EPR). *Altaica*, 2–8.

Derevianko, A. P., Petrin, V. T., & Rybin, E. P. (2000). The Kara-Bom site and the characteristics of the Middle-Upper Paleolithic transition in the Altai. *Archaeology, Ethnology and Anthropology of Eurasia.*

Derevianko, A. P., Petrin, V. T., Rybin, E. P., & Chevalkov, L. M. (1998). The Paleolithic complex of the stratified site of Kara-Bom (Mousterian and Upper Paleolithic) (IAE SO RAN.). Novosibirsk. (in Russian)

Derevianko, A. P., & Rybin, E. P. (2003). The earliest representations of symbolic behaviour by Paleolithic humans in the Altai Mountains. *Archaeology, Ethnology and Anthropology of Eurasia, 4*(3), 27–50.

Derevianko, A. P., Rybin, E. P., Gladyshev, S. A., Gunchinsuren, B., Tsybankov, A. A., & Olsen, J. W. (2013). Early upper paleolithic stone tool technologies of northern mongolia: The case of tolbor-4 and tolbor-15. *Archaeology, Ethnology and Anthropology of Eurasia, 41*(4), 21–37. https://doi.org/10.1016/j.aeae.2014.07.004.

Derevianko, A. P., & Shunkov, M. V. (2010). Anthropogenesis and colonization of Eurasia by archaic populations. Formation of anatomically modern human. In A. P. Derevianko & M. V. Shunkov (Eds.), *Proceedings of the international symposium "Characteristic features of the Middle to Upper Paleolithic transition in Eurasia: Development of culture and evolution of Homo genus"* (pp. 50–74). Novosibirsk.

Derevianko, A. P., Shunkov, M. V., & Kozlikin, M. B. (2020). Who were the Denisovans? *Archaeology, Ethnology & Anthropology of Eurasia, 48*(3), 3–32. https://doi.org/10.17746/1563-0110.2020.48.3.003-032.

Derevianko, A. P., & Volkov, P. V. (2004). Evolution of lithic reduction technology in the course of the Middle to Upper Paleolithic transition in the Altai Mountains. *Archeology, Ethnology and Anthropology of Eurasia, 2*(18), 21–35.

Devièse, T., Massilani, D., Yi, S., Comeskey, D., Nagel, S., Nickel, B., et al. (2019). Compound-specific radiocarbon dating and mitochondrial DNA analysis of the Pleistocene hominin from Salkhit Mongolia. *Nature Communications, 10*(1). https://doi.org/10.1038/s41467-018-08018-8.

Dibble, H. L., Holdaway, S. J., Lin, S. C., Braun, D. R., Douglass, M. J., Iovita, R., et al. (2017). Major fallacies surrounding stone artifacts and assemblages. *Journal of Archaeological Method and Theory, 24*(3). https://doi.org/10.1007/s10816-016-9297-8.

Dogandžić, T., & McPherron, S. P. (2013). Demography and the demise of Neandertals: A comment on 'Tenfold population increase in Western Europe at the Neandertal-to-modern human transition'. *Journal Human Evolution, 64*, 311–313.

Douka, K., Slon, V., Jacobs, Z., Ramsey, C. B., Shunkov, M. V., Derevianko, A. P., et al. (2019). Age estimates for hominin fossils and the onset of the Upper Palaeolithic at Denisova Cave. *Nature.* https://doi.org/10.1038/s41586-018-0870-z.

Dunnell, R. C. (1976). *Systematics in prehistory*. Blackburn Press.

Dunnell, R. C. (2006). Measuring Relatedness. In C. P. Lipo, M. J. O'Brien, M. Collard, & S. J. Shennan (Eds.), *Mapping our ancestors: Phylogenetic methods in anthropology and prehistory* (pp. 109–116).

Eerkens, J., & Lipo, C. (2007). Cultural transmission theory and the archaeological record: Providing context to understanding variationand temporal changes in material culture. *Journal of Archaeological Research, 15*, 239–227.

Eerkens, J. W., Bettinger, R. L., & McElreath, R. (2006). Cultural transmission, phylogenetics, and the archaeological record\. In C. P. Lipo, M. J. O'Brien, M. Collard, & S. J. Shennan (Eds.), *Mapping our ancestors: Phylogenetic methods in anthropology and prehistory* (pp. 169–183).

Fewlass, H., Talamo, S., Wacker, L., Kromer, B., Tuna, T., Fagault, Y., et al. (2020). A 14C chronology for the Middle to Upper Palaeolithic transition at Bacho Kiro Cave, Bulgaria. *Nature Ecology & Evolution*, 1–8. https://doi.org/10.1038/s41559-020-1136-3.

Fitzsimmons, K. E., Iovita, R., Sprafke, T., Glantz, M., Talamo, S., Horton, K., et al. (2017). A chronological framework connecting the early Upper Palaeolithic across the Central Asian piedmont. *Journal of Human Evolution, 113*, 107–126. https://doi.org/10.1016/j.jhevol.2017.07.006.

Flas, D. (2008). *La transition du Paleolithique moyen au superieur dans la plaine septentrionale de l'Europe* (Vol. 119). Bruxelles: Anthropologica et Praehistorica.

