Black obsidian procurement strategies and circulation along the northern coast of the Santa Cruz Province (Argentine Patagonia): human mobility and interaction

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Abstract:

In this article, we examine the strategies behind the acquisition and reduction of black obsidian found in rock shelters and shell middens from the north coast of the Santa Cruz Province, in Argentine Patagonia. Geochemical analyses performed on black obsidian artifacts from this area posit the long-distance circulation of this raw material given its source at Pampa del Asador, located approximately 400 km to the west. In a previous article, we suggested that evidence for the initial knapping of obsidian pebbles, added to the identification of artifacts with high cortex percentage, implied that obtaining pieces of said raw material would have been based on pebble morphologies. Here we expand on this proposal, contending that this was the case at least for Late Holocene occupational contexts.

During the Middle Holocene an exceptionally low representation of very small-sized debris without cortical reserve was observed; cores and tools were not registered. Knapping activities related to intermediate technical steps in the framework of core reduction and blank production were evidenced, including small and very small flakes as well as bifacial preforms. We inferred that obsidian pieces probably entered into these Middle Holocene sites as part of personal toolkits, cores and bifacial artifacts without cortex, within the framework of exploratory incursions into the area.

For the Late Holocene occupations, taking into consideration the presence of obsidian pebbles, of similar dimensions to those registered at the source itself, we suggest that their procurement would have occurred through various mechanisms, such as the establishment and strengthening of social relations within the context of mobility circuits that would have linked the coast to the interior, among other factors.

Keywords: obsidian; procurement; exploitation; hunter gatherers; human mobility; Patagonia.

1. Introduction

In central-southern Patagonia, three obsidian sources have so far been recorded, these are in the western portion of the region. These sources have different varieties of obsidian (Stern 2018). Most of the black obsidian artifacts that have been recorded in surface and stratigraphic contexts at regional level come from the Pampa del Asador (PDA) source, located in the central-

Journal of Lithic Studies (2020) vol. 7, nr. 2, 17 p. doi:10.2218/jls.v3i1.5227

Published by the School of History, Classics and Archaeology, University of Edinburgh
ISSN: 2055-0472. URL: http://journals.ed.ac.uk/lithicstudies/

western region of the Santa Cruz Province (Figure 1) (Belardi *et al.* 2006; Espinosa & Goñi 1999; Stern 1999; 2018; among others). The transport and exchange of nodules of this raw material in Patagonia was proposed by scholars on the basis of evidence obtained from sites located at varying distances from PDA (these include, among others, Ambrústolo *et al.* 2012; Civalero & Franco 2003; Cueto *et al.* 2016; 2018; Gómez Otero & Stern 2005; Hermo 2008: 436; Molinari & Espinosa 1999).

XRF (X-ray fluorescence), ICP-MS (Inductively Coupled Plasma Mass Spectrometry) and NAA (Neutron Activation Analysis) analyses conducted on 56 obsidian artifacts and pebbles recorded from the north coast of the Santa Cruz Province (Figure 1) indicate that this raw material came from Pampa del Asador, located *ca*. 400 km to the west of these sites (Figure 1). These analyses yielded three geochemical types of obsidian, PDAI, PDAII and PDAIIIb (Ambrústolo *et al.* 2012; Nami *et al.* 2017). In this context, we proposed that the black obsidian recorded in the Deseado River Lower Basin area (Figure 1) had been acquired through the exchange of pebbles with groups from the interior (Ambrústolo *et al.* 2012). We formulated this hypothesis given the relatively high frequency of black obsidian artifacts with traces of pebble cortex recorded, among other variables (Ambrústolo *et al.* 2012).

Archaeological studies carried out along the northern coast of the Santa Cruz Province, Argentina, support the notion of an intensive, redundant and variable exploitation of coastal spaces and resources by human hunter-gatherer groups, mainly during the Late Holocene in the Deseado River Lower Basin (Hammond 2015: 518; Zubimendi *et al.* 2015; Zubimendi 2019). The most frequently identified archaeological sites were open-air ones: shell middens on dunes with lithics, animal bones, and malacological remains (Hammond 2015: 535). However, occupations of rock shelters located at differing distances from the coast have also been identified (Ambrústolo *et al.* 2011; Ambrústolo & Ciampagna 2015). The spatial distribution of the sites suggests a structured use of the environment, mainly linked to the availability of mollusc banks and pinniped colonies in the vicinity of certain coastal areas (Zubimendi *et al.* 2011).

The Deseado River Lower Basin has a highly variable availability of lithic raw materials. Rocks are available from primary and secondary sources, with local and non-local siliceous rocks of excellent knapping quality being the commonest lithic raw material recorded. Likewise, we also observed the use of low-energy expedient strategies in the exploitation of some immediately available rocks such as basalt and rhyolite (Ambrústolo *et al.* 2015). In general terms, debitage dominates the lithic assemblages recorded at rock shelters and shell middens of the study area. Cores and tools were identified in low frequencies, less than 10%. Among flaking by-products, there was a predominance of small (20-40 mm), and very small-sized (<20 mm) flakes. There were also low proportions of primary and secondary flakes, suggesting a low-level of initial flaking activities at the sites. The lithic record from the sites suggests the implementation of tasks related to intermediate and, to a lesser extent, final knapping stages. In the samples analysed, a significant variability in raw materials was observed, although chert and translucent chalcedony were the most represented rocks (more than 80%). Aside from some chert varieties, all the identified rocks were locally available, being mostly accessible from secondary sources (Ambrústolo *et al.* 2015). Among the tools, chert was the most frequently utilised raw material. The most commonly represented tools were scrapers, followed to a lesser extent by retouched flakes, bifacial artifacts, knives, and denticulates. These were also mostly small-sized artefacts (20-40 mm).

