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2 – Terminology and data recording

In this chapter, the methodology used to record and interpret the data is described. The technological analysis is based on an attribute analysis supporting a reconstruction of the reduction sequences. Attributes recorded on blanks and on cores are selected in order to describe specific technical decisions that can lead to the identification of technical traditions. Regarding the terminology, appropriate references or definitions are provided when they are specific to the presented study. Some methods of classification have been designed for the purpose of this work, and require some additional explanation.

2.1 TAPHONOMIC APPROACH

One of the main concerns of the present study is to obtain reliable technological and chronological data that would allow testing historical-cultural hypotheses. In the framework of a discussion involving so-called ‘transitions’, taphonomic issues are particularly important as they can explain the coexistence of MP and UP features in a given assemblage (*e.g.* Tsanova, 2008). For these reasons, a conservative taphonomic approach is applied to a selection of the material studied and to the interpretation of the results. Assemblages for which a taphonomic assessment was possible have been studied in a quantitative and qualitative fashion. Practically, the methods used were adapted to the assemblages and mainly consist of technological and breakage refits and spatial distribution of artifacts (Tixier, 1978; Cahen *et al.*, 1980; Cziesla, 1990; Bordes, 2000; Morin *et al.*, 2005; Tsanova, 2008). Assemblages for which the integrity could not be assessed are described qualitatively, and the results are interpreted accordingly.

2.2 THE SAMPLING

The lithic analyses presented here focus on laminar elements, trying to reconstruct the production systems and the observable relationships between other systems of blank and tool production. Assemblages have been selected when laminar elements are described as dominant in the original publications. The analysis is performed on a sample of material selected from stratified and recently excavated sites for which artifacts were individually piece-plotted. Thus, samples may show differences with the previously published artifact counts. Retouched and unretouched blades and bladelets are recognized, following definitions from Tixier (1967) and Tixier *et al.* (1980). Are considered as blades and bladelets elongated flakes with parallel/sub-parallel edges for which the length is at least equal to twice their width. Bladelets are arbitrary characterized by a width of less than 12 mm. All identifiable fragments were included. All forms of identifiable blade and bladelet cores were selected for this study. In all cases, the goal was to obtain attribute values from a representative sample depending on the availability of the material at the time of the study. It was not always possible to reach a sample size significant enough to allow a quantitative attribute analysis. Thus, some of the samples are described in more general and qualitative terms. In light of the results obtained by the attribute analyses performed on significant samples, some additional material may be discussed. In this way, artifacts that may first appear more problematic (*e.g.* taphonomy, layer attribution) can sometimes be re-introduced into the discussion. In such situations, they will not be included in the sample but rather considered separately.

2.3 ATTRIBUTE ANALYSIS AND REDUCTION SEQUENCE

To describe the material, a combination of two main approaches is used: attribute analysis and reduction sequence approach.

2.3.1 ATTRIBUTE ANALYSIS

Attribute analysis describes quantitatively and qualitatively independent features observed on the artifacts in order to build a representative dataset with respect to the variability in the assemblage. The onset of this approach can be traced back to the post-second world war period. From 1945 to the late 60's, human sciences showed a general interest in statistical and mathematic methods. Some archeologists followed the movement and tried to apply quantitative methods to artifact analysis (Bordes and Bourgon 1951; Heinzelin 1960; Laplace 1966; Hodson 1966, 1970). At the beginning of the 1960s, the development and spread of computers in the academic world contributed to the success of quantitative analysis (for more details see also Djindjian, 2009) which was also promoted by processual archeology (Binford and Binford, 1966; Clarke, 1973, 1978; Binford, 1979). Based on the idea of numerical taxonomy, this method can be applied following either a typometric approach (*e.g.* Spaulding, 1953; Movius *et al.*, 1968; Hahn, 1977; Djindjian and Vigneron, 1980; Gob *et al.*, 1987; Noiret, 2009) or a technological approach (*e.g.* Dibble, 1995; McPherron, 1999; Tostevin, 2000). Statistical and typometric analyses applied to Paleolithic artifacts are also known in the Eastern European and Central Asian literature since at least the 1940s (*e.g.* Bonch-Osmolowski, 1940; Suleimanov, 1972; Medvedev, 1981; Medvedev *et al.*, 1981; Kaikhunova, 1985). Based mostly on metric measurement, this method significantly improved the objectivity of lithic analyses which previously relied on poorly defined categories.

When following a technological approach, attributes may be recorded on all artifacts from a given archeological level. In doing so, the analyst tries to avoid considering a priori one type of blank as the goal of the production, without rejecting the idea of a distinction between intentional blanks and by-products. As Dibble notes (1995: 112-113), one cannot understand a core reduction by looking only at the cores, as they represent only the final stages of the process. Following the same reasoning, it would be difficult to tackle the issue of blank selection by looking only at the tools. In this situation, one option is to include some of the flakes usually described as 'by-products' or to record attributes on all elements from the assemblage.

However, in the context of a blade-based assemblage, such an approach sometimes leads to a practical dilemma. Considering all artifacts as potentially intentional seem more objective (Dibble, 1995a) and supported by a more robust theoretical background. Depending of the research goals, it can also be misleading. Considering all categories of lithic artifacts equally could underline economic factors that would mask specific features of the technical tradition. As a matter of fact, artifacts are not equally informative regarding the reduction sequence and some can be clearly ubiquitous. For example, in the case of a blade production on a raw material site, it is likely that shaping flakes would be numerous compared to the blades or cores that would be exported. Their frequency could lead the analyst to consider the sample as reflecting a 'flake-based' assemblage but blade cores or blades, although less numerous, would remain esantial for the reduction sequence reconstruction. Moreover, a single artifact can sometimes be considered as 'precocious' (Tostevin, 2003) but it may also be a key for understanding the rest of the assemblage. On the contrary, flakes are often well represented but are ubiquitous elements. In fact, based on blank frequencies, one can expect that no matter the period considered, most of lithic assemblages may come out as 'flake-based'.

