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Bipolar flaking as a component of a supraregional lithic resource base: A comparative study of cores from the Pampean and Northcentral Patagonian Atlantic coasts (Argentina)

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KEYWORDS: bipolar flaking; lithic resource base; cores; comparative study; Pampean and Northcentral Patagonian Atlantic coasts

ABSTRACT

Several authors argue that bipolar technology is an expeditious and versatile strategy, efficient for the reduction of small nodules. However, few studies analyze the use of bipolar reduction in relation to the lithic environmental supply. At the Pampean and Patagonian maritime coast, the technique has been widely recorded and seems to be conspicuous in indigenous populations that occupied coastal areas. With the aim of assessing and comparing the application of bipolar reduction, 196 nuclei recovered from sites of diverse chronologies in the Pampean and northcentral Patagonic coasts were analyzed. The use of the bipolar technique was observed in relation to the lithic environmental structure, the size of nodules and their raw material. The results revealed high frequencies of bipolar nuclei at the Pampean coast (87%) and moderate frequencies at the northcentral Patagonic coast (39%). It was determined that the variables that influenced the application of bipolar techniques the most were the small size of the nodules and their rounded shape, generally thick, and without flat surfaces. As for raw material quality, the technique was applied on good to medium quality rocks at the Pampean coast, while in the northcentral coast it was exclusively applied on pebbles and cobbles of superior qualities (very good to excellent). The differences observed are most likely linked with technological choices made by different coastal populations to make the best use of widely available local rocks.

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Abstract:

Several authors argue that bipolar technology is an expeditious and versatile strategy, efficient for the reduction of small nodules. However, few studies analyze the use of bipolar reduction in relation to the lithic environmental supply. At the Pampean and Patagonian maritime coast, the technique has been widely recorded and seems to be conspicuous in indigenous populations that occupied coastal areas. With the aim of assessing and comparing the application of bipolar reduction, 196 nuclei recovered from sites of diverse chronologies in the Pampean and northcentral Patagonic coasts were analyzed. The use of the bipolar technique was observed in relation to the lithic environmental structure, the size of nodules and their raw material. The results revealed high frequencies of bipolar nuclei at the Pampean coast (87%) and moderate frequencies at the northcentral Patagonic coast (39%). It was determined that the variables that influenced the application of bipolar techniques the most were the small size of the nodules and their rounded shape, generally thick, and without flat surfaces. As for raw material quality, the technique was applied on good to medium quality rocks at the Pampean coast, while in the northcentral coast it was exclusively applied on pebbles and cobbles of superior qualities (very good to excellent). The differences observed are most likely linked with technological choices made by different coastal populations to make the best use of widely available local rocks.

Keywords: Bipolar flaking; Lithic Resource Base; Cores; comparative study; Pampean and Northcentral Patagonian Atlantic coasts

1. Introduction

Bipolar flaking on an anvil is one of the earliest lithic reduction techniques in the history of humankind. It has been documented in diverse archaeological contexts from all over the world and covers a wide timespan (Shott 1989; Nami 2000; Guyodo & Marchand 2005; Le Brun-Ricalens 2005; Arthur 2010; Mourre & Jarry 2011; Soriano et al. 2011; Pargeter & Metin 2017). It has also been documented by ethnographers and etnoarchaeologists among diverse populations using traditional technologies (White 1968; Flood 1980; Hayden 1980; Sillitoe & Hardy 2003). Intense debates have taken place regarding the aims for which human groups applied the technique, attributed both to the physical and natural constraints of lithic resources and to social factors related to stylistic preferences and cultural traditions or

ethnicities (Flegenheimer et al. 1995). It has recently been defined as a sophisticated technique that demands continuous decision-making, intensive learning and practice, and may be associated with women (Arthur 2010). Frequently mentioned among the main functional causes behind its application are the use of rock supports too small or of poor flaking quality (Binford & Quimby 1963; Flenniken 1981); the preservation or recycling of raw material of high quality or from distant sources (Goodyear 1993) and the optimization of the time and energy invested in tool manufacture (Shott 1989; Nami 2000). Its use has also been suggested in the manufacturing of microliths to insert in compound tools such as Australian spears (Hayden 1980; Flood 1980; Goodyear 1993; Fleghenheimer et al. 1995). Whatever these causes may be, there is common agreement among archaeologists across the globe that the bipolar technique is versatile and within the range of expeditive strategies that favors an efficient use of nodules.

