Constraints on temperature and timescale of granitic melts from Hf isotopes

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Hf isotope analysis in zircon crystals has been widely used to constrain the source features and magmatic processes during the formation of granitic rocks. It is common that magmatic zirons from one single hand specimen can show varied Hf isotope ratios, but its petrogenetic significance is still an open question. Whatever geological processes for its origin, Hf isotopic variation in magmatic zircons record the disequilibrium of Hf isotopes within granitic melts, while the disequilibrium is the result of the dissolution of zircon grains in magma source and the Hf diffusion in the resulting granitic melts. Given the disequilibrim melting due to the "zircon effect" in the magma source, Hf diffusion in granitic melts is a constant of melt temperature and timescale that are the two fundamental issues of granitoid petrogenesis. Therefore, it is possible to propose a model to constrain the two issues based on the Hf diffusivities in granitic melts, by which estimates of the two parameters can be carried out easily just according to the Hf isotopic variation in magmatic zircons. Compilations on published zircon Hf isotopes have shown relatively large variations for many I- and S-type granitic rocks but limited ranges for A-type granites and gabbros. Our modeling results suggest that a single granitic melt is unlikely to have existed as long as >1 m.y. because of limited Hf isotopic variations, and most I- and S- type granitic plutons have melt temperatures higher than 800 ºC, in contrast to the results by Ti-in-zircon thermometry but overally consistent with the results by Zr saturation thermometry. The modelling can be used on the Hadean zircons whose host rocks have not been found. Previously published Hf isotopes on the Jack Hills zircons show narrow εHf(t) variation for every time interval divided by 20 m.y. If some of the Jack Hills zircons are sourced from granitic rocks, their limited Hf isotopic variations indicate that the melting regime of the supracrustal rocks of the earliest crust may have taken place at the amphibole-stability field (i.e., dehydration melting), rather than a water-saturated melting. This further suggests that free water or other complementary fluids may have not been prevailed in the deep-seated melting zones of the earliest crust, which may preclude plate tectonics on the earliest time.