STRUCTURAL EVOLUTION OF THE SIERRAS DE CORDOBA (ARGENTINA)

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ABSTRACT : The Sierras de Cordoba (Argentina) shows the evolution of the western margin of the Rio de la Plata craton during the panamerican (=pampean) orogeny.from the extensional to the compressive stages This domains remained later on the internal (cratonic) side of the subsequent caledonian, variscan and andean orogenies.

KEY WORDS : Sierras pampeanas, Panamerican, Caledonian and Andean orogens

INTRODUCTION

The Sierras de Cordoba (Argentina), which corresponds to the easternmost Sierras Pampeanas, appear as a horst of metamorphic and magmatic terranes of precambrian and paleozoic age, uplifted by the andean movements. In spite of the synthesis proposed by Gordillo & Lencinas (1979), local structural observations (Dalla Salda 1984, Martino 1988) and of various geotectonical models (Ramos 1991), little is known on its orogenic evolution. The purpose of this paper in to present a first synthesis of this evolution based on a cross section on the central part of the Sierras (approximately at latitude 31°15' S) including cartography, structural analysis, geochemistry and study of the metamorphism.

PRE-OROGENIC EVOLUTION

Five main lithostratigraphic units have been recognised :

-- the **Sierra Chica Este** group, subdivided by the major La Estanzuela fault into the La Calera sub-group (kinzigites, calc-silicate-gneiss, marbles) of upper amphibolite facies and the El Diquecito subgroup (metagrauwackes, metabasic rocks) of granulite facies. This group which provided K/Ar ages of 1390-1516 My, is considered to be the western margin of the Rio de la Plata craton ;

- the **San Carlos group**, of amphibolite grade, is made of a very thick and monotoneous sequence of metagrauwackes with minor intercalations of metapelites and calc-silicate gneisses ; ortho-amphibolites, mafic and ultramafic (serpentine, harzburgite) rocks of MORB afinities (Mutti, Baldo 1992), dated by the K/Ar method between 850 and 1200 My, appear interbeded or constitute tectonic scales within the San Carlos group ; this group represent a deep seated sedimentation developped at the western margin of the Rio de la Plata craton, possibly in part on an oceanic crust ;

- the **orthogneissic group** represents pre-orogenic intrusives of granodioritic - granitic composition forming a calcalcaline trend, emplaced within the San Carlos group ;

- the **Igam group**, of amphibolite facies, comformably rests on the San Carlos group ; its lithologic association (calcitic and dolomitic marbles, calc-silicates gneiss, meta-quartzites, meta-litharenites, metapelites) represents a plateform sedimentation ;

The sedimentary environment contrast between the San Carlos and the Igam groups as well as the presence of orthogneisses in the sole San Carlos group sets the problem of possible orogenic movements prior to the Igam group deposition ;

- the **Mermela group**) appears only in the western part of the Sierra where it is limited by andean faults ; it is made of green pelites with minor levels of red pelites ans arenites ; its metamorphism and deformation are very weak ; in the Sierra de San Luis, the equivalent "filitas verde y esquistos" group contains moreover conglomerates and acidic vulcanites ; this group may represent the molasses of the panamerican orogeny (upper-proterozoic).

OROGENIC EVOLUTION

Early phases of deformation and metamorphism

The first recorded events are two phases of syn-metamorphic recumbent folds : the D1 folds, of centimetric to plurimetric scale, are accompagnied by a strong transposition and by migmatisation ; the D2 folds which are the most obvious, form pluri-kilometric structures with a westwards vergence.

The prograde metamorphism M1, of medium pressure type, is contemporaneous of these first tectonic events. Remnants of kyanite and staurolite are known, but the most common association observed in the metapelites is garnet + biotite1 + sillimanite + K feldspar + plagioclase + quartz. + ilmenite The major part of the Sierra de Cordoba presents a metamorphism of high amphibolite facies. There is no recorded isograde neither in the metapelites nor in the metabasites ; but variations of the metamorphic grade may be estimated using the variations of the compositions of the mineralswith in the metapelites : for instance the titanium content of the biotites may be a revelant parameter.

