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Geochemistry of ocean floor serpentinites world-wide: constraints on the ultramafic input to subduction zones

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Serpentinite can be a major component of the upper part of the oceanic lithosphere and is a significant H2O-contributor to subduction zones (Scambelluri et al. 2004). Serpentinite dehydration releases large amounts of water through a very limited number of discontinuous reactions and it is therefore expected to have the potential of leaving a trace element chemical fingerprint in overlying rocks (Ulmer and Trommsdorff 1995; Scambelluri et al. 2004; see also Pettke et al. 2009). We present major and trace element whole rock (XRF, ICP-MS and PGAA) and in-situ mineral (EPMA and LA-ICP-MS) analyses of serpentinized peridotites sampled on DSDP/ODP drilling cruises, in order to chemically characterize the hydrated ultramafic input of subduction zones. The studied 39 samples cover all major geodynamic settings where serpentinites occur on recent ocean floors (fast and slow spreading mid-ocean ridges, passive margins and supra-subduction zones).

All rock samples consist of one or two serpentine (srp) polymorphs, brucite (brc), magnetite (mag), and relic high-temperature mantle minerals: olivine (ol), orthopyroxene (opx), clinopyroxene (cpx) and spinel (spl). Serpentine + brc replace ol, forming a mesh-like network around relic crystal fragments. Magnetite usually forms strings of individual crystals along the srp mesh-network. Very rare iowaite (a H2O and Cl-bearing Fe-Mg oxy-hydroxide) remnants were found around the ol core of mesh srp and in the srp ± brc replacements after ol mesh cores. Orthopyroxene alters to bastitic pseudomorphs which consist of srp rarely accompanied by brc. Associated mag is generally absent. The degree of ol and opx alteration is variable, i.e., there are samples in which opx is completely whereas ol is only partially altered and vice versa, which suggests variable temperatures of alteration (alteration rate of opx is higher than that of ol above ca. 350 °C; Martin and Fyfe 1970). Clinopyroxene and spl appear to be weakly altered in thoroughly serpentinized samples. Where present, carbonate (cab) forms veins or fills former srp ± brc pseudomorphs after ol or opx.

Major, minor and trace element chemistry of the serpentinites generally reflects that of their ultramafic precursor (Mg-rich and Si-poor rocks with low trace element contents). With respect to certain elements, however, we detect significant serpentinization-related changes. Besides their high H2O-contents (8.7-17.2 wt. %), the hydrated harzburgites and lherzolites also display high B and Cl concentrations (8-177 µg/g and 1160-5920 µg/g, respectively) relative to depleted mantle values (0.06 and 0.51 ppm, respectively; Salters and Stracke 2004). Supra-subduction zone serpentinites contain 10 to 100 times more Cs (0.04-1.2 µg/g) and Rb (0.1-7.1 µg/g) than samples from mid-ocean ridges and passive margins (Cs: below 0.07 µg/g; Rb: 0.004-1.17 µg/g). We often observe 100 to 1000-fold enrichments in U, Pb, Sr and Li relative to elements of similar compatibility in the mantle.

In-situ mineral analyses suggest that B and Cl reside in serpentine minerals. Cesium and Rb whole rock and mineral chemical data correlate well, too. If carbonates are not present, the Sr budget of serpentinites is largely controlled by serpentine minerals that take up 0.36 to 21 µg/g Sr, i.e., orders of magnitude more than concentrations of precursor ol and opx. Bastites tend to have (about 1.5-4 times) higher trace-element concentrations than mesh rims, suggesting that precursor mineralogy (e.g. harzburgites vs. dunites) and alteration temperature (Martin and Fyfe 1970) can affect serpentinite chemistry. Enrichments of U, Pb and Li may have multiple origins, i.e., may be only partly related to serpentinization and low-temperature carbonate addition.

Our study shows that serpentinites from representative geodynamic settings have variable, but generally depleted chemical character, inherited from precursor mantle rocks. However, notably B and Cl are enriched, but not

uniformly so and independent of geodynamic setting. Supra-subduction zone serpentinites reveal additional enrichments in Cs, Rb, ±Sr, identifying an alteration fluid source that is not pure seawater. In conclusion, precursor mineralogy and magmatic history together with hydration temperature govern the trace element budget of ocean floor serpentinites, which, apart from supplying H2O to the subduction zone, may also be a significant source of B and Cl to the arc magma source and, depending on geodynamic setting, may even influence the element budget for Cs, Rb, Pb, U and .Sr.

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