MAGMATIC EVOLUTION OF THE EASTERN PART OF THE CHILEAN PATAGONIA (AYSEN REGION): GEOCHRONOLOGICAL AND GEOCHEMICAL CONSTRAINTS

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INTRODUCTION

Numerous studies have been done in the Northern Patagonian Batholith (NPB) in order to characterize the accross-NPB temporal and compositional variations (Halpern & Fuenzalida, 1978; Hervé, 1984; Bartholomew & Tarney, 1984; Bruce et al., 1991; Pankhurst & Hervé, 1994). A large number of radiometric dates obtained with different method (Rb-Sr, K-Ar and Ar-Ar) indicate that the Meso-Cenozoic plutonism have developed in a more stationary condition than the eastward migrating plutonism developed in the Andes of central Chile (cf. Drake et al., 1982; Parada et al., 1988). This study includes rocks of the NPB and rocks of the poorly dated volcanic units developed further east. The Liquiñe - Ofqui Fault Zone (LOFZ), is the western boundary of this study. It represents a major dextral srtike-slip fault system along which important displacements of the western block of the continental margin are not ruled out (Cembrano & Hervé, 1993). Based on publihed and 34 new ages together with geochemical and isotopic data, we attempt to characterize the main Meso-Cenozoic magmatic events. This study was carried out in three areas: i) eastern part of the NPB at about 44°30' S; ii) eastern part of the Aysén Region, between Coihaique and Balmaceda (45° 30' - 46°S), and iii) along the rivers Rio Chacabuco and Rio Baker (47° - 47°30'S).

TRANSVERSE AGE VARIATIONS IN THE NPB AT ABOUT 44° 30' S.

At a regional scale the spatial age distribution in the NPB gives rise to across-batholith zonation in which the youngest ages (Miocene) are in the central part adjacent to the LOFZ (Hervé, 1984; Pankhurst & Hervé, 1994). To the east of the LOFZ the plutons are Cretaceous in age, whereas to the west, Jurassic to Eocene intrusions are recognized (Bartholomew & Tarney, 1984; Bruce et al., 1991; Pankhurst & Hervé, 1994) forming poorly-defined belts. At 48° S, the NPB do not exhibit regular unidirectional migration of the intrusions with time (Weaver et al., 1990). Sixteen Ar-Ar ages were obtained accross the eastern part of the NPB. They confirm the previous documented regional scale age zonation characterized by Upper Miocene plutons at the LOFZ, Lower Miocene rocks further east and extensive Lower Cretaceous intrusions in the easter part of the NPB.

At the local scale, three age ranges emerge from the data of the Miocene event: 15 - 18 Ma, 9 - 11 Ma and 5 - 7 Ma. The first range is documented with a whole-rock Rb-Sr isochron (Pankhurst & Hervé, 1994) and three new Ar-Ar hornblende ages obtained in samples from the El Queulat diorite located 10 Km east of the LOFZ. Three new Ar-Ar biotite ages obtained in the same samples of the El Queulat diorite, and previous whole-rock Rb-Sr isochron and Ar-Ar ages obtained in three different garnet granite plutons (Hervé et al., 1993), define the second range. The third range is given by three Ar-Ar ages in garnet granites plutons. In addition, ages of 5.5 Ma were obtained in biotite and muscovite of three milonite samples from the LOFZ near Puerto Cisnes.

The emplacement of one Miocene plutonic unit appears to trigger the uplift and subsequent cooling of the previous unit. The first age range represents the plutonic emplacement of the El Queulat diorite. The second range includes emplacement ages of the garnet granite intrusions and cooling ages

of the El Queulat diorite emplaced during the first range. The third range represents cooling ages of the garnet granite pluton. The ages of the milonite fall within the third age range and suggest that the subsolidus cooling of the garnet granites was produced by the youngest activity of the LOFZ recorded in the area.

Accross the Cretaceous plutonic belt of the NPB between 44° and 44° 30' S, an eastward decreasing ages emerge from the previous radiometric data and 4 new Ar-Ar ages. Those ages range from 124 to 75 Ma.

AGES OF VOLCANIC ROCKS IN THE AREA BETWEEN COIHAIQUE AND BALMACEDA

Based on previous and new (11) radiometric dates (Ar-Ar in biotite and plagioclase and whole-rock K-Ar), three volcanic events can be recognized between 115 - 40 Ma. The oldest event is formed by abundant felsic tuffs, minor amount of basalts and small plutons that crop out along the foothill of the Patagonian Andes between Coihaique and Balmaceda. Rocks of this event have Ar-Ar and K-Ar ages between 100 and 115 and were assigned to the Cerro Divisadero Volcanic Complex (Belmar, 1996). The second event corresponds to a bimodal association (basalt and rhyolite) which developed to the east of the former event. Previous and new (5) age determinations define a range between 90 and 75 Ma, with the exception of one Ar-Ar age of 96 Ma. Basalts and rhyolitic tuffs from the Alto Rio Coihaique, as well as pilow basalts and associated rhyolitic tuffs near Balmaceda, form part of this event. A sequence of olivine basalts represents the last volcanic event, which have K-Ar ages of 46 and 55 Ma (cf. Belmar, 1996). A new whole-rock K-Ar age of 49 Ma was obtained for a basalt from a sequence located 5 Km north of Balmaceda.

