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Obsidian circulation in south-central Andes after ca. 1100 BP: A contribution based on geochemical studies in Argentinean Southern Puna Plateau

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ABSTRACT

This work investigates questions regarding obsidian circulation among the late populations (since ca. 1100 BP) of Antofagasta de Sierra (Catamarca Province, Argentinean Southern Puna Plateau). By means of geochemical provenance studies conducted on obsidian artefacts, the sources of obsidian that these groups accessed have been identified. The samples considered in this study were collected at three radiocarbon-dated sites in the micro-region: La Alumbrera, Bajo del Coypar II and Campo Cortaderas.

The results obtained are compared with those available for other contemporary sites and Formative contexts (ca. 3000–1100 BP) within the area of study. A preliminary discussion is presented on the basis of the environmental, political and social tendencies that characterized the times after ca. 1100 BP at the micro-region and south-central Andes.

1. Introduction

Since Archaic times (10000–3500 BP), relations and contact with other distant zones have been pointed out in the micro-region of Antofagasta de la Sierra (Fig. 1), on the basis of the study of vegetal remains (Olivera et al., 2003, 2003/2005; Rodríguez, 2003), rock art (Aschero, 2000; Martel and Aschero, 2007), lithic and mineral materials (Escola and Hocsman, 2007; López Campeny and Escola, 2007; Yacobaccio et al., 2002, 2004), and ceramics (Olivera, 1991a, 1991b; Raffino and Cigliano, 1973).

This work aims to identify the distant places that may have been accessed, in a direct or indirect way and by means of different mechanisms (exchange, reciprocity, caravan traffic), by the groups that dwelt in the micro-region of Antofagasta de la Sierra since ca. 1100 BP. Geochemical provenance studies have been conducted on obsidian artefacts collected from different sites in the micro-region considered in this temporality: La Alumbrera, Bajo del Coypar II and Campo Cortaderas. The analysis allows us to establish the distances covered by the different obsidian varieties from their sources, as well as to distinguish contacts with distant populations. Finally, we add the results obtained on obsidian artefacts from other contemporary sites in the area and compare them with those available from Formative sites (ca. 3000–1100 BP). We want to contribute to the discussion about the variations in the access to different sources of obsidian and their circulation in political, social and economic scenarios that characterized the times after ca. 1100 BP in the Argentinean Northwest (NOA) and south-central Andes.

2. Background

2.1. Antofagasta de la Sierra: geography and environment

The micro-region of Antofagasta de la Sierra is in the Argentinean Southern Puna, in the extreme northwest of Catamarca Province (Argentina). The Andean Puna has an extremely arid climate, with summer regime precipitations, wide daily and seasonal thermal amplitudes, and low atmospheric pressure. In summary, it is an extremely variable environment in the short term and highly unpredictable (Olivera et al., 2004).

There are three micro-environments in the micro-region that present ecological and topographic differences, as well as differential offerings of faunal, vegetal, lithic and mineral resources (Olivera and Podestá, 1993): basin bottom (3400–3500 m.a.s.l.), intermediate sectors (3550–3900 m.a.s.l), and high ravines (3900–4600 m.a.s.l) (Fig. 1).

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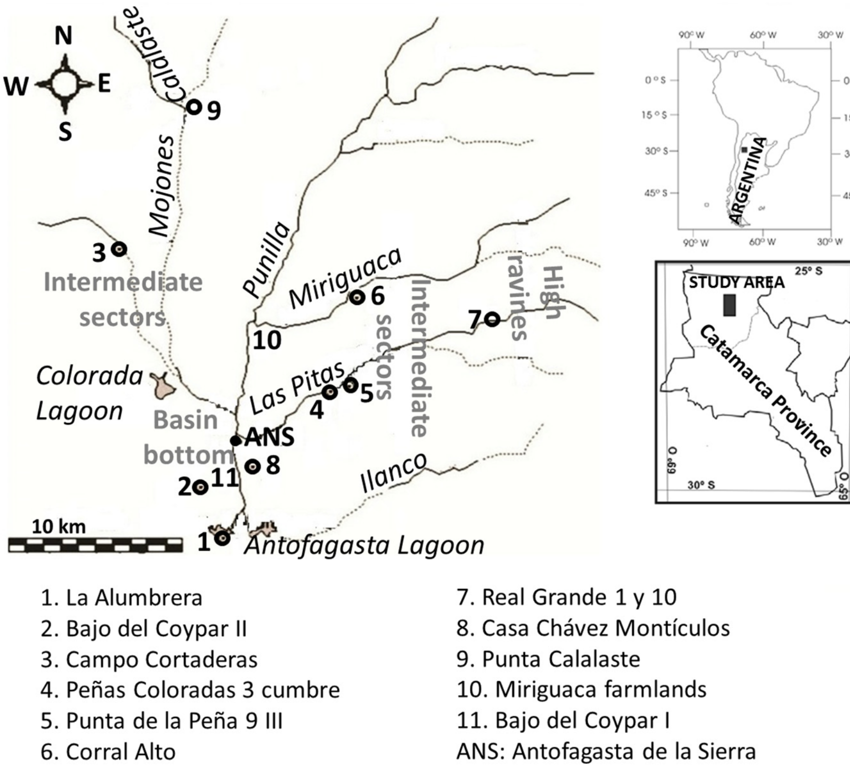

Fig. 1. Archaeological sites of Antofagasta de la Sierra micro-region.

2.2. NOA and south-central Andes societies after ca. 1100 BP

The period ca. 1100–550 BP has been characterized by relevant changes in societies from different regions of the NOA and south-central Andes: a more intensive uses of the territories; an increase in the importance of agriculture in subsistence; the development of internally hierarchical systems in which certain groups centralized the economic, political and social power; the existence of different socio-political systems in conflict for the access to productive land; the regionalization of certain materialities (e.g. ceramic) (Albeck, 2001; González and Pérez, 1993 [1972]; Nielsen, 2001; Núñez Regueiro, 1974; Nuñez and Dillehay, 1995 [1979]; Tarragó, 2000; among others).

