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Moving obsidian: The case of Antofagasta de la Sierra basin (Southern Argentinean Puna) during the late Middle and Late Holocene

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ABSTRACT

This paper presents the results of an XRF analysis on the provenience of 118 obsidian artifacts from archaeological sites of the Antofagasta de la Sierra basin (Catamarca Province Argentina) dating to the late Middle and Late Holocene (*c.*4500–1100 BP). The time span considered encompasses a local process of gradual transformation from hunter-gatherer/early agro-pastoral groups to consolidated agro-pastoral societies. For this study, non-destructive elemental analysis of obsidian artifacts was conducted using two different X-ray fluorescence spectrometers (ED-XRF). This information was then supplemented by previous provenience results, undertaken on 59 obsidian archaeological artifacts from the same area. A comparative synthesis of chemical and macroscopic characterization of five obsidian sources located in Southern Argentinean Puna is also presented. The provenance of archaeological materials was assigned by comparison with twelve presently known Argentine sources. On this basis, late Middle and Late Holocene obsidian regional movement patterns, differential distribution and use of this raw material are discussed. Furthermore, this obsidian research lends support to the existence of exchange networks based on the use of different extra-regional obsidian sources located in the Northern Argentinean Puna.

1. Introduction

The study of obsidian and obsidian regional movement are key topics in the archaeology of the Andes nowadays (Craig et al., 2010; Eerkens et al., 2010; Barberena et al., 2011; Fernández et al., 2015; Cortegoso et al., in press). In the South Central Andes, research based on obsidian sources and related investigations of obsidian exchange networks dates from the mid–1970s (e.g., Burger and Asaro, 1977, 1978, 1979; Burger, 1980; Glascock and Giesso, 1994; Brooks et al., 1997). Nevertheless, in Northwestern (NW) Argentina this kind of analysis was systematically overlooked until the 1990s (e.g., Vázquez and Escola, 1995; Yacobaccio and Lazzari, 1996–1998). From that time onwards, there has been a sustained growth in obsidian-oriented contributions providing new information about raw material procurement, reduction and discard as well as territorial distribution and exchange patterns (e.g., Escola, 2000, 2004; Yacobaccio et al., 2002; Yacobaccio et al., 2004; Sprovieri and Glascock, 2007; Escola et al., 2009; Flores and Morosi, 2010; Elías, 2013; Chaparro and Avalos, 2014). Some contributions have even investigated the non-utilitarian role of obsidian (Scattolin and Lazzari, 1997; Escola, 2007; Carbonelli, 2014).

So far, in NW Argentina obsidian provenance studies have focused on fully-fledged, consolidated agro-pastoralist communities as well as on urban and Inka occupations. Only recently have obsidian studies tackled hunter-gatherer and late hunter-gatherer (groups in transition to food production) groups sequestered in highland desert environments (Mondini et al., 2013; Yacobaccio et al., 2013; Pintar et al., in press).

Following this concern, in this paper we aim to provide a more comprehensive understanding of obsidian procurement and distribution during the late Middle and Late Holocene (*c.*4500–1100 BP) in the Southern Argentinean Puna. This time span encompasses a local process of gradual transformation from hunter-gatherer/early agro-pastoral groups to consolidated agro-pastoral societies. Consequently, we discuss obsidian regional transport patterns in a highland desert environment during this period, and the differential distribution and use of this raw material in such a place. This paper presents a comparative synthesis of the geochemical and macroscopic characterization of five known obsidian sources located in Southern Argentinean Puna, as well as the source-determinations of 118 obsidian artifacts from six archaeological

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sites located in the Antofagasta de la Sierra basin (Catamarca). This information is then complemented by existing provenience analysis performed on 13 obsidian archaeological artifacts from three of the six sites analyzed here and 46 samples from an agro-pastoralist site located in the same area. In sum, this obsidian research lends support to the existence of exchange networks based on the use of different extra-regional obsidian sources located in the Northern Argentinean Puna.

The Argentinean Puna is a natural continuation of the Peruvian-Bolivian high mountain plateau, located above 3500 m above sea level and forms part of the Atacama Puna. From an environmental standpoint, the Puna is a high desert biome characterized by an arid and cold climate, intense solar radiation due to altitude, an ample day/night thermal range, a marked seasonality with poor summer rains, and low atmospheric pressure (Bruniard, 1999). Vegetation is scarce and mainly xerophytic with the presence of peat-bogs (*vegas*) on the banks of small permanent rivers. The weather is very unpredictable in the short and medium term. The summer rainfall regime, for example, may alternate between years of extreme drought and periods of abundant rains, therefore conditions from year to year are practically unforeseeable (Garreaud and Aceituno, 2001).

Antofagasta de la Sierra is located in the Northwestern corner of the Catamarca Province (Department of Antofagasta de la Sierra). It includes a diversity of landforms and a mosaic of resources and microenvironments typical of the salty Puna, a very extreme environment (Fig. 1). This area also comprises the Punilla River basin and is the product of a patch environment with many sectors favorable for human occupation surrounded by an extreme desert. The Las Pitas and Miriguaca Rivers, in whose valleys the archaeological sites discussed in this paper are located, are both tributaries of the Punilla River.

Past environmental conditions during the Holocene in the South-central Andes have been extensively studied in the past 15 years (see Yacobaccio and Morales, 2005; Núñez et al., 2013; Tchilinguirian and Morales, 2013.). Paleoenvironmental reconstructions in the study area were constructed from sedimentological and biological analysis (diatoms) (Grana et al., in press; Tchilinguirian and Morales, 2013; Tchilinguirian and Olivera, 2014). These paleoenvironmental analyses establish variable conditions during the time span covered by this research. From 8000 to 3000 years BP arid conditions predominated. The rivers were mostly ephemeral, wetlands scarce and differentially distributed throughout the basin (Arid Phase). This would have created a period of high environmental heterogeneity both at the intra- and inter-basin scale. Between 3000 and 1600 BP humid conditions prevailed with greater development and stability of wetlands throughout the basin (Humid Phase), during this phase there was an increased spatial homogeneity in water availability throughout the region. From 1600 years BP to the present, dry conditions have prevailed (Arid Phase) (Grana, 2013; Tchilinguirian and Olivera, 2014; Grana et al., in press).

Intensive archaeological research in Antofagasta de la Sierra has yielded abundant and important information regarding the transition from hunter-gatherer to agro-pastoralist societies (*c.* 4500 –

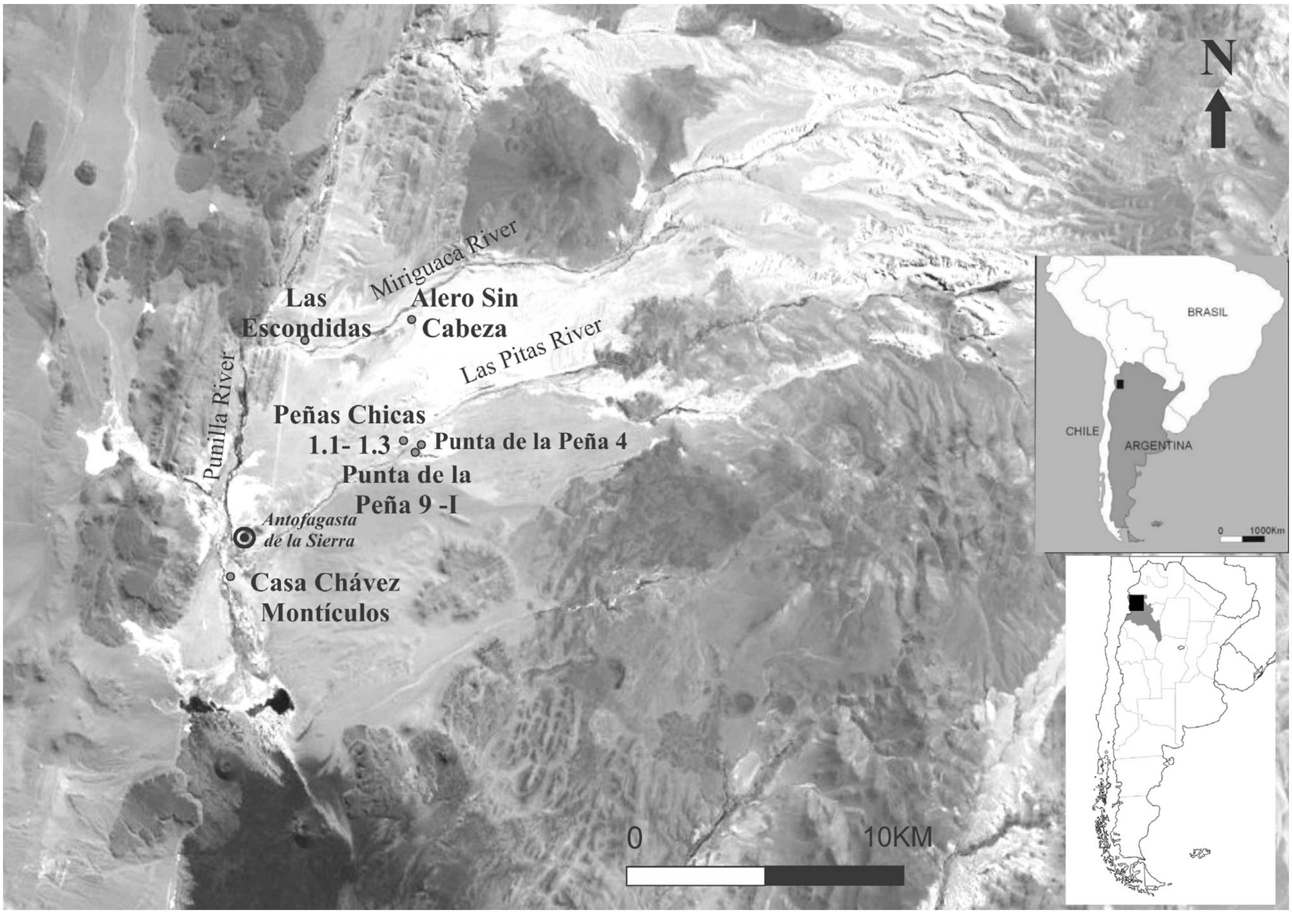

Fig. 1. Relative location of the study area and location of archaeological sites.

