

# MULTIPLE PRIMARY AND SECONDARY SOURCES FOR CHEMICALLY SIMILAR OBSIDIANS FROM THE AREA OF PORTADA COVUNCO, WEST-CENTRAL NEUQUÉN, ARGENTINA\*

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*In west-central Neuquén Province, Argentina, in the area around Estancia Llamuco, west of Zapala, south of Las Lajas and north-east of Lago Aluminé, there are multiple primary and secondary sources of obsidian. Primary sources occur within the south-east extension of the Plio-Quaternary volcanic chain that runs from Copahue volcano through Pino Hachado. Secondary sources include river-bed gravels within the valleys of Arroyo Cochicó Grande and Río Kilca as far south as where this river joins with Río Aluminé, and the Quaternary fluvial–glacial sediments cut by the valley of Río Covunco as far east as Portada Covunco. Visually variable obsidians from these two secondary sources include homogeneous black and grey-translucent types, porphyritic and banded types, and an abundant quantity of oxidized red and black obsidian. However, all these visually distinct obsidians have similar and unique chemistry, with Ba between 220 and 340 ppm, different from any other obsidians previously reported from Neuquén, which all have Ba > 500 ppm, as do obsidians from sources to the north in Mendoza and to the west in Chile. This chemical distinctive obsidian has been exploited and transported over a wide area, beginning prior to 4000 BP, and occurs in local archaeological sites, as well as sites  $\geq 300$  km to the north-east in La Pampa Province,  $\sim 430$  km to the south in Chubut Province, and  $>75$  km to the west across the Andean drainage divide in Chile.*

**KEYWORDS:** OBSIDIAN, PATAGONIA, NEUQUÉN, ARGENTINA

## INTRODUCTION

Obsidian derived from the area of Portada Covunco, the location where Ruta Nacional 40 crosses Río Covunco in west-central Neuquén Province (Figs 1 and 2), Argentina, has been identified in archaeological sites over 300 km to the north-east in La Pampa province (López *et al.* 2009a; Stern and Aguerre in prep.),  $>400$  km to the south in Chubut (Bellelli *et al.* 2006) and  $>75$  km to the west in Chile (Stern *et al.* 2009), as well as in sites closer to this source (Fig. 2; López *et al.* 2009b; Stern and Pereda 2011). Here, we report on the multiple primary sources as well as the

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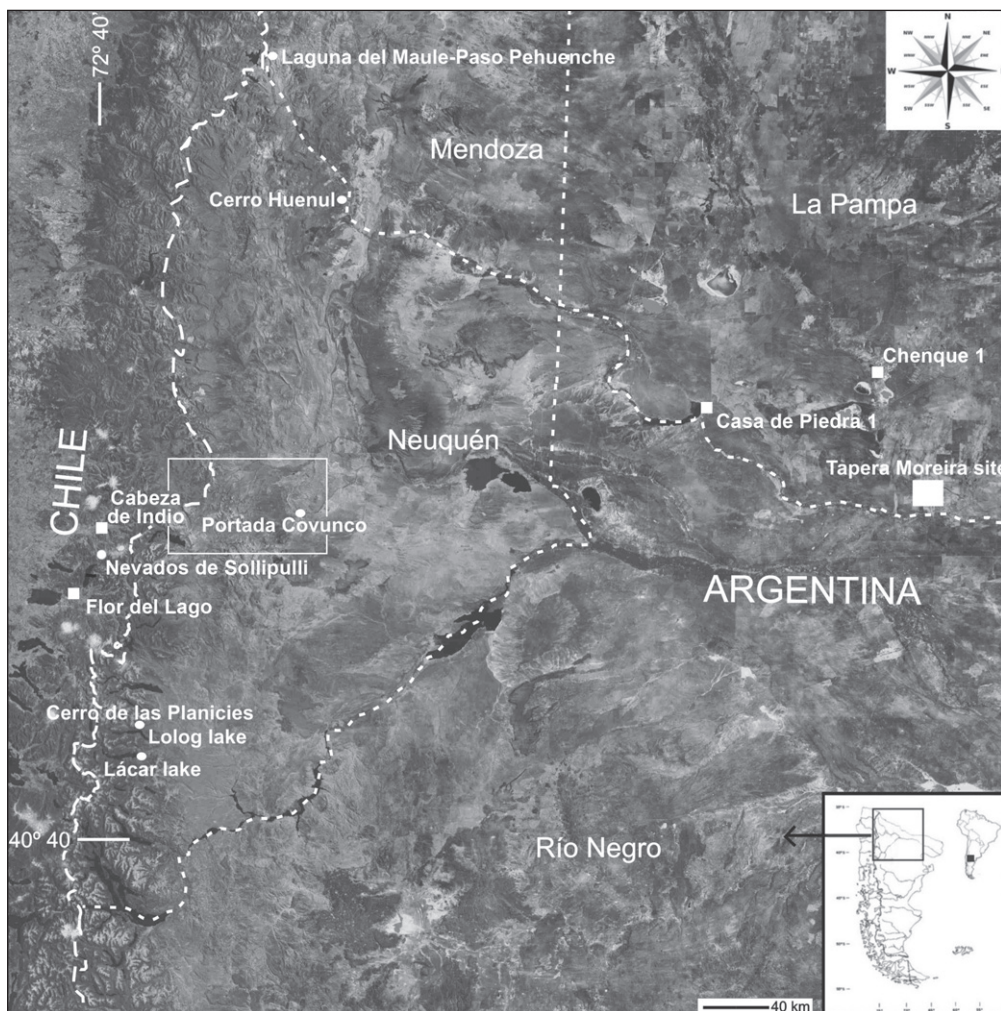


