GEOLOGY AND METAMORPHIC EVOLUTION OF IGNEOUS ROCKS; COASTAL CORDILLERA OF N'CHILE BETWEEN 23°25' AND 24°20'S.

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Resumen

En la Cordillera litoral, S'Antofagasta, N'Chile ocuren rocas plutonicas que se presentan afectadas por un metamorfismo de la facies granulitica de alta temperatura y baja presion. Debido al la penetracion posterior de una fase fluida los gneises de piroxenos se presentan parcialmente anfibolitizados y migmatizados. Posteriormente se emplazaran cuerpos gabroicos y tonaliticos. Estos cuerpos todavia fueron afectados por dicho evento del metamorfismo de la facies anfibolitica. El termino del ciclo magmatico es documentado por el emplazamiento de dikes y de rocas volcanicas.

Palabras claves: Cordillera litoral N'Chile, Ortogneises, facies granulitica, metamorfismo controlado por las fluidas.

Introduction

The Coastal Cordillera north and south of Antofagasta, N'Chile is mainly build by volcanic rocks, intrusiva and sediments of the jurassic magmatic arc but also contains some rocks of paleozoic age. South of Antofagasta parts of the coastal cordillera are uplifted along the Atacama fault system with increasing rates to the western blocks (RÖSSLING, 1989). Our investigations concentrate on the deepest accessable part of the fossil arc. First results presented here should be considered as 'work in progress'.

Geological setting

From the southern tip of Peninsula Mejillones down to at least Caleta Cobre extends an area (120 x 10-20km) between the coastline and the western main fault of the Atacama system showing considerably amounts of pyroxene gneisses and amphibolites.

The felsic pyroxene gneisses with minor amphibolitized parts strike N-S along the coastline. To the east they become increasingly amphibolitized and amphibolites with minor pyroxene gneiss relics predominate. Foliation in the amphibolites is sometimes well-developed striking N-S, locally subordinate E-W directions, but always steeply dipping. N-S directions are probably related to the jurassic-recent Atacama fault system but there may be also older N-S directions at the continental margin. Amphibolites show locally frequent migmatitic textures that also affect to a minor extent the pyroxene gneisses. Deformed mafic dikes can be found in the amphibolites.

These rocks are intruded by prevailing small gabbro stocks also following the N-S trend. Diffuse migmatitic contacts to the host rock are common. The larger gabbros show magmatic layering. Fabrics are undoubtly magmatic.
Along the western side of the western main fault of the Atacama system a quartz diorite pluton cuts very sharply all migmatitic textures of the amphibolite. At its edges it is usually foliated but the core preserves its magmatic fabric.
All rocks except the gabbros are cut by steeply dipping, SE striking andesitic dikes. Ductile textures in the country rock are unconformable cut and do not continue into the dikes.
Quartz lenses and veins appear in all rocks at all stages of deformation except the formation of pyroxene gneisses.
Ouartz-feldspar, less carbonate, veines are sometimes frequent. They are not ductile deformed.
In the south andesitic and basaltic volcanic rocks of a terrestrial deposition environment partly cover this plutonic-metamorphic sequence in isolated patches. Contact relations between these series are not sufficiently known, but there may be despite the obvious tectonical contacts also unconformable erosion contacts.

Metamorphic evolution (T-t-path)

The metamorphic history is presented in a T-t-plot (Fig.1) because of the lack of pressure sensitive associatons in all rocks.

