Early Holocene blade technology in southern Brazil

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A B S T R A C T

This article presents the results of the technological analysis of assemblages from the sites of Alto Alegre 3, Linha Policial 1 and Linha Policial 3 in the states of Santa Catarina and Rio Grande do Sul (Brazil), dated to the Early Holocene. Alongside other reduction sequences, these sites also present sequences for exclusive blade production, described for the first time for Brazilian prehistory. Despite the lack of cores, analysis of the blades has established that: (1) blade production took place using a single method, with centripetal core initialization and unidirectional production; (2) knapping techniques by direct hard and soft percussion were both used to produce blades; and (3) the blades obtained were destined for different functions, the active part mainly lateral and sometimes used without retouch. This study presents an example of obvious technological convergence, since blade production is known in other prehistoric contexts throughout the world without historical links with that observed at the three sites analyzed here. It also shows the necessity of developing detailed technological analyses to understand the settling of South America in all its complexity.

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Introduction

Blade production, an iconic lithic production mode in prehistory, is generally associated with the later periods in European and Near Eastern prehistory. Here we present an industry with blade production found in southern Brazil in the states of Santa Catarina and Rio Grande do Sul, dated to the Early Holocene. This type of production, rarely described for American prehistory, has until now been entirely unknown in Brazilian contexts.

Blade production

Blade production consists in the systematic and exclusive removal of long and narrow blanks. It is based on a specific volumetric structure of the core, including longitudinal convexities (carène) and lateral or transversal convexities (cintre) of the flaking surface that enable control of the elongation of blanks and their sequential removal. However, variability exists in the concepts, methods and knapping techniques employed (Inizan et al., 1999 p. 71–80, Tixier, 1984).

Often associated with the most recent periods in prehistory, blade production actually first appears during the Middle Pleistocene in different regions throughout the world. In Western Asia, it is known in contexts older than 150,000 years, where it is part of different industries, such as the Amudian and the Hummalian (Barkai et al., 2009; Garrod and Bate, 1937; Hours, 1982; Meignen, 2011; Shimelmitz et al., 2011). In Western Europe, systematic blade production is present in the Middle Paleolithic, also more than 150,000 years ago (Delagnes, 2000; Revillon and Tuffreau, 1994). In Africa, it appears in the south, in the Howiesons Poort complex after 70,000 years BP (Soriano et al., 2007), and in East Africa may date back to 500,000 years (Johnson and McBrearty, 2010). However, blade production earlier than 50,000 years ago seems to have occurred as isolated technological episodes without continuity in time or space.

After around 40,000 years BP, blade production in Europe and Western Asia becomes the nearly exclusive system for the production of blanks for tools. Blades are the preferred support for the entire Upper Paleolithic until the Neolithic, or for more than 30,000 years. The predominance of these elongated blanks appears to have led to changes in the range of tools, whose end is often retouched into end-scrapers, burins, etc., and allows the creation of projectile armatures (Demars and Laurent, 1989; Pelegrin, 1995; Pigeot, 1987).

Blade production is also found in other regions but, it appears, not as exclusive and for shorter periods, evidence of intermittent episodes of its use.

For the Americas, two blade industries are well known; in Central America, obsidian pressure blade production by Classical...
societies (Darras, 2012; Hirth, 2012) and bladelet (or microblade) production by pressure from the Pleistocene–Holocene transition in the northwest of North America, in Alaska, British Columbia and the Yukon, the eastern extension of an industry also known in Siberia and the Far East (Ackerman, 1992; Gómez Coutouly, 2012). But in addition to these specialized cases, blade production is also present in other American contexts with different technological modalities. In lithic industries associated with the Clovis culture, while most publications focus on bifacial projectile points, several researchers have pointed out the systematic presence, in the south-central United States, of large robust curved blades obtained from specific core types (Collins, 1999; Collins and Lohse, 2004; Beck and Jones, 2010). In the Pacific Northwest and the Interior Plateau of North America, macroblade production (as opposed to microblades also present in these zones), comparable to that found in Clovis contexts, is also mentioned at sites dating to the Early and Middle Holocene (Dumond, 1962; Sanger, 1968). During the Late Holocene, blade production is also known in industries found at Middle Woodland sites in Illinois and Ohio (Greber et al., 1981; Montet-White, 1968; Odell, 1994; Yerkes, 1994). The blades produced are thin, light and fairly small.

In South America, blade production is noted only in the southern tip of the continent in Argentinian Patagonia, in particular in the Casapedrense industry in the Middle Holocene levels at Los Toldos (Cardich et al., 1973; Mansur-Franchomme, 1984; Menghin, 1952). Detailed technological analyses of this material is lacking, but published drawings of large retouched blades leave no doubt that they were obtained from a system of blade production. More recently, other sites have yielded similar material, and provide further evidence of this group as a local coherent technological episode (Hermo and Magnin, 2012). Again in Argentina, but in the northwest, the existence of Middle Holocene blade production has been noted very recently (Réstifo and Hoguin, 2012) and has been the focus of a detailed analysis (Hoguin, 2013).

