V45D-0154 - What we can learn in the kitchen sink: an example from garnet granulite

Thursday, 16 December 2021
17:00 - 19:00
Convention Center - Poster Hall, D-F

Abstract

Interpretation of geochronological and petrological data from partially-melted granulite is challenging. However, integration of multiple chronometers and mineral assemblage diagrams (MAD) can be used to estimate the nature and duration of processes. Excellent lower-crustal exposures of garnet granulite from the Malaspina Pluton, Fiordland New Zealand provide an ideal place to employ this kitchen sink approach. We use zircon U-Pb ages from LA-ICPMS, SHRIMP-RG, and CA-TIMS, garnet Lu-Hf and Sm-Nd ages, and MAD in order to evaluate local partial melting vs. melt injection, equilibrium volumes, P-T conditions, and the duration of lower crustal thermal events. Host diorite (H), garnet-clinopyroxene reaction zones (GRZ), coarse garnet selvages, and tonalite veins provide a record of intrusion and granulite facies partial melting.

Zircon U-Pb ages range from 123 to 107 Ma (all); LA-ICPMS ages contain the entire range; CA-TIMS ages range from 118.30±0.13 to 115.7±0.18 Ma; and SHRIMP-RG ages range from 121.4±2 to 109.8±1.8 Ma. The latter two techniques are interpreted to indicate primary igneous crystallization from ~119 to ~116 Ma and the youngest ~110 Ma ages are interpreted as metamorphic zircon growth. Garnet ages for ~1 cm grains are ~113 Ma (Lu-Hf & Sm-Nd) and record metamorphic growth, and <0.3 mm grains with Sm-Nd ages from 113 to 104 Ma reflect high temperature intracrystalline diffusion and isotopic closure during cooling to amphibolite facies. Zircon trace-element compositions indicate 2 distinct crystallization trends reflecting evolution of primary magma batches. MAD indicate that garnet was not in equilibrium with sampled rock compositions. Instead, garnet shows apparent equilibrium with a modeled mixture of the GRZ and the H and grew in equilibrium with an effective bulk composition that shifted toward the leucosome. This would produce the observed increase in garnet grossular content.

We conclude that: Malaspina rocks from Crooked Arm preserve evidence for 2 igneous layers which evolved as discrete magmas, igneous crystallization lasted 2 to 3 m.y., granulite metamorphism peaked ~ 3 m.y. after intrusion, metamorphism lasted ≥3 m.y., cooling occurred at ~20°C/m.y., and granulite minerals equilibrated with a mixture of solid phases and melt at ~14 kbar and 920°C (based on garnet compositions and MAD).

Plain-language Summary

The isotopic composition of zircon and garnet indicate that high temperature metamorphic rocks from the lower crust of a magmatic arc exposed in Fiordland New Zealand preserve a record of multiple magmatic intrusions followed by high temperature metamorphism. All of which lasted from c. 119 to c. 104 million years before present. Forward thermodynamic models indicate that metamorphic garnet grew in equilibrium with a mixture of solid and melt phases at 14 kbar and 920 ºC.

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