TECTONIC AND GEOCHEMICAL SIGNIFICANCE OF TERTIARY PATAGONIAN BASALTS, (40-50°S) ARGENTINA

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Abstract

Basaltic volcanism in the Patagonian plateau occurs with distinct events at different times and places. In the south, voluminous Eocene basalts and Late Miocene-Pliocene basalts with no arc-like chemical affinities are related ridge subduction, while to the north the Eocene basalts are arc related. The significance of voluminous Late Oligocene-Early Miocene plateau volcanism is unclear, but may be related to global events with melting concentrated in this region because of the geometry of the Eocene subduction zone. Plio-Pleistocene basalts are related to extensional back-arc activity.

Key words: Patagonia, Tertiary, basalts, ridge subduction, plateau, back-arc volcanism.

Introduction

Basaltic volcanism in the Patagonian Plateau (36-52°S) in southern South America occurred discontinuously from the late Cretaceous to the Recent. Important episodes took place at different places and times with no one cross section of Patagonian being representative of all the activity (Fig. 1a-d). The most important episodes occurred when there was minimal volcanism in the arc to the west. Despite the extended volcanism, evidence for important continental extension is lacking. Tectonic explanations for the different volcanic episodes vary, as does the influence of an arc-like component in the source region (Fig. 2). However, a common factor is that throughout this time the ocean crust subducted along this margin was relatively young and oceanic ridges were nearby and at times subducted.

Paleocene-Eocene

Paleocene to Eocene volcanism in central and southern Patagonia is dominated by arc volcanic activity north of 43°S and extensive basaltic activity in the extra-Andean region to the south. Volcanic rocks between 41-43°S (Huitrera Fm) have a subdued arc geochemical signature (Rapela and Kay, 1988) compared to modern SVZ (southern volcanic zone) arc rocks suggesting that they are back-arc to the main arc to the west or geochemically transitional with the basalts with intraplate signatures to the south (Posadas Fm). Voluminous silicic volcanic rocks (also Huitrera Fm.) with a subdued arc geochemical signature to the east of the arc between 41-43°S could have resulted from melting associated with basaltic underplating of the crust in the transition region.

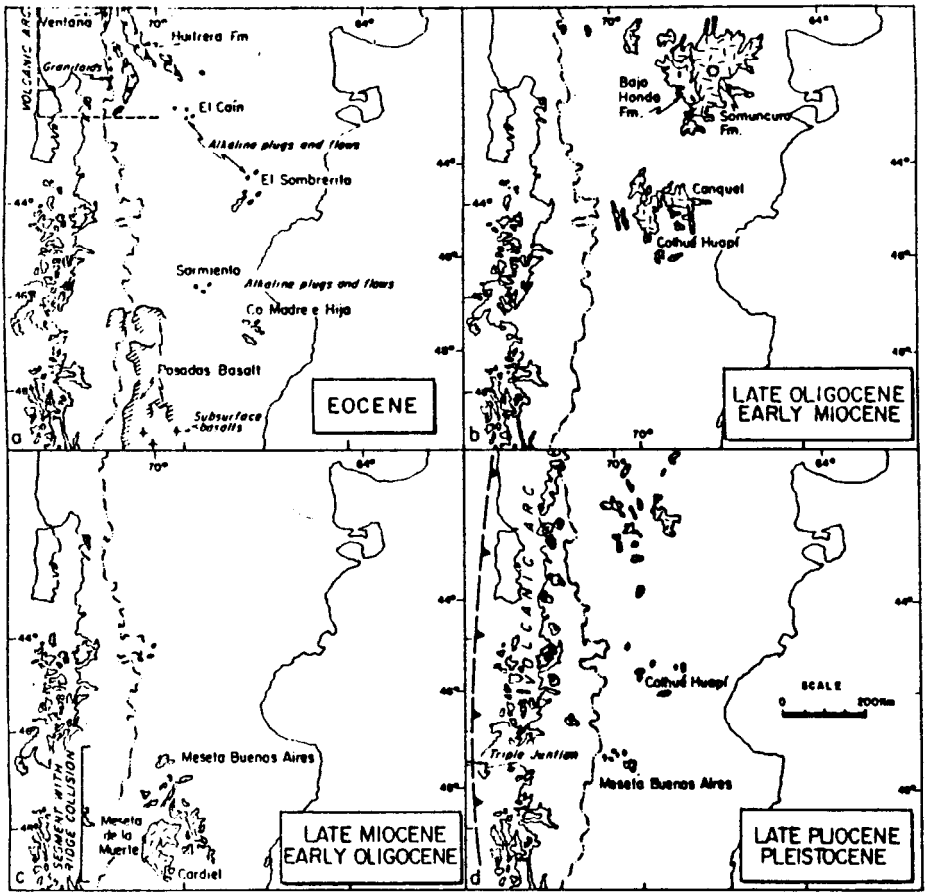

Figure 1a–d: Patagonian plateau basalts and magmatic arc activity through the Cenosoic.

