TECTONIC EVOLUTION OF THE MAIN CENTRAL ANDES AT PASO PIUQUENES (33°30'S), ARGENTINA AND CHILE

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INTRODUCTION

The Piuquenes pass along the border between Argentina and Chile is one of the classic localities first described by Darwin in 1835 during his celebrated world trip. His precise stratigraphic descriptions were the first geological observations in the Central Andes. The excellent exposures of the Aconcagua fold and thrust belt as well as the widespread development of the Cenozoic volcanism made this area an interesting target to analyze the relationship between volcanism and tectonics through Cenozoic times which is the aim of the present study.

The area is located east of the city of Santiago de Chile, and west of Tunuyán city in Argentina. The access in the Chilean side is by road up to 10 kilometers of the Piuquenes pass while from Argentina the pass is more than 30 kilometers away from a secondary road and is reached after two days walk.

The original description of Darwin (1846) recorded the first fossiliferous Mesozoic marine sequence of the Central Andes. But, perhaps more important for the scope of this work is the description of the Tunuyán Conglomerates where he analyzed the provenance of the clasts. He mentioned the occurrence of large clasts of crystalline basement in these conglomerates that should have been derived from an eastern source. More than a century latter, the regular survey of the region by Polanski (1964) was the only other published reference of the geology of the area. In recent years, the laboratory of Andean Tectonics of the University of Buenos Aires surveyed the area in detail at both slopes of the Andes.

GEOLOGIC SETTING

The area has a Proterozoic metamorphic basement emplaced by Carboniferous to Permian arc-related granitoids. These rocks are unconformably covered by the Choiyoi Group volcanic sequence. These Permo-Triassic rocks range from basalts, andesites to rhyolites and record the transition from a subduction related volcanism at the base to a widespread extensional intraplate volcanism in the uppermost rhyolites during Triassic times.

The Mesozoic sedimentary sequence is composed by marine and continental deposits and has been the object of different studies (Polanski, 1964, Thiele, 1980). The lower detachment is controlled by a Middle Jurassic gypsum and is responsible for the presence of Callovian rocks in the core of the Yeguas Muertas anticline in the Chilean side (Godoy, 1993). The eastern slope of the Andes is characterized by an imbrication of thrust slices detached from the Auquilco Gypsum (Oxfordian). As a result of that, red beds, black shales, and carbonates of Tithonian to Neocomian age are repeated and deformed along the axis of the fold and thrust belt. These sequences interfingered to the west with volcaniclastic and volcanic products derived from the arc.

THE SYNOROGENIC DEPOSITS

A series of shales and fine sandstones of lacustrine to low energy fluvial facies represent the distal synorogenic deposits of Paleogene age. The overlying Tunuyán Conglomerates, which are correlated with the Santa María Conglomerates of the Aconcagua region, located further north, range in age from 20 to 8 Ma. The Tunuyán Conglomerates are a coarsening up sequence, deposited in alluvial fans and breaded proximal rivers, and reached up to 1,300 m. Most of their clasts are derived from the different lithologies deformed and uplifted in the fold and thrust belt, west of the thrust front of Cerro Palomares. These conglomerates are covered by the Butaló Formation (Polanski, 1964), which consists of fine sandstones and clays, with reworked tuffs and thin limestones and shales with fossil gastropods. Fine conglomerates of this unit record the first clasts of crystalline basement that show an east provenance, probably derived from the Cordón del Portillo.

THE CENOZOIC VOLCANICS

There are three major volcanic episodes in the region. The Contreras Formation is the lowermost unit at the base of the Tunuyán Conglomerates. It consists of lava flows and basaltic breccias, covered by andesitic pyroclastic flows. All these rocks have been folded and thrust during deformation of Tunuyán conglomerates. These rocks are correlated with the 22 Ma old Máquinas Basalt in the flat subduction segment (Ramos et al., 1989). The geochemical analyses of Contreras volcanics indicate a typical retroarc or intraplate setting (Fig. 1).

