



THE ALESSANDRINI COMPLEX: EARLY JURASSIC PLUTONISM IN NORTHERN PATAGONIA, ARGENTINA

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INTRODUCTION

Extensive outcrops of plutonic and volcanic rocks are found in the northwest part of Patagonia, Argentina. In the La Esperanza area, Llambías and Rapela (1984) and Rapela and Llambías (1985) recognized the existence of an event related to the Gondwanan Magmatic cycle. According to these authors, two complexes form part of this event. The first and older, the La Esperanza plutonic complex, comprises granodiorites, granites, pegmatites, and aplites. The upper complex, Dos Lomas Plutonic and Volcanic Complex, is composed of rhyolitic lavas, ignimbrites, rhyolitic domes and granitic bodies.

Somewhat further north, in the El Cuy area, Bjerg et al. (1997), Saini-Eidukat et al. (1999, 2000) and Gregori et al. (2000) mapped and described well-exposed outcrops of plutonic, volcanic, and metamorphic rocks. These rocks trend NE-SW for more than 40 km, following the Cañadón Soledad, between the Patú-Co, La Totorá and El Loro lineaments. At least two units can be differentiated stratigraphically. The older, foliated, unit consists of porphyritic granites, aplites and pegmatites. These rocks were assigned by Bjerg et al. (1997) to the Mamil Choique Formation due to their similarity. The younger units had been assigned to the Donosa granite, a component of the La Esperanza Plutonic Complex. However, a Rb/Sr mineral isochron (Saini-Eidukat et al., 1999) indicated that the crystallization age of this unit is 192 ± 0.2 Ma, thus calling into question the previous interpretation.

Exposures of intrusive rocks with Jurassic ages are relatively limited in North Patagonia, in contrast to the extensive occurrence of silicic and intermediate volcanic rocks which are widespread in this area. This paper will discuss details only of the younger intrusive unit, referred to as the Alessandrini Complex.

THE ALESSANDRINI COMPLEX

Based on field mapping (Fig. 1), it has been possible to subdivide this magmatic cycle into an intrusive episode (Facies a, b, c and d) and a volcanic episode (Facies e and f):

a) Alessandrini Facies: This facies is coarse-grained pink granite, with porphyritic tendencies. It occurs in the eastern part of the body and extends from the area near the Ea. La Señá in the east to the area of the Puesto Mendoza in the west.

b) Cortés Facies: Represented by fine-grained gray granites. The most important outcrops occur east of the Puesto Cortés, mainly in the area on the north border of Cañadón Soledad.

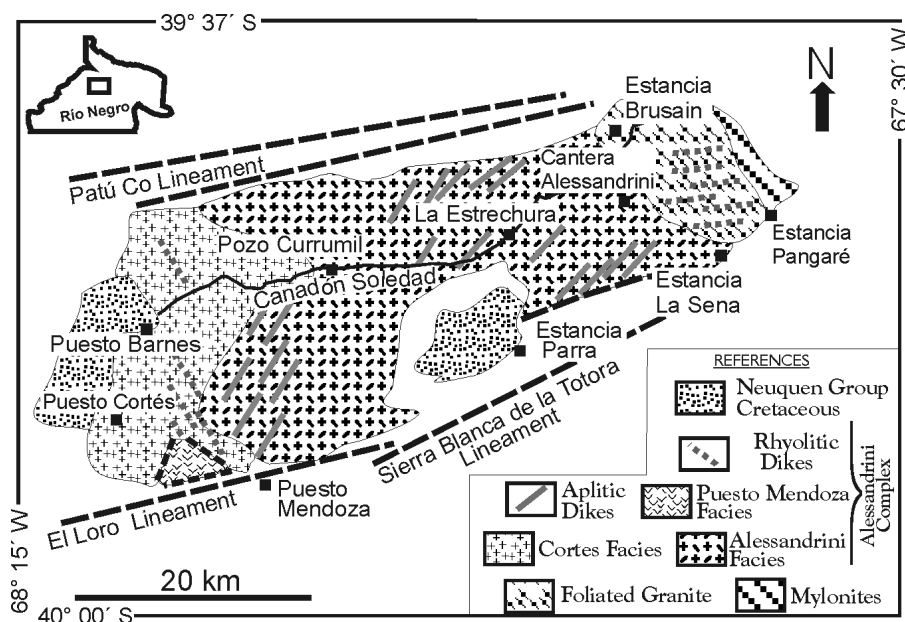


Figure 1: Geology of Alessandrini Complex.

