Quaternary International 375 (2015) 72–83

Contents lists available at ScienceDirect

Quaternary International

journal homepage: www.elsevier.com/locate/quaint

Raw material circulation at broad scales in southern Patagonia (Argentina): The cases of the Chico and Santa Cruz River basins

Nora Viviana Franco [a,*], Natalia Andrea Cirigliano [b], Lucas Vetrisano [c], Pablo Ambrústolo [d]

[a] CONICET-IMHICIHU and University of Buenos Aires, Saavedra 15, 5to. Piso, Ciudad de Buenos Aires, 1083, Argentina
[b] CONICET-IMHICIHU, Saavedra 15, 5to. Piso, Ciudad de Buenos Aires, 1083, Argentina
[c] University of Buenos Aires, Puán 480, Ciudad de Buenos Aires, 1406, Argentina
[d] CONICET, University of La Plata, Museo de La Plata, Paseo del Bosque s/n, La Plata, Buenos Aires province, 1900, Argentina

ARTICLE INFO

Article history:
Available online 24 January 2015

Keywords:
Southern Deseado Massif
Santa Cruz River
Hunter–gatherers
Circulation
Obsidian
Siliceous rocks

ABSTRACT

The purpose of this paper is to begin to understand human mobility through rock transport at different times in two areas with different environmental characteristics: the Southern Deseado Massif and the basaltic canyons north of the Santa Cruz River. We focus on obsidian, which has a clear geochemical signature and an uneven distribution. Additionally, we use macroscopic information on siliceous rocks, which at present have only been identified in northern areas, although they may also be recovered randomly and in low frequencies in southern ones.

During the initial peopling of the Southern Deseado Massif (ca. 10,800 BP), inhabitants were transporting black obsidian as well as translucent chalcedony, probably as part of the individual gear. During the Late Holocene, the number of obsidian artifacts decreased in the Southern Deseado Massif, related to a better knowledge of the high-quality local lithic resources and/or to the existence of higher population densities. Obsidian artifacts are more abundant in the northern Santa Cruz River basin than in the southern Deseado Massif, suggesting the existence of a relationship with areas located to the northwest, close to the obsidian source, as other lines of evidence suggest. In addition, the presence in the basaltic canyons of artifacts made from high-quality siliceous rocks, more abundant and predictable in northern areas, could also be the result of human movements following a north-south direction.

1. Introduction

Human mobility has been an important topic within hunter–gatherer studies (e.g. Binford, 1980; Kelly, 1995; Binford, 2001), and has been evaluated in different ways. While isotopic studies provide direct information on human movements, measured at the scale of the individual, as the time scale variable (e.g. Ambrose, 1993; Richards et al., 2005), the study of raw materials provides a different kind of information, as it measures the area utilized by a group (e.g. Geneste, 1988; Johnson, 1989; Cortegoso, 2008). The quantity of artifacts recovered at a specific archaeological site made from a particular raw material depends not only on the distribution of these rocks but on the frequency of group movements and discard rate, among others (e.g. Ingbar, 1994). In any case, a good knowledge of the regional lithic resource base (sensu Ericson, 1984) is required in order to understand human mobility.

The purpose of this paper is to begin to explore human mobility by studying the transportation of rocks at different times in two areas with different environmental characteristics: the Southern Deseado Massif and the basaltic canyons north of the Santa Cruz River. We focus on obsidian, which has a clear geochemical signature and an uneven distribution. Additionally, we use macroscopic information on siliceous rocks, which have been identified only in northern areas. The results are considered to be exploratory.

2. Study areas

Two areas will be studied: the southern tip of the Deseado Massif and an area located to the south, between the Chalia and Santa Cruz River basins, composed of basaltic canyons. The archaeological sites located in the two areas are separated by a minimum distance of ~140 km.

* Corresponding author.
E-mail addresses: nvfranco2008@gmail.com (N.V. Franco), naticirigliano@hotmail.com (N.A. Cirigliano), lucasvetri@yahoo.com.ar (L. Vetrisano), pambrustolo@hotmail.com (P. Ambrústolo).

http://dx.doi.org/10.1016/j.quaint.2014.11.058
1040-6182/

The Deseado Massif is a morphostructural region of 60,000 km^2 located near the center of the Santa Cruz Province, which was shaped by volcanic activity during the Jurassic (De Giusto et al., 1980). The region has mineral veins that penetrate the volcanic and sedimentary bedrock, numerous caves, and excellent raw materials for high-quality flintknapping (e.g. Panza et al., 1998; Cattaneo, 2000; Panza and Haller, 2002; Miotti and Salemme, 2003; Cattáneo, 2004; Echeveste, 2005; Paunero et al., 2007; Hermo, 2008; Paunero, 2009; Skarbun, 2009).

Within the southern tip of the Deseado Massif, there are archaeological localities in different environments: La Gruta and Viuda Quenzana (Fig. 1). The first one is dominated by closed depressions in volcanic and sedimentary rocks that may contain seasonal lagoons and occasionally permanent bodies of water. Some 25 km to the north, in the locality of Viuda Quenzana (Fig. 1), seasonal lagoons are less frequent, but there are seasonal streams and even a few large canyons with semi-permanent streams and springs. Late Pleistocene-Early Holocene dates have been obtained from the archaeological locality of La Gruta (Franco et al., 2010a,b), while both La Gruta and Viuda Quenzana localities have provided early and middle Holocene ages (Aguerre, 2003; Durán et al., 2003; Mancini et al., 2012; Franco et al., 2013). Outside of our study area, in La María locality, 25 km to the east of El Verano, human occupations corresponding both to the Pleistocene–Holocene transition and early Holocene have been identified (Paunero, 2009).