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2100 BP). This process is characterized by a progressive reduction of residential mobility that culminated in a high degree of sedentism, involving the year round occupation of dwellings towards 2000 BP (Hocsman, 2002, 2006; Aschero and Hocsman, 2011). This can be seen in the increased ratio of residue discard and the intensification of permanent site material culture such as grinding stone tools and stone walls, which point to increased management of residential spaces (Babot et al., 2006, 2014; Aschero and Hocsman, 2011). Other evidence, such as local differentiation in rock-art motifs and projectile point designs, as well as the increasing use of local raw lithic materials shows growing signs of identity and territorial rights (Hocsman, 2002, 2006; Aschero, 2007; Aschero and Hocsman, 2011).

The settlement pattern involved an intensive use of rock shelters and open-air sites. It is generally agreed that by 2100 BP sedentary communities settled in small villages while still managing the ample territories needed to sustain a pastoralist way of life (Olivera, 1998). There was an intensified exploitation of subsistence resources – both animal and plant – involving domestication/appropriation of productive techniques which begun at the start of the time span considered here (Babot, 2011; Aschero et al., 2014; Urquiza and Aschero, 2014). In this regard, early quinoa cultivation is an important example (Escola et al., 2013; Babot and Hocsman, 2015). The agriculture of roots, tubers, cereals, pseudocereals together with camelid pastoralism were the main economic strategies; these where often combined with hunter-gatherer activities in the period post-2000 BP (Olivera, 1998; Babot, 2011; Escola et al., 2013).

The transition to food production involved the incorporation of new technologies such as pottery and the development of ritual practices related to agriculture and pastoralism (Olivera et al., 2003; Aschero and Hocsman, 2011). There is also evidence of a very active exchange of goods, knowledge and information between areas across great distances, for instance covering the Argentinean Northwestern and the Chilean desert and coast (Olivera, 1998, 2006; Olivera and Vigliani, 2000–2002; Hocsman, 2006). More specifically, these long distance interaction networks involved biotic and abiotic resources devoted to food, subsistence and for prestige purposes (Olivera et al., 2003; Rodríguez, 2004; Aschero and Hocsman, 2011). Besides, symbolic and stylistic items were shared and this can be seen in the iconographic symbology used as well as in the construction method. Taking into account the above regional processes, within the context of the time-span considered, the use and movement of obsidian is an important proxy marker that serves to describe issues of mobility and the wider structure of social and exchange networks.

The obsidian samples come from a number of residential bases in rockshelters and open air sites. These sites correspond on one hand, to late hunter-gatherers with evidence of productive activities dated between 4500 and 3000 BP (Peñas Chicas 1.3, Peñas Chicas 1.1 and Punta de la Peña 4), and on the other hand, full agro-pastoralist groups dated between 2000 and 1100 BP (Las Escondidas and Punta de la Peña 9) (Table 1). Although in the study area we have recorded limited occupation and offering sites for the period *c.* 3000–2000 BP (Hocsman, 2006), there is no archaeological evidence of contemporary residential bases with obsidian artifacts. Consequently, there is a lack of obsidian samples from residential bases for that time period.

Table 1
Radiocarbon Dates and Site Characterization

Archaeological site	Laboratory code	Material dated (level)	Measured 14C age BP	Site description	Reference
Peñas Chicas 1.3	LP 1461	Charcoal (3/4)	3490 ± 60	Residential base in rock-shelter with prepared and equipped spaces	Hocsman (2007)
	UGA 15092	Charcoal (7)	3680 ± 50		Aschero and Hocsman (2011)
Peñas Chicas 1.1	LP 263	Charcoal (3)	3590 ± 55	Equipped residential base in rock-shelter	Aschero and Hocsman (2011)
	LP 261	Charcoal (4)	3660 ± 60		
Alero Sin Cabeza	LP 1846	Charcoal (3)	3390 ± 70	Residential base in rock-shelter with prepared and equipped spaces	Escola et al. (2013)
	LP 1835	Charcoal (2)	3470 ± 60		
	LP 1796	Charcoal (2)	3610 ± 70		
Punta de la Peña 4	UGA 8354	Camelid bone (5(6)2)	3250 ± 50	Residential base in rock-shelter with prepared and equipped spaces	Urquiza and Aschero (2014)
	UGA 9254	Charcoal (3x)	3820 ± 100		
	Beta 77748	Wood (4a)	3870 ± 90		
	Beta 77749	Wood (4b1)	4060 ± 90		
	UGA 7976	Charcoal/charred wood (5(6)2)	4100 ± 160		
	UGA 15094	Camelid bone (8(3))	4560 ± 60		
Las Escondidas Estructura 4	AA 86671	Animal bone (2)	1976 ± 41	Open-air residential base with prepared and equipped spaces	Escola et al. (2015)
	AA 86670	Animal bone (2)	2021 ± 48		
Punta de la Peña 9 Estructura 3	LP 2104	Charcoal 2(1)	1180 ± 70	Open-air residential base with prepared and equipped spaces	Babot (2015)
	AA 89389	Endocarp of Geoffroea decorticans (offering into the wall)	1269 ± 29		
	LP 2110	Camelid feces (2(3))	1290 ± 70		
	LP 1473	Charcoal (2(5))	1410 ± 70		
	LP 1430	Camelid feces (2(4))	1430 ± 60		
	LP 2106	Charcoal (2(5))	1430 ± 60		
	AA 89390	Endocarp of *Geoffroea decorticans* (offering into the wall)	1465 ± 29		

Peñas Chicas 1.3 (PCh1.3) is a residential base of hunter-gatherers in transit to food production, it is located in a shelter under a great block near a large ignimbrite cliff near the Las Pitas River. It is a single-component site with a stone wall and grinding stone artifacts. It is dated between 3700 and 3400 BP (Hocsman, 2007; Aschero and Hocsman, 2011; Babot, 2011). Peñas Chicas 1.1

(PCh1.1) is a residential base of hunter-gatherers in transit to food production in a rockshelter at the ignimbrite cliff of Peñas Chicas close to the Las Pitas River. It is a multi-component site with grinding stone artifacts. It is dated between 3700 and 3500 BP (Hocsman, 2007; Aschero and Hocsman, 2011; Babot, 2011). Finally, also near the Las Pitas River, Punta de la Peña 4 (PP4) is a residential base of hunter-gatherers in transit to food production in a rockshelter with a large protected area in the upper portion of an ignimbrite cliff at Punta de la Peña. It is a multi-component site with a small circular stone walls, rock art and grinding stone artifacts. It is dated between 4500 and 3200 BP (Aschero and Hocsman, 2011; Urquiza and Aschero, 2014).

In an ignimbrite cliff at Miriguaca River is a rockshelter called Alero Sin Cabeza (ASC). It is a residential base of hunter-gatherers in transit to food production. This single-component site with small subcircular stone walls, rock art and grinding stone artifacts is dated between 3700 and 3300 BP (Escola et al., 2013).

In the case of the agro-pastoralist sites, Las Escondidas (LE) is a single-component open air site exhibiting six large structures and at least three smaller with double subcircular stone walls. It is a residential base dated *c.* 2000 BP (Escola et al., 2015) where domestic activities such as artifact production, food processing and consumption as well as specific sumptuary activities were carried out. At the same time, Punta de la Peña 9 (PP9) is a multi-component open air site set on a terrace next to an ignimbrite cliff, with an agro-pastoralist occupation known from ca. 2000 BP. until modern times. It is a residential place and consists of open spaces, stone-walled enclosures and rock-shelters. The structure E3 is a multicomponent enclosure occupied between *c.* 1430 and 1180 BP comprising occupations on farmyard activities alternating with others in which the artifact production and the food processing and consumption were dominant (Babot et al., 2006; Babot, 2015).

2. Obsidian sources: geochemical and macroscopic characterizations

The first step in isolating the different obsidian sources was already undertaken in the period starting in 1995 with the location and identification of the chemical footprints of twelve potential obsidian sources located within the Argentine Northwest (Vázquez and Escola, 1995; Yacobaccio et al., 2002, 2004; Escola et al., 2009; Glascock, 2010). In general, these obsidian sources appear as small domes and lava-domes associated with large Tertiary calderas as well as strato-volcanoes composed mainly of andesite-dacite lavas and large ignimbrite deposits, as well as isolated Quaternary events (González, 1992). In essence, these are the products of highly explosive arc volcanism of the Plinnian type, and a less explosive vulcanian type with fewer pyroclastic products. Obsidian is always related to surge phases with rhyolite bearing pumicite brecchias, Plinnian ash falls and obsidian lavas (Hughes and Smith, 1993).