Among the changes mentioned, we are interest to focus on the occurrence of generalized endemic conflicts. They were associated with a cycle of prolonged droughts as evidenced by various paleo-environmental data (Nielsen, 2002). The analysis of oxygen isotopes and concentrations of atmospheric dust particles in the glacier of Quelccaya (Southern Peruvian Andes) indicate a dry period between ca. 840–500 BP that was especially intense between ca. 750–690 BP. On the other hand, in the glacier of Huascarán, located further north in the Cordillera Blanca (Perú), there is an enrichment of ^{18}O, indicating a warm period between ca. 1150–900 BP (Thompson, 1995; Thompson et al., 1985, 1995). Additionally, there was a marked decrease in the levels of Lake Titicaca ca. 970–720 BP (Binford et al., 1997; Kolata and Ortloff, 1996). Abbott et al. (1997) suggest that around ca. 950 BP a drought led this lake to its minimum level, which it maintained until approximately 600 BP. With regards the NOA, in the zone of El Infiernillo (Tafi Valley, Tucumán Province), the study of palynological profiles allowed notice of a decrease in the bush pollen percentage and the predominance of herbaceous species towards 875 ± 20 BP, which suggests a drop of humidity in relation to preceding times (Garralla, 1999). The environmental dryness would also have increased from ca. 1100 BP in the Tapia-Tranca basin (Tucumán Province) (Sayago et al., 2002).

In this drought scenario, with severe conditions during the second half of the XIII century, there may have been greater competition for certain resources in a wide geographic space. Nielsen (2002) points out that the consequences of this climate phenomenon must have been dramatic. To face this period of aridity the groups may have had to choose between two non-exclusive alternatives: on one hand, to intensify agricultural exploitation in the more humid and irrigable zones; on the other, put pressure on the fertile spaces where they probably faced resistance from established groups. Once the wars begun, they may have perpetuated with their own force, fed by the interests of those sectors promoted to privilege positions due to the conflict (Nielsen, 2002). In this regard, it should be mentioned the emergence of *pukaras* around ca. 750 BP in different regions of NOA and the Circum-Puna Andes. These are defensive dwelling sites locate on high places from where there is a wide control of the surroundings.

If we focus now on Antofagasta de la Sierra, similar changes were proposed among the populations that inhabited the micro-region since ca. 1100 BP. It has been suggested that environmental conditions became more arid since ca. 1600 BP, lagoons retracted and part of the wetlands degraded. River volumes may have descended, as well as the availability of hydrological, animal and vegetal resources. In addition, increasing values of ^{18}O indicate higher evaporation, possibly related to the rise in temperature (Olivera et al., 2004).

This process of increased aridization coincided with changes in settling and subsistence patterns. In an attempt to counter the decrease in resources, the societies may have intensified agriculture, incorporated new technology (terraces, irrigation canals and dikes) and extended their cultivation area. Considerable crop fields areas and canals attributable to this chronology have been registered: Campo Cortaderas, Miriguaca, Punta Calalaste y Bajo del Coypar I (Fig. 1) (Olivera and Vigliani, 2000/2002; Olivera et al., 2003/2005; Olivera et al., 2008; Vigliani, 2005). Hence, this and other tendencies seem to support that around ca. 1100 BP the importance of agricultural production was greatest among societies of Antofagasta de la Sierra, in the context of a highly diversified economy in which pastoralism and camelid hunting may have continued as important activities, not

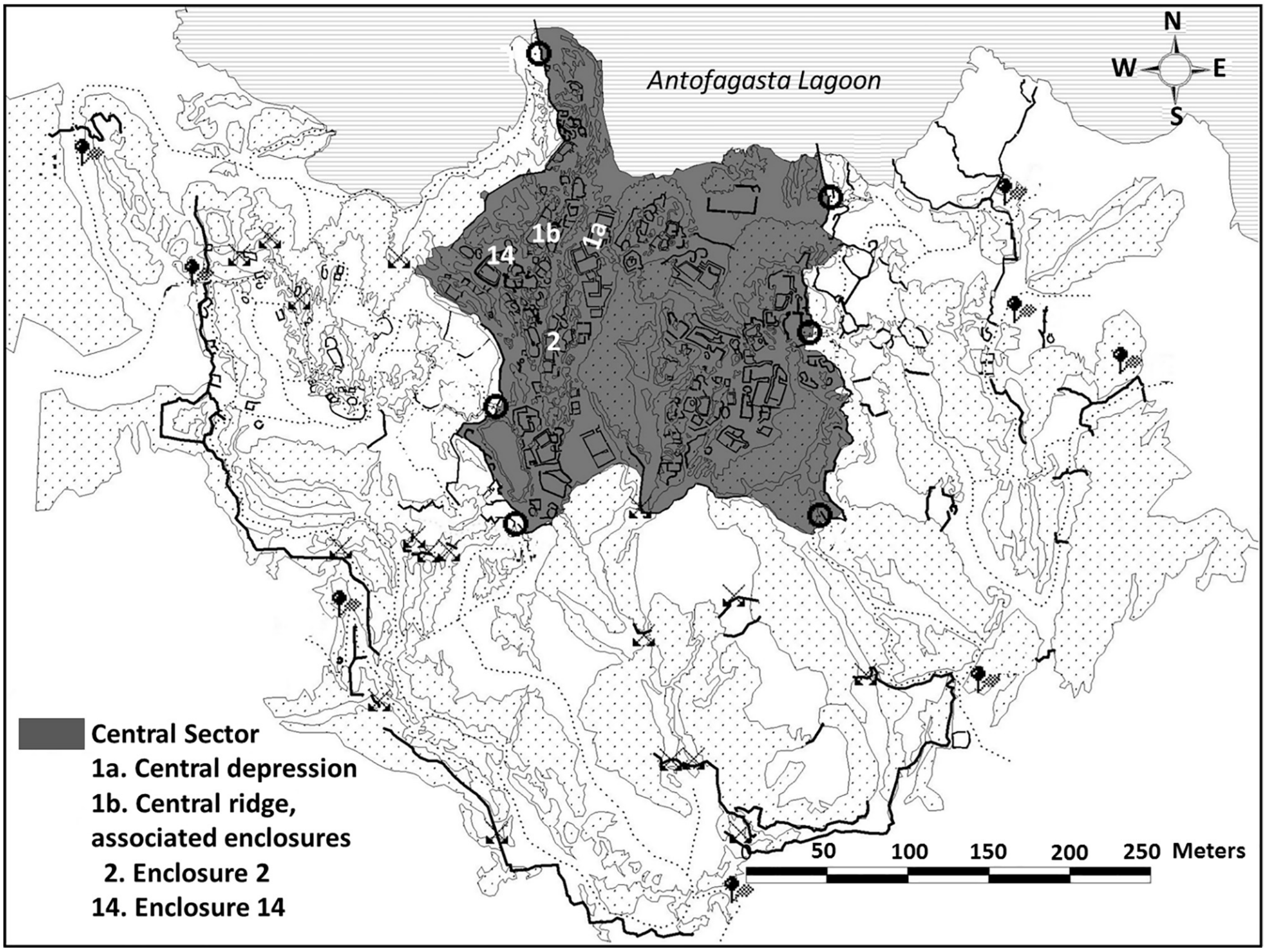

Fig. 2. *Pukara* La Alumbrera (modified plan from Salminci, 2015).

disregarding some gathering as well (Elías, 2007; Escola et al., 2006; Olivera, 1997; Olivera and Vigliani, 2000/2002; Olivera and Grant, 2008; Olivera et al., 2003/2005; Vigliani, 2005).

