Isotopic zonation in zircon as a recorder of progressive metamorphism

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Zircon and garnet share some common traits: both are typical metamorphic phases in granulites; both are important sinks for heavy REEs; and both tend to preserve complex compositional zoning that reflects growth behaviour during high-temperature metamorphism. Although characterizations of P-T paths often rely on growth stages recorded in garnet porphyroblasts, zircon tends to be treated as a single stage mineral, with growth (and consequently age estimates from U-Pb isotopic dating) tied to a poorly defined thermal maximum. This is in contradiction to the complex zoning commonly seen in metamorphic zircon grains, especially those in metapelitic migmatites. Such zoning can only be understood through the same methods by which garnet growth is studied; ie. compositional mapping and thin-section examination of petrographic relationships. Zircon grains from metapelite samples of the granulite-grade Lutzow-Holm Complex of east Antarctica show a complex range of textures and ages. Whereas previous SHRIMP ages from zircon grain separates concentrate around 530-550Ma, and were interpreted as timing peak metamorphism, new analyses yield a spread of age estimates from 510 to 610Ma. In-situ analyses of zircon inclusions in garnet porphyroblasts reveal a stage of U-rich zircon growth at c.600Ma, with flat HREE-MREE profiles indicating prograde growth in the presence of garnet. Zircon preserved in a garnet megacryst grown in association with felsic pegmatite that fills boudin necks in a metapelitic layer show multiple stages of metamorphic growth (Fig. 1), with c.600Ma flat H-MREE (garnet-equilibrated) cores, c.570Ma rims with outward steep to flat H-MREE growth zoning, and resorbtion prior to incorporation in the garnet megacryst and crystallization of the felsic pegmatite at c.550Ma. Although the 100Ma spread of zircon ages could be interpreted as recording separate metamorphic events, the textural and chemical associations between zircon, garnet and felsic melt suggests that zircon growth was progressive through a prolonged metamorphic event, and that a large proportion of zircon growth at 530-550Ma occurred during retrograde rather than peak metamorphism.

Fig. 1. Electron microprobe (backscattered electron) and ion microprobe (REE, Y & P) mapping of a zircon grain enclosed in a garnet porphyroblast. SHRIMP spot ages were determined prior to isotopic mapping.