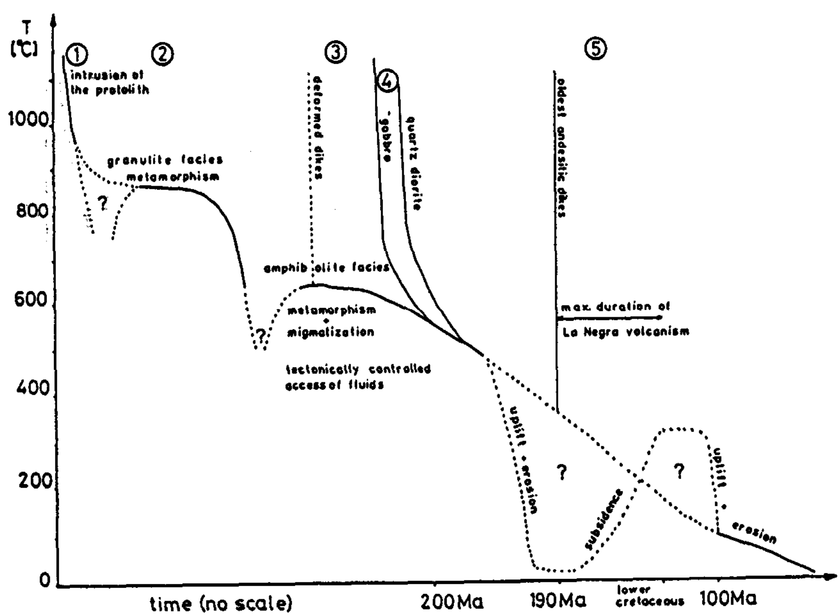

Fig.1 Metamorphic evolution: T-t-plot. Numbers refer to the text.The 200 Ma age is according to DAMM et al. (1986) for a gabbro, the maximum duration of the La Negra volcanism by biostratigraphic evidence, for references BUCHELT & TELLEZ (1988). 100 Ma refers to SCHEUBER & ANDRIESSEN (in press, fission track age of apatite is 118 ± 13Ma).

Maximum pressure for the granulite facies may be up to 10 kbar indicated by the stability of an-opx-cpx. The real pressure might be much lower. For the subsequent amphibolite facies the pressure was <5 kbar (amph-plag composition). Also garnet is lacking. Changes in metamorphic conditions are mainly recorded as changes in temperature, deformation and fluid access.

1. Intrusion of the protolith of the pyroxene gneisses. Numerous smaller intrusions of gabbroic magma of relativly homogeneous chemical composition build up the batholith. Layering is not found, differentiation products are very rare. Pyroxene gneisses and amphibolites show sometimes relics of a magmatic fabric and more frequent plagioclases with zoned an-rich (70<an<90) cores.

2. Formation of the pyroxene gneisses at granulite facies conditions. All stages of fabric developement from a magmatic to a fully recrystallised granoblastic one are observed. Foliations are quite rare. The prevailing mineral association is plag (an 50-60) - opx (enstatite) - cpx (diopside). Minor phases are biotite, magnetite, ilmenite, apatite, different amphiboles and occasionally other retrograde minerals like chlorite, quartz and epidote.

Temperatures (two pyroxene thermometry) range between 700 -900°C depending on the employed thermometer. For one thermometer no systematic thermal gradient can be derived for different samples. Some pyroxenes are slightly zoned with increasing alumina and calcium (only opx) to the core. Rims are very small and unzoned pyroxenes are found in the same samples. So the occurence of slightly lower temperatured rims may be ascribed to retrograde exchange.

3. Formation of the amphibolites by fluid controlled metamorphism of the pyroxene gneisses. The typical paragenesis is plag (an 30-40) - amph (one ore more generations) ± biotite, quartz, magnetite, ilmenite. Other minor minerals are predominantly retrograde formations like chlorite,