Magmatic rocks of tonalitic composition which often contain cordierite, are emplaced in the deepest part of the Sierra after this M1 event ; the bodies of this "San Carlos tonalite" present many migmatitic characters : numerous inclusions of the host rocks, progressives contacts with their surroundings. The metamorphic event M2 is linked with the emplacement of those migmatitic tonalites : the earlier M1 parageneses are reequilibrated into biotite2 + cordierite ± garnet + K feldspar + plagioclase + quartz + ilmenite. The conditions during this M2 event appears to be rather uniform : the estimated temperatures are of 650-700°C and the estimated pressures to 4,5 - 5 kb.

The D3 tectonic event forms north - south trending folds with a vertical axial plane marked by a fracture cleavage ; the emplacement of belts of pegmatites and of some granites appears to be controlled by these structures.

Ductile shearing and thrusting

Eastwards dipping, north - south trending mylonitic belts rework the earlier structures ; theses mylonites are often located in correspondance of the axial plane zones of the majors D2 folds ; their thickness ranges from a few 10 meters to more than a kilometer ; the streching lineations indicate a displacement towards north-west with a sinistral wrench fault component. These mylonites.have been initiated in a medium to high grade metamorphic surrounding (biotite + muscovite + sillimanite) which later evolved into greenschist facies. Mafic and ultramafic rocks often mark out theses mylonitic belts. In the eastern part of the Sierra, dykes of biotite-hornblende tonalites, dated at 570 My (K/Ar method) cut, and thus postdate, the mylonites.

These mylonitic belts carve the Sierra de Cordoba into several major blocks. Each block is thrusted westward over its neighbour and present a metamorphism wich increases towards the west. Thus, since blocks of higher metamorphic grade are trusted over blocks of lower grade, the metamorphic grade globally increases eastwards. The whole pattern shows how the Rio de la Plata craton was thrusted over its margin

The late panamerican and the youngest events

Several late phases of gentle folding, which locally interfere to form basin and dome structures, represent the latest manifestations of the panamerican orogeny.

In the Sierras de Cordoba, there is no obvious tectonic structure which may be related to the famatinian (=caledonian) orogeny. But, further west, in the Sierra de San Luis, this orogeny clearly affects the "filitas verde y esquistos" group. The Achala batholith, which is a very large (2500 km^2) composite intrusion of potassic peraluminous character, with an important crustal contribution, is dated of upper devonian to basal carboniferous (Rapella & al. 1991). It would thus represent the most intern magmatism of this orogeny.

The whole Sierras including the Achala batholith, are crosscut by large dextral wrench faults, which reactivate earlier structures. The small basins of Chancani and Tasa Cuna, of upper carboniferous to permian age, appear as pull-apart basins developed along these wrench faults.

The youngest structures are the andean inverse faults which induce the stricking horst and graben structure of the Sierras de Cordoba. Those andean faults frequently, but not always, rework the earlier accidents.

CONCLUSION

The Sierras de Cordoba show the evolution of the western margin of the Rio de la Plata craton, from the extensional stage (deposition of the San Carlos group) to the compressive stage during the panamerican (= pampean) orogeny. Later, this domain remained practically undeformed during the caledonian (=famatinianan) orogeny (as well as the subsequent variscan and andean orogenies) and was permanently located on the cratonic side. The main event of that caledonian orogeny is the emplacement of the Achala batholith in a very internal position.

