"GONDWANA" MAGMATISM OF PATAGONIA: INNER CORDILLERAN CALC-ALKALINE BATHOLITHS AND BIMODAL VOLCANIC PROVINCES

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INTRODUCTION

The Permian to Jurassic silicic igneous provinces of southern South America are characteristic of the Gondwana supercontinental stage in this region. "Gondwana" magmatism exhibits distinctive composition, geological setting and spatial distribution compared with those typical of the Cretaceous to modern Andes. Whereas the large rhyolite provinces of Permian–Triassic and Middle Jurassic age have attracted much attention (e.g. Kay et al., 1989; Pankhurst & Rapela, 1995), the role of the intraplate batholiths has usually been overlooked. The precise timing and complete compositional characterization of both episodes are crucial to an understanding of the early stages that lead to "Andean type subduction" and the mechanisms that triggered the breakup of the supercontinent. New Rb-Sr geochronological and geochemical data are reported for three key localities of northern Patagonia that, together with results from previous studies, allow us to reach a broader view of the "Gondwana" magmatic episode and its possible tectonic scenario.

INNER CORDILLERAN BATHOLITHS AND COEVAL VOLCANISM

Recent geochronological and geochemical studies have shown that a series of calc-alkaline batholiths and plutons was emplaced in central and south-eastern Patagonia during the interval from 220 to 200 Ma (Rapela et al., 1992; Rapela & Pankhurst, in press). This episode preceded the eruption of the widespread syn-extensional rhyolites and related rocks of the Patagonian Jurassic Volcanic Province (Fig.1) by some 10-30 Ma. The main subdivisions of this Late Triassic–Early Jurassic intrusive episode are: (a) the NNW-ESE Batholith of Central Patagonia, closely associated with the Gastre Fault System, (b) Subcordilleran plutonism between 40 and 44º S and (c) the monzonite suites of the Deseado Massif at 48º S. Permian intrusive rocks are restricted to north-central Patagonia, near the Chasicó area (Pankhurst et al., 1992).

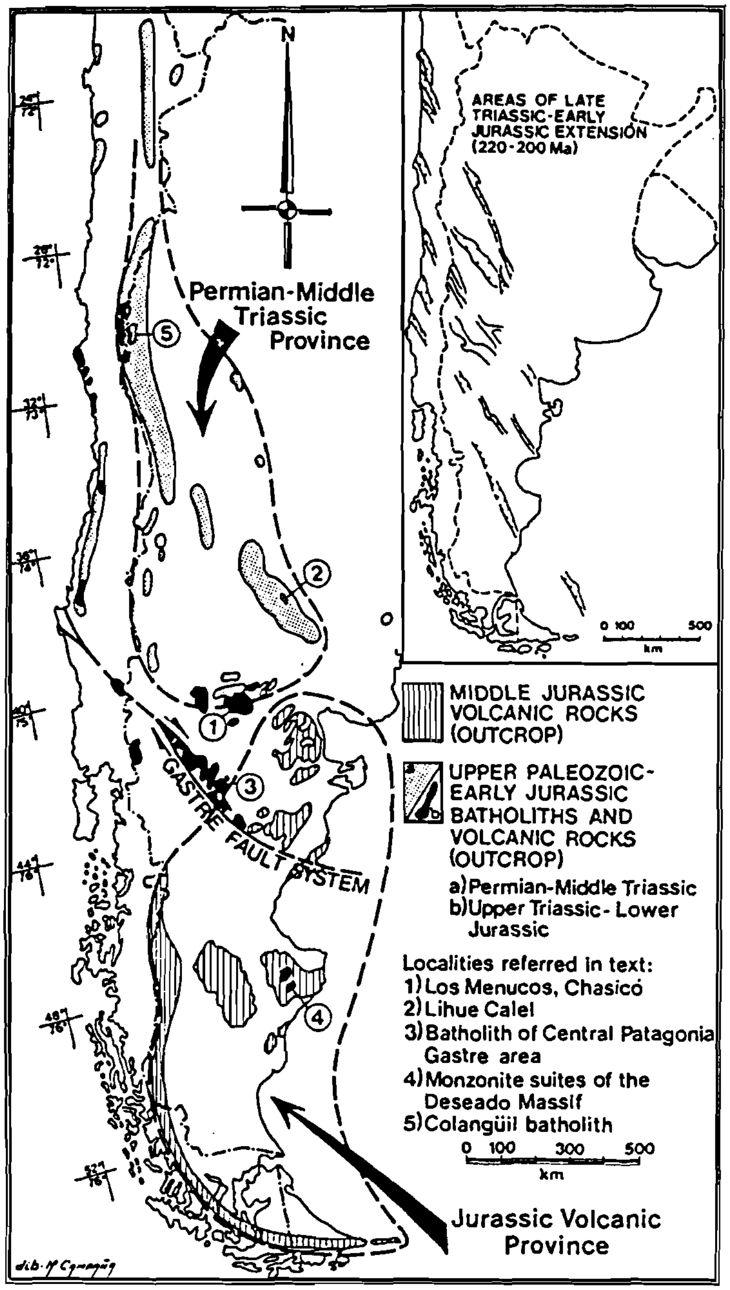

Figure 1: *Simplified geological map showing the distribution of Permian to Jurassic magmatic rocks in southern South America. Insert shows the regional distribution of the Triassic-Early Jurassic extensional basins (Uliana et al., 1989).*

