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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 ≥ 300 km to the north-east in La Pampa Province, ~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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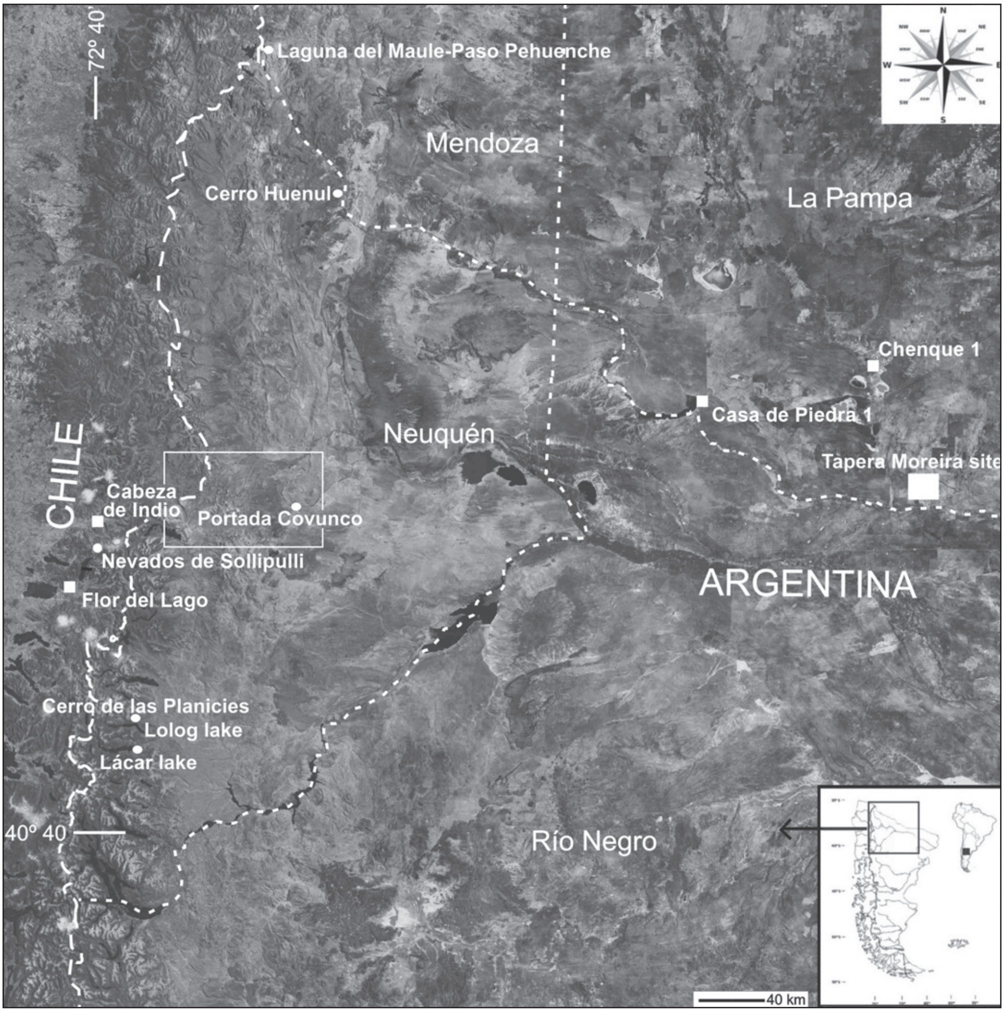

Figure 1 *A large-scale regional map showing the location of the Portada Covunco obsidian source in central-west Neuquén, and some archaeological sites (white squares) in La Pampa and Chile where this obsidian is found. The figure also shows the location of other obsidian sources (white dots) in northern (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