In our study area, dates of ca. 10,840 BP were obtained at La Gruta 1 (Table 1), a site that overlooks a nearby lagoon (Franco et al., 2010a, b; 2013). There is more evidence for human occupation around 9000–8000 BP (Table 1). Archaeological evidence corresponds to the localities of La Gruta, La Martita and El Verano, separated by ~25 km (Aguerre, 2003; Durán et al., 2003; Mancini et al., 2012; Franco et al., 2013). The area shows evidence of occupation until the Late Holocene, although there is no continuous record of occupation at any locality (Aguerre, 2003; Rubinos Perez,

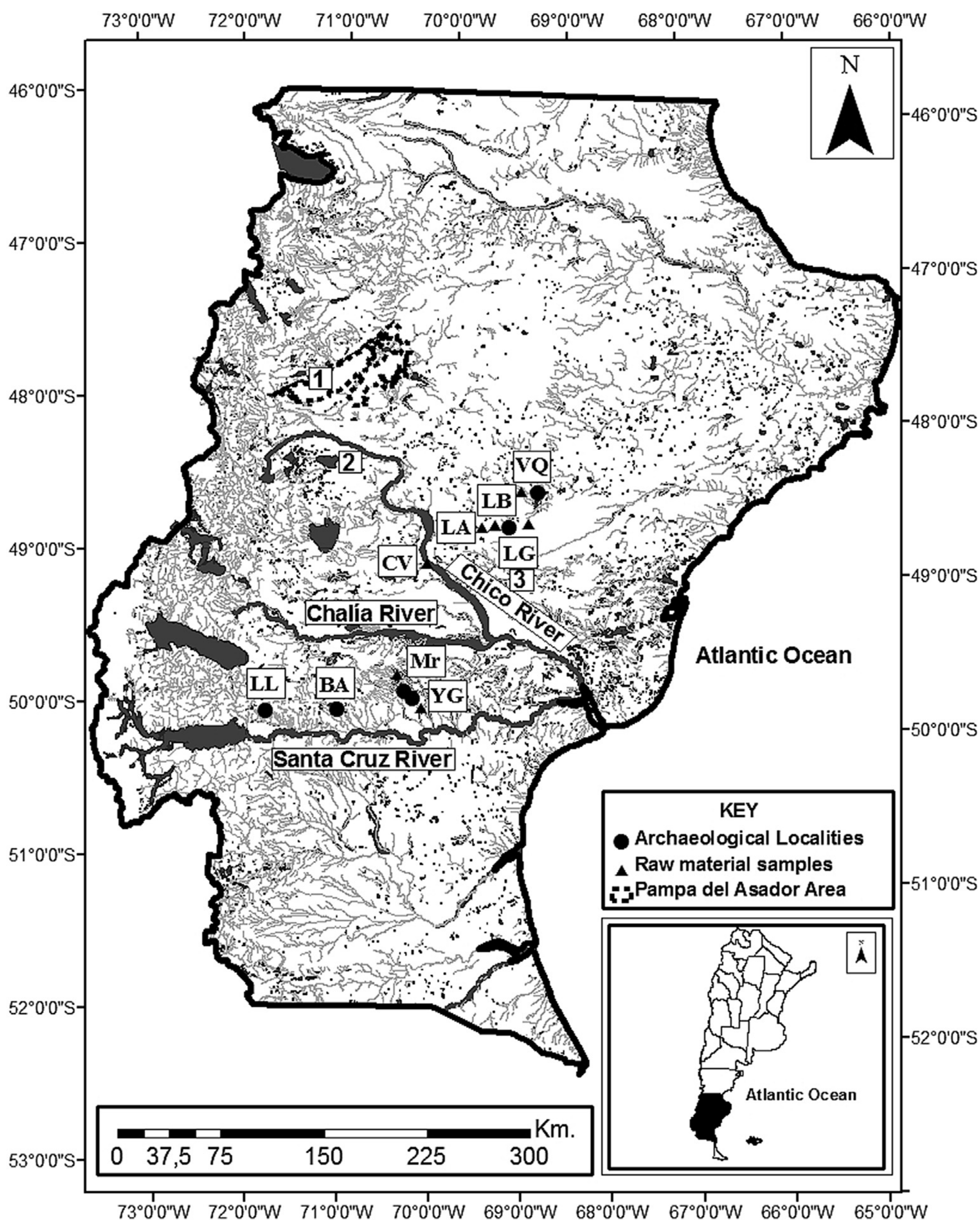

Fig. 1. Map showing main localities mentioned in text. 1. Cerro Pampa, 2. Strobel plateau; VQ: Viuda Quenzana, LG: La Gruta, LB: La Barda, LA: La Alianza, CV: Cerro Ventana, LL: La Laurita, Mr: Mercerat, YG: Yaten Guajen. This figure is based on hydrologic shapes from the Instituto Geográfico Nacional de la República Argentina (2013).

2003; Brook et al., 2013; Franco et al., 2013). Two different periods of human occupation during the Late Holocene were identified in La Gruta 1, one centered between ca. 1800 to 1400 BP and the other at ca. 400 BP (Table 1).