c) Granodiorites: These rocks are represented by dark-colored dikes with coarse-grained texture. They are rare and their occurrence is scattered, without any observed structural control.

d) Aplitic and pegmatitic dikes: The aplitic dikes are abundant and widely distributed, mainly on the north side of Cañadón Soledad. Their lengths can be up to 1 kilometer. The pegmatitic dikes are limited in occurrence. The best examples can be observed in the quarries located on either side of Cañadón Soledad.

e) Puesto Mendoza Facies: This group is composed of ignimbrite flows, exclusively occurring in a very small area in the SW of the study area, a few km to the NW of Puesto Mendoza. These outcrops are bordered by faults, so it is impossible to determine their relationship with the Cortés Facies.

f) Rhyolitic and dacitic dikes. These bodies, which can have lengths measured in km, can be found throughout the area. In the Estancia La Señá and Estancia Pangaré areas, they have a general E-W strike, and cut the other facies of the Alessandrini Complex.

In addition to the above facies, a few basaltic and andesitic dikes cut the granitic facies, typically in the area of the El Loro and Patu-Co lineaments, following the south and north borders of the granitic body.

PETROLOGY AND GEOCHEMISTRY

ALESSANDRINI AND CORTÉS FACIES

This facies is composed of pink to red and gray granites, without foliation. In the Estancia La Señá, Cantera Alessandrini and Cañadón Soledad areas, where Alessandrini facies predominate, the rocks show inequigranular to porphyritic texture, with crystals of microcline up to 7 cm in length.

The feldspar is mainly perthitic, while the plagioclase shows polysynthetic twinning. Biotite, titanite, and zircon occur, but no hornblende. In the western sector (Puesto Cortés, Puesto Mendoza, Puesto Barnes, Pozo Currumil) the Cortés facies is very well represented. These rocks have a similar mineralogy, with an equigranular and fine-grained texture. On a QAP diagram both facies plot in the monzogranite and granodiorite regions.

Geochemically, they are subalkaline and show a calc-alkaline tendency according to Irvine and Baragar (1971). They are mostly peraluminous, with a few being metaluminous. On the diagram of Middlemost they plot in the area of granites and alkali-feldspar granites.

Harker diagrams (SiO_2 vs TiO_2 , Al_2O_3 , MgO , Na_2O , Zr, Sr, Ba) indicate clear negative trends according feldspar and accessory mineral fractionation.

Sr/Rb and K/Rb diagrams display negative and positive correlation as expected for samples belonging to an unique magmatic episode.

On chondrite-normalized REE diagrams (Sun and McDonough, 1989) they show up to 300 times enrichment over chondrite. In general, all have negative Eu anomalies, possibly due to plagioclase fractionation. (Fig. 2 A and B).

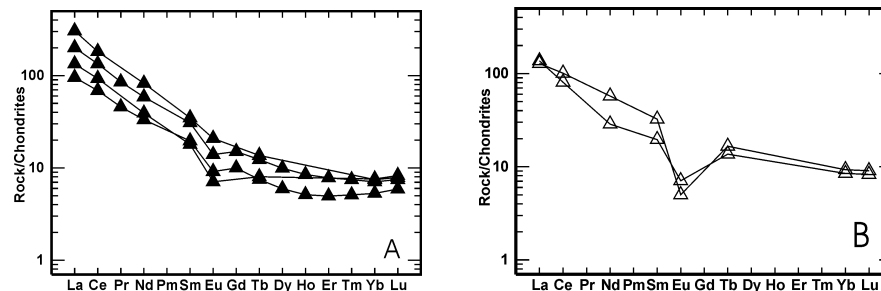


Figure 2. A: Alessandrini facies spider diagrams (SiO_2 : 68.84 to 76.53 wt%) B: Cortés facies spider diagrams (SiO_2 : 73.58 and 77.80 wt.%)