Prior to the publication of this article, no blade production had been noted in Brazil.

**Blade production in the Foz do Chapecó region (Brazil)**

Here we present a new industry, based on the production of silicified sandstone and flint blades, found in the Foz do Chapecó region in southern Brazil in the eastern part of the state of Santa Catarina and the northeastern part of the state of Rio Grande do Sul. This industry is associated with sedimentary contexts dating to the Early Holocene.

**Environmental and archaeological context**

This blade production was discovered during archaeological research undertaken in the framework of the construction of the Hydroelectric Plant of Foz do Chapecó, 6.5 km upstream from the confluence of the Chapecó and Uruguay Rivers. Research was done by the Scientia Consultoria Científica/Santa Catarina enterprise between 2006 and 2010, and financed by Engevix as part of the “Projeto de Arqueologia Preventiva – UHE Foz do Chapecó SC” directed by Caldarelli (2010). We present the analysis of the blade reduction schemas from three archaeological sites (Fig. 1):

- Alto Alegre 3 or ALP-AA-3 (AA3), commune of Alpestre, in the state of Rio Grande do Sul.
- Linha Policial 1 or ACH-LP-1 (LP1), commune of Águas de Chapecó, in the state of Santa Catarina.
- Linha Policial 3 or ACH-LP-3 (LP3), commune of Águas de Chapecó, in the state of Santa Catarina.

The Chapecó River is part of the catchment of the Uruguay River in the western part of southern Brazil. The rivers of this network typically have pronounced gradients.

The zone corresponds to the Serra Geral Cretaceous formation of volcanic origin. The sediments, which come from basalt weathering, are clayey-silty-sands and sometimes sandy silts and are maroon-red or brown.

The landforms of the zone correspond to a large plateau, parts of which have been intensely dissected. The natural vegetation is semi-deciduous forest, now modified by human activities.

More than 10% of the total surface of each of the three sites studied (AA3, LP1 and LP3) was excavated by artificial horizontal spits. AA3 extends across an area of 216 m² on a flat plateau, delimited to the west by the left bank of the Uruguay River, the east and north by steep slopes and the south by a deeply incised stream. LP1 is found on a slightly convex plateau with a total area

![Fig. 1. Map showing site locations. 1: ALP-AA3; 2: ACH-LP1; 3: ACH-LP3.](image-url)
of 2480 m$^2$, about 50 m from the right bank of the Uruguay. Incised streams delimit it to the north and south. LP3 has a total area of 2160 m$^2$ on a flat plateau about 150 m from the right bank of the Uruguay, flanked on the west by an abrupt bank. It is located about 350 m from LP1 and 3300 m from AA3.

These sites have yielded the same sequence of three broad cultural horizons. The earliest layers, from the pre-ceramic period, contain only lithic artifacts. The intermediate layers have yielded ceramic, lithic and bone remains. The ceramics have been attributed to the Tupiguaran Tradition (Caldarelli, 2010). The final occupation, visible on the surface, corresponds to modern farming, fishing and hunting populations present in the region since the mid-20th century.

The stratigraphy is identical in all three sites, with three strata of varying thickness. This resemblance may be linked to the similarity in the topography of the sites on the terraces of the Uruguay River. The superficial stratum is humic with roots. The second stratum is a thin layer of dark brown clayey-sandy sediment. In these first two strata, the presence of rare basalt blocks has been noted. The lower stratum, which is the thickest, is a uniform red clayey-sandy sediment without basalt blocks (Fig. 2).

Excavations reached a depth of 170 cm at AA3, 130 cm at LP1 and 80 cm at LP3. Bedrock was not reached at any of the sites.

At the three sites, the blades were found in the lowest stratum (Fig. 2: archaeological assemblage 2). They are associated with dates between ca. 7500 and 5800 years cal BC (Table 1).

Following post-depositional disturbance due to the installation of fence posts, a few blades were found in the levels from the ceramic period. A total of 101 blades were found: 14 from AA3, 28 from LP1 and 59 from LP3 (Table 2). However, no blade cores were present in these assemblages.

**Lithic production systems associated with blades and cultural attribution of this industry**

The lithic assemblages from the lower levels at AA3, LP1 and LP3 were made on local raw materials, available as cobbles along the riverbanks or as blocks from rocky outcrops.

These levels include more than artifacts produced by blade production. Flake production is also amply represented by many cores and flakes. Testing of blocks was done by one or more short unidirectional series without preparation of the flaking surface. Bipolar on anvil reduction is also common.