Figure 1 A large-scale regional map showing the location of the Portada Covunco obsidian source in central-west Neuquén, and some archaeological sites (white squares) in La Pampa and Chile where this obsidian is found. The figure also shows the location of other obsidian sources (white dots) in northern (Cerro Huenul) and southwestern (Cerro de las Planicies, Lago Lolog and Lácar Lake) Neuquén, in Mendoza (Laguna del Maule) and Chile (Nevados de Sollipulli). The area in the box around Portada Covunco is shown in more detail in Figure 2.

regional extent of secondary sources for this chemically distinctive, but visually very variable, and certainly aesthetically attractive, obsidian from west-central Neuquén.

#### BACKGROUND

Table 1 summarizes previously published analysis of both geological and archaeological samples of obsidian derived from the Portada Covunco source in west-central Neuquén. Bellelli *et al.* (2006) analysed, by bulk-rock ICP-MS techniques, one sample of an unworked river-bed cobble of obsidian from Portada Covunco, as well as two samples, with similar chemistry (their

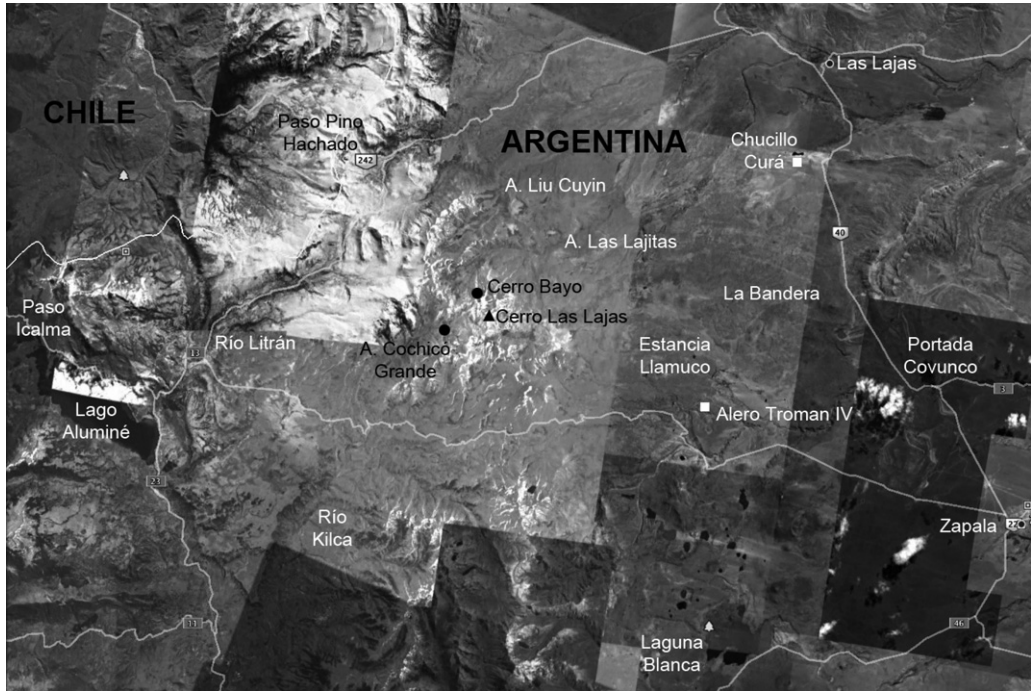


Figure 2 A map of the region around Estancia Llamuco in west-central Neuquén, showing various primary (black dots; Cerro Bayo and in the valley of the Arroyo Conchicó Grande) and secondary (Portada Covunco, La Bandera and Río Kilca) source locations for obsidian with distinctive Ba contents between 220 and 340 ppm (see Fig. 3). Also shown are the locations of archaeological sites (white squares; Alero Troman IV, Cuchillo Curá) that contain this obsidian.

