The Argentine Frontal Cordillera between 30° 00'and 31° 30'S latitude: polycyclic structure and tectonic evolution

La Cordillera Frontal Argentina entre los 30° 00' y 31° 30' de latitud S: Estructura policíclica y evolución tectónica

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RESUMEN

En el sector de la Cordillera Frontal Argentina comprendido entre los 30° y 31° 30' de latitud S, se diferencian dos conjuntos de rocas con naturaleza y estructuración diferentes: un substrato paleozoico y una cobertera mesozoico-terciaria. El substrato paleozoico está constituido por rocas sedimentarias depositadas en ambientes marinos o de transición, entre el Devónico superior y el Pérmico inferior, deformadas durante los Ciclos Orogénicos Famatiniano y Gondwánico, e intruidas por rocas graníticas permotriásicas. En la serie carbonífero-pérmica se diferencian una sucesión preorogénica, y otra sinorogénica separadas por una discordancia. Las principales estructuras gondwánicas son sistemas de cabalgamientos y pliegues relacionados, con un acortamiento del 60-70%.

La cobertera mesozoico-cenozoica se caracteriza por un predominio de rocas volcánicas, depositadas en ambientes continentales, intruidas por granitoides mesozoicos y cenozoicos. Se pueden diferenciar dos conjuntos de rocas originadas en contextos tectónicos distintos y separadas por discordancias de diversa magnitud: uno inferior (Grupo Choiyoi), ligado a un proceso extensional, que desarrolla fallas de dirección N-S, con geometría lístrica, y otro superior, ligado a un evento compresional posterior que produce la inversión de las estructuras extensionales previas. El acortamiento cortical calculado en la Cordillera Frontal es del orden del 10%.

Key words: *Frontal Cordillera, Tectonic evolution, Inversión tectonics, Andean cordillera*

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Introduction

The Cordillera Frontal presents a polycyclic structure verging eastwards. In spite of the type and morphology of the different structures they were deformed following different patterns. So, rocks and tectonic structures from three different orogenic cycles can be differentiated on the study area (Figs. 1):

-A Paleozoic basement, constituted by sedimentary rocks, which was strongly deformed during the Famatinian and Gondwanic Orogenic Cycle and is intruded by Upper Paleozoic granitoids.

-An Andean cover, which lies unconformably over the Paleozoic basement, constituted by Permo-Triassic and Tertiary volcanic and volcanoclastic rocks and intruded by Meso-Tertiary granitoids.

The Paleozoic basement: Famatinian and Gondwanic Orogenic Cycles

The Paleozoic basement, formed by sedimentary rocks deposited between the Devonian and the lower Permian periods, was deformed by the Famatinian and Gondwanic Orogenic Cycles and separated by a major unconformity. They would have developed in marine or transitional conditions and were intruded by Upper Paleozoic granitoids.The Carboniferous-Permian rocks (Agua Negra Formation) can be divided in two tectonostratigraphic units, separated by a clearly visible erosive surface. The two units represent preorogenic and synorogenic successions related with a main tectonic event.

At the Carboniferous-Lower Permian time the Frontal Cordillera had a backarc position (Ramos, 1988). Under this geotectonic setting the most likely sedimentary evolution would have been the propagation of the deltaic system from the Precordillera and Pampean ranges to the Frontal Cordillera, where they would initially have met more open marine conditions. During the deposit of the Permian synorogenic succession, a dramatic change of the main source area of sediments took place in the Frontal Cordillera. At this time the uplift of a volcanic arc and a Famatinian basement is show by the presence of volcanic and sedimentary pebbles in the conglomerates with western provenance. Besides the existence of stromatolithic pebbles in the conglomerates of the top of succession, represent the cannibalization of the earlier foreland sedimentary basin and its progradation to the east. The most likely geotectonic setting the Frontal Cordillera at this time is a retroarc foreland basin. This event can be related with the Gondwanic Orogeny, with the same propagation sense.