A common characteristic of all these high-level or subvolcanic plutons is the predominance of an intermediate igneous facies ranging in composition from hornblende-biotite granodiorite to quartz-monzonite (typically 65–69% SiO2; Fig.2a). This facies shows a transition to abundant biotite granites (70-74% SiO2) and leucogranites (75-77% SiO2). Rocks with less than 65% SiO2 (diorite to quartz monzodiorite) have been found in the suites of the Deseado Massif, but they are restricted to a marginal facies and enclaves, which have been interpreted as cumulus-rich differentiates (Rapela & Pankhurst, in press). Geochemical data for the Batholith of Central Patagonia and Deseado suites display an arc-dominated signature, and the isotopic data (initial 87Sr/86Sr = 0.7048 to 0.7058 and εNdt = -0.3 to -3.1) are consistent with an origin in the mantle or depleted lower crust (Rapela et al., 1992; Rapela & Pankhurst, in press).

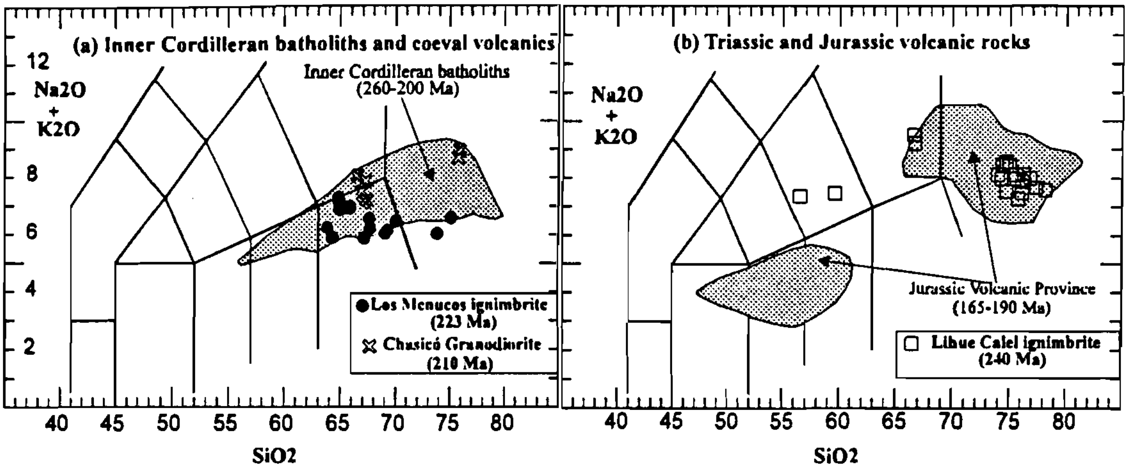

Figure 2: *Alkali-silica variation diagram of Permian to Jurassic magmatic rocks of Patagonia. (a) the field of plutonic rocks is from Rapela & Llambías, 1985; Rapela & Pankhurst 1996 and Rapela et al., 1992. (b) the field of the Jurassic Volcanic Province is from Pankhurst & Rapela, 1995. Note that the hornblende-bearing Late Triassic volcanic rocks of Los Menucos show a different compositional range to that of the silicic members of the Jurassic Volcanic Province.*

The hornblende-biotite dacite ignimbrites of Los Menucos in northern Patagonia (Figs 1, 2) are especially significant since related air-fall deposits carry a rich Dicroidium and other associated flora (Labudía et al., 1995). Fourteen ignimbrite samples define a perfect Rb-Sr whole-rock isochron (MSWD = 1.1), corresponding to an age of 222 ± 2 Ma and initial 87Sr/86Sr ratio of 0.7079 ± 0.0001. Hornblende-biotite granodiorites and consanguineous aplites of the Chasicó area 90 km north-west of Los Menucos (Fig. 1, 2a) give an isochron relationship (MSWD = 0.8) corresponding to an age of 210 ± 2 Ma and an initial 87Sr/86Sr ratio of 0.7058 ± 0.0001. These results indicate that equivalent intermediate-to-evolved calc-alkaline volcanism accompanied the intrusion of the early-emplaced suites of the Batholith of Central Patagonia in the Gastre area (220 ± 3 Ma, Rapela et al., 1992). The shallow emplacement of these granodioritic (dacitic) magmas seems to have occurred over a period of at least 20 Ma in northern Patagonia.