Group B), from archaeological sites near Cholila, Chubut, located >400 km to the south, and they concluded that these two archaeological samples were derived from the same Portada Covunco source. López *et al.* (2009b) presented bulk-rock ICP-MS analysis of obsidian from archaeological sites around the area of Cuchillo Curá, located 25 km north of Portada Covunco (Fig. 2) and concluded that five of these samples were chemically similar to obsidian from this source area (Table 1). Giesso *et al.* (2008) published bulk-rock INAA analysis of five samples from archaeological sites in La Pampa, >300 km north-east of Portada Covunco, which they concluded were derived from a source that they referred to as La Bandera. López *et al.* (2009a) later suggested that La Bandera was in fact part of the same extended secondary source as Portada Covunco, on the basis of both the chemistry of the five samples (Table 1) and the location of this source, only a few kilometres north of Portada Covunco along Ruta 40 (Fig. 2). Stern and Aguerre (in prep.) also identified chemically similar obsidian in other sites in La Pampa (Table 1). Stern *et al.* (2009) identified eight samples with similar chemistry (Table 1) from sites in the Andean Cordillera of Chile, >75 km to the west of Portada Covunco (Fig. 1), that they concluded came from this same source.

All these samples have similar unique chemistry, with Ba between 220 and 340 ppm, distinguishing them from all other obsidian types from the region of Neuquén, all of which have Ba >500 ppm (Fig. 3). Obsidians from both Mendoza to the north and also from Chile to the west are also characterized by a significantly higher Ba > 500 ppm (Seelenfreund *et al.* 1996; Stern *et al.*

Table 1 Previously published compositions (ppm) of obsidian from Portada Cocunco

Ref. No.	1 3	2 5	3 5	4 3	5 9	6 PDA1
Ti	910	980	–	1063	996	802
Mn	439	498	424	414	405	271
Cs	7.9	8.4	7.6	7.8	6.8	10.2
Rb	163	177	158	170	162	195
Sr	45	46	49	51	48	35
Ba	258	278	278	247	241	242
Y	19	18	–	17	17	35
Zr	151	157	194	163	155	137
Nb	31	29	–	27	28	25
Th	27.2	26.8	–	24.7	25.8	19.1
Hf	5.2	4.8	5.2	5.0	5.2	5.6
Pb	–	22.4	25.1	16.5	19.8	11.7
U	7.4	7.9	7.6	7.0	7.6	5.4
La	33.8	33.4	32.3	30.7	30.1	36.8
Ce	57.5	63.7	57.6	55.2	54.3	69.2
Pr	5.72	5.85	–	5.57	5.49	7.71
Nd	18.7	18.7	19.4	19.8	18.9	30.9
Sm	3.30	2.79	3.78	3.08	3.04	6.39
Eu	0.37	0.43	0.37	0.40	0.40	0.31
Gd	2.49	3.08	–	3.51	3.39	7.41
Tb	0.43	0.55	0.43	0.45	0.42	1.05
Dy	2.82	2.95	–	2.65	2.76	5.96
Ho	0.59	0.60	–	0.57	0.55	1.16
Er	1.89	1.78	–	1.79	1.83	3.33
Tm	0.34	0.32	–	0.29	0.27	0.46
Yb	2.47	2.19	2.35	2.13	2.14	3.42
Lu	0.37	0.36	0.4	0.35	0.31	0.47

1, Bellelli *et al.* (2006), group B; 2, López *et al.* (2009a), samples from Cuchilla Cura; 3, Giesso *et al.* (2008), samples from La Pampa; 4, Stern and Aguerre (in prep.), samples from La Pampa; 5, Stern *et al.* (2009), samples from Chile; 6, Stern (2004), average of PDA1 from Pampa del Asador.

