How do large hot orogens work? Lessons from the middle crust

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Large hot orogens are characterized by their broad areal extent, crustal thicknesses exceeding ca. 60 km, central plateaux bounded by external thrust wedges, and internal temperatures high enough to promote widespread partial melting in the middle and lower crust. In these systems, meltweakened middle crust can flow in response to a pressure gradient and/or underthrusting by a strong indentor, leading to lateral transport of ductile middle crust (infrastructure) relative to both cooler upper crust (superstructure) and stronger lower crust and upper mantle. The resulting dynamic behaviour and geological characteristics of large hot orogens are therefore fundamentally different from those of typical fold-and-thrust belts. The Mesoproterozoic Grenville orogen of Ontario presents a superb opportunity to investigate the mid-crustal level of a large, hot, convergent orogenic system. Over the past 30 years, field, structural, petrological, and geochronological studies along the wellexposed Georgian Bay transect have illuminated the fundamental tectonic characteristics of the western end of the orogen. It was assembled by northwest-directed ductile thrusting towards the Archean foreland between ca. 1100– 1040 Ma, and reworked by ductile extension and flattening between 1040–1000 Ma. Widespread upper amphiboliteto granulite-facies assemblages record P-T conditions of 10-14 kb at 700–900°C. Protoliths were largely pre-1200 Ma Laurentian crust with some peri-Laurentian accreted terranes. 2D thermal-mechanical numerical models were used to investigate the geodynamic behaviour of the system. The results suggest that lateral flow of migmatite in the orogenic core was triggered by transport of strong lower crust beneath melt-weakened middle crust. Post-convergent flow was accompanied by ductile thinning and extension in the orogenic core and coeval thrusting on its flanks. While there is good first-order agreement between model predictions and observations, further testing against geological data is required. Comparison of model results with observations from the Grenville orogen and similar systems suggests that significant volumes of Proterozoic orogenic crust may have been reworked by ductile lateral flow of middle crust.

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