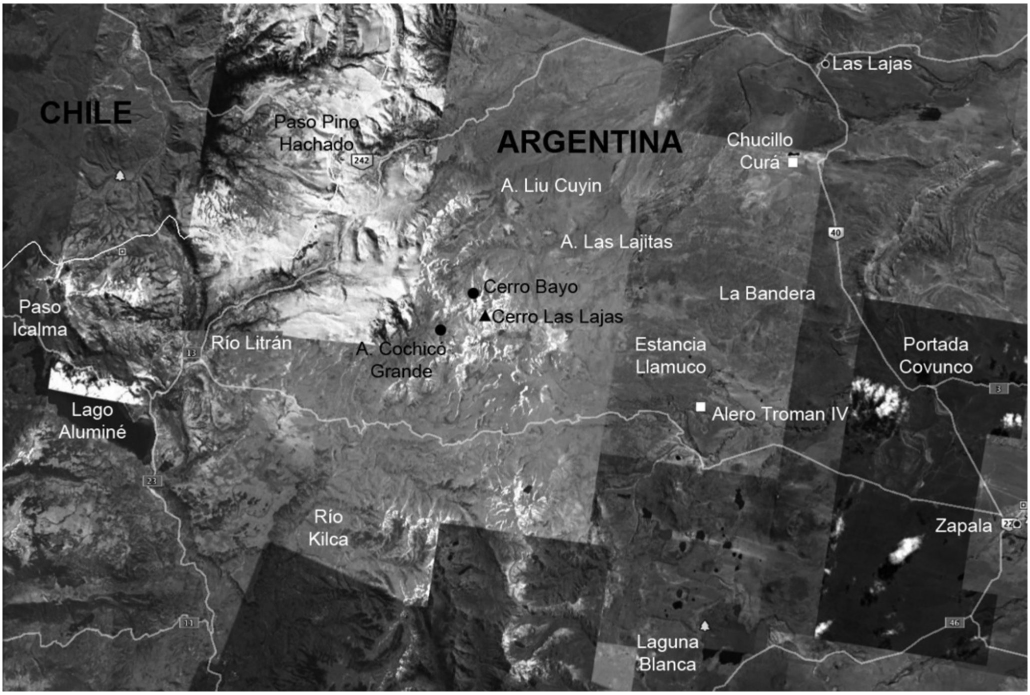

Figure 2 *A map of the region around Estancia Llamuco in west-central Neuquén, showing various primary (black dots; Cerro Bayo and in the valley of the Arroyo Conchicó Grande) and secondary (Portada Covunco, La Bandera and Río Kilca) source locations for obsidian with distinctive Ba contents between 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.	*1*	*2*	*3*	*4*	*5*	*6*
No.	*3*	*5*	*5*	*3*	*9*	*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

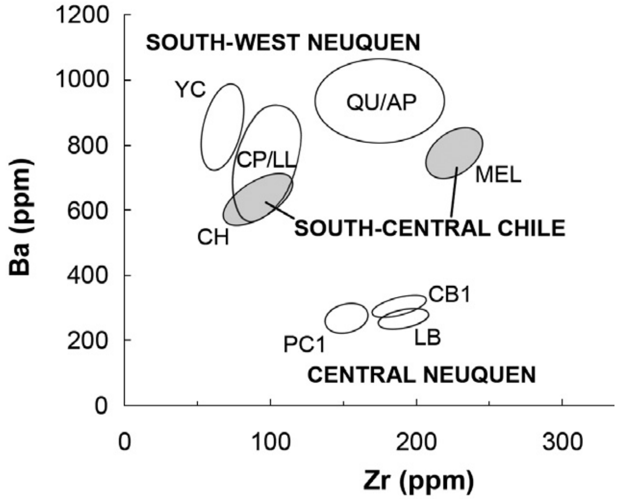

Figure 3 *Zr (zirconium) versus Ba (barium) contents (in ppm = parts per million) of different types of obsidian from different sources in west-central Neuquén (PC1 from Portada Covunco and Arroyo Cochicó Grande, CB1 from Cerro Bayo, and LB from La Bandera; Tables 1 and 2; see also Fig. 6), south-west Neuquén (YC from Yuco, CP/LL1 from Cerro Planicies/Lago Logo, QU/AP from Arroyos Quilahuinto 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 Monticulo 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

