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Microtextural controls on the dissolution of monazite and zircon during biotite-dehydration melting

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Differentiation of the continental crust into an upper layer enriched in heat-producing elements (U, Th, K) and a complementary lower crust depleted in these elements is key for continental stability[1]. Recent analysis indicates that ultrahigh temperatures (>900°C) may be required to effectively redistribute U and Th from the lower to upper crust[2], yet the exact mechanism that accounts for this observation is uncertain.

Here we test the hypothesis that mineral armouring modulates the dissolution of monazite and zircon—key Th and U carrier phases, respectively—in silicate melt produced during biotite-dehydration melting. We present microtextural and trace element geochemical observations from a suite of aluminous metasedimentary rocks (Ivrea-Verbano Zone) that preserve a record of partial melting under peak temperatures spanning the biotite-dehydration melting interval (700-900°C). Automated SEM mapping of thin sections reveals a strong positive correlation between biotite and monazite modal abundances. In the amphibolite-facies samples 8-27% of monazite is either included or adjacent to biotite grains whereas in granulite-facies and ultrahigh temperature samples that decreases to 0-22% and 0% respectively. The amount of monazite included in garnet increases from 3-10% in amphibolite to 75% in ultrahigh temperature samples. Zircon abundance is poorly correlated to biotite but still shows a similar trend of decreasing association with biotite (15-44% to 0%) and increasing association with garnet (3-29% to 38%) from amphibolite to ultrahigh temperature samples.

These findings suggest that the textural availability of accessory phases imposes an important control on the flux of U and Th into silicate melt produced during anatexis. Prior to the consumption of biotite, included carrier phases may be shielded from interacting with melt; peritectic growth of garnet serves to sequester carrier phases in the residuum. Work is ongoing to incorporate this microtextural framework into a forward model describing the evolution of melt U, Th concentrations during biotite-dehydration melting and to explore implications for crustal differentiation.

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[2] Ultra-hot origins of stable continents, Smye & Kelemen (2025), *Nature Geoscience* 18, 1296–1302.