Geochemical analysis (neutron activation analysis) of the potential sources conducted by the Archaeometry Laboratory at the University of Missouri Research Reactor (MURR) have made it possible to accurately discriminate between the various sources. Moreover, provenance studies carried out on obsidian archaeological artifacts have proven that eight of the twelve sources (Zapaleri or Laguna Blanca, Quirón, Tocomar, Archibarca, Ona-Las Cuevas, Salar del Hombre Muerto, Laguna Cavi and Cueros de Purulla) are the most used obsidian quarries within the NW Argentinean exchange networks. Fig. 2 shows bivariate plot for Zr/Rb (confidence ellipses were drawn at 90%) detailing the discrimination between the eight obsidian sources, while Table 2 presents summary statistics for the elements analyzed. Five of these sources are located in the Department of Antofagasta de la Sierra (Catamarca Province) and are regional sources for the purposes of this study.

Table 2

NAA mean compositions and standard deviations for eight obsidian sources.

Element	Zapaleri/Lag.B.Boli/Arg/Chile (n = 58)	Archibarca Catamarca (n = 8)	Salar del H. Muerto Catamarca (n = 8)	Ona-Las Cuevas Catamarca (n = 104)	Cueros de Purulla Catamarca (n = 31)	Laguna Cavi Catamarca (n = 15)	Alto Tocomar Salta (n = 19)	Quirón Salta (n = 5)
Ba	666 ± 25	845 ± 13	100 ± 21	589 ± 14	624 ± 15	81 ± 26	147 ± 22	166 ± 19
La	46.3 ± 1.0	55.3 ± 0.4	17.8 ± 0.8	24.9 ± 1.5	55.5 ± 0.7	11.1 ± 0.3	6.4 ± 0.8	9.1 ± 1.2
Lu	0.525 ± 0.024	0.251 ± 0.018	0.620 ± 0.048	0.24 ± 0.06	0.403 ± 0.012	0.719 ± 0.060	0.49 ± 0.05	0.596 ± 0.049
Nd	40.9 ± 4.6	34.2 ± 1.7	25.7 ± 3.0	17.3 ± 2.0	36.0 ± 2.1	13.7 ± 1.8	5.4 ± 1.3	8.9 ± 1.5
Sm	8.51 ± 0.29	5.09 ± 0.03	10.28 ± 0.36	3.97 ± 0.11	6.53 ± 0.16	6.88 ± 0.07	3.25 ± 0.08	4.29 ± 0.17
U	7.5 ± 1.2	3.1 ± 0.4	27.6 ± 1.6	12.3 ± 2.0	5.9 ± 0.9	20.0 ± 4.5	29.3 ± 2.8	33.1 ± 1.6
Yb	3.10 ± 0.18	1.48 ± 0.06	1.49 ± 0.19	1.10 ± 0.07	2.10 ± 0.11	3.49 ± 0.16	0.66 ± 0.06	1.14 ± 0.06
Ce	95.8 ± 2.3	98.3 ± 0.8	54.1 ± 1.3	48.1 ± 2.8	104.8 ± 1.5	28.5 ± 0.5	11.8 ± 0.8	18.0 ± 2.3
Co	0.281 ± 0.171	0.785 ± 0.806	0.080 ± 0.000	0.298 ± 0.115	0.712 ± 0.025	0.128 ± 0.07	0.125 ± 0.026	0.441 ± 0.069
Cs	10.8 ± 0.2	2.7 ± 0.02	91.5 ± 0.9	11.4 ± 0.3	7.4 ± 0.1	38.7 ± 0.5	269.1 ± 5.9	106.7 ± 1.4
Eu	1.229 ± 0.030	1.031 ± 0.016	n.d.	0.564 ± 0.013	1.156 ± 0.020	0.139 ± 0.003	0.116 ± 0.013	0.098 ± 0.009
Fe	10915.3 ± 428	8655.05 ± 40.1	2886.1 ± 83.6	5070 ± 162	9443.9 ± 330	3959 ± 84	3601.9 ± 88.7	5122.6 ± 180
Hf	6.65 ± 0.52	3.99 ± 0.04	4.47 ± 0.09	3.20 ± 0.13	4.73 ± 0.08	3.33 ± 0.10	1.28 ± 0.05	1.92 ± 0.05
Rb	213 ± 4	112 ± 1	1087 ± 12	222 ± 4	173 ± 2	480 ± 6	753 ± 18	676 ± 10
Sb	0.421 ± 0.048	0.081 ± 0.010	1.393 ± 0.139	0.176 ± 0.059	0.355 ± 0.023	0.637 ± 0.043	1.531 ± 0.352	4.753 ± 0.219
Sc	4.24 ± 0.16	2.43 ± 0.02	13.3 ± 0.18	1.88 ± 0.04	3.16 ± 0.05	8.14 ± 0.13	0.087 ± 0.02	10.15 ± 0.26
Sr	181 ± 30	380 ± 23	n.d.	173 ± 33	366 ± 41	n.d.	n.d.	n.d.
Ta	1.94 ± 0.04	1.27 ± 0.01	15.99 ± 0.12	2.03 ± 0.06	2.39 ± 0.04	3.91 ± 0.03	14.31 ± 0.30	11.93 ± 0.14
Tb	1.062 ± 0.048	0.523 ± 0.016	1.247 ± 0.151	0.345 ± 0.023	0.748 ± 0.024	1.295 ± 0.056	0.144 ± 0.017	0.358 ± 0.155
Th	21.6 ± 0.4	14.7 ± 0.1	9.4 ± 0.3	22.1 ± 0.5	19.7 ± 0.3	16.8 ± 0.2	2.5 ± 0.1	3.4 ± 0.6
Zn	72 ± 9	50 ± 2	104 ± 6	35 ± 7	55 ± 14	46 ± 6	47 ± 5	36 ± 21
Zr	266 ± 25	144 ± 13	191 ± 24	164 ± 10	198 ± 8	168 ± 12	235 ± 15	285 ± 6
Cl	611 ± 92	370 ± 98	167 ± 48	761 ± 93	551 ± 132	165 ± 27	408 ± 40	529 ± 51
Dy	6.41 ± 0.50	2.60 ± 0.38	6.21 ± 0.49	2.02 ± 0.28	4.26 ± 0.36	7.75 ± 0.46	1.05 ± 0.32	1.65 ± 0.23
K	37459.6 ± 2207	33035.2 ± 2131	32131.3 ± 2167	38889.2 ± 1802	37418.4 ± 1890	35204.5 ± 1287	35895.0 ± 1983	39523.1 ± 1223
Mn	557 ± 8	548 ± 9	1872 ± 17	402 ± 9	623 ± 16	818 ± 10	977 ± 20	608 ± 10
Na	28602 ± 918.4	28646 ± 461.9	33535 ± 320.9	25935 ± 513.6	28338 ± 456.5	31545 ± 755.5	28910 ± 574.2	28997 ± 670.4

Note: The samples include source and artifact specimens analyzed by MURR. Source data for Zapaleri/Laguna Blanca, Ona-Las Cuevas, Cueros de Purulla, Alto Tocomar and Quirón have been published previously (Yacobaccio et al., 2002).

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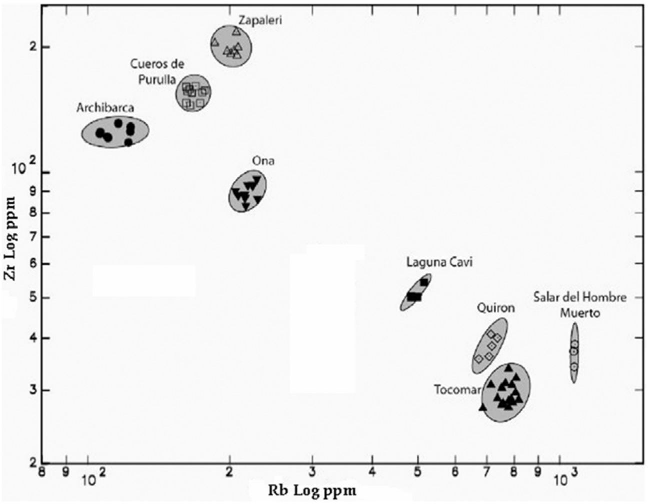

Fig. 2. Geochemical composition of eight obsidian sources from Northwestern Argentina. This plot use logarithms of the ppm concentrations on both axes.

Specifically, the first three regional sources are located in the northern sector (Fig. 3): Ona-Las Cuevas, Archibarca and Salar del Hombre Muerto. The Ona-Las Cuevas (3700 masl) source comprises of many outcrops and secondary deposits. It is located about 80–90 km northwest of the village of Antofagasta de la Sierra. The obsidian is fine-grained and is present in medium to large nodules (20–30 cm in diameter). The most common color is a translucent black and gray-black, although light gray and reddish-brown nodules are also found. Meanwhile, the Archibarca (4040 masl) source is situated about 100 km northwest of the village of Antofagasta de la Sierra and is composed of secondary deposits (Dr. Moreno, E., Personal communication). The obsidian in this case is an opaque black with gray bands, present in medium to large nodules (20–25 cm in diameter). Finally, the Salar del Hombre Muerto (4150 masl) source is located about 70–80 km northeast of the Antofagasta de la Sierra village. It occurs as a secondary deposit, on the north bank of the namesake Salar (Chaparro, 2009). In this case the same chemical fingerprint provides both a type of black, shiny obsidian, as well as a transparent yellowish cloud type.