The naturalist Florentino Ameghino (1910) recorded it in the Atlantic coast of Argentina at the beginning of the 20th century, and deemed it a simple and "primitive" procedure applied by a predecessor of modern humans, the *Homo pampæus*, to manufacture stone tools by breaking rounded beach-deposited pebbles. Some authors assigned it to coastal populations with economies oriented towards the exploitation of marine resources in the Pampean and Patagonic regions (Ameghino 1910; Menghin 1952, 1963; Bórmida 1964; Díaz de Chiri 1977; Conlazo 1983) (Figure 1). Others suggested links with hunter-gatherer groups from the inland plains that, either occasionally or sporadically, occupied the littoral zone and made use of the available lithic and faunal resources (Outes 1909; Holmes 1912; Hrdlicka 1912; de Aparicio 1932; Politis 1984). Based on an Austro-German culture-historical perspective, Menghin and Bórmida (Menghin 1952; Bórmida 1964) suggested that bipolar flaking corresponded to an ancient "epiprotolithic" tradition of inferior coastal foragers that made use of the rounded pebbles available at the Pampean and Patagonian coastlines to manufacture choppers, unifacial tools, scrapers and denticulates. They distinguished this tradition from a more modern one, named "miolithic", of superior inland hunters who produced flakes, blades and bifacial tools like projectile points and made eventual use of coastal areas. Towards the late 1980s, new theoretical and methodological approaches derived from processual approach enabled archaeologists to refute and overcome Menghin and Bórmida's main assertions (Politis 1984; Borrero 1995; Gómez Otero 1996; Cruz & Caracotche 2008; Orquera & Gómez Otero 2008). In this regard, Bonomo (2005) was able to demonstrate that the lithic workshops with abundant bipolar artefacts from the dunes along the coast of the *Interserrana* area of the Pampean region were produced by hunter-gatherers occupying both the Atlantic coast and the inland plains (Figure 1). Subsequent advances in Pampean and Patagonian archaeology pointed to a significant spatial and temporal variability in the use of coastal areas and a diversity of technological strategies used by past human populations (Orquera & Gómez Otero 2008).

A comparative technological study of lithic assemblages from the coast of the *Interserrana* area of the Pampean region and the northcentral Patagonic coast carried out by Banegas (2016) enabled the observation of differences and similarities between both sectors (Figure 1). One of the technological features shared by both areas is the bipolar flaking of pebbles and cobbles. This work presents the results of the comparative analysis of 196 cores - bipolar and not - recovered from 14 archaeological sites of diverse chronology along the Pampean coast (between Cape Corrientes and the Quequén Salado river mouth) and the northcentral Patagonic coast (between Verde Stream and Cracker Bay) (Figure 1). The aim is to assess the application of bipolar flaking in both areas. Spatial and temporal trends are explored and compared with the archaeological evidence of the bipolar technique in other sectors of the continental Atlantic coast. We have chosen to analyze only the cores from

among all of the recovered artefactual classes[1] these provide the most information about the first stages of lithix raw material exploitation for tool manufacturing, that is to say, the initial selection and initial reduction of the nodules.

1.1. Areas of study and research background

The Pampean coastal sector under study lies within the *Interserrana* area, Buenos Aires province, and extends from Cape Corrientes to the mouth of the Quequén Salado river (Figure 1). Two geomorphological sectors can be distinguished: a higher one with cliffs carved by marine erosion, and a lower one characterized by a dune barrier formed by the deposition of sandy sediments (Bonomo 2005). The coastal gravel is mainly comprised of clasts of volcanic origin carried by coastal drift currents and deposited on the beaches of Buenos Aires province. Nowadays these deposits are mainly located within the area under study, but very scarce quantities can also be found north of Cape Corrientes and southwest of the Quequén Salado river (Bayón & Zavala 1997).

Archaeological research shows that since the early/mid Holocene, human populations intensively exploited this coastal environment and its marine resources (Politis & Bayón 1996; Politis et al. 2009; Bonomo & Leon 2010; Bayón et al. 2012; Bonomo et al. 2013). However, earlier evidence of coastal pebbles and cobbles, and marine molluscs has been found at archaeological sites of the inland plains, indicating the Pampean coast was exploited since the beginning of the human occupation of the region, that took place during the late Pleistocene (Bonomo 2005). In the coastal lithic assemblages, debitage and cores predominate, while tools manufactured by flaking (such as end-scrapers, side-scrapers, and knives), anvils and hammerstones appear in lesser quantities. The most commonly used raw materials are basalt pebbles, although quartzites from the Sierras Bayas formation, located inland between 80 and 160 km away from the coast, and a small amount of obsidian of unknown origin were also used (Bonomo 2005). Quartzites are the most used raw material along the plains of the Pampean region since the late Pleistocene until late Holocene.