Since ca. 700 BP a social, political and economic centralization of the societies in the micro-region may have occurred (Martel and Aschero, 2007; Olivera and Vigliani, 2000/2002). With respect to this, for example, cases of iconographic superposition and imposition have been pointed out in rock art between ca. 700–400 BP. These were associated with the emergence of power groups with growing social, political and economic control (Aschero, 2000; Martel and Aschero, 2007).

Regarding the endemic conflict that characterized the Late Period, it should be mentioned that in Antofagasta de la Sierra there is a settlement that has several characteristics of the *pukaras*: La Alumbrera. It is a large residential site, located in a place with a wide visual control, with two wall defensive systems (one external and other internal) and control parapets (Olivera, 1991b; Salminci, 2015).

The arrival of the Inca Empire (ca. 550 BP) entailed various changes in the social, political and economic organization of the societies that inhabited the NOA and south-central Andes. Before the *Tawantinsuyu*, no state in the Andes expanded through such wide spaces (from Ecuador to central Chile) and included such diversity of ethnic groups. In order to control these different populations, the Incas developed diverse strategies of domination, annexing territories both in a peaceful way and by force of arms. They organized a vast administrative system and built various settlements (fortresses, administrative centers, storage centers) and an important road system (Williams, 2000; Mulvany, 2003). Substantial progress has not yet made in the investigation of the changes generated by the Inca Empire among local populations of Antofagasta de la Sierra or in the strategies of domination and control that it implemented. However, it has been preliminarily suggested that the potential of the area for agriculture and livestock breeding and the mineral wealth explain its presence and that it led to modifications in the agricultural infrastructure, characterized by the expansion of the production system (Olivera and Vigliani, 2000/2002).

2.3. Objects, ideas and people circulation after ca. 1100 BP

Some proposals indicate that networks of short distances caravan traffic developed in the central-south Andes from ca. 1000 BP. The rise of these routes was related to the conflicts between different regional socio-political systems in order to protect their territories and access to basic resources. The tensions restricted the space covered by the caravans, although after ca. 800 BP these socio-political systems could have started to make agreements, establishing mutual complementation (Nuñez and Dillehay, 1995 [1979]).

On the other hand, some authors emphasize that violence and caravan traffic coexisted and they encourage to re-evaluating the assumption that the control of territories or routes by the authorities in conflict limited the traffic (Nielsen, 2007). Likewise, within the framework of these arguments, it has been pointed out that it is necessary to consider the role that other practices, difficult to control and repress by late power groups, would have had on the circulation of goods, objects and ideas (e.g. adoption of consorts, kinship relationships) (Nielsen, 2007; Yacobaccio et al., 2002, 2004).

With respect to the circulation of objects and ideas among the

Table 1
Radiocarbon dates from archaeological sites of Antofagasta de la Sierra.

	Site	Sector	Enclosure	Lab	ID	Sample	^{14}C years BP	References
Formative Period	Casa Chávez Montículos	Mound 1	–	Beta analytic	B-27199	Charcoal	1670 ± 60	Olivera (1991a)
				Beta analytic	B-27201	Charcoal	1530 ± 70	
				Beta analytic	B-27202	Charcoal	1740 ± 60	
				Beta analytic	B-27200	Charcoal	1930 ± 70	
				LATYR	LP-299	Bone	2120 ± 60	
				LATYR	LP-251	Charcoal	1660 ± 60	
		Mound 4	–	Beta analytic	B-27198	Charcoal	1740 ± 100	
Late and Late-Inka Periods	Bajo del Coypar II	III	b	University of Georgia (UGA)	7374	Charcoal	790 ± 60	Olivera and Vigliani (2000/2002)
				UGA	7315	Charcoal	1020 ± 60	
				UGA	7375	Charcoal	700 ± 60	
				UGA	8625	Human bone	1080 ± 210	
		IV	b	UGA	7517	Charcoal	650 ± 50	
				UGA	7519	Charcoal	630 ± 60	
				UGA	7520	Charcoal	660 ± 60	
				UGA	7518	Charcoal	880 ± 80	
	La Alumbrera	No data	Collective grave	No data	No data	Human bone	210 ± 70	Olivera and Vigliani (2000/2002); Elías (2010)
		East central	1	NSF-Arizona AMS Lab	AA82552	Charcoal	916 ± 50	
		West central	grave	NSF-Arizona AMS Lab	AA82550	Wood	534 ± 59	
			1	NSF-Arizona AMS Lab	AA78543	Charcoal	981 ± 39	
			2	NSF-Arizona AMS Lab	AA82551	Charcoal	1007 ± 50	
				NSF-Arizona AMS Lab	AA78542	Charcoal	536 ± 42	
	Campo Cortaderas	1	1	NSF-Arizona AMS Lab	AA82553	Charcoal	620 ± 49	Olivera et al. (2008)
				NSF-Arizona AMS Lab	AA78545	Charcoal	670 ± 38	
		2	5	NSF-Arizona AMS Lab	AA78544	Charcoal	853 ± 39	
	Corral Alto	Northeast	1	No data	Ua-33241	*Chañar* seed	720 ± 40	Escola et al. (2015)
				La Plata	LP-1986	Charcoal	660 ± 60	
				La Plata	LP-2535	Charcoal	860 ± 60	
	Peñas Coloradas 3 cumbre	–	No data	La Plata	LP-1930	Charcoal	850 ± 60	Cohen (2014)
	Punta de la Peña 9	III	3 y 4	La Plata	LP-1553	Charcoal	380 ± 70	Somonte and Cohen (2006)
				UGA	9067	Charcoal	706 ± 60	
				UGA	9261	No data	1290 ± 50	
				UGA	15106	No data	1090 ± 50	

societies in Antofagasta, Aschero (2000) points out the repetition of certain design patterns, in rock art and other supports, between the micro-region and distant regions such as Alto Loa (Chile) and Santa María Valley (Catamarca Province, Argentina) (Berenguer, 2004; Tarragó et al., 1997). He says it is quite unlikely for this to have happened without fluent information exchange over long distance. The author suggests that after ca. 1100 BP there was a restriction in the circulation of sumptuary or crafted goods (e.g. ceramics) but not necessarily for other exotic goods of immediate consumption (e.g. wood, seeds and fruits). Thereby, he points out that the reiteration of motifs and themes in the Circum-Puna rock art would indicate that this region continued operating as a great interaction and distance information exchange area along Chilean Late Intermediate Period or NOA Regional Developments Period.