2002, 2008; Durán *et al.* 2004; De Francesco *et al.* 2006; Giesso *et al.* 2010), while obsidians from Chubut to the south are characterized by either Ba < 20 ppm or >300 ppm (Stern *et al.* 2000; Bellelli and Pereyra 2002; Gomez and Stern 2005; Bellelli *et al.* 2006). The only other obsidian type in all of Patagonia with values of Ba similar to those from west-central Neuquén (Table 1) is type PDA1 black obsidian from Pampa del Asador (Table 1; Stern 1999, 2004), which is located far to the south in Santa Cruz Province. However, PDA1 obsidian is otherwise chemically distinct from the Portada Covunco obsidian, having, for example, higher Cs, Rb, La and Yb, and lower Sr and Th (Table 1), and it has clearly not circulated this far to the north.

#### METHODS AND RESULTS

Samples of obsidian were collected from the Río Covunco at the point where Ruta 40 crosses this river, north-west of Zapala, as well as from a few kilometres north of Río Covunco, on the surface

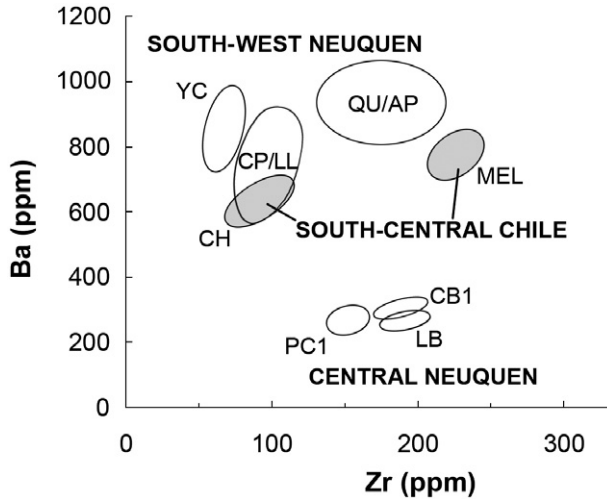


Figure 3 Zr (zirconium) versus Ba (barium) contents (in ppm = parts per million) of different types of obsidian from different sources in west-central Neuquén (PC1 from Portada Covunco and Arroyo Cochicó Grande, CB1 from Cerro Bayo, and LB from La Bandera; Tables 1 and 2; see also Fig. 6), south-west Neuquén (YC from Yuco, CP/LL from Cerro Planicies/Lago Logo, QU/AP from Arroyos Quilahuínto and Pocahullo; López et al. 2009a), south-central Chile (CH from Chaitén, MEL from Nevados de Sollipulli; Stern et al. 2002, 2008, 2009), illustrating the distinctive low Ba (220–340 ppm) of the obsidian from central Neuquén compared to the other obsidian types in the area (>500 ppm).

of the pampa of fluvial–glacial sediments that this river crosses. The surface of this broad pampa occurs at an altitude of approximately 915 m.a.s.l. and is accessible all year around. Samples were also collected from the headwaters of drainages close to two primary sources located in the mountains well to the west of Portada Covunco. These primary sources, which are both at higher elevation (>1500 m.a.s.l.) and not accessible during the winter, occur along the southeastern extension of the chain of Plio-Quaternary volcanoes that runs from Copahue through Pino Hachado (Fig. 2; Muñoz and Stern 1988). The highest peak in this area is Cerro Las Lajas (2650 m). One of the two primary sources is Cerro Volcán or Bayo (38°45'42"S and 70°41'57"W), located along the north-west flank of Cerro Las Lajas (Fig. 2). Cerro Volcán is drained to the north by Arroyos Liu Cuyin and Las Lajitas, both of which flow into the Río Agrio near the city of Las Lajas. The other primary source is located a few kilometres to the south-west of Cerro Las Lajas, along the eastern side of the Arroyo Cochicó Grande (38°49'46"S and 70°45'52"S), which flows southwards into the Río Kilca. Large cobbles of rhyolite obsidian occur in the drainage valley in the general vicinity of both these two sources (Fig. 4). Samples were also collected from the drainage valley of Río Kilca > 30 km to the south downstream, near where the Río Kilca joins with the Río Aluminé north of the city of Alumine.

Obsidians from all these areas are visually very variable (Fig. 5) and include homogeneous crystal-free black to translucent types, banded black and transparent obsidian, porphyritic types with 1–3% crystals of feldspar, and also a notably significant quantity of mixed black and red obsidian, in which the oxidized red areas occur either as bands or spots, or in some cases as the dominant colour such that black unoxidized areas are subordinate in area.