The northcentral coast of Patagonia extends from the mouth of the Verde stream to Cracker Bay (Figure 1). It is characterized by plateaus that do not exceed 100 m a.s.l., dissected by canyons and gullies (Súnico 1996). A succession of coastal bars, paleocliffs, and ancient tidal flats are the result of isostatic and eustatic changes, and neotectonics during the Pleistocene and Holocene (Codignotto et al. 1992; González & Weiler 1994). Dunes have developed atop the cliffs and on the coastal bars of ancient bays (Súnico 1996). Three types of coastline can be distinguished: with gulfs (San Matías, San José and Nuevo), with spits and barrier islands at Valdés Cove and with an open sea coastline at the Valdés Peninsula. As regards geology, Tertiary and Quaternary-aged sedimentary rocks prevail (Haller 1981). The supply of lithic raw material for flaking is abundant: secondary deposits of pebbles are available, as well as blocks of ignimbrites and chalcedonies from veins of the Marifil formation (Malvicini & Llambías 1978) that outcrops at the Verde Stream.

Archaeological research shows that the area has been occupied at least since the Middle Holocene - between 7400 and 200 years BP - but with spatial and temporal variations in the use of coastal space (Gómez Otero 2006; Gómez Otero et al. 1999; 2013). The highest archaeological density has been determined close to the present coastline, which indicates that mobility and settlement were mostly restricted to the littoral sector (Gómez Otero 2006). A

[1]Diagnostic features of bipolar technique can be found in both cores and flakes: for example, chipped or splintered butts at opposing ends, with columnar extractions, flat flakes without or with negative bulbs, among others (Binford & Quimby 1963; Kobayashi 1975; Curtoni 1995; Nami 2000).

progressive increase in the amount of sites and diversity of activities at these sites has been recorded starting at 2000 BP. The diet combined terrestrial resources (*guanacos* and plants) complemented with marine resources such as molluscs, pinnipeds and fish (Gómez Otero 2006; Gómez Otero 2007; Svoboda 2015). As regards lithic technology, local pebbles of basalt and flint of very good flaking quality and, less frequently, rhyolites of medium quality, were used. Non-local rocks are represented by six obsidian varieties, among which stand out the T/SCI and SI types from sources located on the northcentral plateau 180 to 300 km away from the coast stand out (Gómez Otero & Stern 2005). Other frequently chosen rocks are chalcedonies and fossilized wood, but their origin has not yet been established (Banegas et al. 2016).