The production of volumetric blanks by bifacial shaping is also very typical. Bifacial tools can be fairly massive or very fine and thin. Among the latter are several projectile points.

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**Table 1**

Absolute radiocarbon dates for the sites of LP1 and LP3 (Caldarelli, 2010).

<table>
<thead>
<tr>
<th>Site and depth of the sample</th>
<th>Lab code</th>
<th>14C date</th>
<th>Calibrated BC age range (2 sigma)$^a$</th>
</tr>
</thead>
<tbody>
<tr>
<td>LP1 (40–50 cm)</td>
<td>BETA 236422</td>
<td>8370 ± 60 BP</td>
<td>7570–7200 cal BC</td>
</tr>
<tr>
<td>LP1 (50–60 cm)</td>
<td>BETA 236423</td>
<td>8270 ± 70 BP</td>
<td>7490–7080 cal BC</td>
</tr>
<tr>
<td>LP3 (30–40 cm)</td>
<td>BETA 236420</td>
<td>7260 ± 60 BP</td>
<td>6230–6020 cal BC</td>
</tr>
<tr>
<td>LP3 (40–50 cm)</td>
<td>BETA 236421</td>
<td>6990 ± 70 BP</td>
<td>6000–5740 cal BC</td>
</tr>
</tbody>
</table>

$^a$ Calibration dataset: IntCal13.14c (Reimer et al., 2013), with CALIB REV7.0.0 radiocarbon calibration program (Stuiver and Reimer, 1993).

**Table 2**

Number of lithic artifacts and blades by level at sites AA3, LP1 and LP3.

<table>
<thead>
<tr>
<th>Site</th>
<th>Level</th>
<th>Number of lithic artifacts</th>
<th>Number of blades</th>
</tr>
</thead>
<tbody>
<tr>
<td>AA3</td>
<td>Surface – 60 cm (ceramist level)</td>
<td>1256</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td>60–170 cm (pre-ceramist level)</td>
<td>728</td>
<td>11</td>
</tr>
<tr>
<td>LP1</td>
<td>Surface – 20 cm (ceramist level)</td>
<td>1198</td>
<td>5</td>
</tr>
<tr>
<td></td>
<td>20–130 cm (pre-ceramist level)</td>
<td>4181</td>
<td>23</td>
</tr>
<tr>
<td>LP3</td>
<td>Surface – 20 cm (ceramist level)</td>
<td>662</td>
<td>4</td>
</tr>
<tr>
<td></td>
<td>20–80 cm (pre-ceramist level)</td>
<td>2031</td>
<td>55</td>
</tr>
</tbody>
</table>

---

Fig. 2. Stratigraphic section of LP1 (photo: Caldarelli, 2010).
Such technical traits support attribution of this industry to the Umbu Tradition (Caldarelli, 2010).

The Umbu tradition is defined as an archaeological group in the southern and southeast regions of Brazil and extends into Argentina and Uruguay. Its chronological position has not been clearly established, as associated dates range from 11,500 to 300 BP. Sites with this tradition are found in plains zones and on the slopes leading to the plateau. Dietary remains indicate generalized hunting and fruit gathering. Lithic artifacts of the Umbu Tradition, made on flint, chalcedony, sandstone, basalt and quartz, were obtained by direct hard and soft percussion. The most representative pieces are projectile points tanged, barbed, triangular and leaf-shaped, some of which have been retouched by pressure flaking. Other bifacial and unifacial tools are also present, including endscrapers, cobbles tools (choppers and chopping-tools) and large bifaces. Associated with these tools are polished or semi-polished axe blades, bolas an polishers (Kern, 1981, 1991, 1994; Ribeiro, 1979, 1991; Schmitz, 1981, 1984, 1985, 1991; Dias, 2003; Hoeltz, 2005).

It should be noted that other authors have attributed this industry to the Altoparanaense Tradition, or Humaitá (see in particular Schmitz, 2011), given its massive bifacial tool component.

**Blade production system**

The reconstruction of blade production modes at these sites is made more difficult given the lack of cores associated with this industry. Only the products are available to address the form of production system.

Detailed analysis of these artifacts, using an appropriate methodology, does, however, enable us to partially fill this gap by reconstructing some elements of the reduction process used to produce the blades studied here.

**Analytic methodology and terminology**

Given the relatively small area excavated (around 10% of the estimated area of each site) and the lack of some artifact categories in the chaîne opératoire of blade production, the approach to production modes could not include physical refitting of the artifacts. In this context, we have only the methodological tool of mental refitting to reach the goals of the analysis (Tixier, 1978, p. 39). Mental refitting consists in reconstructing the phases of production of the artifacts studied via a two-step analysis of the material. First, a detailed technological analysis is done for each artifact, based on examination of knapping traces left on the surface. A diacritical diagram for each artifact can then be established by describing the nature, direction and order of the observed removal scars (Fig. 3B). Second, a synthetic approach to the totality of the data recorded in the first step is used to propose a precise idea of the different phases in the chaîne opératoire corresponding to the industry analyzed.