In this article, we summarise the discussion regarding north-eastern Santa Cruz hunter-gatherer procurement and circulation strategies of obsidian as a raw material. This discussion is based on the record of black obsidian pebbles which have similar dimensions to those identified at the PDA source. We evaluate, applying a techno-morphological approach, the lithic assemblages from stratigraphic contexts within six rock shelters and four shell middens located in the Deseado River Lower Basin area (Figure 1). The results were then analysed and compared against data obtained from neighbouring areas. The ensuring results are presented here, and describe two different periods: *ca.* 7,000-3,500 years ^{14}C BP and 3,500-1,000 years ^{14}C BP.

Figure 1. Location of the obsidian sources and archaeological sites containing obsidian. Abbreviations: NCSCP - North Coast of Santa Cruz Province; DRLB - Deseado River Lower Basin; PDA - Pampa del Asador; 17M - 17 de Marzo; PMAL - Punta Medanosa Archaeological Locality; 1 - Cueva Marsicano; 2 - Alero El Oriental; 3 -

Cueva del Negro; 4 - Alero 1; 5 - Alero 4; 6 - Alero El Veneciano 1; 7 - UNPA; 8 - Playa del Negro; 9 - Puesto Baliza 1; 10 - Puesto Baliza 2; 11 - La Lobería; 12 - La Señal.

1.1. Pampa del Asador source area

The Pampa del Asador source is located in the centre-west area of the Santa Cruz Province (Figure 1). It was initially defined by Espinosa & Goñi (1999) as a black obsidian procurement area exploited at a regional scale. Belardi *et al.* (2006) provides a detailed description of the geology and geomorphology of the area. They indicate that PDA is a large geoform roughly 80 km in length in a northeast to southwest direction, and with an average width of 15 km. PDA is composed of sedimentary deposits of fluvioglacial origin formed into flatlands; these deposits are of a sandy to sandy-silty matrix including gravels of varying sizes. The fluvioglacial origin is what characterises PDA as a secondary source (Nami 1992).

The first studies and discussions concerning the characteristics of the obsidian pebbles present in PDA, also found in nearby archaeological contexts, was provided by Espinosa & Goñi (1999). The authors recorded the size of the pebbles, the quantity and variety of artifacts, and the presence of cortex on the flakes. The maximum dimensions of the pebbles were evaluated according to a predetermined scale: small (up to 5 cm), medium (between 5.1 and 10 cm), and large (more than 10 cm) (Espinosa & Goñi 1999). The authors mainly identified pebbles and flakes -with and without cortex- of medium and small dimensions. Some of the samples obtained were geochemically analysed and six types of obsidian were recognized: PDAI, PDAIIa and b, PDAIIIa, b and c (Stern 1999). Belardi *et al.* (2006), based on sampling carried out at the foot of the Musters site, that located approximately at the centre of the obsidian distribution in PDA, were the more common pebble sizes present in accordance to the Espinosa & Goñi scale. This sampling reveals that most of the pebbles were small (n = 23; 88%) or medium (n = 3; 12%), among the latter they recorded an average length of 5.6 cm.

In a recent paper, Franco *et al.* (2017) presented data concerning the existence of a "distal secondary source" known as 17 de Marzo of Pampa del Asador. In a small area to the south of the Deseado Massif (17M; Figure 1), they identified 25 black obsidian pebbles within fluvioglacial deposits. They undertook geochemical analysis on eight pebbles and identified four varieties of PDA obsidian (PDAI, PDAII, PDAIIIa, PDAIIIb and PDAIIIc). The source is at a linear distance of *ca.* 170 km from Pampa del Asador and 250-290 km from the Deseado River Lower Basin sites. The pebbles were small, with a maximum length of between 16 and 48 mm. The researchers argued that the procurement and exploitation of these pebbles could have been carried out locally, within the framework of embedded strategies (*sensu* Binford 1979).

1.2. Obsidian exploitation in the north-central region of the Santa Cruz Province

Molinari & Espinosa (1999) conducted one of the first systematic regional studies analysing several techno-morphological variables in obsidian artifacts from the Thierauf Collection. These are pieces that were collected unsystematically from 340 archaeological sites, covering a wide spatial range within the Santa Cruz Province. The authors considered Pampa del Asador as the only known source of obsidian for Santa Cruz. They also observed that the distribution of black obsidian artifacts covered all the environmental zones of Patagonia, covering the precordillera, central plateaus and coast.