Samples were also selected for analysis from collections obtained by previous archaeological excavations of sites in the area (Fig. 2; see also Table 3 below), including Alero Tromen IV (38.51°S; 70.26°S; Perrotta and Pereda 1984), 'parapetos de piedra' around Laguna del Flamen-



Figure 4 A photograph of obsidian boulders near the primary sources (a) along the headwaters of Arroyo Cochicó Grande and (b) at Cerro Volcán.

cos (38.50°S; 70.20°S; Perrotta *et al.* 1982) and a single sample from the site Laguna Montículo 1 (38.51°S; 70.28°S; Goñi 1991). Obsidian is the most common lithic material (816 out of 1239 total artefacts) observed in all three occupational levels (surface, intermediate and early) of Alero Tromen IV, while basaltic (292) and silica (131) artefacts are less abundant (Perrotta and Pereda 1984). The samples analysed from Alero Tromen IV include some randomly selected from the

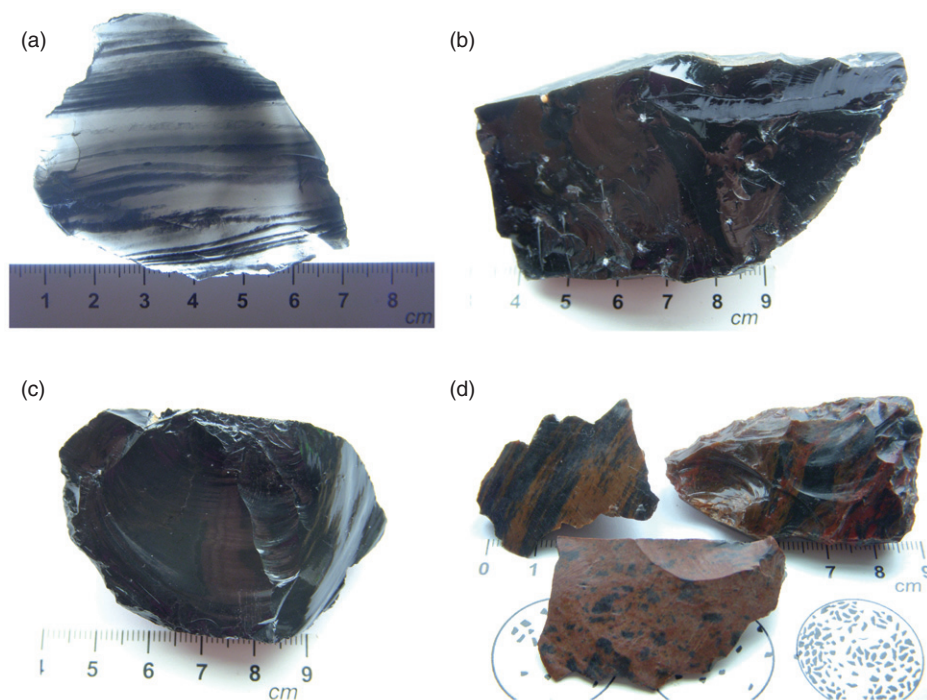


Figure 5 Photographs of visually different obsidian types from central-west Neuquén; A, banded black and transparent; B, porphyritic black and red; C, homogeneous black; D, black with red oxidation areas.

surface (two samples) as well as from older occupational levels dated as  $890 \pm 120$   $^{14}\text{C}$  yr BP (two samples),  $3560 \pm 70$   $^{14}\text{C}$  yr BP (four samples) and  $4400 \pm 100$   $^{14}\text{C}$  yr BP (one sample). The sample from Laguna Monticulo 1 comes from between 40 and 60 cm depth, and is dated between  $1040 \pm 140$   $^{14}\text{C}$  yr BP and  $1740 \pm 80$   $^{14}\text{C}$  yr BP.

The samples were ground to a fine powder, dissolved in a dilute solution of HF, and analysed for trace elements using standard ICP–MS techniques in the Laboratory for Environmental Geology at the University of Colorado. Repeat analysis of laboratory standards indicates that precision for all elements is better than  $\pm 10\%$  at the concentration levels of the samples. Averages for the geological samples (29 in total) from different areas are presented in Table 2, and complete analysis for the 13 archaeological samples in Table 3.