The blade production system is characterized by a specific volumetric conception of the core. This should have a suitable structure from the start of blade production to allow control of the length of the blanks produced and their sequential recurrent removal. The chaîne opératoire is thus organized in two successive phases: (1) initialization, or core preparation, to give the core its intended form; and (2) production, during which the intended blanks, blades, are obtained. It is therefore possible to divide the flakes obtained during blade production into two broad classes: flakes removed during initialization, which are not produced for themselves but for the consequences they leave on the core’s surface; and flakes obtained during the production phase, which are the blades.

These two successive phases take place according to different methods and knapping techniques. By method, we mean here the “orderly sequence of actions carried out according to one or more techniques, and guided by a rational plan” (Inizan et al., 1999, p. 145) and by technique, the means employed to apply the method, as for example direct hard or soft percussion (Tixier, 1967; Pelegrin, 1995).

Interpretation of the diacritical diagrams for blades is facilitated by the fact that blade production permits only blades to be removed. It is not possible to produce other kinds of

![Fig. 3. Analytic method for blades. (A) conventional drawing; (B) diacritical diagram showing the direction and sequence of dorsal removal scars; (C) interpretive schema showing the attribution of each dorsal scar to the phase of the chaîne opératoire to which it belongs.](image-url)
groups D to F. Finally, the re-initialization phases can be reconstructed using group D, where initialization scars are partial, obscured by remo-

tion, re-initialization and a second series of production. By record-

ing and taking into account this information as a whole, we can distinguish between re-initialization scars and those that are not. Two exceptions exist. First, scars made after removal of the blade being analyzed (retouch scars) are not part of the blank production phase, but rather the subsequent phase of tool production or functionali-

tization of the blank. Second, scars prior to blade removal located near the platform in the proximal part of the blades corre-

spond to the preparation of the point of impact prior to the blow struck to remove the blade. Such preparation scars are common in blade production and can be done prior to the detachment of each blade, even within a single production sequence. They are thus considered as part of the knapping techniques rather than a separate method (Pelegrin, 1995).

On its dorsal face then, a single blade can preserve evidence in the form of scars of several reduction cycles: initialization, production, re-initialization and a second series of production. By recording and taking into account this information as a whole, we can address the methods of initialization and production used for the blades analyzed in this article (Supplementary Fig. 1).

Depending on the information provided by dorsal scars, blades can be classified into six groups (Table 3). Two-thirds of the artifacts have only blade scars (group C). Blades with scars from ini-

itiation and production removals (group B) and those with scars from production and re-initialization (group E) are also well represented but less abundantly.

Using the properties of each of these classes, we know where to find information related to each phase of the chaîne opératoire.

The initialization phase can be evaluated by artifacts in groups A, B and D. It is evident that those in group A, which have only ini-

tialization scars, provide much more information than those in group D, where initialization scars are partial, obscured by remo-

vals in the production and re-initialization phases.

The production phase can be examined by artifacts in groups B to F. Finally, the re-initialization phases can be reconstructed using groups D to F.

Table 3

Definition of blade groups based on phase of the chaîne opératoire represented by dorsal scars.

<table>
<thead>
<tr>
<th>Group</th>
<th>Dorsal scars</th>
<th>Number of blades</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Initialization</td>
<td>Production</td>
</tr>
<tr>
<td>A</td>
<td>x</td>
<td></td>
</tr>
<tr>
<td>B</td>
<td>x</td>
<td></td>
</tr>
<tr>
<td>C</td>
<td>x</td>
<td></td>
</tr>
<tr>
<td>D</td>
<td>x</td>
<td></td>
</tr>
<tr>
<td>E</td>
<td>x</td>
<td></td>
</tr>
<tr>
<td>F</td>
<td>x</td>
<td></td>
</tr>
<tr>
<td>Indeterminate</td>
<td>x</td>
<td></td>
</tr>
</tbody>
</table>

A short scar after a series of large elongated scars belongs to a re-initialization phase, following a production phase.

Among the scars made after blade removal, it is necessary to distinguish between re-initialization scars and those that are not. Two exceptions exist. First, scars made after removal of the blade being analyzed (retouch scars) are not part of the blank production phase, but rather the subsequent phase of tool production or functionalization of the blank. Second, scars prior to blade removal located near the platform in the proximal part of the blades correspond to the preparation of the point of impact prior to the blow struck to remove the blade. Such preparation scars are common in blade production and can be done prior to the detachment of each blade, even within a single production sequence. They are thus considered as part of the knapping techniques rather than a separate method (Pelegrin, 1995).