Flas, D. (2011). The Middle to Upper Paleolithic transition in Northern Europe: The Lincombian-Ranisian-Jerzmanowician and the issue of acculturation of the last Neanderthals. *World Archaeology.* http://www.tandfonline.com/doi/abs/10.1080/00438243.2011.624725.

Foley, R., & Lahr, M. M. (1997). Mode 3 Technologies and the evolution of modern humans. *Cambridge Archaeological Journal, 7*(1), 3–36. https://doi.org/10.1017/s0959774300001451.

Fu, Q., Li, H., Moorjani, P., Jay, F., Slepchenko, S. M., Bondarev, A. A., et al. (2014). Genome sequence of a 45,000-year-old modern human from western Siberia. *Nature, 514*(7253). https://doi.org/10.1038/nature13810.

Fu, Q., Meyer, M., Gao, X., Stenzel, U., Burbano, H. A., Kelso, J., & Pääbo, S. (2013). DNA analysis of an early modern human from Tianyuan Cave, China. *Proceedings of the National Academy of Sciences of the United States of America, 110*(6), 2223–2227. https://doi.org/10.1073/pnas.1221359110.

Fu, Q., Posth, C., Hajdinjak, M., Petr, M., Mallick, S., Fernandes, D., et al. (2016). The genetic history of Ice Age Europe. *Nature.* https://doi.org/10.1038/nature17993.

Germonpré, M., & Lbova, L. (1996). Mammalian remains from the Upper Palaeolithic site of Kamenka, Buryatia (Siberia). *Journal of Archaeological Science, 23*(1), 35–57.

Goebel, T. (1993). *The middle to upper Paleolithic transition in Siberia*. Ph.D. diss. University of Alaska, Fairbanks.

Goebel, T. (1999). Pleistocene human colonization of Siberia and peopling of the Americas: An ecological approach. *Evolutionary Anthropology: Issues, News, and Reviews, 8*(6).

Goebel, T., & Aksenov, M. (1995). Accelerator radiocarbon dating of the initial Upper Palaeolithic in southeast Siberia. *Antiquity, 69*, 349.

Goebel, T., Derevianko, A. P., & Petrin, V. T. (1993). Dating the middle-to-upper-paleolithic transition at Kara-Bom. *Current anthropology, 34*(4), 452.

Goebel, Ted. (2015). The overland dispersal of modern humans to eastern Asia: An alternative, northern route from Africa. In Y. Kaifu, M. Izuho, & T. Goebel (Eds.), *Emergence and diversity of modern human behavior in Paleolithic* (pp. 437–452).

Goring-Morris, N. A., & Belfer-Cohen, A. (2020). Noisy beginnings: The Initial Upper Palaeolithic in Southwest Asia. *Quaternary International, 551*, 40–46.

Greenbaum, G., Friesem, D. E., Hovers, E., Feldman, M. W., & Kolodny, O. (2019). Was inter-population connectivity of Neanderthals and modern humans the driver of the Upper Paleolithic transition rather than its product? *Quaternary Science Reviews, 217*. https://doi.org/10.1016/j.quascirev.2018.12.011.

Groucutt, H. S. (Ed.). (2020). *Culture history and convergent evolution: Can we detect populations in prehistory?* Springer International Publishing 302 p.

Gunchinsuren, B., Bazargur, D., Yi, S., & Lee, J. (2017). The study results of Stone Age site Rashaan khad. *Studia Archaeologica*, 225–229.

Haidle, M. N. (2014). Building a bridge-an archeologist's perspective on the evolution of causal cognition. *Frontiers in Psychology, 5*(DEC). https://doi.org/10.3389/fpsyg.2014.01472.

Haidle, M. N. (2010). Working-memory capacity and the evolution of modern cognitive potential: Implications from animal and early human tool use. *Current Anthropology, 51*(SUPPL. 1). https://doi.org/10.1086/650295.

Haidle, M. N., & Schlaudt, O. (2020). Where does cumulative culture begin? A plea for a sciologically informed perspective. *Biological Theory.* https://doi.org/10.1007/s13752-020-00351-w.

Henrich, J. (2004). Demography and cultural evolution: How adaptive cultural processes can produce maladaptive losses—The Tasmanian case. *American Antiquity, 69*(2), 197–214. https://doi.org/10.2307/4128416.

Henrich, J., & McElreath, R. (2012). Dual-inheritance theory: The evolution of human cultural capacities and cultural evolution. In *Oxford handbook of evolutionary psychology*. Oxford University Press. https://doi.org/10.1093/oxfordhb/9780198568308.013.0038.

Higham, T. F. G., & Lbova, L. V. (2018). New perspectives on the chronology of the Initial Upper Palaeolithic of the Transbaikal, Russia. In *Session XXXIX perspective on the prehistory of Central Asia, 18th UISPP world congress, Paris, June 2018 SE (book of abstract)* (p. 32).

Hoffecker, J. F. (2009). The spread of modern humans in Europe. *Proceedings of the National Academy of Sciences, 106*(38), 16040–16045.

Hoffecker, J. F. (2017). *Modern humans: Their African origin and global dispersal*. Columbia University Press.