The basaltic canyons and plateaus north of the Santa Cruz River differ from the southern Deseado Massif both in cave and water availability. In this area, human presence is discontinuous and has been dated between ca. 7700 BP and historical times (Burmeister, 1892; Gradin, 1976, 2000; Franco, 2008, 2013; Halvorsen, 2011; Cirigliano and Vommaro, 2014; Franco et al., 2014a). We will focus here on the evidence from La Laurita stream and El Lechuza, where Bi Aike 3 is located, Yaten Guajen and Mercerá canyons (Fig. 1, Table 1). The canyons are incised into a series of basalt flows dating to different volcanic eruptions (Panza and Franchi, 2002). Canyons and streams run in a general north-south direction and in some cases reach the water table.

Previous information indicates the presence of black obsidian artifacts throughout the area (i.e. Franco et al., 2007, 2010a), and throughout southern Patagonia (Stern, 2000, 2004). Geochemical evidence suggests their primary source is Pampa del Asador (Stern, 2000), with secondary sources extending 30 km to the east (Belardi et al., 2006). At the Cerro Pampa source, located within the Pampa del Asador area, the most abundant cobbles are less than 100 mm in diameter (Espinosa and Goñi, 1999). Taking into account the location of the source and the general direction of the glaciations (e.g. Clapperton, 1993; Coronato et al., 1999), the transport of obsidian along the Chico River valley cannot be ruled out. Very recently, a secondary source of very small pebbles of black obsidian has been identified between the southern Deseado Massif and the middle Chico River. The biggest pebbles recovered have maximum lengths of ~36 mm. Geochemical composition is similar to that of Pampa del Asador (Franco et al., 2014b).

The presence of black obsidian in archaeological sites far to the south, including Tierra del Fuego Island (Stern, 2004), suggests either transport or long distance interactions between hunter–gatherer groups. The reasons for this transport could be its excellent flintknapping quality along with the lack of internal impurities.

Siliceous rocks with macroscopic characteristics similar to the ones identified in the Deseado Massif have been recovered at archaeological sites in the basaltic environments north of Santa Cruz River (Franco and Cirigliano, 2009; Franco et al., 2011a). On the basis of geological information, it is possible to find isolated siliceous pebbles, randomly distributed and in low frequencies in this area, in Pampa Alta formation (Panza et al., 2005). However, sampling carried out in the area has not revealed this kind of raw material. Siliceous rocks which can originate in sedimentary deposits are not macroscopically similar to the siliceous rocks from the Deseado Massif.

Table 1
Chronological information from the studied localities.

Site	Radiocarbon age (^{14}C yr BP)	Reference
Southern end of the Deseado Massif		
La Gruta 1	10,845 ± 61	Franco et al., 2010a,b
La Gruta 1	10,840 ± 62	Franco et al., 2010a,b
La Gruta 1	10,790 ± 30	Franco et al., 2013
La Gruta 1	10,656 ± 54	Franco et al., 2010a,b
La Gruta 1	10,477 ± 56	Franco et al., 2010a,b
El Verano Cave 1	8960 ± 140	Durán et al., 2003
La Gruta 1	8090 ± 30	Mancini et al., 2013
La Martita Cave 4	8050 ± 90	Aguerre, 2003
La Martita Cave 4	7940 ± 260	Aguerre, 2003
La Gruta 2	7560 ± 30	Franco et al., 2013
El Verano Cave 1	7500 ± 250	Durán et al., 2003
La Gruta 1	3487 ± 38	Franco et al., 2013
La Gruta 1	1888 ± 39	Franco et al., 2013
La Gruta 1	1829 ± 47	Franco et al., 2013
La Gruta 1	1452 ± 38	Franco et al., 2013
La Gruta 1	400 ± 20	Franco et al., 2013
Canyons North of Santa Cruz River		
Yaten Guajen 12	7717 ± 77	Franco, 2008
Mercerat 1	1640 ± 20	Franco et al., 2014a
Yaten Guajen 1	1323 ± 38	Franco et al., 2014a
Yaten Guajen 12	1306 ± 38	Franco, 2013
Bi Aike 3	1155 ± 40	Franco et al., 2007
La Laurita 1	1000 ± 40	Franco et al., 2007

3. General background and methodology

In order to understand raw material circulation, a proper knowledge of the regional lithic resource base is needed (Ericson, 1984), including all kinds of sources. We follow Church (1994) who defines a primary source as the rock outcrop from which the material was obtained; a secondary source as material eroded from a primary source (e.g. colluvium, talus, scree, gravel, cobbles); and a tertiary source as a lithic artifact assemblage that becomes a source of lithic material for later populations. The importance of this distinction lies in the different amount of energy and time needed to acquire the raw materials.

Primary siliceous rock sources were identified only in the Deseado Massif (Franco and Cirigliano, 2009; Franco et al., 2011a, 2012). Secondary sources are abundant in the area due to extensive glaciation (e.g. Clapperton, 1993; Coronato et al., 1999) and to the presence of rivers. This abundance poses a problem when trying to identify the raw material sources. However, in studies of other areas in southern Patagonia, general source areas of rock provisioning (dacites and chalcedonies) were identified through detailed sampling of potential sources (e.g. Franco and Borrero, 1999; Franco and Aragón, 2004). In addition, the different geological and geomorphological characteristics of the Deseado Massif and the basaltic environments located to the south suggest that it should be possible to identify general provisioning areas for a variety of raw materials.

