SKARN FORMATION BENEATH LASCAR VOLCANO, N CHILE: EVIDENCE FOR THE WESTERN CONTINUATION OF THE YACORAITE FORMATION (LATE CRETACEOUS) OF NW ARGENTINA

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INTRODUCTION

We report the occurrence of skarn xenoliths in the eruption products of Lascar volcano, N Chile. These rocks are samples of a chemically zoned metamorphic-metasomatic skarn body developed around the subvolcanic magma chamber. This skarn system is still actively developing at present. Using a variety of geochemical techniques we have identified the host rock as impure limestones and carbonate-cemented sandstones belonging to the Late Cretaceous Yacoraite formation, which outcrops extensively in NW Argentina, thus proving that this unit extends a considerable distance westwards beneath the young volcanic zone in this area.

YACORAITE FORMATION

In the Early Cretaceous several rift troughs opened in northwest Argentina and surroundings, thus starting the accumulation of the Salta Group basin and equivalents. During Mid-Eocene times the Inca diastrophism inverted the basin and interrupted sedimentation (Marquillas and Salfity, 1988; Salfity and Marquillas 1994). The Yacoraite Formation (Maastrichtian-Eopaleocene) is an extensive, partly dolomitic limestone of the postrift accumulations of the Salta Group. This unit has developed not only over the former synrift troughs but also over the San Pablo high and other structural highs (Figure 1). In the Argentinian Puna the limestone lies on Ordovician basement at the northern El Toro Lineament, and on Precambrian basement in the south. In the Puna the outcrops are scarcer and more isolated than in other areas. The development of these accumulations also affected the territories of Bolivia and very probably the north of Chile. The Yacoraite Limestone was deposited by epeiric flooding, in a frame of tectonic quiescence; deposition occurred under shallow water conditions, with frequent subaerial exposure. These transgressive deposits are mainly ooid grainstone, packstone, stromatolites, sandstone, and in the relatively deep facies, shales and the calcareous mudstones. A maximum thickness of 200 m has been recorded.

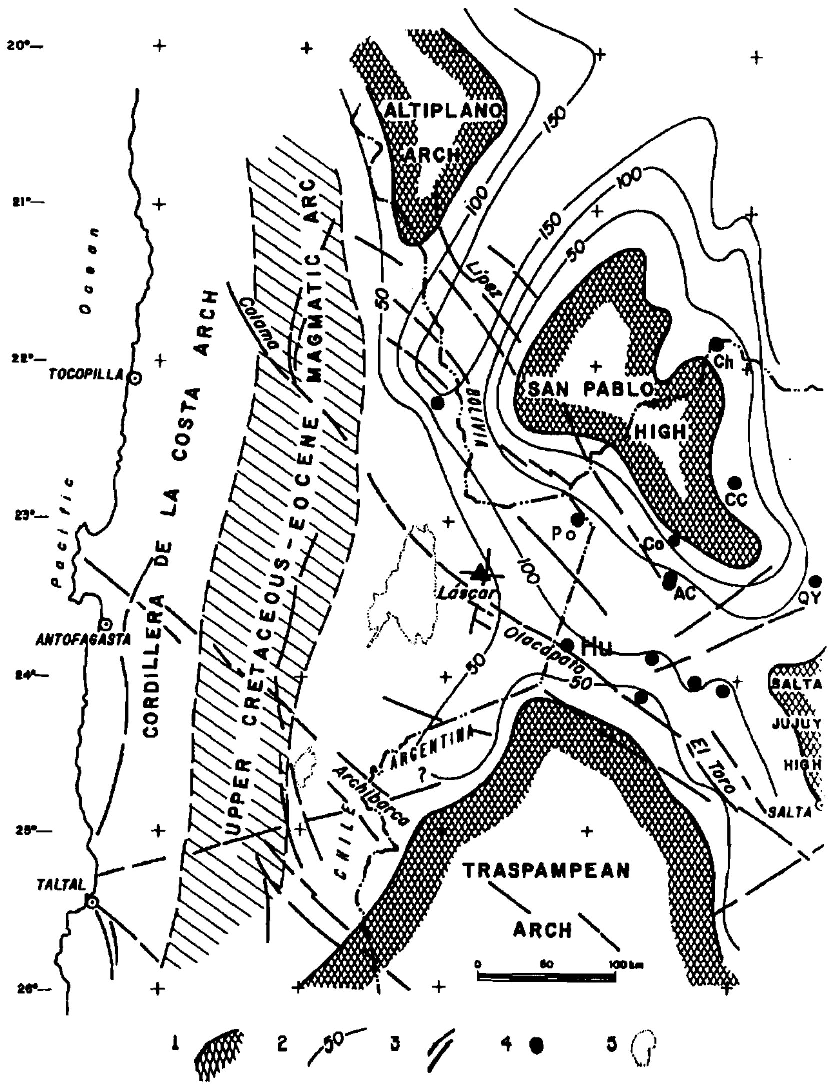

Figure 1. Isopach map of the Yacoraite formation, showing the position of Lascar volcano. 1: Basement high. 2: Isopach in metres. 3: Fault or lineament. 4: Isopach control point. 5: Salar. Hu = Huaytiquina, Po = Poquis, Ch = Chaupiorco, CC = Casa Colorada, Co = Coranzuli, QY = Quebrada Yacoraite, AC = Abra Calvario.

