BASALTS OF THE CHILEAN ALTIPLANO, SOUTH-CENTRAL ANDES

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INTRODUCTION

Six basalts have been sampled on the Chilean Altiplano, along the Calama–Olacapato–El Toro lineament, in the Central Volcanic Zone (CVZ) of the Andes (fig. 1). This is the first record of occurrence of basalts (SiO_2 < 53 wt %) upon the Chilean Altiplano in South-Central Andes (SCA), whereas basalts have already been sampled in northermost Chile as parasitic cones of Nevados de Payachata volcanic complex (Wörner *et al.*, 1988; Davidson *et al.*, 1990) in Peru (Lefèvre *et al.*, 1973; Kontak *et al.*, 1986) Bolivia (Soler and Jimenez, 1993; Davidson and de Silva, 1995) and Argentina (Hörmann *et al.*, 1973; Viramonte, unpublished). The Chilean basalts are undoubtedly of Recent age and occur as small lava flows, some of them being accompanied by a small (< 0.01 km^3) unnamed pyroclastic cone near the Argentina–Chile boundary. It is noteworthy that these basalts are exposed East of large stratovolcanoes (e.g. Miscanti, Lascar) classically made of andesites and dacites but nearby minor eruptive centers (e.g. Cordón Puntas Negras, Volcan Puntas Negras, Déruelle, 1994).

PETROGRAPHY AND MINERALOGY

The basalts have a typical microlitic porphyritic texture with phenocrysts of plagioclase (An 53.2–70.4) sometimes in disequilibrium, of olivine (up to Fo 86.8), diopside and augite (Wo 42.2–47.4), magnetite and chromite (38.4 < Cr_2O_3 wt % < 44.8; 12.0 < Al_2O_3 wt % < 21.9) in a groundmass of plagioclase, augite, magnetite and chromite. These basalts contain neither orthopyroxene nor ilmenite. Their mineralogy is quite different from that of alumina basalts that frequently occur in Meridional Andes (Southern Volcanic Zone) and contain phenocrysts of plagioclase, olivine, and scarce augite in a groundmass of plagioclase, augite, and Fe-Ti oxides sometimes accompanied with microcrysts of olivine (Déruelle,1982).

The occurrence of chromite as phenocrysts is uncommon in Chilean basalts. Chromite is not rare as tiny inclusions in olivine phenocrysts in Andean alumina basalts and basaltic andesites (Déruelle, unpublished) as well as in peridotite xenoliths occurring in alkali basalts (Xu *et al.*, 1993).

GEOCHEMISTRY

Chilean Altiplano basalts have similar TiO_2, Fe_2O_3, CaO and Na_2O contents as SVZ alumina basalts but have lower Al_2O_3 and higher MgO and K_2O contents (fig. 2a, b). They contain higher Rb,

