A qualitative guide to recognize bipolar knapping for flint and quartz

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Abstract

This paper presents a list of macroscopic characteristics for recognising pieces resulting from bipolar knapping. I performed specific experiments in fine grained flint and in quartz. I describe the main characteristics of bipolar knapping in a qualitative manner and discuss the usefulness and limitations of this qualitative methodology for these two types of rocks.

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Cet article présente une liste de caractéristiques macroscopiques servant à identifier les pièces lithiques issues de la taille sur enclume. J'ai conduit une série d'expériences sur silex à grain fin et sur quartz. Je décris les principales caractéristiques de la taille sur enclume de manière qualitative et discute de l'utilité et des limitations présentées par cette approche pour ces deux types de matières premières.

Keywords

Bipolar knapping, Flint, Quartz, Splintered piece, pièce esquillée, knapping method

Introduction and objective

Confusion in the bipolar world… (Hayden 1980); that was the name of an article about the distinction between bipolar cores and intermediate pieces in this same journal. This debate was not new in the 1980s; since the beginning of the Prehistoric discipline, splintered pieces (and the recognition of bipolar knapping) have caused much misunderstanding and disagreement, as Hayden pointed out.

Splintered pieces (also called *pièces esquillées* in the French terminology) are a lithic morphotype that was defined in the very beginning of the twentieth century by Bardon and Boussonye (1906). These researchers thought that these pieces were battered flint fragments and that the objective for this type of aggressive percussion was the production of sharp edges. Since then, splintered pieces have been identified not only in Upper Paleolithic contexts of Western Europe (in fact, it would not be out-of-place to suggest that is the most common lithic morphotype in many Upper Palaeolithic contexts), but also in many periods and other parts of the world (see different works in Mourre and Jarry 2011, as an example of this variability).

Multiple interpretations have been offered for this lithic morphotype: that they are fire strikers used to produce fire, or intermediate hammers (or punches), intermediate pieces[1] to work hard material such as wood or bone (as wedges or chisels), or as cores on anvils / bipolar cores (Octobon 1938). These two last hypotheses have reappeared on multiple occasions, but from different perspectives and different methodological approaches (e.g. example, Binford and Quimby 1963; Tixier 1963; Escalon de Fonton 1969; Semenov 1981; Mazière 1984; Chauchat 1985; Le Brun-Ricalens 1989, 2006; Shott 1989, 1999; Goodyear 1993; Gibaja et al. 2007, de la Peña 2011) Therefore, in short, splintered pieces have been linked, by different studies, with two activities: bipolar knapping and the use as an intermediate tool for working hard materials (e.g. bone, wood and antler).

In previous publications I highlighted the macroscopically qualitative characteristics in order to distinguish between bipolar knapping and the use of intermediate pieces as wedges to work hard material (such as wood, antler and bone) with fine grained flint. See in this regard the experimental

[1] Intermediate piece is used in some of the literature to name these types of pieces, probably because of a direct translation from French studies. I have chosen to use this terminology because it includes the use of wedges and chisels and it is not only restricted to wedges. Subsequently in the paper, when I only refer to wedges, I will specify this.

approach in de la Peña 2011; and the application to archaeological contexts in the Iberian Peninsula (de la Peña and Vega Toscano 2013 or Rios et al. 2012), I will summarize here some of these results. The choice of a qualitative macroscopic approach to the study was not arbitrary. The dynamics of the two procedures mentioned, either as intermediate pieces (wedges) or as bipolar cores, presupposes that microwear traces that are created during these processes are destroyed immediately, or very quickly, since the method always involves violent percussion. It is for this reason that it was then decided to opt for an experimental program that puts the emphasis on the knapping characteristics or macroscopic removal scars since they do remain on the bipolar pieces (*contra* Lucas and Hays 2009). This proposal was similar to other experiments that have addressed similar problems with stone tools, such as projectile points (Fischer et al.1984) or *mâchurées pièces* (Fagnart and Plisson 1994), where a macroscopic approach seems the most optimal option.

The aim of this paper is to offer a brief list of macroscopically qualitative characteristics to distinguish pieces resulting from bipolar knapping for flint and quartz and to highlight the main characteristics and differences for these two different rock types (at least for archaeologists). Moreover, at the end, I will highlight the achievements and limitations of this qualitative macroscopic approach.

Bipolar knapping is one of the most common lithic methods used in all periods from the first industries made by other hominin species, to the last lithic craft documented in ethnological work. However, even if the method is not usually complex (although see Pargeter and Duke in this volume), the different contexts produce different end products and, in later times in Prehistory and in ethnographical examples, it is usually related to microlithic strategies. Paradoxically enough, bipolar knapping has not received as much attention as other knapping methods such as bifacial reduction or centripetal methods (such as *Levallois* or discoidal strategies). Moreover, it should be highlighted that in the case of bipolar knapping the distinction is not clear between method and technique (*sensu* Tixier 1967), because it can be both as Australian prehistory and historical lithic assemblages have shown us (White 1968; Flenniken 1981; Flenniken et al. 1985; Flood 1980; Shott 1989; Sillitoe and Hardy 2003; etc.)

