THE RASPAS METAMORPHIC COMPLEX (SOUTHERN ECUADOR): REMNANT OF A LATE JURASSIC-EARLY CRETACEOUS ACCRETIONARY PRISM. GEOCHEMICAL AND ISOTOPIC CONSTRAINTS

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KEYWORDS : High-pressure rocks, Raspas complex, isotope geochemistry, N-MORB and OIB sources, Ecuador.

INTRODUCTION

Along the western boundary of the Eastern Cordillera of north-central Ecuador, a major fault system marks the suture of the Amotape-Chaucha Terrane (Litherland et al., 1994), and extends northwards into Colombia. Dextral transcurrent motion associated with clockwise rotation (Mourier et al., 1988), which was concurrent or subsequent to subduction-accretion of the Amotape-Chaucha Terrane, has resulted in the exhumation *en bloc* of previously subducted portions of this terrane (El Oro Metamorphic Complex) which comprises exotic blocks of eclogite-blueschist-amphibolite known as the Raspas Complex (Duque and Feininger (1974; Figure 1). Arculus *et al.* (1999) demonstrated that the basalts and gabbros have N-MORB and oceanic plateau affinities while the pelitic schists represent crust-derived sediments.

MAJOR, TRACE ELEMENT AND ISOTOPIC CHEMISTRY

On the basis of major, trace element and isotopic geochemistry, two groups of meta-igneous rocks can be recognized. The first, composed of eclogite, garnet-amphibolite and one meta-gabbro exhibits E-MORB affinities; the second group, comprising greenschist- and amphibolite-facies basalts and gabbros is similar to N-MORB.

The relatively high MgO (7 to 8%) and TiO_2 (1.5 to 2.2 %) contents of the eclogites and N-MORB type basalts indicate that they do not represent strongly fractionated melts. The gabbros differ from the basalts by lower TiO_2 (0.4 to 0.8 %) and higher Al_2O_3 (~17 %) contents, suggesting that they contain cumulus plagioclase. In contrast, the high MgO (10.36 %) and Cr (542 ppm) of the garnet amphibolite indicate that the protolith of this rock was a clinopyroxene cumulate gabbro. The harzburgites are characterized by high MgO (~ 37 %) and Cr (2280 to 2614 ppm) correlated with very low Al_2O_3 (< 3 %). The major- and trace-element chemistry of the pelitic schists is very homogeneous. Variations in Zr content are interpreted as reflecting the presence of detrital zircon.

The rare earth element (REE) pattern of the eclogite is clearly distinct from the other basalts of the Raspas Complex in that it is enriched in light REE (LREE) relative to heavy REE (HREE) [$(La/Yb)_n$ = 1.15; $(La/Sm)_n$ = 1.0] while the other basalts are depleted in LREE [0.55 < $(La/Sm)_n$ = 0.9] (Figure 2). The gabbros differ from the basalts by lower REE abundances (~ 10 times the chondritic abundances), lower (La/Yb)n ratios (0.55 to 0.6; with the exception of 97CE19), and Eu positive anomalies (Figure 2). The Nd-to-Ln_n spectrum of the harzburgites are within the general range expected of refractory ultramafic lithologies (Figure 2). However, two features may reflect a more complex origin: i) enrichments of La, Ce and Pr relative to MREE; ii) a positive Eu anomaly (Eu/Eu*=1.76). Both features might result from original veining by melt-related material.

The REE_n abundances of the pelitic schists (Figure 3) resemble those of bulk continental crust. All these rocks are LREE enriched relative to HREE [4.27 < $(La/Yb)_n$ < 5.82]. There is no indication in these high-grade pelitic rocks of bulk or differential selective loss of REE. Noteworthy in this respect is absence of selective loss of the light REE compared with medium to heavy REE.

The N-MORB-normalised, extended trace element abundances of the varied mafic-ultramafic lithologies are informative (Figure 2). For greenschist-facies rocks, with the exception of Rb and Ba (on one sample of metagabbro) and Pb (in both meta-basalts and gabbros), overall abundances are relatively unfractionated. Likewise, smooth relative enrichments in certain LILE of the eclogite (Th, U, Nb, Ta, and Pb) are consistent with faithful preservation of original E-MORB or OIB abundances. Conversely, abundances of Rb, Ba, and Sr are significantly depleted compared with fluid-immobile LILE. Garnet amphibolite differs from the eclogite in that it shows significant depletion in Nb and Ta and compared to the gabbros, and is enriched in Th and U. However, this rock shows Like the greenschist-facies samples and the harzburgites, this rock is relatively enriched in Pb. While Ba is below detection limit (5 ppb) and may have been lost from the serpentinite, there are no apparent losses of Rb, Th, U, and Sr. An absence of Ba loss distinguishes the preserved harzburgite differs from the serpentinized samples.