All these rocks were strongly deformed during the Gondwanic Orogenic Cycle. The structures preserved in the area, were generated during the San Rafael phase in the Permian (Ramos, 1988). The structures resulting from the deformation are thin-skinned type with very low metamorphism and cleavage. The most important structures are thrust sheets and related folds with east tectonic transport direction (Fig. 2A), producing very important shortening (60-70%).

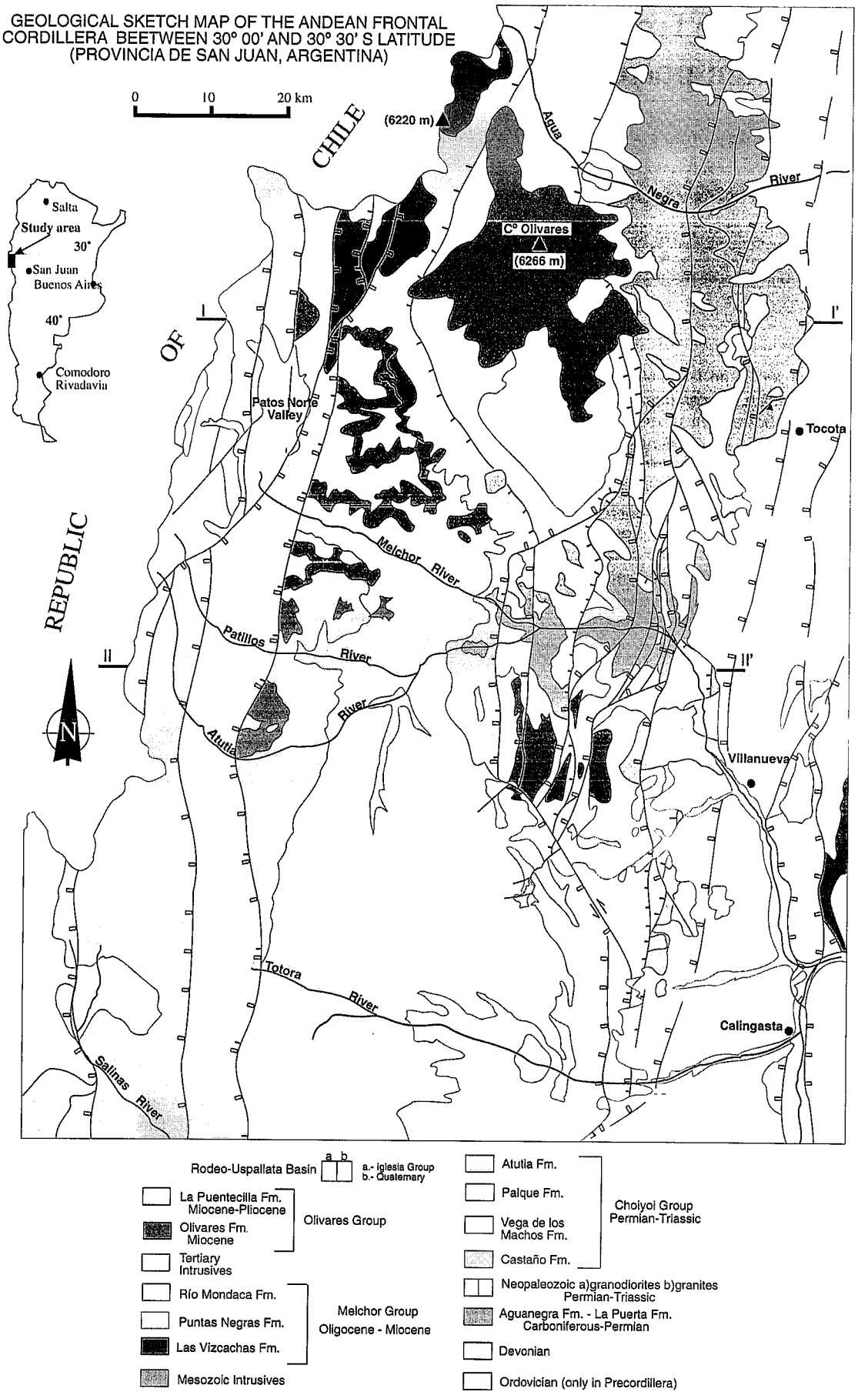

Fig. 1- Geological sketch map of the study area.