On its dorsal face then, a single blade can preserve evidence in the form of scars of several reduction cycles: initialization, production, re-initialization and a second series of production. By recording and taking into account this information as a whole, we can address the methods of initialization and production used for the blades analyzed in this article (Supplementary Fig. 1).

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Using the properties of each of these classes, we know where to find information related to each phase of the chaîne opératoire.

The initialization phase can be evaluated by artifacts in groups A, B and D. It is evident that those in group A, which have only initialization scars, provide much more information than those in group D, where initialization scars are partial, obscured by removals in the production and re-initialization phases.

The production phase can be examined by artifacts in groups B to F. Finally, the re-initialization phases can be reconstructed using groups D to F.

Table 4

Raw materials of blades.

<table>
<thead>
<tr>
<th>Raw materials</th>
<th>Number</th>
</tr>
</thead>
<tbody>
<tr>
<td>Silicified sandstone</td>
<td>78</td>
</tr>
<tr>
<td>Flint</td>
<td>19</td>
</tr>
<tr>
<td>Chalcedony</td>
<td>4</td>
</tr>
<tr>
<td>Total</td>
<td>101</td>
</tr>
</tbody>
</table>

Raw materials

The blades in the assemblages were produced mainly on very fine-grained brown to greenish silicified sandstone (Table 4). Natural surfaces sometimes present on the dorsal face show that they come from unrolled blocks, probably acquired in primary context.

A non-negligible number of artifacts were also made on a maroon flint, and more rarely on a green flint. The presence of neocor-
tex on the dorsal face of some of these products shows that the raw material was collected in the form of cobbles, possibly near the bed of the nearby Uruguay River or one of its tributaries. Finally, four blades were made on a white translucent chalcedony for which the acquisition context is unknown.

Initialization methods

Artifacts with dorsal scars from the initialization phase (groups A, B and D) provide extremely consistent information that demonstrates the use of a single method for preparing the flaking surface of the core. This involves centripetal removals that create the lateral and distal convexities needed to detach the first series of blades. Even when initialization scars have been partially effaced by later phases (groups B and D), information obtained from the edges and/or the distal end of the blades is in concordance with the centripetal method (Fig. 4A–C).

It should be noted, however, that in some cases, complete ini-

tialization of the flaking surface was not needed since about a dozen blades have some dorsal cortex remaining (Fig. 4C–F). For these, initialization only complemented natural elements already present on the knapped block.

Initialization modes relatively common in other contexts, such as crest preparation, or use of a long protruding ridge to detach the first blade, are entirely absent in the collections studied here.

As for the striking platforms on the cores, the rare presence of cortex on only two platforms of the blades analyzed suggests that preparation of the striking platform took place during the initialization phase.

Production methods

Artifacts in groups B to F clarify a pattern as important for the mode of blade production as for core preparation (Figs. 4 and 5). The production method is very clearly unidirectional parallel. The blades were nearly always detached from a single striking plat-

form. Only three blades show evidence of bidirectional production, involving two opposed striking platforms (Supplementary Fig. 1).

Most of the blades from the production phase (group C) tend to show the high recurrence of the production method, which allows detachment of long series of blades without requiring re-initialization phases. The dorsal face of the blades may have up to five scars from preceding blade removals (Fig. 3B and C), but the series were certainly even longer.

Re-initialization methods

From artifacts in groups E and F, it can be noted that in some cases, the production phase may have been temporarily interrupted for partial re-initialization of the flaking surface in order
to reestablish elements of convexity needed to continue the reduction process. In most cases, these phases, like initialization, are done using a centripetal method. The removals are located on the edges and/or the distal ends of the blades.

It is also important to note, however, the existence of another re-initialization process seen on two blades, not encountered in the initialization phase. This consists of a series of small centrifugal removals extending to different degrees that form a partial or total “neo-half-crest” (Figs. 3 and 5E). This process simultaneously smoothes a guiding ridge that is too protuberant and reestablishes linearity.

Such re-initialization enables continuation of blade production in a second series using the same unidirectional method as the first (Fig. 5F).

Fig. 4. Drawings and diacritical diagrams for blades from the site of AA3, LP1 et LP3.
Knapping techniques

Examination of knapping traces and platform characteristics on blades shows the use of two different knapping techniques for these products: direct internal percussion and direct marginal percussion (Soriano et al., 2007).

Direct internal percussion causes a fracture by a blow well behind the edge of the core using a stone percussor. Characteristic traces left on the products are a small and well-marked point of impact, a prominent bulb, a thick platform and relatively robust blades.

