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Magmatic history of the Fitz Roy plutonic complex, Chaltén, Patagonia, Argentina

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Introduction

The Fitz Roy plutonic complex (FRPC) in Chaltén, Argentina, is one of the numerous magmatic features related to the subduction of the Nazca and Antarctica plate beneath the South American plate in the Patagonia. The FRPC belongs to a group of Miocene intrusions located South of the recent triple junction in a back-arc position, between the plateau basalts in the East and the Patagonian batholith in the West.

The Chile ridge has been subducted beneath the South-American plate and the associated triple junction is migrating to the north since 14 Ma [1]. The main result of the ridge subduction has been fast uplift and extensional tectonism [2]. A contractional tectonism pre-date the ridge collision [2]. Ages of other Miocene intrusions indicate: 12.5 Ma in Torres del Paine [3], located South of the FRPC, and 5.6-6.6 Ma in San Lorenzo [4], in the North. This suggests a progression towards younger ages to the North that seem to coincide with the migration of the triple junction. This relation and other arguments have been used to speculate about a causal relation between subduction of the ridge and intrusion of these Miocene plutons. The previously published age [5] of 18 ± 3 Ma for the FRCP, however, seem to be out of sequence – too old – to attribute the FRPC to ridge subduction magmatism. Yet, until now the FRPC has rarely been studied [6].

Here we integrate new data from petrology, geochemistry, geochronology and field observations to discuss the magmatic evolution of the FRPC in the context of subduction processes.

Field observations

The Fitz Roy plutonic rocks intrude five different host rock formations, from Paleozoic to Cretaceous in age. The entire area is characterized by a complex structure, dominated by the Magallanes fold and thrust belt.

Four plutonic units can be distinguished. From older to younger they correspond to: (1) an ultramafic unit, (2) a mafic unit, composed of gabbros and diorites, (3) a tonalite unit and (4) a central granitic unit composed of a granodiorite and 2 types of granites.
The mafic unit and the tonalite show syn-magmatic deformation, undulated contacts and mingling textures. Gabbros and diorites show shearing and folding, often associated with secondary mineralogy (actinolite, biotite, quartz, K-feldspar). The tonalite displays a characteristic magmatic foliation as illustrated by deformed gabbroic xenoliths. In contrast, the granitic rocks show sharp and brittle contacts and they are not deformed. The whole suite is cut by micro-monzonitic and sub-volcanic dykes.

Petrology & Geochemistry

Unzoned minerals, interstitial plagioclase with a very restricted composition (88-95% An) and a positive slope in the CaO-SiO_2 diagram in the ultramafic rocks indicate cumulate processes. For gabbros, clinopyroxene crystallization pressures between 3-4 kbar were obtained using the Cpx-liquid equilibrium geothermobarometer by [7].
The most differentiated granite (granite 2) presents fresh and unzoned minerals. Graphic textures are widespread and miarolitic cavities are common; indicating crystallization at eutectic condition and water saturation. Phase relation in the Qz-Ab-Or-H_2O system [8] crystallization condition of 2kbar and 680°C for this granite.
The whole rock analysis of the FRCP defines a typical calc-alkaline trend. Comparing with data from Torres del Paine, the FRPC shows lower contents of alkalis and higher Ca-contents. The Nb-Ta negative anomalies and Nb/La ratios are compatible with a subduction related signature.
Harker diagrams illustrate a typical evolution from mafic to differentiated compositions. Note, however, that the granodiorites do not entirely follow the general differentiation trend. They show lower contents of TiO_2, MnO, MgO, FeO_{total}, P_2O_5 and higher contents of Al_2O_3, Eu, Zr, Nb and Hf compared to the other granitics rocks. Despite certain similarities between granodiorite and granite 1, the granodiorite presents differences in chemistry that indicate fractionation of Fe-Ti oxides in the source. Characteristically low ∑REE-concentrations (<10 chondrite normalized) are observed in the ultramafic rocks. Gabbros and diorites can display similar values but have mostly higher concentration, with both positive and negative Eu anomalies. Consistently higher REE-concentrations (~100 chondrite normalized) are observed in tonalite, granodiorite and granites. The decrease in LREE and the increase in HREE observed in the granite 2 suggest the subtraction of allanite. A micro-monzonitic dike shows a very steep REE pattern (La/Lu=248) that resembles the nearby Chaltén adakite body [9].

Geochronology

The FRCP has been previously dated at 18 ± 3 Ma [5]. Yet, this age does not permit to correlate Fitz Roy magmatism to other regional events or to define the internal history of the complex. New $^{40}Ar/^{39}Ar$ data confirm the sequence defined by the field observation.

An age of 19.3 ± 0.4 Ma (Hbl) was obtained in a gabbro. Hornblende from a tonalite indicates 18.8 ± 0.2 Ma. The granodiorite was dated at 17.2 ± 0.1 Ma (hornblende) and 16.1 ± 0.1 Ma (biotite). Slightly younger ages were obtained for the granite 1 (16.9 ± 0.1 Ma, hornblende; 14.2 ± 0.2 Ma, biotite). Due to the similarities in their REE signatures the micro-monzonitic dike could be correlated to the Chaltén adakite, that is dated at 14.5 ± 0.29 Ma [9].

Discussion and conclusions

The different styles of emplacement (P-T conditions, contact relations) and deformation suggest a period of exhumation (1km/Ma minimum average) and cooling between the intrusion of the mafic and the granitic units. In addition, the chemical difference between granodiorites and granites and field observations lead us to suggest that the granite unit has been formed by at least two magma batches.

According to our observations, the main body of the FRPC is composed of at least three magmatic cycles: the oldest correspond to the ultramafic, mafic and tonalitic units at around 19 Ma and 4-3 kbar (?), related to the regional deformation. The second correspond to the granodiorite at 17.2 Ma, around 2 kbar. And the third corresponds to the granites at 16.9 Ma, at 2 kbar, probably differentiated from a magma, similar to the magma of the first cycle. The micro-monzonitic and sub-volcanic dikes further indicate the magmatism was still ongoing in the late stage of exhumation.

Far away from the batholith (100 km eastward of its Eastern limit) the FRPC presents a typical arc-related calc-alkaline signature. It is interesting to note, that the FRCP tonalites show strong similarities in chemistry and intrusion ages to tonalitic intrusions of the Patagonian batholith (23-18 Ma) [10]. Yet, it is not as rich in alkalis as other back-arc intrusions (e.g. Torres del Paine). The differences between Torres del Paine and the FRPC demonstrate that there is no common history for the so called "Miocene" intrusions. The new Ar-Ar ages of the FRPC pre-date the ridge collision by more than 7 Ma, discarding any relation with the ridge subduction.

But the question remains, what are mechanisms responsible for magma localization and magma ascent in this particular region? The joint between the ENE lineament of the Madre de Dios fracture zone and the front of the Magallanes fold and thrust belt define the position of the FRPC. This spatial relation temporally coincide with a calc-alkaline magmatism concentrated between 48°33'S - 50°47'S, involving the arc (Patagonian batholith, 23-18 Ma) and the back-arc (FRPC, 19-16 Ma). The beginning of this magmatism also correspond to a change of the plate motion at ~25 Ma [1] and a period of fast subduction at 25-10 Ma [11].

The calc-alkaline magmatism of the FRPC in the back-arc could be related to the period of fast convergence with a compressive tectonism previous to the ridge collision. This change in the subduction conditions, together with the East vergente structures associated to the Magallanes fold and thrust belt could be responsible for the transport of magma into the back-arc region. Adakitic [9] and the subvolcanic magmatism observed in the area could later use the same structures for magma ascent.

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