AGE AND ORIGIN OF SOUTHERN PATAGONIAN FLOOD BASALTS, CHILE CHICO REGION (46°45'S)

N. PETFORD[1], M. CHEADLE[2] & B. BARREIRO[3]

(1)School of Geology, Kingston University, Kingston, KT1 2EE, UK
(2)Department of Earth Sciences, University of Liverpool, Liverpool, L69 3BX, UK
(3)NIGL, Keyworth, Nottingham,NG12 5G, UK

KEY WORDS: Basalts, Patagonia, Slab Window, Plumes

New chemical and age data from the Chile Chico region (ca. 46°S), located within the current Andean volcanic arc gap are reported from a detailed traverse 250 m through an exposed lower plateau basalt sequence of Hy-normative olivine tholeiites. $^{40}Ar/^{39}Ar$ ages of 51.7 ± 0.7 to 51.8 ± 0.9 imply an eruption time of ca. 0.1 Ma and confirm the similarity in age of these rocks with the neighboring Posadas basalts in Argentina. Ages less than 10 Ma in an upper sequence of Ne-normative alkali olivine basalts confirm the wide range in ages reported in earlier K-Ar reconnaissance studies of the region, and show that flood basalt magmatism occurred throughout most of the Tertiary (ca. 50 Ma) in this region of Patagonia. The minimum estimated volume of the lower sequence and surrounding Miocene basalts exposed between 46-49°S is ca. 2 x 10^4 km^3, giving an average magma eruption rate of 0.2 km^3 yr, comparable with the Parana lavas.

The basalts are OIB-like (Ba/La < 15, La/Nb < 1.6) with Mg numbers up to 67, epsilon Nd values of +6 to +2 and $^{87}Sr/^{86}Sr$ ratios of 0.7030-0.7045. Correlation between La/Nb, TiO_2 and sotopic composition between the lower and upper sequence basalts suggest a switch in source region from predominantly asthenospheric to lithospheric mantle with time.

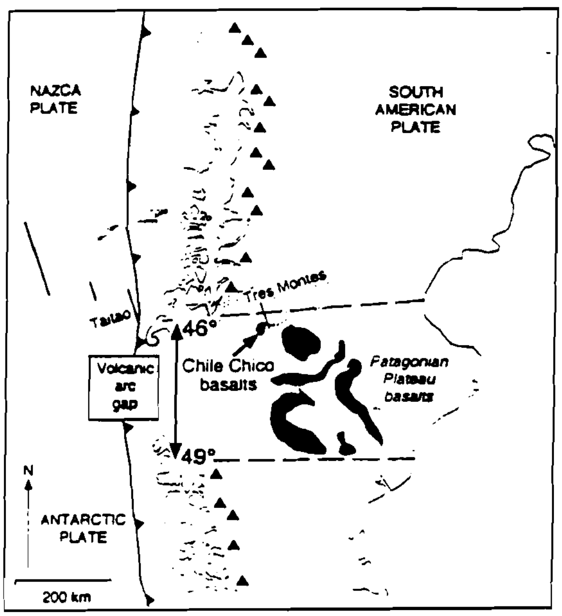

Fig. 1. Present day plate tectonic setting of the Patagonian flood basalt provence (after Murdie et al., 1993).

LOCAL GEOLOGY

The Chile Chico basalts (ca. 46'30°-46'45°S) are located on a plateau (Meseta) at a mean elevation of 2000 m, close to the Chilean-Argentinean boarder (Fig 1). The plateau is itself an extension of the larger Meseta Buenos Aires (ca. 500 km^2) located mainly in Argentina, but which has been deeply dissected by the Rio Heinemeni which marks the boarder between both countries in this region. They form a sequence of basalt lavas and occasional sills and intercalated sediments covering an area of approximately 300 km^2 where they rest upon Mesozoic-Tertiary volcaniclastic rocks and marine sediments. The orientation of the well exposed lower sequence lavas ranges from subhorizontal to ca. 25° SW/140°. The estimated current thickness of the lower sequence is about 250 m, giving a minimum estimated volume of 75 km^3. However, the pile is cut by volcanic necks and plugs (including the nodule-bearing Cerro Lapiz) which acted as feeders for younger surface cones and flows, indicating the basalt pile was once much thicker. The minimum estimated volume of the lower sequence and surrounding Miocene basalts exposed between 46-49°S is > 10^4 km^3

$^{40}Ar/^{39}Ar$ BASALT AGES

The $^{40}Ar/^{39}Ar$ age spectra and stratigraphic position of analysed basalts in the Chile Chico lower sequence are shown in Figure 2. $^{40}Ar/^{39}Ar$ Ages from the base and upper part of the sequence are within error, indicating extrusion rates of the order of 0.1 Ma. $^{40}Ar/^{36}Ar$-$^{39}Ar/^{40}Ar$ isochron ages range from 51.7 ± 0.7 Ma at the base of the sequence to 51.8 ± 0.9 just beneath the plateau surface, both comparable with the minimum K-Ar age of Charrier et al (1979) from Cerro Lapiz.