Yet, in looking at a limited sample of such an assemblage, the probability of obtaining reliable economic reconstructions is very low. Archeological assemblages are samples, as the spatial extension of a 'site' often remains unknown and as most of the lithic accumulations reflect palimpsests. Whether the poor representation of a given type of artifact is the result of an 'invention' which failed to become an ‘innovation’ (Hovers, 1998; Tostevin, 2003) can rarely be determined only based on intra-assemblage variability.

The described methodology is adapted to a technological analysis of the laminar productions. Given the nature of the archeological record, issues related to technical traditions are addressed instead of testing techno-economic models. This approach allows a certain degree of flexibility in the attribute analysis requirement. For these reasons, it was judged unecessary to include all blanks in the database. Assuming that laminar production will show technological traditions, a targeted attribute analysis is adopted, focusing on laminar elements that support further reconstructions of reduction sequences. Mixed, too small and too large assemblages have been studied only qualitatively. This was done so that a maximum of the existing assemblages could be included in the analysis.

2.3.2 REDUCTION SEQUENCE

The reduction sequence approach is used to propose an analytical reconstruction of the blank production processes. The concept of operational sequence *(chaine operatoire)* was introduced in Western European archeology by the work of Leroi-Gourhan (1943, 1945), himself inspired by Mauss (Mauss, 1967) (see also Schlanger, 1990). Reduction sequence analysis became popular among French Paleolithic archeologist (*e.g.* Geneste, 1985; Pigeot, 1987; Boëda, 1988, 1990, 1994; Boëda *et al.*, 1990; Pelegrin, 1995) but also elsewhere (*e.g.* Schiffer, 1975; Jelinek, 1991; Bar-Yosef and Meignen, 1992; Van Peer, 1992; Marks and Monigal, 1995; for more see also Bar-Yosef and Van Peer, 2009), and it offers an alternative to the classic typological approach. Interestingly, the concept seems to rise by convergence, independently in the English and in the French-speaking world (Sellet, 1993; Shott, 2003). It can be summarized as follow: if one considers that an artifact when uncovered represents the last stage of its uselife, by reconstructing the steps taken from the selection of the raw material through to discard of that artifact, the material constraints encountered and the technical options followed by the knapper can be analyzed (Pelegrin *et al.*, 1988). Due to raw material physical properties, conchoidal fractures are printed in stone artifacts, leaving characteristic traits (Cotterell and Kaminga, 1986; Bertouille, 1989). Traces of percussive events are then recorded through these observable traits. This set of features allows the determination of the point of origin of the percussion, the direction taken by the removal and the chronology of the previous removals (Dauvois, 1976; Boëda, 1984; Pelegrin, 2005). Basically, the reduction sequence approach relies on lithic technology but integrates the notion of a chronology between technological actions. Observations recorded on large series of artifacts may provide short sequences that represent fragments of one or more reduction sequences (Tixier *et al.*, 1980; Pigeot, 1987; Ploux, 1991; Karlin, 1992; Pelegrin, 1995, 2005) deciphered by reconstructing the chronology of removals (schema diacritique) (Dauvois, 1976; Boëda, 1986; Pigeot, 1990) or through refits (Volkman, 1983; Pigeot, 1987; Cziesla, 1990; Davidzon and Goring-Morris, 2003; Skrdla, 2003b). Practical experiments play an important role by proposing reconstructions of the techniques and methods used during the knapping process. According to Tixier (1967), the techniques include all physical factors involved in the flaking as the methods are assimilated to the systematization within a given assemblage of reduction sequences.

The French *chaine operatoire* concept differs from the American ‘behavioral chain’ (Schiffer, 1976) as it includes the notion of intentionality. During the reconstruction of the sequence, the analyst infers the goal of the production from the material he observes. This particular aspect of the concept has led researchers to investigate cognitive issues through technological analysis and is probably the most controversial (Sellet, 1993). The well-known case of Biache St. Vaast (level IIa) shows that Boëda’s technological reading identified two main reduction strategies (Boëda, 1988) but fails to recognize the relationship between the two (Dibble, 1995a). Based on the same material, Dibble’s combination of attribute analysis and reduction sequence analyisis establishes a direct relationship between stages of reduction and the strategy in use. For Boëda, the different strategies represent clear-cut mental templates whereas Dibble insists more on the flexibility of the process. The two also differ in the degree of quantification with Boëda giving less importance to metric attributes.

Although in some cases, experimental by-products, end-products and cores seem highly consistent with archeological data, Dibble notes (1995: 107) that experimental knappers can use different techniques and methods to reach the same goal. Then, without the support of an attribute analysis, the accuracy of the reconstruction becomes a matter of chance, underlining the limits of the approach. Bar-Yosef and Van Peer (2009) provide another convincing example of discrepancies between the reconstructed reduction sequence and the refitted block from Taramsa 1. Among the points they underline, they suggest that the model based on the observation of technological attributes sometimes artificially isolate reduction sequences, which when observed on the refits, coexist on the same block. This situation is expected when one considers fragments of reduction sequences as evidence for strictly independent methods. Long refitted sequences provide another picture, demonstrating combinations and sometimes a hierarchy of methods on the same block. Unfortunately, the nature of the sample and more generally of the site rarely offer the optimal conditions required for refitting long sequences.

Some authors suggest that attribute analysis and reduction sequence approaches show strong and weak points and are more efficient when considered as complementary (Tostevin, 2003; Bar-Yosef and Van Peer, 2009; Torre and Mora, 2009; Stout *et al.*, 2010). When dealing with arbitrary samples, the risk to miss a part of the techno-economic system exists whatever the approach in use. Due to the nature of the sample considered, the present study follows the assumption that the laminar technology is representative (but not exclusive) of the selected assemblages and their technical traditions. A clearly defined set of attributes recorded on blanks, retouched tools and cores is used in order to support the reconstructed reduction sequences. An attempt is made to find a suitable balance between the requirements of the method and the necessity to deal with a representative sample. Ultimately, the goal is not to tackle cognitive issues, but rather to point out the recurring technological choices, which beyond environmental and economic constraints, may testify to a technical and social identity (Leroi-Gourhan, 1964; Pelegrin *et al.*, 1988; Lemonnier, 1992).

