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Fluid and melt production in natural high and ultrahigh pressure rocks and the interaction of subduction-zone agents with the overlying mantle wedge

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The consumption of oceanic and continental lithosphere at subduction zones causes the recycling of crustal components from slab reservoirs into the mantle. This large-scale exchange drives to a chemical differentiation of the Earth which is largely mediated by the fluid phases (or hydrous melt, or aqueous silica-rich solutions) produced by the dehydrating subducting plates. The slab fluids are the focus of petrological and geochemical research and become to be rather known: they mostly correspond to aqueous solutions enriched in large ion lithophile (LILE), light (B, Li) and light rare earth (LREE) elements. At this purpose, the antigorite breakdown to olivne and orthopyroxene is identified as an important deep dehydration episode in oceanic plates: it is witnessed in nature by metamorphic harzburgites (Betic Cordillera) containing primary fluid inclusions. These represent remnants of the antigorite dehydration fluid: their LAM ICP MS analysis has shown fluid enrichment in LILE, Li and B (Scambelluri et al., 2004a; b). The inclusions thus represents an agent enhancing mantle metasomatism and carrying components recycled in arc magmas; direct access of this fluid to the mantle wedge enables transfer a crustal signature to it. Moreover, the eclogitic pressure-temperature equilibration of alpine serpentinites is close to the water-saturated melting curves and to the critical end points of granites and pelites (Hermann, 2003). Interaction of the antigorite-breakdown fluid with sedimentary and/or granitic slab layers enhances partial melting and/or production of aqueous silicate-rich (supercritical) fluids enriched in the incompatible element (LREE

included) predicted in the arc lava sources.

Despite the advancements in the understanding of the slab fluids, still few are the direct observations of their pristine interaction with the mantle wedges, which remain the least known pieces of the subduction factory. At this purpose, relevant information can be gained by the study of orogenic UHP ultramafic rocks, which locally correspond to peridotite slices (locally of mantle wedge provenance) metasomatized by the influx of crustal components. A relevant case study is represented by garnet orthopyroxenite from the Maowu ultramafic complex (Dabie Shan, China) hosted by UHP garnet-coesite gneisses (Malaspina et al., 2006, submitted). The pyroxenites have a peak assemblage of orthopyroxene (opx_2)+garnet (gnt_2) $\pm$ clinopyroxene. Orthopyroxene replaces previous Si-undersaturated minerals (olivine and Ti-clinohumite) which co-existed with former fine-grained garnet (gnt_1) and orthopyroxene (opx_1). Opx_2 thus overgrows a previous garnet-harzburgite assemblage. The bulk rock Mg# and the high Ni content indicate that the orthopyroxenites derive from former mantle peridotites. The REE patterns are comparable with the ones of mantle rocks: an enrichment in LREE is their main distinctive feature and such an enrichment is also recorded by Opx_2. The observed features indicate that the pyroxenites derive from harzburgite by the addition at UHP conditions (4.0-6.0GPa, 700-750˚C) of a SiO_2, Al_2O_3 and LREE-rich agent, most likely a hydrous granitic melt, sourced from the associated crustal rocks. Polyphase inclusions found in gnt_2 have negative crystal shapes and constant volume proportions of the infilling minerals (hydrous phases and 10-20vol% of opaque): they correspond to an original solute-rich aqueous fluid. Their trace element compositions are enriched in LILE, with spikes of Cs, Ba, and Pb, high U/Th ratios, and LREE. Such a signature suggests that the trapped fluid derived from crustal reservoirs and had an incompatible element enrichment very similar to the one observed in arc lavas. The metasomatised ultramafic rocks represent a proxy for the trace element transfer from subducted crustal rocks to the mantle wedge at sub-arc depths. Hydrous granitic melts, likely produced by subducted sediments, react with mantle wedge peridotites. The reaction produces a metasomatic LREE-enriched garnet-orthopyroxenite layer plus a residual aqueous fluid which concentrates the LILE and transports a crustal signature to the locus of partial melting within the mantle wedge.

Hermann 2003, Lithos 70; 163-182; Scambelluri et al. 2004, EPSL222, 217-234; Scambelluri et al. 2004, Int Geol Revs, . 46, 595-613; Malaspina et al. 2006, EPSL submitted.