From greenschist to granulite: A mineral equilibria approach to melting and melt loss

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RUNNING TITLE: MELT LOSS AND MELT REINTEGRATION MODELLING

ABSTRACT

Melt loss during regional high-grade metamorphism has important consequences for interpreting the metamorphic evolution of the lower crust and for understanding processes leading to the chemical differentiation of the crust. However, melt loss typically modifies the protolith; making it difficult to reconstruct the conditions of prograde metamorphism and the extent to which melt loss modified the rock composition. The Reynolds Range in central Australia preserves a rare example where a single melt-prone stratigraphic unit can be traced from greenschist to granulite grade conditions. Using this as a natural laboratory, *P*–*T* mineral equilibria forward models have been calculated to explore melt loss and melt reintegration where both the protolith and the residuum compositions are preserved. Incremental melt loss modelling from the protolith composition along an isobaric heating path at 5 kbar shows that the residual granulite facies rock composition is consistent with around 18% melt loss from the protolith. Large-scale, one-step melt loss from a closed rock system that had built up 18% melt resulted in a similar residual composition to incremental melt loss. The fertility of the open (incremental) system and the closed system showed the closed system produced 5.4% more melt along a heating path from 700–800 °C. Determination of the concentrations of K–U–Th with increasing metamorphic grade shows that K and U concentrations decreased with increasing metamorphic grade. Conversely, Th concentrations increased, resulting in a slight overall increase in heat production from the protolith to the residuum, despite around 18% volume loss associated with melt extraction. An implication for this is that for melt prone rocks such as metapelites, melt loss during granulite facies metamorphism does not deplete the concentration of heat producing elements in the lower crust as is typically assumed.

KEYWORDS

Metamorphic; Reynolds Range; pseudosection; melt loss; melt reintegration; THERMOCALC; catastrophic melting; heat production

MINERAL ABBREVIATIONS

bi, biotite; mu, muscovite; chl, chlorite; ma, margarite; g, garnet; opx, orthopyroxene; sill, sillimanite; ky, kyanite; and, andalusite; sp, spinel; mt, magnetite; cd, cordierite; liq, silicate melt; ksp, K-feldspar; q, quartz; pl, plagioclase; ep, epidote; ru, rutile; st, staurolite; hem, hematite; ilm, ilmenite.

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