Hoffecker, J. F., Holliday, V. T., Nehoroshev, P., Vishnyatsky, L., Otcherednoy, A., Salnaya, N., et al. (2019). The dating of a Middle Paleolithic blade industry in Southern Russia and its relationship to the Initial Upper Paleolithic. *Journal of Paleolithic Archaeology.* https://doi.org/10.1007/s41982-019-00032-6.

Hublin, J. J. (2012). The earliest modern human colonization of Europe. *Proceedings of the National Academy of Sciences of the United States of America.* https://doi.org/10.1073/pnas.1211082109.

Hublin, J. J. (2015). The modern human colonization of western Eurasia: When and where? *Quaternary Science Reviews.* https://doi.org/10.1016/j.quascirev.2014.08.011.

Hublin, J. J., Sirakov, N., Aldeias, V., Bailey, S., Bard, E., Delvigne, V., et al. (2020). Initial Upper Palaeolithic Homo sapiens from Bacho Kiro Cave, Bulgaria. *Nature, 581*(7808), 299–302. https://doi.org/10.1038/s41586-020-2259-z.

Hublin, J. J., Spoor, F., Braun, M., Zonneveld, F., & Condemi, S. (1996). A late Neanderthal associated with Upper Palaeolithic artefacts. *Nature, 381*(6579), 224–226. https://doi.org/10.1038/381224a0.

Hughes, S., Hayden, T. J., Douady, C. J., Tougard, C., Germonpré, M., Stuart, A., Lbova, L., Carden, R. F., Hänni, C., & Say, L. (2006). Molecular phylogeny of the extinct giant deer, Megaloceros giganteus. *Mol. Phylogenet. Evol., 40*(1), 285–291.

Hussain, S. T., & Will, M. (2020). Materiality, Agency and evolution of lithic technology: An integrated perspective for Palaeolithic archaeology. *Journal of Archaeological Method and Theory.* https://doi.org/10.1007/s10816-020-09483-6.

Inizan, M. L., Reduron, M., Roche, H., & Tixier, J. (1995). *Technologie de la pierre taillee*. Meudon: Centre de Recherches et d'Etudes Prehistoriques.

Izuho, M., Tsogtbatar, B., Yamaoka, T., Hayashi, K. & Enkhtor, A. (2009) Preliminary report of geoarchaeological investigation at Khanzat-1, Eastern Mongolia. In: *Current archaeological research in Mongolia* (eds. an Bemmann, Hermann Parzinger, Ernst Pohl, Damdinsüren Tseveendorzh), Vor- und Frühgeschichtliche Archäologie Rheinische Friedrich-Wilhelms-Universität Bonn, 31–45.

Kadowaki, S. (2013). Issues of chronological and geographical distributions of Middle and Upper Palaeolithic cultural variability in the Levant and implications for the learning behavior of Neanderthals and Homo sapiens. In *Dynamics of learning in Neanderthals and modern humans* (Vol. 1, pp. 59–91). Tokyo: Springer.

Klaric, L. (2006). Des armatures aux burins: des criteres de distinction techniques et culturels a partir des productions lamellaires de quelques sites du Gravettien moyen et recent (France). In *Burins préhistoriques: formes, fonctionnement, fonctions, Table-ronde Maison méditerranéenne des sciences de lhomme, Aix-en-Provence, 3-5 mars 2003* (pp. 199–223). Luxembourg: musée national d'histoire et dart.

Kline, M. A., & Boyd, R. (2010). Population size predicts technological complexity in Oceania. In *Proceedings of the Royal Society B: Biological Sciences* (Vol. 277, pp. 2559–2564). Royal Society. https://doi.org/10.1098/rspb.2010.0452

Kobayashi, Y., & Aoki, K. (2012). Innovativeness, population size and cumulative cultural evolution. *Theoretical Population Biology, 82*(1), 38–47. https://doi.org/10.1016/j.tpb.2012.04.001.

Kolobova, K. A., Roberts, R. G., Chabai, V. P., Jacobs, Z., Krajcarz, M. T., Shalagina, A. V., et al. (2020). Archaeological evidence for two separate dispersals of Neanderthals into southern Siberia. *Proceedings of the National Academy of Sciences of the United States of America, 117*(6). https://doi.org/10.1073/pnas.1918047117.

Kolodny, O., Creanza, N., & Feldman, M. W. (2015). Evolution in leaps: The punctuated accumulation and loss of cultural innovations. *Proceedings of the National Academy of Sciences of the United States of America, 112*(49), E6762–E6769. https://doi.org/10.1073/pnas.1520492112.

Kondo, Y., Sano, K., Omori, T., Abe-Ouchi, A., Chan, W.-L., Kadowaki, S., et al. (2018). Ecological niche and least-cost path analyses to estimate optimal migration routes of Initial Upper Palaeolithic populations to Eurasia. In *The Middle and Upper Paleolithic archeology of the Levant and beyond* (pp. 199–212). Singapore: Springer Singapore. https://doi.org/10.1007/978-981-10-6826-3_13.

Kuhn, S. L. (2003). In what sense is the Levantine Initial Upper Paleolithic a "transitional" industry. In *The chronology of the Aurignacian and of the transitional technocomplexes. Dating, stratigraphies, cultural implications* (Vol. 33, pp. 61-70). Instituto Português de Arqueologia Lisbon.