GRANODIORITES

These occur as dikes up to 1 m in thickness and length less than 5 m. Sometimes they appear as inclusions up to 50 cm diameter within granitic rocks. They were observed north of Estancia La Seña and in the Cantera Alessandrini. They are not found within the Cortés Facies. They have an equigranular texture with 30 % biotite and dark minerals, followed by plagioclase, quartz and alkaline feldspar. Also, accessory minerals titanite and allanite were recognized. On a QAP diagram these rocks plot in the granodiorite and quartz diorite fields. Geochemically, they plot on the alkaline/subalkaline boundary. On Shand's diagram, they plot in the metaluminous field, while on the Middlemost diagram, they plot between monzodiorite and quartz-monzodiorite. On the ACF diagram, they show a tholeiitic tendency but more samples are needed to confirm this interpretation.

The chondrite-normalized REE diagrams are similar to those of the Alessandrini and Cortés facies. However, in general, there are no negative Eu anomalies, with the exception of sample QA-3 (Fig. 3A).

APLITIC AND PEGMATITIC DIKES

Aplitic dikes are regionally distributed and structurally controlled. Strikes in the Estancia Parra-Estancia. La Seña are $\text{N}70\text{--}80^\circ$, whereas north of Puesto Mendoza are $\text{N}40\text{--}45^\circ$. Their texture is saccharoidal, and in the case of the aplites, they are composed of quartz, plagioclase, and K-spar. Some biotite and opaque minerals are observed. The REE diagram shows major positive Eu anomalies, produced by abundant accumulation of K-spar and plagioclase (Fig. 3B). Pegmatitic dikes are small dikes, less than 1 m thick, with length always less than 5 m. They outcrop mostly in the Cantera Alessandrini and Cañadon Soledad areas and apparently are not structurally controlled.

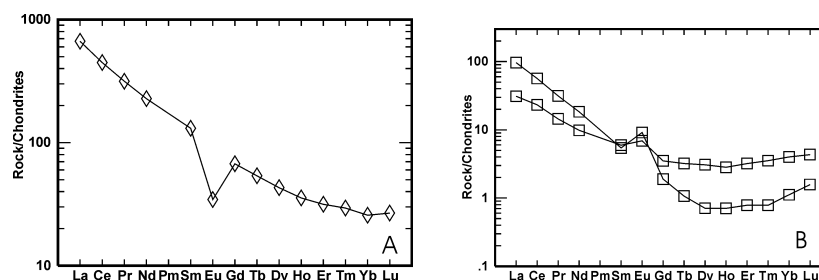


Figure 3. A: Granodiorite spider diagrams (SiO_2 : 62.01 wt%) B: Aplitic dikes spider diagrams (SiO_2 : 77.10 to 78.18 wt%)

PUESTO MENDOZA FACIES

These outcrops are fault bounded; for this reason it is impossible to establish the relationship with the Cortés and Alessandrini Facies; however the rhyolitic dikes cut them. They are present NW of Puesto Mendoza. They show eutaxitic texture and abundant flow textures of millimeter size. On a QAP diagram, these samples plot in the rhyolite field. Chemical analyses of these rocks have not yet been carried out.