Siliceous rocks abundant in the Deseado Massif are present in the Chon Aike and La Matilde formations, both corresponding to Bahía Laura Group. These formations contain Jurassic ignimbrites and tuffs with varying silicification, as well as quartz veins with different silicification degrees, hydrothermal hydration veins, and crack fills in ferrous hydrothermal environments, some reddish, black, grey and white (e.g. Panza et al., 1998; Schalamuk et al., 2002). Silicified wood as well as opals have been identified in the Baqueró Formation (Panza et al., 1998), at Viuda Quenzana archaeological locality. In the same formation, Durán et al. (2003) have also identified siliceous rocks of different colours (mainly red) as well as silicified wood near the el Verano archaeological site.

In the basaltic area, chalcedonies and other siliceous rocks occur as vesicle fillings or as veins within the basalts, some of them highly localized. Translucent chalcedony has only been recovered in secondary deposits (Franco and Cirigliano, 2009). According to geological information, acid silicified ignimbrites and tuffs could be found randomly and in limited amounts in piedmont deposits, coming from primary deposits to the west (Panza et al., 2005), although they have not been recovered during raw material sampling.

High quality siliceous rocks, mostly reddish, beige, and black, are more frequent and predictable in the Deseado Massif. Because the Chico River could have been larger in the past, it could also have transported siliceous rocks from the northwest, a possibility which we will take into account in this analysis.

In many areas of the world, geochemical analyses (e.g. NAA, XRF) have been used to identify raw material provenance. The application of these techniques to potential siliceous sources has shown that in some cases the internal variability within the source is greater than the variability between sources (Luedtke, 1979). The technique has proved useful in differentiating siliceous rocks from volcanic outcrops and those from sedimentary formations in southern areas (Franco and Aragón, 2004). In order to apply this analysis, it is necessary to have information coming from a large number of samples in an area, which is not available yet. Because of this, in this paper we will focus on obsidian transport, which is the most homogenous raw material and whose origin has been geochemically traced to the sources (e.g. Stern, 2000; Belardi et al., 2006; Franco et al., 2014b). Complementary, we will provide information on artifacts made from siliceous rocks using macroscopic data. In the future, once the quantity of samples available has increased, geochemical analyses are planned.

In order to begin to understand the lithic regional resource base (Ericson 1984), sampling was carried out in localities with different environmental characteristics. They were selected taking geological information into account. However, as this information is generated at a scale which is different from the human one, additional data was generated by sampling in places with different characteristics, such as, in the case of secondary sources, places where cobbles of different sizes (and potentially, different raw material) could be expected (Franco, 2002). Raw material selection was based on its quality, focusing on good, very good, and excellent ones (Franco and Borrero, 1999), as well as on the ones which were present or can be expected to be present in the archaeological record. In the case of primary sources, samples were taken in different parts of the outcrop and homogeneity was estimated on the basis of quality variations within the samples obtained.

As secondary deposits are abundant in the area, as a whole it was important to explore internal variation within them. In order to do so, sampling of secondary sources was carried out by 2 or 3 people during a fixed amount of time in order to have information comparable with other areas where the same methodology was applied (Franco and Borrero, 1999). Although time and quantity of people were not always the same, the information obtained in the field could be compared through mathematical procedures. All the results were normalized to a sample obtained by 2 people in 10 min. Type of raw material, size (maximum length, width and thickness, expressed using the median because of high measurements variability), flintknapping quality, and productivity (percentage of raw material which corresponds to the specified quality in each case (Franco et al., 2011a), were recorded. As it was important to understand siliceous rocks' availability and variability between sources, quality was evaluated taking into account only these raw materials.

Systematic raw material samplings were carried out in the southern Deseado Massif, in areas close to the Chico River basin, due to the possibility of rock transport in the past, and in the basaltic plateaus close to the Santa Cruz River (Fig. 1). Unsystematic sampling was also carried out in order to complete information in locations between systematically sampled areas. In this case, the same information was recorded.

Raw materials can be acquired through direct or indirect procurement, which have different archaeological consequences. In cases of direct procurement, we expect a decrease in the quantity of raw materials and artifact size and an increase in the discard angle of curated tools (e.g. endscrapers) at increasing distance from the source (Renfrew, 1977; Dibble, 1987; Franco, 1991, 1994, 2014; Morrow, 1997). In cases of raw material exchange or indirect provisioning, we expect to find few tools (instead of artifacts) coming from localized sources (Meltzer, 1989), although cores and nodules can also be exchanged, which would result in the presence of debitage (Franco, 2014).

The archaeological samples come from sites located in different environments. In the southern Deseado Massif, we analyzed La Gruta 1 site, a rock shelter in a cliff overlooking a seasonal lagoon, with evidence of human occupation from ca. 10,800 to 400 BP (Franco et al., 2010a,b; 2013; Brook et al., 2013). Lithic evidence as well as the site location point to a logistic occupation of this rock shelter, probably by few people, during the Pleistocene–Holocene transition (Franco et al., 2010a,b). According to available evidence, its function would have been the same throughout the Holocene. Information from this site is compared to that obtained by Aguerre and Durán in La Martita and El Verano localities respectively, located 25 km distant.

