Original Study

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Obsidian Distribution of the Northern Patagonian Forest Area and Neighboring Sectors during the Late Holocene (Neuquén Province, Argentina)

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Abstract: Analysis of 519 obsidian artifacts (pebbles, debitage, cores and small bifaces) by nondestructive X-ray fluorescence from forests and steppes of southern Lanín National Park in the northern Patagonian Andean region, from Lácar (chemical group QU/AP), Lolog (CP-LL 1), Filo Hua-Hum (FHH), Paillakura (Pk, former unknown 1 group), Meliquina (MQ, former unknown group 2) and Yuco (YC) sources. Neutron activation analysis was applied to 29 of the artifacts. We identified for the first time the presence of obsidian from distant Covunco (PC1) in the center of Neuquén. This paper is the first English language publication of our ongoing, ten-year-long research. In accordance with previous work, but using other analytical techniques, the most frequently used sources during the late Holocene remain CP/LL 1 and Pk, here we add YC, mainly by the incorporation of new sites recently surveyed in the islands and the coast of Lake Lácar, next to its source. Another result consistent with previous work is the absence of obsidian from Mendoza and Chilean sources; therefore, we suggest these obsidians circulate just to the east and northeast, allowing us to discuss issues of human territoriality during the Late Holocene.

Keywords: Obsidian, XRF, INAA, Neuquén, Patagonia

1 Introduction

In the southern sector of the province of Neuquén obsidian appears in the archaeological record at the earliest sites, approximately 10,000 years BP (Ceballos, 1982; Crivelli Montero, Curzio, & Silveira, 1993; Crivelli Montero et al., 1996; Palacios, Vázquez & Hajduk, 2010). At the same time, in the west-central area of the province its presence is recorded in contexts pre-dating 7000 BP in the Chenque Haichol cave (Fernández, 1988–1990).

In Neuquén there are at least three areas where obsidian sources are located (Figures 1 and 2). The northernmost is the area of Cerro Huenul and consists of primary and secondary sources on an extra-cordilleran plateau located on the right bank of the Colorado River (Durán et al., 2004). Obsidian is quite abundant and most are present in the form of medium- and small-sized nodules (Giesso et al., 2011; De

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Francesco *et al.*, 2006; Duran *et al.*, 2004; Seelenfreund *et al.*, 1996). Several chemically similar artifacts are distributed in sites in the south of Mendoza, La Pampa as well as central Chile (Giesso *et al.*, 2008; Barberena *et al.*, 2011; Duran *et al.*, 2012; Salgan, Gil, & Neme 2014). A second area is located around Portada Covunco (Bellelli, Pereyra, & Carballido, 2006), south of Cerro Huenul. These are obsidian nodules associated with Arroyo Covunco (Bellelli, Pereyra, & Carballido, 2006), and along the rivers Kilca and Aluminé (Salazar & Stern, 2013). Obsidian artifacts with similar chemical composition to the latter source are found 430 km to the south at archaeological sites in the area of Cholila, in the western part of the province of Chubut (Bellelli, Carballido, & Stern, 2018), and sites of the central Chilean valleys 70 km from the source (Stern, Pereda, & Aguerre, 2012) as well as islands in the Pacific, as in the case of Mocha island in the last 1.000 years BP (Stern, 2017; Campbell, Stern, & Peñaloza, 2016; Campbell *et al.*, 2018), Rincón Chico 2/87, 150 km to the southeast (Palacios, 2009; Perez, López, & Stern, 2012) and at sites of the San Matías gulf, 500 km to the East, on the Atlantic coast (Alberti *et al.*, 2016). The third area is the National Lanín Park, where there are several sources, and which we will refer to in this paper. The most widespread of them is CP/LL1, whose material was found around 400 km to the east-northeast, in the southern part of the province of La Pampa (Giesso, Berón, & Glascock, 2008; Lopez, *et al.*, 2009).

In the western flanks of the Cordillera, the obsidian dome of Volcán Chaitén, a translucent grey-green rhyolitic obsidian source is present in different places from the Grande Island of Chiloé to the tip of Chan Chan and along the north coast of Valdivia and Pacific Island sectors (Stern *et al.*, 2008). More recently, a quarry with black obsidian has been discovered in the Nevados de Sollipulli (MEL), west of the Sollipulli volcano, in the area of Melipeuco, Araucanía Region (Figure 2). Artifacts made with this obsidian are found on archaeological sites near this quarry (Stern *et al.*, 2008; Stern, 2017) in the areas of Caburga and Villarica (Navarro *et al.*, 2011). The obsidian is black with fine white flow bands with a low proportion (< 1%) of plagioclase crystals. It is darker and with fewer crystals of plagioclase than obsidian in the Chaitén volcano (CH), rhyolitic, translucent, grey-greenish (Stern *et al.*, 2008; Stern, 2017). No Chaitén nor Sollipulli obsidian have been yet found on the eastern side of the Cordillera.

Here we present a synthesis of the present-day knowledge of the spatial and temporal distribution of chemical groups of obsidian from the southern Neuquén forests, in northwestern Patagonia (Argentina). At the end we integrate our results with the information obtained by other scholars that work in nearby and distant sites (Fernández & Vitores, 2015; Alberti *et al.*, 2016; Campbell, Stern, & Peñaloza, 2016; Campbell *et al.*, 2018; Stern, 2017; Belleli, Carballido, & Stern, 2018) who have reported data or have done interpretations on the chemical groups from our area of study (Figure 1).

