Geochemical evolution of Triassic and Jurassic volcanic successions in Northern Chile between 20° and 26°30' latitude south

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INTRODUCTION

Triassic volcaniclastic and intermediate to acid volcanic remainders can be found in some small graben-like structures whereas preserved volcanic successions of a Jurassic magmatic arc/back arc system are widespread in Northern Chile between around 20° and 26°30' latitude south within the Coastal Range and subordinate in the Precordillera.
Interbedded lava flows, pyroclastica, and other sediments with fossil content on places allow biostratigraphic age-correlations as shown in Table 1. New findings and analytical results characterize the Mesozoic volcanic successions of Northern Chile as rather variable in space and time.

OCCURRENCES AND SOME GEOLOGICAL-VOLCANOLOGICAL FEATURES

The pyroclastica-lava series of Upper Triassic graben-like structures from the Coastal Range are calc-alkaline and of intermediate to acid character, different from the Triassic Paramillos volcanic complex of the Cuyo basin, West-Argentina. This is made up by alkaline basalts (cf. Ramos & Kay 1991).
Predominant pyroclastic rocks and lavas, which are concentrated around eruptive centers, appear in the Lower Jurassic (Sinemurian) *Posada de los Hidalgos-Formation* south of Taltal. They are calc-alkaline intermediate rocks.
The volcanic successions, chiefly formed in the Middle Jurassic, are predominant mafic and may reach great thicknesses, e.g. up to more than 5 km near Antofagasta (cf. Palacios 1978). They are built up by lava flows and may be intruded by porphyritic and doleritic sills and dykes. Partly they were extruded submarine, forming pillow lavas, e.g. in the *Caleta Ligate-* and *El Godo-Formations*, and comprise trachydacitic to rhyolitic lavas or ignimbrites. Often the successions form laterally extensive lava flows, in part composed by finger-like flows as within the *La Negra-Formation* near Antofagasta and Taltal.
More than 300 m thick basaltic andesitic series occur in the Quebrada Tranquita area, Precordillera. They correspond to the basaltic andesitic to trachyandesitic La Negra volcanics of the Coastal Range between Taltal and Antofagasta by their chemical character. They have no analogy immediately westward in the Coastal Cordillera.
Around 22° longitude south volcanics of the La Negra-Formation appear in the Coastal range near Tocopilla (cf. Palacios 1978), but alkaline olivine basalts have been recognized as intercallation into sediments of the Cerro Jaspe, Precordillera.
The youngest volcanic succession investigated, according to Thomas (1970) is of Lower Cretaceous age. It is part of the *Puntas Barancos-Formation* and comprises trachydacitic to rhyolitic lavas as well as pyroclastic- and tuff-breccias.

Table 1: Preliminary results on the occurrence of Triassic to Upper Jurassic/Lower Cretaceous volcanic successions from volcano-sedimentary formations of the Northern Chilean Coastal Range and Precordillera, simplified. Age correlation on biostratigraphic base according to Kossler (1996), Prinz et al. (1994) and Thomas (1970). Abreviations: c-alk: calk-alkaline, alk: alkaline, LREE: light rare earth elements