The other two regional sources are located southeast and southwest of Antofagasta (Fig. 3). The Laguna Cavi (4260 masl) source is located about 30–40 km from the village, this secondary deposit produces obsidian in small translucent gray-black nodules. The Cueros de Purulla (4380 masl) source is situated about 60–70 km from Antofagasta and comprises a volcanic dome producing an opaque obsidian present in large blocks and nodules, some exceeding 25 cm in length. Black obsidian is common, but dark gray and black-reddish colors also occur. In this regard, it must be noted that black obsidian responds to opaque shiny volcanic glass and dark gray and black-reddish to an opaque satin one.

The Salar del Hombre Muerto and Laguna Cavi sources where recently located. The geochemical analysis of their obsidian showed almost total convergence with the chemical fingerprint of two previously unknown sources – A and B respectively – characterized until now only through obsidian archaeological artifacts (Escola, 2004; Escola and Hocsman, 2007).

3. Method and archaeological samples

Over the past few decades, a variety of physical, chemical, and isotopic methods have been used for provenance research on archaeological obsidian (Tykot, 2004). The three main analytical methods used most often are Neutron Activation Analysis (NAA), X-ray fluorescence (XRF), and laser ablation-inductively coupled plasma-mass spectrometry (LA-ICP-MS) (Glascock, 2002, 2010). Each of these methods has specific advantages and disadvantages with respect to the analysis of obsidian. In this regard, the choice of one is principally subject to availability, cost, speed, accuracy, existence of comparative data and ability to discriminate between sources. NAA offers excellent sensitivity, precision and accuracy for a large number of elements, and it is considered the most reliable of the three methods. Thereby, it was used for the initial source characterization (Section 2) and for the first program of obsidian provenance studies in NW Argentina (Yacobaccio et al., 2002, 2004).

NAA is more time-consuming and expensive than the other analytical methods. It also generally requires for the samples to be reduced to powder. This means that archaeological artifacts cannot normally be sampled. XRF offers good sensitivity and accuracy for several of the key trace elements (Rb, Sr, Y, Zr, and Nb) identified as important for discriminating between sources (Hall and Kimura, 2002; Craig et al., 2007; Shackley, 2008). XRF can be performed non-destructively, and it is both a rapid and inexpensive method. On this basis, and taking into account the possibility to analyze complete tools such as projectile points, the non-destructive XRF was the method of choice for the source-assignment of archaeological artifacts in this study.

The artifact analysis was conducted using two different X-ray fluorescence spectrometers (ED-XRF). Eighteen samples were analyzed at the University of Missouri Research Reactor (MURR) in 2007/2008 using an ElvaX desktop energy-dispersive X-ray fluorescence spectrometer. In order to measure eleven elements -potassium (K), titanium (Ti), manganese (Mn), iron (Fe), zinc (Zn), gallium (Ga), rubidium (Rb), strontium (Sr), yttrium (Y), zirconium (Zr), and niobium (Nb)- the X-ray tube was operated at 35 kV using a tube current of 45 μA. Measurement times on the samples were 400 s. Concentrations were calculated in parts per million, using the ElvaX spectral analysis package. The instrument was calibrated using data from a series of well-characterized obsidian source samples in the MURR reference collection. Consensus values for the obsidian calibration sources were previously determined at MURR (using both NAA and XRF) and other laboratories (XRF only). Artifacts with a flat surface greater than 0.8 cm across, being those most suitable for this semi-portable spectrometer, were selected.

In turn, in 2009, the analysis of 100 samples was conducted at the Universidad Nacional de Cuyo – CONICET (Mendoza) using a hand-held ED-XRF spectrometer (Tracer III–V portable). The Bruker instrument with a rhodium anode was operated at 40 kV and 17 μA. Count times were 180 s. The Bruker spectral analysis package allowed the quantification in parts per million of thirteen elements including the same previous elements plus Pb (lead), and Th (thorium). The instrument was calibrated using the same procedure as the previous spectrometer. However, it must be noted that although MURR has used NAA to characterize obsidian sources in Argentina, recently, the reference samples were re-analyzed using XRF to enable comparisons for artifacts analyzed outside of MURR when measured by the Brucker hand-held portable XRF. In this analysis of 100 analyzed artifacts, only a small number had a diameter smaller than 0.8 cm or thickness of 0.3 cm. Even though XRF technique has limitations in the case of small/thin samples, MURR has recently started to use XRF on small artifacts from Argentina, resulting in a reliable degree of certainty.

Source determinations for both spectrometers were performed from a table of measured concentrations and with the assistance of bivariate plots of trace element data for the artifacts. Artifacts were assigned to a specific obsidian source if the diagnostic trace element values fell within two standard deviations of the analytical

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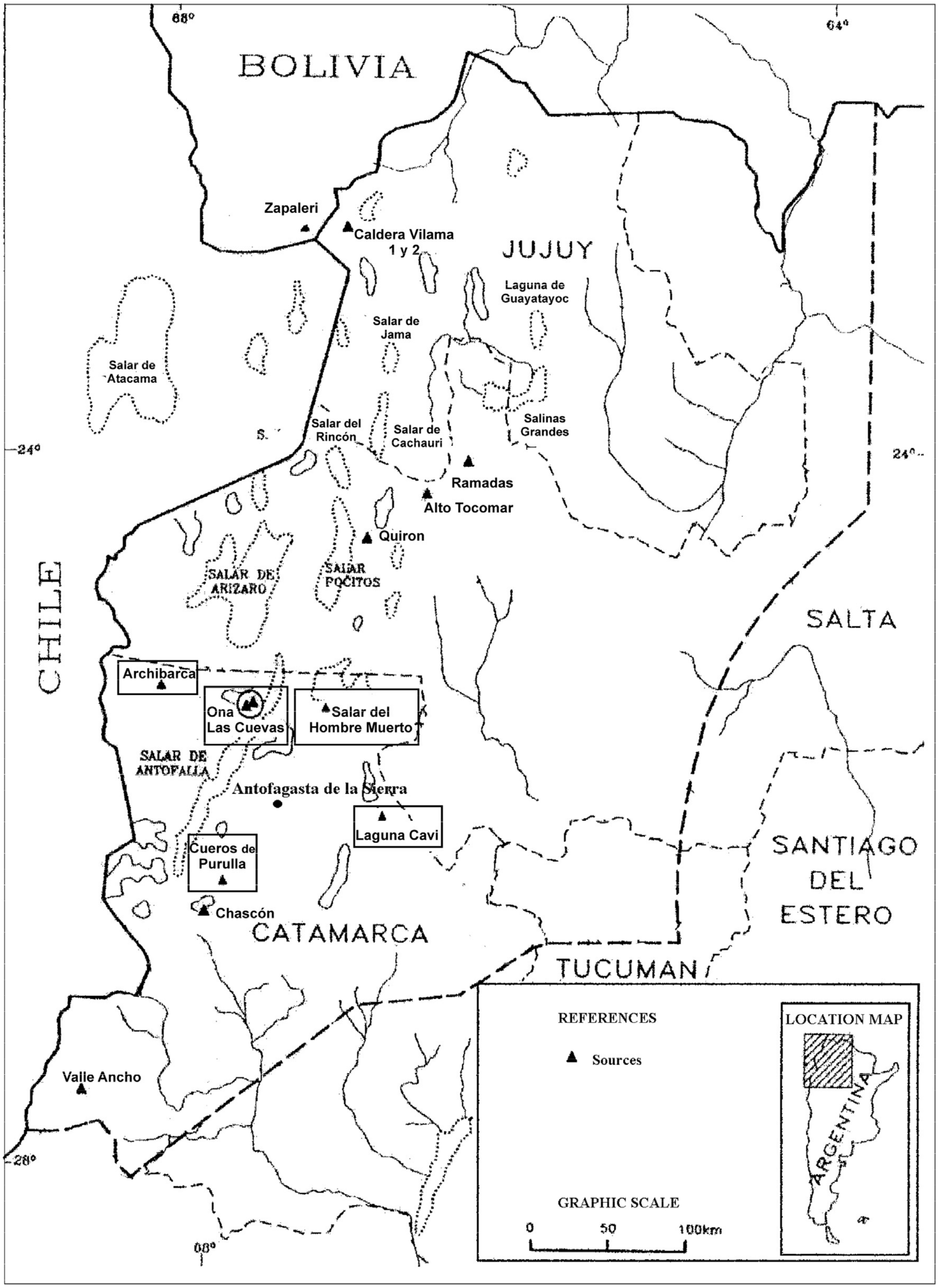

Fig. 3. Obsidian sources location in the Department of Antofagasta de la Sierra (Catamarca) and in relation to obsidian sources in Northwestern Argentina (Modified from Yacobaccio et al., 2002).

uncertainty of the upper and lower limits of chemical variability recorded for each source.