Volcanism in the Eocene arc corresponds with a period of rapid subduction and major volcanism along the Andean front and in the circum-Pacific region. The lack of arc volcanism and the important plateau volcanism to the south is tentatively correlated with the Eocene subduction of the Aluk-Farallon ridge in this region proposed by Cande and Leslie (1986). Limited geochemistry on the basalts (Posadas Fm. and El Sombrerito basalts, see Fig. 2) shows no arc influence and is consistent with a depleted oceanic (ridge-like) source. The lack of a residual arc geochemical signature is also consistent with a steep late Cretaceous subduction zone below the Patagonian batholith that did not influence the lithosphere in the eastern region.

Late Oligocene-Early Miocene

Late Oligocene-Early Miocene plateau volcanism occurred predominantly in the Somuncura plateau and central Chubut (40-45°S) and was the most voluminous single magmatic event of the Patagonian plateau. The initial stages of this volcanism (Somuncura Fm.) formed the massive Somuncura plateau (40.5-43°s) which is over 200 km long and up to 250 km wide and from 10-100 m thick. Some of the plateau-forming flows, which are transitional tholeiitic to alkaline basalts and hawaiites (52-54% SiO2), were extremely fluid with single flows extending over 100 km. Their geochemistry has similarities to flood basalts and to Hawaiian tholeiites,

consistent with a major mantle melting event. These flows overlie and are underlain by tuffs that bracket their ages between 34-25 Ma. An analyses of the available K-Ar whole rock ages led Remesal (1988) to conclude that most of this volcanism took place near 26 Ma (±2).

In the eastern and southern parts of the Somuncura plateau, the Somuncura flows (Ardolino 1981) are locally covered with the Quiñelaf Formation which consists of less voluminous, more alkaline mafic flows and differentiated alkaline rocks. The 25 Ma old tuffs could be related to this event. The differentiated series follows the sequence - hawaiite, mugearite, benmorite, trachyte, and comendite (Corbella 1984). Volcanism ends with the eruption of the early Miocene alkalic basalts which are interlayered with acidic tuffs (Bajo Hondo Fm.) and could temporally overlap the Quiñelaf Formation. The geochemistry of these later flows suggests a somewhat cooler mantle associated with lesser amounts of melting.

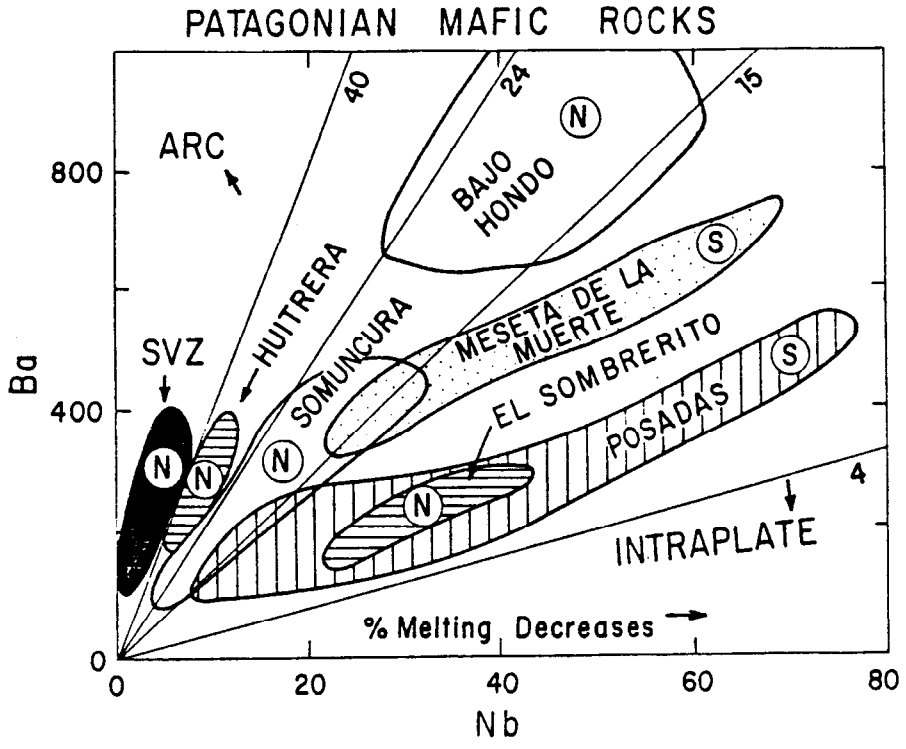

Figure 2: Plot of Ba versus Nb (or Ta*15) showing regional and age variations in relative amounts of melting (increase with abundance) and influence of arc-like component (increasing Ba/Nb ratio). Eocene (lined), Late Oligocene-Early Miocene (unshaded), Late Miocene - Pliocene (dotted), modern arc - SVZ (dark). Circled N -(≈ 40-44 °S), circled S - (≈ 48-52 °S0).