In the case of the basaltic canyons, information comes from the following rock shelters (Table 1): La Laurita (ca. 1000 BP), Bi Aike 3 (ca. 1100 BP), Mercerat 1 (ca. 1600 BP), Yaten Guajen 1 (ca. 1300 BP) and 12 (dated at ca. 7700 and 1300 BP) (Franco et al., 2007, 2014a; Franco, 2008). Site function is not clear in most of these sites, with the exception of Yaten Guajen 12, where flintknapping activities seem to have had an important role during its latest period of occupation.

Based on the available dates from archaeological sites in the study area we will focus on the following three periods: 1) 10,840–10,400 BP; 2) 8000–3000 BP; 3) from 1800 BP to the arrival of Europeans in the area. The longer extent of period 2 is due to the existence of an erosion episode or hiatus in sedimentation in La Gruta 1 (Brook et al., in press), which makes it very difficult to differentiate artifacts corresponding to its beginning and end.

Variables analyzed in the archaeological samples were the percentage of each of these raw materials, artifact classes (i.e., flakes, ends-scrapers, projectile points), maximum length, and presence of cortex. We are aware that the frequency of cortex can be related not only to the vicinity to the source, but also to the size of the available cobbles or pebbles (Bradbury and Carr, 1995). Classes and size of artifacts recovered can also vary in relationship with the site function (among others, Binford, 1978, 1980; Shott, 1986; Cowan, 1999).

In order to explore how raw materials were obtained, obsidian frequencies, sizes and presence of cortex in the different archaeological sites are compared with information of its provenance. Complementarily, we seek tendencies in the case of siliceous rocks.

4. Results

This paper will focus on obsidian utilization and will provide preliminary information on siliceous rocks' availability and transport using macroscopic data, mainly in the Deseado Massif.

4.1. High-quality raw material availability

These raw materials include obsidian and some varieties of siliceous rocks (cherts, translucent, yellow, reddish and brownish chalcedonies, opals, silicified woods, etc.; see Fig. 2).

4.1.1. Obsidian

The primary source of black obsidian is located at Pampa del Asador, with its dispersion area at a minimum distance of ~120 km (Espinosa and Goñi, 1999; Belardi et al., 2006) northwest of our study area (Fig. 1). Recently, obsidian pebbles of very small size were located at 17 de Marzo, north of Chico River, with a geochemical composition similar to that of Pampa del Asador (Franco et al., 2014b). This opens the possibility of the existence of more obsidian pebbles in the area between the primary source and 17 de Marzo.

Fig. 2. Hand samples of some of the raw materials available in the southern Deseado Massif. References: 1. Yellowish chalcedony; 2. Reddish siliceous rock; 3. Brownish opal; 4. Reddish siliceous rock; 5. Brownish siliceous rock; 6. Red siliceous rock; 7. Translucent chalcedony; 8. Grey and reddish chalcedony; 9. Brownish and black siliceous rock.

4.1.2. Siliceous rocks' availability

High-quality siliceous rocks are more abundant in the southern Deseado Massif, and they could also have been transported through the Chico River. As mentioned, they can be randomly found at piedmont deposits (Pampa Alta Formation, cf. Panza et al., 2005) near the basaltic canyons (Fig. 1). Systematic samplings were carried out in these different locations.

4.1.2.1. Southern Deseado Massif. Siliceous rocks are more available in the Southern Deseado Massif than elsewhere in our study area, although size and general characteristics of the rocks vary from place to place (Tables 2 and 3). Primary sources of siliceous rocks were identified in La Alianza, La Barda, and La Gruta (Table 3), the first one of better quality. In the case of La Gruta, a brownish chalcedony sinter was identified. In the Viuda Quenzana locality, high-quality siliceous rocks are abundant (Table 2). The largest sizes correspond to La Gruta (Fig. 3) and La Barda (Table 2), probably related to its close proximity to the outcrops. Excellent and very good chalcedonies (Fig. 4) are more frequent in Viuda Quenzana (Table 2). In this locality, silicified wood was only recovered during unsystematic surveys (not included in Table 2), probably coming from the Baquero Formation (Panza et al., 1998) (Fig. 5).

Fig. 3. Hydrothermal cherts from La Gruta locality.

Fig. 4. Translucent chalcedony from Viuda Quenzana locality.

South of the Deseado Massif, the Chico River could have transported siliceous rocks. Because of this, samplings were carried out near the Cerro Ventana volcanic basaltic neck (Panza et al., 2005). The presence of chalcedony, silicified wood, and other siliceous rocks with macroscopic characteristics similar to the ones recovered in the Bahía Laura Group was identified. They are cobbles, most of small sizes, with a high percentage (70.83%) of siliceous rocks of very good quality (Table 2).

4.1.2.2. North of the Santa Cruz River basin. In this area, dacites are common, but they are generally of inferior quality than other siliceous rocks (Fig. 6). Translucent chalcedonies were recovered only during unsystematic surveys near the mouths of the canyons, but they are present in very low frequencies (Fig. 7). Only six specimens have been recovered, with median sizes of 50.5, 38.5, and 25.5 mm, with standard deviations of 25.23, 19.45, and 11.23. All are macroscopically different from the chalcedonies available at the Deseado Massif.

4.2. High-quality raw material utilization

4.2.1. Obsidian

Obsidian was utilized during different time periods.

4.2.1.1. 10,840– 10,400 BP. This raw material was recovered in small quantities in the deepest deposits of La Gruta 1 (Table 4). Its small size opens the possibility of the utilization of the 17 de Marzo source (~18 km), and could have been obtained during daily activities.