RHYOLITIC AND DACITIC DIKES

These rocks are commonly found in the entire study area. They can be differentiated into two groups based on structural control. The first group, with a strike N 75-90° E, is present in the Estancia La Seña and Estancia Pangaré areas. These dikes cut the intrusive rocks of the Alessandrini Complex, and foliated granites. They have lengths up to 2 km and thickness between 7 and 9 meters. These dikes are subparallel to each other, separated by about 2 kilometers. The second group is found north of Cañadón Soledad, between Puesto Cortés and La Estrechura. In this case, the dikes strike N30-45°, with length over 5 km and width 25 m. These have a porphyritic texture and are composed of quartz, with common corrosion textures, K-spar, albite and some biotite. They plot in the rhyolite field on the QAP diagram. They are subalkaline and plot in a group in the A corner of the AFM diagram, so it is not possible to characterize their calc-alkaline tendency. On Shand's diagram, they are located in the peraluminous field. In general, these rocks have chemistries very similar to the intrusive facies. The enrichment of the REE's and the negative Eu anomaly are at approximately the same levels as the granitic facies. (Fig. 4A).

BASALTIC DIKES AND ANDESITES

Only a few outcrops of these types are observed in the El Cuy area. Mainly, they follow the lineaments that border the north and south margins of the Alessandrini Complex. They are rectilinear dikes, emplaced in fault zones. The maximum length observed was 40 m, with thickness of 4 m. In the Estancia Brusain area, they cut the rhyolitic dikes. They have a porphyritic to trachytic texture formed by potassium feldspar and tabular plagioclase with polysynthetic twinning and zonation. Some interstitial nepheline is present. Hornblende and biotite also occur; both altered to chlorite. Geochemically, these are alkaline and metaluminous, plotting as trachyandesite and alkaline basalts. On tectonic plots, they are classified as intraplate basalts. On REE diagrams, they behave quite differently than the rhyolitic dikes, which points toward a different source and genesis for these rocks (Fig. 4B).

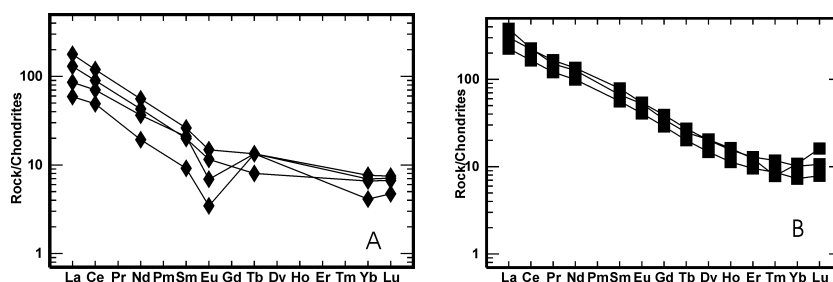


Figure 4. Chondrite-normalized REE diagrams of the rhyolites (A) and intermediate/mafic rocks (B)

GEOCHRONOLOGY

Previous age dating of the granites in the Alessandrini Complex shows evidence of a lower Jurassic age, an intrusive event represented poorly in Northern Patagonia. New age dates determined using granitic and granodioritic samples of Alessandrini and Cortés facies as well as aplites of this complex at the Radiogenic Isotope Laboratory at University of Wisconsin-Madison indicate an age of 195 ± 11 Ma. (MSWD = 7.3, see Fig. 5). This age

show good agreement with the Rb/Sr mineral isochron of Saini-Eidukat et al. (1999), which indicates an age of 192 ± 0.21 Ma.

A whole rock Rb/Sr isochron based on the rhyolitic and dacitic dikes using samples from the Estancia Pangare, Estancia Parra and Puesto Mendoza areas is shown in Fig. 6. Although the calculated age of 193 ± 13 Ma has a very high MSWD (777), several lines of evidence, such as field relationships and major and trace element geochemistry, indicate that this age might be a reasonable crystallization age and that these rocks could be considered as part of the Alessandrini Complex.