Direct marginal percussion consists in applying the fracture-initiating blow on the edge of the core with a soft percussor, which can be mineral (soft stone), animal (antler) or vegetal (heavy wood). Traces vary according to the kind of percussor used, the bulb being less marked and the platform often thin and delimited by a pronounced lip; the products are more regular and less thick than with internal percussion (Pelegrin, 2000). For artifacts from the sites of AA3, LP1 and LP3, the configuration of the platform, the length of the blades and the absence of accidents typical of soft stone percussion tend to suggest that marginal percussion with organic percussors was used. Many small proximal removal scars

Fig. 5. Drawings and diacritical diagrams for blades from the sites of AA3, LP1 and LP3.
on the blades obtained by marginal percussion show abrasion and very careful preparation of the point of impact before detachment of each blank.

No evidence of indirect percussion was found.

In the collection of blades analyzed, the two techniques are represented in relatively equivalent proportions (Table 5).

The presence of two different techniques raises the question of their relationship during the process of blade production. Three possibilities can be theoretically proposed:

1. Two different chaînes opératoires, each using a specific technique.
2. A single chaîne opératoire with intercalated use of the two techniques.
3. One chaîne opératoire, starting by internal percussion followed by marginal percussion.

With the lack of cores, it is difficult to determine from these three hypotheses, which best fits the context studied. The second one, however, can be eliminated when the dorsal blade scars on the blades analyzed were obtained using the same technique (when it is possible to identify) as the blade itself.

The presence of dorsal cortex, that could indicate removals near the start of core reduction, is clearly more important for blades produced by internal percussion than by marginal (Table 6), the first being as common as the second in the larger length classes, more than 10 cm long (Fig. 6). This tends to support the third hypothesis, that of the succession of the two techniques during reduction of the same core.

However, blades obtained by marginal percussion with dorsal cortex do exist (Table 6) and internal percussion is as common as marginal percussion for blades less than 10 cm long (Fig. 6). Similarly, the three blades with only initialization scars (group A), expected to be found at the start of the chaîne opératoire, were produced by marginal percussion and those with evidence of several initialization/production cycles (groups D, E and F) were obtained equally by both internal and marginal percussion (Table 7).

In sum, only a direct analysis of cores would enable clear establishment of the relationship between these two knapping techniques within one or more blade production chaînes opératoires. Regardless, the methods of initialization and production are the same for both knapping techniques used, which proves the existence of a single conception of the core.

Synthesis of the blade production system and hypothetical core structure

The blades from the sites of AA3, LP1 and LP3 were thus produced by both internal and marginal percussion, but following the same method of production: centripetal initialization of the flaking surface and unidirectional blade production. Despite the lack of cores, preventing more detailed determination of this production system, the elements revealed by analysis of the blades allow a hypothetical reconstruction of the core structure (Fig. 7). The core has a single striking platform and a flaking surface with sufficiently marked lateral and distal convexities to control the length and width of the blades and their sequential removal. Traits on the back of the core cannot be identified using the characteristics present on the blades.

Centripetal initialization involves a clear delimitation between the flaking surface and the rest of the core by an intersection plane. This is thus surface reduction, although convex, rather than volumetric turning reduction (the blades are not produced around the entire circumference of the core) (Boëda, 1990). The presence

Table 5
Blade knapping techniques.

<table>
<thead>
<tr>
<th>Technique</th>
<th>Internal percussion</th>
<th>Marginal percussion</th>
<th>Indeterminate technique</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>47</td>
<td>35</td>
<td>19</td>
<td>101</td>
</tr>
</tbody>
</table>

Table 6
Presence/absence of dorsal cortex on blades according to knapping technique.

<table>
<thead>
<tr>
<th>Technique</th>
<th>With cortex</th>
<th>Without cortex</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Internal percussion</td>
<td>13</td>
<td>34</td>
<td>47</td>
</tr>
<tr>
<td>Marginal percussion</td>
<td>5</td>
<td>30</td>
<td>35</td>
</tr>
<tr>
<td>Indeterminate technique</td>
<td>2</td>
<td>17</td>
<td>19</td>
</tr>
<tr>
<td>Total</td>
<td>20</td>
<td>81</td>
<td>101</td>
</tr>
</tbody>
</table>

Table 7
Knapping techniques according to blade production group.

