Geophysical Research Abstracts, Vol. 7, 04958, 2005
SRef-ID: 1607-7962/gra/EGU05-A-04958

The link between zircon behaviour and ages in high-grade metamorphism: constraints from zircon-garnet REE relationships.

N. M. Kelly, S. L. Harley
School of GeoSciences, University of Edinburgh, UK (Nigel.Kelly@glg.ed.ac.uk)

The timing of zircon growth during metamorphism is commonly ambiguous. However, knowing when zircon forms or is modified along a P-T path is key to placing tighter constraints on the rates of orogenic processes. Supporting textural and mineral chemical criteria are essential in order to place such zircon ages in a P-T, reaction and assemblage context, and to discriminate between various processes of metamorphic zircon formation. Rare earth element (REE) signatures in zircon and co-existing metamorphic minerals such as garnet are one key to addressing such problems, and has been applied here to better constrain the timing of peak UHT metamorphism in the Archaean Napier Complex, east Antarctica. UHT metamorphism in the Napier Complex, is interpreted to have occurred between ∼2600-2485 Ma. Pre-UHT ∼2626 Ma tonalitic orthogneiss places a maximum age on the onset of metamorphism, and although metamorphic zircon ages pre-dominantly fall within the period 2500-2485 Ma, it is not clear if this episode of zircon growth is linked to peak metamorphism.

To address the timing of zircon growth with respect to UHT assemblages in the Napier Complex, D_{REE} (Zrc/Grt) coefficients were calculated empirically using zircon and garnet that crystallised in equilibrium in garnet-bearing leucosome that cuts across UHT fabrics. Texturally simple zircon grains within the leucosome have flat HREE depleted patterns that produce D_{REE} (Zrc/Grt) values in the range 1.0 (Eu) decreasing to 0.7 (Yb). These grains typically have ages between 2590-2550 Ma, with older ages not confined to cores of grains. Therefore, crystallisation of zircon in equilibrium with garnet is interpreted to have occurred at $\geq$2590 Ma, a minimum estimate for peak UHT conditions.

Equilibrium D_{REE} (Zrc/Grt) criteria established using the UHT leucosome have been

used to evaluate the timing of zircon growth in two garnet-bearing paragneisses from the Napier Complex. Aluminous paragneiss preserves reaction textures suggesting garnet-breakdown to orthopyroxene and sapphirine following peak metamorphism. Zircon grains in this rock have zoned, detrital magmatic cores with ages $\geq$2800 Ma, and weakly zoned, lobate rims with ages between 2600-2400 Ma. Zircon cores have steep REE profiles typical for magmatic zircon, whereas rims have flat, HREE-depleted profiles that suggest growth in the presence of garnet. D_{REE} (Zrc/Grt) values indicate a zircon rim composition that is MREE-depleted relative to garnet, and is interpreted to be out of equilibrium. Therefore, zircon rims most likely grew during post-UHT garnet-breakdown and their age does not record peak metamorphism.

Garnet-bearing feldspathic paragneiss contains coarse-grained mesoperthite, which is interpreted to reflect equilibration at UHT conditions. Three generations of metamorphic zircon can be identified based on internal zoning patterns: low-moderate CL cores, low CL outer rims and mod-high CL rims. All three generations have flat, HREE-depleted patterns, reflecting growth in the presence of garnet. However, REE concentration in zircon decreases with age, with the oldest ($\sim$2550 Ma) low-moderate CL grains highest in REE and high CL rims ($\sim$2490 Ma) lowest, suggesting sequential growth and depletion of the REE reservoir during different stages in the UHT event. D_{REE} (Zrc/Grt) values for each generation suggest that $\sim$2550 Ma zircon is enriched relative to garnet and therefore not in equilibrium with the UHT assemblage, and $\sim$2510-2490 Ma zircon is close to equilibrium but MREE-depleted relative to garnet. We suggest that although the younger zircon population may have approached equilibrium with garnet, these rims grew after the peak of UHT metamorphism.

These data suggest that D_{REE} (Zrc/Grt) relationships are useful for assessing the timing and significance of ages from metamorphic zircon. In the Napier Complex example, we suggest that most zircon growth occurred at some time following peak UHT conditions, and that the bulk of metamorphic zircon in high-grade terranes may also grow due to a post-peak process. However, better understanding of D_{REE} (Zrc/Grt) relationships, including the effects of pressure, temperature, fO_2 and mineral composition is required to place more confidence in the interpretation of such information in natural systems.