LASCAR VOLCANO

Lascar is a composite calc-alkaline stratovolcano located on the volcanic front in NE Chile (5,592m, 23°22'S, 67°44'W). Its eruption products are medium- to high-K andesitic to dacitic rocks in the form of lavas and pyroclastic flows (Matthews *et al.*, 1994a). The magmas are the product of combined magma mixing, fractional crystallization and assimilation of country rocks. The dominant magmas are 2-pyroxene andesites although 2-pyroxene dacites and hornblende- and biotite - rich dacites are also important. Lascar magmas are highly oxidized, containing anhydrite phenocrysts, and this has been attributed to fO_2 buffering by a coexisting SO_2 - H_2S rich gas phase (Matthews *et al.*, 1994b).

SKARN XENOLITHS

Skarn xenoliths are common throughout the stratigraphy of the volcano (Matthews *et al.*, 1994a; 1996). They have a variety of mineralogies, ranging from contact-metamorphic wollastonite-rich rocks to pyroxene-garnet and magnetite-pyroxene-rich samples which are interpreted as the product of Fe-Mn-Mg-Ti-Al metasomatism. These xenoliths originated in a zoned skarn system around the subvolcanic magma chamber of the volcano. Retrograde alteration by magma-derived acid sulphate fluids produced secondary carbonate veins and sulphate alteration.

RELATIONSHIPS WITH THE YACORAITE FORMATION

Skarn xenoliths from Lascar are interpreted as fragments of a zoned skarn body around the subvolcanic magma chamber. The protolith has been identified as the Yacoraite formation on the basis of whole-rock major element and REE compositions. Following normalization of the whole rock major elements in both the xenoliths and samples of Yacoraite rocks by removal of the CO_2 from the analyses (e.g. CaOn = CaO X TOTAL / (TOTAL - CO_2), the wollastonite skarns fall in the range of Yacoraite compositions. Other skarn types can be related to the Wollastonite skarns by metasomatic addition of Fe, Mn, Mg, Ti and Al. Examples are shown in Figure 2.

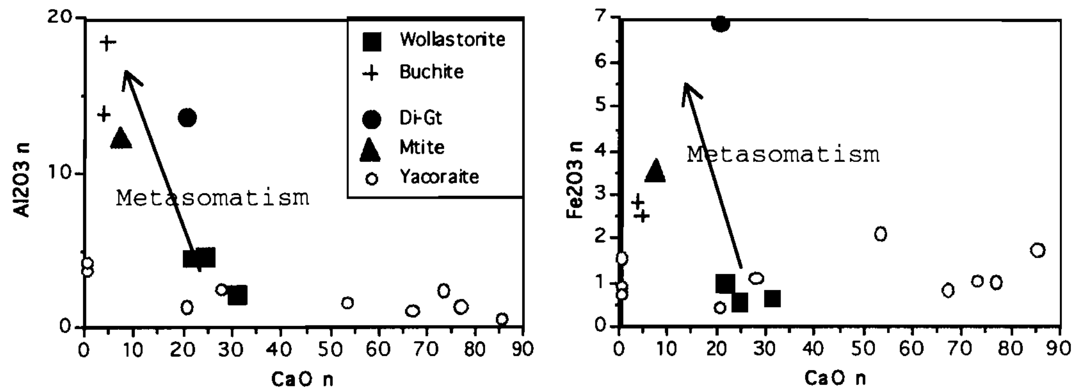

Figure 2. Plot of normalized whole-rock Al_2O_3 and Fe_2O_3 showing the relationship between various types of Lascar skarn xenoliths and rocks of the Yacoraite formation. The wollastonite skarns are the product of thermal metamorphism.

Chondrite-normalized REE spiderplots of Yacoraite samples are similar to those of the skarn xenoliths (light REE enrichment, positive and negative Eu anomalies). The slopes of the plots for both Yacoraite samples and the skarn xenoliths fall in the same range. The wollastonite skarns have a negative Ce anomaly of variable size which can be traced to late-stage retrograde calcite veins. REE and stable isotopic data (^{13}C and ^{18}O) indicate that this calcite was dissolved from Yacoraite country rocks and redeposited in the skarn by magma-derived acid fluids (Matthews *et al.*, 1996).

CONCLUSIONS

Lascar volcano is underlain by a zoned skarn body developed within impure limestones which have been identified on geochemical grounds as belonging to the Yacoraite formation. The limestone protolith was geochemically similar to outcropping Yacoraite rocks along the Chile-Argentina border, indicating that similar facies are likely to underlie Lascar. This confirms previous interpretations that this unit extends a considerable distance westward beneath the Puna of NE Chile. It is likely that the subvolcanic intrusions beneath the volcanic zone in this area have developed an extensive field of skarn orebodies and that the volcanoes represent the surface expression of such an orefield.

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