Hot nappes and lumpy channels: Application of large hot orogen models to the western Grenville orogen

Rebecca A. Jamieson*[1], Nicholas G. Culshaw[1], Christopher Beaumont[2], and Trond Slagstad[1,3]

[1]Department of Earth Sciences, Dalhousie University, Halifax, N.S. B3H 3J5; [2]Department of Oceanography, Dalhousie University, Halifax, N.S. B3H 4J1; [3]Geological Survey of Norway, 7491 Trondheim, Norway

Recent models for the tectonic evolution of large, hot orogens (Beaumont *et al.* 2001; in press) suggest that weak middle orogenic crust may flow outward in response to a topographically-induced pressure gradient. In laterally homogeneous crust the outward flow forms a low-viscosity channel bounded by thrust-sense and normal-sense shear zones ("homogeneous channel", Fig. 1a; Beaumont *et al.*, 2004). Where lower crust is laterally heterogeneous, crustal thickening leads to the formation and stacking of a series of discrete thrust nappes ("hot nappes", Fig. 1c) that may be expelled over a colliding strong lower crustal block. An intermediate flow regime may arise where lower crustal nappes become disrupted by and partly incorporated into heterogeneous channel flow at mid-crustal levels. In this case, the resulting crustal structure could include moderately dipping, lower-crustal thrust sheets overlain by a "lumpy channel" (Fig. 1b) consisting of shallow-dipping migmatites containing fragments of lower crustal rocks.

The Mesoproterozoic Grenville Province represents a Himalayan-scale convergent orogen formed on the southeastern margin of Laurentia at ca. 1200-1000 Ma. In the Central Gneiss Belt (CGB) of Ontario, Laurentian crust was reworked at syn-orogenic depths of 25-35 km, mainly during the Ottawan phase of the Grenvillian orogeny (ca. 1090-1040 Ma). Widespread migmatite and granulite record peak metamorphic conditions of 750-900°C at 10-12 kb, probably beneath an orogenic plateau (Culshaw *et al.*, 1997). Conditions within this part of the Grenville orogen may thus have been favourable for channel flow and/or the formation of hot nappes.

Based on a combination of Lithoprobe seismic profiles and a wide range of geological, structural, petrological, and geochronological data, we propose that the Georgian Bay - Muskoka region, at the western end of the CGB, may represent the exhumed remnants of a hot nappe-channel system active at the peak of the Ottawan orogeny. Evidence for a low-viscosity channel comes mainly from the Muskoka domain, which comprises shallow-dipping, highly migmatitic orthogneisses that form thin, laterally extensive, lobate sheets. Voluminous syntectonic leucosome formed at ca. 1065 Ma (Timmermann *et al.*, 1997); the high-strain zone at the base of the Muskoka domain is cut by a ca. 1047 Ma granite dyke (Slagstad *et al.*, submitted). Underlying rocks are much less migmatitic and contain significant volumes of mafic to intermediate granulite. On the crustal scale, however, the CGB and the adjacent Central Metasedimentary Belt Boundary Zone (CMBBZ; Fig. 1d; White *et al.*, 2000) display moderately dipping reflective zones suggesting a "hot nappe" style of deformation. Allochthonous granulites of the Parry Sound domain preserve steep, pre-Ottawan structures that could be the disrupted remnants of an early Grenvillian (Elzevirian) hot lower crustal nappe.

Fragmented anorthosite and retrogressed eclogite bodies are widespread within the CGB, particularly along domain boundaries (e.g., Ketchum & Davidson, 2000); their petrology indicates that they must have originated at a much deeper crustal level than is currently exposed.

These features suggest that "hot nappes" played a role in the tectonic evolution of the CGB, and that early-formed lower crustal nappes may have been disrupted by and locally incorporated into a low-viscosity channel during the Ottawan orogeny. If so, the accretionary history of the CGB may have been much more protracted, and lateral transport of the various lithotectonic domains may have been far greater, than previously suspected. This interpretation may help to reconcile different views on the timing of the main Grenvillian collision (ca. 1160 Ma *vs* 1080 Ma; e.g., Carr *et al.*, 2000).