2.4 ARTIFACTS GENERAL CLASSIFICATION

Samples are described according to a general classification reference works such as Tixier *et al.* (1980) and Inizan *et al.* (1995) for technology and Brezillon (1968), Demars and Laurent (1992), Debenath and Dibble (1994) and Bordes (Bordes, 1961) for typology. The goal of this classification is to provide an overview of the assemblage prior to more detailed analysis. As here mainly laminar elements are considered, only a few arbitrary classes are used for analytical purposes. Artifacts are classified as blade (length= 2 x width and >12 mm width), bladelet (length= 2 x width and <12 mm width) and microblade (length= 2 x width and <6mm), core and retouched tools. Microblades are, therefore, classified based on their width and do not necessary imply pressure flaking. Occasionally, artifacts on flakes are recorded when they present a specific preparation of the platform or have a particular technological interest related to blade production (*e.g.* core tablet, fronto-lateral flake). Results obtained on the samples are later integrated into the research background and compared with the published material.

2.5 ATTRIBUTE ANALYSIS: BLANK ATTRIBUTES

Assemblages from open-air sites for which laminar elements have been described as dominant in the original publications are selected. Attribute analysis is applied in order to describe the laminar technology. Practical and controlled experiments have provided a set of qualitative and quantitative attributes which are considered useful for the identification of knapping techniques and methods, mainly by observing features on the archeological material (Tixier, 1967; Tixier *et al.*, 1980; Cotterell and Kaminga, 1986, 1987; Whittaker, 1994; Pelegrin, 1995;

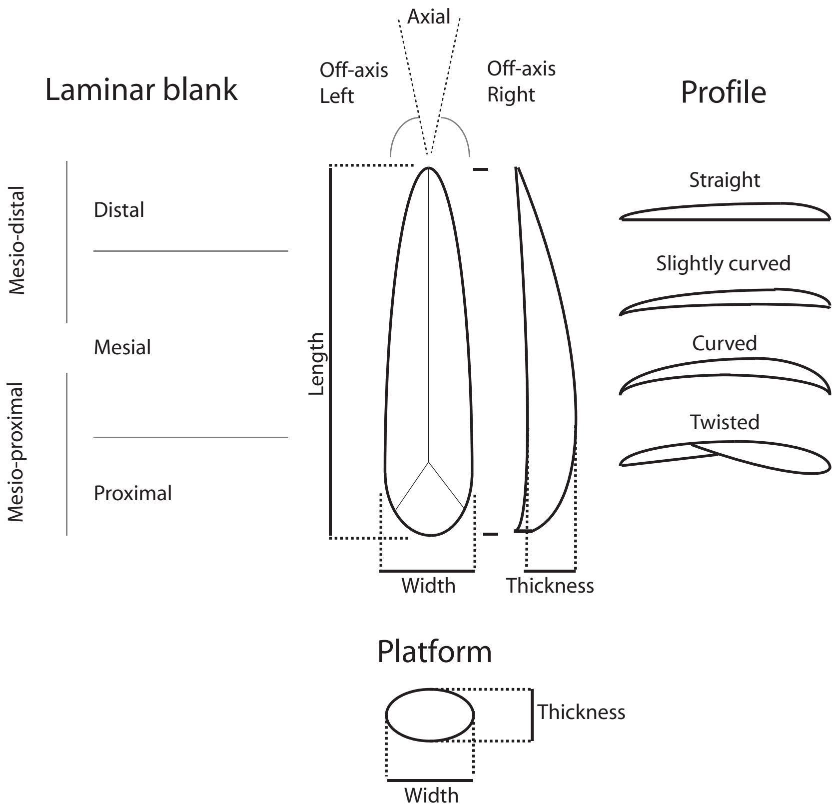

Figure 11: Breakage, size, platform size, orientation and profile attributes

Pelcin, 1997a, 1997b; Odell, 2000, 2001; Andrefsky, 2005; Dibble and Rezek, 2009; Rezek *et al.*, 2011). For the blanks, these attributes are recorded on each individual artifact. The description includes the state of preservation, size, cross-section, profile, platform size and morphology, dorsal scar patterns, orientation, retouch locations (on which face), retouch dorsal and ventral location (along which edges, on which parts), angle of retouch, morphology of retouch, type and additional attributes. In the following section, the attributes recorded are described in detail.

- Breakage: fragmentation of the blanks can occur during knapping activities (Inizan *et al.*, 1995) but can also reflect trampling or other taphonomic processes affecting the assemblage (McBrearty *et al.*, 1998). This attribute is recorded in order to infer the minimum number of individual (MNI) blanks in a given sample (Hiscock, 2002). The results of the attribute analysis can be compared between the MNI sample and the overall sample to detect possible repetition of measurements or dorsal scar pattern descriptions. Blanks are grouped in several categories according to their degree of breakage. Fragments are considered as proximal or distal when only the end of a blank is preserved. Mesio-distal and mesio-proximal fragments have one end preserved and additionally a significant part of the blank itself. Mesial fragment have neither end preserved. Complete elements are unbroken. The MNI corresponds to the sum of proximal, mesio-proximal and complete elements.

- Size: all measures are in millimeters and rounded to one decimal. Measurements are recorded using a Mitutoyo electronic caliper 500-17X-20 (150 mm) using E4 software linked to an MSaccess database (oldstoneage.com). The length, width and the thickness are measured at their maximum.

The length is measured only when the specimen is complete.

- Profile: profiles of laminar elements have been here classified qualitatively according to their general morphology. This description is based on previously published analysis of blade and bladelet assemblage (*e.g.* Brezillon, 1968; Bon, 2002; Bordes and Tixier, 2002; Le Brun-Ricalens and Brou, 2003; Le Brun-Ricalens, 2005; Chiotti, 2005; Teyssandier, 2006). Categories are mainly based on the degree of curvature of the blank and classified as curved, slightly curved or straight. One additional category groups blanks showing a twisted profile, where the torsion affects the proximal end of the blank and extends to at least the mesial part.

- Cross-section: the cross-section is characterized in order to determine if one or more ridges are guiding the removal (Tostevin, 2003). Combined with the dorsal scar patterns it provides insights into the general morphology of the core flaking surface. Sections are observed in the mesial part of the blank and are classified as flat, rectangular, triangular, trapezoidal or polyhedral.