Within this context, they hypothesised that obsidian procurement was the product of large displacements or exchange mechanisms (Molinari & Espinosa 1999). They assessed the size and cortex proportion of the pieces as direct indicators in the analysis of the relationship between the presence and distribution of these artifacts, their state of conservation, and distance to the source. They identified 329 obsidian artifacts, most of them (n = 197; 59.9%) originating in what they termed the “Precordillera” zone. To a lesser extent, they recorded artifacts from the “Central Plateaus” (n = 100; 30.4%) and the “Coast” (n = 31; 9.7%). The authors assumed the provenance of obsidian as coming from PDA, based primarily on the fact that it was the only source detected to date (Stern 1999), they did not undertake geochemical studies. Insofar as the dimensions and presence of cortical reserve was concerned, they observed a decreasing trend directly proportional to an increase in the distance from PDA. In general terms, this fits into the fall-off distribution model (contrast with Renfrew 1977).

Several studies have highlighted the existence of variations in the techno-morphological characteristics and the absolute and relative frequencies of PDA obsidian pieces based on an increase in the distance of the contexts in regards to the source (Belardi *et al.* 2006; Cueto *et al.* 2016; 2018; Franco *et al.* 2017; Méndez *et al.* 2018; Pallo & Borrero 2015; among others). In provenance studies, obsidian artifacts have been chemically analysed to detect trace elements using XRF (X-ray fluorescence) or ICP-MS (Inductively Coupled Plasma Mass Spectrometry) techniques.

In the case of the Deseado Massif (Figure 1), evidence of PDA obsidian exploitation was recorded from the beginning of the occupational sequence (Cueto *et al.* 2016; 2018; Franco *et al.* 2017; Hermo 2014; Hermo & Miotti 2011). These sites date to the Pleistocene-Holocene transition. At these sites, obsidian debitage of very small sizes (<20 mm) in very low proportions (average 0.41%) were recorded, and only a few pieces with limited cortical reserve (25-49% coverage) were identified (Cueto *et al.* 2018). During the Early Holocene (*ca.* 9,500-7,000 ^{14}C years BP) there was an increase in the relative frequencies of black obsidian (average 9.61%), with a greater variability of classes and typological groups being represented, including larger pieces. Mainly debitage size was very small (<20 mm) or small (20-40 mm). Among the tools, it is worth noting the identification of un-stemmed projectile points at the sites of El Verano Cueva 1 and La Martita Cueva 4 (Aguerre 2003; Durán *et al.* 2003).

In La Martita Cueva 4, the black obsidian PDA was also used to make end- and side-scrapers, triangular projectile points, bifacial artifacts and bifacial reduction flakes (Aguerre 2003, Franco *et al.* 2017). Cueto and collaborators suggest that PDA black obsidian would have been brought into these cave and rock-shelter sites as tools. At Cueva del Minero 1, Cueva de la Ventana, and La Mesada there is little evidence of end-phase work on the tools, represented by retouch and micro-retouch flakes (Cueto *et al.* 2018). During the period between 7,000 and 3,500 ^{14}C years BP there are low relative frequencies of black obsidian artifacts recorded across these sites; on average, when considering the total sample of lithic pieces identified for this period, only 2.62% PDA black obsidian artifacts were observed. The maximum dimensions of these pieces do not exceed 40 mm and are comprised mainly of debitage of very small (<20 mm) size and, to a lesser extent, small size (20-40 mm). Bifacial thinning flakes, retouch, and micro-retouch flakes (among those produced during the final phase tool manufacture, including re-flaking, retouch, bifacial thinning), were recorded (Cueto *et al.* 2016; 2018). Very few tools were identified, although a retouched blade was recorded at La Mesada and a unifacial tool was recovered from Cerro Tres Tetas 1 (Cueto *et al.* 2018). In most contexts cortical reserve was recorded.

During the Late Holocene (3,500-1,000 ^{14}C years BP) there is evidence of exploitation of PDA black obsidian in five rock shelters sites located in the Deseado Massif (Casa del Minero 1, La Gruta 1, Cueva La Hacienda, Cueva Maripe and Cueva Moreno). In general, with respect to the previous chronological time period, there is an increase in the relative frequency of obsidian artifacts (average 8.63%) recorded at these places. Mainly, debris was identified, represented by flakes and blades (of a standardised size and un-retouched edges). Artefactual variability was observed, for example, among tools from Casa del Minero 1, projectile points, scrapers, and retouch flakes were recorded (Cueto *et al.* 2018). Among the largest objects, medium-small sized pieces (40-60 mm) were registered. On most of the occupations, artefacts with cortex reserve were identified. Due to this, Hermo & Miotti (2011) suggested that during the Middle and Late Holocene, PDA black obsidian could have entered the Deseado Massif in pebble-form.

Existing studies (Cueto *et al.* 2018; Franco *et al.* 2017; Pallo & Borrero 2015) confirm that at a regional scale the relative frequency and distribution of PDA black obsidian in central-southern Patagonia tends to decrease as the distance from the procurement source increases (Renfrew 1977). In sites relatively close to PDA, up to *ca.* 50 km, proportions greater than 60% were registered. Variable relative frequencies -between 60% and 10%- are recorded up to about 125 km away; in the Deseado Massif and north of the Santa Cruz River, at *ca.* 125 and 180 km of PDA the frequency varies between 13% and 1%. In the Deseado River Lower Basin, at *ca.* 350 km from PDA proportions of between 1% and 5% were observed. At distances greater than 400 km contexts with frequencies below 1% were identified.

