

ARC RELATED IGNEOUS AND METAIGNEOUS ROCKS IN THE COASTAL CORDILLERA OF NORTHERN CHILE: CONTINUOUS REPLACEMENT OF THE CRUST?

F. LUCASSEN (1), G. FRANZ (2) & C.M.R. FOWLER (1)

(1) Geology Department, Royal Holloway, University of London, Egham Hill, Egham, Surrey TW20 0EX, U.K.

(2) TUB, Fachgebiet Petrologie, EB310, Strasse des 17.Juni 135, 1000 Berlin 12, Germany

RESUMEN

Durante la fase jurásica de actividad magmática, la corteza continental preandina de la Cordillera de la Costa del norte de Chile (región de Antofagasta) fue reemplazada por rocas intrusivas precoces y sus equivalentes metamórficos, por rocas intrusivas tardías y por rocas volcánicas. El lapso de tiempo de este episodio magmático parece estar restringido a 50 m.a. Terminó alrededor de 150 m.a. y empezó aproximadamente hace unos 200 m.a. Sin embargo, las edades del inicio del magmatismo y del subsecuente metamorfismo son imprecisas. Los detalles del marco tectónico y de la evolución de esta adición de magma a gran escala en la corteza no están aún claros.

Key Words: Arc magmatism, magmatic arc metamorphism, crustal growth by magmatism, tectonic setting of the magmatism

INTRODUCTION

Early intrusive rocks and their metamorphic equivalents, late intrusive rocks, and volcanic rocks replaced the Preandean continental crust during the Jurassic phase of magmatic activity in the Coastal Cordillera of northern Chile, Region Antofagasta. The time span of magmatism seems restricted to 50 Myr. It terminated around 150 Myr and started at +/- 200 Myr). The onset of magmatism and subsequent metamorphism is, however, less certain. The details of the tectonic setting and history of this large scale addition of magma to the crust are not yet clear.

GEOLOGICAL SETTING (Coastal area between 23²⁰ - 24²⁰S)

Metaplutonic rocks (metabasites) and plutonic rocks are exposed along the coastline south of Antofagasta and at the southern tip of the Mejillones peninsula. The metabasites constitute low pressure granulites (two pyroxene plagioclase gneisses), relicts of their magmatic protolith and foliated amphibolites derived from the pyroxene gneisses. Layered gabbros (numerous small intrusions) and a quartz diorite pluton (large homogeneous intrusion) intruded into the metamorphic unit. Mafic dyke swarms crosscut the foliation and other textures in the metabasites and the quartz diorite. They were not deformed under ductile conditions. To the south (24⁰) relicts of volcanic rocks ("Formacion La Negra") are widespread (continental deposits as lava flows). Contacts of the volcanic rocks with their basement are not well known, except in some places, where tectonic and intrusive contacts were observed. Preandean continental crust is not found between south Mejillones and Paposos. (for details: Lucassen & Franz, 1992 and references therein)

METAMORPHISM DURING MAGMATIC ACTIVITY

The recrystallization of the early magmatic rocks under granulite facies temperatures was enhanced by the intrusive magmatic activity. The magmas were essentially dry and the recrystallization occurred on the cooling path of the area. No relicts of a prograde temperature path were found for granulite and subsequent amphibolite facies rocks. Temperatures in the pyroxene gneisses (800°C, two pyroxene thermometry) and in the amphibolites (600-700°C, amphibole compositions) are not related to the geographical distribution of the samples (no regional temperature gradient). Quantitative pressure estimations for the formation of the metabasites are not possible because garnet is generally lacking. Considering Mg/(Fe+Mg) ratios between 50 and 60 for most samples our suggestion that pressure did not exceed some 5 kbar is "on the safe side". Pressures of ≤ 5 kbar were derived for minerals formed at greenschist facies temperatures by phengite composition and fluid inclusions.