Kuhn, S. L., & Zwyns, N. (2014). Rethinking the initial Upper Paleolithic. *Quaternary International, 347*(1). https://doi.org/10.1016/j.quaint.2014.05.040.

Kuhn, S., & Zwyns, N. (2018). Convergence and continuity in the initial upper Paleolithic of Eurasia. In M. J. O'Brien, B. Buchanan, & M. Ehren (Eds.), *Convergent evolution in stone-tool technology* (pp. 132–152). The MIT Press.

Kuhn, S. L. (2019). Initial upper Paleolithic: A (near) global problem and a global opportunity. *Archaeological Research in Asia, 17*, 2–8.

Kuhn, S. L., Stiner, M. C., & Güleç, E. (1999). Initial Upper Palaeolithic in south-central Turkey and its regional context: a preliminary report. *Antiquity, 73*, 505–517.

Kuzmin, Y. V., & Keates, S. G. (2020). The chronology of the hominin fossils in the Altai Mountains, Siberia: an alternative view. *Journal of Human Evolution, 146*, 102834.

Lbova, L., (1991). The palaeolithic site of Kamenka-1: preliminary results of investigation. In: Drozdov, N. (Ed.), *The archaeological and ethnographical problems of Siberia and the Far East* Krasnoyarsk: Pedagogic Institute of Krasnoyarsk, (pp. 90–91) (in Russian).

Lbova, L. (2000). Orlova, L., Kuzmin, Y., Lbova, L., 2005. Radiocarbon dates of the Paleolithic and Mesolithic of the Transbaikal and Mongolia. In: *Paleolithic culture of Zabaikal and Mongolia (new facts, methods and hypotheses)*. Novosibirsk, pp. 88–92 (in Russian)

Lbova, L. (2011). Evidence of modern human behavior in the Baikal Zone during the Early Upper Paleolithic period. *Bulletin of the Indo-Pacific Prehistory Association, 30*, 9–13.

Lbova, L., Kozhevnikova, D., & Volkov, P. (2010). Musical instruments in Siberia (early stage of the Upper Paleolithic). *Actes du Congrès de l'IFRAO, Tarascon-sur-Ariége, 2011*, 324–325.

Le Brun-Ricalens, F. (2019). Transculturation versus acculturation: A clarification. In Y. Nishiaki & O. Jöris (Eds.), *Learning among Neanderthals and Palaeolithic modern humans. Replacement of Neanderthals by modern humans series*. Singapore: Springer. https://doi.org/10.1007/978-981-13-8980-1_13.

Li, F., Kuhn, S. L., Gao, X., & Chen, F. Y. (2013). Re-examination of the dates of large blade technology in China: A comparison of Shuidonggou Locality 1 and Locality 2. *Journal of Human Evolution, 64*(2), 161–168. https://doi.org/10.1016/j.jhevol.2012.11.001.

Li, F., Vanwezer, N., Boivin, N., Gao, X., Ott, F., Petraglia, M., & Roberts, P. (2019). Heading north: Late Pleistocene environments and human dispersals in central and eastern Asia. *PLOS ONE, 14*(5), e0216433. https://doi.org/10.1371/journal.pone.0216433.

Li, F., Kuhn, S. L., Chen, F. Y., & Gao, X. (2020). Intra-assemblage variation in the macro-blade assemblage from the 1963 excavation at Shuidonggou locality 1, northern China, in the context of regional variation. *PLoS ONE, 15*(6), e0234576.

Lombard, M., Högberg, A., & Haidle, M. N. (2019). Cognition: From Capuchin rock pounding to Lomekwian flake production. *Cambridge Archaeological Journal, 29*(2), 201–231. https://doi.org/10.1017/S0959774318000550.

Lucas, A. J., Kings, M., Whittle, D., Davey, E., Happé, F., Caldwell, C. A., & Thornton, A. (2020). The value of teaching increases with tool complexity in cumulative cultural evolution. *Proceedings of the Royal Society B, 287*(1939), 20201885.

Lycett, S. J. (2009a). Are Victoria West cores "proto-Levallois"? A phylogenetic assessment. *Journal Human Evolution, 56*(2), 175–191 https://www.sciencedirect.com/science/article/pii/S0047248408002078.

Lycett, S. J. (2009b). Understanding ancient hominin dispersals using artefactual data: A phylogeographic analysis of acheulean handaxes. *PLoS ONE, 4*(10). https://doi.org/10.1371/journal.pone.0007404.

Lyman, R. L., O'Brien, M. J., & Dunnell, R. C. (1997). *The rise and fall of culture history*. New York: Plenum Press.

Madsen, D. B., Oviatt, C. G., Zhu, Y., Brantingham, P. J., Elston, R. G., Chen, F., et al. (2014). The early appearance of Shuidonggou core-and-blade technology in north China: Implications for the spread of anatomically modern humans in northeast Asia? *Quaternary International, 347*(1), 21–28. https://doi.org/10.1016/j.quaint.2014.03.051.

