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The geochemical fingerprint of serpentinite- and crust-dominated plate-interface settings: some tectonic implications

Enrico Cannaò (1), Marco Scambelluri (1), Samuele Agostini (2), and Sonia Tonarini (2)
(1) University of Genova, Dipartimento di Scienze delle Terra, Ambiente e Vita, Genova, Italy (marco.scambelluri@dipteris.unige.it), (2) IGG-CNR, Via G. Moruzzi, 1, 56124 Pisa, Italy

The interface between converging plates is made of kilometre-thick domains where slab and upper plate mantle materials are tectonically slicied within a matrix dominated either by (meta)sedimentary/crustal rocks or by serpentinite. The latter may correspond to supra-subduction mantle altered by uprising slab fluids. Once formed, these plate-interface domains act as hydrated low-viscosity layers where tectonic stress and fluid-mediated mass transfer are strongly focussed.
Here we present the geochemical study of two plate-interface environments: (1) serpentinite-rich, represented by the high-pressure serpentinites of the Ligurian Alps (Erro-Tobbio and Voltri Units); (2) sediment-dominated top slab mélange, represented by de-serpentinized garnet peridotite and chlorite harzburgite bodies (hosting eclogite and metarodingite) embedded in paragneiss and micaschist from Cima di Gagnone (Adula Unit, Central Alps). The Ligurian serpentinites derive from oceanic and wedge mantle tectonically coupled and dragged to depth during Alpine subduction: they may represent the hydrated precursors of the Cima di Gagnone peridotites. The B, Pb and Sr isotopic composition of the above sets of rocks helps defining tectonic and mass transfer processes during accretion of slab and suprasubduction mantle rocks in plate-interface domains, and to retrieve the imprint of fluids from these settings, which that ultimately affect arc magmatism.
The serpentinized peridotites from Erro-Tobbio (ET) show high B (10-30 ppm), delta11B (10-25 per mil), B/Nb ratio (>380) and limited enrichment in 206Pb/204Pb (18.17-18,51) and 87Sr/86Sr (0.7046- 0.7060). Scambelluri & Tonarini (2012) interpreted the B and Sr isotopic imprint of ET as representative of upper plate mantle altered by slab-fluids. The B contents (up to 30 ppm), delta11B (18-30 per mil), B/Nb ratio (>900) and 206Pb/204Pb (18.09-18.22) of the Voltri serpentinites are similar to ET. Their 87Sr/86Sr (0.7079 to 0.7105) is higher than ET. The garnet peridotite and harzburgite from Gagnone have low B (up to 9 ppm), low B/Nb (<100) and high Pb and Sr isotopic ratios (206Pb/204Pb up to 18.84; 87Sr/86Sr 0.7124). Eclogite and HP metarodingite in the Gagnone peridotite show comparable values. The host metasediments and gneiss show higher B (6-16 ppm), 206Pb/204Pb (up to 18.98) and 87Sr/86Sr (0.7275). than peridotites and mafic rocks. All the Gagnone rocks have negative delta11B (ultramafic and mafic rocks = 0 to -10 per mil; country rocks = -3 to -12 per mil). The Gagnone peridotites reveal geochemical mixing between ultramafic and host crustal reservoirs. Considering that these peridotites derive from serpentinized protoliths, we expect that the initial high 11B of serpentinites was modified by two combined processes: (1) serpentine dehydration, releasing heavy B to fluids, and (2) exchange between ultramafic rocks and sediment-derived subduction fluids during burial and exhumation.
The geochemical signature of the Voltri serpentinites is indicative of interaction with slab fluids enriched in heavy B-rich and in crust-derived components, such as in mantle rocks which evolved atop of the subducting slab. This implies that the slices of the downgoing slab are emplaced early during their burial history atop of the subducting plate. The geochemical signature of peridotites and host metasediments from Gagnone, points to significant exchange between ultramafic bodies and host rocks during prograde subduction prior to peak metamorphism. This again indicates accretion to the plate interface of slab and wedge materials during an early stage of subduction. Moreover, Voltri and Gagnone represent distinct reservoirs, showing positive versus negative delta11B. Serpentinite-dominated settings, like Voltri, produce high B and 11B fluids which can explain 11B-enrichment of much Pacific arcs. Differently, the sediment- and gneiss-dominated Gagnone mélange shows high B, negative δ11B, high radiogenic Pb and Sr: fluids released from such a mélange fit the composition of lavas from convergent margins affected by continental subduction.