My purpose in this paper is to give a short description for recognizing bipolar knapping in quartz and flint, to avoid the typological definition of splintered piece or *pièce esquillée,* as I believe in a technological interpretation of material culture. Many of the experimental qualitative conclusions that I reach here have been published already for similar experiments (Flenniken 1981; Callahan 1987; Knutsson 1988; Lombera-Hermida 2009; Driscoll 2010; etc.) but I argue that each experimental program has its own value and I think that to put the emphasis on the qualitative and graphical outcome will be useful for other archaeologists.

The rocks at hand

Quartz can be divided into two broad categories: crystalline quartz, commonly called macrocrystalline quartz, and the dense and compact forms, which usually are named cryptocrystalline or microcrystalline. The differences between these two broad categories are simply a consequence of the way they form. Macrocrystalline quartz grows by adding molecules to the crystal's surface, whereas cryptocrystalline forms come from colloidal watery solutions of silica. Crystalline quartz is very abundant. Within the crystalline quartz assemblage two main categories can be distinguished: vein quartz (milky) and crystal quartz (also called hyaline) . Cryptocrystalline quartz includes varieties such as chert, flint, opalines and chalcedony (Luedtke 1979). Usually, in archaeological publications when references to quartz are made they refer to crystalline quartz.

As pointed out by Lombera-Hermida (2008: 102) crystalline 'quartz formation processes must be taken into account in order to establish a good petrological classification and characterization', and these characteristics have important implications in the mechanical properties of different quartz varieties. Taking into account crystal habit two large groups can be distinguished: Quartz hyaline (automorph quartz) and vein quartz (xenomorph) (Mourre 1996). Xenomorph presents a greater variability because of different chemical and physical causes during its formation process (Lombera-Hermida 2008: 102). All these conditions generate different types of crystalline quartz and, therefore, different types of mechanical properties. Martínez and Llana (1996) made a morphostructural classification taking into account grain and planes (flaws or crystalline surfaces) of crystalline quartz.

Four morphostructural groups were distinguished: NN: no grain, no plane; NS: No grain, plane; SN; grainy, no plane; SS: grainy, plane. These different varieties will lead to different mechanical properties when knapping. For the experiments I used vein quartz from Johannesburg, Limpopo (South Africa) and Namibia. The Johannesburg and Namibian quartz could be classified as NS (No grain, plane) and the Limpopo quartz as SN (grainy, no plane) of Martínez and Llana (1996)'s morphostructural classification. In the case of the flint, I used *bergeracois* fine grained flint (France).

The experiments

The main objective of this experimentation was to find out the main characteristics of bipolar knapping for flint and quartz; and, on the other hand, to find out if there was a qualitative means to distinguish between freehand and bipolar percussion for quartz.

The "mixed" design of the experiment involved variables known and controlled as well as replication. For the design of the experiment I followed the study by González Urquijo and Ibáñez (1994). The macroscopic characteristics of the scars were described also following González Urquijo and Ibáñez (1994). The main attributes were edge delineation, density of scars, position, distribution, dispersion, extensiveness, and scar size (large, >5mm; medium, 1–5 mm; and small, <1 mm).

First I experimented with bipolar knapping. I knapped *Bergeracois* flint pebbles and southern African vein and glassy quartz, flakes, and other types of blanks with a quartzite hammer and anvil. More than 20 tests were conducted for flint and 10 tests for quartz. I recorded the number of strokes needed in order to obtain a blank and documented the hammered edge and the edge in direct contact with the anvil.

Moreover, bifacial freehand percussion for quartz was compared to the bipolar knapping results presented here from quartz, as I have previously published experiments involving freehand knapping related to bifacial pieces in Sibudu's Howiesons Poort[2] layers (see de la Peña et al. 2013). The methodological protocol of that experimentation was the following. Vein quartz was selected from sources in Namibia, Polokwane and Johannesburg. First, flake blanks were produced using a discoidal reduction sequence. Secondly, blanks were selected based on the average length, breadth and thickness of the Sibudu points, that is, about 4 cm length, 2.5−3 cm breadth and 2 cm thick. I used different knapping techniques (Tixier 1967) with soft mineral hammer (sandstone), hard mineral hammer (quartzite and iron stone), bone hammer (antelope metapodial) and pressure flaking (with the bone retouchers previously published in d'Errico et al. 2012). More than 100 tests were accomplished. However, not all of the products ended up as finished points because on many occasions the preform points broke during knapping, or the selection of the primary blank-flake was not optimal. Also, some tests were carried out simply to compare different knapping techniques. Fifty-five tests were conducted only using hard mineral hammer and soft mineral hammer. In this paper I will put the emphasis on the results of the freehand hard and soft mineral percussion.

