The partial melting of ultrahigh-pressure eclogite: Insights from forward petrological modeling

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Partial melting of ultrahigh-pressure (UHP) eclogites is a fundamental petrological process that leads to crustal differentiation and may trigger the exhumation of deeply subducted continents. However, the pressure-temperature (*P*–*T*) conditions of initial melting, the amount of melt generated, the exact melting reaction(s), and the melt composition are still under study, precluding a comprehensive understanding of the role of the anatexis of UHP eclogite for exhumation of UHP terranes. Here, we explore the potential of UHP eclogites to partially melt during continental collision and exhumation to mid-crustal depths. We conducted forward phase equilibrium modeling of three compositional end-member types of UHP eclogites: Ca-, Mg-, and Fe- rich natural eclogites. We utilized two different *P*–*T* paths to model the partial melting: one experienced by small (and 'cold') UHP terranes and other by large ('hot') UHP terranes (Kylander-Clark *et al.*, 2012). The models show that the three end-member UHP eclogites do not melt during prograde metamorphism along any of the *P*–*T* paths considered here, indicating that partial melting of UHP eclogite plays a limited role in triggering the exhumation of mafic portion of the subducted continents. Partial melting of UHP eclogites only occurs during exhumation along the path experienced by large UHP terranes. Two end-member scenarios were modeled to account for the partial melting: dehydration (± vapor) melting and fluid-fluxed melting. In the first scenario, melting occurs at ~2.7 GPa and ~822 °C (except in the Mg-rich eclogite), triggered by phengite breakdown. During dehydration melting, only small amounts of melt (< 2 vol.%) are generated and are characterized by SiO_2 = 70–71 wt.%, K_2O/Na_2O = 0.3–1.5, and Sr/Y = 400–650. These small melt fractions will likely be unable to channelize and escape the source rock. For the fluid-flux melting scenario, melting occurs at ~2.6–2.3 GPa and ~810–820 °C. In contrast to the previous scenario, larger melt fractions are generated and are characterized by SiO_2 = 71–74 wt.%, K_2O/Na_2O = 0.1–1.4, and highly variable Sr/Y, with key phases involved in melting as phengite + clinopyroxene ± quartz ± garnet ± kyanite ± epidote. The maximum melt fractions generated by the eclogites are ~28 vol.%, suggesting that melt migration can potentially occur in this scenario.

Kylander-Clark, A. R., Hacker, B. R., Mattinson, C. G., 2012. Size and exhumation rate of ultrahigh-pressure terranes linked to orogenic stage. *Earth and Planetary Science Letters*, 321, 115-120.