The youngest rock dated in this study is a basaltic dyke that cuts up through the Chile Chico lower sequence. Its isochron age of 8.5 ± 0.2 Ma coincides with early Miocene to Pliocene ages reported by Charrier et al (1979) for the upper unit of the Mestea Buenos Aires at Chile Chico, and is a likely feeder dyke for these younger rocks. Taking the estimated minimum basalt volume of Eocene basalts in Patagonia we obtain an average (minimum) eruption rate of 0.2 km^3 yr, comparable with the Parana flood basalts.

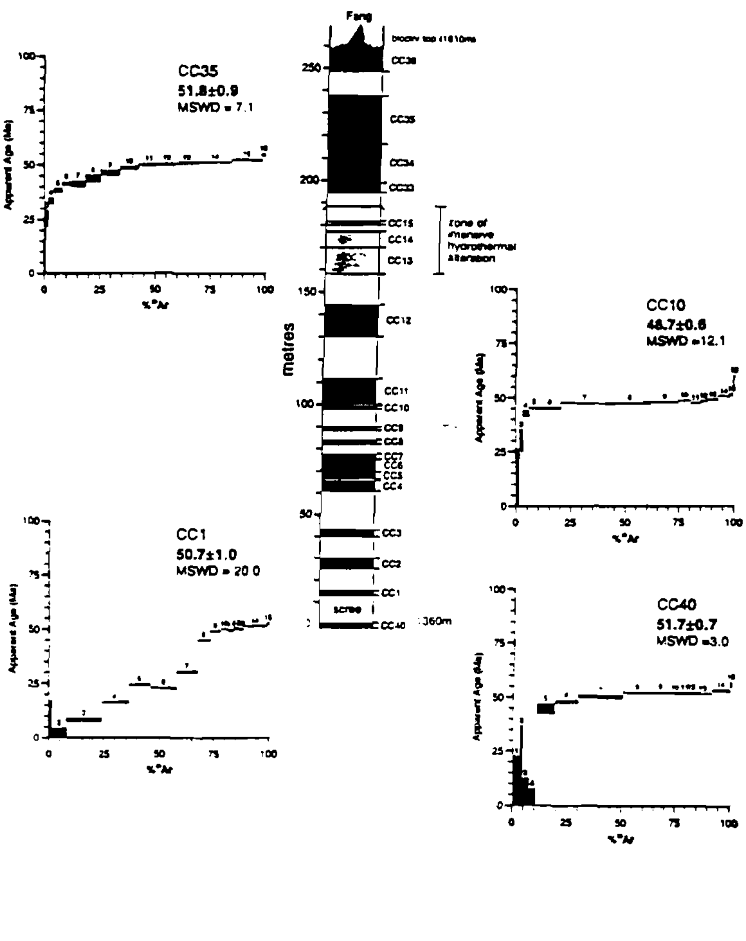

Fig. 2. Composite log through the lower sequence basalts showing position and thickness of each basalt unit sampled. Quoted errors are ± 1 sigma.

BASALT CHEMISTRY

Half the Chile Chico basalts have Mg numbers > 60 similar to primary mantle-derived liquids. The upper and lower sequence basalts can be subdivided according to TiO_2 contents into a high Ti-group (TiO_2 > 2 wt%) and a low-Ti group (TiO_2 < 2 wt%). Incompatible element abundances are similar to the Eocene Posadas basalts (Ramos and Kay, 1992), with a general enrichment of HFSE over LILs (Fig. 3). Low Ba/La (< 15) and La/Nb (< 1.5) ratios similar to those reported in previous studies are further evidence for the OIB-like nature of the Patagonian flood basalts. Although εNd (+6 to +2) and $^{87}Sr/^{86}Sr$ ratios (0.7035-0.7045) suggest derivation from a relatively depleted mantle source, in detail their are important differences in the chemical and isotopic compositions of both groups (Fig. 4). Eocene Lower Sequence basalts have εNd values of +5 to +4, 2-3 wt% TiO_2 and Nb/La > 1, while the post-Eocene Upper Sequence basalts have more evolved εNd values of +3.5 to +2, 2-1 wt% TiO_2 and Nb/La ratios < 1, consistent with a switch from asthenospheric to lithospheric mantle source regions with time (cf. Columbia River basalts).