1.1 Regional Archaeological Assemblages

Our study area includes sites located in three main basins: 1) the Basin of the River Limay archaeological area (as defined in Crivelli Montero, 2010), 2) the eastern sector of the archaeological area of the basin of the Valdivia River (Pérez, Giesso, & Glascock, 2015), and 3) the archaeological area of Neuquén river basin (Cúneo, 2010). Among the sites of the second, which in Argentina it is limited to the Lake Lácar basin, we use the classification of Early and Late Ceramic periods, following Chilean classifications for the broader area, as we recognize a continuity between the landscape and the material culture along the drainage basin of the Valdivia River (Pérez, 2016). The first period began around 1700 BP, and is characterized by the presence of pottery, expedient/informal lithic instruments, typical fauna of the forests and lake area, plant collection, supplemented by hunting, fishing and horticulture. These assemblages are similar to those described to the west of the Cordillera in sites that correspond to the Archaeological Tradition of the Temperate Forests (ATTF) (Adán, García, & Mera, 2010), formerly known as Pitrén Complex based on the funerary pattern (Aldunate, 1989) and its pottery (Dillehay, 1990). Recently, the ATTF was characterized based on settlement pattern, subsistence and technological organization as an adaptive strategy to forests and lakes (Adán, García, & Mera, 2010; Adán & Mera, 2011; Navarro, Dillehay, & Alfaro, 2011).

The Late pottery period, also defined in the trans-Andean region, is well-represented in the northern and central sector. It is estimated that it began in the 11th century AD, and these populations coexisted with those of the ATTF until the 15th century AD (Reyes, 2009; Adán & Mera, 2011; Navarro, Dillehay, &

Alfaro, 2011; Pérez, 2011). The Late period contexts are characterized by an increase in the production scale, including formal and planned agriculture, more permanent and more complex residential settlements based on the northern sector of the Mahuidache-Lastarria corridor in the central Chilean valleys, and from there we find enclaves distributed from the Pacific coast to the west of the Cordillera. It is characterized by a red-on-white pottery, called El Vergel, which includes the Valdivia style (Aldunate, 1989; Adán, García, & Mera, 2010; Navarro, Dillehay, & Alfaro, 2011). Some Late period sites also contain exotic (Old World) fauna, glass beads, and Spanish ceramic wares known as Pucopiense, which even though there are no dates for them, can be assigned to the Post-contact or Early Colonial period (Menghin, 1962).

From a geographic point of view, the study area corresponds to the lake and forest environment of the Andean Cordillera. The topography is typically hilly, with steep slopes and a landscape dominated by the glacial geoforms, and traces of volcanic action (Mermóz et al., 1997; Funes et al., 2006). The region has many bodies of water, among which the lakes of glacial origin stand out. Almost all of the main fluvial systems and lagoons drain the Patagonian rivers to the Atlantic Ocean, the only exception being Lake Lácar, which drains into the Pacific Ocean.

2 Materials and Methods

The sample is made up of 519 lithic artifacts and raw material from all sources described in our region of study (519 were analyzed by XRF and of those, 29 were analyzed by NAA). Analyses were conducted in several stages from 2008 until November 2018: initial work took place at the University of Missouri Research Reactor (MURR), both by neutron activation and by X-ray fluorescence (ElvaX and Bruker). The 90 analyses done with ELVA-X in 2009 (in first 90 items of the XRF table) should be compared with caution with those done with the Bruker portable spectrometer. Two later stages were with a portable Bruker XRF spectrometer at the National University of Cuyo (Mendoza). Finally, a recently acquired Bruker XRF Tracer 5i was utilized at the Laboratory of Material Culture of the Anthropology Department of the Catholic University of Temuco in southern Chile (8 samples from Los Radales 1).

The materials come from sites from the southern sector of the province of Neuquén, specifically the Huechulafquén, Lolog, Lácar, Meliquina, Filo Hua-Hum and a good part of the Chapelco range, both rock shelter/cave sites and Lake coast sites and islands (Table 1 and Figure 1).

In the first stage, four sources were identified through the neutron activation analysis of 29: 9 correspond to the Lacar Lake source, 8 to the Lolog Lake, 4 to Meliquina, 4 to Yuco. The remaining 4 were outliers.

The neutron activation analyses at MURR consisted of two irradiations and a total of three gamma ray counts (Glascock, 1992; Neff, 1992, 2000). The procedures start with a short irradiation through a pneumatic tube system. The 100mg samples are irradiated in sequence, two at a time, for five seconds with a neutron flux ($8 \times 10^{13} \text{ n cm}^{-2} \text{ s}^{-1}$). The 720-second count produces a gamma-ray spectrum that contains peaks for short-lived elements: Al, Ba, Cl, Dy, K, Mn, and Na. The second irradiation uses 200 mg samples that are irradiated for 24 hours with a neutron flux of $5 \times 10^{13} \text{ n cm}^{-2} \text{ s}^{-1}$. After irradiation, samples are left for seven days and the samples are counted for 2000 seconds using a high-resolution germanium detector coupled to an automatic sample changer. This first count produces determinations of seven elements of medium half-life, specifically Ba, La, Lu, Nd, Sm, U, and Yb. After an additional three or four weeks, a final count of 9,000 seconds is made for each sample. The latter measurement produces data for 15 long half-life elements: Ce, Co, Cs, Eu, Fe, Hf, Rb, Sb, Sc, Sr, Ta, Tb, Th, Zn, and Zr.

An Elva-X portable X-ray fluorescence spectrometer was used for the first measurements in 2008. The ElvaX spectrometer was operated with a voltage of 35 KeV, a current of 45 microamps, and operating time of 400 seconds. The resolution was 180 eV at 5.9 KV. Concentrations were calculated in parts per million using the ElvaX Regression program, based on the quadratic regression model of a series of reference obsidian samples previously characterized by both neutron activation and XRF. The elements quantified were K, Ti, Mn, Fe, Zn, Ga, Rb, Sr, Y, Zr, and Nb. This equipment allowed processing between 70 and 80 samples daily.

Subsequent XRF measurements employed a Bruker Tracer III-V and 5i portable spectrometers with counting times of 60 to 180 seconds. Between 100 and 120 samples could be analyzed daily with these spectrometers.

This research expands on previous analyses. At that point one of us (Perez) had 110 results through various analytical techniques on debitage. The samples included 15 geological samples from the top of the CP and 20 artifacts of the LM-FI assemblage, using the technique of the ICP-MS (laser ablation inductively-coupled plasma mass spectrometry) (Pérez & López, 2010). Another 75 samples had been analyzed using INAA (instrumental neutron activation analysis), XRF (X-ray fluorescence) and ICP-MS with dissolution (López, Pérez, & Stern, 2009; López, Silveira & Stern, 2010; Pérez, Lopez, & Stern, 2012).