I also experimented with intermediate pieces used as wedges of flint, as this activity has traditionally been proposed for splintered pieces. For the experiments with flint wedges I used flakes of various sizes and morphologies to cut lengthwise or to cross-section hard materials such as bone, wood, and antler. As for the bipolar knapping, in this experiment all of the intermediate tools were *Bergeracois* flint flakes, and the hammers were quartzite pebbles. I cut long bones (10 tests) and rib epiphyses (10 tests) from *Bos taurus* on their transverse axis. I made longitudinal cuts to the lateral extremities of the ribs (6 tests). I also cut *Sus scrofa domestica* (7 tests), *Bos taurus* (10 tests), and *Rangifer tarandus* (7 tests) metapodials lengthwise. For the wood I used branches of 3–5 cm in diameter and trunks between 15 and 20 cm in diameter. The branches were *Acacia triacanthos*, *Quercus robur*, *Salix repens*, and *Populus alba*, enabling me to evaluate the effects of wood taxa with different hardnesses.

[2] Sibudu is a South African site located approximately 40 km north of Durban, and about 15 km inland of the Indian Ocean. This site is one of the main references for Southern Africa Middle Stone Age archaeology. Howiesons Poort is a techno-complex of the Middle Stone Age, characterized typologically by backed pieces (Henshilwood 2012). Jacobs et al. (2008) calculated single-grain optically stimulated luminescence ages for the Howiesons Poort at Apollo 11, Klasies River, Melikane, Klein Kliphuis, Rose Cottage Cave and Sibudu and suggested that it spanned not more than about five thousand years, ending at about 62 ka. In 2013 de la Peña , Wadley and Lombard published the first technological description of an assemblage of Howiesons Poort bifacial pieces mainly made on quartz.

I performed both cross-sectional (34 tests) and longitudinal (15 tests) cuts. The trunks were of *Fagus sylvatica*, *Carpinus betulus*, and *Buxus sempervirens*, and they were only cut lengthwise (29 tests). The trunks were submerged in water for one day before I attempted to cut into them. Finally, I cut several pieces of *Rangifer tarandus* antler (23 tests).

Flint bipolar knapping results

The main characteristics documented for flint bipolar cores are:

- The hammered edge and the opposite edge become smooth and rectilinear. If the hammered side is rotated, the core becomes quadrangular or rectangular (Figure 1A).
- Both the striking platform and the side placed on the anvil develop numerous scars. However, normally the majority of scars are on the striking platform.
- The scars are bifacial if the profile of the core is symmetrical, but if the piece is asymmetrical they tend to occur on only one of the sides. If the core profile has one straight and one convex side, the scars will tend to be on the convex side (Figure 2A).
- The core rapidly becomes smaller as a result of knapping. In fact, bipolar knapping can be applied to extremely small cores (as small as 2 or 3 cm) (Figure 2B).
- Although the cores are not prepared in any way, a striking platform is automatically created as a result of the hammering process (Figure 2C).
- The scars resulting from hammering are usually step or hinge terminations (Figure 1 B, C and D).
- The scars on bipolar cores normally have deep ripples (Figure 1F).
- The scars, especially on the striking platform, develop in the following way: at first, the scars are large and usually overlap. The fact that the initial scars are hinged means the subsequent ones are also hinged, but smaller (Figure 1C and Figure 2D). This second bout of hammering tends to produce a row of parallel scars. Eventually, the area immediately next to the edge fissures and becomes blunt (Figure 1D, E and G). This type of scar-production is what is called *écaillé* retouch in European laplacian typology, which indeed is not a retouch.

- It is very common that at the last stage of the bipolar knapping the core split in two or more pieces. This is what Driscoll (2010) termed a chilled-core (Figure 2E).

The main features of blanks resulting from flint bipolar knapping are:

- A wide variety of bipolar blanks is obtained, including flakes, bladelets and chunks. Some of the by-products are what Cotterel and Kamminga (1987: 685) term ‘compression flakes’. Some others develop the characteristics of those flakes on both extremities, some others from only one (like a normal conchoidal flake) (Figure 3 and 4).
- They generally have broken or linear butts and the front part shows the fissures mentioned above (Figure 4 A, B, C, D and E).
- They do not exhibit a distinguishable impact point (Figure 4 A, B, C, D and E).
- The ripples on the bulbar faces are very marked and close to each other (Figure 4E).
- The profile of the bipolar blanks tends to be rectilinear, but this depends on the morphology of the core (Figure 4D).
- A specific feature of recurring knapping is a pronounced hinge bulb (Figure 3A and B).