Mafessoni, F., Grote, S., Filippo, C. de, Slon, V., Kolobova, K. A., Viola, B., et al. (2020). A high-coverage Neandertal genome from Chagyrskaya Cave. *bioRxiv*, 2020.03.12.988956. https://doi.org/10.1101/2020.03.12.988956

Marks, A. E., & Ferring, C. R. (1988). The Early Upper Paleolithic of the Levant. *The Early Upper Paleolithic: evidence from Europe and the Near East. BAR International Series*, *437*, 43–72.

Marks, A. E., & Volkman, P. (1983). Changing core reduction strategies: A technological shift from the Middle to the Upper Paleolithic in the southern Levant. *The Mousterian legacy: Human biocultural change in the Upper Pleistocene*, (pp. 13–34).

Marks, A. E. (1990). The middle and upper Palaeolithic of the near east and the Nile Valley : The problem of cultural transformations. In P. A. Mellars (Ed.), *The emergence of modern humans : An archaeological perspective* (pp. 56–80). Edinburgh.

Massilani, D., Skov, L., Hajdinjak, M., Gunchinsuren, B., et al. (2020). Denisovan ancestry and population history of early east Asians. *Science, 370*(6516), 579–583.

Mathias, C., & Bourguignon, L. (2020). Cores-on-flakes and ramification during the middle palaeolithic in Southern France: A gradual process from the early to late middle palaeolithic? *Journal of Archaeological Science: Reports, 31*, 102336.

Mauss, M. (1936). Les techniques du corps. *Journal de psychologie, 32*(3–4), 271–293.

Mauss, M. (1967). *Manuel d'ethnographie* (2e éd ed.). Paris: Petite Bibliothèque Payot.

McElreath, R. M. (1997). *Iterated parsimony: A method for reconstructing cultural histories* (Master's thesis, UCLA).

McGhee, G. R. (2018). Limits on the possible forms of stone tools: A perspective from convergent biological evolution. M. J. O'Brien, B. Buchanan, & M. Ehren (Eds.), *Convergent Evolution in Stone-Tool Technology* (pp. 23-46), The MIT Press.

Mesoudi, A. (2011). A Darwinian theory of cultural evolution can promote an evolutionary synthesis for the social sciences. *Biological Theory, 2*(3), 263–275. https://doi.org/10.1162/biot.2007.2.3.263.

Mesoudi, A., & O'Brien, M. J. (2008). The cultural transmission of Great Basin projectile-point technology II: An agent-based computer simulation. *American Antiquity, 73*(4), 627–644.

Mesoudi, A., & Aoki, K. (Eds.). (2015). *Learning strategies and cultural evolution during the Palaeolithic*. Springer Japan.

Moore, M. (2011). The design space of stone flaking: Implications for cognitive evolution. *World Archeology, 43*(4), 702–715.

Muller, A., Clarkson, C., & Shipton, C. (2017). Measuring behavioural and cognitive complexity in lithic technology throughout human evolution. *Journal of Anthropological Archaeology, 48*. https://doi.org/10.1016/j.jaa.2017.07.006.

Nehoroshev, P. E. (2004). Technology of primary flaking at the site of Shlyakh Layer 8 (The Middle Don, Russia). *Acts of the XIVth UISPP Congress, University of Liege, Belgium, 2-8 September 2001. Section 5, The Middle Palaeolithic, general session and posters (diricted by Philip Van Peer, Patrick Semal, Dominique Bonjean)*, (pp.117–126), BAR Series.

Nehoroshev, P. E., & Vishnyatsky, L. B. (2000). Shlyakh—A new Late Middle Paleolithic site in the South Russian Plain. *Neanderthals and modern humans-discussing the transition: Central and Eastern Europe from 50 000-30 000 BP*, (pp. 256–266).

Nishiaki, Y. (1996). Side-blow blade-flakes from Tell Kashkashok II, Syria: A technological study. In *Neolithic chipped stone industry of the fertile crescent, and their contemporaries in adjacent regions* (pp. 311–327). Ex Oriente.

O'Brien, M. J., Darwent, J., & Lyman, R. L. (2001). Cladistics is useful for reconstructing archaeological phylogenies: Palaeoindian points from the Southeastern United States. *Journal of Archaeological Science, 28*(10), 1115–1136. https://doi.org/10.1006/jasc.2001.0681.

O'Brien, M. J., & Lee Lyman, R. (2002). Evolutionary archeology: Current status and future prospects. *Evolutionary Anthropology, 11*(1), 26–36. https://doi.org/10.1002/evan.10007.

O'Brien, M.J., B. Buchanan, & M. Ehren (Eds.) (2018) *Convergent evolution in stone-tool technology* (pp. 132–152). The MIT Press.

Odsuren, D., Bukhchuluun, D., Janz, L. & Rosen, A. (2017) Preliminary results of ongoing research at Stone Age site Zaraa uul). In:*Archaeological research, preservation, and protection in Eastern Mongolia*. Mongolian Academy of Sciences, Ulaanbaatar, 234–248.

Okladnikov, A. P. (1978). The Paleolithic of Mongolia. In F. Ikawa-Smith (Ed.), *Early Paleolithic in South and East Asia (pp. 317–325)*. Paris.

Okladnikov, A. P. (1983). Paleoliticheskaya stoianka Kara-Bom v Gornom Altae (po materialam raskopok 1980 goda). *Paleolit Sibiri*, 5–20 (in Russian).