<table>
<tr><td colspan="2"></td><td colspan="3">Coastal Range</td><td colspan="2">Precordillera</td></tr>
<tr><td colspan="2"></td><td>Taltal - Chanaral</td><td>Antofagasta - Tocopilla</td><td>Iquique</td><td>Quebrada Tranquita Sierra Candeleros</td><td>Cerro Jaspe</td></tr>
<tr><td>Lower Cretaceous</td><td></td><td></td><td></td><td>Punta Barrancos-Form.
Trachydacite, Rhyolite,
weak alk, high Th, La/Yb and LREE</td><td></td><td></td></tr>
<tr><td>Upper Jurassic</td><td>Lower Oxfordian</td><td></td><td></td><td>? ? ?</td><td></td><td></td></tr>
<tr><td rowspan="3">Middle Jurassic</td><td>Callovian Bathonian</td><td colspan="2" rowspan="2">? ? ?
La Negra-Formation
Basaltic Andesite, Andesite, Trachy-basalt (Rhyodacite),
predominant c-alk, weak alk, medium LREE
? ? ?</td><td>El Godo-Formation
Basalt, Basaltic Andesite
c-alk to weak alk, medium LREE,</td><td>Basaltic Andesite, Basalt, Trachyandesite, medium LREE, low & medium Ti</td><td></td></tr>
<tr><td>Bajocian</td><td>Caleta Ligate-Form.
see El Godo-Formation +
(Trachydacite, Rhyolite)
Oficina Viz-Formation
Basalt, Bas. Andesite,
c-alk, low LREE
? ? ?</td><td></td><td>Alkaline Basalt,
negative Nb-Ti-anomalies missing</td></tr>
<tr><td>Lower Jurassic</td><td>Sinemurian</td><td>Posada de los Hidalgos-Formation
Trachyandesite, alk, c-alk, low LREE</td><td>Quillagua: Andesite, Trachy-andesite, c-alk, alk, high LREE</td><td></td><td></td></tr>
<tr><td>Triassic</td><td></td><td>Cifuncho-Form.
Trachydacite, Dacite, Rhyolite,
c-alk, low REE</td><td>Cerro de Cuevitas:
Rhyolite</td><td></td><td></td><td></td></tr>
</table>

TRACE ELEMENT TRENDS

Figure 1 gives a first glance over the hygromagmatophile (incompatible) element abundances. It shows different LILE(large ion lithophile elements)/HREE(heavy rare earth elements) ratios with the highest concentrations of LILE in the Cretaceous dacites and lowest HREE in the Triassic volcanics.
All the investigated Triassic to Lower Cretaceous volcanic rocks which occur along the Costal Range and in the Precordillera around 27° latitude south display negative Nb-P-Ti anomalies and are primarily calc-alkaline which is characteristic for collisional or subductional areas.
Recorded by the contents of SiO_2, MgO, Cr and other trace elements, the Jurassic volcanics are predominantly mantle-derived mafic rocks (cf. also Lucassen & Franz 1994), and they are crustal-influenced as indicated by variable Th/Nb and La/Sm ratios. A negative Eu-anomaly becomes more significant in the course of the Bajocian to the Lower Callovian time resulting from increasing fractionation of plagioclase. Indicated by Th/Nb and La/Sm ratios, there is an increasing crustal contamination within mafic and intermediate volcanics with time.
The hygromagmatophile element abundances of the alkaline Cerro Jaspe basalt show convex-up pattern which are typical of asthenospheric mantel provenance.

CONCLUSIONS

As shown by the interdigitation of biostratigrafically dated sediments, volcaniclastics and lava flows, on principle, the volcanic activities are lasting and quite intensive during Jurassic times in Northern Chile, beginning in the Sinemurian (e.g., Posada de los Hidalgos-Formation) and extending up into the Callovian (El Godo-Formation). A coastal profile south of Iquique verifies volcanic eruptions throughout the Bajocian, Bathonian and Callovian. The distribution of the calc-alkaline basaltic andesites and trachyandesites south of Taltal and in the Quebrada Tranquita area, Precordillera, hint at a possible eastwards-dislocation of the volcanic arc around 27° latitude south.
The Jurassic, especially Middle Jurassic, magmatism procured a huge input of melts from the mantle wedge into the arc crust. It may have triggered acid crustal melting (ignimbrites). The Jurassic volcanism is clearly bimodal by those intercalated acid lavas and ignimbrites. Triassic and part of Lower Jurassic precursors of intermediate to acid character have predominant crustal sources. Until now we know one Jurassic alkaline basalt complex (Cerro Jaspe) with an asthenospheric source within the study area. These may be due to a slab 'window', caused by either rift subduction or a flattening slab.
The chemical changes (increasing crustal influence) up to the Upper Jurassic/Lower Cretaceous reflect a development towards the maturation stage of the Mesozoic volcanic arc.

