



Valhalla orogenesis in the North Atlantic region: characterisation of the Knoydartian and Renland events using integrated phase modelling and in situ LA-ICPMS geochronology

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The Meso-Neoproterozoic rocks of northern Scotland have experienced multiple metamorphic events over the interval c. 1000-420 Ma. The most recent of these, the Caledonian Orogeny (c. 460-420 Ma) has obliterated much of the Neoproterozoic tectonic record, making reconstruction of the tectonic system at that time problematic. However by using a combination of in situ monazite geochronology, garnet mineral chemistry and modelled metamorphic phase relations it is possible to make inferences about the style and extent of Neoproterozoic tectonothermal events recorded in the northern British Isles. This integrated approach allows the characterisation of three discrete Neoproterozoic (Knoydartian) events in Scotland as well as a Neoproterozoic Renland event in Shetland. The presence of these events suggests a long-lived history of intermediate P-T tectonism, referred to as the Valhalla Orogen (Cawood et al., 2010).

The oldest of the Knoydartian events is c. 830 Ma (Vance et al., 1998), recorded in Moine metapelites at Polish, and involves an up pressure and temperature evolution resulting in peak conditions of c. 7 kbar and 550 °C (Cutts et al., 2009a). The second event at c. 790 Ma is recorded in metapelites at Polish and also Glen Urquhart (Vance et al., 1998). P-T conditions from Polish indicate a near isobaric temperature increase resulting in peak conditions of c. 8 kbar and 650 °C (Cutts et al., 2009a). Glen Urquhart conditions at c. 790 Ma are poorly constrained, but based on garnet compositional modelling are estimated to be c. 6 kbar and 600-650 °C. The final event at c. 725 Ma is recorded in metapelites from Glen Urquhart. P-T conditions are initially around 7 kbar and 650 °C and increase to peak conditions of around 9-10 kbar and 700 °C (Cutts et al., 2010).

In Shetland, the Renland event is manifest on western Unst as upper amphibolite-grade metamorphism occurring at 950-930 Ma. Neoproterozoic metamorphism achieved peak conditions of c. 7 kbar and 700 °C. The Neoproterozoic sillimanite bearing assemblages were overprinted by later kyanite bearing assemblages interpreted to be Caledonian in age with peak P-T conditions of c. 8.5 kbar and 650 °C. Elsewhere on Shetland the Caledonian Orogeny is recorded at c. 460 Ma with peak pressures of 8-10 kbar and temperatures of 550-750 °C (Cutts et al 2009b).

The areal and temporal extent of individual Neoproterozoic events is still poorly constrained. However in each case metamorphism was associated with burial of supracrustal packages to depths of around 25 km, strongly suggesting that metamorphism occurred in contractional regimes. At least for the Polish region, the available geochronology is sufficiently precise to constrain average burial velocities to comparatively slow rates, suggesting that contractional deformation may have occurred within a slowly evolving tectonic regime.

References:

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