Orlova, L., Kuzmin, Y., Lbova, L., 2005. Radiocarbon dates of the Paleolithic and Mesolithic of the Transbaikal and Mongolia. In: Paleolithic culture of Zabaikal and Mongolia (new facts, methods and hypotheses). Novosibirsk, pp. 88–92. (in Russian)

Oswalt, W. H. (1976). *An anthropological analysis of food-getting technology*. Wiley.

Otte, M. (1994). Rocourt (Liège, Belgique): industrie laminaire ancienne. In S. Revillon & A. Tuffreau (Eds.), *Les industries laminaires au Paléolithique moyen. Dossier de Documentation Archéologique* Vol. 18, (pp. 179–186).

Otte, M. (2019). Denisova et les traditions paléolithiques en Asie Centrale. *L'Anthropologie, 123*(2), 452–477.

Pelegrin, J. (1995). *Technologie lithique: le Chatelperronien de Roc-de-Combe (lot) et de La Cote (Dordogne)*. Paris: CNRS edition.

Perreault, C. (2019). *The quality of the archaeological record*. Chicago and London: The University of Chicago Press.

Perreault, C., Jeffrey Brantingham, P., Kuhn, S. L., Wurz, S., & Gao, X. (2013). Measuring the complexity of lithic technology. *In Current anthropology, 54*. https://doi.org/10.1086/673264.

Renard, C. (2010). *Les premieres expressions du Solutreen dans le Sud-Ouest francais. Evolution techno-economique des equipements lithiques au cours du Dernier Maximum Glaciaire*. British Archaeological Reports International Series 2070.

Revillon, S. (1995). Technologie laminaire au Paleolithique moyen en Europe Septentrionale : etat de la question. *Bulletin de la Societe Prehistorique Francaise, 92*(4), 425–441.

Reyes-Centeno, H., Hubbe, M., Hanihara, T., Stringer, C., & Harvati, K. (2015). Testing modern human out-of-Africa dispersal models and implications for modern human origins. *Journal of Human Evolution, 87*. https://doi.org/10.1016/j.jhevol.2015.06.008.

Reynolds, N., & Riede, F. (2019a). House of cards: cultural taxonomy and the study of the European Upper Palaeolithic. *Antiquity, 93*(371). https://doi.org/10.15184/aqy.2019.49.

Reynolds, N., & Riede, F. (2019b). Reject or revive? The crisis of cultural taxonomy in the European Upper Palaeolithic and beyond. *Antiquity, 93*(371), 1368–1370. https://doi.org/10.15184/aqy.2019.156.

Richerson, P., & Boyd, R. (2005). *Not by genes alone: How culture transformed human evolution*. University of Chicago Press.

Riede, F., Araujo, A. G., Barton, M. C., Bergsvik, K. A., Groucutt, H. S., Hussain, S. T., de Pablo, J. F. L., Maier, A., Marwick, B., Pyne, L., & Ranhorn, K. (2020). Cultural taxonomies in the Paleolithic—Old questions, novel perspectives. *Evolutionary anthropology, 29*(2), 49.

Rigaud, S., Manen, C., & García-Martínez de Lagrán, I. (2018). Symbols in motion: Flexible cultural boundaries and the fast spread of the Neolithic in the western Mediterranean. *PLoS One, 13*(5), e0196488.

Roussel, M., Soressi, M., & Hublin, J. J. (2016). The Châtelperronian conundrum: Blade and bladelet lithic technologies from Quinçay, France. *Journal of Human Evolution, 95*. https://doi.org/10.1016/j.jhevol.2016.02.003.

Rybin, E P. (2000). K voprocu "rykovodyatsik ickopaemiikh" v industrialniikh komplekcakh rannei porii verknego paleolita gornogo altaya. In *Paleogeografiya kamennogo veka. Korreltisya prirodniik cobotii i arkheologicheskiik kultur paleolita severnoy azii in sopredelniik territorii: Materialii Mejdunarodnoi konferentsiii* (RIO KGPU., pp. 123–126). Krasnoyarsk.

Rybin, E. P. (2014). Tools, beads, and migrations: Specific cultural traits in the Initial Upper Paleolithic of Southern Siberia and Central Asia. *Quaternary International, 347*(1), 39–52. https://doi.org/10.1016/j.quaint.2014.04.031.

Sackett, J. R. (1982). Approaches to style in lithic analysis. *Journal of Anthropological Archaeology, 1*, 59–112.

Sackett, J. R. (1986). Style, Function and artifact variability: A reply to Binford. *American Antiquity, 51*(3), 628–634.

Shea, J. J. (2011). Stone tool analysis and human origins research: Some advice from uncle Screwtape. *Evolutionary Anthropology: Issues, News, and Reviews, 20*(2), 48–53. https://doi.org/10.1002/evan.20290.

Shea, J. J. (2013). Lithic modes A–I: A new framework for describing global-scale variation in stone tool technology illustrated with evidence from the East Mediterranean Levant. *Journal of Archaeological Method and Theory, 20*(1), 151–186. https://doi.org/10.1007/s10816-012-9128-5.