Flint intermediate pieces used as wedges

In almost all of the operations using flint wedges, the scars on the hammered edges of the intermediate tools are practically identical to those described above for the hammered edges produced by bipolar knapping; in other words, the actions produced what is described as splintered retouch (*écaillé* retouch in European laplacian typology, see above Figure 1C). Because I applied the same type of hammer percussion (quartzite) and the hardness of the worked material (wood, bone, or antler) is similar, the problem of equifinality was resolved. However, on the working edge (the one in direct contact with the materials being worked) I recognized notable macroscopic differences between wedges and products from bipolar knapping. For this reason I now describe in detail the active edges on the wedges used in the different tests, those edges being the most distinctive in order to differentiate wedges from flint bipolar knapping:

Results for antler, long bones and rib epiphyses

I noticed variability in size of scars, irregular distribution of the scars along the edges (Figure 5A, B and C), large fractures (Figure 5D), and the working edge of the wedges acquired the reverse shape of the bone being worked (Figure 5E). The macroscopic characteristics that resulted from cutting long bones are similar to those produced from cutting antler. Such scar patterns could be classified as splintered retouch (*écaillé* retouch). However, neither the variability in scar size or fractures nor the irregular distribution of scars, as found in bipolar knapping, was apparent.

The tests involving cutting long bones and antler were moderately successful, although both required a large expenditure of rock because of the aggressive hammer percussion and the hardness of both bone and antler.

Results for ribs and metapodials

The rest of the tests with bones (ribs and metapodials) generated scars on the working edge, but in lower density and with smaller scars (usually medium or small in our classification) (Figure 6A, B and C). Some tests produced no scars at all. In other words, these actions did not produce what typologically is recognized as splintered retouch (*écaillé* retouch).

Results for branches

For woodworking, the cross-sectional tests on small branches produced a great number of bending fractures (following Cotterel and Kamminga 1987: 683). In addition, the working edge developed an irregular delineation and small scars formed along a restricted extension of the inner part of the piece (Figure 7 B4). Again, no splintered retouch (*écaillé* retouch) was noticed. The longitudinal splitting of branches also produced an abundance of fractures (Figure 7 B2), although they were small and restricted to the edge of the wedges. Furthermore, unlike the previous test with branches, the wedges in these tests continued to work well after the fractures appeared because the sides of the flakes conducted the main work in splitting the branches. Again, none of these tests with branches produced what is typologically recognized as *écaillé* retouch.

Results for trunks

The experiment using wedges on *Buxus sempervirens* trunks was unsuccessful. Unlike results from previous experiments (Gibaja et al. 2007; Le Brun- Ricalens 1989), the wood was hardly affected. Tests with other types of wood were also largely ineffective—just one *Carpinus betulus* trunk could be split in two after having been submerged in water for several days. The wedge that split it did not exhibit macroscopic scars on the working edge (Figure 8D). Again it appears as if the sides of the wedge were the working areas. Moreover, a large number of wedges used for experiments on tree trunks exhibited bending fractures on the working edges and similar macroscopic characteristics described for wedges used on smaller branches (cf. Figure 8 B2 and Figure 7 B4).

Summary of work performed by wedges

In summary, one of the conclusions that can be reached after the experiments was that there are significant differences, at a macroscopic level, between the pieces that result from bipolar knapping and wedges that have been used as intermediate tools (de la Peña 2011). More importantly, the use of wedges does not usually generate splintered retouch or *écaillé* retouch (Figure 1D to see an example) on the working edges (Figure 9). This is the principal macroscopic method of distinguishing between products of bipolar knapping and the use of wedges. In the two cases where wedges exhibited splintered retouch on the active edge (in the antler and long bone tests), other characteristics allow us to differentiate the use of wedges and products of bipolar knapping: variability in size of scars, irregular distribution of the scars along the edges, the presence of large fractures, and the acquisition of the negative shape of the bone being worked. In general, the hammered and working edges of wedges have asymmetrical morphologies (de la Peña 2011). In contrast, bipolar knapping always produces symmetrical scars on opposing edges. The edges will develop similar macroscopic characteristics because they are both in contact with the same type of material (rock) (Figure 9).

Quartz freehand knapping

The experimentation using a hard mineral (quartzite) and soft mineral (sandstone) hammer and freehand percussion produced in the bifacial pieces:

- Very pronounced contrabulbs (Figure 10A to H).

- Fissures on the edge knapped (Figure 10C).
- Hinge and step terminations in the scars (Figure 10A, B, C, E, F, G and H).
- Rectangular-shaped scars as the most frequent shapes (Figure 10F and G).
- Irregularity and heterometry between the different scars.
- Hinge and step scars in cascade (Figure 10 A, E and D).

The by-products produced have some of the typical dorsal faces of bifacial reduction, but with a high proportion of step and hinge terminations. Conchoidal flakes and compression flakes (Cotterel and Kamminga 1987) and chunks are produced with different frequencies.

All these attributes partially coincide with those obtained by Callahan (1987) Lombera-Hermida (2009:8) and Knutsson (1988), who have highlighted similar characteristics for hard mineral percussion with freehand percussion of quartz, such as:

- Radial and transverse fissures.
- Step terminations.
- Striking platforms fissures.
- Splintering.
- Scales.
- Edge battering (or bluntness).

However, I believe that radial and transverse fissures, as well as scales are common to any kind of knapping with quartz.