AGES OF MAGMATIC ROCKS ALONG THE RIVERS RIO CHACABUCO AND RIO BACKER

Three magmatic episode are recognized in this area: Middle Jurassic, Cretaceous and Eocene. The volcanic products of each episode were deposited over polymetamorphic and polydeformed schist and phyllites of a Paleozoic basement.

The Middle Jurassic event has been dated in two areas. In the Alto Rio Chacabuco, near the Chile - Argentina boundary, rhyolitic tuffs of a felsic volcanic sequence have Ar-Ar biotite and plagioclase ages of 160 and 144 Ma respectively. This sequence is intruded by a granitic pluton around which an argillic alteration developed at about 130 Ma. U-Pb and Ar-Ar biotite ages of about 155 and 158 Ma respectively, were obtained in two plutons intruding a volcanic sequence in the El Faldeo area, south of Cochrane. These jurassic ages represent the oldest mesozoic magmatic event in the studied segment of the Chilean Patagonia and correspond to the volcanism of the Ibáñez formation. At Levicán Peninsula in the General Carrera lake (~ 46° 30'S) a rhyolitic tuff of the Ibáñez formation gave an Ar-Ar biotite age of about 130 Ma.

Two Cretaceous ages of 104 and 92 Ma (K-Ar and Ar-Ar respectively) were obtained from a volcanic-sedimentary sequence developed to the west of the Jurassic volcanics of the Rio Chacabuco. The older age was obtained in a rhyolite located near the confluence of the rivers Rio Chacabuco and Rio Backer, whereas the younger age was obtained in an andesite located 20 Km further east. A sample of hornblende tonalite from the easternmost part of the NPB of these latitudes, gave an Ar-Ar hornblende age of 114 Ma.

An Eocene volcanic-sedimentary sequence, developed along the NNW-SSE segments of the rivers Rio Backer and Rio El Salto, is documented by two K-Ar ages of about 47 Ma obtained from rhyolitic tuffs The sequence also includes sedimentary breccias, basalts and felsic sills.

GEOCHEMISTRY

Compositional variations have been observed accross the NPB at about 44° 30' S. Within the Tertiary granitoids near the LOFZ, two types of granitoids were recognized: garnet-muscovite granite and hornblende-biotite diorite. This plutonic association differs from that of hornblende-biotite granite and tonalite, which characterize the Cretaceous granitoids developed further east. All the analyzed NPB

granitoids have VAG signatures. However, more fractionated REE patterns and LIL element enrichment are observed in the Cretaceous granitoids than in the Tertiary diorites.

The volcanic events recognized in the studied area are characterized by an association of abundant rhyolitic tuffs, and minor basaltic to andesitic lavas. The exception is the poorly known Jurassic event, in which only felsic material have been recognized. Similarities among the rhyolitic tuffs of the different events are recognized. These rocks have La/Yb between 5 and 20 and negative Eu anomalies. In addition they have near constant HREE enrichment of about 10 x chondrite values, precluding the garnet participation as a residual phase. Likewise the rhyolitic tuffs, the basaltic materials do not show significant differences. Compared with basalts of the Southern Volcanic Zone, most of the analyzed basalts show high LILE and moderate HFSE enrichment respect to MORB. Some of the Eocene basalts have OIB signatures.

Sr and Nd isotope data were obtained for representative samples from the Jurassic, Lower Cretaceous, Upper Cretaceous and Eocene magmatic events. Most of the rhyolitic - dacitic samples have initial Sr ratios between 0.705 and 0.712 and εNd values between 0.0 and -4.6, which suggest and important crustal contribution. Sr and Nd isotopic values within the same ranges have been obtained for Middle Jurassic granitoids south of Cochrane.

CONCLUSIONS

The studied segment of the NPB represents a portion of the magmatic arc developed during the Cretaceous and Upper Tertiary. The jump of the plutonism to the LOFZ indicates that this structure became in the locus of the magmatism and constituted the uplifted Neogene margin north of the collision of the Chile ridge with the trench at 47° S. Taking all the avilable radiometric data, an age correlation exists between plutonism and volcanism. However, the plutonic counterparts for the Middle Jurassic, Upper Cretaceous volcanism are poorly represented.

Unlike the plutonism, the Mesozoic - Early Cenozoic volcanism generated a bimodal magmatism. The felsic materials exhibit geochemical and isotopic similarities regardless the age, suggesting a common origin. According to the published Sr isotopic data, the NPB and Southern Patagonian Batholith (SPB) have comparatively lower values than theirs volcanic counterparts. In the SPB at 48°S, the initial Sr ratios increase with increasing age (from Middle Jurassic to Eocene), indicating that the crustal contribution decreases with time (Bruce et al., 1991). Such coherent age - crustal contribution relationship is not observed in the Mesozoic - Paleogene volcanic rocks. On the contrary, the crustal contribution appears to be ubiquitous in the origin of the studied felsic volcanic rocks.

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