Shea, J. J. (2014). Sink the Mousterian? Named stone tool industries (NASTIES) as obstacles to investigating hominin evolutionary relationships in the Later Middle Paleolithic Levant. *Quaternary International, 350*, 169–179. https://doi.org/10.1016/j.quaint.2014.01.024.

Shea, J. J. (2019). European Upper Palaeolithic cultural taxa: better off without them? *Antiquity, 93*(371), 1359–1361. https://doi.org/10.15184/aqy.2019.117.

Shennan, S. (2001). Demography and cultural innovation: A model and its implications for the emergence of modern human culture. *Cambridge Archaeological Journal, 11*(1), 5–16. https://doi.org/10.1017/s0959774301000014.

Simon, H. A. (1962). The architecture of complexity. *Proceedings of the American philosophical society, 106*(6), 467–482.

Sitlivy, V., Medvedev, G. I., & Lipnina, E. A. (1997). *Les civilizations prehistoriques d'Asie Centrale. 1. Le Paleolithique de la rive occidentale du Lac Baikal*. Bruxelles: Musees Royaux d'Art et d'Histoire - Monographies de Prehistoire generale.

Škrdla, P. (2013). The Bohunician in Moravia and adjoining regions. *Archaeology, Ethnology and Anthropology of Eurasia, 41*(3), 2–13. https://doi.org/10.1016/j.aeae.2014.03.002.

Slavinsky, V. S., Rybin, E. P., Belousova, N. E., Fedorchenko, A. Y., Khatsenovich, A. M., & Anoikin, A. A. (2017). Specific technique of core platform preparation in the initial upper Palaeolithic of South Siberia and Central Asia. *Stratum plus, 17*(1), 221–244 (in Russian).

Slavinsky, V. S., Rybin, E. P., Khatsenovich, A. M., & Belousova, N. E. (2019). Intentional fragmentation of blades in the initial upper Paleolithic industries of the Kara-Bom site (Altai, Russia). *Archaeological Research in Asia, 17*, 50–61. https://doi.org/10.1016/j.ara.2018.05.002.

Slavinsky, V. S., & Tsybankov, A. A. (2020). Towards the question of evolutionary continuity of the Middle and Upper Palaeolithic industries on the territory of the Gorny Altai (a criticism of the autochthonous development hypothesis). *Stratum plus, 2020*(1), 45–104 (in Russian).

Slimak, L. (2006). L'impossible burin moustérien, devenir du burin moustérien, une apparition de la vieille chute de burin et de la petite chose moustérienne. In M. de Araujo Igreja, J. P. Bracco, & F. Le Brun-Ricalens (Eds.), *Burins préhistoriques: formes, fonctionnement, fonctions, Table-ronde Maison méditerranéenne des sciences de lhomme, Aix-en-Provence, 3-5 mars 2003* (pp. 23–33). Luxembourg: Musée National d'histoire et d'art.

Soriano, S., Villa, P., & Wadley, L. (2007). Blade technology and tool forms in the Middle Stone Age of South Africa: The Howiesons Poort and post-Howiesons Poort at Rose Cottage Cave. *Journal of Archaeological Science, 34*(5), 681–703. https://doi.org/10.1016/j.jas.2006.06.017.

Stolarczyk, R. E., & Schmidt, P. (2018). Is early silcrete heat treatment a new behavioural proxy in the Middle Stone Age? *PLoS ONE, 13*(10). https://doi.org/10.1371/journal.pone.0204705.

Stout, D., Semaw, S., Rogers, M. J., & Cauche, D. (2010). Technological variation in the earliest Oldowan from Gona, Afar, Ethiopia. *Journal of human evolution, 58*(6), 474–491 http://www.sciencedirect.com/science/article/pii/s0047-2484(10)00030-8.

Svoboda, J. (2004). Continuities, discontinuities, and interactions in Early Upper Paleolithic technologies. In P. L. Brantingham, S. L. Kuhn, & K. W. Kerry (Eds.), *The Early Upper Paleolithic beyond Western Europe* (pp. 30–49).

Technocomplex. (2020). In Oxford Online Dictionary. Retrieved from https://www.oed.com/view/Entry/198460?redirectedFrom=Technocomplex#eid19090696

Tennie, C., Call, J., & Tomasello, M. (2009). Ratcheting up the ratchet: On the evolution of cumulative culture. *Philosophical Transactions of the Royal Society B: Biological Sciences, 364*(1528), 2405–2415. https://doi.org/10.1098/rstb.2009.0052.

Tennie, C., Premo, L. S., Braun, D. R., & McPherron, S. P. (2017). Early atone tools and cultural transmission: Resetting the null hypothesis. *Current Anthropology.* https://doi.org/10.1086/693846.

Teyssandier, N., & Zilhão, J. (2018). On the entity and antiquity of the Aurignacian at Willendorf (Austria): Implications for modern human emergence in Europe. *Journal of Paleolithic Archaeology, 1*(2), 107–138. https://doi.org/10.1007/s41982-017-0004-4.

Tixier, J. (1963). *Typologie de l'Epipaléolithique du Maghreb*. CRAPE, Mém. n° II, Paris, A.M.G., 209p.