Following Borrero (2012), the fact that it is a distribution of artefacts of known origin constitutes a sufficient characteristic for a declination pattern to be fulfilled, a pattern that depends on the distance from the source. Pallo & Borrero (2015) point out that, at the large-scale, the PDA obsidian fall-off point would be below 125 km from the sector closest to the Pampa del Asador source area. The relative frequencies would reach another threshold (<15%) close to 400 km; from there, they argue that the presence of obsidian is very low (<1%). Around the first threshold at *ca.* 125 km from PDA, that is to say the dividing point between high and low deposition intensity, there is the suggestion that the settlements in this area would have been spatially structured within a typical framework of home ranges, which would not necessarily be directly associated with obtaining obsidian. In this sense, it is worth mentioning that Méndez *et al.* (2018) identify similar trends for central western Patagonia, where they observe an exponential decrease in the frequencies of obsidians at about 100 linear km from the sources.

2. Materials and methods

Obsidian remains from stratigraphic contexts recorded in rock shelters (Cueva Marsicano, Alero El Oriental, Cueva del Negro, Alero 1, Alero 4 and Alero El Veneciano 1) (Ambrústolo *et al.* 2011; Ambrústolo & Ciampagna 2105) and shell middens (Playa del Negro, Puesto Baliza 1, Puesto Baliza 2 and UNPA) were analysed (Hammond 2015: 285). Likewise, the artifacts from surface samplings of two shell middens were also studied (La Lobería and La Señal). The analysed sample consists of 132 obsidian artifacts (See Table 1 and Figure 1).

The occupation chronology was established using radiocarbon dates. In cases where there were no available absolute ages, relative dates were proposed based on the minimum ages assigned to the coastal cords systems in the vicinity of the sites (Zubimendi 2019). As mentioned, based on a chronological criterion, the information was structured around two temporary blocks: *ca.* 7,000-3,500 years ^{14}C BP and 3,500-1,000 years ^{14}C BP (See Table 1).

During the technological study of obsidian artifacts, their morphological and technical attributes were considered. The traits taken into consideration were: size of the artifacts, type of flakes and tools, and the presence and amount of cortex available. Geochemical analyses were not performed on pieces of the sample studied here, instead the trends obtained from trace element studies on obsidian artifacts previously recorded for the study area were taken as reference (Ambrústolo *et al.* 2012; Nami *et al.* 2017). Following Cueto *et al.* (2016; 2018), the technological analysis involved determining the stage of reduction to which the obsidian remains from the different sites belonged. This approach enabled us to organise the artifacts according to the following technical steps: 1. Core preparation and initial reduction (decortication), 2. Core reduction and blank production, and 3. Final shaping of tools (re-flaking, retouch, bifacial thinning).

Table 1. ^{14}C dates of analysed sites.

Period	Site	Date	References
ca. 7,000-3,500 years ^{14}C BP	Alero El Oriental	LP-2318: 6,930 ± 100 years ^{14}C BP LP-2310: 5,860 ± 90 years ^{14}C BP LP-2310: 5,860 ± 90 years ^{14}C BP LP-2218: 5,810 ± 110 years ^{14}C BP LP-2311: 5,150 ± 80 years ^{14}C BP	(Ambrústolo *et al.* 2011)
	Cueva Marsicano	AA80415: 6,853 ± 48 years ^{14}C BP AA80414: 6,684 ± 48 years ^{14}C BP LP-3645: 4,670 ± 100 years ^{14}C BP	(Paunero *et al.* 2019)
	Alero El Veneciano 1	LP-3652: 3,510 ± 90 years ^{14}C BP	Unpublished
3,500-1,000 years ^{14}C BP	Cueva Marsicano	LP-3633: 3,140 ± 90 years ^{14}C BP LP-3630: 2,120 ± 60 years ^{14}C BP LP-3642: 1,970 ± 60 years ^{14}C BP	Unpublished
	Alero 4	LP-2762: 2,760 ± 70 years ^{14}C BP LP-2908: 1,690 ± 90 years ^{14}C BP	(Ambrústolo & Ciampagna 2015)
	Alero El Veneciano 1	LP-3662: 2,310 ± 80 years ^{14}C BP	Unpublished
	Alero 1	undated	
	Cueva del Negro	LP-2071: 1,730 ± 80 years ^{14}C BP LP-2320: 1,390 ± 70 years ^{14}C BP LP-2065: 1,340 ± 60 years ^{14}C BP LP-2279: 1,290 ± 50 years ^{14}C BP LP-2047: 1,220 ± 80 years ^{14}C BP LP-2290: 1,170 ± 110 years ^{14}C BP	(Zubimendi *et al.* 2011)
	Alero El Oriental	LP-2267: 1,530 ± 60 years ^{14}C BP	(Ambrústolo *et al.* 2011)
	Playa del Negro	LP-2682: 1,450 ± 60 years ^{14}C BP	(Hammond 2015:285)
	Puesto Baliza 1	undated	
	Puesto Baliza 2	LP-2732: 1,290 ± 60 years ^{14}C BP	
	UNPA	LP-2891: 970 ± 50 years ^{14}C BP	

