

Ba-Sequestering Phases in the Subduction Environment (Eastern Cuba Mélanges): Implications for Arc Magmas

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INTRODUCTION.

In eastern Cuba two serpentinite mélanges (La Corea and Sierra del Convento) bearing high-pressure blocks have been interpreted as fossil subduction channels formed after onset of subduction of the Proto-Caribbean (i.e. Atlantic) lithosphere in Aptian times below the Caribbean plate (García-Casco et al. 2006, 2008a; Blanco-Quintero et al., 2010). High-pressure blocks found in these subduction mélanges are mainly composed of amphibolite with N-MORB affinity (Lázaro and García-Casco 2008). An exceptional characteristic is the presence of tonalitic-trondhjemitic bodies, dikes and veins formed after fluid-induced partial melting of MORB derived amphibolites at peak conditions of 700-750 °C and 15 kbar under a hot geothermal scenario. Elemental and isotopic geochemical characteristics of amphibolites and tonalitic-trondhjemitic rocks led Lázaro and García-Casco (2008) to infer a depleted fluid likely evolved from dehydrating serpentinites.

However some varieties of MORB-derived amphibolite, associated tonalite-trondhjemitic, and vein rocks from these mélanges are rich in Ba and other LILE, suggesting the presence of additional fluids derived from sediment of oceanic lithosphere. In this contribution we study the mineral and bulk-rock geochemistry of these rocks, and give clues to understand the behaviour of fluids and melts evolved in the subduction environment, with emphasis in the mobility of barium and other LILE.

ANALYTICAL TECHNIQUES.

Whole-rock major element and Zr compositions were determined with a PHILIPS Magix Pro (PW-2440) X-ray fluorescence equipment (University of Granada) using a glass beads, made of 0.6g of powdered sample diluted in 6g

of $\text{Li}_2\text{B}_4\text{O}_7$. Trace elements, except Zr, were determined by ICP-MS (University of Granada) after $\text{HNO}_3 + \text{HF}$ digestion of 0.1000 g of sample powder in a Teflon-lined vessel at $\sim 180^\circ\text{C}$ and ~ 200 p.s.i. for 30 min, evaporation to dryness, and subsequent dissolution in 100 ml of 4 vol.% HNO_3 . Trace element LA-ICP-MS measurements of minerals were performed at the C.I.C. of Granada University using a 213 nm Mercantek Nd-YAG laser coupled to an Agilent 7500 ICP-MS with a shielded plasma torch. Mineral compositions were obtained using WDS with a CAMECA SX-100 microprobe (University of Granada) operated at 15 kV and 15 nA. Elemental X-ray images were obtained with the same machine operated at 20 kV, 150 nA beam current, step (pixel) size of 7 μm and counting time of 30 ms.

RESULTS AND DISCUSSION.

The main mineral assemblage of the amphibolite sample consists of pargasite, epidote, garnet and minor Ba-rich phengite ($\text{Ba}_{\text{Max.}} = 0.57$ apfu, $\text{Si}_{\text{Max.}} = 6.86$ apfu and $\text{Mg}_{\text{Max.}} = 0.68$). Trondhjemitic is a non-deformed leucocratic rock consisting of medium-grained magmatic plagioclase and quartz and subordinate Ba-rich phengite ($\text{Ba}_{\text{Max.}} = 0.22$ apfu, $\text{Si}_{\text{Max.}} = 6.12$ apfu and $\text{Mg}_{\text{Max.}} = 0.19$ apfu); orthoclase, celsian and cymrite are also present. Pegmatite samples are formed by quartz, albitic plagioclase, and Ba-rich phengite with magmatic textures ($\text{Ba}_{\text{Max.}} = 0.38$ apfu, $\text{Si}_{\text{Max.}} = 6.05$ apfu and $\text{Mg}_{\text{Max.}} = 0.37$). Quartz-muscovite samples contain Ba-rich phengite ($\text{Ba}_{\text{Max.}} = 0.50$ apfu, $\text{Si}_{\text{Max.}} = 6.27$ apfu and $\text{Mg}_{\text{Max.}} = 0.39$). All phengite grains are larger than 3 mm in length and display concentric to patchy zoning, with the core more enrichments in Ba than rim (Fig. 1).

Major and immobile trace elements composition of the amphibolite sample

indicate a basaltic MOR affinity (Fig. 2a), even if LILE abundances indicate enrichments relative to N-MORB. These enrichments are interpreted as the consequence of interaction with Ba-rich fluids. The trondhjemitic sample is inferred to have formed after wet partial melting of MORB-derived amphibolite fluxed by LILE-rich fluids derived from subducting sediments. Enrichment in LILE and depletion in most of the HFSE (Fig. 2b) strengthen this view. The coarse-grained crystals (>4 mm) of pegmatites indicate crystallization from a H_2O saturated melt. The close spatial relationships between these rocks and K- Ba-rich trondhjemitic suggest formation of the former as a result of the magmatic differentiation of the later. The Ms+Qtz rocks may represent a direct evidence for the circulation of high temperature sediment-derived primary fluids rich in K and Ba in the subduction environment.

