Structural evolution of the North Patagonian Andes (41°-42° S), Argentina

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INTRODUCTION

The study area is located in the Rio Negro province (Argentine), between San Carlos de Bariloche (41° S) and El Bolsón (42° S) towns. The main objective of this work is to characterize the regional structure of the northern Patagonian Andes. The most important aspects pointed out are: i) the structure of the pre-Cenozoic basement and its control on the Andean deformation, ii) the relationship between the Cenozoic deformation, sedimentation and magmatism, and iii) their implications in the plate tectonics history.

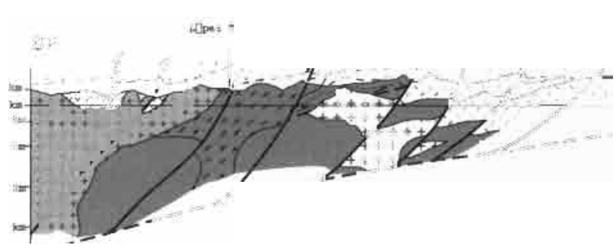
STRATIGRAPHY

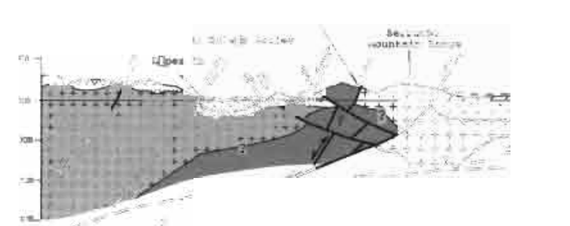
Three main lithological units have been differentiated in this area:

I.- Igneous-metamorphic basement (Colohuincul Complex) (1, 2). The Gondwanic Andean basement outcrops along wide areas of the Patagonian Region. In this area it is mainly represented by, i) albite-garnet schists, biotite gneisses and thin interbedded albite-epidote amphibolites and amphibole-epidote banded anphibolites, ii) amphibole-plagioclase-quartz orthogneisses and, iii) intrusive metaluminous calc-alkaline diorites to granodiorites as well as scarce deformed peraluminous two-mica granites. The available age for these rocks is Carboniferous and Permian (2). These rocks are intruded by mesozoic and tertiary granitoids (fig. 1).

II.- Mesozoic plutons and equivalent volcanic and volcano-sedimentary rocks. Lower-middle Jurassic plutonic rocks are grouped in the Subcordilleran Batholith (3), and constituted in this area by peraluminous biotite granites and micro-granites. Volcaniclastic and sedimentary roof-pendants are preserved in the western side, over the cretaceous Cordilleran Batholith. The roof-pendants are formed by andesite-rhyodacite both pyroclastic rocks and lavas, shales, sandstones, conglomerates and limestones levels of Liasic age. The cretaceous Cordilleran Batholith is mainly formed by metaluminous calc-alkaline hornblende-biotite diorites to granodiorites, porphyritic granites and andesite dykes, intruding and developping conctac metamorphism in the stratified jurassic rocks.

III.- Cenozoic volcanic and sedimentary rocks. Volcanic rocks outcrop in two N-S trend belts (4). The Pilcaniyeu one (Huitrera Fm, upper Paleocene-middle Eocene), located in the foreland border of the Andean orogen, shows a dominant rhyolitic signature. Towards the west, the Maitén belt (Ventana Fm, Oligocene) is formed by andesites and by basalts with some interbedded continental and marine sedimentary rocks. The Tertiary foreland basin is tectonically divided in some minor basins (5). In the Bolsón basin (71° 30'W) marine-continental sedimentary





Fms and equivalents). Cenozoic circumscribed plutons, constituted by peraluminous very coarse-grained biotite granites and granophyric biotite granites, intrude and post-date the López, Catedral and Otto thrusts. Finally, Pliocene basaltic rocks outcrop in the foreland basin. In the hinterland basalts, forming the Monte Tronador volcano, are interbedded with alluvial fans deposits.

PRE-ANDEAN STRUCTURE

The structural analysis shows that basement metasediments have been affected by three main deformation events, probably Permian to Triasic (gondwanic) in age (2). The regional penetrative foliation shows a NW-SE trend in all study area and appears in thin section as a D2 foliation (S2). S1 is well shown in S2 domains and also preserved within albite and garnet porphyroblasts. Both foliations are defined by preferred orientation of muscovite, albite and quartz. Albite is syn-post-D1 and syn-D2 in age. Regional foliation (S2) has been folded by N-S upright open folds with associated crenulation locally developed in the D3 folds hinge zones. Both D2 and D3 have developed under low-grade metamorphic conditions.