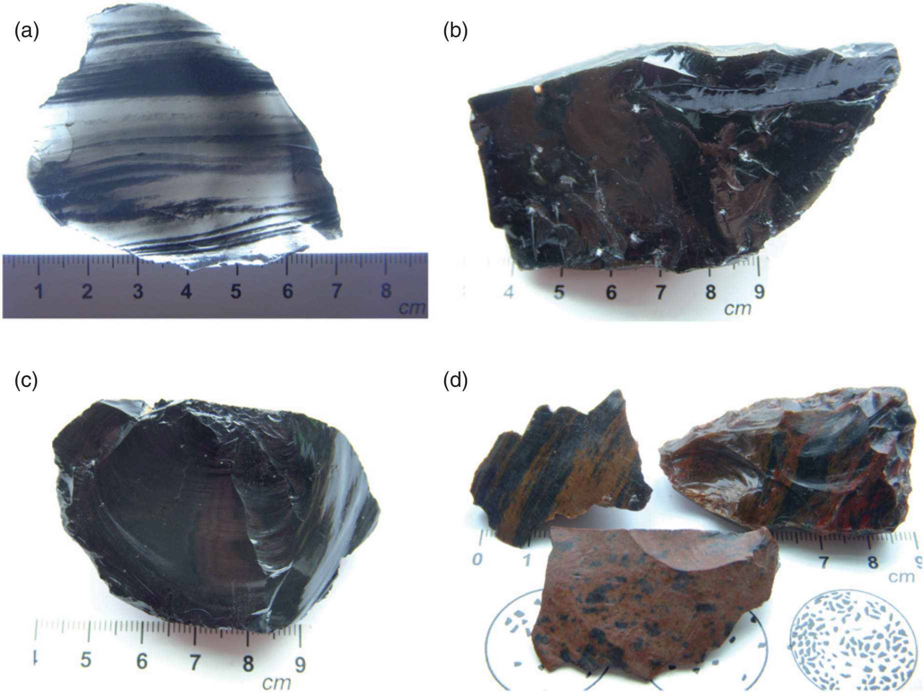

Figure 5 *Photographs of visually different obsidian types from central-west Neuquén; A, banded black and transparent; B, porphyritic black and red; C, homogeneous black; D, black with red oxidation areas.*

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

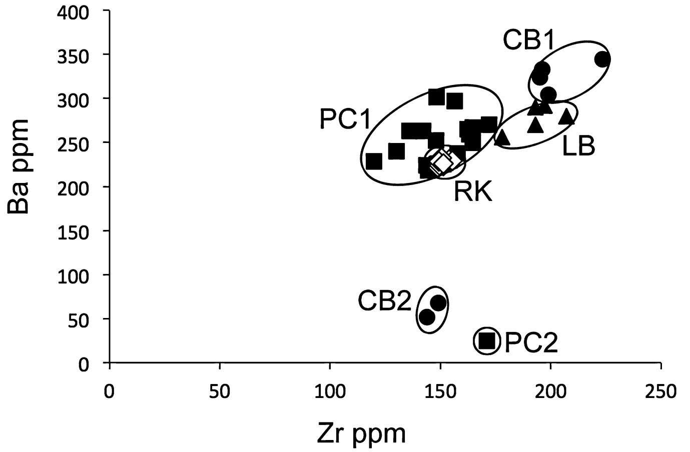

Figure 6 *Details of the Zr (zirconium) versus Ba (barium) contents (in ppm = parts per million) of different types of obsidian from different sources in central Neuquén, including PC1 and PC2 from Portada Covunco (solid squares), all determined by bulk ICP–MS techniques (this paper; Bellelli* et al. *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 ± 120 ^{14}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 (ceràmica 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.

REFERENCES

Bellelli, C., and Pereyra, F. X., 2002, Análisis geoquímicos de obsidiana: distribuciones, fuentes y artefactos arqueológicos en el Noroeste del Chubut (Patagonia Argentina), *Werken*, **3**, 99–118, Santiago de Chile.

Bellelli, C., Pereyra, F. X., and Carballido, M., 2006, Obsidian localization and circulation in northwestern Patagonia (Argentina): sources and archaeological record, in *Geomaterials in cultural heritage* (eds. M. Maggetti and B. Messiga), 241–55, Special Publications, **257**, Geological Society, London.

Berón, M. A., 1995, Cronología radiocarbónica de eventos culturales y algo más. Àrea del Cuaracó. La Pampa, *Cuadernos del INAPL*, **16**, 261–82, Buenos Aires.