<table>
<thead>
<tr>
<th>Production group</th>
<th>Internal percussion</th>
<th>Marginal percussion</th>
<th>Indeterminate technique</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>0</td>
<td>3</td>
<td>0</td>
<td>3</td>
</tr>
<tr>
<td>B</td>
<td>9</td>
<td>3</td>
<td>1</td>
<td>13</td>
</tr>
<tr>
<td>C</td>
<td>31</td>
<td>21</td>
<td>14</td>
<td>66</td>
</tr>
<tr>
<td>D</td>
<td>1</td>
<td>1</td>
<td>0</td>
<td>2</td>
</tr>
<tr>
<td>E</td>
<td>2</td>
<td>5</td>
<td>1</td>
<td>8</td>
</tr>
<tr>
<td>F</td>
<td>3</td>
<td>2</td>
<td>0</td>
<td>5</td>
</tr>
<tr>
<td>Indeterminate</td>
<td>1</td>
<td>0</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>Total</td>
<td>47</td>
<td>35</td>
<td>19</td>
<td>101</td>
</tr>
</tbody>
</table>

Fig. 6. Distribution of blade length according to knapping techniques. Only whole blades for which the technique is not indeterminate (n = 49) are included here.
of blades with asymmetric section (e.g., Fig. 4D) tends to confirm this interpretation: symmetric blades would have been produced from the middle of the flaking surface while asymmetry is more pronounced when production is closer to the lateral edges of this surface.

Such a volumetric structure of the core has links with some already known reduction concepts. The division of the core into two hierarchical surfaces of which only one serves as the flaking surface, is similar to the Levallois concept (Boëda, 1994, 1995), which is however aimed at the production of different kinds of flakes and not exclusively blades. But blade production systems with cores that show such ranking of surfaces and a single striking platform have already been described in different contexts:

- In southwest France, the Canaulian cores, attributed to the onset of the Upper Paleolithic, have such a structure (Guichard et al., 1989).
- In a more recent period, during the Final Neolithic in central France, “livre de beurre” cores are also based on the same general structural principles of the core, but the reduction system has unique characteristics including blade sizes more than 25 cm long, the knapping technique employed and the low recurrence in each reduction series (Millet-Richard, 1997; Airvaux and Primault, 2002).
- In South Africa, the Howiesons Poort industries, dated to ca. 65,000 BP, show the production of small blades by marginal soft percussion with some cores having two hierarchical surfaces. This structure differs from that of Levallois cores in that, unlike the latter, the surface of the striking platform is flat and the flaking surface very convex (Villa et al., 2010).

The data available on the blades from the sites of AA3, LP1 and LP3 informs only on the flaking surface, while properties of the striking platform are often indeterminate, such that it cannot be established whether the striking platform was flat, like the Howiesons Poort cores, or clearly convex, like the Canaulian.

Properties and purpose of blade blanks

The blades from AA3, LP1 and LP3 are supports for different tool classes. Their size is quite variable. Length of whole blades ranges from 3 to more than 14 cm. Use of internal and marginal percussion techniques for their detachment also causes variability in thickness and contour.

Table 8

<table>
<thead>
<tr>
<th>Retouched blades</th>
<th>Unretouched blades with macrotraces of use</th>
<th>Other unretouched blades</th>
</tr>
</thead>
<tbody>
<tr>
<td>28</td>
<td>19</td>
<td>54</td>
</tr>
<tr>
<td>27.7%</td>
<td>18.8%</td>
<td>53.5%</td>
</tr>
<tr>
<td>Total</td>
<td>101</td>
<td>100%</td>
</tr>
</tbody>
</table>

To these differences in volumetric and technological properties of unretouched blades can be added variability in patterns of retouch. More than a quarter have intentional modification after detachment (Table 8). Retouch is mainly direct, in a single row and located on one or both edges of the blade. There are also a few examples of bifacial and unifacial shaping of these blanks.

The main functional objectives seem to have been tools for which at least one of the sides has a long rectilinear or slightly convex edge with a steep cutting angle (30–40°). When the required properties were acquired during detachment, the blank was not retouched. Indeed, more than half of the blades are unretouched (Table 8). This is confirmed by the presence on 19 blades of splintering and crushing of the edges due to use, systematically located on one or both edges (Fig. 5A).

Some retouched pieces have the same techno-functional properties as unretouched blades. In this case, retouch may have served to rejuvenate the active part or to obtain certain specific traits, such as microdenticulation (Fig. 5D).

Blade tools with a lateral working edge are not the only knapping objectives. Some tools with retouched transformative parts on the end of the blade are also present: three pieces with a rounded end (endscrapers) and a double burin (Fig. 8B), for example. Blades were also used as supports for shaped tools. Unifacial shaping is attested (Fig. 8A), but bifacial shaping is more common, particularly to create small leaf-shaped tools (Fig. 8C) and shouldered projectile points (Fig. 8D).

Finally, some blades have proximal retouch for prehensile function (Fig. 5B and C). More than half of the blades in these assemblages were found as fragments, but for now, except for the projectile points, analyses do not provide sufficient data to confirm hafting of these tools.

In summary, the blades from AA3, LP1 and LP3 clearly belong to a single class of knapping products, but were used as supports for a range of tool types. The dominant techno-functional trait is the presence of long steep lateral working edges (“knives”), retouched or not. Blades with distal transformative parts are relatively rare. These patterns show a clear difference with other known blade contexts in the world, particularly in the European and Near Eastern Upper Paleolithic, where blade tools are typically retouched on the distal ends.

