GEOCHEMISTRY OF EARLY TERTIARY BACK-ARC BASALTS FROM AYSÉN, SOUTHERN CHILE (44-46° S): GEODYNAMIC IMPLICATIONS.

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INTRODUCTION

The geology of the Aysén region (44-47° S) is dominated by the presence of a huge calc-alkaline batholite, the North Patagonian Batholite (NPB), which constitute the spine of the chain. This 200 km wide plutonic complex intruded to the west the Chonos Late Paleozoic metamorphic complex, and to the east, Paleozoic and Mesozoic volcanic and sedimentary units (Pankhurst and Hervé, 1994). The Mesozoic stratigraphy comprises two main subduction-related volcanic episodes, the Middle to Upper Jurassic Ibañez Formation and the Middle Cretaceous Divisadero Formation. The Lower Cretaceous marine Coyhaique Group, deposited in a back-arc basin, provides a useful stratigraphic marker between the volcanic successions (Bell et al., 1994; De la Cruz et al., 1994). Volcanic activity resumed after a period of quiescence in Eocene time. Mesa basalts, situated in a back-arc position, crop out in the Balmaceda and Río Cisnes regions. Pliocene and Quaternary andesitic stratovolcanoes and monogenetic basaltic centres of the volcanic arc are located westward, near the Liquiñe-Ofqui fault zone (LOFZ), a 1000 km long, trench parallel, dextral strike-slip duplex, which has been active at least since the mid-Tertiary (Cembrano and Hervé, 1993).

GEOLOGICAL SETTING

A basaltic succession, approximately 150 m thick, composed of subhorizontal lava flows with frequent columnar jointing, outcrops in the Balmaceda basin. The flows tend to be thicker toward the top (up to 10 m). The first eruptions occurred in a subaqueous environment as revealed by the presence of pillow lavas with interstitial hyaloclastites and sediments, or finely stratified surtseyian-type surge deposits exposed in the Río Oscuro valley. In this last locality, the basaltic sequence lies above poorly-welded tuffs which are probably also Tertiary (Suárez et al., 1994). The Balmaceda basalts were overlaid by Miocene to Pliocene continental sediments with intercalated acidic pyroclastic units. Base upon a whole rock K/Ar radiometric age (46 ± 2 Ma; Baker et al., 1981), an Eocene age can be assigned to the Balmaceda basalts. Some zeolites are visible in hand specimen, and were identified as heulandite clinoptilolite in the pillows, and chabazite in the massive flows. Two basaltic plugs with abundant fresh