3 Obsidian Sources by Areas

3.1 Lolog Area

The area of the Lolog lake basin presents two chemical groups, one exclusive to the Lolog-Quilquihue basin and another shared with the Lácar basin that until recently we had characterized as exclusive to Lácar (López, Pérez, & Stern, 2009; Pérez, Lopez, & Stern, 2012; Pérez, Giesso, & Glascock, 2015).

Lolog is a primary source located at the top of the Cerro de las Planicies (39° 59' 12" S – 71° 23' 10" W), near the north shore of Lake Lolog, in the jurisdiction of Lanín National Park (Pérez & López, 2004, 2007). The site is named in the geological sheet 37 A, B of Junín de los Andes (Turner, 1973). The hill is 1732 m in height and is next to Cerro Aseret (2018 m), both are part of the Aseret Formation. Its top is bare, covered by abundant obsidian nodules (angled and pebbles), the nodules have sizes from 1.6 cm to above 25 cm in diameter. Different colors and shades are represented, such as black, black with grey and black veins, and/or brown or reddish spots, of which flakes were extracted, which according to the thickness, can be translucent to transparent with veins or black spots, or completely transparent when they are thinner. Homogeneous nodules are available and they are of excellent quality for knapping.

Lake Lolog presents secondary sources of this chemical group composed of pebbles located in different sectors of the north coast of the lake in different densities (López, Pérez, & Stern, 2009). These boulders are more abundant and larger on the coast near the base of the hill. Both variables – abundance and size – decrease as the distance increases with respect to the hill according to the natural slope that follows the direction of runoff of the basin in eastern direction, transporting raw material to the Arroyo Quilquihue, even reaching the Colloncura River in the form of small boulders.

Its vitreous texture (crystalline) and polychromy are the most outstanding characteristics of this chemical group, and that differentiates them from the others nearby, being the translucent black variety to transparent, or black spots and black with veins and/or brown spots. The black with brown or reddish veins or spots type is the most represented.

Obsidians chemically similar to those of the Cerro de las Planicies were found in the area of Lake Meliquina, 40 km. south of the source (Pérez & López, 2007), in the steppe (Fernández & Vitores, 2015), plateau (Boschín & Massafiero, 2014) and on the Atlantic coast of Rio Negro, in the Gulf of San Matías, 560 km east of the source (Favier Dubois, Stern, & Cardillo, 2009; Alberti *et al.*, 2016), in sites of La Pampa, 520 km distant from it (López, Pérez, & Stern, 2009) and 370 km to the south, in sites of the Cholila forested area of the province of Chubut (Stern, 2017; Bellelli, Carballido, & Stern, 2018).

3.2 Lacar Area

Chemical group QU/AP

There are two chemical groups in Lake Lácar, one of them called Quilahuinto/Pocahullo (López, Pérez, & Stern, 2009; Pérez, Giesso, & Glascock, 2015), the most represented along the northeastern coast of the lake. The second, called Yuco (López, Pérez, & Stern, 2009), appeared to be present only at one beach on Lake Lácar (López, Pérez, & Stern, 2009; López, Silveira, & Stern, 2010; Pérez, Lopez, & Stern, 2012). During the summer of 2014 we located two secondary sources on the coast of the southwestern sector of Lake Lolog (Pérez, Giesso, & Glascock, 2015). The presence and abundance of Yuco perlite obsidian (YC) suggests the southern slope of the Sabána range, near Lake Lácar as its source of origin (Pérez, Giesso, & Glascock,

2015). We will focus here on the description of the most abundant chemical group of the Lácar Basin, called Quilahuinto/Pocahullo (QU/AP), which is only present here. The name comes from the first secondary sources described by one of us (López, Perez, & Stern, 2009; Pérez et al., 2008). The obsidian seems to have its origin in a narrow area of the Sabána range, whose highest peak is the Cerro Colorado at 1,778 meters above sea level. Its distribution and southeast dispersion coincides with visible glacier dynamics. We have recently identified a moraine that constitutes an important secondary source, concentrating the largest amount of raw material, abundance of perlite and the largest sizes, which seems to confirm the origin of this chemical group and project its distribution to the secondary coastal sources we had previously characterized (Pérez, Giesso, & Glascock, 2015).

QU/PH obsidian is black and grey, also present in fine veins with alternating proportions of both colors. Unlike obsidian from Cerro Las Planicies, the predominant texture is silky, and to a lesser extent they are crystalline and translucent. The nodules do not exceed 5 cm in diameter on the coasts but can exceed 10 cm in the moraines that are in the form of cones around the Sabána range.

Chemical group shared between the Lolog and Lácar basins:

Yuco (YC):

Yuco is a secondary source composed of translucent black obsidian pebbles deposited on a beach near the locality of Yuco (40° 9' 31" S – 71° 30' 44" W). It is an extensive beach on the north-central coast of lake Lácar (Pérez, 2008), with lake access, which features obsidian pebbles of excellent quality, some exceeding 5 cm in diameter (López, Pérez, & Stern, 2009; Pérez, Lopez, & Stern, 2012). Recently, within this sector, we have also identified perlite obsidian nodules, some of which exceed 20 cm in diameter and weigh up to 1 kg. This suggests the presence of a primary source close by. The peculiarity of Yuco is that pebbles of excellent quality and sizes up to 5 cm in diameter are present in at least two secondary sources (beaches) of the southwestern coast of lake Lolog, which makes it a source available in both watersheds (Pérez, Giesso, & Glascock, 2015).

Scarce fragments of ceramics and lithic artifacts associated with knapping activities were found on the site. In front of the beach, on the south shore of the lake, in a place also difficult to access terrestrially, there is a small cave with rock paintings.

