OBDUCTION EVIDENCE ON THE BOLIVAR ULTRAMAFIC COMPLEX, SOUTH-WESTERN COLOMBIA

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RESUMEN: Asociado a un complejo de rocas ultramáficas y máficas, deformadas, anfibolitizadas y localmente migmatizadas ocurren tanto diques pegmatíticos que cortan a través de éste, como un depósito de magnesita criptocristalina. Estos rasgos se interpretan como producto del transporte de fluidos derivados de la base de un bloque de litósfera oceánica durante su obducción sobre la margen continental de Sur América.

KEY WORDS: ultramafic rocks, pegmatitic dykes, magnesite, obduction, plateau basalt province.

INTRODUCTION

Geological and geophysical studies show that the Northern Andes are made of two lithospheric Cretaceous provinces of different affinities: continental to the east and oceanic (the Oceanic Western Lithospheric Province - OWLP) to the west. The boundary is marked by the Cauca-Almaguer Fault (also called Romeral Fault and Dolores-Guayaquil Megashear) that parallels the western flank of the Central Cordillera from the Gulf of Guayaquil, through Ecuador and Colombia, to the Caribbean sea. To the east of the fault, calculated values of both gravimetric anomalies and seismic velocities (Case *et al.* 1971, 1973; Meyer *et al.* 1977; Ocola *et al.* 1977) suggest a crust composed of sialic materials (M=40-50 Km; Case *et al.* 1984). To the west the Andes are made of high density, high velocity materials, commonly interpreted as oceanic crust (M=25-30 Km; Case *et al.* 1984). The Pre-Cenozoic rocks of the eastern province consist on Precambrian and Paleozoic igneous and metamorphic rocks intruded by Mesozoic granitoid plutons, whereas the OWLP is made of Mesozoic (not older than Lower Cretaceous) basic volcanic rocks, associated with ultramafic complexes and marine sedimentary strata. Interpretations of the evolution of the lithosphere in Colombia (Barrero 1979; Bourgois *et al.* 1982; McCourt *et al.* 1984; Aspden & McCourt 1986) consider that the OWLP was accreted to the northern margin of the South American continent during the Late Cretaceous.

Associated with the OWLP, within a belt situated some 20-30 Km to the west of the Cauca-Almaguer Fault, are found several bodies of ultramafic rocks, the best known of which is the Upper Cretaceous Bolivar Ultramafic Complex (BUC). This complex is a) the host rock of a stockwork deposit of cryptocrystalline magnesite, b) cut by a suite of mafic pegmatitic dykes and c) exhibits local zones of strong pervasive deformation and amphibolitization. It is proposed that these three features are related with the suture event of the two provinces during which the the leading edge of the OWLP was obducted on top of the Cretaceous continental margin of South America.

GEOLOGICAL SETTING

The Upper Cretaceous BUC outcrops on the eastern flank of the Western Cordillera of the Andes in southwestern Colombia. To the east and north it is covered by the recent deposits of the Cauca River. To te west the Roldanillo fault marks its contact with the Volcanic Formation a thick sequence of Cretaceous tholeiitic basalts and dolerites. Based on similarities in the geochemical characteristics between fine grained isotropic gabbros from the BUC and tholeiites from the Volcanic Formation the two units have been interpreted as comagmatic (Nivia 1987), the former representing the products accumulated on the magmatic chambers where the latter evolved. The chemistry of tholeiites from the Volcanic Formation include low LIL-element abundances (Zr/Nb =8 to 17) and flat to enriched REE patterns (Ce_N/Yb_N = 0.9 to 3.5) that allow positive comparisons with thick oceanic crust typical of Iceland or with plateau basalt provinces such as those of the Nauru Basin or the Caribbean (Millward *et al.* 1984; Nivia 1987). These suspected materials of the WOLP might represent fragments of the Caribbean Plate stripped off during its emplacement between North and South America.

Three different horizons are present in the BUC: a lower one of intercalated bands of serpentinized dunites, lherzolites, olivine websterites and olivine gabbronorites; and intermediate horizon of banded (cumulus) gabbronorites and an upper one of isotropic gabbronorites. Replacement of pre-existing pyroxenes by uralite, cummingtonite and hornblende is conspicuous on the gabbro layers. On outcrop, these same horizons show strong pervasive foliation parallel to the cumulus banding and local development of migmatitic textures with clear intrusive relationships between coarse grained leucogabbros cutting through fine grained, often cumulitic, melagabros.

The BUC is cut by a suite of dykes, 50 cm thick on the average, that consist mainly on very coarse grained hornblende, plagioclase and quartz crystals. The composition of the dykes seems to vary according to their level of intrusion. The lower parts of the complex are cut by plagioclase-hornblende dykes whereas in the upper parts the dykes are rich in plagioclase, quartz, muscovite and sericite. The presence of dumortierite associated with the latter phases is also reported.

Serpentinites of the lower horizon form the host rock of a stockwork deposit of cryptocrystalline magnesite veins that are 5 cm thick on the average. Opal veins deposited after the magnesite ones occur in the upper levels of the deposit.

The facts previously presented can be interpreted in terms of an obduction event during which the leading edge of the Caribbean plateau was overthrust on the continental margin of northern South America. The lack of the tectonic harzburguite on the BUC and on other ultramafic complexes placed in similar structural situation might indicate that the decoupling of this piece of oceanic lithosphere was produced at the level of the petrological Moho. During this processes the geotherm of the lithosphere that carried the obduction shifted to a region of higher temperature distilling the H_2O, CO_2 and boron contained in the terrigenous and calcareous sediments found in the continental lithosphere's upper part. The transportation of these fluids through the overthrusted block might then have cause both local fusion (by lowering of the solidus) leading to the formation of migmatites and amphibolitization of gabbros. Also, the products of the reaction between these fluids and the liquids produced by local fusion might have crystallized at fractures leading to the formation of the pegmatite dykes that cut the BUC. On the other hand, the mechanism of forming the magnesite deposits associated with ultrmafic rocks is commonly believed to involve altering serpentine by CO_2-rich waters, produced by steam distillation at depth. This mechanism agreed with the obduction model proposed and allowed to postulate a genetical model for the formation of the Bolivar magnesite deposit. In addition, the world's most important deposits of this type, located on a discontinuos belt through former Yugoslavia, Albania and Greece (particularly those of the Chalkidiki Peninsula in Greece; Dabitzias 1980) have similar characteristics to those of the Bolivar deposit. These characteristics suggest that these deposits formed as the result of obduction processes during the closure of Neo-Tethys.

CONCLUSIONS

The BUC was probably formed by crystallization in the magmatic chamber where the Volcanic Formation tholeiites (documented as formed on a oceanic plateau basalt province) evolved. During the collision of this plateau against the proto-South American continent its leading edge was obducted on top of the continental margin. During this process, connate waters contained on terrigenous and calcareous sediments that laid on top of the continetal platform were expelled as well as B and CO_2. The introduction of H_2O to the base of the obducted lithosphere (probably hot) and the heat generated by friction during thrusting of the oceanic plateau helped in the production of fluids that filled the open cracks where crystalized as pegmatitic dykes. The action of hydrothermal CO_2-rich waters on serpentinites formed by alteration of basal dunites of the CUB, produced Mg-enriched solutions that precipitated as veins close to the surface when the total pressure change from lithospheric to hydrospheric or whenever the craks caused by tectonism produced pressure drops.

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