3. Results

For the period *ca.* 7,000-3,500 ^{14}C years BP only 10 black obsidian artifacts were registered (Table 2). If the total lithic pieces identified at the three sites presented here are considered (n = 684), the average relative frequency of obsidian in this case is 1.46%. All cases were very small-sized debris (<20 mm) (Table 2). Among the complete pieces (n = 6; 60%), core reduction flakes (n = 5; 83.3%) and a bifacial thinning flake (n = 1; 16.7%) were identified. These indicate that at these sites the main tasks undertaken were those of core reduction and final shaping of tools. The predominance of lineal platforms (n = 3; 50%) and, to a lesser extent, flat (n = 1; 16.7%), prepared (n = 1; 16.7%), and punctiform (n = 1; 16.7%) platforms, supports the observed trends. No artifacts with cortex reserve were identified, which suggests that core preparation and initial reduction activities were not being carried out at these sites.

Table 2. Characteristics of obsidian assemblages of the period *ca.* 7,000-3,500 years ^{14}C BP.

Period *ca.* 7,000-3,500 years ^{14}C BP			
	Alero El Oriental	Cueva Marsicano	Alero El Veneciano 1
Obsidian N (%)	6 (1.3)	3 (1.75)	1 (2.7)
Typological classes	Debitage	Debitage	Debitage
Maximum length	14 mm	12 mm	No data
Distance to PDA	Between *ca.* 300-350 Km		
Cortex	No	No	No

Table 3. Characteristics of obsidian assemblages of the period 3,500-1,000 years ^{14}C BP.

Period 3.500-1.000 years ^{14}C BP						
Rock shelter	CM	A4	AEV1	A1	CDN	AEO
Obsidian N (%)	4 (1.1)	91 (4.7)	1 (1.9)	4 (5.2)	8 (1.1)	2 (4.2)
Typological classes	Deb.	Deb., Core, Tool	Tool	Deb., Tool	Deb.	Deb., Core
Maximum length	23 mm	35 mm	35 mm	19 mm	36 mm	27 mm
Distance to PDA	Between *ca.* 300-350 km					
Cortex	Yes	Yes	No	Yes	No	Yes
Shell midden	PDN	PB1	PB2	UNPA		
Obsidian N (%)	4 (1.6)	1 (1.8)	3 (3.75)	4 (0.1)		
Typological classes	Deb.	Deb.	Deb.	Deb., Tool		
Maximum length	20 mm	20 mm	20 mm	40 mm		
Distance to PDA	Between *ca.* 300-350 km					
Cortex	No	No	No	No		

The relative frequency of black obsidian artifacts recorded for the period between 3,500 and 1,000 ^{14}C years BP was slightly higher than that identified for the initial period (n = 110; 3.46%) (Table 3). There was some variability in the typological classes represented. In addition to the majority of the black obsidian artifacts being identified as debris (n = 104; 94.5%), tools (n = 4; 3.6%) and cores (n = 2; 1.8%) were also recognized (Table 4). Tools were represented by retouched flakes (n = 3; 75%) and a bifacial preform (25%) (Figure 2c); in all cases they were small in size (20-40 mm) (Table 3). At the La Lobería site (Figure 1), in a surface context, a small projectile point with evidence of resharpening was also recorded (Figure 2e). Debris were mostly flakes (n = 94; 90.4%) and, to a lesser extent, undifferentiated pieces were also identified (n = 10; 9.6%). Exactly half the flakes were fractured.

Among the complete pieces (n = 47; 50%), the majority were core reduction flake and blank production (n = 45; 95.7%). Two pieces (4.3%) were related to core preparation and initial reduction tasks (Table 5). Flakes were mostly very small size (<20 mm) (n = 39; 83%) and, to a lesser extent, small (20-40 mm) (n = 8; 17%) (Table 6). It is interesting to note that among the complete flakes there was a high relative frequency of pieces with cortical reserve (n = 9; 19.1%). In relation to the cortex reserve, the majority had between 25-50% (n = 5) of the cortex reserve, followed by those that had less than 25% (n = 3) and, finally, those that had a coverage of between 50-75% (n = 1) (Table 7). The two identified cores had high cortex proportions, one was very small in size, and the other was small. The latter presented evidence of bipolar flaking (Figure 2b), probably due to its dimensions (23.6 mm x 20.4 mm x 8.5 mm).

This size was similar to that recorded in the pebbles from the 17M source (Figure 1), on the southern margin of the Deseado Massif, located *ca.* 280 km from the Deseado River Lower Basin. In this sense, is important to highlight that at the La Lobería site (Figure 1), in a surface context, a small core with cortical remains and evidence for bipolar flaking (Figure 2d) was recorded. There were no significant differences in the characteristics of the lithic assemblages identified at rock shelters and shell middens.

Table 4. Typological Structure of the assemblages from each period.

	***ca.* 7,000-3,500 years ^{14}C BP**		**3,500-1,000 years ^{14}C BP**	
Typological Classes	N	%	N	%
Debitage	10	100	104	94.5
Core	-	-	2	1.8
Tool	-	-	4	3.6
Total	10	100	110	100

Table 5. Artifact frequencies according to reduction stage.