Meanwhile, Podestá and Olivera (2006) suggest an intensification of both intra- and inter-regional organized and systematized caravan traffic around late moments of the Antofagasta de la Sierra sequence. They highlight the frequent representation of llamas as burdened beasts in rock art and its higher standardization, connecting it with the gradually increasing socio-political complexity since ca. 1000 BP.

Regarding Inca times, some authors point out that the state would have used the exchange circuits of pre-Inca populations without perform coercion on them. Meanwhile, others suggest that the Inca road infrastructure and the associated settlements were destined to control and dismantle the old exchange circuits as a way of limiting the network of alliances that these could generate; such alliances could have been factors of resistance to Inca control (see Mulvany, 2003). In a similar argumentative line, other researchers point out, specifically regarding obsidian circulation, that the Incas did not necessarily seek to regulate it, but that it was altered to the extent that other state control strategies were applied (e.g. resettlement of populations) (Chaparro, 2013).

In this framework, we aim to contribute to understanding the circulation and use of obsidians after ca. 1100 BP in NOA and south-central Andes, comparing the provenance information obtained from Formative contexts and from sites dated after ca. 1100 BP in Antofagasta de la Sierra.

3. Sites, samples and geochemical studies

We will present below the methodological aspects of this contribution. The obsidian-analysed artefacts were taken from settlements in different micro-environments of the Antofagasta de la Sierra micro-region.

La Alumbrera is located on the banks of the Antofagasta Lagoon, in the basin bottom of the Punilla River. It is a big settlement with diverse structures (simple and compound buildings of different size, tombs, and defensive walls) distributed on the basalt rock formations of the

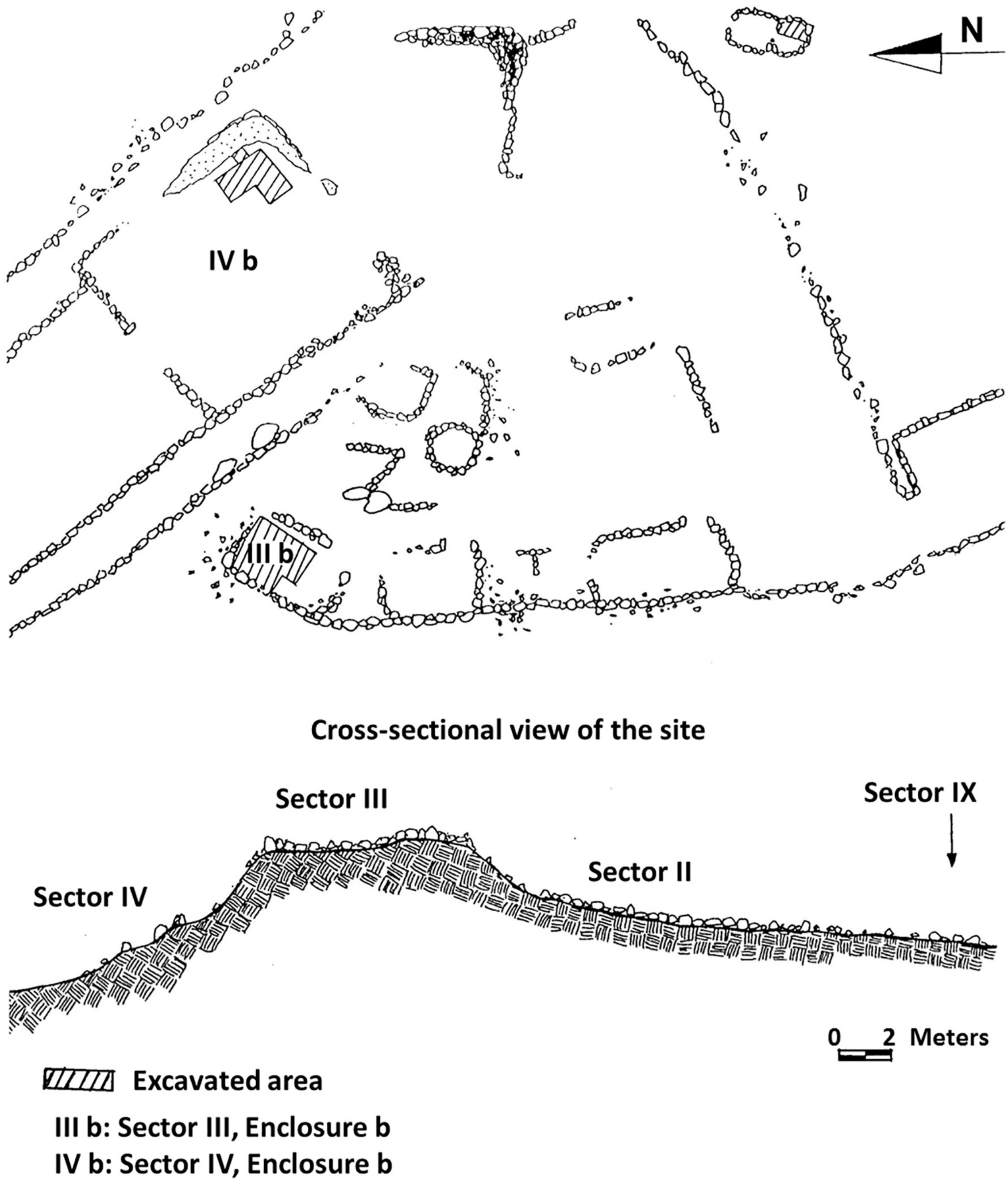

Fig. 3. Bajo del Coypar II (modified plan from Vigliani, 2005).