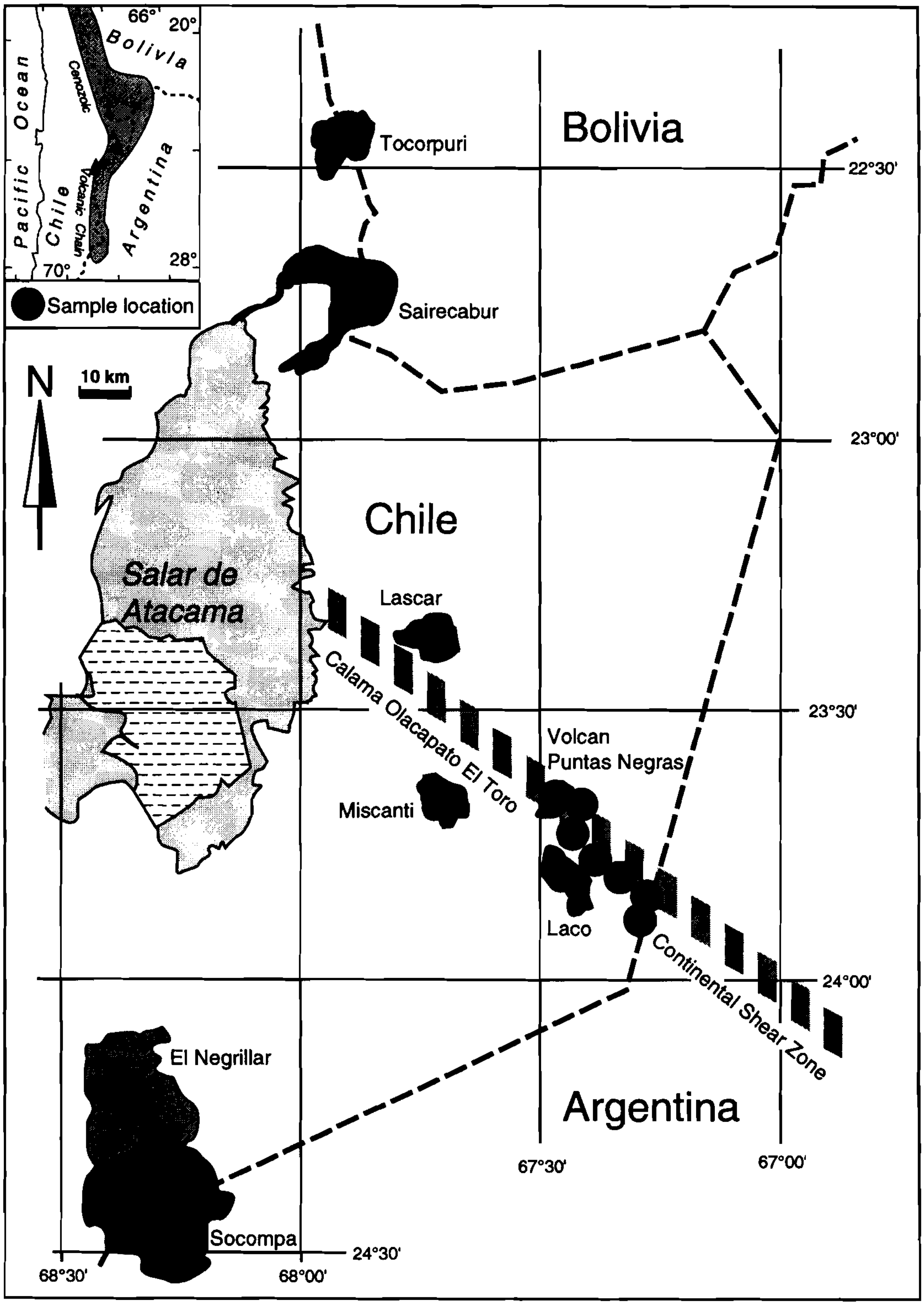

Fig. 1. Location the Chilean Altiplano basalts

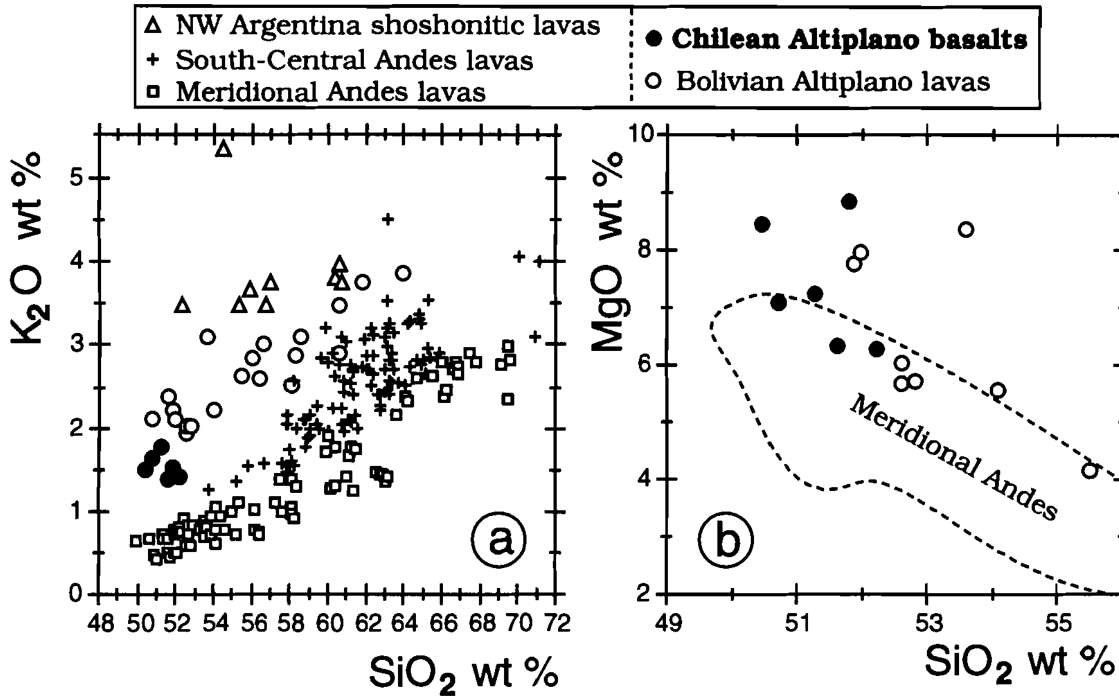

Fig. 2. SiO_2 *vs* K_2O (a) and MgO (b) diagrams (all data after Déruelle, 1982, 1991, except Bolivian Altiplano