4.2.1.2. Ca. 8000– 3000 BP. In the interior of the Deseado Massif, in La Gruta 1, only one obsidian flake was recovered. It is a bifacial reduction flake, larger than those in the previous period (Table 5). In La Martita Cave 4, the percentage of obsidian reaches 12.41% of the total sample (Aguerre, 2003), and in El Verano Cave 1, comprises 14.40% of the tools and 6% of the debitage. In La Martita Cave 4, obsidian was used for side-scrapers, triangular projectile points, bifacial artifacts, and bifacial reduction flakes (Aguerre, 2003). In this case, obsidian artifact length reaches 50 mm (Aguerre, 2003), which points to the knowledge of the Pampa del Asador area.

In the canyons north of Santa Cruz River, 23.71% of the artifacts were made of obsidian in Yaten Guajen 12 site (Table 5). This percentage, along with the presence of cores, flakes and end-scrapers would suggest the utilization of cobbles, probably by direct procurement. The largest recovered is 25 mm (Table 5).

To sum up, the percentage of obsidian in Yaten Guajen 12 is much higher than the one found in the sites of the Southern Deseado Massif (La Gruta 1, La Martita Cave 4 and El Verano Cave 1), in spite of the fact that the first one is farther away from obsidian sources than the ones located in the Deseado Massif (Fig. 1). In addition, the amount of cortex reaches 90% in Yaten Guajen 12, while there is no cortex in La Gruta 1 (Table 5). The small size of the cobbles and pebbles available at the sources can explain the high percentages of cortex (Bradbury and Carr, 1995) in Yaten Guajen 12.

Taking the evidence into account and that the minimum distance to the secondary identified source (17 de Marzo) is ~125 km, three possibilities arise: a) the existence of another source of black obsidian closer to the area, as has been suggested by local inhabitants, b) the scarcity of very good quality rocks in the canyons, or c) a differential behavior towards obsidian due to some of its characteristics, such as a higher flintknapping quality than the other available rocks, lack of internal impurities, or its light weight and vitreous quality (Callahan, 1979; Nami, 1986). Because of these reasons, different tools can be obtained from small nodules, which make it ideal for long-distance transport (Nelson, 1991). Geochemical NAA analysis carried out on surface samples of obsidian artifacts from the basaltic canyons points to Pampa del Asador as the source (Stern pers. comm.).

4.2.1.3. Since ca. 1800 to 400 BP. Obsidian is also present in both areas during this period. In the case of the Southern Deseado Massif, it occurs at the lowest frequency in the youngest deposits (ca. 400 BP). The largest size is, in the case of La Gruta 1, 25 mm (Table 6), opening up the possibility of the utilization of any source. The decrease in the quantity of obsidian can probably be related to a better knowledge of high-quality raw material availability.

The frequency of this raw material varies in sites located along the canyons north of the Santa Cruz river, higher in Yaten Guajen than in La Laurita and El Lechuza canyons. In addition, its frequency is higher in Yaten Guajen 12 and Mercerat 1 sites (~12%) than in the Southern Deseado Massif (less than 3%), even though the first two sites are farther away from the known obsidian sources (Fig. 1). The variety of artifacts classes recovered is higher in Mercerat 1 (flakes and end-scrapers) than in the Southern Deseado Massif (only flakes), a difference which could be related to site functions (Tables 7 and 8).

In the case of the size of artifacts, the largest have been recorded at Mercerat 1 (30 mm maximum length). In addition, in the basaltic canyons, both Yaten Guajen 1 and Mercerat 1 have artifacts with a high percentage of cortex (100% and 80% respectively), in contrast to La Gruta 1, where there is no cortex. These data reinforce the idea of the transport of cobbles to the basaltic canyons.

4.2.2. Siliceous rocks

4.2.2.1. 10,840–10,400 BP. In La Gruta 1, translucent reddish chalcedony macroscopically similar to raw materials available at Viuda Quenzana, 25 km away, was identified. The distance is well within the home range of hunter–gatherers at these latitudes (Binford, 1980; Kelly, 1995). This suggests that human groups were probably obtaining siliceous rocks within their regular daily activities. In Table 4 and subsequent tables, the percentage of siliceous rocks indicates only those not available in La Gruta area, i.e., which were probably transported from nearby areas.

4.2.2.2. Ca. 8000–3000 BP. During this period, the reddish chalcedony, probably coming from Viuda Quenzana, continued to be used (Table 5). In addition, a cache composed mainly of bifacial

Fig. 5. Hand samples from Cerro Ventana locality.

preforms (Fig. 8) recovered in La Gruta area (Franco et al., 2011b) has similar technological characteristics to the artifacts identified in the oldest deposit of La Martita Cave 4, dated to ca. 8000 BP (Aguerre, 2003). These artifacts are made from a high quality chert, which was also recovered in El Verano Cave 1 site, with dates between 9000 and 8000 BP (Durán et al., 2003) and in La Gruta 1 in the deposits included in this time period. The utilization of the same raw material and the striking similarities in the technological characteristics of the caches of La Gruta, El Verano (Durán pers. comm.) and La Martita deposits, corresponding to initial manufacturing stages, allow us to attribute the three assemblages to the same time interval. These similarities in sites that are less than 25 km apart suggest that they probably fall within the area used by the same human group. Bifacial tools or early-stage bifaces of this size have not been recovered in the area or to the south after ca. 8000 BP (Aguerre, 2003; Durán et al., 2003). In the basaltic canyons, very low frequencies of flakes made from siliceous rocks have been recovered (Table 5).