In the case of the bivariate plots, source assignment was performed by projecting artifacts against the reference ellipses of different and known sources. Specifically, the artifacts were projected against the 90% confidence ellipses for the known sources. These ellipses were generated from samples of sources much larger in size than the artifact samples. It should be noted that small/thin

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samples (less than 0.8 cm in diameter and 0.3 cm thick) did not always coincide with, or occur within, an ellipse reference since they were significantly smaller and thinner than the source samples used for calibration. In cases of small and thin samples that do not match with the reference ellipses, provenance determination was determined by using and comparing various plots of several pairs of elements (e.g., Rb vs. Sr, Rb vs. Zr, Zr vs. Sr). In this way, it is possible to assess the source of artifacts with an acceptable degree of confidence (Glascock, 2010). There were 12 analyzed archaeological samples that where less than 3 mm thick.

The macroscopic attributes variability of the obsidian artifact assemblages is taken into account during selection of the samples so that all potential known and/or unknown sources are represented. Specifically, attributes such as color, color texture, light transmittance, surface luster and surface texture were regarded. Also in the selection the relative frequency of the different varieties of obsidian was considered. Prior to sending samples to laboratory for analysis a macroscopic control and a tentative allocation of origin was performed to later compare against the geochemical results. This was very useful because it allowed us to reinforce the geochemistry identification especially in the cases of small and thin samples. Since most of the varieties of obsidian had distinctive macroscopic characteristics it was possible to establish their provenance in case of close ellipses. This occurred in the case of the Ona, Cueros de Purulla, Laguna Cavi, Salar del Hombre Muerto and Zapaleri sources, the Tocomar and Quiron sources shared macroscopic similarities possibly because they are located close to each other and therefore belong to a supra-regional area. The information obtained here was supplemented by previous provenience NAA results (Escola and Hocsman, 2007) performed on 13 obsidian archaeological artifacts from three of the six sites analyzed here, and on 46 samples from an agro-pastoralist site located in the same area (Yacobaccio et al., 2002).

4. Results

A total of 118 obsidian samples from six archaeological sites located in the Argentinean Puna of the Antofagasta de la Sierra basin (Catamarca Province, Argentina) were studied. All of these came from stratified, well-dated archaeological levels. Sixty-two obsidian samples were, on the one hand, from the rock-shelters Punta de la Peña 4 (PP4) (Fig. 4), Peñas Chicas 1.1 (PCh 1.1), Peñas Chicas 1.3 (PCh 1.3) (Fig. 5) and Alero Sin Cabeza (ASC) (Fig. 6) which were residential bases for hunter-gatherer in the process of food production dating to *c.* 4500–3000 BP (Aschero, 1986; Pintar, 1996; Aschero et al., 2005; Hocsman, 2006; Escola et al., 2013a). The other fifty-six obsidian samples where collected from two open-air sites – Las Escondidas (LE) (Fig. 7) and Punta de la Peña 9, Sector I (PP9.I) (Fig. 8). These were also residential bases, but with consolidated agro-pastoral contexts dated to *c.* 2100–1100 BP (Babot et al., 2006; Escola et al., 2013b) (Fig. 1).

All the archaeological samples were recovered from excavations and include both stone tools (projectile points) and lithic debitage. Data from previous provenience NAA results performed on 13 obsidian archaeological artifacts from Punta de la Peña 4 (4 samples), Peñas Chicas 1.1 (5 samples) and Peñas Chicas 1.3 (4 samples) were added in the analytical phases to augment the results thus obtained (Escola and Hocsman, 2007, Figs. 3 and 4). Basic obsidian assemblage statistics for each site are illustrated in Table 3, which takes into account the total number of obsidian artifacts at each site and the proportion of obsidian artifacts sampled from each site.

Table 3
Obsidian assemblage statistics

	4500–3000 BP								2000–1100 BP			
	PP4		PCh1.1		PCh1.3		ASC		LE		PP9	
	N	%	N	%	N	%	N	%	N	%	N	%
Obsidian Artifacts	385	100	21	100	92	100	334	100	168	100	86	100
Obsidian Artifacts Sampled (N = 131)	32	8.3	6	28.6	24	26.1	13	4.0	23	13.7	33	38.4

It is necessary to bear in mind that a relatively small number of samples per site was analyzed; therefore the interpretation of the percentages only reflects the existence of relative trends of the intensity of use of the different sources.

Table 4 presents the source-assignment results for the analyzed archaeological samples (n = 131). Of these, 123 artifacts were assigned to the five regional sources. From the remaining eight artifacts, three belonged to supra-regional obsidian from distant sources (Tocomar and Zapaleri/Laguna Blanca), two were identified as belonging to the compositional groups “Unknown-C” and “Unknown-G” and three could not be grouped (“Unassigned group”) (Fig. 3). Regarding the supra-regional sources, it is worth noting that Tocomar source located in Salta Province is 200 km distant, while the other (Zapaleri or Laguna Blanca source) in the Southwestern portion of the Altiplano de Lípez (Potosí, Bolivia) is 360 km distant. Meanwhile, Unknown groups “Unknown-C” and Unknown-G” have been previously recorded in very low density at later sites located in the study area suggesting that these minor sources might be from the Puna of Catamarca (Yacobaccio et al., 2002).

Table 4
Obsidian artifact characterization

Sources	4500–3000 BP								2000–1100 BP					
	PP4		PCh1.1		PCh1.3		ASC		LE		PP9		Total	
	N	%	N	%	N	%	N	%	N	%	N	%	N	%
Ona-Las Cuevas	20	62.5	1	16.7	8	33.3	3	23.1	14	60.9	27	81.8	73	55.7
Archibarca					3	12.5							3	2,3
Salar del H. Muerto	4	12.5	2	33.3	7	29.2	5	38.5	2	8.7			20	15.3
Laguna Cavi	4	12.5	2	33.3			4	30.8			2	6.1	12	9.2
Cueros de Purulla	3	9.4			3	12.5			6	26.1	3	9.1	15	11.5
Tocomar					2	8.3							2	1.5
Zapaleri/Lag. Blanca											1	3.0	1	0.8
Unknown C					1	4.2							1	0.8
Unknown G			1	6.7									1	0.8
Unassigned	1	3.1					1	7.7	1	4.3			3	2.3
Total	32	100	6	100	24	100	13	100	23	100	33	100	131	100

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In order to better understand regional movement in obsidian for the period under study the existing NAA results of 46 archaeological artifacts from the Casa Chavez Montículos site were also taken into account. This site is located in the basin of the Punilla River, nine kilometers away from the sites described previously. It is an open-air residential base with consolidated agro-pastoral contexts dating to *c.* 2400–1500 BP (Olivera, 1991). This chronology makes this site the oldest agro-pastoral settlement within the study area and therefore important in any study of this nature. The data from the Casa Chavez Montículos site has been previously published as part of a macro-regional approach (Yacobaccio et al., 2002) and is shown in Table 5 below.

5. Discussion: archaeological artifacts and differential patterns in obsidian distribution

All five regional sources – Ona-Las Cuevas, Archibarca, Salar del Hombre Muerto, Laguna Cavi and Cueros de Purulla – supplied obsidian to the groups in Antofagasta de la Sierra Basin over the period considered in this paper (*c.* 4500–1100 BP). However, the frequency of obsidian transport was not homogeneous and the data clearly shows that the Ona-Las Cuevas source was the most heavily used (56.6%). This source aside, two other geographically opposed sources particularly stand out. In the northern sector, there is a noted preferential use of the Salar del Hombre Muerto source

Table 5
Obsidian artifact characterization. Casa Chavez Montículos site.

	Ona source		Cueros de Purulla source		Laguna Cavi source		Salar del H. Muerto source		Unknown H source		Total No.
	N	%	N	%	N	%	N	%	N	%	
Casa Chávez Montículos(*c.* 2400 – 1500 BP)	31	67.4	8	17.4	2	4.3	4	8.7	1	2.2	46

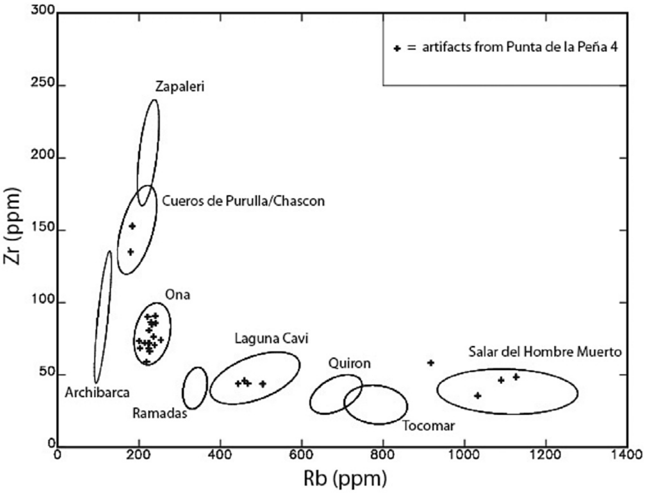

Fig. 4. A bivariate plot (Zr/Rb) of the obsidian sources represented at Punta de la Peña 4. The Unassigned sample is not included in the plot.