	***ca.* 7,000-3,500 years ^{14}C BP**		**3,500-1,000 years ^{14}C BP**	
Reduction stages	N	%	N	%
Decortication	-	-	2	4.3
Core reduction	5	83.3	45	95.7
Final shaping	1	16.7	-	-
Total	6	100	47	100

Table 6. Size of complete flakes by period.

	***ca.* 7,000-3,500 years ^{14}C BP**		**3,500-1,000 years ^{14}C BP**	
Size	N	%	N	%
Very small (<20 mm)	6	100	39	83
Small (20-40 mm)	-	-	8	17
Total	6	100	47	100

Table 7. Amount of cortex in complete flakes by period.

	***ca.* 7,000-3,500 years ^{14}C BP**		**3,500-1,000 years ^{14}C BP**	
Cortex	N	%	N	%
None (0%)	6	100	38	80.8
Scarce (1-25%)	-	-	3	6.4
Partial (25-50%)	-	-	5	10.6
Abundant (50-75%)	-	-	1	2.2
Very abundant (+75%)	-	-	-	-
Total	6	100	47	100

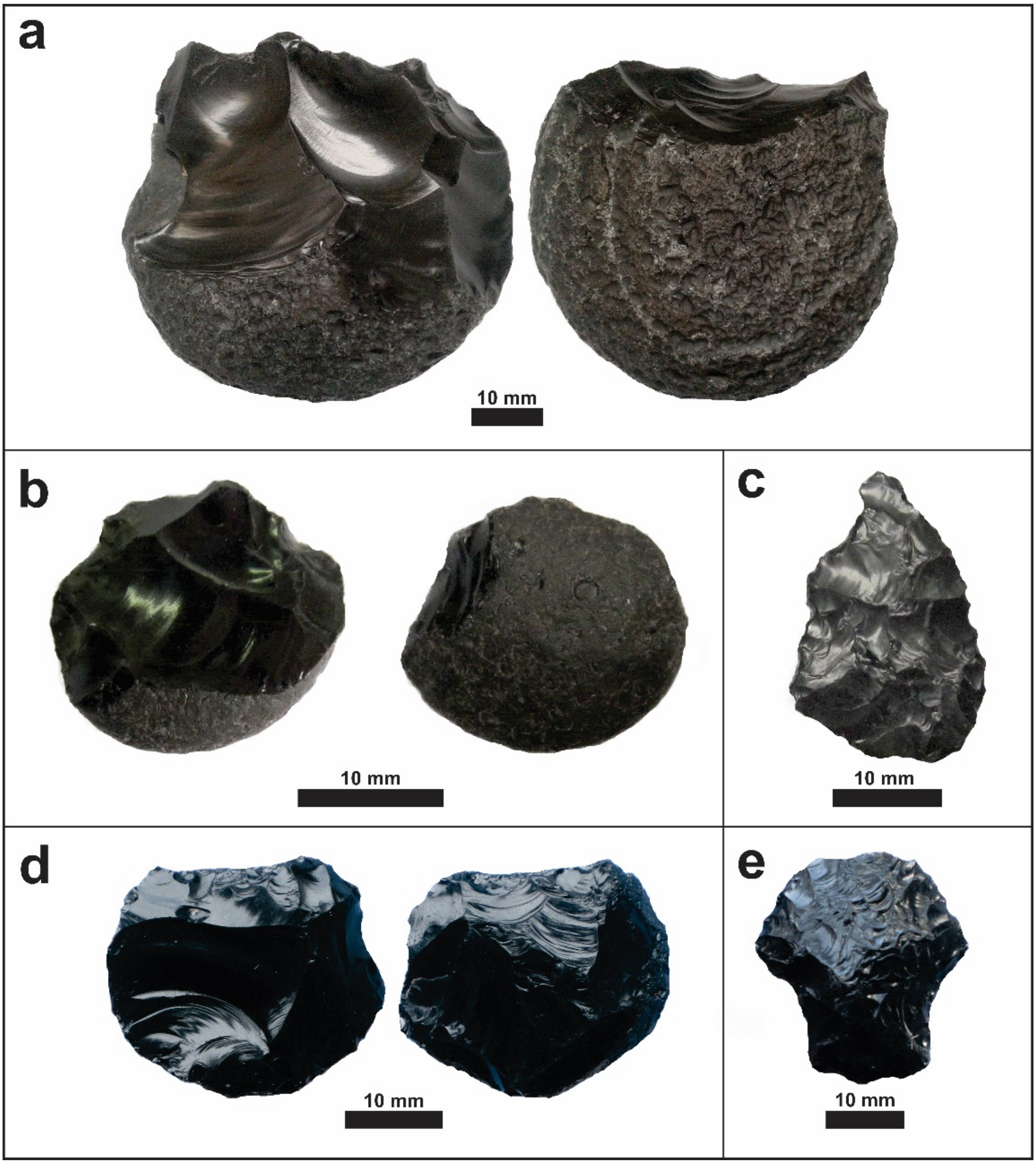

Figure 2. a: Medium-sized obsidian pebble with knapping evidence; b: Small-sized obsidian pebble with evidence of bipolar flaking; c: Obsidian bifacial preform; d: Bipolar core on small obsidian pebble; e: Projectile point.