3.3 Area Chapelco Range

Paillakura chemical group (Pk)

Paillakura is a new source identified from one of the most abundant chemical groups among the lithic artifacts previously studied and characterized as what we called Unknown source 1 (López Pérez, & Stern, 2009; López, Silveira, & Stern, 2010; Pérez & López, 2010; Pérez, Lopez, & Stern, 2012). This is a primary source located in part of the western slope of a hill in the Paraje Paillakura, Central Eastern sector of the Chapelco range (Pérez, Giesso, & Glascock, 2015). It is obsidian of excellent quality, located on a sandy slope where pieces of obsidian of more than 500 g of weight descend by gravity. Some are true nuclei, which allows us to characterize the site as a quarry-workshop. The Pk obsidian is homogeneous, silky black in color, a distinctive trait that differentiates it from the remaining nearby chemical groups. Due to its location, this chemical group may be available in isolation or at secondary sources along the interior of the Chapelco range by means of glacial retraction, and in greater quantity and sizes by gravity and dynamics of the Paillakura river, which flows into the river Caleufú in its middle to upper section, and then into the river Colloncura at 40° 24' 03" S – 70° 42' 59" W, and 17 km from its confluence with the river Limay.

3.4 Meliquina Area

Chemical groups MQ and FHH

Meliquina is a secondary source of obsidian that is currently discontinuously distributed on the west coast of Lake Meliquina and the basin of the river of the same name (Pérez, Giesso, & Glascock, 2015). The second chemical group represented among the artifacts of the area Meliquina was characterized until now as Unknown 2 (López, Perez, & Stern, 2009; López, Silveira & Stern, 2010; Pérez & López, 2010; Pérez, Lopez,

& Stern, 2012). It is present in sizes greater than 50 cm in diameter and 5 kg in weight as perlites in proximity to its intersection with the River Filo Hua-Hum. Both rivers are very dynamic and are full of basaltic and granite boulders of great hardness, a combination of factors that determines that good quality obsidian is fragmented and can only be recognized at present in its most resistant form, which is of poor quality for knapping. Its color is black or translucent grey. This may have been an important source when the watercourses were less dynamic, providing pebbles of greater quantity, accessibility and quality.

3.5 Filo Hua Hum Area

We have recently characterized this chemical group as unique to the lake Filo Hua-Hum basin (FHH) in the form of a secondary source, draining through a canyon of Puesto Domingo ($40^{\circ} 30' 01''\text{S} - 71^{\circ} 22' 12''\text{W}$, 1017 meters above sea level), a seasonal water course that carries pebbles of obsidian among other harder rocks, reaching a course of permanent water that continues downstream into Lake Filo-Hua-Hum, and onto the river of the same name to join the river Meliquina and to create the river Caleufú (Pérez, Giesso, & Glascock, 2015). Obsidian is present as a perlite in sizes greater than 10 cm, while the quality for knapping is limited: few are free of impurities. Its color is translucent grey.

4 Discussion

4.1 Spatial and Temporal Distribution of the Chemical Groups

The oldest published records of the chemical groups identified in our area of study correspond to the effective use of the chemical group Pk (ex. Unknown 1), of the valley and Paillakura River to the East center of the Chapelco range, from the site Epullán Grande (LL6) stratum 07, dated between 9970 ± 100 (LP-213) and 7060 ± 90 BP (Beta-41622) and associated with another artifact of the PC1 chemical group (Fernández & Vitores, 2015; Pérez, Giesso & Glascock, 2015; Stern, 2017). Contemporaneous to these is the presence of CP/LL1 obsidian in Traful I Cave's (CTI 7) Stratum 13 and Pk obsidian in (CTI 6 and 8) Stratum 13, whose chronology is between 7308 ± 285 LP-8113; 7850 ± 70 LJ-5133 and 9285 ± 313 BP LP-6213 (Fernandez & Vitores, 2015). Between 7,000 and 6,000 years BP, both chemical groups, Pk (57%) and CP/LL1 (43%) are represented almost in equal proportions between strata 9 and 15 of the Traful I Cave (Fernandez & Vitores, 2015). Since the Late Holocene, the registries of the Traful area indicate the predominant and continuous use of the chemical groups CP/LL1 and Pk during the last 3,500 years BP, from the preceramic component (ALC, CA-LC) of Alero Los Cipreses, dated between $3,490 \pm 90$ and $2,890 \pm 100$ years BP, where Pk predominates with 7 artifacts and then CP/LL1 with 5, together with 1 unknown source sample (López, Silveira & Stern, 2010; Stern, 2017). The ceramic component of the same site (ALC, CC-LC) dated between $1,510 \pm 90$ and 840 ± 90 years BP, presents the same trend, with 6 artifacts of group Pk and 4 CP/LL1, in association with other samples of a local chemical group of poor quality not used for instrument at the site (López, Silveira, & Stern, 2010). At the nearby site of Alerio Lariviere, from 780 ± 90 years BP, Pk again is represented with 3 artifacts and CP/LL1 with 2, together with samples of local obsidian of poor quality without evidence of use (López, Silveira, & Stern, 2010). In the sites of the Limay area, Cueva Epullán Grande there is an exclusive use of 3 artifacts of the Pk group in its Stratum 19 3a, dated to 2740 ± 50 BP (Beta-47402), and in lesser quantity in Stratum 19 1a and 2a, with a date of 2360 ± 50 BP (Beta-61146), 2 artifacts where one belongs to the MQ group. Almost synchronously in Cave Traful I, stratum 4 of CTI 1, 2 and 3, dated to 2720 ± 60 BP (LJ-5131), of 3 artifacts, 2 (66.6%) correspond to the Pk group and 1 (33.3%) to CP/LL1. In Casa de Piedra de Ortega (CPO), province of Río Negro, for the year 2000 ± 90 BP (LP-168) an artifact of the Pk group is recorded in its PCO E2 stratum. While for the strata CPO H, 2720 ± 60 years BP (LJ-5131), there are one of each of MS1 and CP/LL1.