Fig. 1- Mapa geológico esquemático del área estudiada.

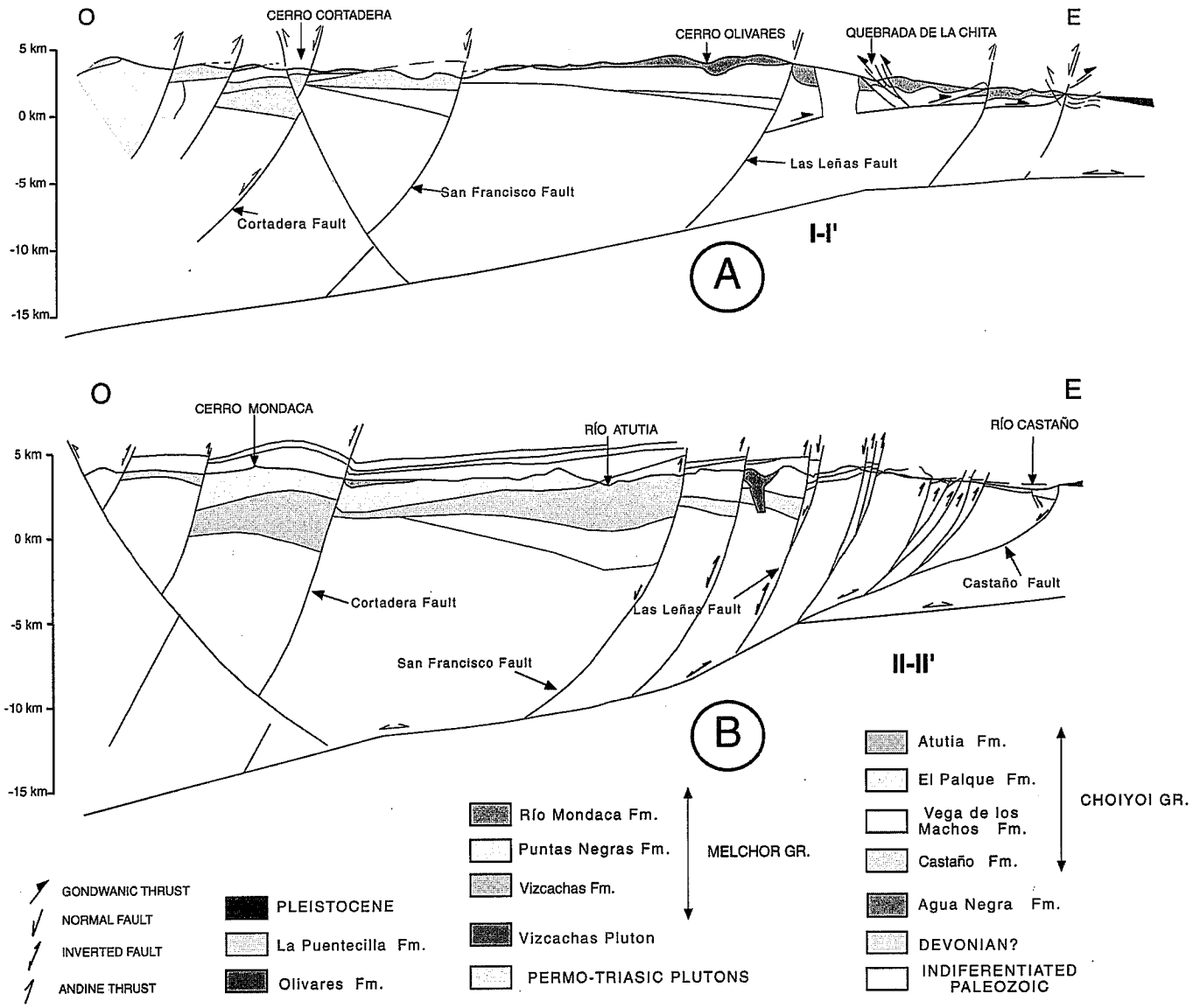

Fig. 2- Geological cross sections of the Frontal Cordillera in the study area. See location in Figure 1.

Fig. 2- Cortes geológicos de la Cordillera Frontal en el área estudiada. Localización en la Figura 1.

The Upper Paleozoic-triassic granitoids show the evolution from a high-K calc-alkaline magmatism, typical of an orogenic environment, linked to an Andean type subduction, to an alkaline and peralkaline anorogenic one (Llambías and Sato, 1995; Rodríguez Fernández *et al.*, 1996; Espina *et al.*, 1998). They intruded at the end of the Gondwanic Orogen during a regional postorogenic extensional period, in permissive conditions. They mainly are granodiorites and granites corresponding respectively to i-type and s-type granites, although some of their are a-type hypersolvus (agpaitic textures) granites, consistent with their plot in the volcanic arc and within plate fields of Pearce *et al.* (1984) (Fig. 3).

Andean cover: extension and inversion tectonics and related synorogenic units

The Andean cover lies unconformably over the Paleozoic basement (Fig. 1). It is characterized by the presence of Late Permian to Upper Tertiary volcanic and volcanoclastic rocks, with some interbedded sedimentary rocks deposited in strictly continental conditions, and intruded by Jurassic and Miocene granitoids. Intrusive rocks are subvolcanic porphyritic andesites and high-K calc-alkaline granodiorites and granites, which plot in the volcanic arc granites field of Pearce *et al.* (1984) (Fig. 3).

Two synorogenic sequences can be differentiated: a lower one formed by the Choiyoi Group Rodríguez Fernández *et al.* 1996, connected to an extensional process, and an upper sequence integrated by Melchor and Olivares groups, related to a later compressional episode producing the inversion of the previous structures. All the units are separated by unconformities of varying magnitude and they are a remarkable stratigraphic gap that accounts for most of the Mesozoic.

The lower unit (Choiyoi Group, Permian and Triassic) can be related with the Upper Paleozoic and Triassic granitoids and is affected by normal faults with downthrow of the western blocks and intruded by Jurassic granodioritic rocks. The faults in this unit involve the Gondwanic basement in a typical thick-skinned tectonic style and are grouped in bands with N-S direction (Figs. 1 and 2).