The cause of this voluminous volcanic event (≈ 1500 km^3 ± 50% in the Somuncura plateau) is unclear. This important period of plateau volcanism appears to have been contemporaneous with a period of relative quiescence in the arc as basaltic rocks to the west have extremely subtle arc characteristics and are indicative of high degrees of melting or very depleted sources (Rapela and Kay, 1989). Evidence of extension is minimal. There is no relation with a rifting ocean basin or known hotspot. This volcanism coincides with a period of relative slow convergence along the South American margin and plate adjustment in the southern Pacific, but these events do not explain why voluminous activity occurred specifically in central Patagonia. Plateau volcanism of this age appears to be essentially absent south of ≈ 46°S.

Perhaps, there is a relationship between the Somuncura volcanism and the locus of Eocene

subduction as the Somuncura plateau occurs to the east of the southern terminus of the Eocene subduction zone. The Somuncura and Bajo Hondo flows have arc-like high alkaline earth/light REE ratios (see Fig. 2), but intraplate-like Ta(or Nb)/light REE ratios. These ratios could reflect complex lithospheric enrichment associated with a relatively shallow Eocene subduction zone in this region and its later demise. The subducted plate would have been young and thin, consistent with the transition to ridge subduction to the south. Removal of the subducting plate from beneath an enriched, relatively hydrated lithosphere could have contributed to extensive melting of the mantle.

Late Miocene-Pliocene

Late Miocene to Early Pliocene plateau volcanism is concentrated in southern Patagonia (46-49°S), although scattered basalts occur throughout the plateau. In the north, they are back-arc to arc volcanism. Pliocene to Late Pleistocene activity occurs throughout the plateau and north of 52°S is generally back-arc to the active Andean volcanic arc.

The distribution and chemistry of Late Miocene-Pleistocene plateau basalts between 46-49°S (e.g., Meseta de la Muerte, Fig. 2), as well as the distribution and chemistry of arc volcanic rocks (Stern et al. 1984) and the youngest activity in the Patagonian fold and thrust belt, appear to be spatially and temporally associated with the intersection of the Chile ridge with the trench (Cande and Leslie 1986; Ramos 1989). Where the ridge is currently intersecting the trench, arc volcanism is absent. To the south, where the ridge has already intersected the trench, arc volcanism is occurring. These arc volcanic rocks have a larger slab component than those north of the Chile ridge consistent with melting of a young slab in a preheated mantle. To the south, where the ridge intersected the trench 6-10 Ma, compressional deformation ended just prior to the eruption of the plateau basalts in the Meseta de Muerte. These 8-4 Ma plateau flows are dominantly alkali basalts which correlate in volume and incompatible element abundances with the passage of a thermal anomaly (slab window) associated with the former ridge beneath the region. They have no geochemical arc affinities consistent with the absence of an arc to the west and no previous lithospheric enrichment associated with arc volcanism.

Late Pliocene-Pleistocene

This magmatic activity occurs throughout the plateau backarc to the Andean volcanic arc. Activity in the Somuncura region (40-43°S) is often clearly fault-related and has variable amounts of a subdued arc signature. This signature is generally strongest in basalts overlying the modern subducting slab. It also occurs in a few basalts in the northeastern part of the region which may be related to the complex pattern of arc-like and intraplate basalts recognized by Muñoz and Stern (1988) to the north of 39°S. Extra-Andean basalts far to the east generally represent smaller degrees of melt than those to the west.

References

Ardolino, A. 1981. El vulcanismo cenozoico del borde suroriental de la meseta de Somun Cura. VIII° Congr. Geol. Arg., Actas III: 7-23, Buenos Aires.

Cande, S.C. and Leslie, R.B. 1986. Late Cenozoic tectonics of the southern Chile Trench. J. Geophys. Res. 91: 471-496.

Corbella, H. 1984. El Vulcanismo de la Altiplanicie del Somuncura. IX° Cong. Geol. Arg., Relatorio: 267-300.

Rapela, C.W. and Kay, S.M. 1988. Late Paleozoic to Recent magmatic evolution of Northern Patagonia. Episodes 11: 175-182.

Muñoz, J. and Stern, C.R. 1988. The Quaternary of the southern continental margin of South America: transverse structural and geochemical variations across the segment between 38°S and 39°S. J. South Am. Earth Sci. 1: 147-162.

Ramos, V.A., 1989. Foothills structure in Northern Magallanes Basin, Argentina. A.A.P.G. Bulletin 73(7): 887-903.

Remesal, M.B. 1988. Geología y Petrología de los Basaltos de la Meseta de Somuncura. Ph.D. Thesis, Universidad de Buenos Aires, 207pp.

Stern, C.R., Futa, K. and Muehlenbachs, K. 1984. Isotope and trace element data for orogenic andesites from the Austral Andes in Andean Magmatism: Chemical and isotopic constraints, Harmon R.S. and Barreiro (eds)., Shiva Publishing Ltd., Cheshire, England, 31-46.