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The effect of supercritical fluids on Nb-Ta fractionation in subduction zone: Geochemical insights from a coesite-bearing eclogite-vein system

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Supercritical fluids are ideal media for mass transfer from the subducting slab into the mantle wedge. However, little is known about the role of natural supercritical fluids in subduction zones. A combined study of petrology, geochemistry and zirconology was carried out for a coesite-bearing eclogitic vein and its surrounding eclogites from the Dabie-Sulu orogenic belt. The results are used to reveal the composition and source of supercritical fluids, the P-T conditions and timing of their formation and their geochemical effects in subduction zones. The eclogitic vein is composed of garnet, omphacite, quartz, amphibole, rutile and apatite, with minor amounts of epidote, plagioclase and zircon. Zircons from the vein give concordant U-Pb ages of 223 ± 5 to 228 ± 9 Ma and flat HREE patterns for newly grown rims, consistent with their crystallization at UHP eclogite faceis. The vein shows similar Hf-O isotopes to the host UHP eclogites, indicating that the fluid responsible for the UHP veining is internally derived from the UHP eclogites. Minerals in the vein not only contain higher contents of Cr, Sr, REE and HFSE, but also multiphase crystal inclusions (such as omphacite, quartz, epidote, apatite, amphibole, plagioclase, mica, rutile, calcite, and anhydrite) as well as liquid and gas phases of H_2O. The *P*-*T*-t path of the UHP eclogite-vein system indicates that the second critical endpoint of the basalt-H_2O system is located close to 3.4 GPa and 770°C. High Nb/Ta ratios of rutile crystals in the vein and quantative modelling indicate that the dehydration of subducting eclogites at subarc depths can produce supercritical fluids with suprachonritic Nb/Ta ratios. The mantle wedge metasomatized by the supercritical fluids can have suprachondritic Nb/Ta ratios and thus provide a complementary reservoir for mafic arc magmas to balance the subchondritic reservoirs on Earth. Two indices are proposed to identify the existence of supercritical fluids: (1) rutile crystallized from the supercritical fluids contains the lower Nb contents than aqueous solutions and hydrous melts; (2) UHP eclogites associated with the supercritical fluids have a difference >0.1 between their Nb-Ta compositions and the line defined by basalts in the plot of log[Nb] vs. log[Ta].