It must be highlighted that the characteristics pointed out were particularly marked for the Namibian quartz (NS-No grain, plane). Meanwhile the Limpopo quartz (SN-grainy, no plane) showed a higher tendency to produce normal conchoidal negatives. This difference maybe could be better tackled through quantitative analysis.

Quartz bipolar knapping results

During experiments with quartz bipolar knapping (Figure 11) I noticed some of the characteristics already highlighted for bipolar knapping on flint, such as:

- The hammered edge and the opposite edge become smooth and rectilinear. If the hammered side is rotated, the core becomes quadrangular or rectangular.
- The core rapidly becomes smaller as a result of knapping. In fact, bipolar knapping can be applied to extremely small cores (as small as 2 or 3 cm).
- Although the cores are not prepared in any way, a striking platform is automatically created as a result of the hammering process.
- The residual core shapes in quartz bipolar knapping are quite like the ones described for flint, with a predominance of rectangular and quadrangular shapes. Moreover, chilled-cores (Driscoll 2010) are also common.

In addition, some of the qualitative characteristics highlighted for freehand knapping with quartz (see above) appeared frequently, such as: bluntness of the hammered edge (Figure 11E).

On the contrary, bipolar knapping percussion produced other characteristics observed during freehand knapping with quartz, but in lower frequencies, such as:

- Hinge and step terminations in cores and bipolar blanks.
- The predominance of rectangular-shaped scars.
- Irregularity and heterometry.
- Hinge and step scars in cascade.

The main features of blanks resulting from quartz bipolar knapping are described below:

- A wide variety of bipolar blanks was obtained, including flakes, bladelets and chunks. Most of the by-products are what Cotterel and Kamminga (1987) term compression flakes (Figure 12).
- They generally have broken or linear butts and the dorsal surface shows the fissures mentioned above (Figure 12 details on the right).

- They do exhibit a marked blunted whitish edge. This was particularly high in the Namibian quartz (NS-No grain, plane).
- The profile of the bipolar blanks tends to be rectilinear.
- An extremely low rate of conchoidal flakes is produced. However, these were more frequent in the Limpopo quartz (SN-grainy, no plane).
- As a general remark bipolar knapping produces low frequencies of by-products with hinge and step terminations.
- As pointed out by other researchers already (Hiscock 1996) bipolar knapping on quartz enables the continuation of knapping small quartz chunks and pebbles that would be impossible to continue reducing by freehand knapping. This could be one of the main factors to explain why this type of knapping has been commonly selected in prehistory and historic times.

Discussion

From a qualitative and macroscopic point of view bipolar knapping in flint is easily to recognise. Moreover, the by-products are usually compression flakes that are also quite distinguishable. The macroscopic qualitative list provided and the combination of cores and by-products in an archaeological assemblage should be enough to recognize this type of knapping on flint (and similar cryptocrystalline material, such as opaline).

As highlighted before, I also think that this type of bipolar knapping with flint is *clearly* distinguishable from the use of intermediate pieces to work hard materials (as wedges or chisels) (cf. with de la Peña 2011; de la Peña and Vega Toscano 2013). In general, the hammered and working edges of wedges have asymmetrical morphologies (de la Peña 2011). In contrast, bipolar knapping always produces symmetrical scars on opposing edges. The edges will develop similar macroscopic characteristics because they are both in contact with the same type of material (rock) (see above the conclusions for the use of wedges with flint and Figure 9).

It is striking that the scar characteristics obtained by freehand percussion on quartz are similar to the ones produced on bipolar knapping on flint, but when applying bipolar knapping on quartz the characteristics are different for bipolar knapping on flint (cf. Figure 1 and 10). One would have expected that the characteristics produced by the two bipolar methods would be similar, even if different rock types were involved.

However, the distinction between freehand and bipolar knapping with quartz is not clear from a qualitative point of view (see in this regard Díez-Martín et al. 2009; Sánchez Yustos et al. 2012; Eren et al. 2013). It has been proposed that this distinction is clearer from the cores than from the by-products (Jeske and Lurie 1993), and my experimentation agrees with that conclusion. The quartz bipolar cores have a remarkably conspicuous morphology that unequivocally identifies this type of knapping in a quartz assemblage (as highlighted in other archaeological analyses already, see de la Peña and Wadley 2014). The residual cores have, in general, very similar morphologies to the ones in flint and cryptocrystaline material. Following this reasoning, for the distinction of the two different types of knapping (freehand and bipolar) on quartz debitage I think it would be appropriate to use a quantitative approach. Such methods could measure the degree of bluntness of platforms or the rate of formation of hinge and step terminations (see above the list of characteristics that appear less frequently for quartz bipolar knapping). Controlling these parameters in an experimental program would reveal significant statistical differences between freehand and bipolar techniques. However, for this purpose it should also be taken into consideration that the variety of quartz can have a huge impact on the results. In fact, although quartz specimens from different sources are apparently similar, when studying archaeological materials, it similar varieties of quartz should be used for experiments to explain the archaeological lithics. In this regard, morphostructural classifications, such as the one of Martínez and Llana (1996), can be extremely important to tackle this problem, because these characteristics, which are closely related to the specific mechanics of these rocks, can have a high impact in the qualitative and quantitative results of different assemblages (archaeological or experimental). Following this line of reasoning, the qualitative characteristics highlighted for the crystalline quartz presented in this paper are valid only for NS (No grain, plane) and SN (grainy, no plane) quartz pieces of Martínez and Llana's (1996) morphostructural classification; and, as pointed out above, these two types of xenomorphic quartz showed slightly different qualitative results which could perhaps be defined better through a quantitative approach.

