Accreted eclogites with oceanic plateau basalt affinities in Ecuador

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High-pressure, regionally-metamorphosed rocks (the Raspas Formation) outcrop extensively (more than 10 km long and 3 km wide) within a terrane including extensively serpentinized harzburgite in El Oro Province, Ecuador. The high-pressure rocks consist of pelitic schists, eclogite, eclogite amphibolite and mafic rocks retrograded into amphibolites and greenschists. Exhumation of these high-pressure rocks would have occurred at about 132 Ma, based on K/Ar ages obtained from phengite (Feininger, 1980).

Eclogites are composed chiefly of euhedral garnet, omphacite, black stubby amphibole and quartz. The garnet is peppered with abundant rutile inclusions, pyroxene and tiny quartz crystals. This metamorphic assemblage equilibrated under conditions of about $P_{(total)}$ = 1.3 GPa 1.5–2 GPa (~ 45–60 km depth) and a T of 600°.

On the basis of the major element compositions, the protoliths of the eclogites were basaltic (e.g. 97CE1: SiO_2 = 49%; MgO = 7.58%; TiO_2 = 1.48%; Fe_2O_3 =12.44%) and/or cumulate gabbroic (e.g. 97CE4A: SiO_2 = 47%, MgO = 10.36%; TiO_2 = 0.46%; Fe_2O_3 = 8.12%). Trace element abundances have been determined both by bulk solution ICP-MS as well as laser ablation-ICP-MS analysis of individual (~ 50 μm spots) mineral grains. The metabasalt has slightly enriched light rare earth element (*LREE*) abundances relative to heavy (H)*REE* [chondrite-normalised ($_{CN}$) $(La/Yb)_{CN}$ = 1.3] with a slight negative Eu anomaly. In contrast, the metagabbro is characterised by depleted *LREE* abundances relative to *HREE* [$(La/Yb)_{CN}$ = 0.54] and a marked positive Eu anomaly. Relative to N-MORB, the metabasalt is Nb-, Ta-, Th-, U-, La-, and Ce-enriched, and Sr- and Rb- depleted. In contrast, the gabbro is depleted in most of these the elements, additionally in Nb, Zr, and Hf, but has significant enrichments in Ba and Sr.

Omphacite and amphibole separates have complementary *REE* abundance patterns, i.e. amphibole is depleted in *LREE* relative to the *HREE* [$(La/Yb)_{CN}$ = 0.41] while omphacite is enriched [$(La/Yb)_{CN}$ = 5.95]. Absolute *REE* concentrations of amphibole and omphacite are low (about 10 times chondritic abundances). In terms of isotopic characteristics, omphacite has an $\varepsilon Nd_{(T=150Ma)}$ = +7.96, which is slightly higher than that of the amphibole (+6.82), but both ratios fall within the range of OIB. The metabasalt has a relatively high $(^{87}Sr/^{86}Sr)_i$ [0.70649; $\varepsilon Sr_{(T=150Ma)}$ = +30] which is likely related to oceanic hydrothermal alteration.

Remarkably, the trace element abundances (absolute and relative) and isotopic characteristics of both eclogitised basalt and gabbro do not differ significantly from those of unmetamorphosed equivalents of an oceanic plateau origin, elsewhere in Ecuador (e.g. basalts and diabases of the Piñón Formation, San Juan cumulate gabbro; refer to figure). We note further that the subcreted portion of the accreted

oceanic plateau likely forms part of the basement for the active Andean arc volcanoes. Two generally important observations can be made from the present geologic and geochemical data: (1) The pro-grade metamorphism of the mafic lithologies of the subducted/subcreted oceanic plateau has not resulted in pervasive loss of the potentially 'fluid-mobile' elements (e.g. Ba, U, Sr, and *LREE*) that are thought by many to be lost from subducting slabs to supra-subduction mantle-crust systems; (2) The eclogite facies mafic basement may well serve as a protolith for the high-Mg, intermediate-SiO_2, high *LREE/HREE* (so-called 'adakites') recognised in some of the active Andean volcanoes, rather than having to invoke melting of the currently subducting slab.

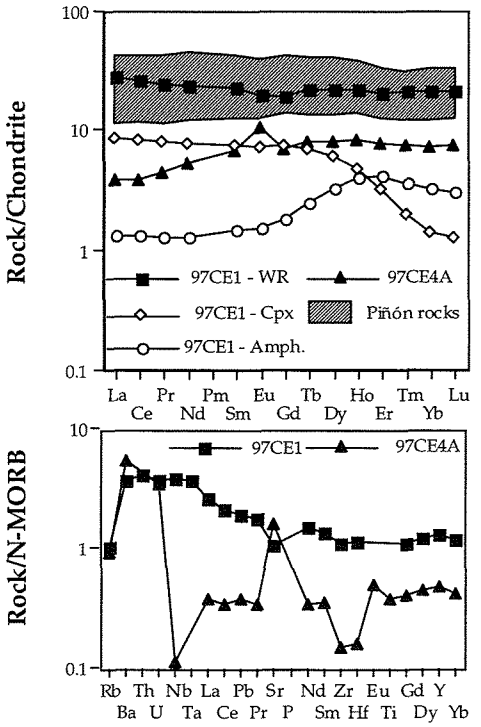

FIG. 1. Chondrite (Sun and McDonough, 1989) normalized rare earth and N-MORB normalized (Sun and McDonough, 1989) incompatible trace element patterns of the eclogites from Ecuador.