At this time we have the record of the first occupations of the LAM (Lago Meliquina site) from the lower component of CPD (Cueva Parque Diana), with people transporting and distributing a limited number of base forms and finished tools in caches through the landscape. Clearly, this behavior is framed in a logistic

use of space (Binford, 1979, pp. 257–258), where individuals or groups of tasks detached from a distant residential base and outside their usual foraging radio are camping in the LAM without leaving much evidence of their interaction with local resources (Pérez 2018). We find the presence of blade technology using Pk obsidian, contemporary with the occupations of cave Epullán Grande and Casa de Piedra de Ortega (CPO), and the circulation of the chemical group MQ as evidence of the supply of raw materials in our area of study, which is significant in residential sites such as Cueva Epullán Grande.

Regarding ceramic contexts, places like Rincón Chico 2/87 (RCH2/1) in its F-layer, level 200–201 dated to 680 ± 65 BP (LP-855) and 710 ± 60 BP (Beta-47403), present 1 artifact of the PC1 group, while the (RCH2/2) layer C, level 125–130 with the same chronology presented an artifact of the Pk group (Fernandez & Vítors, 2015). For historical moments, the site of Casa de Piedra de Ortega, in the 280 ± 50 BP (LP-191) level, has two artifacts of the CP/LL1 group and another corresponding to MQ.

Another sample of heterogeneous origin in Northwest Patagonia that includes forest sites was made by energy dispersive X-ray fluorescence (Palacios, Vázquez, & Hajduk, 2010). We analyzed 76 samples, corresponding to 53 artifacts from 15 archaeological sites and a remaining 23 samples of reference raw material from 4 sources. These are sites in the northern sector of Neuquén in the steppe area of the Curi-Leuvú river basin, then in the center of Neuquén near Portada Covunco, where only samples of raw material were obtained. Finally, the sample included 37 artifacts from several sites located in the upper and middle Limay river basin, such as El Trébol in a wooded and lacustrine area, the Trafal I cave in the forest steppe ecotone and Arroyo Corral I and Epullán Grande Cave in the steppe.

We note that in the sites located from the center to the north of the province of Neuquén, the chemical groups represented are mostly PC1. On the contrary, towards the southern sector the association or grouping between the artifacts from Arroyo Corral I, Valle Encantado 1, Trafal I cave, Epullán Grande, El Jarillal and Rosita Quevedo with the primary and secondary sources of the Cerro de las Planicies-Lake Lolog of the central sector of our area of study (Palacios, Vázquez, & Hajduk, 2010), this association is already confirmed in the works of Fernandez and collaborators for the sites Cave Trafal I and Cueva Epullán Grande (Fernández & Vítors, 2015). The samples that remain without association in these same sites were attributed to natural sources of obsidian that were until then unidentified. They highlight the relative proximity of the archaeological sites of the Limay River basin, particularly Arroyo Corral I; Valle Encantado 1; Trafal I Cave and Epullán Grande Cave, to the natural source of obsidian CP/LL 1 located between 80 and 100 km away. However, without ruling out the presence of obsidian of distant provenance, we have confirmed that the chemical variety Pk, characterized earlier as Unknown 1, is among the best represented in sites in the middle and upper basin of the Limay River from the earliest moments of its population (Fernández & Vítors, 2015). This corresponds to the primary source that we have identified and described here as Paillakura (Pk), confirming the potential loci for the nearest supply of, abundant and excellent quality obsidian, so we suppose that Paillakura obsidian could be present since the earliest occupations of the sites Arroyo Corral I (< 50 km) and El Trébol (< 90 km), knowing that it is already accessible and effectively used towards 9970 ± 100 BP (LP-213) in Cueva Epullán Grande.

4.2 Regarding the Southernmost Records

Recently, information on sites of the forested area of the province of Chubut has been published, around the area known as Andean region of the Comarca Andina del Paralelo 42° Sur (Stern, 2017; Bellelli, Carballido, & Stern, 2018). Obsidian from Portada Covunco was found there, more than 370 km south of its source (Bellelli, Pereyra, & Carballido, 2006). This finding suggests that obsidian circulated from the north, but without interaction with forest sites, a view that now has changed based on the identification of four of the chemical groups from the forests of southern Neuquén that we found and described previously (Pérez et al., 2015). Bellelli and collaborators (2018) identified the presence of Pk (700 ± 60 BP) and QU/AP (680 ± 60 BP) obsidian in the El Manzo site, and CP/LL1, YC and Pk in the Cholila site (all dated to around 680 ± 60 BP). In most cases the materials are tools such as projectile points and reactivation and maintenance debitage (see Bellelli, Carballido, & Stern, 2018, p. 5).

Figure 1. Location of sources and archaeological distribution of chemical groups from southern Neuquén (site references in Table 1).

Table 1. Obsidian chemical groups analyzed. Early Pottery Period, II to XIth centuries AD. Late Pottery Period, XI–XVIth centuries AD; LC: Lower Component; MC: Medium Component; HC: Higher Component. Unk: unknown.