Tixier, J. (1967). Procédés d'analyse et questions de terminologie dans l'étude des ensembles industriels du Paléolithique récent et de l'Épipaléolithique en Afrique du Nord-Ouest. In W. W. Bishop & J. D. Clark (Eds.), *Background to Evolution in Africa* (pp. 771–820). Chicago: Chicago Press.

Tostevin, G. (2003a). Attribute analysis of the lithic technologies of Stránská skála II–III in their regional and inter-regional context. In J. Svoboda & O. Bar-Yosef (Eds.), *Stránská skála. Origins of the Upper Paleolithic in the Brno Basin, Moravia, Czech Republic* (Vol. 500, pp. 77–118). Cambridge: Peabody Museum of Archaeology and Ethnology, Harvard University.

Tostevin, G. B. (2003b). A quest for antecedents: A comparison of the Terminal Middle Palaeolithic and Early Upper Palaeolithic of the Levant. In A. N. Go (Ed.), *More than meets the eye: Studies on Upper Palaeolithic diversity in the Near East* (pp. 54–67). Oxford: Oxbow Books.

Tostevin, G.B. (2007). Social intimacy, artefact visibility, and acculturation models of Neanderthal-modern human interaction. *Rethinking the human revolution: new behavioural and biological perspectives on the origins and dispersal of modern humans* (2007): 341-357

Tostevin, G. B. (2012). *Seeing lithics: a middle-range theory for testing for cultural transmission in the Pleistocene*. American School of Prehistoric Research Monograph Series, Peabody Museum, Harvard University; and Oxbow Books.

Touzé, O. (2018). Aux prémices du Gravettien dans le Nord-Ouest européen. Étude de la production des pointes lithiques à Maisières-Canal (province de Hainaut, Belgique). *Bulletin de la société préhistorique française, 115*(3), 455–495 https://orbi.uliege.be/handle/2268/228459.

Turner, C. G., Ovodov, N. D., & Pavlova, O. V. (2013). *Animal teeth and human tools: A taphonomic odyssey in ice age Siberia* (p. 490). Cambridge University Press.

Vaesen, K., Collard, M., Cosgrove, R., & Roebroeks, W. (2016). Population size does not explain past changes in cultural complexity. *Proceedings of the National Academy of Sciences of the United States of America, 113*(16). https://doi.org/10.1073/pnas.1520288113.

Vanhaeren, M., & D'Errico, F. (2006). Aurignacian ethno-linguistic geography of Europe revealed by personal ornaments. *Journal of Archaeological Science, 33*(8), 1105–1128. https://doi.org/10.1016/j.jas.2005.11.017.

Vardi, J., & Gilead, I. (2011). Side blow-blade flakes from the Ghassulian sickle blade workshop of Beit Eshel: A Chalcolithic solution to a Neolithic riddle. In E. Healey, S. Campbell, & O. Maeda (Eds.), *The state of the stone: Terminologies, continuities and contexts in near eastern lithics* (pp. 343–356). Berlin: Ex Oriente.

Viola, B, Markin, S., Mednikova, M., Dobrovolskaya, M., Le Cabec, A., Shunkov, M., et al. (2012). New Neanderthal remains from Chagyrskaya cave (Altai Mountains, Russian Federation). In *Paleoanthropology annual meeting-abstracts*.

Viola, B, Zwyns, N. (2015). The dispersal of modern humans in Asia: The northern route revisited. In *The 84th annual meeting of the American Association of Physical Anthropologists*.

Wrinn, P. J. (2010). Middle Paleolithic settlement and land use in the Altai mountains, Siberia. In N. J. Conard & A. Delagnes (Eds.), *Settlement dynamics of the Middle Paleolithic and the Middle Stone Age Vol* (pp. 163–194). Tubingen: III.

Yeh, D. J., Fogarty, L., & Kandler, A. (2019). Cultural linkage: The influence of package transmission on cultural dynamics. *Proceedings of the Royal Society B, 286*(1916), 20191951.

Zhang, X., Witt, K. E., Ko, A., Yuan, K., Xu, S., Nielsen, R., & Huerta-Sánchez, E. (2020). The history and evolution of the Denisovan-EPAS1 haplotype in Tibetans. *bioRxiv*.

Zwyns, N., & Lbova, L. V. (2019). The Initial Upper Paleolithic of Kamenka site, Zabaikal region (Siberia): A closer look at the blade technology. *Archaeological Research in Asia, 17*, 24–49. https://doi.org/10.1016/j.ara.2018.02.004.

Zwyns, N., Rybin, E. P., Hublin, J. J., & Derevianko, A. P. (2012). Burin-core technology and laminar reduction sequences in the initial Upper Paleolithic from Kara-Bom (Gorny-Altai, Siberia). *Quaternary International, 259*, 33–47.

Zwyns, N. (2012). *Laminar technology and the onset of the Upper Paleolithic in the Altai, Siberia*. Leiden: Leiden University Press.

Zwyns, N., Paine, C. H., Tsedendorj, B., Talamo, S., Fitzsimmons, K. E., Gantumur, A., et al. (2019). The northern route for human dispersal in Central and Northeast Asia: New evidence from the site of Tolbor-16, Mongolia. *Scientific Reports, 9*(1). https://doi.org/10.1038/s41598-019-47972-1.

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