GEOCHEMISTRY

The formation of the pyroxene gneisses from the igneous protolith was isochemical (no dehydration reactions involved), and the compositional changes by the amphibolitization are negligible (major and trace elements including REE, Sr and O isotopes for selected samples). The majority of metabasite samples are typical calcalkaline rocks with SiO₂ contents (48-54 wt%) in the range of the basalt - basaltic andesite transition. The quartz diorite is similar in composition to the rare SiO₂ rich metabasites. The dykes also follow a calcalkaline trend in their element abundances with minor differences compared to the metabasites. The late gabbros show a tholeiitic composition at SiO₂ around 45 wt%. The volcanics are also chemically different from all other (meta)igneous rocks. They are rich in Na, Fe, and HFSE, and low in Al and Ca at a restricted SiO₂ range (mostly between 52 and 55 wt%) compared to the calcalkaline rocks. Even considering a possible influence of alteration on the

mobile elements in the volcanic rocks, they are not related to any other rock unit of the area.

In all rock types including volcanics and gabbros Sr isotope ratios are low (< 0.7040) and REE distribution patterns are flat (La/Yb typically between 2-3 for most samples). We suggest magmas from the upper mantle as the major component in all rocks.

REGIONAL IMPORTANCE OF THE RESULTS

The composition of the crust from a deep section of the arc as outlined above might be representative for the upper 20 km of the present crustal profile in the Coast Range. Geophysical data of the gravity field and the seismic velocities from a north-south profile (20-26°S) in the Coast Range prove the existence of abundant high density mafic rocks (2850-3000 kg m⁻³) in the upper 5 - 22 km of the crust (Strunk, 1990 and references therein). In E-W direction the high density rocks are restricted to the Coast Range, but they extend over at least 600 km in N-S direction. No major parts of typical continental crust are obvious either in the gravity field or in the distribution of seismic velocities.

A comparison of geochemical data of igneous rocks from the Coastal Cordillera shows striking similarities between data from the literature and our data. The volcanic rocks are not related to any other rock unit on the regional scale.

PROBLEMS

Replacement of the continental crust by prevailing basic intrusions and their metamorphic equivalents at midcrustal levels requires a considerable stretching and thinning of the crust. The intrusion mechanism must have prevented contamination of the basic magmas by a crustal component, and therefore magmatic underplating is preferred. The regional distribution of high density rocks in the upper crust from geophysical data suggest extension normal to the continental margin plate boundary. Typical tectonic settings for large scale plutonism and volcanism are those of continental extension and rifting. Locations with extension normal to the plate boundary at active continental margins are back arc basins (e.g. Aguirre et al., 1989 for the Cretaceous volcanism in the Andes) or the magmatic arc itself (Scheuber & Reutter, 1992 for the Jurassic arc of N'Chile). A back arc setting for the Jurassic rocks seems less likely, because there are only minor intercalations of sediments in the volcanic rocks and the volcanic rocks are largely deposited above sea level. Furthermore, we would have to explain where the arc and fore arc region are today. The essential problem is the same for both settings: There is no indication for a widespread distribution or at least important remnants of continental crust in the Coast Range. The complete removal of continental crust by extension of the lithosphere and their replacement by igneous rocks would lead to the special case of continental rifting and spreading caused by extreme thinning of the lithosphere (and crust) in the framework of models considering continuous extension as the only or major tectonic process. Geological settings or chemical compositions of the igneous rocks typical for rift or spreading situations were not found in the area. Recrystallization of the early intrusions, their spatial relationship to the volcanic rocks and the chemical differences between volcanic rocks and the metabasites exclude a contemporaneous

development of the rocks at the same geographical position (thrust tectonics can be excluded). Therefore uplift and erosion of the Coastal Cordillera is required before deposition of the volcanics and before the emplacement of at least some of the late intrusive rocks. The cause and exact timing of this hypothetical event and its relation to the subduction process is yet unclear.

We are working on thermal models of the arc crust with the given data and attempting to obtain age relations of the early history of the Jurassic arc by additional radiometric dating with the aim of testing various hypotheses of the magmatic and tectonic history of the arc crust.

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