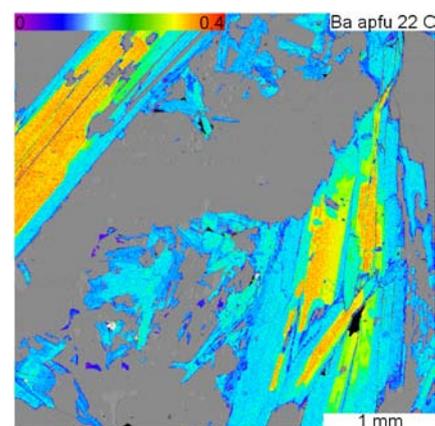


fig 1. XR image of pegmatite showing geochemical variation of phengite expressed in atom per formula units (colour scale bar), clipped to show muscovite-phengite chemistry, and set on top of calculated Z black-and-white image.

LA-ICP-MS trace element measurements of the composition of the cores and rims of select phengite crystals show similar trends, strongly concentrate Cs, Rb and Ba, as would be expected (e.g., Zack et

palabras clave: Canal de Subducción, Fengita, Celsiana, Cymrita

key words: Subduction Channel, Phengite, Celsian, Cymrite

al. 2001), while are poorer in HFSE relative to their respective whole rock compositions (Fig. 2).

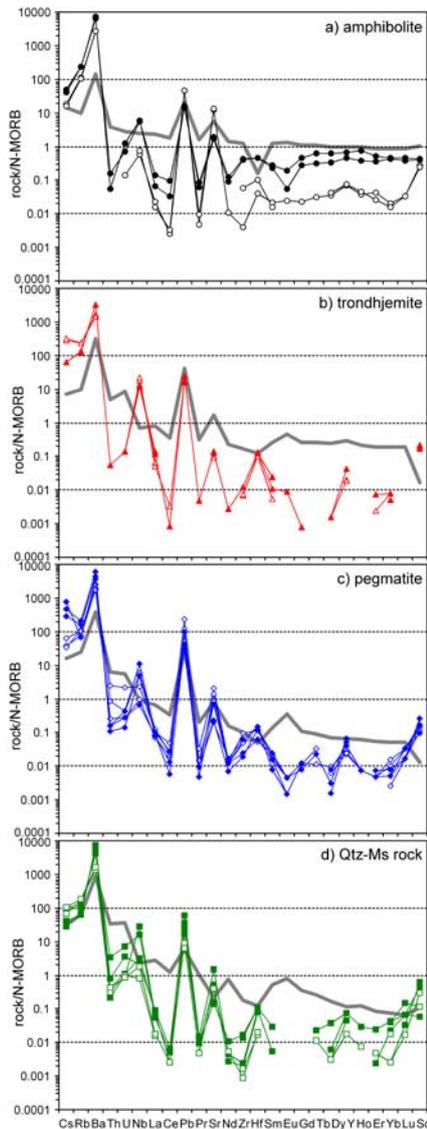


Fig. 2. Spider diagrams normalized to N-MORB (Hofmann, 1988) of phengites from a) amphibolite, b) trondhjemite, c) pegmatite and, d) Qtz-Ms rock. Solid and empty symbols correspond to core and rims, respectively. The compositions of the respective whole rock samples are indicated by thick grey lines.

Principal Component Analysis (PCA) indicates that the celadonite exchange $MgSi^{(VI)Al}_1$ contributes 67.31 % to the total chemical variability of the micas. The celsian exchange $BaAl(SiK)_1$ contributes moderately, 23.07 %, while the paragonite NaK_1 exchange contribution is faint (9.62 %). The great importance of celadonite exchange is a relevant conclusion. First, because it allows considering the relatively Si-poor Ba-rich compositions as phengitic, even if the amounts of Si are low, suggesting a relatively high pressure of

crystallization at high temperature. Second, because the sluggish kinetics of the celadonitic exchange in the micas did not allow homogenization in crystals formed at high temperature (e.g., Dempster, 1992), explaining the preservation of the strong chemical core-rim zoning that characterize the studied micas.

Celsian and cymrite are common minerals in rocks formed in subduction complexes. Typically, these minerals are related to metasomatic transformations induced by Ba-rich fluids in the subduction channel, including jadeitite deposits (e.g. Harlow 1994). Recently, García-Casco et al. (2009) reported jadeitite deposits in the Sierra del Convento mélangé. The presence of celsian and cymrite-forming fluids in the studied rocks strongly suggest a genetic link between these fluids and jadeitite-forming fluids the studied mélanges.

The large stability field of phengite in subduction environment (Schmidt 1996; Hermann 2002) implies that these LILE were trapped in phengite and were not transported to the mantle wedge. Thus, the fluids/melts of the Sierra del Convento and La Corea mélanges acted as sinks rather than sources for LILE elements as far as they crystallized at depth in the subduction environment (ca. 50 km; García-Casco et al. 2008), preventing their transfer to the volcanic arc. Contemporaneous volcanic arc rocks do not show strong enrichment in Ba and Pb and depletion in HREE and other compatible elements. For example, tonalite arc magmas of similar age (110-115 Ma) as those from the eastern Cuba mélanges occurring in the volcanic arc Los Ranchos Formation of the Dominican Republic (Escuder-Viruete et al. 2006). Colder geothermal gradients prevents partial melting at shallow depths, however, allowing decomposition of phengite at sub-arc depths (100-150 km) and the transfer of LILE to the sub-arc mantle and the volcanic arc. These inferences strengthen the importance of the thermal state of subducting slabs for the transfer of matter to the hanging wall plate.

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