3.1 Obsidian pebbles from northeastern Santa Cruz

As previously mentioned, at the Punta Medanosa Archaeological Site, located *ca.* 30 km south of the Deseado River Lower Basin (Figure 1), knapped black obsidian pebbles were identified in surface contexts. These were shell middens located on coastal dunes near the Atlantic coast (Hammond 2015: 28; Zubimendi 2019; among others). The archaeological record is composed basically of lithic, animal bone, and malacological remains. Four black obsidian pebbles were recovered from one site (Table 8; Figure 2). These were pieces with discoidal morphology that presented knapping evidence and had an abundant cortex reserve, more than 75% of the surface. As can be seen in Table 8, based on the size ranges proposed by Espinosa & Goñi (1999) for pebbles recorded near Pampa del Asador, piece d had a maximum dimension which assigned it to the small category (up to 5 cm), while the remaining objects were all medium pieces (between 5.1-10 cm) (Figure 2a).

Table 8. Black obsidian pebble size

Black obsidian pebbles				
	Dimensions (mm)			Morphology
Sample	Length	Width	Thickness	
a	57.2	52.4	26	Discoidal
b	53	43.3	-	Discoidal
c	50.5	46	-	Discoidal
d	46.6	33.1	-	Discoidal
Mean	51.8	43.7	-	

4. Exploitation of black obsidian along the northeastern Santa Cruz coast: General trends

In general terms, very low frequencies of black obsidian artifacts were recorded in the Deseado River Lower Basin for the two periods considered here. In both cases, the average proportions did not exceed 3.5%, and were lower than those identified in the central-southern portion of the Deseado Massif during the same time periods (Cueto *et al.* 2016; 2018; Franco *et al.* 2017). In DRLB only a slight increase in frequencies of 2% was observed between the distinct periods. We consider that the observed trends regarding the strategies of exploitation of black obsidian in both temporal blocks were not related to the sample sizes, which in proportional terms were representative of the variations observed in the lithic assemblages identified for both periods.

During the period *ca.* 7,000-3,500 ^{14}C years BP an exceedingly low representation of very small size debris without cortical reserve was observed; cores and tools were not identified. Knapping activities related to intermediate technical steps in the framework of core reduction and blank production were evidenced, with probably small and very small sizes, and bifacial preforms (based on the identification of bifacial thinning flakes). From this we inferred the probable entry to the various sites of pieces belonging to personal toolkits with cores and bifacial artifacts without cortex. In black obsidian assemblages from contexts assignable to 3,500-1,000 ^{14}C years BP period, a greater artefactual variability was observed in terms of typological classes represented (debitage, cores and tools).

5. Discussion and conclusions

The identification of black obsidian pebbles of similar sizes to those available at PDA constitutes a good material correlate to evaluate these discoveries and the artefacts identified in the context of a discussion regarding the possible procurement strategies in an area very distant from the original source. In this sense, it is important to contrast the expected archaeological traits to determine situations of direct and indirect procurement (Charlin 2009; Civalero & Franco 2003; Franco 2014; Meltzer 1989; Odell 1996, among others). According to the principles of raw material economy (*sensu* Odell 1996), for direct procurement scenarios (based on the declination model proposed by Renfrew (1977)) high frequencies of the rock are to be expected. Furthermore, these will present all manufacturing stages and include the presence of cores, high cortex indexes and a generalized raw material use, not restricted to a particular artifact class (Franco 2014).

On the other hand, in indirect procurement contexts, Franco (2014) proposes the existence of two possible scenarios: the exchange of artifacts (usually tools), or raw material exchange (pebbles, blanks and cores). In archaeological contexts, the representation of different stages of the manufacture sequence would be expected, although there could be a prevalence of final stages in accordance to the strategies of raw material economy, and would entail the presence of blanks or cores, as well as flakes and artifacts with cortex (Civalero & Franco 2003; Franco 2014). In both alternatives of indirect procurement, we would expect that the raw material had a low representativeness within the lithic assemblages and that its use would be restricted to certain kinds of tools that were in turn curated (*sensu* Binford 1979).

Based on the expectations of Franco (2004), in general terms the characteristics of the black obsidian record in the north coast of Santa Cruz which presents artifacts (very small and small, in some cases with cortical reserves) and pebbles (small and medium-sized, similar to those observed at PDA), both at low frequencies, suggests that these contexts could be the result of forms of human transport and interaction not directly associated with exchange in formal terms (Smith *et al.* 2012) or direct procurement. Formal exchange (Smith *et al.* 2012) would be linked to reciprocity mechanisms. Based on ethnographic data, the material correlate of this mechanism would be the presence of abundant items outside the area of origin (Kelly 2011). As such, ethnographic studies indicate that hunter-gatherer groups can obtain resources through formal exchange mechanisms motivated by economic issues, and informal exchange whether planned or opportunistic, structured according to the establishment or support of social relationships (Smith *et al.* 2012: 400). This last option is probably the one that best explains the general characteristics identified in the black obsidian assemblages from the Deseado River Lower Basin during the Early to Late Holocene.