VOLCANIC PROVINCES

The Jurassic volcanic rocks of eastern Patagonia are part of one of the largest known silicic igneous provinces (Fig. 1). Rb-Sr geochronology has indicated eruptive ages of 168-190 Ma and significant southward diachronism of activity (Pankhurst & Rapela, 1995). The whole province is dominated by high-K rhyolites, but less evolved rocks (47-62% SiO2) showing subalkaline major and trace element geochemistry are sometimes mappable as separate units or occur as a very minor phase within the rhyolite outcrops (Fig. 2b). At individual localities there is always a variable gap in SiO2 between the dominant rhyolites and the intermediate-basic volcanics, defining a bimodal assemblage (Fig. 2b). The majority of the rocks in the most intensively studied, northeastern, part of the province are isotopically uniform, with initial 87Sr/86Sr = 0.7067 ± 0.0003 and εNdt = -4 ± 2. It has been argued that this represents large-scale reworking of relatively unevolved Proterozoic lower crust.

New Rb-Sr isotope data on 13 samples for the Lihue Calel rhyolitic ignimbrites 250 km to the north of the Jurassic Province (Fig. 1) give a perfect fit to the isochron model (MSWD = 1.2), with an initial 87Sr/86Sr ratio of 0.7075 ± 0.0001and an age of 240 ± 2 Ma (Early Triassic). Like the Jurassic volcanic rocks this sequence is bimodal, but has a strongly alkaline signature (Fig. 2b). The more basic trachyandesite and trachydacite members plot on the same isochron as the dominant rhyolites, indicating a cogenetic origin. This observation also holds true for some of the andesites and rhyolites of the Jurassic suite (Pankhurst & Rapela, 1995).

The overall picture of Gondwana magmatism that is begining to emerge from these studies is one of repeated alternation between inner cordilleran calc-alkaline batholiths and bimodal volcanic rocks. The first of these cycles began north of Patagonia, at 28-38°S, and is represented by calc-alkaline plutonic rocks of the Colangüil batholith (320-260 Ma; Llambías & Sato, 1995; see Fig. 1). This phase was followed by widespread eruption of rhyolites of the Choiyoi Province (Kay et al., 1989), with some coeval intermediate volcanic rocks and granites (s.s) (Llambías & Sato, 1995). The Lihue Calel ignimbrites are among the most easterly examples of this event. Calc-alkaline plutonism was then renewed in northern Patagonia (220-200 Ma), followed by the most widespread silicic volcanism in Jurassic times (190-165 Ma). The combined evidence of the plutonic and volcanic history thus reveals alternations that may reflect changes in the tectonic regime. It could be postulated, for example, that the plutonic episodes correspond to periods of oblique-slip subduction and that these alternated with periods of cessation or slowing of subduction during which magmatism was represented by extensive silicic volcanism.

REFERENCES

Kay, S.M., Ramos V.A., Mpodozis, C. & Sruoga, P. 1989. Late Paleozoic to Jurassic silicic magmatism at the Gondwanaland margin: analogy to the Middle Proterozoic in North America? Geology, 17, 324-328.

Labudía, C.H., Llambías, E.J., Rapela, C.W. & Artabe, A. 1995. El Triásico de Los Menucos: procesos volcánicos y sedimentarios. Actas II Reunión del Triásico del Cono Sur, pp 17-21, Departamento de Geología, Universidad Nacional del Sur.

Llambías, E.J. & Sato, A.M. 1995. El batolito de Colangüil: transición entre orogénesis y anorogénesis. Revista Asociación Geológica Argentina, 50, 111-131.

Pankhurst, R.J. & Rapela, C.W. 1995. Production of Jurassic rhyolite by anatexis of the lower crust of Patagonia. Earth & Planetary Science Letters, 134, 23-36.

Pankhurst, R.J., Rapela, C.W., Caminos, R., Llambías, E. & Párica, C., 1992. A revised age for the granites of the central Somuncura Batholith, North Patagonian Massif. Journal of South American Earth Sciences, 5, 321-325.

Rapela, C.W. & Llambías, E.J., 1985. Evolución magmática y relaciones regionales de los complejos eruptivos de La Esperanza, provincia de Rio Negro. Revista Asociación Geológica Argentina, 40, 4-25.

Rapela, C.W & Pankhurst, R.J. 1996. Monzonite suites: the innermost Cordilleran plutonism of Patagonia. Transactions of the Royal Society of Edinburgh, Earth Sciences (in press).

Rapela, C.W., Pankhurst, R.J. & Harrison, S.M. 1991. Triassic "Gondwana" granites of the Gastre district, North Patagonian Massif. Transactions of the Royal Society of Edinburgh, Earth Sciences, 83, 291-304.

Uliana, M.A., Biddle, K.T., & Cerdan, J. 1989. Mesozoic extension and the formation of Argentine sedimentary basins. In Tankard, A.J. & Balkwill, H.R. (Eds) Extensional Tectonics and Stratigraphy of the North Atlantic Margins. America Association of Petroleum Geologists Memoir 46, 599-614.