- Platform size and preparation: platforms are described according to their size and to their preparation. Platform width is the distance between the two lateral platform edges. Platform thickness is the maximum platform thickness. Only complete and identifiable platforms have been measured. In addition, platforms have been grouped into formal categories such as plain, facetted, dihedral flat, dihedral convex and punctiform (Inizan *et al.*, 1995). Platforms are considered as highly informative from a technological point of view. Results of controlled experiments have demonstrated the existence of a linear relationship between the platform area (platform width x platform thickness) and the blank surface area (blank Length x Width) (Dibble, 1995b, 1997). According to controlled experiments, thickness of the platform may predict the morphology of blanks. A thick platform combined with an inward striking movement increases the probability of obtaining a overshot blank (Cotterell and Kaminga, 1986, 1987; Pelcin, 1997a). Knapping experiments suggest that in the case of direct percussion on flint, the thickness of the platform is linked to the type of hammer (Bordes, 1947; Pelegrin, 1995). A soft hammer (organic) catches the edge of the platform *(percussion tangentielle)* which is flattened by a thin abrasion prior to striking. The platform of the blank is therefore relatively thin. A lip is often observed when the platform is thicker, testifying to a more inward movement (Roche and Tixier, 1982; Pelegrin, 1995). By contrast, hard hammer percussion requires an inward movement *(percussion rentrante)* inducing a thicker platform. Softstone hammers (*e.g.* limestone, sandstone) seem to represent an intermediate technical solution for which the platform thickness seems to overlap with both hard and soft hammer percussion. A significant smoothing of the external platform edge by intensive abrasion, literally rounding the angle, seems to be required for the use of such hammers in producing blades (Pelegrin, 2000). However, as Pelegrin notes (1995: 67-68), only the combination of several criteria allows a discrimination between hard and soft hammer. The characteristics of hard hammer includes the occurrence of an impact point (hertzian cone), thick bulb (sometimes with ripples) and relatively thick platform (>4 mm). Soft hammer is more likely associated with a smooth and elongated bulb (especially when numerous ripples are visible), absence of a clear impact point on the platform, thin platform (<4 mm) and a thin abrasion of the external edge of the platform (1995: 67-68). More recently, experimental and archeological studies on bifacial tool production using limestone hammers have underlined the difficulty of quantifying such attributes (Roussel, 2009). An identification of the percussion technique is proposed here (when possible) as a hypothesis, based on the size and the morphology of the platform, the occurrence of a lip, and preparation of the external platform ridge. In addition, the presence of a percussion cone and flaking of the bulb are sometimes observed.

- Dorsal scar pattern: The dorsal scar patterns allow for a determination of the point of origin of the percussion, the direction taken by the removal and the chronology of the previous removals (Dauvois, 1976; Boëda, 1986; Pelegrin, 2005). When the dorsal face is cortical, has a crest or a secondary crest *(sous-crête),* the blank is associated with the initial stage of reduction. In the course of reduction, transversal or longitudinal bending may require core management operations. These can be identified by the presence of neo-crests *(néo-crête)* (Pelegrin, 1995). When visible, ripples and radial fissures *(lancettes)* show the direction taken by the previous removals. The chronology of removals *(schéma diacritique)* is based on the presence of radial fissures, which occur along both scars from the last removal, along one scar from the previous ones, or not at all (Inizan *et al.*, 1995). In addition, the last removal sometimes leaves a deeper negative. The superposition of removals can be more or less visible depending on the case, and it is not always possible to reconstruct their chronology. Considered as a whole, the set of dorsal features provides data regarding the reduction system in use, however, they are sometimes misleading. For example, if the blanks are produced by short, alternate, unidirectional sequences (*i.e.* switching to the opposed platform after a couple of removals), they will tend to appear as strictly unidirectional. Bidirectionality will be more likely visible if the sequence is of more than three removals per platform. In other words, as here we do not restrict bidirectionality to a platform switch after *each* removal (alternate platform), the frequency of bidirectional scars observed will under-estimate the number of blanks produced by such a system. As Pelegrin (1995: 122) notes, in the case of direct percussion, bidirectional removals can also testify of a hierarchy between a main platform, from which elongated blanks are removed, and a secondary one. The latter is interpreted as distal preparation for the production of straight blanks. These preparations are identified according to their morphology, to the context of the assemblage (*e.g.* frequent occurrence of similar preparation on the cores), and to the preparation of the platform from which they are removed. Moreover, as several reduction sequences can be in use on the same nodule, features observed on dorsal scar patterns have to be compared with the other recorded attributes.

- Orientation: orientation is described qualitatively in order to determine if the laminar reduction is oriented toward the production of axial, off-axis elements *(déjeté)*, or randomly orientated elements. Orientation is qualitatively recorded from a reconstructed axis drawn from the center of the platform. Blanks are then classified as off-axis on the right side, on the left side, or axial.

- Retouch location (face): retouch is located according its direction (Tixier *et al.*, 1980; Demars and Laurent, 1992) either dorsal (direct), ventral (inverse), both dorsal and ventral (alternate), or randomly distributed (sporadic).

- Dorsal retouch location (edge): when retouch is observed on the dorsal face, it is located according to its position along the edges. The terminology described for the breakage attribute is used, including all possible combinations. Right and left edges are identified with the percussion point observed or inferred (in the case of fragment) at the bottom.

- Ventral retouch locations (edge): when retouch is observed on the ventral face, it is located according to its position along the edges. As for the dorsal face, the terminology described for the breakage attribute is used, including all possible combinations. Right and left edges are identified from the dorsal face.

- Angle of retouch: retouch is described by the angle it takes with the section view of the artifact (Barnes and Kidder, 1936; Brezillon, 1968; Demars and Laurent, 1992). However, definitions vary depending of the authors. Here we use: flat (<30°), thin (30°-60°), semi-steep (60-80°), steep (90°), or possible combinations. Angles are not measured but rather evaluated.

- Morphology of retouch: the morphology follows Brezillon (1968) and is described as marginal, scalariform, notch (only when it bears several notche removals on the top of each others), denticulate, abrasion retouch (when it is linked with abrasive contact).