lavas, after Davidson and de Silva, 1995).

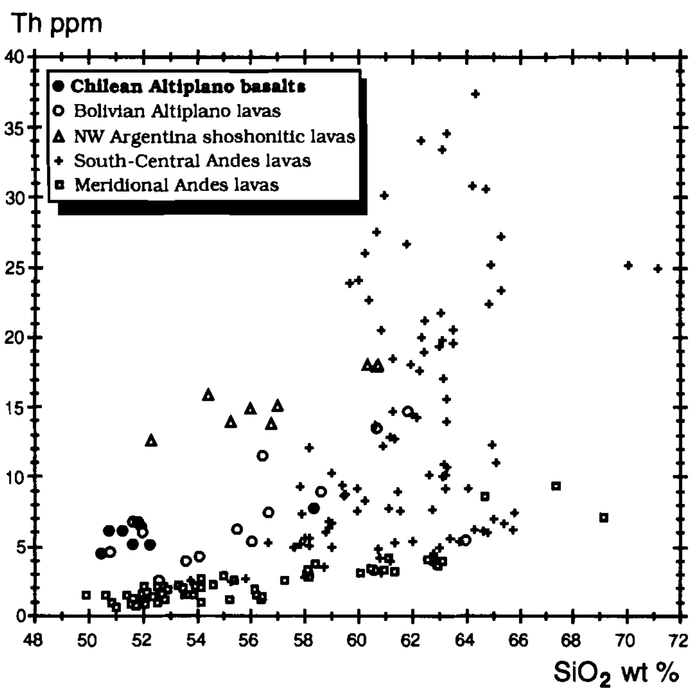

Fig. 3. SiO_2 *vs* Th diagram (same data source as in fig. 2).

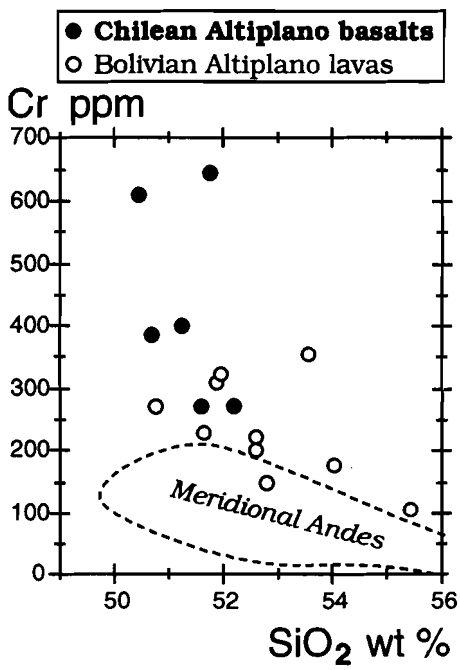

Fig. 4. SiO_2 *vs* Cr diagram (same data source as in fig. 2).