Antofagasta Volcano (Figs. 1 and 2). Based on radiocarbon dates (Table 1) and architectural and ceramic evidence, its occupation has been assigned to the Regional Developments (ca. 1100–550 BP), Inka (ca. 550–470 BP) and historical periods (Spanish conquest and colonization). It was a great residential site and an important center/node of storage and exchange (Elías, 2010, 2014; Olivera, 1991b; Olivera and Vigliani, 2000/2002; Olivera et al., 2003/2005; Olivera et al., 2008; Raffino and Cigliano, 1973). Nineteen (19) obsidian samples were geochemically analysed, which were rescued in excavations and surface collections in the central sector of the settlement. Six (6) were obtained by means of stratigraphic interventions in enclosures 2 and 14, where obsidian artefacts represent respectively 2.61% and 4.92% of the gathered lithic samples (a total of 536 artefacts was obtained from Enclosure 2 and 284 artefacts from Enclosure 14). The remaining 13 samples come from surface collections carried out in different locations to the west of the central sector (in three associated enclosures and in the central ravine). Obsidians constitute 3.08% of the gathered artefact set (n = 3829) (Fig. 2; Elías, 2010).

Bajo del Coypar II is also located at the basin bottom of the Punilla River, three kilometres southwest of the current Antofagasta de la Sierra village (Figs. 1 and 3). It consists of a group of structures located on a hillside in Cerros del Coypar. It is spatially associated with a huge area of agricultural fields (Bajo del Coypar I) and a pre-hispanic irrigation canal. This site was occupied until ca. 670 BP by small family groups with a growing development of agricultural practices. Subsequently, it was abandoned as permanent dwelling area and incorporated as productive area for processing and storing of crop products (Olivera and Vigliani, 2000/2002). Sixteen (16) archaeological obsidian samples were selected in Bajo del Coypar II, one (1) rescued on surface and fifteen (15) in stratigraphic contexts. Nine (9) were taken

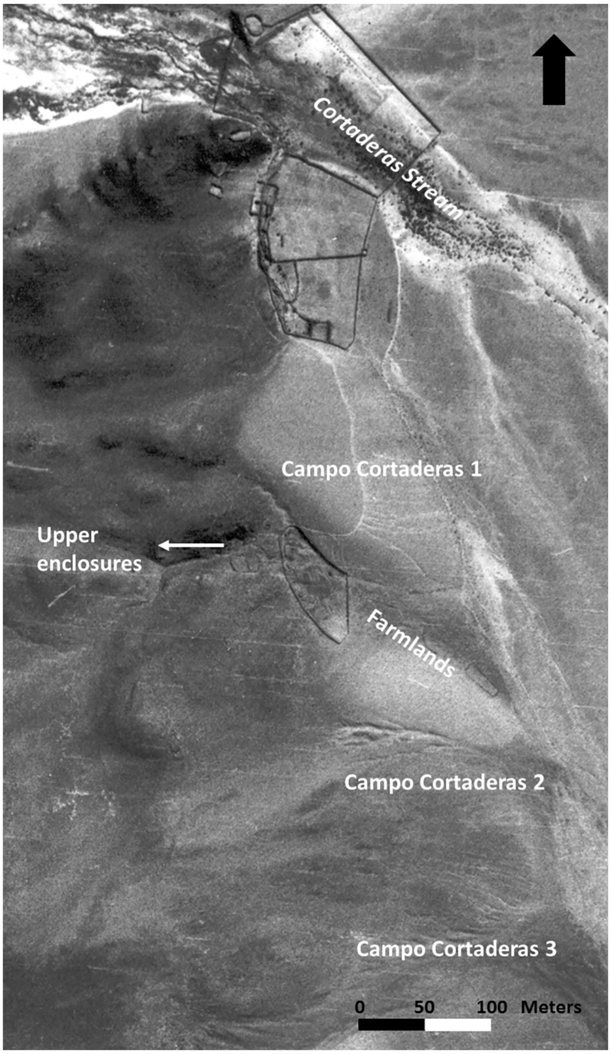

Fig. 4. Aerial photo of Campo Cortaderas.

by means of excavations in Enclosure b of Sector III and seven (7) on surface and stratigraphy in Enclosure b of Sector IV. In total, 1372 lithic artefacts were rescued in both enclosures, among which obsidians constitute 20.9% (Elías, 2010; Escola et al., 2006).

Campo Cortaderas is located approximately 15 km northwest from Antofagasta de la Sierra village (Fig. 1). Along three ravines from north to south, there are several terraced enclosures, cultivation squares and vestiges of a pre-hispanic irrigation canal. Ceramic and lithic vestiges are similar to those collected in La Alumbrera and Bajo del Coypar, with the occurrence of Belén and Belén-Inka ceramic styles, as well as similar formal and technical lithic styles (Elías, 2017; Olivera et al., 2003/2005; Olivera et al., 2008). Only four (4) samples were selected, all from surface collections in different places (superior enclosures and cultivation fields) of the first ravine or Campo Cortaderas 1 (Fig. 4). Among lithic and mineral artefacts rescued (n = 1661) obsidians represent 0.96% (Elías, 2010).

The archaeological obsidian samples were selected with the aim of covering the macroscopic variability range in the sets (colour, banding, opacity, etc.). The geochemical characterization was carried out by means of Energy Dispersive X-ray Fluorescence (EDXRF) at the University of Missouri Research Reactor (MURR) (Giauque et al., 1993; Glascock et al., 1998; Hall and Kimura, 2002). The spectrometer used was an ElvaX calibrated according to information from obsidian samples of the MURR reference collection, including eleven Mesoamerican sources (El Chayal, Ixtepeque, San Martin Jilotepeque, Guadalupe Victoria, Pico de Orizaba, Otumba, Paredon, Sierra de Pachuca, Ucareo, Zaragoza, and Zacualtipan) and three Peruvian sources (Alca, Chivay and Quispisisa). All were previously analysed by means of Neutron Activation Analysis (NAA) and XRF to establish a consistent and reliable calibration curve (Glascock et al., 1998). This calibration curve was also applied on samples of nine obsidian sources from NOA whose locations and geochemical traces were obtained from researches carried on during the 1990's: Quirón, Ramadas and Alto Tocomar (Salta Province), Ona-Las Cuevas, Cueros de Purulla, Chascón and Valle Ancho (Catamarca Province), Laguna Blanca or Zapaleri and Caldera Vilama (Jujuy Province) (Fig. 5). Likewise, in the context of these researches, geochemical characterizations of samples from different NOA archaeological sites allowed determination varieties with unknown sources: A, B, C, E, F, G, H, K and M (Aschero et al., 2002/2004; Yacobaccio et al., 2002, 2004). More recently, it has been identified that the first two come from secondary deposits located in Salar del Hombre Muerto and Laguna Cavi respectively (Catamarca Province) (Escola and Hocsman, 2007; Escola et al., 2009) (Fig. 5). Concentrations (in ppm) of K, Ca, Ti, Mg, Fe, Zn, Ga, Rb, Sr, Y, Zr, and Nb were determined using ElvaX analysis software. The values obtained were compared to those of known obsidian varieties from NOA. Provenance was determined by means of element concentration tables and scatterplots comparing individual artefacts to source groups.