References:

Beaumont *et al.* (2001) *Nature* **414**, 738-742.
Beaumont *et al.* (in press) *J. Geophys. Res.*
Beaumont *et al.* (2004) *this volume*
Carr *et al.* (2000) *Can. J. Earth Sci.* **37**, 193-216.
Culshaw *et al.*(1997) *Tectonics* **16**, 966-982.
Ketchum & Davidson (2000) *Can. J. Earth Sci.* **37**, 217-234.
Slagstad *et al.* (submitted) *Can. J. Earth Sci.*
Timmermann *et al.* (1997) *Can. J. Earth Sci.* **34**, 1023-1029.
White *et al.* (2000) *Can. J. Earth Sci.* **37**, 183-192.

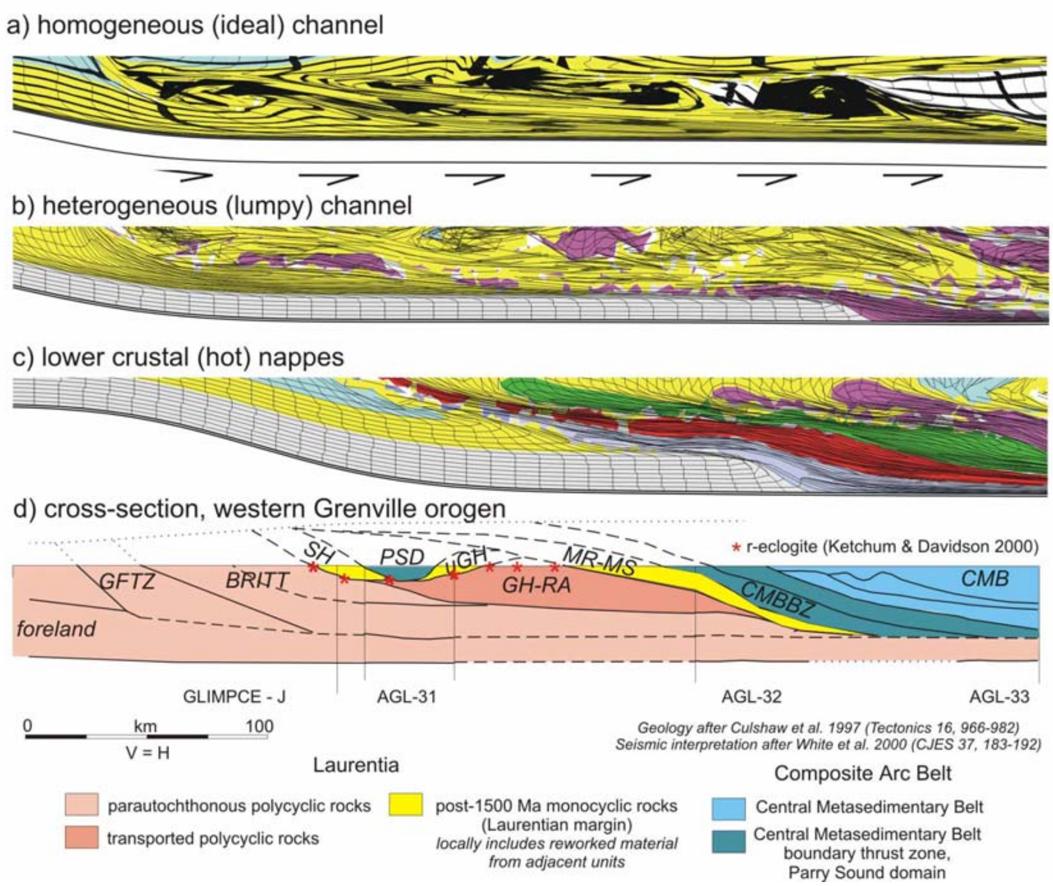

Fig. 1. Model results illustrating possible flow modes in large hot orogens (a, b, c; Beaumont *et al.*, 2004), compared with crustal-scale cross-section for the western Grenville orogen (d).