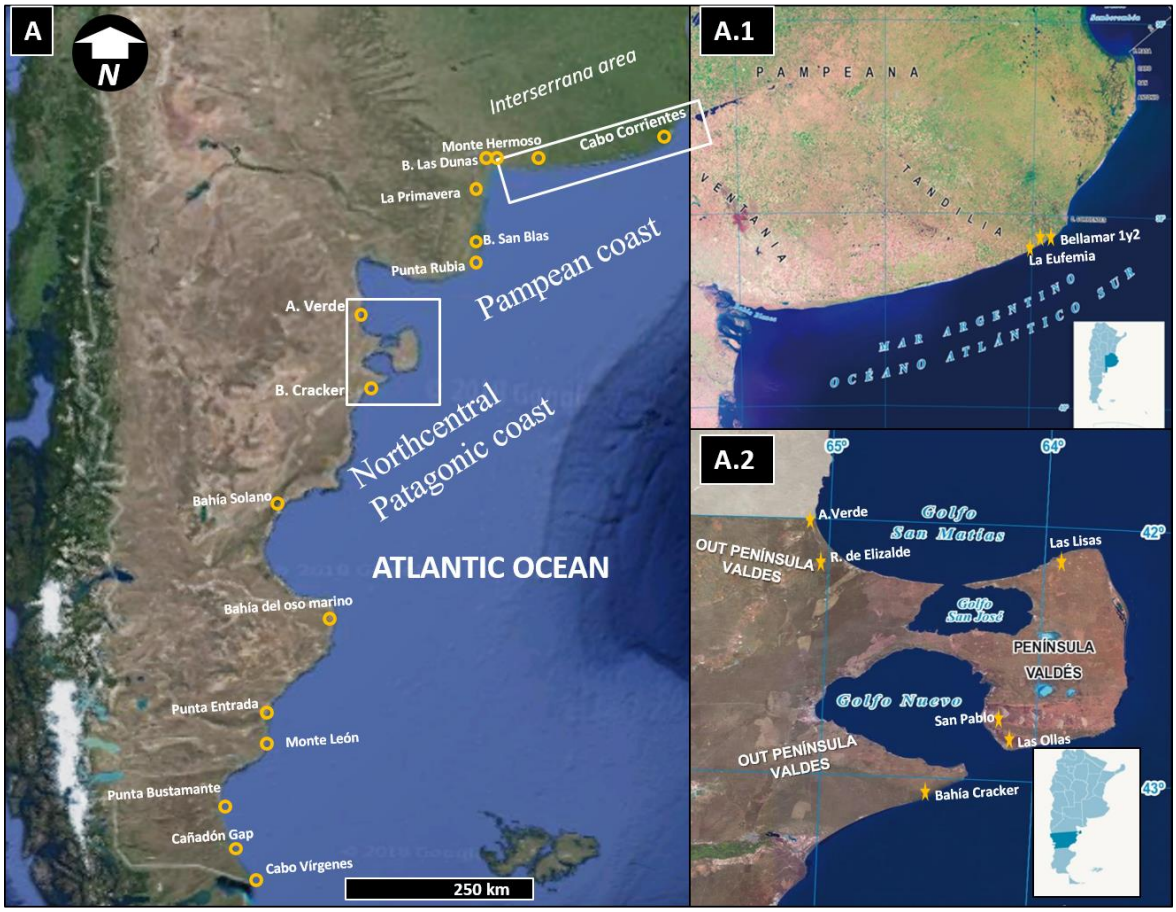

Figure 1. A: Study area and A.1 and A.2 archaeological sites mentioned in the text.

2. Materials and Methods

The characterization of the regional lithic resource base was carried out by Bonomo (2005) for the Pampean coast, and Banegas, Goye and Gómez Otero (Banegas et al 2016) for the northcentral Patagonian coast. It is worth mentioning that for northcentral Patagonian coast, the geographic space was split into two large analytical units following Gomez Otero's (2006) model: the "Valdés Peninsula" and "Outside the Valdés Peninsula" that in turn comprise diverse coastal types. Three temporal blocks were also distinguished: Middle Holocene (from 7400 to 4000 years BP); initial Late Holocene (from 3900 to 1000 years BP) and final Late Holocene (from 1000 to 300 years BP) (Gómez Otero 2006) (Table 1).

The methodology applied by Bonomo (2005) on the Pampean coast consisted of a simple random sampling of the natural deposits of coastal pebbles and cobbles following 1.5 m-wide transects and 0.5 m^2 grids, in order to analyze their spatial distribution, topographic location in the beach's profile, maximum dimensions of clasts and most abundant raw materials. Ten years later, additional sampling was carried out on different marine geoforms from the northcentral Patagonian coast, where every pebble that could be collected within a predefined time-span of between 15 and 20 minutes was considered (Banegas et al. 2016). The maximum dimensions, shapes and lithologic classes were determined, following some of the analytical procedures applied by Nami (1992), Shelley (1993), Berón et al. (1995) and Franco & Borrero (1999). To document the mineral compositions of the rocks in both areas, thirty petrographic thin sections were made from coastal gravels and lithic artefacts (8 from Pampean archaeological sites and 20 from the northcentral Patagonia coast) (Bonomo & Prates 2014; Banegas 2016).

The 196 cores under study were collected from systematic samplings in archaeological sites of different function and chronology (Table 1). To identify bipolar cores, the presence of the following attributes was considered: 1) unprepared, splintered or lack of striking platforms, 2) crush marks, and/or hinges in one or two poles or opposing distal ends, 3) negatives of flake removals originating from a single or from opposed poles, 4) flake scars on one or both faces, that can cover the full core's original length, and 5) frequent stepped fractures. For each core, the raw material and morphological type were recorded, following different authors Aschero (1975-1983: code 07.b), Brézillon (1983: figure 12), Orquera and Piana (1986: code 50.1.1.1-8) and Prous (2004: figure A27).

Table 1. Archaeological sites with their contextual information and the analyzed samples. H=Holocene.

Sector	Site (total number of lithic artefacts)	Site's function	Period	Total number of cores	Number of bipolar cores
Pampean coast	Bellamar 1 (1133)	Lithic workshop	Middle/Late H.	55	47
	Bellamar 2 (74)	Lithic workshop	Middle/Late H.	16	15
	La Eufemia (175)	Lithic workshop	Middle/Late H.	13	11
	Total			84	73 (87%)
Valdés Península (VP)	Las Lisas 2 C2-M2 (363)	Location	Initial Late H.	18	9
	Flechero del 39 (229)	Location	Initial Late H.	6	1
	Las Ollas 1 M1 (81)	Residential base	Final Late H.	6	4
	Pta. Cormoranes 3-F1 (11)	Station	Middle H.	1	1
	San Pablo 4-M3 (101)	Location	Initial Late H.	2	1
	San Pablo 6-C2-M2 (61)	Midden	Final Late H.	1	1
	Total			34	17 (50%
Outside VP	Aº Verde M1-2 (214)	Location	Middle H.	15	--
	R. de Elizalde 1 (411)	Temporary camp	Initial Late H.	28	24
	R. de Elizalde 5 (93)	Location	Final Late H.	4	1
	B.Cracker 4M1 (166)	Location	Middle H.	27	1
	B.Cracker 8 (83)	Location	Middle H.	4	1
	Total			78	27 (34%)