#### DISCUSSION AND CONCLUSIONS

The data indicate that the multiple primary obsidian sources in the vicinity of Cerro Las Lajas, and the associated secondary sources in west-central Neuquén, have produced obsidians of similar chemistry, with the most common obsidian types, from the Portado Covunco (PC1) and La Bandera (LB) secondary sources, from the Arroyo Cochicó Grande primary source and Río Kilca drainage (RK), and from the Cerro Bayo (CB1) primary source, all having Ba between 220 and 340 ppm (Table 2; Figs. 3 and 6). This suggests that despite having erupted from separate, but spatially relatively close individual centres, genetic processes of obsidian generation were generally similar for the volcanic centres in west-central Neuquén, and distinct from other areas

Table 2 Compositions (ppm) of geological samples

Location	Portada Covunco			Río Kilca	Río Kilca	Río Litrán	C. Bayo 1	C. Bayo 2
	2011	2000	Ref #2	2011	2011	2011	2000	2000
Year	2011	2000	Ref #2	2011	2011	2011	2000	2000
No.	10	2	1	10	2	1	4	2
Type	PC1	PC1	PC2	PC1	PC1	PC1	CB1	CB2
Ti	1001	1134	784	997	976	1000	1219	1232
Mn	382	412	500	377	376	375	509	427
Cs	7.5	7.1	11.5	7.7	7.5	7.5	6.8	9.2
Rb	163	164	206	171	161	160	160	191
Sr	42	47	9	41	41	44	52	9
Ba	226	258	25	214	226	226	284	<10
Y	17	17	18	18	16	16	19	18
Zr	149	151	171	145	149	151	181	151
Nb	27	27	34	28	27	26	30	32
Th	25.0	25.1	30.2	25.3	25.5	24.7	22.7	26.6
Hf	5.2	5.1	6.1	5.0	4.8	5.1	5.9	5.4
Pb	17.6	20.4	24.1	18.0	17.6	17.6	20.5	23.7
U	6.9	7.0	8.3	7.3	6.9	6.8	6.7	7.5
La	30.5	29.9	36.4	30.6	30.7	30.3	31.4	33.7
Ce	54.7	55.7	65.6	54.8	54.4	52.9	60.4	64.8
Pr	5.53	5.36	6.81	5.57	5.55	5.38	6.02	6.28
Nd	17.3	18.7	22.4	17.8	17.8	16.9	22.4	21.5
Sm	3.03	3.05	2.78	3.14	3.11	3.05	3.62	3.36
Eu	0.39	0.38	0.11	0.36	0.38	0.39	0.46	0.10
Gd	3.31	3.41	4.01	3.42	3.42	3.38	3.80	3.77
Tb	0.44	0.41	0.47	0.46	0.43	0.44	0.48	0.48
Dy	2.62	2.62	3.07	2.77	2.63	2.77	3.09	2.95
Ho	0.54	0.53	0.65	0.57	0.52	0.58	0.60	0.57
Er	1.82	1.80	1.87	1.95	1.81	1.87	2.01	1.96
Tm	0.30	0.26	0.36	0.31	0.33	0.27	0.28	0.27
Yb	2.15	2.22	2.55	2.29	2.27	2.19	2.51	2.29
Lu	0.32	0.30	0.29	0.34	0.31	0.31	0.35	0.32

Ref #2, López *et al.* (2009a).

of rhyolite obsidian generation elsewhere in Neuquén, as well as to the north in Mendoza and to the west in Chile, where all obsidians have higher Ba > 500 ppm (Fig. 3). Despite their overall chemical similarities, the obsidian CB1 from Cerro Bayo does have somewhat higher Ba, Zr (Figs 3 and 6), Ti and Mn than obsidians PC1 from Portada Covunco and RK from Arroyo Cochicó Grande, indicating that it is a chemically distinct subtype.

A few samples of more differentiated obsidians (PC2 and CB2; Table 2 and Fig. 6), with low Ba and Sr, suggesting removal of alkali feldspar, are also found in this area, but their volume is less significant (<10%), as indicated by their scarcity among the samples randomly collected from secondary river-bed sources, within which all the obsidian types are mixed together.

The five samples attributed to the La Bandera (LB) source area by Giesso *et al.* (2008) also have higher Zr (Figs 3 and 6) than the samples from Portada Covunco, but this obsidian has overall similarity, specifically Ba between 220 and 340 ppm, to other obsidians (PC1 and CB1; Figs 3 and 6) from west-central Neuquén. Because some small chemical variations are also