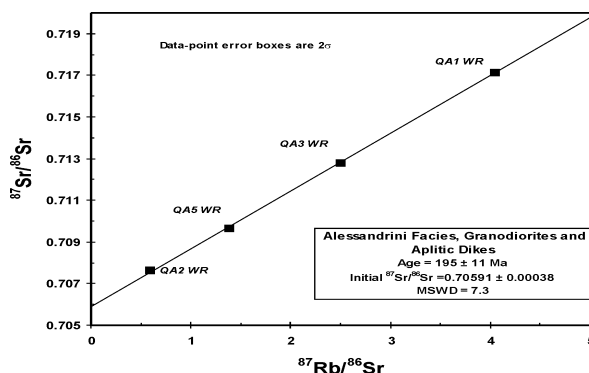


Figure 5: Rb/Sr isochron of Alessandrini Facies granites, granodiorites and aplitic dikes from the Cantera Alessandrini and Canadon Soledad areas

Also, the similarity of the initial $^{87}\text{Sr}/^{86}\text{Sr}$ ratios (Alessandrini facies: 0.70591 ± 0.00038 , rhyolitic and dacitic dikes: 0.70579 ± 0.00088) points to a common source for both groups.

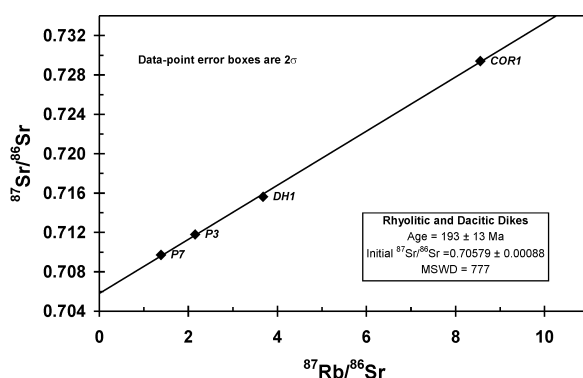


Figure 6: Rb/Sr isochron of rhyolitic and dacitic dikes from the Estancia Pangare, Estancia Parra and Puesto Mendoza areas

DISCUSSION

Together with field data, the geochemistry and age dating show that in the El Cuy region, a magmatic event developed over a large area, which included extrusive and intrusive facies. The event's duration was relatively restricted to the Lower Jurassic. These ages overlap the age of a few other intrusive units in the North Patagonian Massif such as Pilcaniyeu Granites (196 ± 10 Ma, Alonso, 1987).

Also, the Alessandrini Complex ages overlap with those of the Marifil Complex that extends between 150 and 207 Ma.

Regions probably related to this intrusive event include the Lipetrén Suite outcropping in the Gastre area, which give an age of 208 ± 1 Ma (Rapela et al., 1992), the Jara Diorite 170 ± 10 Ma, (Cucchi, 1991), and the Flores Granite 188 ± 3 Ma, (Pankhurst et al., 1993).

Samples of Flores Granite, rhyolitic dikes in the Treneta Complex, the Lipetrén Suite, and the Alessandrini Complex share similar initial $^{87}\text{Sr}/^{86}\text{Sr}$ ratios (Flores Granite: 0.7069, Lipetrén: 0.7057-0.7058, Alessandrini Complex: 0.7057-0.7059), REE patterns and trace elements concentrations (Fig. 7).

The Jurassic magmatic cycle, up to now recognized as composed primary by volcanic rocks, evidently has an important plutonic counterpart exposed NE of El Cuy.