For bipolar cores the approach of Bonomo (2002, 2005) was followed, which distinguishes four groups according to the degree of modification suffered by the extremes of the original pebble or cobble: a) a single modified pole with flake scars, b) both poles modified, c) with three or more poles, d) undifferentiated by fracture (Bonomo 2002b: figure 2). The quality of raw materials was assessed following Franco and Aragón's (2004) criteria. The metric variables - maximum length, width and thickness in mm - were measured with a digital slide caliper. To estimate the degree of core modification, they were grouped according to the proportion of surface covered by cortex, at 20% intervals, as well as distinguishing between active and depleted cores. It should be noted that the coastal pebbles' cortex has not been produced by physico-chemical changes but by marine transport. This mechanical alteration tranforms the external surface of the clasts, resulting in a finer grained matrix on the outside as compared to the inside of the nodule. In other words, the attrition taking place during marine transport homogenizes the exterior surface of rocks by reducing their granulommetry (Bonomo 2005). This particular type of cortex, which characterizes rocks from secondary deposits, is named *néo-cortex* in the French literature (Inizan et al. 1995).

3. Data results

3.1. Characterization of the regional base of lithic resources base

Pampean coast: the rock deposits comprise pebbles and cobbles measuring from 3 to 15 cm in maximum diameter. Clasts with a diameter greater than 3 cm were selected. The average maximum length of the collected rocks is of 9 cm (Bonomo & Prates 2014). As for morphology, the large majority of clasts present elliptical and flattened shapes produced by marine transport (Figure 2). Among the 191 rocks collected, andesites-dacites abound (41%), followed by rhyolites (27%), basalts (16%) and flint (8%). The rocks of the best flaking quality are the siliceous ones, while the rest of the lithologies (basalts, andesites/dacites, quartzites, ftanites) exhibit predominantly good to medium qualities.

Patagonian southcentral coast: the deposits comprise pebbles and cobbles with a maximum diameter of between 2.7 and 13 cm, and an average of 7 cm. It is worth noting that those sampled in VP are smaller (between 4 and 6 cm) than in the other sectors (Figure 2). Flat, rounded rocks predominate, except in Valdés Cove, where they are rounded but thick. The nodules studied from western San Matías gulf, however, present sub-rounded and angular shapes (Banegas 2016). The most abundant raw materials are basalt (42%), rhyolite (18%) and sílex (14%). The rest (andecite-dacites; ignimbrites; quartzites, chalcedony and fossilized woods) do not exceed 6.5%. Some differences were observed between these coastal environments. At the San Matías gulf area, the supply of rhyolites of medium quality stands out (34%) and there are also veins of very good to excellent quality chalcedonies (13%). On the contrary, basalts of different qualities prevail at the Valdés Peninsula (VP) and the south of the Nuevo gulf (56% and 48% respectively). Those of higher quality (good to excellent) were only documented in VP.

3.2. Core morphological types and raw materials

Among the 84 cores from the Pampean coast under study, four morphological types were recognized: bipolar, tabular, discoidal and one with isolated flaking (Fig. 3). Almost all of the raw materials modules are pebbles and cobbles (97.6%), except for two rhyolite tabular chunks. The predominant core type is bipolar (n= 73: 87%), among which prevail those cores

with two modified poles (n= 34: 43.5%), followed by those with only one modified pole (n= 18: 23%) (Figure 3 and Table 2).

On the northcentral Patagonian coast, seven morphological types were identified among the 112 recovered cores. Three stand out: bipolar (n= 44: 39%), with isolated flaking (n= 31: 28%), and discoidal (n= 11: 10%) (Figure 3 and Table 2). The rest (globular, bifacial, pyramidal and polyhedral) are represented by one to five specimens and do not exceed 5% of the total. Thirteen cores were classified as undetermined (n= 13: 12%). The raw materials modules chosen are pebbles and cobbles, but also tabular chunks and undifferentiated supports. It is worth mentioning that bipolar cores reach 50% in Valdés Peninsula, and 34% outside the Valdés Peninsula.

Figure 2. Samplings of lithic raw materials on the beaches. A) Pampean coast, B) northcentral Patagonian coast