Archaeological sites	Level	Pottery period or chronology	Geographical coordinates	Quantitative and qualitative representation of chemical groups
1- El Contra		Early	39° 48' 16" S – 71° 18' 30" W	CP/LL 1:6, Pk: 1
2- Lago Epulafquén (isolated)		Early	39° 47' 43" S – 71° 33' 28" W	CP/LL1: 1
3- Los Chenques		Late	39° 58' 36" S – 71° 55' 06" W	QU/AP: 1; CP/LL1:1
4- Fuente de Arcillas		Early – Late	40° 01' 50" S – 71° 22' 42" W	CP/LL1:16; Pk: 1; CHN: 1
5- El Nido 2		Late	40° 04' 42" S – 71° 19' 21" W	CP/LL1:4
6- Quilquihue 3		Early	40° 04' 07" S – 71° 18' 38" W	CP/LL1:12; Pk:5; NEQ-5: 1; Unassigned: 1
7- Nonthué		Early	40° 07' 24" S – 71° 39' 28" W	MQ: 1;
8- La Puntita		Early		QU/AP:2; CP/LL1:1; YC: 1; Pk: 1
9 – Mirador de Bello		Late	40° 08" S – 70° 17" W	QU/AP: 22; YC: 2; CP/LL1: 12; Pk: 4
10- Lago Queñi (isolated)		Early	40° 09' 19" S – 71° 42' 54" W	CP/LL1:2
11- Playa Lacar		Temp.	40° 09' 37" S – 71° 21' 38" W	QU/AP: 5; CP/LL: 1
12- Catritre		530 ± 50 AP	40° 10' 29" S – 71° 23' 43" W	QU/AP:32 CP/LL1:8; Pk:41; YC: 2; NEQ-5: 1; Unassigned:1
13- Quechuquina 3		Early	40° 10' 02" S – 71° 34' 39" W	YC: 1; CP/LL1:1; Pk:2
14- Yuco		Early	40° 9' S – 71° 31' W	CP/LL1:12; QU/AP: 11; YC: 14; Pk:1
15- Playa Costilla		Early	40° 11' 02" S – 71° 32' 54" W	YC:2; CP/LL1:6;
16- Isla Sta. Teresita		Early – Late	40° 09' 58" S – 71° 34' 25" W	QU/AP:2; YC:7; CP/LL1:3; NEQ-5: 3
17- Lote 19		Early	40° 06' 53" S – 71° 17' 27" W	CP/LL1:1
18- Siete Manzanos		850 ± 60 AP	40° 08' 14" S – 71° 13' 45" W	QU/AP: 1; CP/LL1: 1; YC:1
19- Los Radales 1		480 ± 60 AP	40° 09' 32" S – 71° 18' 44" W	CP/LL1: 12; Pk: 3; MQ:2; Unassigned: 2
20- Rancho Montaña		Early	40° 08' 28" S – 71° 17' 24" W	CP/LL1:1; MQ:1; Pk:2
21- Newen Antug	CS	540 ± 50 AP	40° 09' 44" S – 71° 20' 49" W	YC:4; CP/LL1: 3; NEQ-5: 1; Unassigned: 1
CI				
22- Valle Meliquina		Early	40° 19' 82" S – 71° 19' 52" W	QU/AP:2; CP/LL1:1
23- Alero Doña Mica		Early	40° 18' 43" S – 71° 20' 02" W	MQ:1; Pk:3
24- Las Cachañas		1090 ± 60 AP	40° 21' 19" S – 71° 18' 45" W	Pk:1; MQ: 1
25- Lago Meliquina FS S1		730 ± 80 AP		Pk:3; YC: 2; CP/LL1: 1
		750 ± 60 AP		
Lago Meliquina FM S1			40° 20' 03" S – 71° 19' 08" W	YC:2; MQ:1; Pk:3; CP/LL1: 1; PC1:1
		920 ± 60 AP		
Lago Meliquina FM S2				YC:1; CP/LL1:1; Pk:1
Lago Meliquina FI		Early		QU/AP:1; YC:11; CP/LL1:5; Pk:24; NEQ-5:1
26- CPD: Cueva	LC	2370 ± 70 AP		Pk:1
Parque Diana		900 ± 60 AP	40° 19' S – 71° 20' W	
MC		990 ± 60 AP	YC:1	
HC		580 ± 60 AP	YC:1; CP/LL1:1; MQ: 5; Pk:1;	
		760 ± 60 AP	Unk:1	
27- Lago Machónico		Early	40° 19' 22" S – 71° 24' 47" W	Pk:1
28- Cueva Filo Hua-Hum		Early	40° 30' 04" S – 71° 17' 09" W	Pk:1
29- Cueva Casa de Piedra		Early – Late	40° 29' 52" S – 71° 12' 14" W	YC:2; CP/LL1:3

Other sets cited from neighboring areas in Figure 1:

30- Alero Larivieni; 30- Alero Los Cipreses; 31- Cueva Trafal I; 32- Cueva Cuyín Manzano; 33- Valle Encantado 1; 34- El Trébol; 35- Aº Corral ; 36- Casa de Piedra de Ortega; 37- Epullán Grande; 38- Rincón Chico 2/87.

4.3 Integration at a Regional Scale Level

To summarize, the provisioning of raw materials beginning in the early Holocene included obsidian from sources within our area of study, confirmed by its presence in the initial occupations of the Traful I cave sequence ending towards the 9430 ± 230 years AP in Traful I cave (Crivelli Montero, Curzio, & Silveira, 1993, p.39). In the transition from the Early to Middle Holocene, obsidians were the preferred raw materials during the so-called Component I or “Traful phase” between 8,000 and 6,300 years BP in the Limay River basin (Crivelli Montero, Curzio, & Silveira, 1993). By this time the presence of obsidian suggests planned mobility but of a residential type, and its use focused on the manufacture of instruments such as projectile points (see Crivelli Montero, 2010). Up to this point, dacite is considered to be a closer source than obsidian, but we now know that excellent obsidian was available even closer than the dacites of some sites. During much of the Middle Holocene, but especially in the millennium beginning around 6,200 BP, characterized as Component IIA or “Confluencia phase” of the same regional sequence, the proportion of dacite increases with respect to obsidian among the instruments, including projectile points, instruments in general reduce their size and standardize their designs; for example, the first thumb-nail scrapers appear (Crivelli Montero, 2010). This management of obsidian compared to other raw materials has been interpreted in response to a logistic settlement system, with seasonal mobility within smaller territories than in earlier periods (Crivelli Montero, 2010). The revaluation of obsidians to manufacture extractive instruments during the Late Holocene, especially at times corresponding to Component IIB of the Traful I Cave sequence (Crivelli Montero, Curzio, & Silveira, 1993), a stage recently characterized as of “proliferation of symbols” in regional archaeology (Crivelli Montero, 2010); it is attributed to changes in ethnic frontiers, the use of blades as base forms, experimentation with new hunting techniques – for example, the incorporation of the bow and arrow – and more generalized technologies to exploit diverse resources in forest and steppe, among others (Crivelli Montero, 2010).