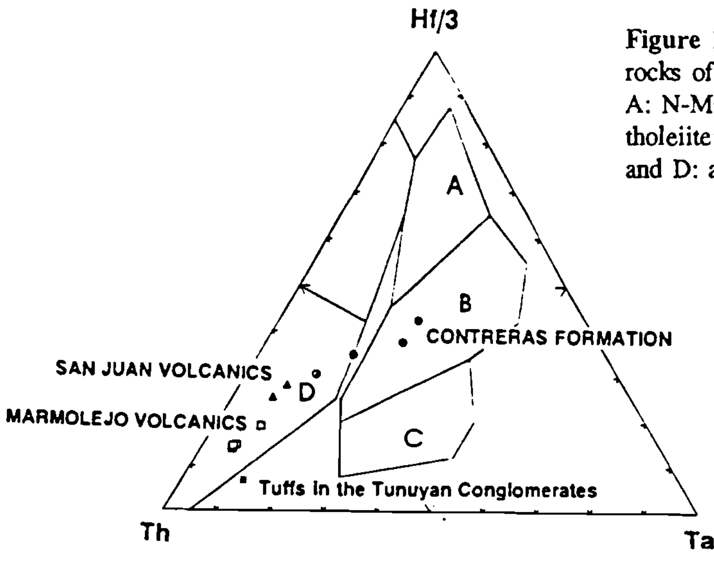

Figure 1: Woods diagram of the volcanic rocks of the Piuquenes Pass region.
A: N-MORB; B: E-MORB & within-plate tholeiite; C: within-plate alkaline basalt, and D: arc volcanics.

The second volcanic sequence corresponds to the andesites and dacites of the Marmolejo volcanic center. These rocks are separated by an angular unconformity from the deformed Mesozoic sequences. They are typical calcalkaline volcanic rocks formed in a magmatic arc setting (Fig. 1). These volcanics are assigned to the Late Miocene-Early Pliocene. The volcanic rocks are tilted by an out-of-sequence thrust.

The third volcanic episodes is represented by andesites and dacites erupted from the San Juan Volcano. These arc related rocks (Fig. 1) are unconformably covering the previous structures and rocks, and are assigned to the Pliocene.

TECTONIC EVOLUTION

The structure of the area has a minimum orogenic shortening of 50 km, produced during the Miocene in a thin skinned fold and thrust belt (Pángaro et al., 1995). The analysis of the structure indicate a piggy-back order for the major thrusts that cannibalized part of the synorogenic deposits. The last episode recorded is an out-of-sequence thrust that west-tilted the base of Marmolejo volcanics, during the Late Miocene-Early Pliocene. This OST may be related to a sticking point produced by the uplift during the Upper Miocene of Cordon del Portillo basement in the Frontal Cordillera. The Pliocene San Juan volcanics postdated all the thrusts in the Principal Cordillera.

An interesting relationship is seen when the geochemical data from the volcanic sequences are introduced in the structural evolution of the area. The REE slope inferred from the La/Yb ratio, were plotted against the relative enrichment of the light REE assumed by the La/Sm (see Fig. 2). As proposed by Kay et al. (1991) in the flat segment there is a clear trend of increasing these ratios during time. This increase was correlated by different authors with the thickening of the crust. Striking similarities are found when the magmatic and tectonic evolution in this normal subduction segment at the latitude of Piuquenes Pass (33°30'S) is compared with the evolution in the flat slab segment (Kay et al., 1987). It is evident that although in both segments the tectonic and magmatic histories are similar there some important differences. The timing of deformation is younger and the degree of crustal thickening is smaller in the southern segment.

