Time-scales and heat sources for Barrovian regional metamorphism

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Time-scales for metamorphism have significant implications for the feasibility of potential heat sources. New constraints for the duration of metamorphism associated with the production of Barrovian assemblages has renewed interest in the origin of Barrovian regional metamorphism.

Geochronological data from the Dalradian of Scotland and Ireland has restricted the duration of the Grampian tectono-thermal episode to ~10-15 Ma or less [1-3]. Models for Barrovian regional metamorphism that invoke thermal relaxation following lithospheric thickening for heating require durations of ~40-50 Ma [4] and are unable to account for such a rapid thermal episode. To explain such a short-lived tectono-thermal event one needs to appeal to alternate or additional heat sources. Regional metamorphism in collisional settings is typically treated within the context of lithospheric-scale shortening. Simple 2D numerical models are used to test a mechanism for short-lived (< 10 Ma) metamorphic heating during extension in the overriding plate at a convergent plate boundary.

Terrane juxtaposition along large-scale, normal-sense shear zones and associated shear heating was modelled as a potential cause for Barrovian regional metamorphism. The heat budget in the upper plate of the model is comprised of heat generated within the shear zone by mechanical heating and conductive heat transferred from the footwall. Preliminary results suggest that for extension accomodated by low-angle (< 20°) normal sense shear, contributions from each heat source is comparable and that the additive effect of both heat sources is able to produce a thermal pertubation of the magnitude required for Barrovian metamorphism in the hanging wall. From the modelling, it is also apparent that the thermal response of the rock mass to shearing is strongly strain rate dependent. For quick shearing, a thermal anomoly is established and temperature increases are sizeable, while for slower shearing heat is effectively dissipated and thermal effects are minimised. According to these models regional metamorphism is essentially the result of shearing during a rapid, post-thickening extension event and displays a punctuated thermal development.

References

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