INTEGRATING MICROSTRUCTURE AND GEOTHERMOBAROMETRY IN DECIPHERING COMPLEX TECTONOMETAMORPHIC HISTORIES: EXAMPLES FROM THE NEW ENGLAND APPALACHIANS, USA

Volume 1

Thesis submitted by

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I declare that this thesis is my own work and has not been submitted in any other form for another degree or diploma at any university or other institution of tertiary education. Information derived from published or unpublished work of others has been acknowledged in the text and a list of references is given.

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STATEMENT ON THE CONTRIBUTION OF OTHERS

T. H. Bell provided supervision, guidance and editorial assistance for this body of work. Funding for fieldwork and analyses was provided from an ARC Large grant to T. H. Bell and a JCU Doctoral Merit Research Scheme grant to myself. Stipend support was received from a JCU School of Earth Sciences and an Australian Postgraduate Award (APA) Scholarship.

The samples and microstructural data seminal to the approaches pursued in this study were originally prepared and acquired by A. P. Ham and N. E. Timms.

Section 2 is a slight variation as to what has been submitted as a paper to an international journal during 2010. It was co-authored with myself by T. H. Bell, T. P. Evans, M. Cihan, A. P. Ham and P. W. Welch. The contribution for this paper of T. H. Bell is around 49% while the combined contribution of M. Cihan, T. P. Evans, A. P. Ham and P. W. Welch for the paper totals around 2%.

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ABSTRACT

The integration of geothermobarometry with microstructure has allowed a temporally constrained comparison and correlation of tectonothermal events across an orogen to a resolution and complexity not decipherable by traditional approaches. A succession of five foliation intersection/inflection axes in porphyroblasts (FIAs) reveal that the New England Appalachians in central Vermont contain rocks that were progressively deformed and metamorphosed from *c.* 430 Ma through to *c.* 360 Ma. The pattern of deformation partitioning shifted with change in FIA trend with distributed strain being initially localized to the Pomfret dome but eventually migrating 45 km southwards to the Chester–Athens dome. They also reveal that garnet porphyroblasts nucleated in pelitic rocks for the first time from location to location throughout this history suggesting that *T*, *P* and bulk composition were not the sole controls on the reactions that proceeded. Rather, deformation partitioning at the scale of a porphyroblast was a key trigger to mineral growth. The *T* and *P* of nucleation of garnet cores were calculated using *P–T* pseudosections in conjunction with Mn, Ca and Fe compositional isopleths via THERMOCALC. A tightly constrained, FIA-controlled *P–T–t–d* path obtained from the cores of garnet porphyroblasts in rocks from the Pomfret dome region of Vermont has enabled an opportunity for real limits to be placed on the errors involved using THERMOCALC. A little varying *P–T* path ranges over a maximum of 2.3 kbar (including thermodynamic error) for all garnet porphyroblasts that progressively nucleated over a >70 million year time span. The narrow *P* range for the samples studied suggests that the Pomfret dome region remained at a stable depth in the crust over this extended period and consequently it proposed that THERMOCALC *P* estimates in these rocks have a limited effective error of less than ± 1.2 kbar; allowing for the variation in the *P–T* path. The pressure remained around 7.2 kbar in the Pomfret region throughout the many deformations that occurred over the next >70 million years. It did not increase to these levels at the Chester–Athens dome until half way through the succession of FIA shifts. At this time, increased competency in the Pomfret region, due to the large amount of garnet growth that had occurred there, forced sub-horizontally directed bulk shortening to partition preferentially into the Chester region, thickening the crust and moving these rocks to 8.4 kbar. The correlation of this area across the Connecticut Valley border fault to the Orford–Piermont region of New Hampshire indicates quantitatively that fundamentally that the same history of orogenesis occurs on both sides of this terrane boundary. Reaction overstepping amounts relative to the incoming of the garnet-in reaction boundary from region to region is variable with magnitudes dependent on what *P–T* conditions operated when partitioning of deformation at the scale of a porphyroblast triggered garnet nucleation.

Key words: New England Appalachians; garnet core; FIA; deformation partitioning; reaction overstep.