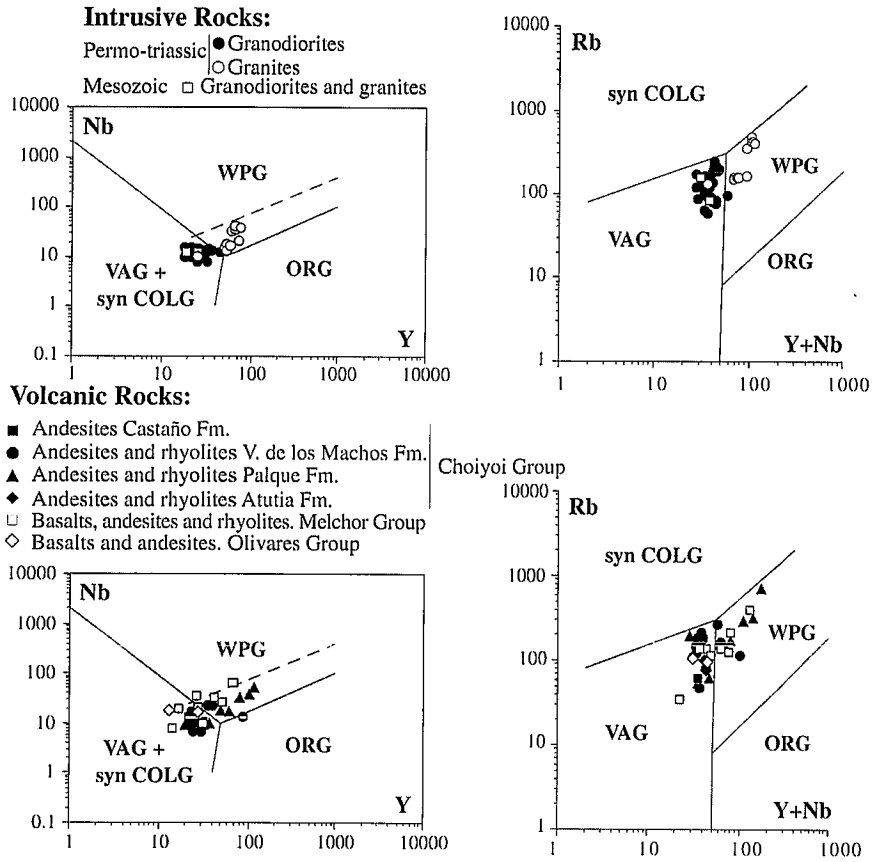

Fig. 3.- Distribution of permo-triassic and mesozoic intrusive rocks and Choiyoi, Melchor and Olivares volcanic rocks, on the Nb-Y and Rb-(Nb+Y) diagrams of Pearce *et al.* (1984). Geochemical data from Sato and Llambías (1993), Llambías and Sato (1995), Rodríguez Fernández *et al.* (1996) and Espina *et al.* (1998).

Fig. 3.- Proyección de las rocas intrusivas, permo-triásicas y mesozoicas, y de las rocas volcánicas de los grupos Choiyoi, Melchor y Olivares en los diagramas Nb-Y y Rb-(Nb+Y) de Pearce et al. (1984). Datos de Sato y Llambías (1993), Llambías y Sato (1995), Rodriguez Fernandez et al. (1996) y Espina et al. (1998).

Their geometry is listric and they share a common detachment level.

As a whole, the Choiyoi Group is made up of high-K calc-alkaline andesites, dacites and rhyolites; however, some rhyolites of the Palque and Atutia formations show anorogenic affinities. Their geochemical features are in agreement with their respective plot on the volcanic arc and within plate fields of Pearce *et al.* (1984) (Fig. 3). As the Permo-triassic intrusive rocks, they show the evolution of an orogenic to anonogenic setting (Sato and Llambías, 1993; Rodríguez Fernández *et al.*, 1996 and Espina *et al.* 1998).

The upper-most units (Melchor and Olivares groups), also lie unconformably over the latter and are mainly formed by high-K calc-alkaline andesites, rare dacites and rhyolites, besides alkaline basalts. Most of the andesites and rhyolites plot in the volcanic arc field of Pearce *et al.* (1984), but some rhyolites of the lower Melchor Group show anorogenic affinities and plot in the within plate field (Fig. 3).

The normal faults (Fig. 2) were inverted in the upper Miocene by the uplifting of the western block, deforming the lower and upper units in a compressional context during the Andean Orogenic Cycle.

The inversion ratio of the reverse faults measured in the Tertiary synorogenic rocks is usually less than 1 km. The crustal shortening calculated in cross sections (Fig. 2) is of about 10%. This fact contrasts with the estimated shortening of over 50% at the Precordillera unit (Gosen, 1992). All this shows that most of the crustal shortening or the Andean Cordillera at the compressional stage has been transferred to the Precordillera unit through the lower detachment fault. These facts also show that the Cordillera Frontal unit is an uplift block in which the extensional structures have been preserved.

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