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The “W-type” LILE signature of deep subduction zone fluids

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Subduction zones are the Earth’s environments where fluids or melts released by the slab recycle elements into the mantle wedge, triggering partial melting and arc volcanism. Despite the recent advancements in understanding the nature and composition of the fluid phase released from the subducted slab, the interaction of this fluid with the overlying mantle wedge remains poorly constrained. Information on the geochemical exchange processes between suduction fluids and sub-arc mantle can be gained by the study of metasomatised UHP ultramafic rocks in continental basements. A relevant case study is represented by garnet orthopyroxenites from the Maowu Ultramafic Complex, Dabie Shan, China. Such pyroxenites are locally bounded by phlogopite-rich layers and are hosted by garnet-coesite gneisses. They contain orthopyroxene (Opx_2) + garnet (Grt_2) $\pm$ clinopyroxene which form at the expense of a previous ultramafic olivine + garnet bearing paragenesis. Grt_2 includes core clusters of primary polyphase inclusions corresponding to a solute-rich aqueous fluid enriched in LILE and LREE (Malaspina et al., 2006a). Textural and geochemical data demonstrate that the Maowu Ultramafic Complex consists of metasomatic layers produced after the reaction of mantle peridotites with a hydrous granitic melt (or a solute-rich supercritical liquid) sourced by the associated crustal rocks at UHP conditions (4.0-6.0 GPa, 700-750 ˚C). This hydrous metasomatic fluid phase likely loses elements such as SiO_2, Al_2O_3 and K_2O during the reactive flow in the mantle peridotites, forming phlogopite-rich layers and garnet orthopyroxenites. On the other hand, the H_2O component of the hydrous solute-rich agent evolves into a residual aqueous fluid which concentrates the incompatible LILE and LREE.

The trace element pattern of this fluid shows a peculiar "W-type" LILE signature characterised by positive spikes of Cs, Ba, and Pb relative to Rb and K, thereby suggesting selective enrichment in some LILE. Previous works on K-Rb-Cs partitioning between phlogopite and fluid at 2.0 and 4.0 GPa (Melzer and Wunder, 2001) indicate that phlogopite preferentially retains Rb and K with respect to Cs. They also demonstrate that with increasing phlogopite crystallisation, the Cs/Rb ratio in the coexisting fluid continuously increases. Formation of phlogopite layers bounding the Maowu orthopyroxenites may play an important role on the partitioning of incompatible elements, resulting in a selective LILE enrichment of the residual crustal metasomatic fluid. The mantle phases pyroxene and olivine do not incorporate large amounts of LILE (Ayers et al., 1997). Moreover, absence of amphibole at $P>3.0$ GPa enables the residual aqueous fluid to transfer the W-shaped signature (positive spikes of Cs, Ba, Pb, and negative anomalies of Rb, K) to the locus of sub-arc partial melting, once it escapes the metasomatic slab-mantle interface. An important aspect of this filtering process is that the trace element fingerpint of other slab lithologies in Dabie Shan (Malaspina et al., 2006b), as well as of wedge-type Alpine amphibole + garnet peridotites (Ulten Zone, Italian Alps) is similar to the one of such residual fluid (Scambelluri et al., 2006). This indicates that the "W-type" slab fluids are able to transfer their trace element signature within the slab and to the locus of fluid-assisted mantle melting.

Malaspina et al. 2006a, EPSL 249, 173–187; Melzer and Wunder 2001, Lithos 59, 69-90; Ayers et al. 1997, EPSL 150, 371-398; Malaspina et al. 2006b, Lithos 90, 19-42; Scambelluri et al. 2006, CMP 151, 372-394.