As previously mentioned, we also consider the geochemical results obtained in other settlements: Casa Chávez Montículos, Corral Alto, Peñas Coloradas 3 cumbre, Punta de la Peña 9 III, and Real Grande 1 and 10 (Fig. 1). The first one is located at the basin bottom of the Punilla River and it corresponds to the Formative Period (Table 1) (Olivera, 1991a; Yacobaccio et al., 2002, 2004). The rest correspond to the Late Period (Table 1). Corral Alto is placed in the intermediate sectors of Miriguaca ravine (Escola et al., 2015, 2016), Peñas Coloradas and Punta de la Peña 9 III in the intermediate sectors of Las Pitas ravine (Cohen, 2014; Somonte and Cohen, 2006), and Real Grande 1 and 10 in the homonymous ravine (Olivera, 1991a; Yacobaccio et al., 2002, 2004).

Finally, it is necessary to clarify that we consider the analysed samples as a group corresponding to the chronological rank after ca. 1100 BP. In the future, we hope to understand the use of obsidian in a chronologically more discriminating manner. To this end, it is necessary to have more representative stratigraphy sets from different sites.

4. Results

At La Alumbrera, obsidians from Ona-Las Cuevas outcrops are the most common, followed by the Salar del Hombre Muerto and Cueros de Purulla varieties (Fig. 6, Table 2). It is worth mentioning that the Laguna Cavi variety was recognized macroscopically among the artefact sets of the site, even though such determination has not yet been geochemically confirmed (Elías, 2010). The Ona-Las Cuevas outcrops are on the western margin of Salar de Antofalla, more specifically in the Ona meadow and Las Cuevas ravine, approximately 80–90 km from La Alumbrera. Cueros de Purulla outcrops are in the homonymous hill, approximately 60–65 km southwest from La Alumbrera, and Salar del Hombre Muerto in the homonymous salt flat, 75–80 km north from the site. Finally, Laguna Cavi is located approximately 41 km from La Alumbrera towards the north-east (Fig. 5).

Among the Bajo del Coypar II samples, Ona-Las Cuevas is also the most common variety, although Salar del Hombre Muerto is present in higher frequencies, followed by Cueros de Purulla (Fig. 7, Table 2). Bajo del Coypar II is placed near La Alumbrera; therefore, the distances the sources of these varieties are from the first site are similar to those found from La Alumbrera (Figs. 1 and 5).

In Campo Cortaderas 1 all the obsidian artefacts come from Ona-Las Cuevas outcrops, approximately 65 km away (Figs. 5 and 8, Table 2). It is pertinent to mention that we identified macroscopically a specimen from Cueros de Purulla (Elías, 2010), whose source is approximately

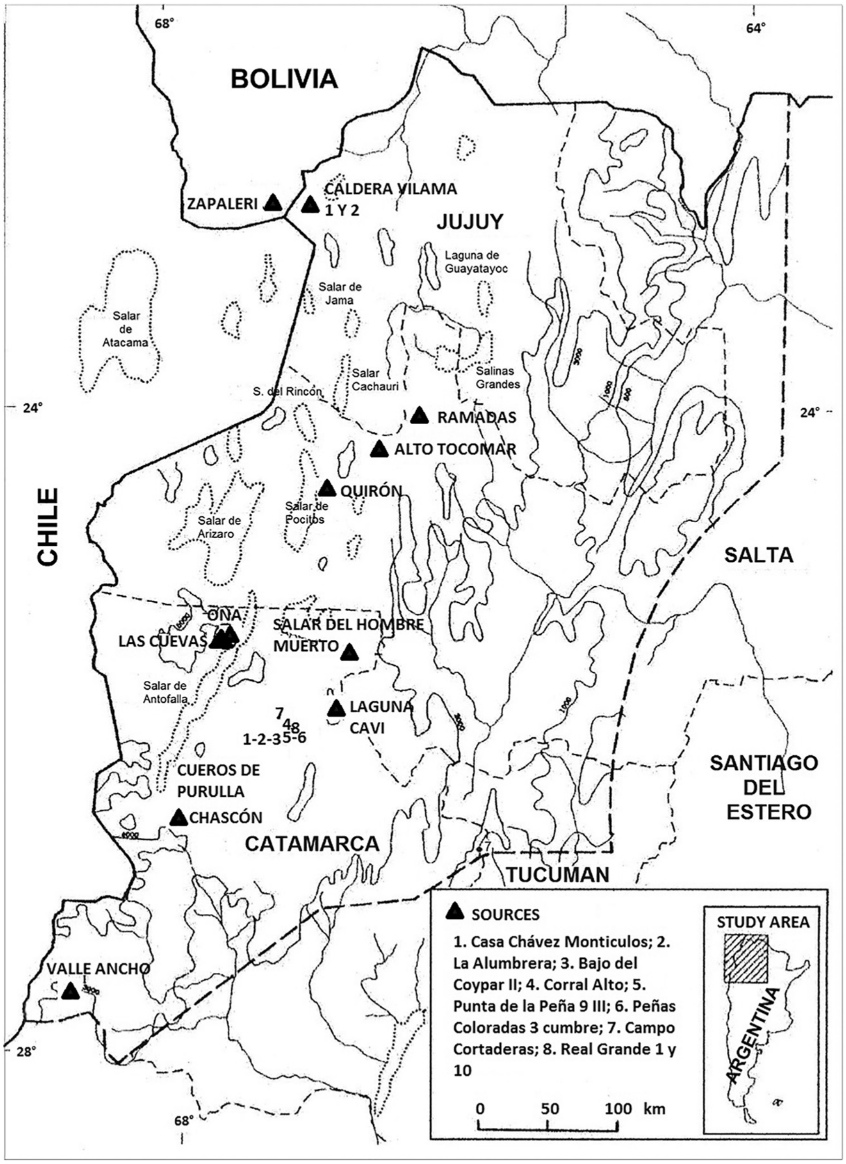

Fig. 5. Location of archaeological sites and NOA's obsidian outcrops (modified from Yacobaccio et al., 2002).