Figures

Figure 1. Macroscopic characteristics of experimental cores resulting from bipolar knapping in *bergeracois* flint. A: Rectilinear morphologies of bipolar cores. B: Bifacial scars as a result of the symmetrical profile of the core. C: Overlap of the removals. D: Detail of the fissure of the edge. E: Bluntness of the edge. F: Pronounced hammer waves on an experimental bipolar core. G: Step and hinge scars on a core. All lithic elements shown here come from a replication experiment. From de la Peña and Vega Toscano, 2013.

Figure 2. Some characteristics of flint bipolar knapping. A: (Above) Knapping process with symmetrical core. (Below) Knapping process with asymmetrical core B: Progressive reduction in core size. C: Involuntary production of striking platform. D: Overlapping of scars. E. The core split in two or more pieces. Modified from de la Peña (2011).

Figure 3. Bipolar cores with its bipolar blanks. Examples A and B show a hinge bulb in the core and the bipolar blank. All lithic elements shown here come from a replication experiment.

Figure 4. Macroscopic characteristics of bipolar blanks in flint. Note the broken and/or linear butts and that they do not exhibit a distinguishable impact point. In the F example it has been attached also the core (above). All lithic elements shown here come from a replication experiment.

Figure 5. Macroscopic characteristics of intermediate pieces or wedges used to cut long bones. The arrows are marking the hammered edge and the dashed line the 'active' edge, the one in direct contact with the bone. Note the linear nature of the hammered edge (regularized), contrasting with the active edge (irregular delineation) and the heterometry of this one (E and D). The two top examples (A and B) are completed pieces, down (C, D and E) I show details of active edges. All lithic elements shown here come from a replication experiment. From de la Peña (2011).

Figure 6. Macroscopic characteristics of intermediate pieces or wedges used to open metapods by bipartition. Note the limited development of the scars in the active edge chipped (A1 and C1) and even in the hammered edge (B1). All lithic elements shown here come from a replication experiment. From de la Peña (2011).

Figure 7. Experimental intermediate parts used for cutting branches from different species. Note the numerous fractures (B2), the limited development of the scars on the active edge (A1, B2, B4 and C2), contrasting with the hammered edge (B1, B3 and C1) where blunting and fissuring is abundant, typical from rock mineral percussion (B1 and C1). From de la Peña (2011). All lithic elements shown here come from a replication experiment.

Figure 8. Experimental intermediate pieces or wedges to open trunks. Specimen A was used with boxwood, note the blunting of hammered edge (A1) and the irregular in the active edge (A2). Pieces B and C were used with other woody species. The hammered edge develops numerous extractions and bluntness (B1) and the active edge fractures (B2), small scars(C1) and may even remain macroscopically intact (D1), since the work was actually performed the flanks of the wedge. From de la Peña (2011). All lithic elements shown here come from a replication experiment.

Figure 9. Above bipolar core in flint. Note that the splinter or *écaille* pseudo retouch develops in both edges (the one hammered and the one above the anvil). Furthermore, note that the scars developed in both edges are quite alike in shape and extension. Below wedge used to split a *Bos taurus* rib. The

asymmetry in morphology between the hammered edge (with *écaille* retouch) and the working edge (with some widely spaced scars and fractures) is visible.

Figure 10. Macroscopic scar characteristics of experimental quartz points knapped with **freehand** hard (quartzite) and soft (sandstone) mineral hammers. Note the pronounced contrabulbs in all the examples (A to H), the heterometry between scars, the fissures of the edges (C), the rectangularly-shaped scars which are the most frequent shapes (F and G), and the step terminations of the scars in 'cascade' (A, E, D). All lithic elements shown here come from a replication experiment. Modified from de la Peña et al. (2013).

Figure 11. Examples of quartz bipolar cores. Note the rectilinear morphologies in all of the examples. In example E I am showing the white bluntness of the edge. All lithic elements shown here come from a replication experiment.

Figure 12. Examples of quartz bipolar-blanks. On the right of the blanks I show magnification of the linear platforms. All lithic elements shown here come from a replication experiment.