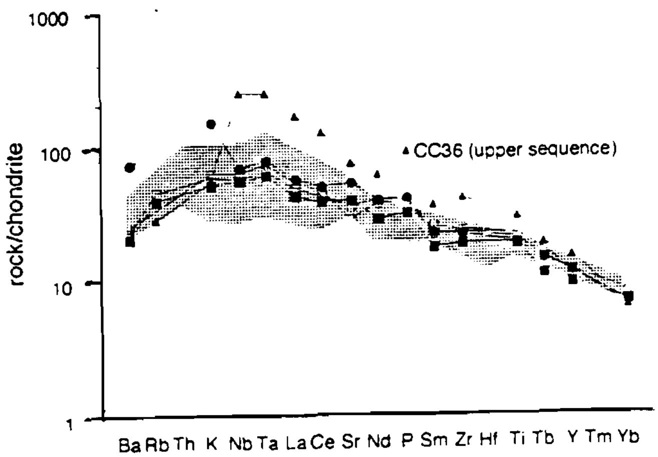

Fig. 3. Incompatible element plot for Chilr Chico basalts. Posadas basalts (shaded) shown for comparison.

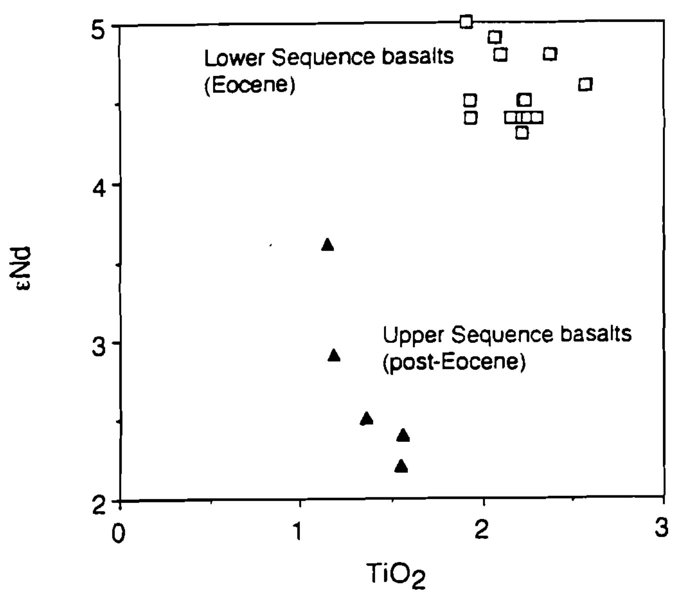

Fig. 4. εNd v TiO_2 plot for Lower and Upper sequence basalts showing a shift towards lower Ti and more enriched (lithospheric) isotopic compositions with time.

ORIGIN OF EOCENE BASALTS

Ramos and Kay (1992) have proposed that the Eocene Posadas basalts are closely related to the collision of the Aluk-Farallon ridge with the Andean subduction zone between 52 and 42 Ma and the subsequent formation of an asthnospheric slab window. Significantly, the new ^{40}Ar-^{39}Ar ages for the Posadas basalts at Chile Chico (51.8 Ma) coincide nicely with the predicted onset of Eocene ridge-trench collision. Major and trace element modelling (Cheadle & Petford, 1993) suggests that the Eocene age Chile Chico magmas originated by ca. 5% melting of an anomalously hot mantle source at between 80-90 km depth, at a mantle potential temperature of 1400-1450°C (Fig. 5). Although the subducting slab normally prohibits hot mantle from rising to melting depths, slab windows within the subducting oceanic lithosphere may provide temporal and spatial opportunities for hot, relatively depleted to OIB-like subcontinental mantle, to rise to more shallow depths where melting can occur. Whether the mantle heat source is deep seated or shallow remains an important open question (King & Anderson, 1996).

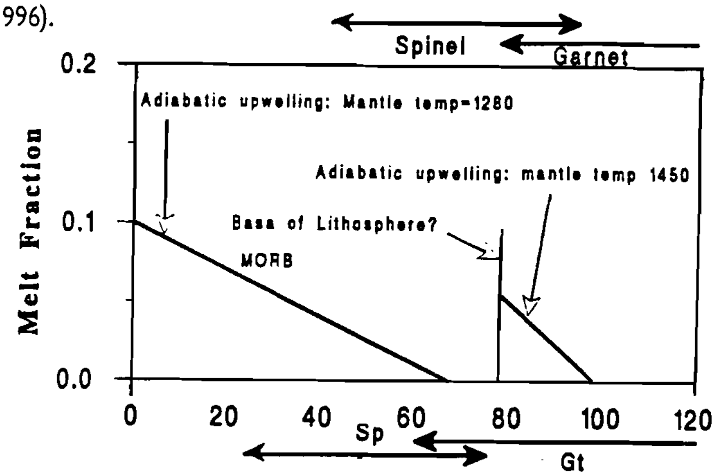

Fig. 5. Melt fraction v depth. Up-welling of hot mantle (Tp 1450°C) at base of 80 km-thick lithsphere produces 5% melt.

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