Geophysical Research Abstracts
Vol. 16, EGU2014-4060, 2014
EGU General Assembly 2014

Caledonian evolution of the Moine Supergroup: Prograde garnet growth and context for quartz fabric-based deformation thermometry

Richard Law, Kyle Ashley, and Ryan Thigpen
Virginia Tech, Geosciences, Blacksburg, United States (rdlaw@vt.edu)

Despite the detailed Caledonian structural/tectonic framework developed for the Moine Supergroup of northern Scotland, debate continues over the tectonic processes that drove metamorphism. Rapid temporal evolution of the metamorphic sequence has led some geologists to suggest that crustal thickening alone cannot provide sufficient heat flow to reach the metamorphic grades observed. Rather, they postulate that large-scale contact metamorphism or initial heating in an extensional, back-arc setting is required. We present coupled petrographic analyses and forward phase stability modeling for quantifying prograde metamorphic evolution in pelite horizons dispersed across the Caledonian thrust sheets. Results suggest garnet growth was syn-kinematic during prograde decompression. Rutile and ilmenite inclusions in garnet cores and rims, respectively, support this claim, while chemical profiles and crystal morphology argue against a detrital origin for these garnet grains. The observed clockwise P-T path for these garnets is incompatible with extensional or contact metamorphic models (would require counter-clockwise paths). Rather, the P-T data suggests advection of isotherms during thrusting as the dominant mechanism for metamorphism (Thigpen et al., 2013). Recent studies in other orogens (e.g., Spear et al., 2012) suggest that heating over long time scales under mid-crustal conditions may not be needed to reach the metamorphic grades observed. Therefore the structurally higher, more hinterland Caledonian thrust sheets may have reached peak metamorphism in a much shorter time period than previously expected.

The paucity of pelitic horizons across the foreland-positioned Moine thrust sheet has previously limited insight into the prograde evolution of these rocks. However, the dominance of quartz-rich units has allowed the thermal structure of the thrust sheet to be evaluated using quartz c-axis fabric opening angle-based deformation thermometry. Microstructures in the pelites sampled indicate that garnet (rim) growth is syn-kinematic with respect to the Scandian (mid-Silurian) deformation fabrics. Deformation temperatures indicated by quartz fabric opening angles are very similar to temperatures of metamorphism constrained using pseudosection and petrographic data from adjacent pelite horizons. This suggests that the deformation- and petrology-based data sets are providing information on the same thermal event. These results support the use of quartz deformation thermometry in obtaining thermal profiles across tectonic units where rock types (usually pelites), with metamorphic mineral assemblages suitable for petrology-based thermometry, are not present.

Thigpen, J.R., Law, R.D., Loehn, C.L., Strachan, R.A., Tracy, R.J., Lloyd, G.E., Roth, B.L., and Brown, S.J., 2013, Thermal structure and tectonic evolution of the Scandian orogenic wedge, Scottish Caledonides: integrating geothermometry, deformation temperatures and conceptual kinematic-thermal models, J. Metamorphic Geol., 31, 813-842.

Spear, F.S., Ashley, K.T., Webb, L.E., and Thomas, J.B., 2012, Ti diffusion in quartz inclusions: implications for metamorphic time scales, Contrib. Mineral Petrol., 164, 977-986.