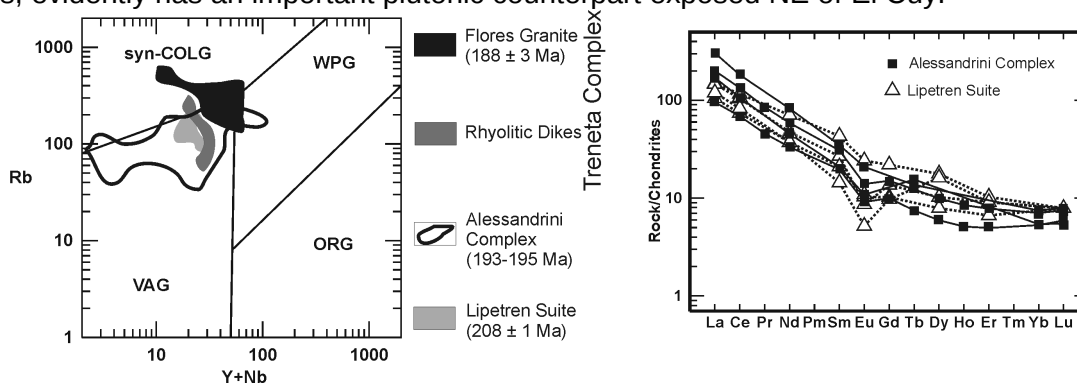


Figure 7: Comparison population in the Rb vs Y+Nb diagram (Pearce et al., 1984) and Chondrite-normalized REE diagrams of Late Triassic-Early Jurassic rocks of North Massif

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REFERENCES

- Alonso, G. B., 1987. Resultados geoquímicos y geocronológicos preliminares de los cuerpos graníticos de Picaniyeu, Provincia de Río Negro. *Actas X Congreso Geológico Argentino*, Actas 4: 27-29.
- Bjerg, E. A., Gregori, D. A. and Labudía, C. H., 1997. Geología de la región de El Cuy, Macizo de Somoncurá, Provincia de Río Negro. *Revista de la Asociación Geológica Argentina*, 52 (3): 387-399.
- Cucchi, R. J., 1991. Las plutonitas de Pilahue, intrusivos Jurásicos del sector occidental del Macizo Nordpatagónico. *Revista de la Asociación Geológica Argentina*, 46 (3-4): 181-187.
- Gregori, D. A., Bjerg, E. A. and Saini-Eidukat, B., 2000. New insights on the Jurassic granites from Somoncure region, Patagonia, Argentina. 17th Symposium on the Geology of Latin America, Stuttgart, Germany. *Profil, Extended Abstracts*, Vol. 18:1-4.
- Llambías, E. J. and Rapela, C. W., 1984. Geología de los complejos eruptivos de La Esperanza, Provincia de Río Negro. *Revista de la Asociación Geológica Argentina*, 34 (3-4): 220-243.
- Pankhurst, R. J., Caminos, R. and Rapela, C. W., 1993. Problemas geocronológicos de los granitoides gondwánicos de Nahuel Niyeu, Macizo Norpatagónico. XII Congreso Geológico Argentino y II Congreso de exploración de Hidrocarburos, Actas 4: 99-104.
- Rapela, C. W. and Llambías, E. J., 1985. Evolución magmática y relaciones regionales de los complejos eruptivos de La Esperanza, Provincia de Río Negro, *Revista de la Asociación Geológica Argentina*, 40 (1-2): 4-25.
- Rapela, C. W., Pankhurst, R. J. and Harrison, S. M., 1992. Triassic "Gondwana" granites of the Gastre district, North Patagonian Massif. *Transaction of the Royal Society of Edinburgh: Earth Sciences*, 83, 291-304.
- Saini-Eidukat, B., Bjerg, E., Gregori, D. A., Beard, B. L. and Johnson, C. M., 1999. Jurassic granites in the northern portion of the Somoncure Massif, Río Negro, Argentina. XIV Congreso Geológico Argentino, Actas 2: 175-177.
- Saini-Eidukat, B., Gregori, D. A. and Bjerg, E. A., 2000. Geochemical characteristics of Jurassic Granitic units from the Somoncure Region, Patagonia, Argentina. *Geological Society of America Annual Meeting Abstracts with Programs*, 32 (7): A-148.
- Sun, S. and McDonough, W.F., 1989. Chemical and isotopic systematics of oceanic basalts: implications for mantle compositions and processes. In Saunders, A. D. and Norry, M. J., *Magmatism in the Ocean Basins*, Geological Society Special Publication No. 42: 313-345.