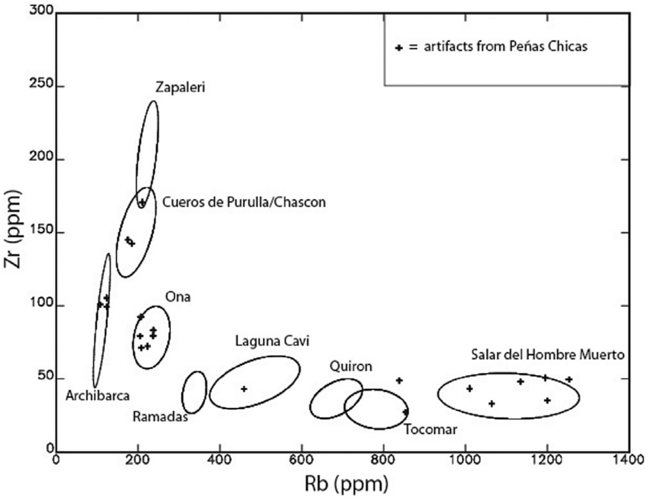

Fig. 5. A bivariate plot (Zr/Rb) of the obsidian sources represented at Peñas Chicas 1.1 and Peñas Chicas 1.3.

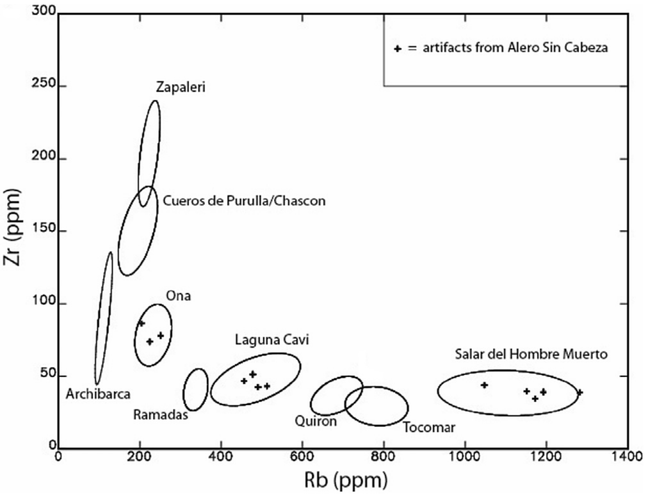

Fig. 6. A bivariate plot (Zr/Rb) of the obsidian sources represented at Alero Sin Cabeza. The Unassigned sample is not included in the plot.

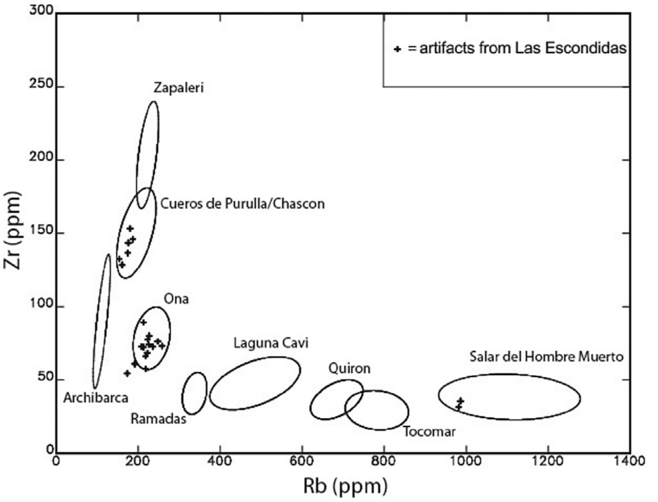

Fig. 7. A bivariate plot (Zr/Rb) of the obsidian sources represented at Las Escondidas. The Unassigned sample is not included in the plot.

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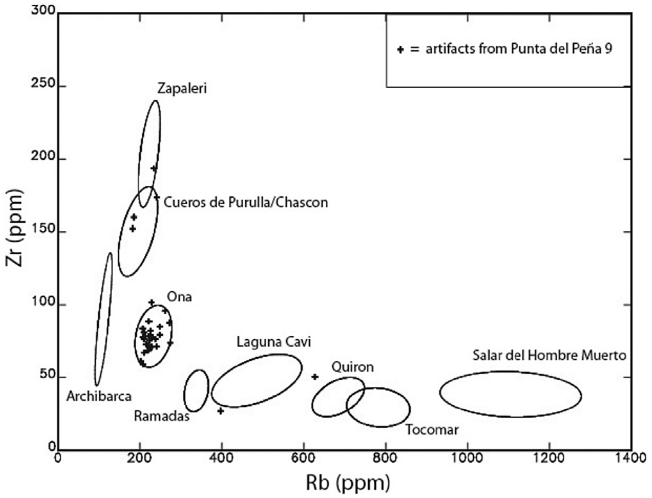

Fig. 8. A bivariate plot (Zr/Rb) of the obsidian sources represented at Punta de la Peña 9.

(14.7%), rather than the Archibarca source (2.3%). While in the southwestern sector, the Cueros de Purulla source seems to have provided more obsidian than Laguna Cavi source, even though the latter source was closer to the Antofagasta de la Sierra basin. The distribution described above is complemented by the presence of supra-regional obsidian from distant sources, one located in Salta Province – the Tocomar source – and the other in the southwestern portion of Altiplano de Lípez (Potosí, Bolivia) – the Laguna Blanca or Zapaleri source. The discovery of Tocomar obsidian and Zapaleri obsidian sources in Antofagasta de la Sierra shows the great distances involved in obsidian transport for the Argentine Northwest at the time studied (Yacobaccio et al., 2002, 2004; Aschero and Hocsman, 2011). In both cases their presence is important because it suggests North–South interactions, previously unidentified. Finally, the assignment of the remaining samples indicates not only the use of two compositional groups of currently unknown sources – Unknown C and Unknown G – but also the presence of an Unassigned group.

Nevertheless, this pattern changes drastically if we divide the use of obsidian sources diachronically between the earlier complex hunter-gatherers and the later consolidated agro-pastoralist groups. In this context a comparative analysis of movement in obsidian (Fig. 9) reveals several interesting trends.

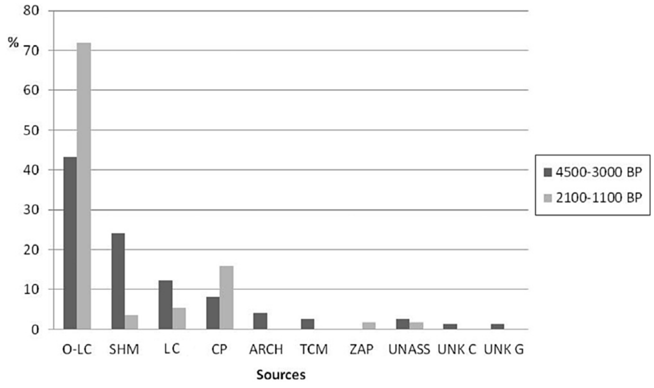

Fig. 9. Obsidian sources distribution and relative intensity of use through time. References: O-LC: Ona-Las Cuevas; SHM: Salar del Hombre Muerto; LC: Laguna Cavi; CP: Cueros de Purulla; ARCH: Archibarca; TCM: Tocomar; ZAP: Zapaleri; UNASS: Unassigned; UNKC: Unknown C; UNKG: Unknown G.

First of all, between *c.* 4500–3000 BP, all five regional obsidian sources were used by complex hunter-gatherers on the transition to food production, but with differential use intensity. In this setting there is a preferential use of the northern regional sources, 60–100 km distant from the sites, highlighting an emphasis on the exploitation of Ona-Las Cuevas (43%) and Salar del Hombre Muerto (24%) sources. In addition, there is use at a lower frequency of the Laguna Cavi (12%) and Cueros de Purulla (8%) sources while the Archibarca (4%) was the least used regional source. In this socio-economic context it is interesting to highlight the use of a supra-regional, yellowish obsidian from the Salta Province (Tocomar – 3%), as well as use evidence of two unknown sources (C and G) (2%). All these add to the great variability in sources used during this period.

In this regard, it is worth noting that for the period *c.* 2200–1100 BP, the Tocomar obsidian has been considered as a minor source with limited dispersion directed northwards providing obsidian to sites in the northern area – Salta and Jujuy Provinces – of NW Argentina (Yacobaccio et al., 2004; Mercuri and Restifo, 2014). At the same time, according to the evidence of Hornillos 2 site (Susques) in the Jujuy Province, obsidian from this source was limited even during the Middle Holocene (Yacobaccio, in press). Thus, even though only two pieces where uncovered, their presence could relate to formal or informal contacts between hunter-gatherers groups in the middle and Southern highlands of NW Argentina.

Meanwhile, the existence of the unknown sources C and G would account for the procurement of other varieties of obsidian from sources as yet unknown, but which we interpret as regional sources (Section 4). The remaining 3% corresponds to samples that could not be grouped (Unassigned group). In brief, eight sources (taking into account the unknown ones) – seven regional and one supra-regional – provided obsidian to the hunter-gatherers in transition to food production (Fig. 10).

During the period between *c.* 2100–1100 BP, it is possible to observe a very different pattern in the use of the obsidian (Fig. 9). Specifically, the data show that one of the Northern sources, Ona-Las Cuevas, was not only the most heavily used source (72%), but also experienced an even more intensive exploitation than at any time previously. In this regard, it is worth noting that during this period Ona-Las Cuevas was the source for almost all the obsidian found in the archaeological sites of the southern sector of NW Argentina, with a distribution range of 340 km. Obsidian from this source supplied archaeological sites in the Puna of Catamarca; sites located in eastern mesothermal valleys such as Valle del Cajón; West Aconquija, and Valle de Santa María (all located in Catamarca Province), as well as areas such as Valle de Lerma and Quebrada del Toro (Salta Province) (Yacobaccio et al., 2002). In the case of the other northern regional sources – Salar del Hombre Muerto and Archibarca – the former is reduced to the least exploited regional source (4%). This is complemented by the absence of obsidian from the Archibarca source in these agro-pastoralist contexts. It would seem that during this time both northern regional sources where scarcely used, or were simply not used by the inhabitants of the Antofagasta de la Sierra basin. Moreover, it is interesting to highlight that, while Cueros de Purulla and Laguna Cavi were exploited simultaneously, the use of the Cueros de Purulla source (16%) increased during this time period at the expense of that from Laguna Cavi (5%).