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References

Bardon, L., Bouyssonie, J. and A. Bouyssonie

1906 Outils écaillés par percussion. *Revue de l'ecole d'Anthropologie* 16: 170-175.

Binford, Lewis R. and George I. Quimby

1963 Indian sites and chipped stone materials in the northern Lake Michigan area. *Fieldiana Anthropology* 36:277–307.

Callahan, Errett

1987 *An evaluation of the lithic technology in middle Sweden during the Mesolithic and Neolithic*. Societas Archaeologica Upsaliensis Vol. 8,,Uppsala.

Chauchat, C., Normand, C., Raynal, J.-P. and S. Santamaría

1985 Le retour de la pièce esquillée! . *Bulletin de la Société Préhistorique Française* 82: 35-41.

Cotterel, Brian and Johan Kamminga

1987 The formation of flakes. *American Antiquity* 52(4): 675-708

de la Peña, Paloma

2011 Sobre la identificación macroscópica de las piezas astilladas: Propuesta experimental. *Trabajos de Prehistoria* 68:79–98.

de la Peña, Paloma and L.Gerardo Vega Toscano

2013 Bipolar Knapping in Gravettian ocupations of El Palomar rock shelter (Yeste, South Eastern Spain). *Journal of Anthropological Research* 69: 33-64.

de la Peña, Paloma and Lyn Wadley

2014 Quartz Knapping Strategies in the Howiesons Poort at Sibudu (KwaZulu-Natal, South Africa). *PLoS ONE* 9(7): e101534. doi:10.1371/journal.pone.0101534

d'Errico, Francesco, Backwell, Lucinda and Lyn Wadley

2012 Identifying regional variability in Middle Stone Age bone technology: the case of Sibudu Cave. *Journal of Archaeological Science* 39: 2479−2495.

Díez-Martín, Fernando, Sánchez, Policarpo, Domínguez-Rodrigo, Manuel and Rebeca Barba

2009 Were olduvai Hominins making butchering tools or battering tools? Analysis of a recently excavated lithic assemblage from BK (Bed II, Olduvai Gorge, Tanzania). *Journal of Anthropological Archaeology* 28: 274-289.

Driscoll, Killian

2010 *Understanding quartz technology in early prehistoric Ireland*. Ph.D. dissertation, University College Dublin, Dublin.

Escalon de Fonton, M.

1969 La pièce esquillée: Essai d'interpretation. *Bulletin de la Société Préhistorique Française* 66:76.

Fagnart, Jean-Pierre, and H. Plisson

1994 Function des pièces mâchurées du Paléolithique Final du Bassin de la Somme: Caractères tracéologiques et données contextuelle. *Chronostratigraphie et environnement des occupations humaines du Tardiglaciare et du début de l'Holocène en Europe du Nord-Ouest. 119 Congrès National de Société Historique et Scientifique*, :95–106. Paris

Flenniken, John Jeffrey

1981 *Replicative systems analysis: A model applied to the vein quartz artifacts from the Hoko River Site.* Washington State University Laboratory of Anthropology Reports of Investigations Vol. 59, Pullman.

Flenniken, John Jeffrey and J. Peter White

1985 Australian flaked stone tools: a technological perspective. *Records of the Australian Museum* 36 (3): 131–151.

Flood, Josephine

1980 *The moth hunters: Aboriginal prehistory of the* Australian Alps. Australian Institute of Aboriginal Studies, Camberra.

Fischer, A., Vemming Hansen, P. and P. Rasmussen

1984 Macro and micro wear traces on lithic projectile points: Experimental results and prehistoric examples. *Journal of Danish Archaeology* 3:19–46.

Gibaja, Juan F., Antoni Palomo, Bicho, Nuno F. and Xavier Terradas

2007 Tecnología y función de los ‘útiles astillados’: Programa experimental para contextos prehistóricos de la Península Ibérica. *Arqueología experimental en la Península Ibérica: Investigación, didáctica y patrimonio,*:157–64. Santander.

González Urquijo, Jesus Emilio and Juan Jose Ibáñez

1994 *Metodología de análisis funcional de instrumentos tallados en sílex*. Universidad de Deusto, Bilbao.

Goodyear, Albert C.

1993 Tool kit entropy and bipolar reduction: A study of interassemblage lithic variability among Paleo-Indian sites in the northeastern United States. *North American Archaeologist* 14:1–23.

Hayden, Brian

1980 Confusion in the bipolar world: bashed pebbles and splintered pieces. *Lithic Technology* 9 (1): 2-7.

Henshilwood, Christopher S.

2012. Late Pleistocene techno-traditions in southern Africa: a review of the still Bay and Howiesons Poort, c. 75e59 ka. *Journal of World Prehistory*, 25: 205-237

Hiscock, Peter

1996 Mobility and technology in the Kakadu coastal wetlands. *Indo-Pacific Prehistory Association Bulletin* 15: 151-157.

Jacobs, Zenobia; Roberts, Richard G.; Galbraith, Rex F.; Deacon, Hilary J.;Grun, Rainer; Mackay, Alexander; Mitchell, Peter; Vogelsang, Ralf and Lyn Wadley.