Table 3 Compositions (ppm) of archaeological samples

Field no. Type	TRAIV-1 PC1	TRAIV-2 PC1	TRAIV890-1 PC1	TRAIV890-2 PC1	TRAIV3560-1 CB2	TRAIV3560-2 PC1
Ti	1121	1118	1163	1128	1217	1105
Mn	427	413	414	416	422	436
Cs	7.0	6.7	6.5	6.8	9.1	6.8
Rb	165	161	161	164	190	167
Sr	48	47	47	47	9	49
Ba	246	248	245	234	<10	244
Y	17	16	17	16	18	18
Zr	150	147	145	151	151	155
Nb	27	26	26	27	32	28
Th	25.1	24.6	24.3	24.8	26.4	25.3
Hf	5.2	5.2	5.2	5.0	5.3	5.5
Pb	20.6	20.1	20.8	20.4	29.4	20.7
U	7.4	6.8	7.1	6.9	7.4	7.1
La	29.8	28.9	29.4	29.7	33.3	30.1
Ce	56.6	54.9	54.1	55.1	64.5	56.5
Pr	5.54	5.16	5.30	5.20	6.30	5.55
Nd	18.7	18.0	18.5	18.6	21.0	18.4
Sm	3.14	2.90	2.94	2.98	3.44	3.04
Eu	0.40	0.35	0.36	0.38	0.10	0.41
Gd	3.52	3.23	3.21	3.31	3.78	3.47
Tb	0.40	0.40	0.40	0.41	0.46	0.44
Dy	2.74	2.58	2.54	2.65	2.84	2.61
Ho	0.54	0.48	0.52	0.50	0.57	0.51
Er	1.65	1.61	1.77	1.74	2.03	1.79
Tm	0.23	0.23	0.26	0.21	0.27	0.26
Yb	2.25	2.10	2.24	2.18	2.38	2.29
Lu	0.29	0.27	0.29	0.30	0.30	0.32

TRAIV, Alero Tromen IV.

Field no. Type	TRAIV3560-3 PC1	TRAIV3560-4 PC1	TRAIV4400-1 PC1	PLF-1 PC1	PLF-2 PC1	PLF-3 PC1	LM1-1 PC1
Ti	1079	1057	1095	1050	1055	1043	1132
Mn	420	434	402	405	425	422	415
Cs	6.7	7.1	6.6	6.6	6.8	6.7	6.7
Rb	162	165	158	160	166	163	162
Sr	46	50	46	46	49	52	46
Ba	257	247	247	244	231	236	249
Y	17	17	16	16	17	17	17
Zr	149	155	146	148	154	153	150
Nb	28	27	27	27	29	30	32
Th	23.8	25.6	23.8	22.4	25.2	24.8	24.4
Hf	5.2	5.1	5.1	4.8	5.1	5.8	5.6
Pb	20.7	21.4	20.4	20.0	21.8	23.2	20.8
U	7.0	7.1	6.7	6.4	7.1	7.3	6.7
La	28.9	30.4	28.8	28.0	29.6	29.0	29.5
Ce	53.7	57.2	53.8	52.0	55.5	55.7	53.9
Pr	5.28	5.34	5.17	5.02	5.19	5.32	5.20
Nd	17.7	18.3	18.6	17.8	18.9	17.9	19.2
Sm	2.89	3.16	2.86	3.00	3.03	2.91	3.01
Eu	0.39	0.41	0.37	0.39	0.39	0.40	0.37
Gd	3.21	3.60	3.01	3.45	3.21	3.38	3.09
Tb	0.36	0.38	0.38	0.36	0.42	0.38	0.40
Dy	2.58	2.86	2.47	2.67	2.65	2.57	2.54
Ho	0.49	0.52	0.50	0.50	0.48	0.51	0.53
Er	1.66	1.76	1.69	1.63	1.65	1.71	1.64
Tm	0.23	0.24	0.24	0.24	0.22	0.23	0.22
Yb	2.10	2.25	2.06	2.16	2.09	2.15	2.14
Lu	0.28	0.28	0.32	0.28	0.31	0.28	0.32

PLF, Parapetos de Piedra en Laguna de los Flamencos; LM1, Laguna Montículo 1.