These records of low obsidian frequencies across both periods would not correspond to a systematic pattern of raw material circulation. In line with what Pallo & Borrero (2015) state, beyond the fact that the assemblages were recorded above the point of fall-off mentioned above, they do not offer clear evidence regarding the interpretation of the data around the implementation of procurement practice mechanisms linked to scheduled or regular exchange systems. Within regional context, obsidian seems to have been systematically provisioned to a relatively small and circular area around PDA (Pallo & Borrero 2015). In the case of the Deseado River Lower Basin, the procurement and exploitation of PDA black obsidian -for both periods- would have occurred within the framework of human group movements through variable spatial dimensions and mobility ranges which could have included relatively inland areas located near to the coast.

Archaeological data concerning the connections between the coast and inland suggests that mobility would have worked on a spatial scale with a maximum amplitude of *ca.* 150 km (Zubimendi & Ambrústolo 2011). The procurement of black obsidian could have been structured around various non-exclusive mechanisms which might have also been acting simultaneously. For instance, as Pallo & Borrero (2015) suggest, focusing on population vectors along a west-east direction, situations of people displacement which would have been configured across wide mobility ranges -probably secondary with respect to the source acquisition ranges. In these displacements it is possible that they were able to occasionally visit the coast. Following from this, they suggest the existence of differential transport of limited quantities of artifacts and the consequent incidental deposition of some of them.

This could have occurred within the structure of the Deseado River Lower Basin population and exploration phase during the period *ca.* 7,000-3,500 years ^{14}C BP. However, we consider that the fact that, in late contexts there are re-usable medium-sized obsidian pebbles and artifact classes and typological group variability, would not suggest that these pieces had been discarded within a framework of eventual use, this approach is in line with Cueto *et al.* (2018).

When considering population movements in a west-east direction and vice versa, obsidian procurement could have been structured around the implementation of visit mechanisms and extended home ranges. Such strategies would involve the movement of people without the specific purpose of carrying out, for example, exchange of goods (Pallo & Borrero 2015). As such, procurement could have been structured around informal exchange mechanisms (Smith *et al.* 2012), which could have been carried out within the framework of opportunistic or embedded situations (*sensu* Binford 1979) depending on territorial or annual movements with the purpose of establishing or strengthening social relations at the point of meeting. In this context, it is worth mentioning that stable isotope studies carried out on human skeletal remains to evaluate the diets of populations that occupied the Deseado River Lower Basin in the past show a clear trend towards the identification of mixed diets during the Middle and Late Holocene (Moreno *et al.* 2011; Zilio *et al.* 2018). The authors argue that this trend could be explained by a seasonal use of the coast within the framework of a complementary exploitation between the inland and coastal areas. In turn, this mobility scenario could have favoured the circulation of obsidian pieces as high-value goods based on the social aesthetic significance materialised in the rock (Hermo 2008: 438; Hermo & Miotti 2011).

Acknowledgements

We thank the anonymous reviewers and editors of the manuscript for their valuable suggestions. We also thank all members of our research team, who have participated in the field work. We extend our gratitude to the Mario Brozoski Museum and the Municipality of Puerto Deseado. The CONICET, FONCYT and UNLP funded this research.

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Estrategias de aprovisionamiento y circulación de obsidiana negra en la costa norte de la provincia de Santa Cruz (Patagonia Argentina): movilidad e interacción humana

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Resumen:

En este artículo, evaluamos las estrategias de aprovisionamiento y reducción de obsidiana negra registradas en refugios rocosos y sitios concheros ubicados en la costa norte de la provincia de Santa Cruz, en la Patagonia argentina. Los análisis geoquímicos realizados en artefactos de obsidiana negra de esta área muestran la circulación a larga distancia de esta materia prima identificada en la fuente Pampa del Asador, ubicada aproximadamente a 400 km al oeste. En un trabajo anterior, propusimos que el registro de evidencias de explotación inicial de guijarros de obsidiana, sumado a la identificación de artefactos con altos porcentajes de corteza, sugeriría que la obtención de piezas de dicha materia prima habría estado bajo morfologías de guijarros. Los resultados de esta presentación refuerzan esa idea, al menos para contextos ocupacionales asignables al Holoceno tardío.

En el Holoceno medio se observa una representación muy baja de productos de talla de tamaño muy pequeño sin reserva cortical, no se registran núcleos ni artefactos formatizados. Se evidencian actividades de talla relacionadas con estadio técnicos intermedios en el marco de la reducción del núcleo y la producción en nódulos, probablemente con tamaños pequeños o muy pequeños, y preformas bifaciales. Se infiere el probable ingreso a los sitios de piezas como parte de equipos de herramientas personales, núcleos y artefactos bifaciales sin corteza, en el marco de los momentos de exploración.

Para las ocupaciones del Holoceno tardío, en función del hallazgo de guijarros de obsidiana que poseen dimensiones similares a las registradas en la propia fuente, interpretamos que su adquisición se habría producido a través de varios mecanismos vinculados, entre otros factores, con el establecimiento y fortalecimiento de relaciones sociales en el marco de circuitos de movilidad que unirían la costa y el interior.

Keywords: obsidiana; aprovisionamiento; explotación; cazadores-recolectores; movilidad humana; Patagonia