- Type and additional attributes: the above-listed attributes were recorded for all artifacts studied. However, depending on the context, general observations on the material may provide additional data. Features such as flaking on the bulb, the occurrence of percussion cone and of a macroscopic lip on the ventral face were recorded. When the sample was not significant enough to justify a quantitative data recording, a more general set of decriptive observations was used. Dealing here with partial samples, occurrence of cortex on the blanks is recorded but not quantified. When possible, retouched tools are typed using standard typology (Bordes, 1961; Brezillon, 1968; Demars and Laurent, 1992; Debénath and Dibble, 1994).

Attribute	Attribute value
Breakage	distal
	Mesio-distal
	Mesial
	Mesio-proximal
	Proximal
	Complete
	Undetermined
Size	Length
	Width
	Thickness
Profile	Straight
	Slightly curled
	Curved
	Twisted
	Undetermined
Cross-section	Flat
	Triangular
	Trapezoidal
	U-shaped
	Rectangular
	Polyhedric
	Undetermined
Platform size	Thickness
	Width
Platform preparation	Plain
	Facetted
	Dihedral Convex
	Dihedral flat
	Punctiforme
	Cortical
	Undetermined
Dorsal scar pattern	Unidirectional
	Unidirectional+cortex
	Unidirectional+distal crest
	Unidirectional parallel
	Unidirectional convergent
	Bidirectional
	Crest
	Neo-crest
	Second crest
	Undetermined
Orientation	None
	Right
	Left
Retouch location (face)	None
	Direct
	Inverse
	Alterne
	Sporadic
	Undetermined
Dorsal retouch location (edge)	Proximal
	Proximal right
	Proximal left
	Mesio-proximal
	Mesio-proximal right
	Mesio-proximal left
	Mesial
	Mesial right
	Mesial left
	Mesio-distal
	Mesio-distal left

… continue next column

… continue page 45

	Mesio-distal right
	Distal
	Distal right
	Distal left
	Undetermined
	Combinations
Ventral retouch location (edge)	Proximal
	Proximal right
	Proximal left
	Mesio-proximal
	Mesio-proximal right
	Mesio-proximal left
	Mesial
	Mesial right
	Mesial left
	Mesio-distal
	Mesio-distal left
	Mesio-distal right
	Distal
	Distal right
	Distal left
	Combinations
	Undetermined
Angle of retouch	Flat (<30°)
	Thin (30°-60°)
	Semi-steep (60°-80°)
	Steep (90°)
	Combinations
	Undetermined
Type of retouch	Marginal
	Scalariform
	Notch
	Denticulated
	Abrasion retouch
Type and additional attributes	

Figure 12: Blank attribute list

2.6 ATTRIBUTE ANALYSIS: CORE ATTRIBUTES

As for the blanks, cores are described following a series of technological and morphological attributes (Figure 15). Artifacts are considered as cores only when they display unambiguous signs of preparation or intentional removals.

For the cores, a list of attributes is established that may or may not be completely recorded, depending on the artifact. Core attributes include the type of blank, initial preparation, back, flaking surface, size (nodule), size (flaking surface), size (last removal), profile (last removal), orientation (last removal), striking platform/flaking surface angle (=External Platform Angle), striking platform preparation, external platform ridge preparation, flaking surface maintenance, maintenance removal location, lateral maintenance type, lateral maintenance orientation, reduction pattern, Mode, type and additional attributes. Core attributes can be divided in two main categories. A series of attributes is related to the general morphology of the core (type of blank, initial preparation, etc…). The other series is related to the flaking surface. In case of two flaking surface, both are described equally with all measurements and observations being done twice. When possible, up to two complete last removals per flaking surfaces are described independently.

- Type of blank: the type of blank on which the core is produced. Blocks are identified according to the general morphology of the blank and the occurrence of natural surface or primary cortex. Pebbles are identified by their rounded edges and the occurrence of neo-cortex. Slabs are flat nodules *(plaquette)*. Flakes are identified when the blank shows a length smaller than twice the width, blades show a length larger than twice the width and parallel edges, and laminar flake is an intermediate class with atypical specimens from the flake and blade category and includes elongated flakes. Crested elements are identified following Pelegrin's description (1995). Thick flakes bearing on their edge semi-circular traces of previous blade removals are considered as core tab-

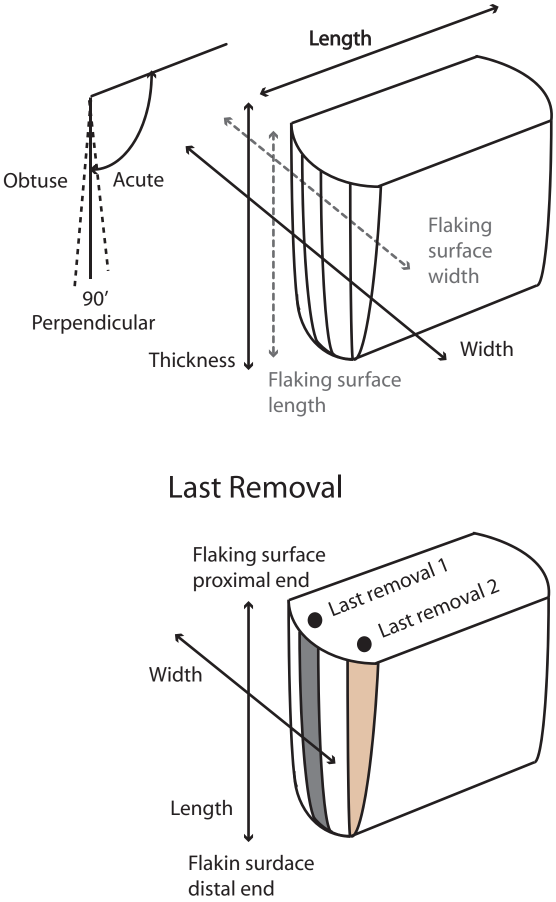

Figure 13: Core measurements

lets. Those negatives have to be relatively wide to avoid confusions with facetted platforms.

- Initial preparation: when visible, the first steps of the reduction are indentified, mainly decortification flaking, primary crests, primary flaking (removal exploiting natural crest or the convenient morphology of the nodule), and removals shaping the nodule in order to obtain a proper longitudinal or transversal convexity or angle to start the reduction process. This type of feature is not always preserved on the core at the point of discard but may be observed more easily on preforms and prepared nodules.