4.2.2.3. Since ca. 1800 -400 BP. In La Gruta 1, artifacts made from rocks with similar characteristics to the ones locally available are present in similar percentages between ca. 1800–1400 BP and ca. 400 BP (Table 6). In the basaltic canyons north of Santa Cruz river basin, artifacts made on high-quality siliceous rocks, mainly reddish and brownish chalcedony (Aragón pers. comm.), were only recovered in Mercerat 1 and Yaten Guajen 1, with dates of ca. 1600 and 1300 BP respectively (Tables 7 and 8). Undetermined tools, blades and small-size debitage have been recovered. They have sizes of less than 15 mm and only in one case was cortex recorded (Table 8). The lack of these raw materials in stratigraphy in western locations could be a result of the small size of the samples of the sites at La Laurita and Bi Aike.

Table 2
Raw materials recovered from secondary sources.

Type of rocks recovered at secondary sources	VQ	LG	LB	CV
Chalcedonies	37.78%	31.96%	56.67%	21.15%
Opals	2.22%	3.09%	0.00%	0.00%
Silicified woods	0.00%	2.06%	0.00%	9.62%
Other siliceous rocks	55.56%	37.11%	6.67%	15.38%
Other type of rocks	4.44%	25.77%	36.67%	53.85%
Median size of silicified rocks in mm (length, width and thickness)	40 × 20.5 × 11	90 × 63 × 40	74.5 × 51 × 30	50 × 36 × 22.5
Percentage of siliceous rocks of excellent quality	7.14%	1.45%	10.53%	4.17%
Percentage of siliceous rocks of very good quality	54.76%	27.54%	5.26%	70.83%
Percentage of siliceous rocks of good quality	19.05%	39.13%	36.84%	12.50%

Key: VQ: Viuda Quenzana; LG: La Gruta; LB: La Barda; CV: Cerro Ventana.

Table 3
Raw materials recovered from primary sources.

Type of rocks recovered at primary sources	LG	LA	LB
Chalcedonies	Yes	Yes	Yes
Opals	No	No	No
Silicified wood	No	No	No
Other siliceous rocks	No	Yes	No
Outcrop quality	Good-vg	vg	Regular-vg
Outcrop homogeneity	Medium	High	Medium

Key: LG: La Gruta; LA: La Alianza; LB: La Barda; vg: very good.

5. General considerations

During the initial peopling of the Southern Deseado Massif, early inhabitants were transporting obsidian as well as chalcedony from nearby localities, probably as part of the individual gear. From ca. 8000 BP, there are similarities in raw material and technology in different localities in the southern tip of the Deseado Massif, which suggests that the area was utilized by the same human group. Obsidian tools recovered in this area (La Martita cave 4 archaeological site) have sizes larger than the ones identified in the 17 de Marzo source, suggesting knowledge of Pampa del Asador. Obsidian continued to be transported until the Late Holocene, decreasing in frequency at the end of this period, which could be related to better knowledge of the local high-quality lithic resources. In the canyons north of the Santa Cruz River, obsidian artifacts are more abundant, related to the very low frequency of high-quality rocks in this area, or to the existence of an unidentified source (a possibility that geochemical results do not support). Obsidian transport could have been the result of relationships with spaces located close to the obsidian sources or from direct acquisition, if the source utilized is 17 de Marzo. Obsidian evidence points to the ease of access to the sources during the late Holocene, which is the period with the most abundant evidence of occupation of the basaltic canyons. Close similarities in guanaco engravings (Franco, 2008; Fiore and Ocampo, 2009; Franco et al., 2014a) between the basaltic canyons and the Strobel plateau (Re, 2010), close to Pampa del Asador, support the existence of contacts between these areas, as has been suggested by other authors (Belardi and Goñi, 2006). Obsidian circulation is consistent with the widening of social networks during moments of higher population density

Fig. 6. Hand samples of dacites from Yaten Guajen locality.

Fig. 7. Chalcedonies recovered in Yaten Guajen area.

(Carden, 2008) and/or to human mobility (Gradin, 1976), as has been suggested on the basis of the wide distribution of different kinds of engravings, such as footprints (i.e. Gradin, 1976, 2001, 2003; Re, 2010). This evidence would suggest that Pampa del Asador is a probable source of the obsidian recovered in the basaltic canyons. Data available at present do not allow us to distinguish between a situation of contact among different cultural groups which share a common cultural background, and the movement of the same human group across the different areas. These movements would have followed a general north-south axis.

Artifacts made on siliceous rocks similar to the ones available at the Chico River basin have also been recovered in the basaltic

Table 4
Obsidian from Pampa del Asador area and siliceous rocks from the Southern Deseado Massif and Chico river area (Viuda Quenzana and Cerro Ventana localities) recovered in the oldest deposits in La Gruta 1. Percentage is calculated on the basis of the total artifact sample of the period.

Ca. 10,800– 10,400 years ^{14}C yr BP		La Gruta 1
Obsidian	Percentage	4,08%
	Artifacts	Flakes
	Maximum length	15 mm
	Cortex presence	No
Siliceous rocks	Percentage	6,12%
	Artifacts	flakes and blades
	Maximum length	20 mm
	Cortex presence	No

Table 5
Obsidian from Pampa del Asador area and siliceous rocks macroscopically similar to the ones available in the Southern Deseado Massif and Chico River areas (Viuda Quenzana and Cerro Ventana localities) recovered in La Gruta 1 and Yaten Guajen 12. Percentage is calculated on the basis of the total artifact sample of the period.