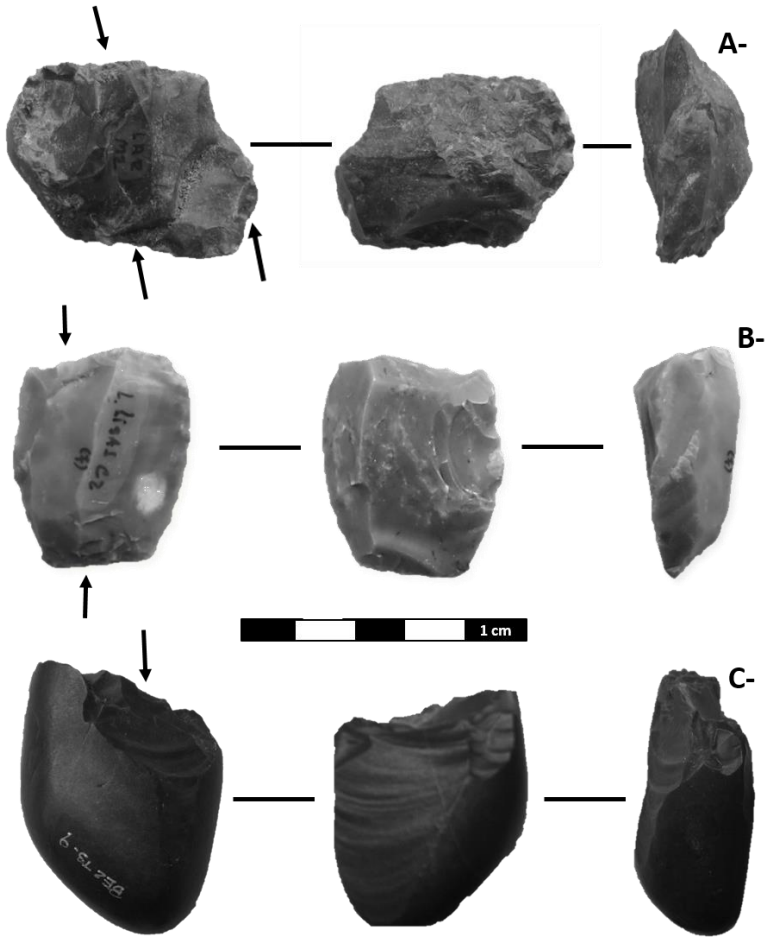

Figure 3. Bipolar cores: A- core with three poles modified; B-both poles modified; C: a single modified pole.

For the sample of Pampean coast, five major lithologies were identified (andesites-dacites; basalts, quartzites, rhyolites, flint), near all of them local, except inland quartzite. Among the bipolar cores, basalts of high quality (90%) dominate, followed by very good-quality flint (4%) and medium quality andesites and medium quality rhyolites (3% of each).

For the sample of northcentral Patagonian coast cores, 10 lithological varieties were recognized (basalts, flint, chalcedonies, fossilized woods, obsidians, rhyolites, ignimbrites, andesites-dacites, quartzite and silicified limestones). Among those found in VP, bipolar flint cores (n=10: 59%), prevail followed by basalt and chalcedony in equal proportions (n= 3: 18% of each). The only obsidian core, of non-local origin, is bipolar. Bipolarity was not documented in fossilized wood or regular-quality rocks ("Other" cathegories) which comprise rhyloites, ignimbrites, andesites-dacites, quartzites and silicified limestones. Outside VP, predominate siliceous bipolar cores (n=17: 63%), followed by basalt (n=7:26%). Unlike at VP, bipolar reduction was documented in two small fossilized wood cores (7%), which come from coarse pebbles. A single core of chalcedony (4%) was found in the Rincón de Elizalde 1 archaeological site, 1 to 20 km away from the primary source of this rock located in Verde Stream. However, the original support could not be determined because of the extensive reduction suffered by the core.

Table 2. Core morphological types.

Core morphological types	Pampean coast	Valdés Península (VP)	Outside VP
Bipolar	73: 87%	17: 50%	27: 34%
Isolated flaking	1: 1%	6: 17%	25: 32%
Tabular	5: 6%	--	--
Discoidal	2: 2%	5: 15%	6: 8%
Undetermined	3: 3%	5: 15%	8: 10%
Pyramid-shaped	--	1: 3%	2: 3%
Globular	--	--	5: 6%
Bifacial	--	--	4: 5%
Polyhedral	--	--	1: 2%

3.3. Core size and state

On the Pampean coast small cores (74%) prevail among which 84% (n=52) are bipolar cores. In decreasing order follow medium-size cores (23%), among which bipolar cores represent a 63%. Two large cores were recorded, neither are bipolar. The minimum number of flake scars varies from one to five removals, with an average 2.98 flake scars per core. Regarding the state at the moment of discard and based on the percentage of cortex, the size and the absence of striking platforms, 54% were deemed to be depleted cores, while 32% had medium intensity modification, and 14% had high intensity modifications.

Small cores predominate at VP (85%): more than 58% are bipolar, of which 15 out of 17 (88%) are depleted cores and can no longer yield useable flakes. Bipolar reduction was not detected in the bigger cores. Outside VP, big cores predominate (51%), followed by medium-sized (31%) and small (18%) cores. The percentage of bipolarity increases as the size of cores decreases: 5% in big ones, 62% in medium-sized ones and 71% in small ones. If both sectors are considered together, the minimum number of flake scars varies between two and four, with an average of 3.2 per core. As for the condition of the cores, the large majority (82%) present high intensity modifications, followed by those with medium intensity modification (11%) and only one with minor intensity modification.