In addition, the presence of obsidian from an extra-regional source, such as Zapaleri (2%), located 360 km distant indicates the existence of possible long-distance contacts with groups from the Northern altiplano (Argentina, Chile and Bolivia). It is interesting to note that the black and shiny obsidian of the Zapaleri source has been uncovered in significant quantities at archaeological sites located in the Jujuy Province, as well as those to the North and West

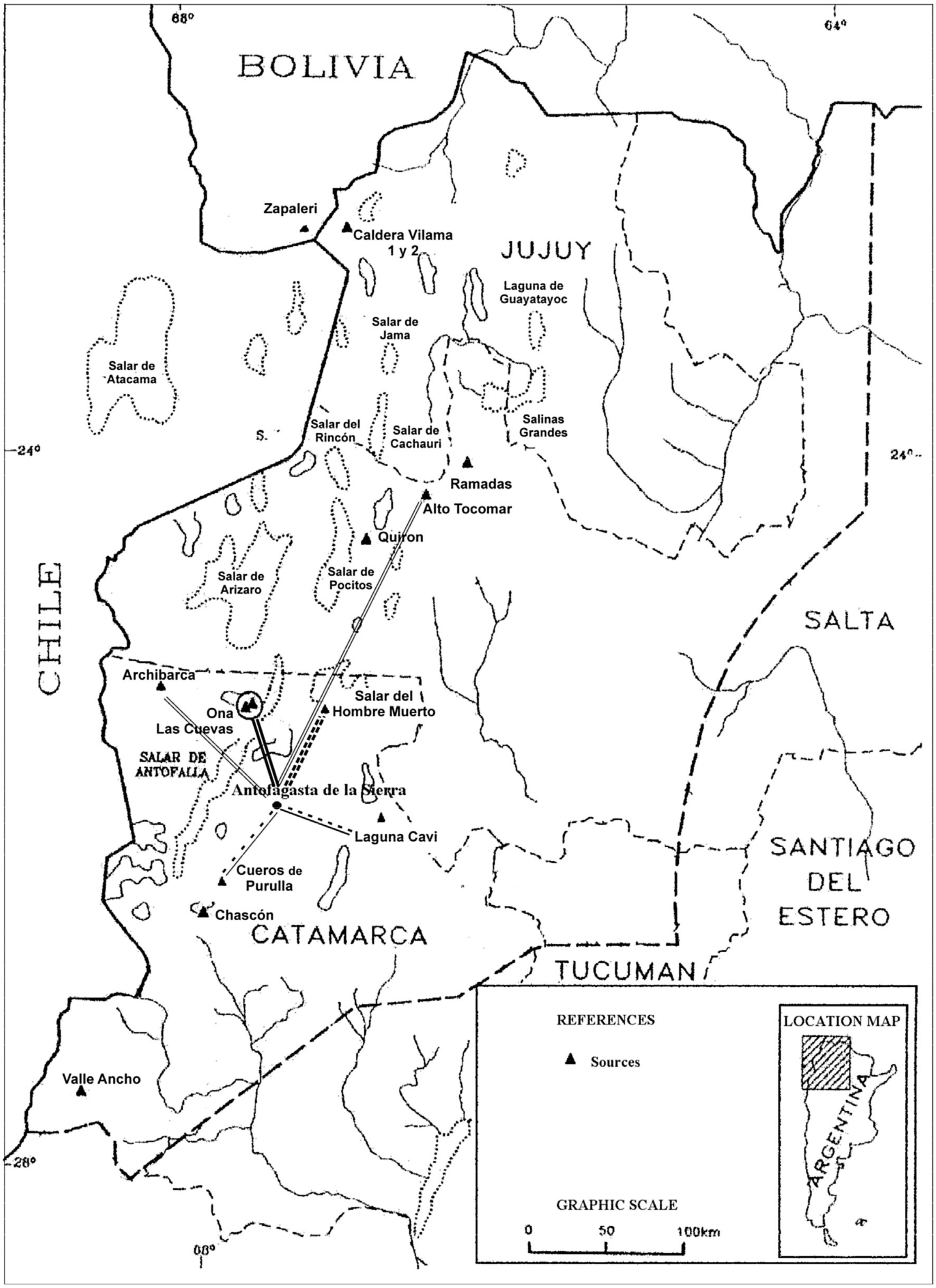

Fig. 10. Obsidian dispersion from regional and supra-regional sources (4500–3000 BP) (Modified from Yacobaccio et al., 2002).

of Salta from the Middle Holocene onwards, across a distribution range of 350 km (Yacobaccio et al., 2002; Yacobaccio, in press). Moreover, the importance of this source to the Northern area of NW Argentina is underscored by the fact that this obsidian is found at Tiwanaku, some 625 km from the source. According to Giesso (2000) and Glascock and Giesso (2012), the presence of Zapaleri obsidian in the Southern Titicaca basin indicates the existence of long-distance exchange between Tiwanaku and groups living in the Southern Bolivian altiplano. In turn, the Southern Bolivian altiplano was in contact with groups located in the South Andean Eastern

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valleys and the Salar de Atacama in Chile. This would suggest that such supra-regional long-distance contacts would be also be directed towards the Southern area. The remaining 2% composes samples that could not be grouped (Unassigned group).

In brief, five sources – four regional and one supra-regional – provided obsidian to the consolidated agro-pastoralist groups. This shows a differential pattern of procurement and use of obsidian with respect to the previous period (Fig. 11): a) Ona-Las Cuevas obsidian became highly predominant; b) the Cueros de Purulla source shows an interesting increase while the Laguna Cavi exhibited an acute diminishing use despite being the nearest source; and, c) the Salar del Hombre Muerto obsidian presented a vertiginous decline in comparison with the earlier period. Taking into consideration the absence of obsidian from Archibarca, it would seem that, beyond the intensive use of Ona source, the supply of obsidian might be linked more closely to Southern regional sources than to the Northern ones, especially the Salar del Hombre Muerto source. These changes could be linked with a reorganization of interaction networks in relation to obsidian supply. It is possible that the social ties which link the agro-pastoral groups of Antofagasta de la Sierra with contemporary societies located South and East acquired a more important role. This would have been detrimental to the links with the inhabitants of northern regions (Babot et al., 2006; López Campeny et al., 2014).

Moreover, if one takes into account the Casa Chávez Montículos samples analyzed (Table 5) with those already presented for this period (a total of 99 samples), this pattern of obsidian distribution is strengthened (Fig. 12). For example, with the inclusion of the Casa Chavez Montículos samples, the frequencies of the Ona-Las Cuevas (70%) and the Cueros de Purulla (17%) sources are maintained, replicating the pattern observed above. At the same time, we note that both the Salar del Hombre (6%) and the Laguna Cavi (5%) sources also replicate the established lower incidence pattern. Furthermore, these results allowed us to identify a new compositional group, Unknown Source H (1%), which makes its appearance with small amounts of obsidian.

Some common themes are evident when evaluating the results of this research of obsidian in Antofagasta de la Sierra. It is clear that between *c.* 4500–3000 BP the hunter-gatherers in transition to food production garnered different types of obsidian from a large number of sources (eight) both regional and supra-regional. We should also highlight that certain biotic and abiotic elements recovered from the archaeological contexts of the sites reinforce the evidence for long-distance contacts with other areas of NW Argentina (mesothermal valleys and the mountainous rainforest known as the *yungas*), as well as the Pacific Ocean coast, including mollusk shells, wood for making shafts and non-local plant species (Aschero and Hocsman, 2011).

Furthermore, this period is characterized by a progressive reduction in residential mobility, leading to increased landscape sedentism by groups at a micro-regional scale. This increase in sedentism can be observed in the use of the local lithic raw materials. The analysis on the frequencies of different varieties of local raw material between the Middle-to-Late Holocene transition and the beginning of Late Holocene indicates a marked increase, during the later period, in the use of the immediately available (within 2 km) lithic raw materials, both among tools (n = 102 -53. 8% – to n = 302 -75.8%) and debitage (n = 6984 – 65.2%- to n = 1818 -72.9%). At the same time, there is a recognizable decrease in the use of distally available lithic raw materials (2–25 km) taking into account tools (n = 102 -44.1%- to n = 302 -21.5%) and debitage (n = 6984 -34.6%- to n = 1818 -26.2%) (Hocsman, 2006, 2014, Table 8.10 and Table 8.11).

In this regard, although there is evidence of a reduction in residential mobility, the obsidian results, along with the presence of non-local resources and goods, still supports the existence of wide and flexible social relationships that would have allowed for exchange practices and transport patterns of goods at a regional/supra-regional scale (Yacobaccio, 2012). Even though the exploitation of certain obsidian through direct access to their sources cannot be rejected, it is possible that reduced micro-mobility, associated to prevailing arid conditions, was supplemented with formal or informal, regional and supra-regional, interactions. In this sense, it appears that taking into account the differences in use intensity of the different sources, obsidian procurement would appear to be mostly from the Northern regional sources.

