Deformation-related modification of U and Th in zircon

N.E. TIMMS[1] , P.D. KINNY[1] AND S.M. REDDY[1]

[1] Dept. Applied Geology, Curtin University, GPO Box U1987, Perth, WA 6845, Australia; N.Timms@curtin.edu.au, P.Kinny@curtin.edu.au, S.Reddy@curtin.edu.au

This study utilises cathodoluminescence (CL) imaging, electron backscatter diffraction, and SHRIMP techniques to document U, Th and Pb concentration variations in a deformed zircon grain from a syn-tectonic pyroxenite in the Lewisian Gneiss Complex of NW Scotland.

The grain records no concentric growth zoning as shown by CL imaging, which shows little variation in the grain centre, and a hetereogenous pattern of reduced CL signal at the grain tips. Orientation data reveal that the grain accommodates over 18˚ of cumulative disorientation by a combination of gradual and discrete changes in orientation. The microstructure is interpreted to have formed due to ductile crystal-plastic deformation localised at the grain tips. Low-angle (<3˚) boundaries have tilt boundary geometry, and are consistent with having formed by accumulation of dislocations into high dislocation density walls that separate of relatively dislocation-free domains. The deformation microstructure matches precisely with the observed variations in CL imaging.

Spatial variations in U, Th, and Pb concentrations (20-60ppm, 30-110 ppm and 14-36 ppm resepctively) obtained by SHRIMP analyses correlate with cumulative misorientation across the grain, with the highest concentrations in all elements corresponding to analyses over low-angle boundaries. A systematic increase in the Th/U ratio indicates a relative increase in Th over U in the deformed zones. The distribution of geochemical data cannot be explained by concentric growth zoning. The trace element variations are best explained by a model involving hetwerogeneous post-growth geochemical modification along deformation microstructures, possibly superimposed on weak growth zoning. A suggested mechanism is localised ‘fast-track’ diffusion associated with the formation and migration of dislocations during crystal-plasticity.

The grain records little variation in $^{207}Pb/^{206}Pb$ ages for individual analyses, which define a concordant mean age of 2470 ± 30 Ma. The lack of systematic variation with deformation indicates that the grain was deformed shortly after initial crystallisation, most probably at granulite facies conditions.

The possibility that zircon trace element geochemisrty can be modified by processes associated with deformation at high-grade conditions could have important implications for U-Pb geochronology of high-grade metamorphic rocks.