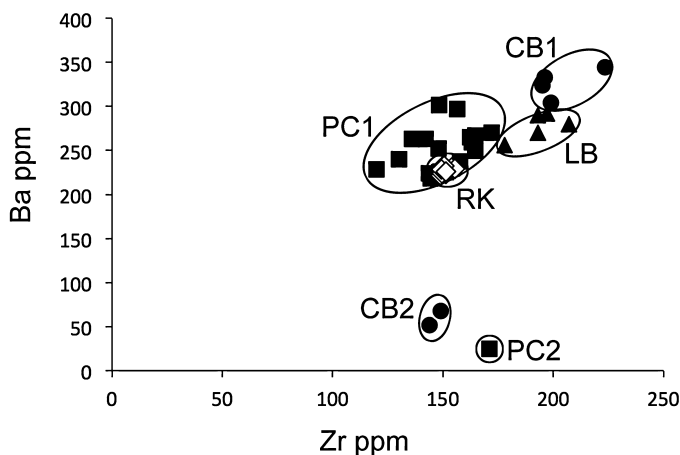


Figure 6 Details of the Zr (zirconium) versus Ba (barium) contents (in ppm = parts per million) of different types of obsidian from different sources in central Neuquén, including PC1 and PC2 from Portada Covunco (solid squares), all determined by bulk ICP–MS techniques (this paper; Bellelli *et al.* 2006; López *et al.* 2009a), RK from Arroyo Cochicó Grande and Río Kilca (open diamonds; this paper) and CB1 and CB2 from Cerro Bayo (solid circles; this paper) also both determined by bulk-rock ICP–MS, and LB from La Bandera (solid triangles), determined using INAA techniques (Giesso *et al.* 2008).

observed between obsidians from the Cerro Bayo and Arroyo Cochicó Grande primary sources, the samples from La Bandera may also represent another subtype of obsidian from this area. However, La Bandera, which is a small basaltic cone, occurs within and is surrounded by the same well-mixed fluvial–glacial sediments that occur at Portada Covunco just a few kilometres to the south, and therefore the chemical difference between PC1 and LB obsidian may only reflect the different analytical techniques used; INAA by Giesso *et al.* for LB and ICP–MS for the Portada Covunco PC1 samples analysed for this paper (Table 2).

All the archaeological samples from Alero Tromen IV and the other sites close to the Portada Covunco source are type PC1 obsidian except for one sample that appears to be type CB2, on the basis of its low Ba and Sr and high Ti (Table 3). The oldest sample of PC1 obsidian from Alero Tromen IV comes from a level dated as 4400 BP (Table 3). One previously analysed sample of PC1 obsidian from Casa de Piedra 1 in La Pampa province (Gradin 1984; Stern and Aguerre *in prep.*) comes from a depth of 70 cm in this excavation. An age of  $6080 \pm 120$   $^{14}\text{C}$  yr BP was obtained at a depth of 100–105 cm, so assuming a constant sedimentation rate in this site suggests an age of ~4200 yrs BP for this obsidian artefact (Stern and Aguerre *in prep.*), approximately the same age as the oldest PC1 obsidian artefact in Alero Tromen IV (Table 3). This implies that exploitation and widespread circulation of obsidian from west-central Neuquén began as early as >4000 BP.

Other previously analysed archaeological obsidian samples with similar chemistry to that of Portada Covunco obsidian are all from chronologically younger occupational levels. These include surface material in sites around Cuchillo Curá, 25 km north of Portada Covunco (Fig. 2), including the cave dwellings Los Cabritos y Caverna del Gendarme (Calzato 1997; López *et al.* 2009a), from excavation collections from the sites Tapera Moreira (Berón 1995; Berón y Curtoni 1998) and El Chenque (all < 1190 BP; Berón 2002, 2007; Giesso *et al.* 2008; López *et al.* 2009b) >300 km to the north-east in La Pampa (Fig. 1), and from excavation collections obtained from sites located >75 km to the west across the continental divide in Chile (all < 2100 yr BP; Fig. 1;

Stern *et al.* 2009), including Cabeza del Indio 1 (38.75°S and 71.50°W; García 2009), Flor del Lago 1 (39.25°S and 72.12°W) and Santa Sylvia (39.25°S and 71.8°W; Sauer 2010, 2011). The samples from Chile are predominantly the red and black oxidized variety, and may have been transported across the drainage divide from Argentina because of their aesthetic appeal (Stern *et al.* 2009).

Stern *et al.* (2009) suggested that the low-elevation Icalma pass west of Lago Aluminé (Fig. 2) was the likely route for obsidian exchange from Argentina into Chile at this latitude. Interchange during the past ~1000 years of ceramics (cerámica Complejo Pitrén and Vergel-Valdivia) across the Andean drainage divide from Chile into Neuquén, Argentina, at this same latitude has also been suggested (Hajduk 1986; Fernández 1988–90; Goñi 1991; Hajduk *et al.* 2011). However, in contrast to the obsidian, this exchange was from west to east rather than from east to west.

In summary, the chemically distinctive obsidians from west-central Neuquén—in particular, obsidian chemical type PC1—have been circulated over a relatively large region of northern Patagonia, as well as north-east into La Pampa province and west into Chile, for an extended period of time, beginning prior to 4000 BP. The specific areas in this region from which this obsidian was collected cannot be determined, but the chemically distinctive obsidian from this region, with Ba between 220 and 340 ppm, is not found anywhere else in southern Argentina or south-central Chile.

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