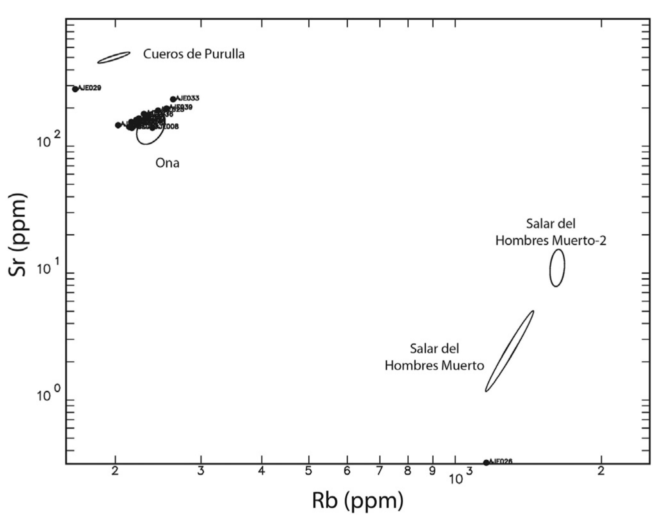

Fig. 6. Obsidian artefacts from La Alumbrera. Logarithmic plot of Rb vs. Sr.

73 km south of the settlement (there is still no geochemical confirmation).

With regard to the settlements dated after ca. 1100 BP within the eastern intermediate sectors of the micro-region, Ona-Las Cuevas is, again, the most frequently represented source at Peñas Coloradas 3 cumbre, followed by Cueros de Purulla. Something similar is observed in Punta de la Peña 9 III, adding to this settlement the Laguna Cavi variety. With respect to Corral Alto, a greater number of samples come from Ona-Las Cuevas, followed by Salar del Hombre Muerto, Laguna Cavi and Cueros de Purulla (Table 2).

In the sites dated after ca. 1100 BP of the high ravines, Real Grande 1 and 10, Ona-Las Cuevas shows important representation, Laguna Cavi and Cueros de Purulla are also identified, and varieties with unknown sources and Quirón are present at lower frequencies (Table 2). Quirón source is located approximately 170 km north of Antofagasta de la Sierra (Fig. 5).

Finally, in Casa Chávez (mounds 1 and 4), the only settlement corresponding to the Formative period, Ona-Las Cuevas prevails along with Cueros de Purulla, Salar del Hombre Muerto, Laguna Cavi and the unknown H (Table 2).

Table 2
Provenance of obsidian archaeological samples from Formative and later archaeological sites of Antofagasta de la Sierra micro-region.

Micro environment	Chronology	Site	Source									
			Obs. O	Obs. CP	Obs. SHM	Obs. LC	Obs. Q	UNK E	UNK F	UNK G	UNK H	n
Basin bottom	ca. 2400–1300 BP	CCHM1 (CI)[a]	9	6	1	–	–	–	–	–	–	16
		CCHM1 (CS)[a]	10	1	2	1	–	–	–	–	–	14
		CCHM4[a]	12	1	1	1	–	–	–	–	1	16
	Since ca. 1100 BP	BCII	9	1	6	–	–	–	–	–	–	16
		LA	17	1	1	–	–	–	–	–	–	19
Intermediate sectors	Since ca. 1100 BP	CCT1	4	–	–	–	–	–	–	–	–	4
		CA[b]	12	2	4	3	–	–	–	–	–	21
		PC3c[b]	9	2	–	–	–	–	–	–	–	11
		PP9 III[b]	6	3	–	1	–	–	–	–	–	10
High ravines	Since ca. 1100 BP	RG1 (CI)[a]	8	1	–	2	1	–	–	–	–	12
		RG1 (CS)[a]	6	–	–	–	–	1	1	1	–	9
		RG10[a]	3	2	–	–	–	1	–	–	–	6
N			105	20	15	8	1	2	1	1	1	154

References: CCHM: Casa Chávez Montículos; BCII: Bajo del Coypar II; LA: La Alumbrera; CCT1: Campo Cortaderas 1; RG: Real Grande; CA: Corral Alto; PC3c: Peñas Coloradas 3 cumbre; PP9 III: Punta de la Peña 9, Sector III; (CS): Upper component; (CI): Lower component; Obs. O: Ona obsidian; Obs. CP: Cueros de Purulla obsidian; Obs. SHM: Salar del Hombre Muerto obsidian; Obs. LC: Laguna Cavi obsidian; Obs. Q: Quirón obsidian; UNK: Obsidian varieties from unknown sources.
[a] Yacobaccio et al. (2002, 2004).
[b] Cohen (2014); Escola et al. (2016).

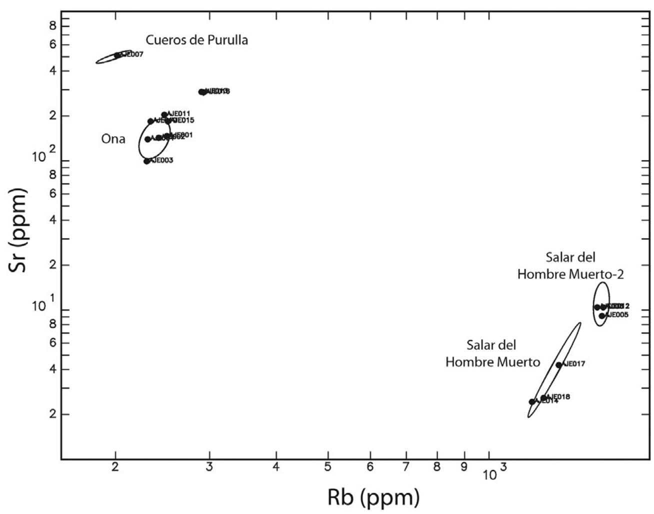

Fig. 7. Obsidian artefacts from Bajo del Coypar II. Logarithmic plot of Rb vs. Sr.