- Back: the back of the core corresponds to the face opposed to the striking surface. The preparation of the back may play a role in the management of the flaking surface convexities (Pigeot, 1987). In bidirectional cores, or cores bearing more than one flaking surface, the back may not be preserved. Natural (natural surface), cortical, prepared (shaped by flaking), crested (Pelegrin, 1995) and ventral (being the ventral face of the blank) are distinguished.

- Flaking surface: flaking is classified according to the scar patterning as unidirectional, bidirectional, two opposed striking platforms, two separated striking platforms (when two flaking surfaces are treated independently) and radial (removals turning around the periphery of the core and oriented toward the center of the flaking surface).

- Size: size is measured in millimeter and rounded at one decimal. Measures are recorded as illustrated in Figure 13.

- Size of the flaking surface: the flaking surface, when complete, is measured independently in mm (see Figure 13). Similar measures are recorded on the second flaking surface, when separated from the first one. In the case of two-opposed striking platforms, the flaking surface is treated as a whole

- Size of the last removal: when a complete last removal is preserved, length and width are measured (see Figure 13).

- Profile of the last removal: if a complete last removal is preserved, profiles are recorded according to the standards used for the blanks (see Figure 13).

- Last removal orientation: in case a complete last removal is preserved, orientation is recorded following the standard applied to the blanks (see Figure 13).

- Striking platform/flaking surface angle: the angle created by these two surfaces is qualitatively characterized. An angle of more than 95° is described as obtuse, between 95° to 85° as perpendicular, and less than 85° as acute. Angles are not measured but evaluated.

- Striking platform preparation: the qualitative values used here are borrowed from previous studies and defined following Inizian *et al.* (1995). Reshaped platforms correspond to striking platforms for which a tablet or partial tablet can be observed.

- External platform ridge preparation: this attribute describes the type of macroscopic modifications occurring at the intersection between the flaking surface and the striking platform. Abrasion is recognized as a light smoothing on the proximal part of the flaking surface (Pelegrin, 1995), flaking corresponds to the removal of small flakes perpendicular to the flaking surface *(facettage)*, and bladelet corresponds to negative(s) of laminar removal(s) observed on the flaking surface itself.

- Flaking surface maintenance: corresponds to a negative which can be clearly associated to a management operation. This interpretation is based on a combination of attributes, such as the marginal location of a removal or a major morphological difference (large and thick flake removed after/during a blade reduction process or an overshot removal) or the production of a neo-crest to reshape the longitudinal or transversal convexities of the flaking surface (cfr. supra). Taking into account the subjectivity of this observation, it is recorded only when a combination of two criteria is observed. In this case, we classify the type of removal based on the morphology of the negatives, as a flake, a blade, a bladelet, a laminar overshot, a crest or a partial crest.

- Maintenance removal location: corresponds to the location of the maintenance removal negative on the flaking surface, on the distal or proximal part. In addition, the removal is qualified as axial, oblique or perpendicular to the flaking surface.

- Lateral maintenance: as for the flaking surface, some lateral removals appear clearly involved in the maintenance of convexities. In this case, we classify the type of removal, based on the morphology of the negatives, as a flake, a blade, a bladelet, or as laminar overshot.

- Lateral maintenance location: removals are placed on the right or the left side (from the striking platform), and as proximal, distal or perpendicular.

- General reduction pattern: the general reduction pattern is an overall observation of the reduction orientation, qualified as parallel, convergent, or a combination of both based on the flaking surface morphology.

- Mode: cores are classified into descriptive modes according their general morphology (Figure 14). Mode A is groups all cores produced on blocks, nodules, slabs or flakes. Modes A1 and A2 are cores showing a flaking surface on their narrow face, A3 and A4 on their broad face, A5 and A6 two independent flaking surfaces, A7 and A8 two-independent and perpendicular flaking surfaces,