ANDEAN STRUCTURE

Two different events can be distinguished in the Andean Cycle i) a Mesozoic extensional phase and ii) a Cenozoic compressive one.

i) The distribution of the lower and middle Jurassic plutonic and volcano-sedimentary rocks can be related with an important N-S system of normal faults, which cross-cutting the gondwanic structures (1). These faults led to the development of extensional basins towards the west, while a basement horst remained in the eastern part and was intruded by plutonic rocks. The eastwards Cretaceous expansion of the plutonic arc was controlled by these faults, which show evidences of tectonic inversion since the Tertiary. Towards the foreland, the Mesozoic extensional regimen is represented by NW-SE structures, parallel to the gondwanic ones, which are responsible for the geometry of the Triasic and upper Cretaceous basins (Pilcaniyeu Fault, fig. 1), as well as for the emplacement of plutonic rocks of the intra-continental magmatic arc (1).

ii) The compressive phase is represented by a fold and thrust belt, controlled by the previous basement structure, with a N-S or NW-SE trending and a concave-shape to the foreland (fig. 1). This belt consists in an east directed imbricate thrust and back-thrust systems. Both the fore-thrusts and back-thrusts have associated folds (fig. 1).

Two structural zones separated by Ventana-Catedral Thrust can be distinguished (1). In the western one, the rocks of the gondwanic basement, Mesozoic plutonic rocks and Tertiary sinorogenic sedimentary rocks (fig. 1) are involved in the deformation. The structure of this zone is represented by the Hielo Azul and Ventana-Catedral thrusts, Piltriquitrón and Serrucho back-thrusts and the El Bolsón Syncline. The scarce folds found in this zone are due to absence of layered rocks. The main structures of the eastern zone are Otto, Pantanoso and Río Chico thrusts, El Maitén back-thrust, Las Bayas klippe and Ñirihuau fold-belt. The gondwanic basement is exhumed by the Río Chico Thrust (fig. 1). The thrusts located to the east of this structure are west-directed (Pilcaniyeu Fault, fig. 1). Deformed sinorogenic sedimentary rocks outcrop in El Bolsón Syncline (Mallín Ahogado Fm) and in the Ñirihuau fold-belt (Ñirihuau Fm). Undeformed Tertiary rocks of the foreland basin are located at the eastern part of the study area (Ñirihuau, Collón Curá and Martín Fms).

The kinematic criteria indicate a main tectonic transport normal to the trace of the thrusts. The deformation age can be estimated by sinorogenic sedimentary rocks and by the relationships between plutonic rocks and thrusts. The sinorogenic sedimentary rocks in the El Bolsón Syncline (middle-upper Eocene) record the oldest compressive deformation. In the central part of the study area, the main compressive phase took place between upper Oligocene and middle-upper Miocene (age of granite emplacement). In the Ñirihuau basin, the Río Chico Thrust is overprinted by upper Pliocene basalts. Therefore, the eastern structures of study area are middle Miocene to Pliocene in age.

Age comparison between the sinorogenic sedimentary rocks and volcanism can be related with Cenozoic convergence of the Nazca and South-America plates (5):

a) The oldest sinorogenic sedimentary rocks in Argentina are coincident in age with the first episode of high velocity convergence between the Nazca and South-America plates (average >100 mm/year), in the middle Eocene (49 Ma) (7). The sinorogenic sedimentation of the Ñirihuau and Collón Curá Fms is coincident with another high velocity convergence episode that begun 26 Ma ago (upper Oligocene) and continued during the Miocene.

b) The great volume of volcanic rocks of the Ventana Fm erupted during Oligocene times (24-34 Ma). This event can be related with an extensional period between two compressive phases. Such extensional event is coincident with a low velocity plate convergence stage (50-55±30 mm/year) between 36-26 Ma (7). On the other hand, a previous period of low velocity between 68 Ma and 49 Ma is time coincident with the Huitrera Fm, a sequence of rhyolitic rocks outcropping in the western limit of the foreland belt.

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