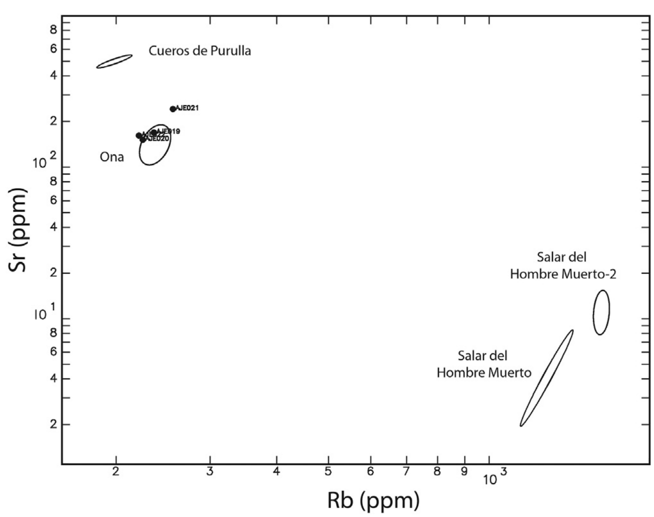

Fig. 8. Obsidian artefacts from Campo Cortaderas 1. Logarithmic plot of Rb vs. Sr.

5. Discussion and conclusions

It could be assumed that the increasing bellicosity among socio-political systems during Late Period in the NOA and south-central Andes led to a limited access to distant spaces and resources, restricting exchange and contact networks among populations from different regions. For example, this assumption underlies the caravan traffic regionalization suggested by Nuñez and Dillehay (1995 [1979]) for the Late Intermediate Period of San Pedro de Atacama (Chile). Something similar would have happened during Inca times: the state could have implemented strategies oriented to control and disrupt the previous exchange circuits and in this way the alliances generated from them (Chaparro, 2013; Mulvany, 2003).

Within the framework of these considerations, how do we understand the continuity between Formative and later moments in the use of Ona-Las Cuevas, Cueros de Purulla and Salar del Hombre Muerto, all corresponding to resources from distant sources? In these terms, it should also be mentioned the increase of obsidian varieties between Formative contexts and later ones, although we are not unaware that this trend is very preliminary. On the one hand, we only have samples from the basin bottom and no samples from the high ravines for times before ca. 1100 BP. On the other hand, unknown varieties (those that contribute mainly to the greater variability observed after ca. 1100 AP) could come from known outcrops whose internal variability is still unknown due to sampling biases. Another option is that these varieties come from an unknown single outcrop with great internal variability (we thank one of the reviewers for these latter suggestions).

These tendencies contribute to consider that during Late and Inca times the opportunities to access certain types of obsidian may not have changed among NOA societies. Likewise, provenance information of obsidian archaeological artefacts obtained in other sites of the NOA allows bringing a critical assessment on the spatial restriction of obsidian circulation after ca. 1100 BP. In this regards, Ona-Las Cuevas has been identified in both Formative and later sites in the Puna and valleys of Salta and Catamarca (Chaparro, 2013; Escola, 2007; Flores and Morosi, 2009; Sprovieri and Baldini, 2007; Yacobaccio et al., 2002, 2004).

The trends recorded in archaeological contexts from Antofagasta de la Sierra and those observed in other regions of NOA make it possible to ponder that the late development of political formations in different areas and the bellicosity among them did not limit access to different obsidian varieties. This coincides with the similarity of rock art design patterns between Antofagasta de la Sierra and distant regions such as Alto Loa and Santa María Valley (Aschero, 2000). Violence and traffic may have coexisted. Therefore, as Nielsen (2007) claims, it is necessary to bring critical assessment to the assumption that traffic and circulation of objects were limited by conflict between the late authorities around territorial or routes control. The geographic characteristics of Circum-Puna Andes, consisting of fertile basins separated by vast non-productive strips and with low population density, and the multiple possible routes to reach almost any destination make it highly improbable that late power groups could have controlled who circulated and who did not in these spaces (Nielsen, 2007). Likewise, we cannot fail to consider the possibility that different political systems may have initiated mutual exchange agreements after ca. 1200 BP (Nuñez and Dillehay, 1995 [1979]). Nor the possible occurrence of neutral groups capable of travelling and exchanging despite hostilities and tensions, or the existence of cycles that alternated wars and trading, the last associated with peace negotiations (Arkush, 2008; Nielsen, 2015).

Moreover, it is necessary to ponder the possibility that the populations of Antofagasta and other regions of NOA and Circum-Puna Andes practiced diverse goods circulation mechanisms difficult to control and limit by the late authorities, including: mutual collaboration among individuals with different origins, consorts adoption, kinship relationships, obsidians acquisition while doing other activities, hand-to-hand exchange chains. Nielsen (2006, 2007) groups these practices under the term of 'incorporated traffic'. Meanwhile, Yacobaccio et al. (2002, 2004) refer to a 'more open and general' access. Late Antofagasta groups may have accessed different obsidian varieties in diverse ways and by means of different mechanisms, already put into practice by previous populations, beyond authorities' control and conflict among political formations. This would not necessarily have prevented people from building ties and networks, especially in a drought scenario in which environmental and productive risk increased and exchange relationships with other groups were certainly a way to resolve it. For example, the occurrence of Quirón may be caused by informal contact among groups (Yacobaccio et al., 2002) or inter-family caravan traffic (Martel and Aschero, 2007), not necessarily organized or controlled by power groups.

The exposed tendencies also contribute in terms of considering that during Inca times the inhabitants of the micro-region continued accessing certain varieties of obsidians probably through the traditional practices and circulation criteria mentioned in the previous paragraph. Even though, it does not mean to dismiss that the Inca state also developed strategies to control the traditional exchange circuits (Chaparro, 2013; Mulvany, 2003).

In summary, the Antofagasta societies continued accessing obsidian sources known to Formative populations. Considering the points made by diverse researchers (Nielsen, 2006, 2007; Yacobaccio et al., 2002, 2004), we suggest that the continuity in the use of different obsidian varieties from distant sources among the inhabitants of the micro-region before and after ca. 1100 BP is associated with the co-occurrence of diverse circulation mechanisms, many previously practiced and which were beyond the control of late power groups and the bellicosity between them, as well as the control by the Inca state.

It is necessary to continue advancing in provenance analysis on obsidians from archaeological contexts in the basin of Antofagasta de la Sierra and to count on a higher number of stratigraphic samples corresponding to different times along ca. 1100–470 BP. This will provide a more accurate picture of the variations in circulation and use of different obsidian varieties between pre-Inca and Inca periods. For these purposes, it would also be relevant to integrate geochemical results with those obtained from technological analysis of obsidian artefact sets. Having said this, to comprehend the circulation of goods, resources and ideas requires connecting the data gathered in different regions and spaces on the basis of varied evidence (rock art, ceramic, vegetal remains, etc.). We hope to have contributed to the discussion of this phenomenon in the social, political and environmental context in which the populations of the micro-region of Antofagasta de la Sierra and south-central Andes dwelled after ca. 1100 BP.

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