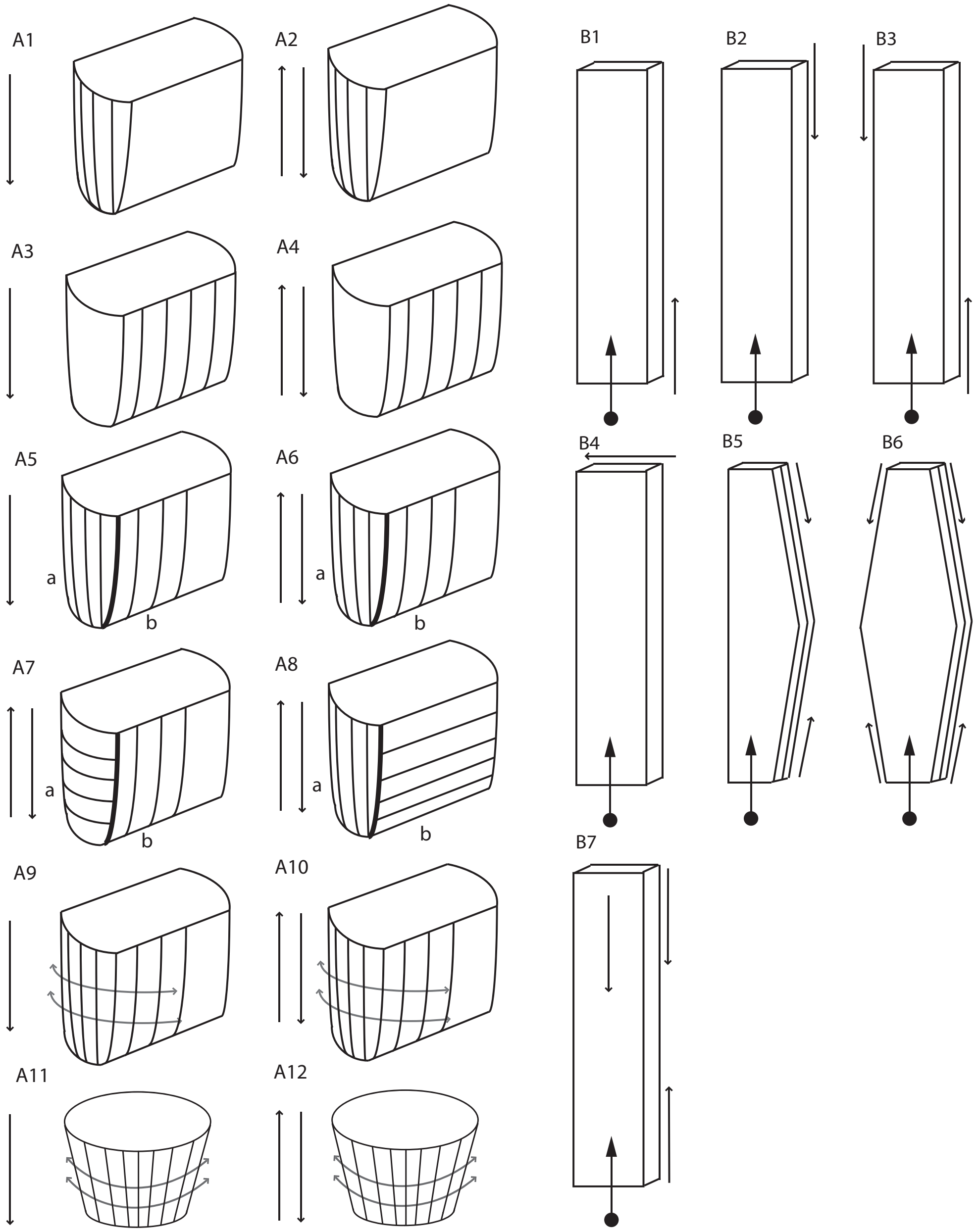

Figure 14: Classification of cores by Modes

A9 and A10 showing a semi-turning *(semi-tournant)* flaking surface (see *e.g.* Pigeot, 1987), and A11 and A12 show flaking surface turning around the core. Mode B groups the cores produced on blades. B1 and B2 show unidirectional removals following the longitudinal axis of the blank along a single edge and struck from a single platform, and B3 shows bi-directional longitudinal removals along two independent edges and struck from two different platforms. B4 show a flaking surface perpendicular to the axis of the core blank. B5 and B6 show respectively a sinle or two bidirectional

Attribute	Attribute value
Type of blank	Block
	Pebble
	Slab
	Flake
	Laminar flake
	Blade
	Crested blade
	Neo-crested blade
	Second-crest
	Tablet
	Other
	Undetermined
Initial preparation	Decortification
	Primary crest
	Primary flaking
	Primary shaping
	None
	Combinations
	Undetermined
Back	Natural
	Cortical
	Prepared
	Crest
	Ventral
	Combinations
	Undetermined
Flaking surface	Unidirectional
	Bidirectional
	Two opposed platforms
	Two separated platforms
	Radial
	Others
Size	Length
	Width
	Thickness
Size flaking surface	Length
	Width
Size last removal	Length
	Width
Profile last removal	Straight
	Slightly curved
	Curved
	Twisted
	Undetermined
Last removal orientation	None
	Right
	Left
	Undetermined
Striking platform/ Flaking surface angle	Acute (<90°)
	Perpendicular (90°)
	Obtuse (>90°)
	Undetermined
Striking platform preparation	Plain
	Facetted
	Reshaped
	Dihedral flat
	Dihedral convex
	Punctiform
	Linear
	Undetermined
External platform ridge preparation	None
	Abrasion
	Flaking
	Bladelet
	Undetermined
Flaking surface maintenance	Flake
	Blade
	Bladelet
	Overshot laminar
	Crest
	Partial crest
	Undetermined
Maintenance removal location	Distal
	Proximal
	Perpendicular (90°)

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	Distal perpendicular
	Distal oblique
	Undetermined
Lateral maintenance type	Flake
	Blade
	Bladelet
	Overshot laminar
	Undetermined
Lateral maintenance orientation	Right perpendicular
	Left perpendicular
	Right striking platform
	Left striking platform
	Right distal
	Left distal
	Combinations
	Undetermined
Reduction pattern	Convergent
	Parallel
	Combinations
	Undetermined
Mode	A1-A12, B1-B7
Type and additional attributes	

Figure 15: Core attribute list

flaking surfaces along narrow edges of the core blank. B7 indicate that the core has flaking surfaces on both narrow and broad faces.

- Type and additional attributes.

2.7 REDUCTION SEQUENCE

In this study, the reduction sequence reconstruction is based on data obtained through the attribute analysis. Basic concepts of reduction sequence (RS) are used, such as a chronological description of the different steps (in continuity or not) of the production of laminar elements (*e.g.* Geneste, 1989). Detailed techno-economic reconstructions and cognitive aspects are not directly addressed here.

For analytical purposes, the lifetime of an artifact can be divided in four main stages, ranging from raw material procurement to discard:

- Raw material procurement: raw material can be collected from a primary outcrop (site of formation of the material) or secondary outcrop (site where the material has been transported from the primary outcrop).

- Technology: this step includes the preparation of the nodule/core, the production of the blank, retouch and resharpening, and all the byproducts of these operations.

- Use: artifact is used either directly where it was produced or on another location. It can be included with other elements in the production of a composite tool. Among others, cores, blanks, byproducts or retouched elements can be used, and then retransformed before being reused.

- Discard: eventually the artifact is discarded, either on the site where it was produced or at another location. After the discard, the artifact can subject to various post-depositional processes.

As shown in Figure 16, these stages are sometimes interconnected and should not be considered as clear-cut chronological steps. This study aims to identify complex dynamics between stages especially when they repeat through time and space.

2.8 REDUCTION SEQUENCE RECONSTRUCTION

The following section summarizes the methodology used to reconstruct the RS. The four levels of analysis presented below run from the detailed description toward to more synthetic reconstructions.

