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Melt generation during exhumation of deeply subducted continental crust

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Although partial melting of deeply subducted continental crust has been widely recognized in the last ten years, the mechanism of melt generation during HP–UHP metamorphism remains controversial. In this study, we discuss the petrogenesis of decimeter- to meter-scale dykes of leucosome that occur in retrogressed migmatitic UHP eclogite in coastal outcrop at General's Hill, central Sulu belt, eastern China. This study provides insight into the generation of hydrous melt during exhumation of deeply-subducted continental crust.

The leucosomes comprise mainly quartz + phengite + albite + allanite/epidote + garnet, with scarce titanite, zircon and apatite. LA-ICP-MS U–Pb dating on new zircon domains from the leucosomes yielded crystallization ages of ca 223–219 Ma, within the well-established range of ages (ca 225–215 Ma) for HP eclogite facies recrystallization in the Sulu belt. Si-in-phengite barometry combined with Ti-in-zircon thermometry yields crystallization P–T conditions for the leucosomes of 3.0–2.5 GPa and 830–770 °C. Leucosome compositions are granitic with chondrite-normalized trace element compositions that are enriched in the LREE relative to the HREE and enriched in the LILE relative to the HFSE, consistent with crystallization from a crustally-derived hydrous melt. The leucosomes have Sr–Nd isotope compositions intermediate between those of the host eclogites and surrounding gneisses, implying derivation from a mixed source.

At the metamorphic peak, the source rocks were likely fluid deficient or absent. We posit that during exhumation from UHP conditions, structural water stored in nominally anhydrous minerals during the prograde evolution was exsolved to form a grain boundary supercritical fluid in both eclogite and gneiss. Strong deformation associated with exhumation as well as the increasing volume of fluid likely promoted interconnection and allowed migration of the fluid along the foliation. By migrating from grain boundaries into channels and draining from the volumetrically dominant gneiss through the eclogite, the fluid acquired a blended Sr–Nd isotope composition intermediate between these two end-members. By the transition from UHP to HP eclogite facies conditions, the ascending fluid had evolved to a denser, more viscous and more polymerized hydrous melt by dissolution of the silicate mineral matrix. Trapped melt crystallized to leucosome by diffusive loss of water to the host eclogite at pressures around the coesite to quartz transition and at temperatures above the wet solidus.

Aggregates of plagioclase + biotite around phengite and thin films and cuspate veinlets and patches of K-feldspar are developed along grain boundaries in the leucosome, consistent with subsequent low degrees of melting by phengite breakdown at lower pressure. Phase equilibrium modelling indicates that this late stage melting occurred across the transition from HP eclogite to amphibolite facies, with the final subsolidus equilibration around 1.04–0.87 GPa and T <640 °C. However, phengite-breakdown melting was not the primary mechanism by which the leucosomes were formed.