Vesuvianite in high-pressure-metamorphosed oceanic lithosphere (Raspas Complex, Ecuador) and its role for transport of water and trace elements in subduction zones

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Abstract: Metamorphosed, vesuvianite-bearing dykes occur in serpentinised peridotites of the Raspas Complex (Ecuador), which represents a piece of oceanic lithosphere that has experienced high-pressure, subduction-related metamorphism. The serpentinite mantle protoliths are geochemically indistinguishable from modern oceanic lithosphere entering subduction zones. Positive Eu anomalies (Eu/Eu* = 1.3–7.2) and relative LREE enrichments (LaN/SmN = 1.2–5.5) point to hydrothermal alteration of the peridotite precursor rocks at or near the seafloor. Major mineral phases in the metamorphosed dykes include chlorite, diopside, amphibole and vesuvianite. In each dyke, only two of these phases – either amphibole + vesuvianite, diopside + chlorite, or amphibole + chloride dominate the modal mineralogy with >90 vol.%, suggesting metasomatic replacement at elevated P-T conditions during subduction, controlled by an external fluid. This fluid caused the decrease in coexisting mineral phases and overprinting of initial Sr isotope ratios (0.7025–0.7031). Preserved geochemical signatures from the dyke protoliths, including positive Eu anomalies (Eu/Eu* = 1.2–2.0) and Na enrichment due to spilitisation, reveal that the dykes originated as oceanic olivine gabbros and troctolites.

Vesuvianite in the Raspas Complex formed by hydration and silica removal from gabbroic mineral assemblages during subduction. It has a wide stability in P-T space for hydrated and silica deficient bulk compositions so that it potentially represents a significant repository for the cycling of elements during subduction. In addition to Ca, Mg and Al, incorporation of significant amounts of Ti, Fe and Na (up to 2.4, 1.7 and 1.6 atoms per formula unit, respectively) in vesuvianite bears evidence for the potential of vesuvianite as petrogenetic indicator, although lack of relevant thermodynamic and experimental data precludes the extraction of quantitative information. For cold subduction zones in particular, vesuvianite appears to be able to carry significant amounts of water to mantle depths. Preferential incorporation of HREE (up to 2.2 ppm Yb), Sr (up to ~300 ppm) and Pb (up to 4.5 ppm) in vesuvianite underlines its potentially important role for the storage, transport and release of these key elements in radiogenic isotope geochemistry during subduction zone cycling.

Key-words: subduction, vesuvianite, oceanic lithosphere, Raspas Complex, serpentinite, trace elements, fluid-rock interaction, geochemistry.

Introduction

Oceanic rocks subducted and exhumed in convergent margin settings provide invaluable information about the age, origin and evolution of these otherwise deeply subducted and not directly accessible materials. Subduction-modified oceanic lithosphere records thermal conditions and geochemical modifications in the subduction zone, such as widespread high-pressure/ultrahigh-pressure (HP/UHP) metamorphic stages and severe metasomatic reworking of the subducted slab (Arculus et al., 1999; De Hoog et al., 2009; Halama et al., 2011; Pabst et al., 2012). Subducted hydrous ultramafic rocks (serpentinites) are of particular interest because dehydration of serpentinites causes release of substantial quantities of water and many fluid-mobile trace elements, such as Li, B, N, Cl, I, Br, As, Sb, Sr, Ba and Pb, into the overlying mantle wedge (Ulmer & Trommsdorff, 1995; Scambelluri et al., 1997, 2004; Schmidt & Poli, 1998; Hattori & Guillot, 2003; Tenthorey & Hermann, 2004; Savov et al., 2007; Bonifacie et al., 2008; Halama et al., 2010). Moreover, serpentinites provide a driving force for exhumation of oceanic crust because of their relative buoyancy compared to dry mantle rocks (Hermann et al., 2000; Schwartz et al., 2001; Agard et al.,...