4.4 The Late Holocene in Our Region

We have not found evidence of the presence of western Andean slope obsidian at Chaitén or Sollipulli (Pérez, Giesso, & Glascock, 2015; Campbell, Stern, & Peñaloza, 2016; Stern, 2017). An important factor might be that on both of the Cordillera, the lithic technology of the forest and lake area was eminently expedient and non-standardized, mostly represented by maintenance instruments over extractive ones, using raw material that was immediately available, taking advantage of natural edges that offer rocks even of regular quality for knapping (Mera & Becerra, 2002; Garcia, 2009; Pérez, 2018). However, there was selectivity regarding the manufacture of extractive instruments, such as small, stemmed points, which are scarce in western mountainous sites but abundant in the eastern area, possibly due to a greater effectiveness in more open spaces. This means that even for the same populations the potential usefulness of obsidian is different in different sectors of its territory. In more enclosed forested spaces where the predominant hunting strategy was trapping (Velázquez & Adán, 1999), its utility to manufacture projectile points decreases, while in sectors where one can make better use of the practice of hunting with weapon systems such as bow and arrow, obsidian nodules distributed throughout the landscape gain greater use value. This may be one of the causes of the recurrence of obsidian during the early first millennium of our era in the region, since good quality nodules of small sizes abound in various secondary sources their procurement increased with the incorporation of technologies such as bow and arrow that require small points.

Reconsidering, at our latitude, the differences between one sector and another of the Andean Cordillera are conditioned by the oblique nature of the transverse valleys, following the topography of the Valdivian hydrographic basin. Therefore, the central sector of our area of study shares many characteristics with the Panguipulli region, while the differences that we observe from the Huechulafquén lake to the north are also present in the eastern sector from the North shore of Lake Villarica. There, despite the location of sources such as MEL in Sollipulli in the vicinity of Lake Caburga, there are records of PC1 obsidian, among many other elements of the shared archaeological record, and where we observe its east-west circulation. In the center and north of the province of Neuquén the archaeological assemblages are characterized by the presence of

small unstemmed points, grey incised pottery, as well as nail-decorated, and with pre-formatted tools and perforated stones or *katan-kura*. While towards the south of the Neuquén River basin, the small projectile points are stemmed, and their distribution also overlaps with the “Trafal instruments” (Pérez, Giesso, & Glascock, 2015), to which we add brown pottery with the absence of formatted basis. From this current research, we can observe that this alternation also corresponds with circulation of different chemical groups of obsidian, so we can postulate that the provisioning reflects aspects of territoriality as proposed by Schobinger (1958), and more recently by Prates (2008). In opposition to divergence by biogeographic west-east cordilleran barriers (Stern, 2017) and north-south hydric barriers (Barberena et al., 2011; Barberena, 2013), in the last case discussed Borrero and Borrazo (2011) point out from multiple observations the case for circulation of the CHN group north of Neuquén towards the Mendoza margin of the Colorado River.

During the second millennium of our era some chemical groups were circulating large distances (Stern, 2017), mainly a red-black variety from the group PC1 circulated from coast to coast (Alberti et al., 2016; Campbell Stern, & Peñaloza, 2016), attributed to a non-functional selection but based on prestige technology (Campbell et al., 2018). Even though some obsidians from forest sites that we describe here were recently attributed a similar Eastern distribution as PC, like CP/LL 1 in the Gulf of San Matias in the Atlantic coast (Alberti et al., 2016) and CP/LL1, PK and YC re identified 370 km south within the forested mountainous area for the same time period (Bellelli, Carballido, & Stern, 2018). In both cases artifacts were arrowheads and by-products (maintenance and recovery debris).

Figure 2. Obsidian distribution of the northern Patagonian Andes and La Araucanía.

5 Final Considerations

The expansion of the sample confirms a pattern of obsidian circulation in the sites of Andean forested areas of northern Patagonia, Argentina, which is multidirectional (North-South and East-West) in the eastern slopes of the cordillera, but is shown to circulate further away as finished instruments and through the analysis of the reactivation and maintenance debitage. The movement of chemical groups is still focused on Lolog (CP/LL1), and to a lesser extent Pk and YC chemical groups in the southern sector, and PC1 in the central area of the province of Neuquén. The last group is hardly present in our region. The movement of raw materials during the late Holocene may be due to the greater availability of primary and secondary sources, forming a landscape that may include a mobility planned for the supply of obsidian.

In second place, there are various aspects that can denote territoriality or differential access to sources. On one hand sites with direct access to more than 5 sources, such as at Lake Meliquina. In these sites there are all types of obsidian by products, suggesting intensive stone tool manufacture. During the last millennium that the sites located to the East of the Meliquina region have less than 5% of obsidian, and mainly instruments such as small stemmed points and reactivation debitage, and of their maintenance. For this reason, we have suggested that manufactured products such as the projectile points were obtained from populations living in the Andean region through indirect access (Pérez, 2010, 2018).

Another potential indicator of territoriality is given by the North-South axis, where the chemical groups present a distribution that is restricted and associated with a different way of manufacturing projectile points, of making and using pottery, and even with the presence of instruments unique to each of these areas. These features have continuity in the western mountainous area. Chilean researchers have also postulated differences between northern and southern sections of the Area Center South of Chile from the Mahuidache-Lastarria range: to the north the development of the Late Ceramic period (AD 1000–1500) had greater socio-political centralization favored by the environmental qualities best for agriculture to the North East and for hunting-gathering South of it, that suggest this corridor was a biogeographic barrier.

The exceptions in our samples are the scarce or rather rare representation of the group PC1 (Portada Covunco) circulating from coast to coast (Stern, 2017; Campbell et al., 2018), coming from more than 120 km to the north, based on a red projectile point and a black stripped obsidian blade, which presents an outline of a stem, found at lake Meliquina's Intermediate Sector 1, in association with Black on Red pottery typical of the Early Ceramic period, dated to 920 ± 60 years C14 BP (LP-1721, charred wood). In both cases, they are the first records in sites of "Inland Forest" (*sensu* Pérez, 2010), and occur in ceramic contexts and in sites located in immediate proximity to other sources of obsidian actually used for several millennia.