Ca. 8000–3000 ^{14}C yr BP		La Gruta 1	Yaten Guajen 12
Obsidian	Percentage	1.85%	23.71%
	Artifacts	Flake	core, flakes, end-scrapers
	Maximum length	25 mm	25 mm
	Cortex presence	No	Yes (up to 90%)
Siliceous rocks	Percentage	5.56%	0.33%
	Artifacts	Flakes	Flakes
	Maximum length	15 mm	15 mm
	Cortex presence	No	No

Table 6
Obsidian from Pampa del Asador and siliceous rocks macroscopically similar to the ones recovered in the Southern Deseado Massif and Chico River basin (Viuda Quenzana and Cerro Ventana localities) present in different archaeological deposits in La Gruta 1. Percentage is calculated on the basis of the total artifact sample of the period.

After ca. 1800 ^{14}C yr BP		La Gruta 1 (ca. 1800–1400 ^{14}C yr BP)	La Gruta 1 (ca. 400 ^{14}C yr BP)
Obsidian	Percentage	2.56%	0.72%
	Artifacts	Flakes	Flake
	Maximum length	25 mm	10 mm
	Cortex presence	No	No
Siliceous rocks	Percentage	7.69%	7.19%
	Artifacts	Flakes	Flakes
	Maximum length	30 mm	15 mm
	Cortex presence	Yes (up to 90%)	No

Table 7
Obsidian from Pampa del Asador and siliceous rocks similar to the ones available in the the Southern Deseado Massif and Chico River basin present in different archaeological deposits in the western basaltic canyons (north of Santa Cruz River). References: NA: not applicable because of the small size of the sample ($n = 1$). Percentage is calculated on the basis of the total artifact sample of the period.

After ca. 1800 ^{14}C yr BP		La Laurita 1 (ca. 1000 ^{14}C yr BP)	Bi Aike 3 (ca. 1155 ^{14}C yr BP)
Obsidian	Percentage	NA	2,85%
	Artifacts	Flake	Flake
	Maximum length	10 mm	10 mm
	Cortex presence	No	No
Siliceous rocks	Percentage	No	No
	Artifacts	No	No
	Maximum length	No	No
	Cortex presence	No	No

Table 8
Obsidian from Pampa del Asador and siliceous rocks similar to the ones available in the Southern Deseado Massif and Chico River basin present in different archaeological deposits in the central basaltic canyons (north of Santa Cruz River): References: YG: Yaten Guajen. Percentage is calculated on the basis of the total artifact sample of the period.

After ca. 1,800 ^{14}C yr BP		YG1 (ca. 1,300 ^{14}C yr BP)	YG 12 (ca. 1,300 ^{14}C yr BP)	Mercerat 1 (ca. 1,600 ^{14}C yr BP)
Obsidian	Percentage	0,76%	12,54%	12,42%
	Artifacts	Flake	Flakes	Flakes, end-scraper
	Maximum length	10 mm	25 mm	30 mm
	Cortex presence	No	Yes (up to 100%)	Yes (up to 80%)
Siliceous rocks	Percentage	1,54%	No	5,08%
	Artifacts	Flake, undetermined tool	No	Flakes, blade
	Maximum length	10 mm	No	15 mm
	Cortex presence	No	No	Yes (up to 60%)

Fig. 8. Bifacial preforms from El Escondrijo (La Gruta locality).

canyons north of Santa Cruz River in low frequencies. These rocks could have also been eventually obtained from the Pampa Alta Formation, although at present they have not been recovered. However, due to the high mobility of these populations, procurement of high-quality siliceous rocks in northern areas would not be surprising, as obsidian shows.

We believe the study of raw material circulation and its continuities and/or changes through time can provide interesting clues to the understanding of human mobility in the past. In the future, additional geochemical analysis will be carried out both on obsidian and on certain varieties of siliceous rocks, in order to investigate the tendencies macroscopically observed.

Acknowledgements

Research was funded by projects PIP 356 and 0447CO (CONICET) and UBACyT W1/0404 (University of Buenos Aires). We wish to thank Drs. F. Skarbun and M. Cueto for their invitation to participate in this publication. A first version of this paper was presented at the Fifth Arheoinvest Symposium, “Stories Written in Stone”, International Symposium on Chert and other Knappable Materials, organized by Otis Crandell, Universităţii Al.I. UAIC. Iasi, Rumania. We are especially grateful to Brenda Gilio for providing us with Fig. 1 and to all the people that took part of the field works. George Brook and two anonymous reviewers made useful suggestions to the manuscript.

Triton S.A. Mining Company provided lodging and food during field work at La Gruta. Piedra Grande S.A. gave support to our work in Viuda Quenzana. The University of Georgia AMS Radiocarbon Laboratory, and University of Arizona Radiocarbon Dating Laboratory provided support for AMS radiocarbon ages. We wish to thank Dirección de Cultura and Dirección de Turismo from Gobernador Gregores (M. Cebeyra and P. Ramirez), and Comandante Luis Piedra Buena (Betty Knoop), and to researchers E. Aragón, A. Aguerre and V. Durán, and to the owners and workers of the ranches (Hudson, Reinsch, Pitchl and Helmich families).

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