Berón, M. A., 2002, El sitio Chenque I. Un cementerio de cazadores-recolectores en la Pampa Seca (Parque Nacional Lihuel Calel), La Pampa, *Revista ATEKNA*, **1**, 241–72.

Berón, M. A., 2007, Circulación de bienes como indicador de interacción entre los pobladores de la pampa occidental y sus vecinos, *Arqueología en las Pampas*, 345–64, Sociedad Argentina de Antropología.

Berón, M. A., and Curtoni, R., 1998, Investigaciones arqueológicas en la Subregión de Pampa Seca. Cuenca del Río Curacó. Pcia. de La Pampa, *Intersecciones en Antropologia*, **2**, 5–30.

Calzato, W. A., 1997, Nuevos aportes arqueológicos al sistema cavernario Cuchillo-Cura, Las Lajas—provincia del Neuquén, informe preliminary, Informe presentado a la Secretaría de Cultura del Neuquén, Grupo Espeleológico Argentino, Departamento de Antropología, Neuquén.

De Francesco, A., Durán, V., Bloise, A., and Neme, G., 2006, Caracterización y procedencia de obsidianas de sitios arqueológicos del área natural protegida Laguna del Diamante (Mendoza Argentina) con metodología no destructiva por fluorescencia de rayos (XRF), *Anales de Arqueología y Etnología*, **61**, 53–67.

Durán, V., Giesso, M., Glascock, M. D., Neme, G., Gil, A., and Sanhueza, L., 2004, Estudio de fuentes de aprovisionamiento y redes de distribución de obsidiana durante el Holoceno Tardío en el sur de Mendoza (Argentina), *Estudios Atacameños*, **28**, 25–43.

Fernández, J., 1988–90, La cueva de Haichol. Arqueología de los pinares cordilleranos del Neuquén, *Anales de Arqueología y Etnología*, **43/45**.

García, C., 2009, Cazadores recolectores en el área lacustre de la vertiente occidental Andina (39°S): cronología, contextos y procesos, in *Arqueología de Patagonia: una mirada desde el último confín* (eds. M. Salemme, F. Santiago, M. Álvarez, E. Piana, M. Vázquez and M. E. Mansur), Editorial Utopías, Ushuaia.

Giesso, M., Berón, M. A., and Glascock, M. D., 2008, Obsidian in western Pampas, Argentina: source characterization and provisioning strategies, *International Association for Obsidian Studies Bulletin*, **38**, 15–18.

Giesso, M., Durán, V., Neme, G. A., Glascock, M. D., Cortegoso, V., Gil, A. F., and Sanhueza, L., 2010, A study of obsidian source usage in the Central Andes of Argentina and Chile, *Archaeometry*, **53**, 1–21.

Gomez, J., and Stern, C. R., 2005, Circulacion, intercambio y uso de obsidianas en la costa de la provincia del Chubut, (Patagonia Argentina) durante el Holoceno tardio, *Intersecciones en Antropologia*, **6**, 93–108.

Goñi, R., 1991, Arqueología de sitios tardíos en el valle del arroyo Vilcunco (Provincia del Neuquén, Argentina), in *Actas del XI Congreso Nacional de Arqueología Chilena* (ed. H. Niemeyer), vol. III, 217–26, Museo Nacional de Historia Natural, Sociedad Chilena de Arqueología, Santiago.

Gradin, C. J., 1984, *Investigaciones arqueológicas en Casa de Piedra*, Pcias. De Buenos Aires, la Pampa y Río Negro, Ente Ejecutivo Casa de Piedra, Ministerio de Educación y Cultura de la provincia de La Pampa.

Hajduk, A., 1986, Arqueología del Montículo Angostura. Primer fechado radiocarbónico. Provincia del Neuquén, *Museo Histórico Provincial de Neuquén Serie Arqueología*, **1**, 1–43, Neuquén.

Hajduk, A., Albornoz A. M., and Lezcano, M. J., 2011, Espacio, cultura y tiempo: el corredor bioceànico desde la perspectiva arqueològica, in *Cultura y espacio: Araucanía–Norpatagonía* (eds. P. Navarro Floria and W. Delrìo), 26-292, Instituto de Investigaciones en Diversidad Cultural y Procesos de Cambio, Universidad Nacional de Rìo Negro, San Carlos de Bariloche.