Regarding the quality of the raw material, we note that Yuco (YC), which had previously been considered of poor quality or low availability (López et al., 2009; López et al., 2010), was widely used, both in maintenance and extractive instruments in the area of Lake Lácar. Yuco is the main raw material in the islands (Pérez, Giesso, & Glascock, 2015) and has circulated inside the forest since 680 ± 60 years BP, more than 350 km to the south, inside forested regions (Bellelli, Carballido, & Stern, 2018). While in the Lake Meliquina (LAM) sites it entered in the form of manufactured products, specifically extractive instruments such as stemmed points. The same is the case with the Late Ceramic levels of the Newen Antug cemetery in the Chapelco range. The MQ chemical group seems to be available in poor quality to manufacture extractive instruments, but it was intensely exploited at the sites immediately available for LAM's expedient instruments and transported to sites as Yuco on Lake Lácar. This allows us to postulate an interaction between populations or self-sufficient residential family units such as those characterized for the populations of the Early Ceramic period (Adán & Mera, 2011; Navarro, Dillehay, & Alfaro, 2011) that are contemporaneously distributed along different lakes and rivers. Another interpretation could be that they are the product of the seasonal alternation in the summer occupation of the LAM and winter sites in the sites as Yuco by the same group.

The absence of the groups Meliquina (MQ), QU/AP and Yuco (YC) in sites in the Traful area may suggest that the mobility between the occupations of the Alero Los Cipreses and the Larivière was made by longer but low resistance routes, outside or bordering the area of forest, passing through the valleys to the east of the Chapelco range (Pk) and even reaching the west coast of Lake Lolog (CP/LL1). However, we consider that some of the occupations of sites such as Alero Los Cipreses may have included logistic activities of task forces in hunting activity, even from the Lake Meliquina (LAM) sites during the Ceramic periods (Pérez, 2010), where hunters would move with personal hunting equipment that included Pk obsidian, to which the LAM occupants had primary access, and that in Traful sites, Rincón Chico and even Quilquihue 3 on Lake Lolog people transported obsidian in the form of small stemmed projectile points. Pk points even reached Catritre and Quechuquina 3 on both margins of Lake Lácar.

We know that between Traful and LAM, Filo Hua-Hum (FHH) obsidian would be available, although its absence is striking. This may be due to the abundance and proximity of other sources of excellent quality, which has notoriously influenced the selectivity and anticipation in the procurement. In brief, why collect bad quality FHH obsidian when they have left their camp with a personal team composed of points of the

abundant and close Pk primary source? If on their way they have traveled the landscape that forms the secondary source of MQ, until mixing at the intersection of the Filo Hua-Hum river with FHH obsidian from where this group is the only present. Only one artifact of this group was identified, with a date of 530 ± 60 BP on the Catritre site from a small stemmed point, which by its size could have been manufactured from the scarce good quality nodules of the right size that we found in the source among many other poor quality materials. Obviously, its use was opportunistic, while that of other chemical groups such as CP/LL1 and Pk was planned. The abundance of YC can also reflect that these populations navigated the lake waters, since we have clarified that the access to this source is by water, but also it is very close to Yuco and Isla Santa Teresita sites, important loci of activity for the settlement and extractive activities such as hunting in open coastal areas, as well as fishing.

Finally, Yuco obsidian (YC) increases in sites of the Late Ceramic period, where the settlement pattern seems to reflect the transition to a residential mobility system at the time of the Early Ceramic period, with small, self-sufficient residential family units. These units interacted and complemented each other, scattered around the main watersheds of our study area. This is a pattern of settlement and logistical mobility during the Late Ceramic period, with a center in the Lácar basin and an integral and contemporary part of the cultural development of the rest of the Valdivian basin (Pérez, 2016), to identify with YC, Pk y QU/AP 680 ± 60 BP more than 350 km south, in the cordilleran forests (Bellelli, Carballido, & Stern, 2018).

5.1 Circulation of Chemical Groups Across the Andes

The distribution of chemical groups in the Patagonian Andes (Argentina) and La Araucanía (Chile), indicates that people utilized the obsidian sources located nearby (< 50 km) in larger quantities, and that regarding finished instruments there is little movement over long distances (Pérez, Giesso, & Glascock, 2015.) and unstemmed projectile points between both coasts at the latitude of their source of origin (Alberti et al., 2016; Stern, 2017; Campbell, Stern & Peñaloza 2016; Campbell et al., 2018).

Recently Stern (2017) postulated that limited obsidian circulation between both sides of the Andes reflected the character of biogeographic barriers the mountains had in the past (Stern, 2017). Regarding PC 1, the only chemical variety recorded so far across the cordillera (Stern, 2017), Campbell and collaborators (Campbell et al., 2018) attributed it to the selectivity of the red-black variety as being a prestigious good, evidence of the hierarchical nature of the El Vergel complex (11th–14th centuries A.D). Without undermining this hypothesis, we notice that it is also selectivity, in addition to colors, that discriminate chemical groups distributed in different environments. The distribution also correlates with the variability of stemmed projectile points, different forms of making and using pottery, use of specific instruments, movement of marine mollusks, metals and crops, among others evidence; contemporaneous in the North and South Neuquén river basin to the East of the cordillera and the Mahuidache-Lastarria range towards the western sector (see Schobinger, 1958; Prates, 2008), at least during the last millennium (Pérez, Giesso, & Glascock, 2015).

To the association of PC 1 obsidian with unstemmed points we add that there are many stemmed points crafted with CP/LL1, Pk, YC, QU/AP y MQ obsidian (Pérez, Giesso, & Glascock, 2015; Alberti et al., 2016; Bellelli, Carballido, & Stern, 2018).

To conclude, our research has increased the spectrum of existing analysis, as the research done by Stern, Campbell (2017) and Bellelli (2018) had a limitation to analyzing debitage as they used destructive techniques. Here we include all types of artifacts, particularly unstemmed and stemmed projectile points. Many of the instruments that are circulating outside sources make it in the form of formatted instruments. An example of this change is the case of the YC obsidian at the LAM sites: before they were absent, now we know they are in second and third place of six chemical groups.

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