3.4. Temporal trends

The sites of the Pampean coast analyzed in this paper are located in blowout depressions on the dune barrier, where no organic material such as bone or charcoal is preserved and anthropic shellfish accumulations (i.e. shell middens) have not been generated; therefore, no absolute radiocarbon dates are available. However, on the basis of Holocene sea level global variations and the absence/presence of several diagnostic features (e.g., pottery and small triangular projectile points) the materials of the dune barrier were assigned to the Middle and Late Holocene (Bonomo 2005). In the three assemblages the frequency of bipolar cores is high and even (between 84% and 93%).

On the Patagonian northcentral coast, where the three temporal blocks are represented, the frequency of bipolar cores varies in time (Table 3). For the Middle Holocene (7000 to 2000 years BP), bipolarity appears in low proportion (6%); from 2000 BP on, it increases significantly and progressively, reaching a 54% by the final Late Holocene (Table 3).

Table 3. Patagonia northcentral coast: frequency of bipolar cores in temporal block

Temporal Bloks	N= cores	N= bipolar cores	Frequency bipolarity
Middle Holocene	47	3	6,3%
Late Holocene	54	26	48,1%
Final Late Holocene	11	6	54,5%

4. Discussion and integration of the data

The selection criteria and technological strategies chosen by hunter-gatherer groups at the analyzed coastal areas can be discussed through the comparison of the local supply of raw materials and the presence of bipolar cores. The results show that bipolar flaking was the main reduction technique applied at the Pampean coast and was very frequent in northcentral Patagonia. Certain differences were noted between the areas. On the Pampean coast, the morphological diversity is low and almost every core is bipolar (87%), even in rocks of medium flaking quality. In northcentral Patagonia, the core type diversity is greater, with bipolar cores representing 50% of the total at the Valdés Peninsula and 39% outside it. As for pebble dimensions, the average size in the Pampean sector is higher: 9 cm as opposed to 7cm for the northcentral Patagonian coast. According to Borrero and Franco, the minimum size that pebbles must have to enable bipolar flaking is 3 cm (Franco & Borrero 1999), so the lithic raw materials form the areas studies would not have prevented a successful application of the bipolar technique. Another possibility could be related to the shape of the nodules. On the Pampean coast, most of the pebbles and cobbles lack natural flat surfaces, which makes them unsuitable for reduction by direct freehand percussion. On the contrary, on the northcentral Patagonian coast there is a greater supply of flattened and faceted gravels, with some flat faces, which could have been used as striking platforms and favored direct freehand percussion. On the northcentral Patagonian coast the bipolar technique was almost exclusively applied to small and medium-sized pebbles and cobbles from rocks of very good to excellent quality, such as flint, basalts, chalcedonies, fossilized woods and obsidians. Bipolar flaking was not observed in small or medium-sized pebbles of medium quality, such as rhyolites. This would therefore corroborate the hypothesis as concerns size, but the data presented and discussed here shows that the shape of rounded nodules was also taken into account. The differential quality of the raw materials seems to have been considered only on the northcentral coast.

As for temporal trends, because the artefactual assemblages of the Pampean coast discussed here do not present absolute chronologies, information from stratified archaeological sites located nearby was taken into account. One of these contexts is the Alfar site, located on the right bank of the Corrientes stream and dated on 5700 ^{14}C years BP. From a total 251 cores, 98.8% are coastal pebbles and cobbles reduced by the bipolar technique. Basalt prevails (93%), among which 90% present good or very good flaking quality (Apolinaire & Silva 2012). Another adjacent archaeological site is Nutria Mansa 1, which yielded radiocarbon dates between 2705 and 3080 14C years BP (Bonomo 2005:196). It was determined that 92% of the 48 cores recovered are bipolar. The great majority come from coastal pebbles and cobbles, among which basalts (40%) and fine-grained quartzites (22%) prevail. As regards later contexts, at the Claromecó 1 archaeological site, dated on 800 ^{14}C years BP (Bonomo et al. 2008), 100% of the 38 cores are bipolar cores made of coastal pebbles, manly of basalt and flint of good to very good quality. These data indicate that on the Pampean coast the bipolar flaking of beach pebbles and cobbles - mainly basalts - was a very frequent practice and was sustained over millennia, and increased towards the Late Holocene.