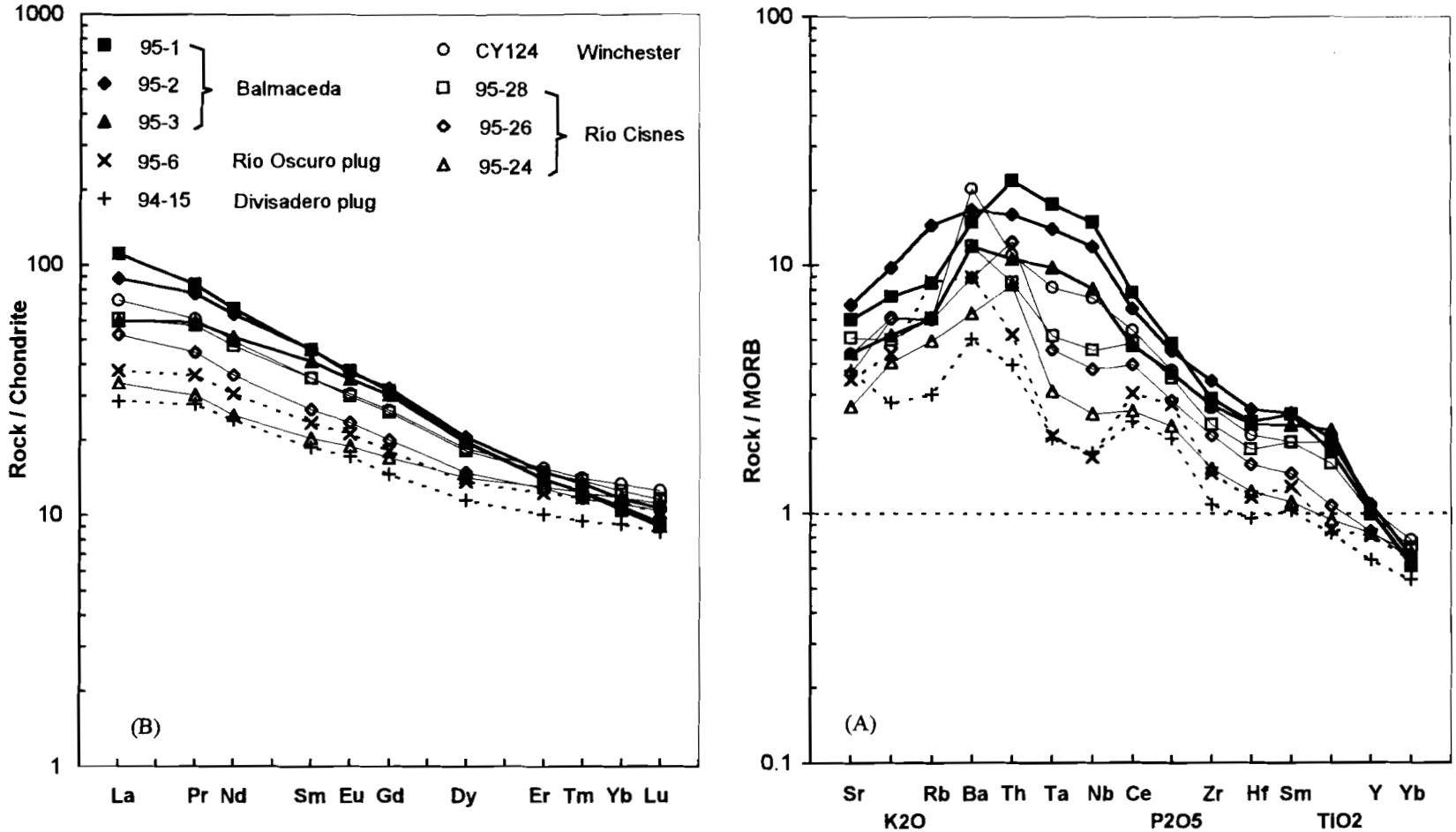

Fig. 1 : MORB-normalised element abundances (B) and Chondrite normalised rare-earth patterns (A) of Early Tertiary basalts from the northern Patagonian Andes. The following observations can be enhanced: (1) progressive fading of the Ta-Nb anomaly for the Río Cisnes and Río Winchester basalts; (2) absence of this anomaly, typical of OIB, for the Balmaceda basalts; (3) progressive enrichment in light-REE and (La/Yb)n ratios (B) from the basaltic plugs through the Río Cisnes and Balmaceda basalts.

olivine were also sampled; one east of Cerro Divisadero (94-15), the type locality for the Cretaceous volcanic succession, and the other in the upper part of the Río Oscuro valley (96-6). These basaltic bodies intruded the ignimbrites and are, therefore, probably also Eocene.

Flat lying mesa basalts also occurred, 200 km north of Balmaceda, in the Río Winchester and Río Cisnes valleys. The Río Cisnes sequence (about 100 m thick) shows a progressive decrease of the thickness of the lava flows (from 20 m for sample 95-28 to 1 m for 95-24) and an increasing oxidation, as revealed by the iddingsitisation of olivine phenocrysts, toward the top of the volcanic pile. Most of these flows are olivine-rich basalts. Peralkaline rhyolitic domes (El Chueco) are associated with the basalts. No radiometric ages are available on these basalts but overlying Lower Miocene continental sediments (Río Frías Formation, Marshall and Salinas, 1990) and Upper Miocene to Pliocene glacial or fluvio-glacial deposits clearly post-date the volcanic activity which can be considered as broadly contemporaneous with the Balmaceda sequence.

GEOCHEMISTRY

The Early Tertiary Patagonian basalts are fairly uniform in mineralogy. Olivine is the principal component, but some flows also contain few clinopyroxene and/or plagioclase phenocrysts. The twenty-one new chemical analyses presented here contribute to define the geochemical signature of these Plateau basalts. All the basalts are olivine normative (48-50 wt % silica); only four contain some nepheline (less than 1%) in the norm. They have the composition of continental tholeiites. Basalts from Balmaceda are more differentiated (Mg# ~ 55) than the Río Cisnes ones (Mg# ~ 64); the basaltic plugs of Cerro Divisadero and Río Oscuro are proximate to a primitive pole with Mg# ~ 68. The geochemical characteristics of the basalts and their spatial evolution are discussed based on Fig. 1. The MORB-normalised trace element abundances, expressed on the Pearce (1983) spidergram, show clear differences between the Balmaceda and Río Cisnes basalts. The later, and the basalts from the Divisadero and Río Oscuro plugs, are enriched in incompatible elements (above all Ba and Th) and present a negative anomaly in Ta and Nb, less pronounced for the Río Winchester basalt. This kind of trend is interpreted either as the result of crustal contamination or as indicative of an origin from the enriched sub-continental lithosphere (Hawkesworth et al., 1990; Arndt and Christensen, 1992; Arndt et al., 1993; Turner and Hawkesworth, 1995). Low Ba/Zr ratios, as defined for the Early Tertiary basalts from south-east Greenland (Fitton et al., 1995), indicate that contamination does not play any role, while low La/Nb and Zr/Nb ratios characterise an enriched lithospheric mantle source. The Balmaceda basalts have a different trend which doesnot exhibit Ta and Nb anomalies and, therefore, more akin to OIB signatures. REE patterns of the Balmaceda basalts are slightly more enriched and the (La/Yb)n ratios higher (5.7 to 10.2) than that of the Río Cisnes basalts (2.5 to 5.4).

CONCLUSION

Early Tertiary basalts from Balmaceda and Río Cisnes are related with incipient extensional tectonism responsible for the generation of back-arc basins. These basalts, of probable Eocene age, correspond to the mostly tholeiitic Early Patagonian plateau basalts (Baker et al., 1981; Stern et al., 1990). More recent (25 Ma to recent) undersaturated alkali basalts extended further East in the Cosmelli basin, on the southern side of Lago General Carrera (Flint et al., 1995), and in Argentina. Differences in the geochemical signatures between the Río Cisnes and Balmaceda basalts, particularly the fading of the Ta-Nb anomaly, remind the widely studied evolution observed in the Basin and Range province of south-western United States and north-western Mexico, interpreted as a typical exemple of progressive decrease of the influence of the lithospheric mantle source during crustal thinning, and the correlative increase of an asthenospheric component (Fitton et al., 1988 and 1991; Kempton et al., 1991). The geodynamic context is fairly similar and corresponds to the progressive cessation of subduction, as a result of the collision of an oceanic ridge with a continental plate (Ramos and Kay, 1992), and the corresponding development of a slab window (Hole et al., 1995) and back-arc extension.

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