The first level of analysis is devoted to the identification of short sequences through the description of

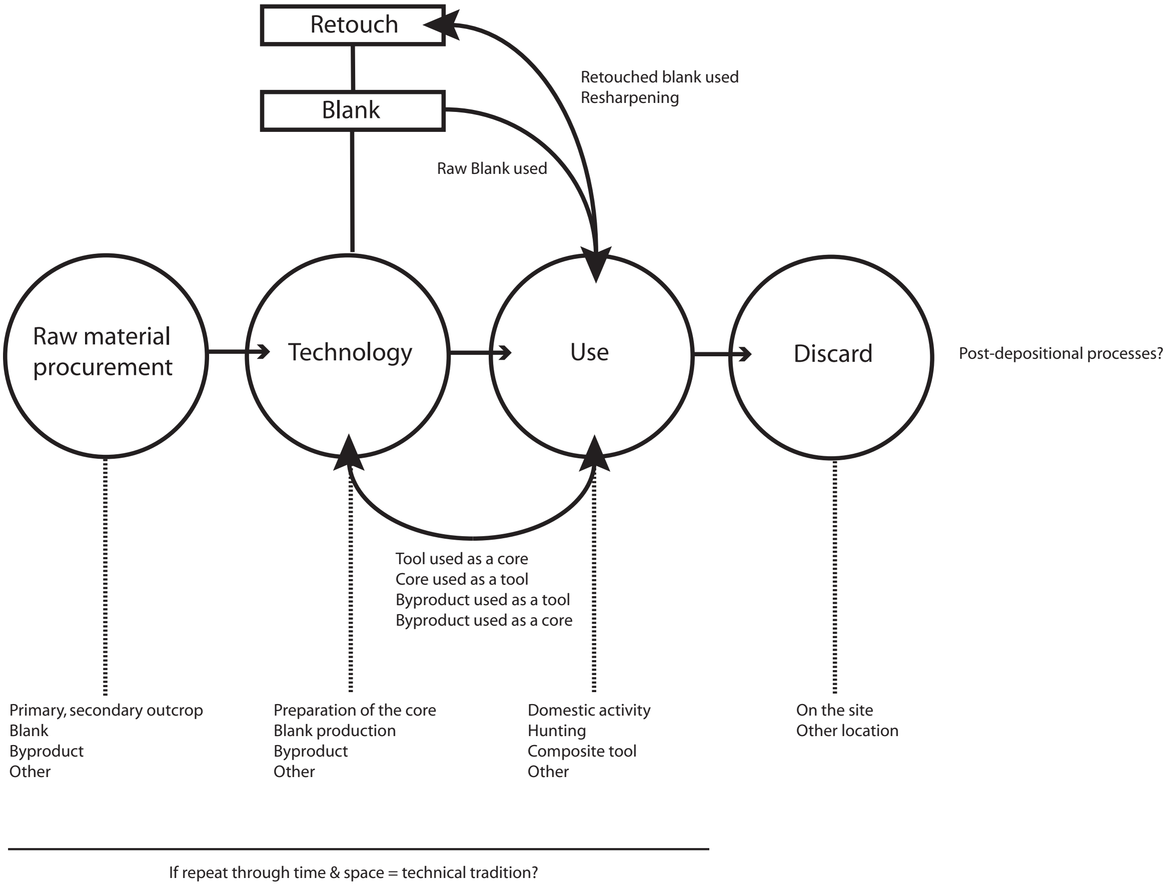

Figure 16: Example of a theoretical reduction sequence (adapted from Grace, 1996)

arifacts technological attributes and through chronological reconstructions of the removals. Cores are described individually to reconstruct the last steps of the reduction prior to discard. Laminar retouched tools and informative blanks are described in order to formulate hypotheses regarding the morphology of the desired endproducts and the goals of the production. Preliminary observations are tested on the material using the body of data obtained through the attribute analysis. The latter supports the reconstruction of the RS and illustrates the technological variability observed within the sample.

The second level of analysis focuses on the frequency of the described RS in the given sample. Based on the data set, patterns, trends and recurring elements that can lead to the recognition of a systematic approach are described. The goal is to reconstruct a RS that can be considered as representative of the sample.

The third level deals with connections between the RS by trying to establish the nature of the links (if there any) between sequences. Analyzis of core blanks and preforms are combined with quantitative data in order to detect reduction effects. Ultimately, laminar reduction systems from different archeological levels and sites are compared with each other in order to identify evidence supporting the existence of one/several technical traditions (Pelegrin *et al.*, 1988).

2.9 REDUCTION SEQUENCE AND TECHNICAL TRADITION

During the reduction sequence, the knapper faces a series of constraints (*e.g.* availability and physical properties of the raw material) in trying to achieve a pre-conceptualized goal. Reaching this goal means making technological choices among a set of technical options within the limits imposed by environmental and economical constraints. It is postulated that the repetition of similar decisions relatively synchronous but separated in space may illustrate an additional social constraint (Lemonnier, 1992). This assumption implies the existence of technical traditions from which a regional and chronological patterning in the archeological record may emerge, as opposed to a situation where, even considering the ecological backgound, totally random decisions would lead to a high level of variaility. The null-hypothesis of this approach assumes that assemblage variability is driven by behavioral ecology (see Isaac, 1986) principles. To reject this assumption, roughly contemporaneous assemblages should show a repetition of major typological and technological similarities in different ecological contexts. Assessing connections between reduction sequences appears usseful in order to keep the production of laminar elements in the context of the overall assemblage. Moreover, repetitions of systems showing similar interconnected sequences in different sites appear meaningful in order to detect technical traditions. A new location is likely to provide more options in terms of raw material, but also new constraints and new needs. It is assumed that the more a complex set of identical knapping sequences repeat through chronologically and geographicaly related assemblages, the less the similarities (and not the variability) can be explained exclusively as a response to ecological setting. The more a complex procedure repeats, the more likely it indicates a shared techno-complex. Following Byrne's approach (2007), the concepts of *intricate complexity* and *near unibiquity* indicates cultural transmission. Intricate complexity corresponds to a level of complexity that is unlikely to be re-invented multiple times. When combined with ubiquity within a population, it likely indicates a cultural transmission process. This approach was adopted by Stout *et al.* (2010) in their reassessment of Oldowan technological variability. If the degree of complexity is considered in the context of Early Upper Paleolithic assemblages, Byrne's theoretical framework can be helpful in order to trace the abstract boundaries between technocomplexes.

Within the same site, complex chains of RS repeating through different archeological levels and covering a relatively long time span could also indicate a technical tradition. It becomes, however, more difficult to reject the null-hypothesis of ecological explanation, as the topographic or environmental location of the site may results in a convergence in the structure of lithic assemblages.