For the Pampean coast it has been proposed cultural changes towards the Late Holocene such as a process of diversification and intensification in the exploitation of fauna, demographic growth, less frequency trips to the sources, the appearance of technological innovations, and the development of wide networks of social interaction and exchange among human groups from different geographical areas (Berón 2007; Bonomo 2005; González 2005; Martínez & Gutiérrez 2004; Mazzanti 2006; Politis et al. 2001). This increasing in the exploitation of the local coastal pebbles (a second class lithic resource in the region) by the bipolar technique, can represent a technological correlate of this process of diversification and

intensification, showing less frequent trips to the distant Sierras Bayas quarries, where better quality quartzites were available (Bonomo et al. 2008). This increase was also observed in the northcentral Patagonian coast for the same period. In this respect, Gómez Otero (2006) hipotetized that the increase of bipolar core technology towards the final Late Holocene could be related with the need to optimize the use of raw materials in a context of demographic growth, reduced mobility and territorial constriction. Therefore, this temporal change in lithic core technology in both areas seems to respond to social matters, technological choices, mobility reduction and new territorial organizations rather than technological needs linked to variations in the availability of coastal raw material.

Temporal and spatial variations can be observed in the application of bipolar flaking in other sectors of the continental Atlantic coastline (Figure 1). In southwest Buenos Aires, province, Bayón and her team detected an almost exclusive application of this technique on local basalt nodules at Middle Holocene contexts, as 58 of the 62 (94%) of the cores recovered from the Las Dunas site are bipolar (Bayón et al. 2012). At the mouth of the Colorado river, the use of small (between 2 to 10 cm) local pebbles of flint and basalt was documented, with bipolar flaking being more frequent in the initial Late Holocene contexts (Santos Valero and Armentano 2017). As an example, at the La Primavera site, 67% (n=12) of the bipolar cores are flint and basalt pebbles, followed by quartzites (Bayón et al. 2004). At the Las Olas site in the San Blas area, Eugenio & Aldazábal (2004) mention that the cores are mainly bipolar (86.2%) and made from basalt pebbles smaller than 10 cm. On the Río Negro coast of San Matías Gulf, Alberti (2013) documented the use of small bipolar cores throughout the occupational sequence –from the Middle Holocene until the recent temporal block- although in low frequencies (13%) and decreasing later (9%). In the San Jorge gulf, bipolar flaking has not been recorded (Borrero & Caviglia 1978; Arrigoni et al. 2008), while only one out of 67 cores analyzed in Late Holocene sites of the Santa Cruz province is bipolar (1.5%) and made from non-local raw material: black obsidian from the PDAI source (Ambrústolo 2013). In southern Patagonia there is no record of bipolar cores at Monte León (Cruz & Caracotche 2008; Cañete Mastrángelo 2016), and their frequency is low in Punta Bustamante (15%) where it is applied to small local fossilized wood stones (Mansur 2008).

On the basis of bipolar core frequencies recorded by different researchers, four ranges were established: high (100 to 60%); medium (59 to 30%); low (29 to 10%) and very low to null (9 to 0%). The sectors with the highest values are the coast of the *Interserrana* area between Cape Corrientes and the mouth of the Quequén Salado river; San Blas Peninsula, the mouth of the Colorado and Negro rivers and the northcentral coast of Patagonia (between 60 and 100%). Medium to low frequencies (59 to 10%) are found in the Río Negro coast of the San Matías gulf, and very low to null (<9%) on the coastline that includes the southern Nuevo gulf, almost all of the San Jorge gulf and the area between Monte León and Punta Bustamante in southern Patagonia.

5. Synthesis and conclusions

The results of the technological analysis perfomed on the cores from two different and distant areas of the continental Atlantic coast determined that the most influential variables for the application of bipolar flaking were the small size of nodules and their round shape, generally thick and with no flat natural surfaces. As regards raw material quality, the Pampean coast displayed bipolar flaking in rocks of very good to medium quality, while on the northcentral coast of Patagonia it was applied only in rocks of the best flaking quality. Furthermore, a progressive increase was documented in the region from the Middle Holocene (6%) until the final Late Holocene (>54%), that is likely associated with the occurrence of social and organizational changes.

The record of bipolar flaking varies among the different sectors along the Pampa-Patagonia region. In the northern sectors it was applied on small basalt pebbles. On the northcentral Patagonian coast bipolar flaking used on small pebbles of both basalt and flint, and further south (northern coast of Santa Cruz and Punta Bustamante) on pebbles of very high to excellent quality, some non-local (such as obsidian) and some of local but limited availability: such as fossilized woods and dark fine-grained rocks. Therefore, this evidence allows us to infer that bipolar flaking or reduction was a technical strategy applied by hunter-gatherer groups of the Pampa-Patagonia region almost exclusively at those areas where raw material was mainly available in the shape of predominantly small pebbles. At those places where availability was more diversified (with supply at primary and secondary sources), bipolar technique was applied to a lesser extent and restricted to local rocks of the best quality. Finally, the differences observed in the frequency of bipolarity along the Pampa-Patagonia maritime coast suggest it was linked with technological choices that different coastal populations made for the best use of small-sized pebbles through the bipolar technique.

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