Meanwhile, the results for the interval *c.* 2100–1100 BP further suggest that the networks continued and strengthened with the consolidation of food production and sedentary communities. However, there were interesting changes in the preferred directionality of obsidian movement. The consolidated agro-pastoralist groups took raw material from fewer sources while at the same time they obtained obsidian from one of the most distant sources within the study area. Clearly, the Ona-Las Cuevas regional source seems to have been the most important source during this period. Furthermore, this obsidian was complemented by the use of other minor sources in low or very low proportions. Indeed the results suggest that the regional supply of obsidian was more intense from the Northwest-Southwestern sectors (Ona-Las Cuevas and Cueros de Purulla) than from the Northeast-Southeastern one (Salar del Hombre Muerto and Laguna Cavi).

It is worth highlighting that for this period there is the distinct possibility that different kinds of exchange practices and transport systems coexisted, involving different goods and even varieties of obsidian. The preferred use of one type of obsidian (Ona-Las Cuevas) could be explained as a result of the wide range of the llama caravans. Indeed, this specific obsidian was at the head of a distribution sphere that spread over the Southern sector of NW Argentina from 2100 BP onwards. Consistent with this pattern, is that this variety of obsidian was the predominant raw material used for the manufacture of small and standardized stemmed arrowheads throughout NW Argentina from ca.2000–1000 BP (Escola, 2007). According to Yacobaccio (2012) this situation was quickly exploited by those in charge of llama caravans, so that specialized tools manufactured from this raw material (Ona-Las Cuevas obsidian) were moved around at levels not previously seen with hunter-gatherers groups.

Together with this transport network, people could also obtain obsidian from minor sources as the result of old and new down-the-line chains of exchange between neighbors, thereby leaving caravans aside. Here it is interesting to highlight that the movement of obsidian between the Northern Puna and the Southern Puna was in full operation. Provenience results from Las Cuevas, an early agro-pastoralist site (Salta Province) and from the Cueva de Cristobal site (Jujuy Province), between 3000 and 2000 BP, indicate the simultaneous supply of obsidian from Zapaleri/Laguna Blanca, Tocomar, Laguna Cavi and Ona-Las Cuevas (Yacobaccio et al., 2002; Dr. S. Hocsman Personal communication).

6. Conclusions and perspectives

This research has greatly expanded our knowledge of obsidian procurement and distribution during the late Middle and Late Holocene (*c.* 4500–1100 BP) in the Southern Argentinean Puna. Specifically, the source-assignments of 177 archaeological obsidian samples open up discussion about obsidian exploitation and the potential exchange systems that underpin it. All against a backdrop of a gradual transformation of hunter-gatherer/early agro-pastoral groups into consolidated agro-pastoral societies. The results indicate not only the existence of different patterns of obsidian

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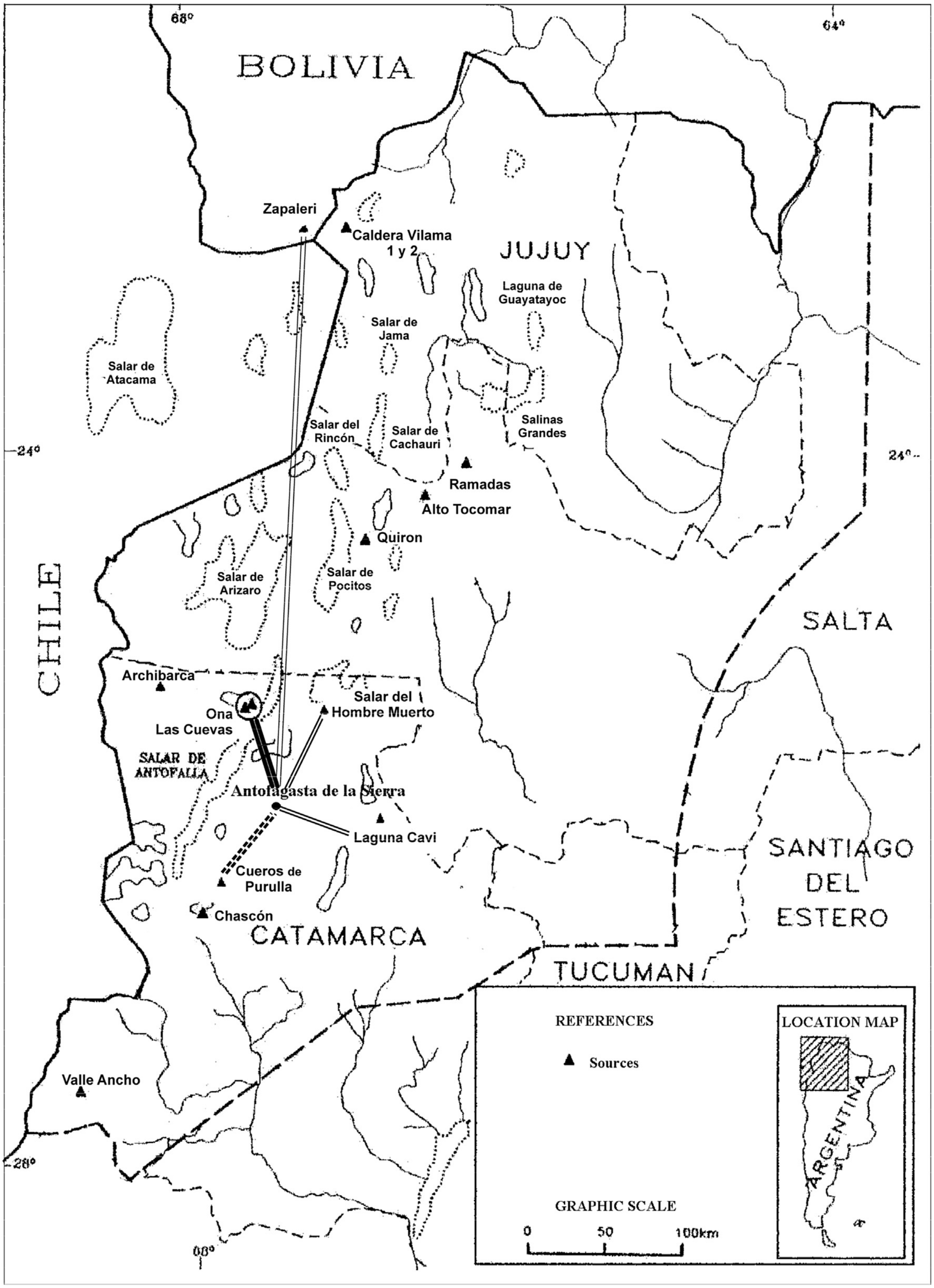

Fig. 11. Obsidian dispersion from regional and supra-regional sources (2100–1100 BP) (Modified from Yacobaccio et al., 2002).

movement and use, but also certain trends in the preferred directionality in obsidian use. We show a decrease in the number of sources used during *c.* 4500–3000 BP and the subsequent period (*c.* 2100–1100 BP). The Ona-Las Cuevas source was the source most frequently used throughout the entire time-span considered, where maximum exploitation took place during *c.* 2100–1100 BP. In regards to the other sources, certain minor differences were also observed. During 4500–3000 BP the Salar del Hombre Muerto and the Laguna Cavi were the sources that, together with other varieties of obsidian, were used with similar intensity by hunter-gatherer

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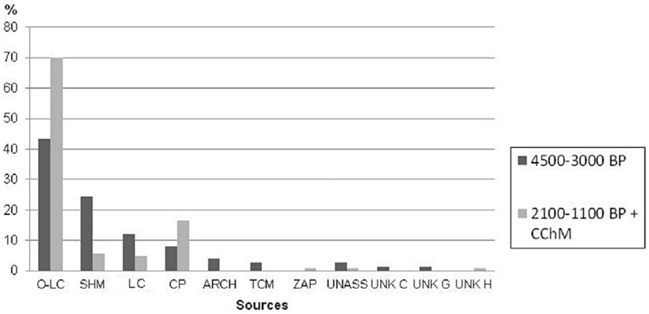

Fig. 12. Obsidian sources distribution and relative intensity of use through time taking into account the obsidian samples of Casa Chávez Montículos. References: O-LC: Ona-Las Cuevas; SHM: Salar del Hombre Muerto; LC: Laguna Cavi; CP: Cueros de Purulla; ARCH: Archibarca; TCM: Tocomar; ZAP: Zapaleri; UNASS: Unassigned; UNKC: Unknown C; UNKG: Unknown G; UNKH: Unknown H.

groups. During the following period – *c.* 2100–1100 BP – the Cueros de Purulla was the preferred source used. The existence of supra-regional contacts in both periods is also important.

This study then has contributed to the archaeology of obsidian movement, differential use of space, and of exchange systems developed by human groups during the transition to food production in the high elevation deserts of Southern South-Central Andes. In this sense, this paper constitutes a valuable contribution to comparative studies on the social dynamics of different desert environments.

Future research will study the ratio of obsidian versus all other raw materials, as well as a contextual, diachronic, analysis of specific tools as projectile points associated with obsidian. This will not only permit a better understanding of the role played by this raw material, but also will begin to address the inherent value and exchange regimes of which obsidian was probably part of.

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