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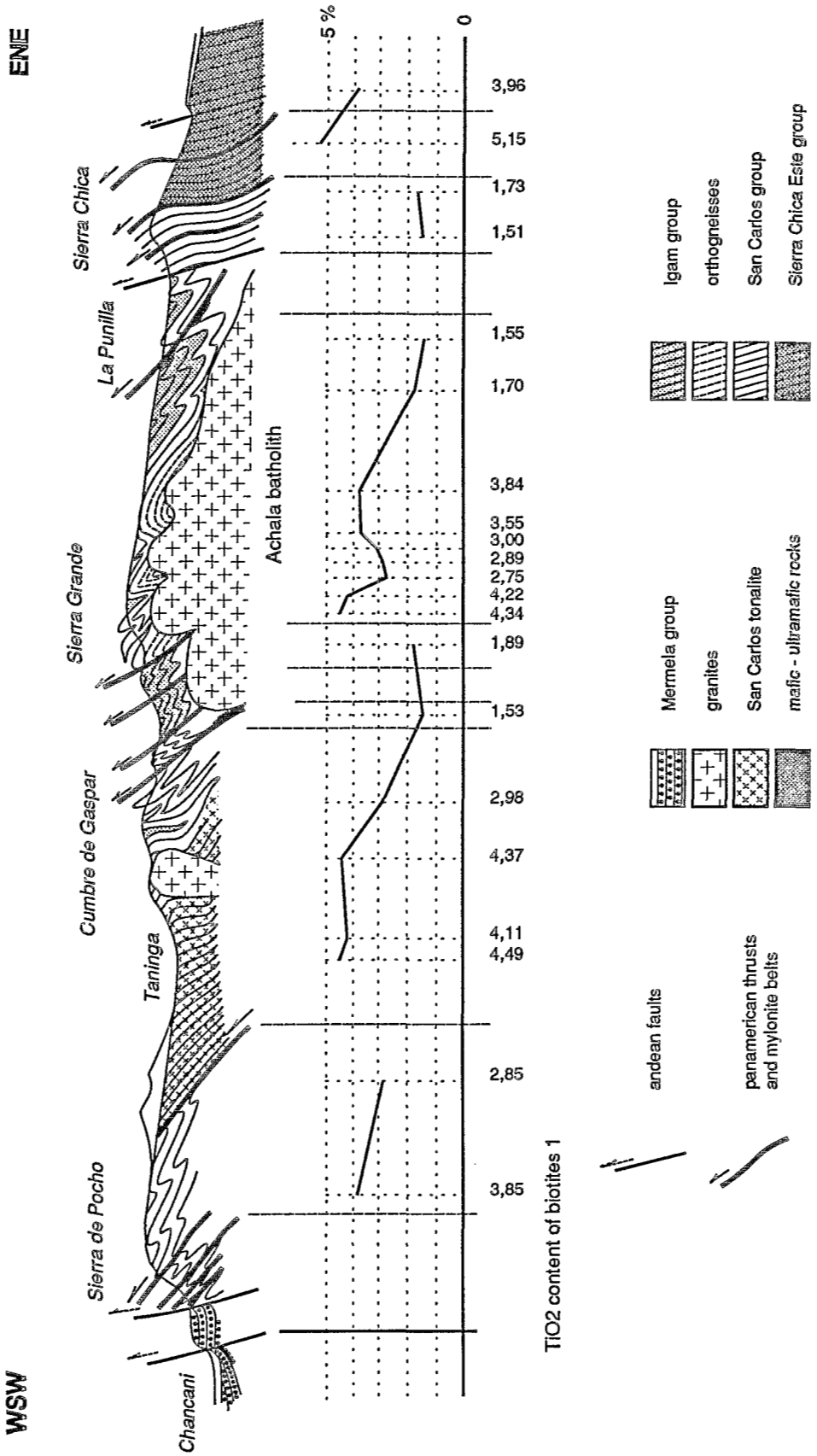
WSW
ENE
Chancani
Sierra de Pocho
Taninga
Cumbre de Gaspar
Sierra Grande
Achala batholith
La Punilla
Sierra Chica
-5 %
0
3,96
5,15
1,73
1,51
1,55
1,70
3,84
3,55
3,00
2,89
2,75
4,22
4,34
1,89
1,53
2,98
4,37
4,11
4,49
2,85
3,85
TiO2 content of biotites 1
andean faults
panamerican thrusts and mylonite belts
Mermela group
granites
San Carlos tonalite
mafic - ultramafic rocks
Igam group
orthogneisses
San Carlos group
Sierra Chica Este group