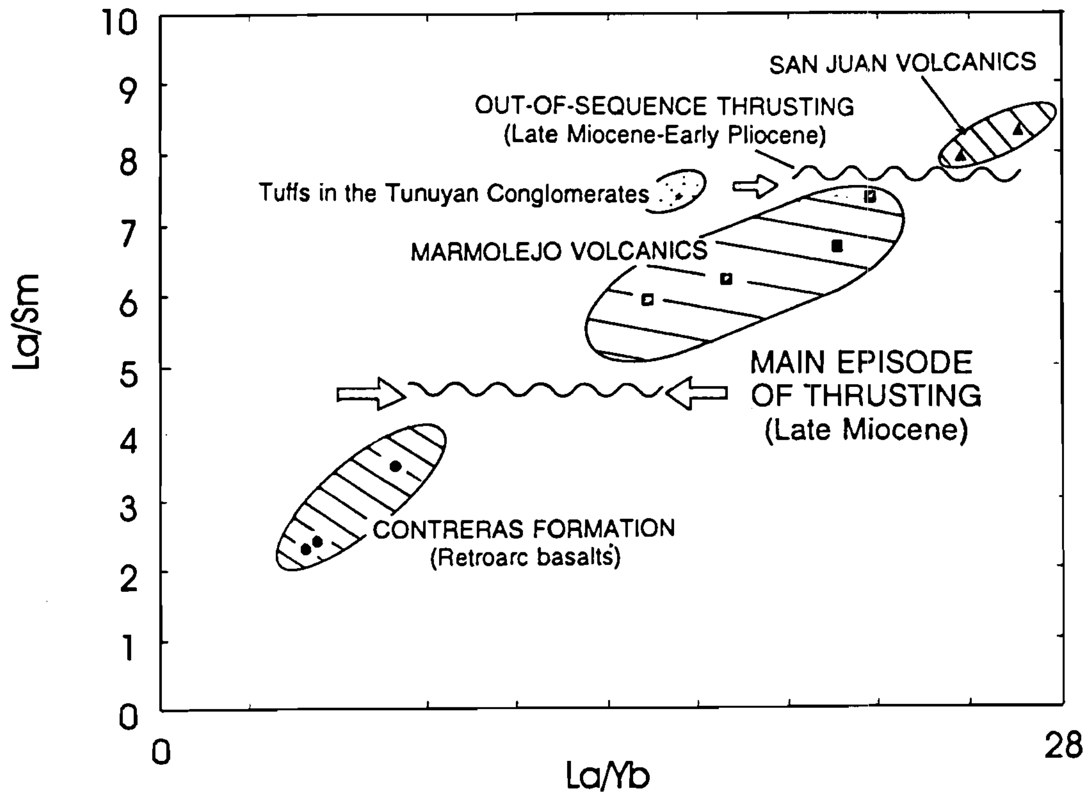

Figure 2: La/Sm and La/Yb ratios of the different volcanic suites of the Piuquenes Pass.

CONCLUDING REMARKS

The integrated survey of the Chilean and Argentine slopes of the Principal Andes shows:

- The tectonic evolution of this segment of the Andes begun with a retroarc basaltic volcanism of Early Miocene age, that is interfingered with the first synorogenic deposits. At this time the crustal thickness was normal or sligthly attenuated.

- The orogenic front migrated from the Chilean side in the Lower Miocene to the Argentine side in the Middle-Upper Miocene. Consequently, thickenning of the crust was followed by an expansion of the westerly derived synorogenic deposits to the east.

- The Marmolejo volcanics during the Late Miocene-Early Pliocene unconformably covered the deformed rocks of the Aconcagua fold and thrust belt. The volcanic front have migrated at that time from the Chilean side to the present international border.

- The uplift of the Frontal Cordillera may have generated a sticking point in the normal piggy-back order of thrusting to the foreland in the Principal Andes. As a result of that an out-of-sequence thrust in the inner previously deformed area tilted the Marmolejo Volcanics.

- During the Pliocene the region became stable, and the andesites and dacites of San Juan Volcano unconformably overly the structure of the fold and thrust belt.

The relationship between the structural evolution, and the magmatic arc trend, indicates that crustal thickening derived from some geochemical parameters tightly matched the thickness obtained through balanced structural cross-sections.

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