López, L., Pérez, A., and Stern, C. R., 2009a, Fuentes de aprovisionamiento y distribución deobsidianas en la Provincia del Neuquén, noroeste de la Patagonia Argentina, *Intersecciones en Antropología*, **10**, 75–88.

López, L., Pérez, A., Batres, D., and Stern, C. R., 2009b, Obsidian artifacts in La Pampa, Argentina, from sources in southwest Neuquén, *International Association for Obsidian Studies Bulletin*, **41**, 4–8.

Muñoz, J., and Stern, C. R., 1988, The Quaternary volcanic belt of the southern continental margin of South America: transverse structural and petrochemical variations across the segment between 38°S and 39°S, *Journal of South American Earth Sciences*, **1**, 147–61.

Perrotta, E., and Pereda, I., 1984, Nuevos datos sobre el Alero IV del Tromen (Dto. Picunches, Prov. de Neuquén), *Primeras Jornadas de Arqueologìa de la Patagonia*, Trelew. Gobierno de la Provincia del Chubut, Serie Humanidades, No. 2, 249–58.

Perrotta E., Pereda, I., and Lynch, J., 1982, Parapetos de Piedra de la Laguna de Los Flamencos, Departamento Picunches—Provincia de Neuquén, Argentina, VII Congreso Nacional de Arqueologìa Argentina, Provincia de San Luis, 18 pp.

Sauer, J. J., 2010, A 16th century fortified house and its implications for ethnohistoric, ethnographic, and archaeological investigation in south-central Chile, Annual meeting of the American Society for Ethnohistory, Ottawa, Canada.

Sauer, J. J., 2011, Resistance and resilience in indigenous social systems: the Araucanian example from south-central Chile, 76th Annual Meeting of the Society for American Archaeology, Sacramento, California.

Seelenfreund, A., Rees, C., Bird, R., Bailey, G., Bárcena, R., and Durán, V., 1996, Trace element analysis of obsidian sources and artifacts of central Chile (Maule River Basin) and western Argentina (Colorado River), *Latin American Antiquity*, **7**, 7–20.

Stern, C. R., 1999, Black obsidian from central-south Patagonia: chemical characteristics, sources and regional distribution of artifacts, in *Soplando en el veinto: advances en la arqueologia de la Patagonia* (ed. R. Goni), 221–34, Publicacion del Centro Nacional Patagonico, Puerto Madryn, Argentina.

Stern, C. R., 2004, Obsidian source and distribution in southernmost Patagonia: review of the current information, in *Contra viento y marea: arqueologia de Patagonia* (eds. M. T. Civalero, A. Guraieb and R. Fernandez), 167–78, Miramar Publishing, Buenos Aires.

Stern, C. R., and Aguerre, A. M., in prep., La procedencia de obsidianas en sitios arqueológicos, Provincia de La Pampa.

Stern, C. R., and Pereda, I., 2011, Obsidianas de la zona centro-occidental de Neuquén, Argentina, *VIII Jornadas de Arqueologia de la Patagonia*, Mendoza, Argentina.

Stern, C. R., Gómez Otero, J., and Belardi, J. B., 2000, Características químicas, fuentes potenciales y distribución de diferentes tipos de obsidianas en el norte de la Provincia del Chubut, Patagonia Argentina, *Anales del Instituto de la Patagonia*, **28**, 275–90.

Stern, C. R., Navarro, X., and Muñoz, J., 2002, Obsidiana gris translucida del volcan Chaiten en los sitios arqueologicos de Quilo (Isla Grande de Chiloe) y Chachan (X region), Chile, y obsidiana de Mioceno en Chiloe, *Anales del Instituto de la Patagonia*, **30**, 167–74.

Stern, C. R., Garcia, C., Navarro, X., and Muñoz, J., 2009, Sources and distribution of different types of obsidian from archaeological sites in central-south Chile (38–44°S), *Magallania*, **37**, 179–92.

Stern, C. R., Navarro, X., Pino, J. D., and Vega, R. M., 2008, Nueva fuente de obsidiana en la region de la Araucania, centro-sur de Chile: quimica y contexto arqueologica de la obsidiana riolitica negra de los Nevados de Sollipulli, *Magallania*, **36**, 207–16.