Geothermometry of the western half of the Central Metasedimentary Belt, Grenville Province, Ontario, and its implications

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ABSTRACT

Calcite-graphite carbon isotope thermometry results are presented for 150 new marble samples across the western Central Metasedimentary Belt (CMB) of the Ontario segment of the Grenville Province. The results show a gradual increase in peak metamorphic temperature from under 500 °C in the Tudor Township area in the east to over 700 °C along the western margin of the CMB. Modestly elevated δ13C values above 3‰ across all terranes in the study area suggest a common temporal, and perhaps depositional origin, for the ~1.3 Ma limestone protoliths. The preserved thermal gradient is consistent with variations in marble mineralogy and character. Based on published geochronology, we argue that these temperatures correspond to peak metamorphism during the 1090–1020 Ma Ottawan orogeny, with the exception of preserved contact aureoles most notably associated with the Tudor gabbro and the Cheddar granite. The lack of significant thermal discontinuities at terrane boundaries and other shear zones, including the Bancroft shear zone and the CMB boundary zone, indicate that the entire region including the adjacent Central Gneiss Belt remained largely intact during and after the Ottawan peak metamorphic event. Variations in deformation style of pre-existing igneous complexes appear to correspond to the Ottawan thermal conditions, which include crystalline thrust sheets at high temperature, and mildly foliated domes to undeformed plutons at decreasing temperatures. In light of the peak temperatures and smooth thermal gradient we show to be superimposed on the established Grenvillian architecture, much of the western CMB should be considered part of the allochthonous medium pressure belt, and separate from the Ottawan orogenic lid that defines the eastern CMB.

Keywords: Grenville Province, Ottawan orogenic lid, thermometry, metamorphism, marble, calcite, graphite, stable isotopes, carbon isotopes, crustal rheology; Isotopes, Minerals, and Petrology: Honoring John Valley

INTRODUCTION

Temperature plays a key role in many processes related to orogenesis, including melting, fluid migration, and deformation mechanisms (either crustal or grain scale), hence the thermal structure of ancient orogens is of primary significance in understanding these processes. The Grenville Province of North America is a deeply eroded mid-Proterozoic, Himalayan-style orogenic belt that serves as an important example for understanding orogenesis. In this paper, we present new thermometry results for a significant area (~3000 km²) of the Ontario segment of the Grenville Province where quantitative data have been lacking until now. The thermal structure revealed has implications for large-scale processes in the orogen.

The Grenville Province of Ontario and New York state (Fig. 1) is a 675 km wide belt of igneous and metamorphic rocks that span a wide range of ages from ~1400 to 950 Ma. The Grenville is bounded on the west by the Archean Superior Province (foreland) and on the east by the Paleozoic Appalachian orogenic belts. The western Grenville includes the Central Gneiss Belt (CGB) (or Ottawa River Gneiss Complex of Rivers and Schwerdtner 2015), which contains reworked older crust, and the Central Metasedimentary Belt (CMB) (or Composite Arc Belt of Carr et al. 2000), which is the focus of this study, and consists of several terranes that together represent an amalgamation of arc rocks and associated sedimentary basins metamorphosed at relatively low pressure. The CMB is in thrust contact against the CGB along the Central Metasedimentary Belt boundary zone (CMBbz). East of the CMB are medium pressure granulite facies rocks of the Adirondack Highlands. Outliers of Grenville-aged rocks occur in many of the Appalachian mountain belts, such as the Green Mountains of Vermont and the Berkshires of Massachusetts.

The complex history of the Grenville involves multiple episodes of igneous and metamorphic activity and tectonic assembly to the present-day architecture. Most relevant to this study is the widespread Ottawan orogeny (~1090–1020 Ma) that resulted in significant crustal thickening followed by late- or post-collisional extension and orogenic collapse (Mezger et al. 1991; Selleck et al. 2005; Rivers 2008, 2012; Jamieson et al. 2010; McLelland...