Sr, Ba, Ta, Th, U and rare-earth elements (fig. 3). They are also richer in Cr (fig. 4) and Ni. Their $^{87}Sr/^{86}Sr$ ratios (0.7057-0.7063) are in the same range as those of lavas from El Negrillar minor eruptive centers in SCA (Déruelle et al, 1982) but are by far higher than those measured in SVZ alumina basalts (< 0.7045, Déruelle *et al.*, op. cit.).

DISCUSSION AND CONCLUSIONS

On the one hand, it is first noteworthy that the basalts studied here are the only ones recorded up to date upon the Chilean Altiplano of SCA, where stratovolcanoes are only made of andesites and dacites. On the other hand, it is clear that Chilean Altiplano basalts are different from those that built up SVZ stratovolcanoes. They are also different from NW Argentina shoshonites and furthermore to alkali basalts occurring farther East, away from the subduction zone. On the contrary they present similarities with Late Cenozoic basalts of the Bolivian Altiplano (Davidson and de Silva, 1995). They are characterized overall by very high chromium contents.

Their magmatic specificity is probably related to a deep origin, and their eruption has been controlled by the Calama–Olacapato–El Toro shear zone. Nevertheless their deep source is probably of lithospheric nature (high Cr and moderate Ta contents) and a crustal contamination may have played a role in their genesis, as attested by their high $^{87}Sr/^{86}Sr$ ratios when compared to those of extra-Andean Argentinian alkali basalts.

REFERENCES

Davidson J.P., McMillan N.J., Moorbath S., Wörner G., Harmon R.S. and Lopez-Escobar L. 1990. The Nevados de Payachata volcanic region (18° S, 69° W, N. Chile) II. Evidence for widespread crustal involvement in Andean magmatism. Contrib. Mineral. Petrol., 105, 412-432.

Davidson J.P. and de Silva S.L. 1995. Late cenozoic magmatism of the Bolivian Altiplano. Contrib. Mineral. Petrol., 119, 387-408.

Déruelle B. 1982. Petrology of the Plio-Queaternary volcanism of the South-Central and Meridional Andes. J. Volcanol. Geothermal Res., 14, 77-124.

Déruelle B., Moorbath S. and Harmon R.S. 1982. Combined Sr–O isotope relationships and petrogenesis of Andean volcanics of South America. Nature 302, 814-816.

Déruelle B. 1991. Petrology of Quaternary shoshonitic lavas of northwestern Argentina. *In*: R.S. Harmon and C.W. Rapela (eds), Andean magmatism and its tectonic setting. *Geol. Soc. Amer. Spec. Paper*, 201-216

Déruelle B. 1994. Volcan Puntas Negras and Cord6n Puntas Negras (northern Chile) : petrology and geochemistry of minor eruptive centers. 7° Congr. Geol. Chileno, Concepci6n, Univ . Concepci6n, 1029-1033.

Hörmann P.K., Pichler H. and Zeil W. 1973. New data on the young volcanism in the Puna of NW-Argentina. Geol. Rundsch. 62, 397-418.

Kontak D.J., Clark A.H., Farrar E. and Pearce T.H. 1986. Petrogenesis of a neogene shoshonite suite, Cerro Moromoroni, southeastern Peru. Canadian Mineral. 24, 117-135.

Lefèvre C. 1973. Les caractères magmatiques du volcanisme plio-quaternaire des Andes dans le sud du Pérou. Contrib. Mineral. Petrol. 41, 259-272.

Soler P. and Jimenez Ch. N. 1993.Magmatic constraints upon the evolution of the Bolivian Andes since late Oligocene times. Second ISAG, Oxford (UK), ORSTOM Ed., Coll. Colloques et Séminaires, Paris, 447-452.

Wörner G., Harmon R.S., Davidson J.P., Moorbath S., Turner D.L., McMillan N.J. and Nye C. 1988. The Nevados de Payachata volcanic region (18° S, 69° W, N. Chile) I. Geological, geochemical and isotopic observations. Bull. Volcanol. 50, 287-303.

Xu Y.-G., Ross J.V. and Mercier J.-C. 1993. The upper mantle beneath the continental rift of Tanlu, Eastern China: evidence for the intra-lithospheric shear zones. Tectonophysics 225, 337-360.