ISOTOPE RESULTS

The isotope compositions of Sr, Nd and Pb were determined on samples from same data set, including whole-rocks and separate minerals. All the isotopic compositions have been corrected for "in situ" decay using an age of 150 Ma for the basic and ultrabasic rocks and 123 Ma for the sedimentary rocks.

The metabasalts clearly show a N-MORB affinity with εNd values ranging between +10 and +11 and ($^{87}Sr/^{86}Sr$)i ranges from 0.70306 to 0.70310 (Figure 4). The two gabbroic samples are different. One sample (Ce13) has a depleted signature similar to the metabasalts (εNd=+10, ($^{87}Sr/^{86}Sr$)i = 0.70396) and probably originated from a N-MORB type reservoir. The second one (Ce19) presents a significantly different signature with a higher ($^{87}Sr/^{86}Sr$)i ratio (0.70507) and a lower Nd composition (εNd=+7) suggesting a more enriched origin similar to E-MORB or OIB. The distinction between the two gabbroic samples agrees quite well with the conclusions previously proposed on the basis of REE and trace element distributions. The composition of sample Ce19 falls in the same domain as the garnet amphibolite and the eclogite whole-rocks in Fig 4 .

The Sr and Nd isotopic compositions of the garnet amphibolite and the eclogite are more enriched and are located on an intermediate position between N-MORB and OIB (Figure 4). The slightly elevated ($^{87}Sr/^{86}Sr$)i ratios of these rocks suggests seawater alteration. For the eclogite sample, we also determined the isotopic compositions on separated clinopyroxene (omphacite) and amphibole (barroisite). The slightly elevated ($^{87}Sr/^{86}Sr$)i ratios (0.70649) determined for the whole-rock compared to the mineral separates (0.70307 and 0.70391 for clinopyroxene and amphibole, respectively) clearly suggest a limited impact of this late low temperature hydrothermal event.

The two ultrabasic samples yield εNd ratios in agreement with an origin from a depleted reservoir. The serpentinite (Ce14) yields a more elevated ($^{87}Sr/^{86}Sr$) ratio (0.70407) than the fresh one which has a lower ($^{87}Sr/^{86}Sr$)i ratio (0.70378).

The pelitic schists exhibit the most radiogenic Sr isotopic compositions ($^{87}Sr/^{86}Sr$)i > 0.715) with εNd values ranging between -6 and -8. These isotopic compositions clearly suggest a continental crustal affinity: the source could have been old detrital sediments with ages ranging from 0.6 to 1.0 Ga.

Pb isotopic compositions are reported in the $^{207}Pb/^{204}Pb$ vs $^{206}Pb/^{204}Pb$ and $^{208}Pb/^{204}Pb$ vs $^{206}Pb/^{204}Pb$ diagrams (Figure 5). The distribution of the analytical points defines three distinct groups of samples. The first, constituted by the metabasalts, one metagabbro (Ce13) and one harzburgite (Ce15), has very low ratios corresponding to an origin from a depleted or N-MORB type reservoir. The second group of samples has more radiogenic ($^{206}Pb/^{204}Pb$)i and ($^{208}Pb/^{204}Pb$)i ratios that overlap the OIB or E-MORB domains. This group includes eclogite, harzburgite, the second metagabbro (Ce19) and the garnet amphibolite. These rocks probably come from a more enriched source than the metabasalts and the gabbros Ce13. Moreover, they show pervasive hydrothermal alteration. The metagabbro Ce19 has an elevated ($^{207}Pb/^{204}Pb$)i ratio compared to the eclogite and harzburgite whole-rocks. This can be explained by a contribution either of small quantities of a sedimentary component (pelagic?) or of old continental crust. The third group of samples, composed of the three pelitic schists, displays a range of Pb ratios that clearly reflect their origin from old crust. The clear distinction between the present data set and the Hispaniola samples supports different origins and precludes, for the Raspas Complex rocks, a similar hotspot contribution. Compared to the 123 Ma Ecuadorian samples, the first Raspas group is less enriched but the second one is similar, which could be interpreted as involvement of the same components (Figure 5; Lapierre et al., 1999).

CONCLUSION

The major-, trace-element and Nd, Sr, Pb isotopic compositions of metamorphosed igneous and sedimentary components of the Raspas Complex define three groups of samples. The meta-basalts, one gabbro (Ce18) and the harzburgites have depleted characteristics corresponding to a N-MORB type reservoir. The eclogite, another gabbro (Ce19) and the garnet amphibolite present strong affinities with a more enriched source similar to that of OIB or E-MORB. Finally, the pelitic schists clearly come from old continental crust probably of Proterozoic or Archaean age (> 0.6 Ga). Pervasive hydrothermal alteration is clearly seen in the oceanic plateau rocks. The distinct origins for these rocks from a restricted area of the El Oro district supports the hypothesis of an accretionary prism including an exotic block of eclogite-blueschist-amphibolite.

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