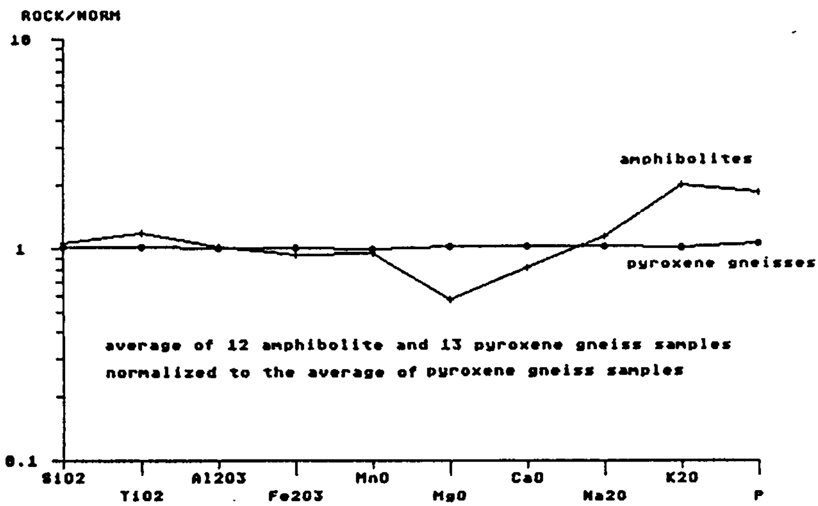

Fig.2 shows qualitatively the gain and loss of elements normalized to pyroxene gneisses by the formation of the amphibolites (primary inhomogeneity should be excluded by sampling).

epidote, sphene, sercite. Amphibolitization of pyroxene gneisses can be observed at different stages. The main reaction is plag + pyx + K-fluid = amph + Mg,Ca-fluid. Changes in the whole rock chemistry (fig.2) by this transformation show evidence for high amounts of fluid.

Temperatures from amph - plag compositions and magnetite - ilmenite pairs range between 500-600°C. Cores of magnetite - ilmenite and amphiboles show compositions equilibrated at lower temperatures before peak conditions. Some mafic dikes must have already intruded before or during amphibolite facies metamorphism because they are strongly ductile deformed.
4. Intrusion of the gabbros and the quartz diorite. Gabbros are chemically different from all other rocks tending to more basic compositions. Primary olivine and pyroxene are often completly changed into amphibole whereas the magmatic fabric and plagioclas composition (an>90) remains unchanged. Subsolidus amphibolitization occurs at different temperatures and covers a range from early corona textures (ca. 800°C from cpx and secondary opx) to late actinolitic amphiboles.
The quartz diorite pluton intruded after the peak of amphibolite facies metamorphism and is not affected by migmatization. At least at the edges of the pluton the rocks show features of subsolidus amphibolitization.
5. Intrusion of the andesitic dikes and deposition of the terrestrial volcanic rocks. Andesitic dikes cut all structures in the host rocks and are hardly affected by ductile deformation. Volcanic rocks (Form. La Negra?) are metamorphosed under maximal greenschist facies conditions (mineral paragenesis in amygdales and alteration products). It is not yet clear for this area wether this is caused by regional (burial) metamorphism or autometasomatism. The base of the volcanics is scarecley known (in other locations: jurassic sediments, BUCHELT & TELLEZ, 1988). The uplift and erosion of the basement before deposition of the volcanics and ensuing subsidence may be reasonable by geological constraints and different metamorphic grades but is not proven.

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References

BUCHELT, M. & TELLEZ, C. (1988): The Jurassic La Negra Formation in the area of Antofagasta, Northern Chile. In BAHLBURG, H., BREITKREUZ, Ch. & GIESE, P. (Eds.), Lecture Notes in Earth Sciences Vol. 17, Springer Verlag Berlin Heidelberg, 1988, 171-182.
DAMM, K.W., PICHOWIAK, S. & TODT, W. (1986): Geochemie, Petrologie und Geochronologie der Plutonite und des metamorphen Grundgebirges in Nordchile. Berliner geowiss. Abh., A66, 73-146.
RÖSSLING, R., (1989): Petrologie in einem tiefen Krustenstockwerk des jurassischen magmatischen Bogens in der nordchilenischen Küstenkordillere südlich von Antofagasta. Berliner geowiss. Abh., A112
SCHEUBER, E. & ANDRIESSEN, P.A.M. (in press): The kinematic and geodynamic significance of the Atacama fault zone, N'Chile. J. Struct. Geol.