2008. Ages for the Middle Stone Age of Southern Africa: implications for human behavior and dispersal. *Science* 322 (5902): 733-735.

Jeske, Robert J. and Rochelle Lurie

1993 The Archaeological Visibility of Bipolar Technology: An Example from the Koster Site. *Midcontinental Journal of Archaeology* 18:131–160.

Knutsson, Kjel

1988 *Patterns of tools use: scanning electron microscopy of experimental quartz tools*. Societas Archaeologica Upsaliensis Vol. 10, Uppsala.Le Brun-Ricalens, Foni

1989 Contribution à l'étude des pièces esquillées: La présence de percuteurs à 'cupules.' *Bulletin de la Société Préhistorique Française* 86:196–200.

Le Brun-Ricalens, Foni

2006 Les pièces esquillées: État des connaissances après un siècle de reconnaissance. *Paleo* 18:95–114.

Lombera-Hermida, Arturo

2008 Quartz morphostructural groups and their mechanical implications. *Annali dell'Università degli Studi di Ferrara*: 101-104

2009 The scar identification of lithic quartz industries. *Non-Flint Raw Material Use in Prehistory. Old Prejudices and New DirectionProceedings of the XV World Congress of the U.I.S.P.P*, edited by F. Sternke, L.J. Costa and L. Eigeland. pp. 5−11, BAR International Series 1939, Oxford..

Lucas, Géraldine and Maureen Hays

2004 Les pièces esquillées du site paléolithique du Flageolet I (Dordogne): Outils ou nucléus?” in *XXV Congrès Préhistorique de France*: *Approches fonctionnelles en préhistoire, Nanterre, 24–25 Novembre 2000,* S pp. 107– 20, ociété Préhistorique Française, Paris. .

Luedtke, Barbara E.

1979 The Identification of Sources of Chert Artifacts., *American Antiquity* 44(4) : 744-757.

Martínez Cortizas, A. and C. Llana Rodríguez

1996 Morphostructural variables and the analysis of their effect on quartz blank charecteristics. In: *Non-Flint Stone Tools and the Palaeolithic Occupation of the Iberian Peninsula*, edited by N. Moloney, L. Raposo and M. Santonja. Pp. 49-53. Tempus Reparatum, 649 Oxford.

Mazière, Guy

1984 La pièce esquillée, outil ou déchet? *Bulletin de la Société Préhistorique Française* 81 (6): 182-187.

Mourre, Vincen and Marc Jarry (dirs.)

2011 *Entre le marteau et l'enclume: La percussion directe au percuteur dur et la diversité de ses modalités d'application. Actes de la table ronde organisée à Toulouse du 15 au 17 mars 2004*. La Société des Amis du Musée National de Préhistoire et de la Recherche Archéologique avec le concours de l'Université de Toulouse le Mirail. PALEO, Toulouse

Octobon, Commandant

1938 Contribution à l'étude des outillages. Ciseaux et pièces esquillées. *Bulletin de la Société Préhistorique Française* XXV (101):409–12.

Rios, Joseba, de la Peña, Paloma and Aixa San Emeterio

2012 Las industrias líticas y óseas de la Cueva de Aitzbirate III (sector entrada). In : *La Cueva de Aitzbitarte III (Rentería, Guipúzcoa) Sector Entrada*, edited by JesusAltuna, Koro Mariezkurrena and JosebaRios, pp:79-345 EKAB. San Sebastián.

Sánchez Yustos, Policarpio, Díez-Martín, Fernando, Domínguez-Rodrigo, Manuel and Antonio Tarriño Vinagre

2012 Discriminación experimental de los rasgos técnicos en la talla bipolar y a mano alzada en lascas a través de los cuarzos de Naibor Soit (Garganta de Olduvai, Tanzania). *Munibe* 63: 5-26.

Semenov, Sergei A.

1964. *Prehistoric lithic technology: An experimental study of the oldest tools and artefacts from traces of manufacture and wear.* Cory, Adams and Mackay, London..

Shott, Michael J.

1989 Bipolar industries: Ethnographic evidence and archaeological implications. *North American Archaeologist* 10:1–24.

Shott, Michael. J.

1999 On bipolar reduction and splintered pieces. *North American Archaeologist* 20:217–38.

Sillitoe, Paul., and Karen Hardy

2003. Living lithics: Ethnoarchaeology in Highland Papua New Guinea. Antiquity 77:555–66.

Tixier, Jacques

1963 *Typologie de l'Epipaléolithique du Maghreb.* Arts et Métiers Graphiques, Paris.

Tixier, Jacques

1967 Procédés d'analyse et questions de terminologie dand l'etude des ensembles industriels du Paléolithique recent et de l'Epipaléolithique en Afrique du Nord-Ouest. In: *Background to Evolution* *in Africa*, edited by W.W. Bishop and J. D. Clark, pp. 771-820.The University Chicago Press, Chicago and London..

White, J. Peter

1968 Fabricators, outils écaillés or scalar cores? *Mankind* 6:658–66.