From source disequilibrium melting to magmatic homogenization recorded by Hf isotopes in zircons

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Formation of granitic rocks represents a complicated process from partial melting in magma sources to emplacement and cooling at a shallower crustal level. Different from mafic magmas that have relatively high melt temperature and low viscosity, granitic magmas commonly show large variations in isotopes (e.g. Sr and Hf). The variations originally stem from source because continental crust is heterogeneous in mineral assemblages and isotopic compositions. In particular, the dissolution of Hf-enriched minerals (like zircon) will exert a strong influence on the bulk Hf isotopes of resulted different batches of melt. Mixing of different batches of melt in later magmatic processes and magmatic advection would promote the isotopic homogenization but this is commonly not enough. Zircon overgrowths sometimes can preserve the initial Hf isotopes as the dissolving zircon cores. In contrast, melt temperature may be an important factor controlling the isotopic homogenization because it can facilitate isotopic diffusion and also decrease magma viscosity. Hf isotopic variation in magmatic zircons from granitoid rocks therefore records temperature-dependent diffusion of this element, whatever the variation was inherited from source disequilibrium melting or magma mixing. Such variation can thus be used to calculate the melt temperature of granitoid rocks, assuming a given melt residence time. We thus propose a possible geothermometer for granitic melts regardig on Hf isotopes in magmatic zircons. The results suggest that a single granitic melt is difficult to be existed as long as >1 Myr Moreover, a temperature of at least 770 °C and possibly higher than 810 °C is suggested for granitic melts generated in Hadean time, assuming a melt residence time of less than 1 Myr. Based on the consideration of Hf isotopes, the contribution of mafic crust to the generation of intermediate–felsic rocks has remained essentially stable since the early Archean, suggesting that the composition of middle to upper crustal rocks supplying these melts has not changed substantially since early Archean times.