Synthesis, discussion and implications

Analysis of the lithic assemblages from the sites of AA3, LP1 and LP3 demonstrates the existence of exclusive blade production in southern Brazil during the Early Holocene. Despite the lack of cores in the zones excavated, the blades themselves provide abundant data with respect to the operatory scheme to which they belong. Such production is done by internal and marginal percussion using a single method: centripetal initialization of the flaking surface and unidirectional blade production.

The technological system in which such blade production is found also includes the production of retouched tools on large flakes and bifacial tools. The latter are wide and massive bifaces and projectile points are light and thin. This industry has been attributed to the Umbu Tradition based on the presence of these projectile points (Caldarelli, 2010). However, given the currently available data, we prefer not to propose a cultural attribution for...
the occupations in the earliest levels of the three sites studied, particularly since the technological system described here was previously unknown in southern Brazil. The presence of blade production has never been considered a criterion proper to the Umbu Tradition and, in fact, based on the published research, no site attributed to this tradition has as yet yielded evidence of such production. Similarly, attribution to the Altoparaense Tradition (Schmitz, 2011), based on the presence of massive bifacial tools, would ignore the existence of such blade production. The presence of this blade production operatory scheme in southern Brazil thus encourages a finer redefinition of the technological traits of regional lithic industries that goes beyond the general typological aspects presently used for cultural attributions.

In a more technological view, one could raise the question of the origin of blade production in this part of South America during the Early Holocene. We have pointed out the specific aspects of the volumetric structure of the cores. Conceptually, some parallels were discussed above, for example with the Canaulian and Howiesons Poort. However, given the significant spatial and temporal distance between them, a direct historical link between these Old World and African industries and those studied here cannot be proposed. Among the American occurrences of blade production, we note some similarities to Clovis contexts (Collins, 1999; Collins and Lohse, 2004). The contours of the blades are fairly close: long, somewhat thick, curved, with a triangular or trapezoidal cross section and sometimes quite large. The kinds of retouch (distal or lateral) and use-wear on unretouched pieces indicate a broad range of functions. Based on their descriptions, marginal percussion dominates, but some drawings also suggest the existence of internal percussion. The production method is also primarily unidirectional. In contrast, the volumetric concepts of the cores differ slightly. Two structures have been described for Clovis cores: conical and wedge-shaped. The first is not compatible with the blades found at the southern Brazilian sites. The second consists of surface reduction, with the production of symmetric blades in the middle of the flaking surface and asymmetric blades on the sides. These traits are similar to the industry described here, but the Clovis wedge-shaped cores do not have the sharp peripheral crest between the flaking surface and the striking platform necessary for the centripetal initialization observed on the Brazilian blades. In addition, in Clovis contexts initialization is most often centrifugal, with the creation of crested blades. While Clovis and Brazilian blade production appear to be broadly similar, they are conceptually different. Regardless, given the lack of spatial (and chronological) continuity between these two “blade” archaeological complexes, it is difficult to envisage historical links between them.

The existence of blade production in the Southern Cone of South America thus does not appear to be explained by the spread of populations or ideas, and should rather be considered as a local innovation. This is therefore a phenomenon of technical convergence, a concept in which a single technological scheme can appear and develop independently in different places and at different times (Leroi-Gourhan, 1945; Boëda, 2013). This example of convergence is not unique in South America, since Levallois reduction has been described from Late Holocene sites in Tierra del Fuego (Morello, 2005), separated by thousands of kilometers and tens of thousands of years from the Mousterian. Further, an independent origin for each of the blade episodes in North America has also been proposed (Parry, 1994).

Although blade production in the Southern Cone had a local origin, it is not clear whether the industry described in this article is...
completely isolated from a technological viewpoint. In the figures of some publications on the prehistory of southern Brazil (e.g., Schmitz, 2011), other possible evidence of blade production can be noted. Beyond the Brazilian border, in northwest Argentina, Late Holocene blade production was recently the focus of a technological analysis (Hoguin, 2013). The blades show variability comparable to those in southern Brazil, as much in terms of form and size as in terms of potential functions. In contrast, the volumetric concepts of the core seem to differ, with the presence of rotating and semirotating reduction and the use of both bidirectional and unidirectional methods. The presence of crested blades is also evident for centripetal initialization. In Patagonia, technological analyses of Casapiedras industries were not detailed, limiting the possibilities of comparison.

So, the existence of such operatory schemes in South American prehistoric contexts reveals much more significant variability in lithic production than can be seen in macro-regional syntheses. With the increase in analyses being done, the wealth of lithic prehistoric contexts reveals much more significant variability in Europe. Cahiers du Quaternaire. No 14. CNRS, Bordeaux.


