Time constraints of granite magma extraction from lower crustal sources derived from precise Lu-Hf and Sm-Nd garnet ages and garnet ionprobe data

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We present trace element abundances measured with an ionprobe as well as new high-precision multi-fraction Lu-Hf garnet ages obtained on restitic garnet from a medium-sized (120 km^2) granite pluton from the Central Damara orogen (Namibia) [1]. The granite is unique among other garnet-bearing granites from the Damara orogen in preserving garnet crystals that have 3 mm-wide, low-CaO (~ 1wt%) cores and broad (~1.5 mm-thick) rims with higher (~ 2 wt %) CaO abundances. The boundary between core and rim is marked by a sharp change in CaO abundance. Application of the various accessory mineral- and garnet-biotite Fe-Mg exchange geothermometers together with garnet-plagioclase geobarometers yielded equilibration temperatures of 800-900^{o}C at pressures of 9-10 kbar, implying a lower crustal source for this granite.

Besides the apparent disequilibrium in CaO between core and rim, the garnet is strongly zoned in HREE (Yb, Er, Dy), LREE (Sm, Nd), and Sr, with higher concentrations of these elements in rims relative to cores. Lu-Hf, U-Pb, and Sm-Nd garnet ages are 521±1 Ma, 500±20 Ma (large error mainly due to low $^{206}Pb/^{204}Pb$, i.e., < 60) and 493±6 Ma, respectively. ^{235}U-^{207}Pb matrix monazite ages range from 518±1 to 511±2 Ma. A poorly constrained Rb-Sr biotite-whole rock age suggests ca. 478 Ma [2]. These features imply that (i) the hot, water-undersaturated granite was capable of crystallizing igneous garnet upon pre-existing restitic garnet during ascent through the crust and (ii) the residence time of garnet was sufficiently short to preserve the zonation in CaO, HREE, and LREE in the garnet. The results also have important implications for closure temperatures of Sm-Nd, U-Pb, and Lu-Hf in garnet.

References

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