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Trace Element Mobility and Compositional Evolution in (U)HP Fluids - A Study on High-Grade Metamorphic Veins from Dabieshan, E' China

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Element solubilities in aqueous liquids are known to increase at elevated pressures, including high field strength elements (HFSE), particularly in halogen-bearing fluids. A related high pressure fractionation of Nb and Ta in metamorphic rutile has been advocated to explain varying Nb/Ta ratios in the Earth's reservoirs.
We performed a study of coesite-bearing eclogites and associated high-grade hydrometamorphic veins from the Dabieshan ultra-high pressure (UHP) belt by XRF, EMP and in-situ LA-ICPMS, aiming to characterise and quantify element redistribution and fluid evolution linked to deep continental subduction of basaltic protoliths.
Epidote group minerals yield the highest trace element concentrations (REE, Sr, Pb), except for HFSE, Rb and Ba. REE are furthermore incorporated by zircon, garnet (M-/HREE) and apatite (MREE). Rutile, zircon and subordinatedly allanite hold the entire HFSE inventory (Nb, Ta, Zr, Hf, Ti), while phengite and paragonite are the main hosts of LILE (Rb, Ba, Sr), next to apatite (Sr). U and Th contents are controlled by epidote, zircon and rutile. Omphacite, kyanite, quartz and barroisite have negligible influence on the trace element budget.
Petrography, relative age relations of the veins and mass balance calculations indicate a changing fluid composition from silica- and HFSE-rich, aqueous fluids during the UHP-metamorphic peak towards complex post-peak HP-fluids, dominated by SiO_2 + Al_2O_3 + CaO + K_2O + H_2O and enriched L- to MREE and LILE, along with a relative retention of MgO + FeO + HFSE + HREE in the host rock.
Zoning in epidote indicates a development from high trace element contents in early HP fluids towards lower concentrations, interpreted to reflect the dissolution of a trace element rich mineral such as allanite followed by a depletion of dissolved trace elements in the fluid during the precipitation of vein minerals.
Several vein minerals feature fractionated ratios of Nb/Ta, Zr/Hf (rutile), Rb/Sr (phengite, paragonite, epidote), U-Th/Pb ('early' epidote, zircon, apatite) and Sm/Nd (apatite, 'early' epidote, zircon). Vein rutiles hold higher Ta over Nb ratios compared to rutile in the eclogite host, suggesting an initially subchondritic fluid. As most minerals that occur both in veins and eclogites (e.g. phengite and epidote) do not show significant differences in their major and trace element contents, a local derivation of the metamorphic fluids is supposed.
Our results support the hypothesis that residual, rutile-bearing eclogites could be a potential source for an Earth's 'hidden' high-Nb reservoir, whereas both eclogites and vein minerals do not represent a low U/Pb reservoir that could be linked to the 'lead paradox'. It becomes clear that fluids liberated during high-grade metamorphism are powerful agents of element transfer and fluid-rock interaction in UHP environments is critical for our understanding of the Earth's trace element budget.