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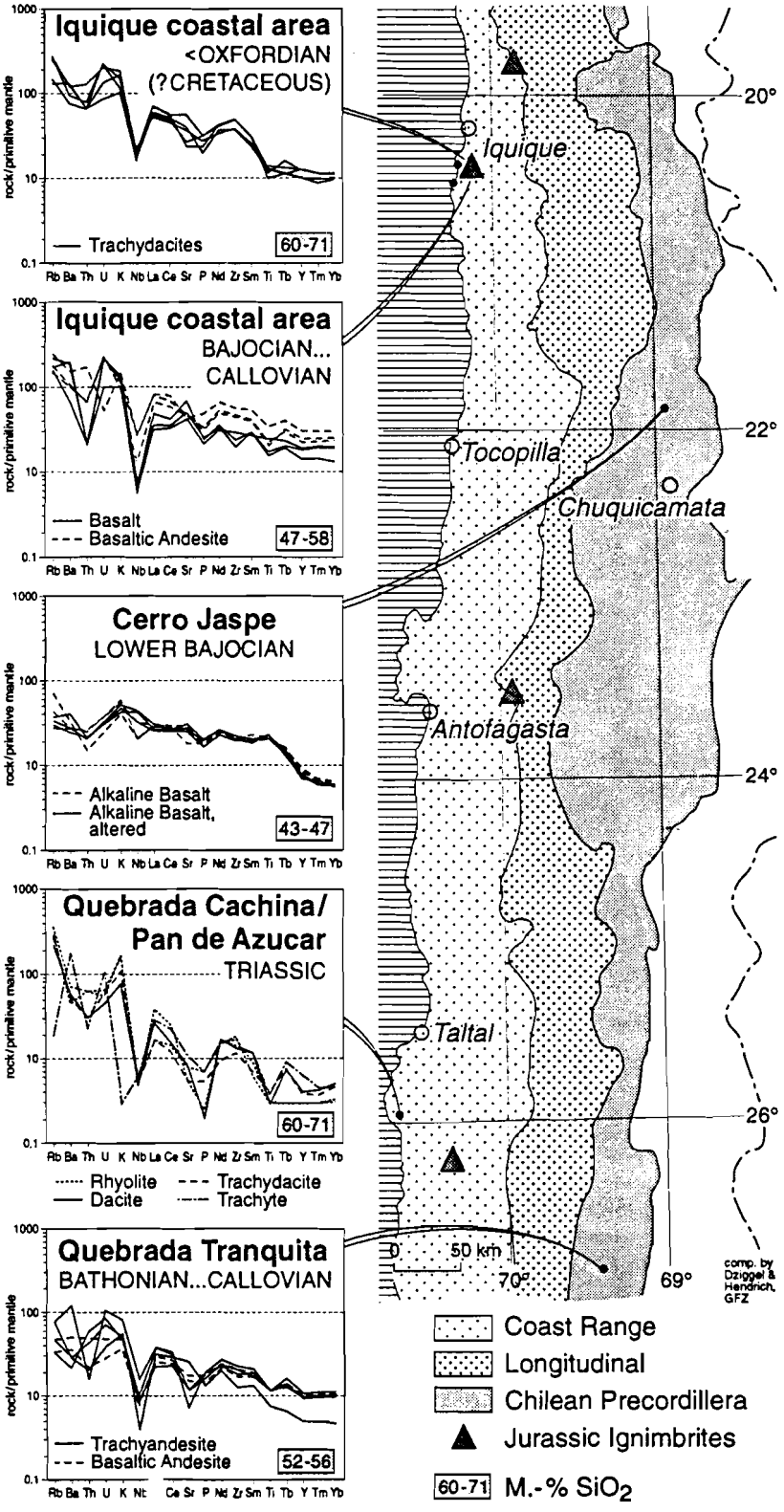

Figure 1. Sketch map of the study area in North Chile and hygromagmatophile element abundances normalized to primitive mantle according to Hofmann (1980). The selected examples may nearly represent the variability of the abundances in mafic to intermediate Mesozoic volcanites.