THE LITHOPROBE ABITIBI-GRENVILLE TRANSECT: TWO BILLION YEARS OF CRUST FORMATION AND RECYCLING IN THE PRECAMBRIAN SHIELD OF CANADA

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Lithoprobe studies in the southeastern Precambrian shield of Canada, in the western and central parts of the Grenvillian orogen and in the southeastern Superior Province, have provided some of the most complete information about the formation, stabilisation and reworking of crust.

In the southeastern Superior Province, the studies have revealed the processes of accretion of primitive crust during subduction related to a prograding arc system, which resulted in the formation of the largest fragment of Archean continental crust preserved on Earth. This addition of primitive material to Earth's surface occurred rapidly as a result of short-lived collisions between two or more protocontinents at around 2700 to 2680 Ma. A well defined relict suture zone bounding terranes of different age and character, for which the seismic fabric resembles that of modern small orogens such as the North Island of New Zealand, is inferred to testify to arc-accretion processes similar to those of the modern day. The immature crust was rapidly reworked both by intrusion from the mantle and by melting of deep crust resulting from tectonic thickening of crust in the Opatica Plutonic Belt and the Pontiac subprovince. Maturation of the Archean crust continued for at least 200 million years, and shear zones were the sites of repeated fluid egress and metamorphic regression in the upper crust. Magmatism and rifting associated with stretching of the southern margin of the Superior craton at around 2400 Ma resulted in re-heating and metamorphism of the lower crust of the Abitibi section of crust, and thinning of the crust towards the present location of the Grenville Province. This Archean craton and its underlying lithosphere provided the buttress for the Grenvillian orogeny.

Lithoprobe results for the Grenvillian orogen provide the best model of a deep continental-collision zone so far studied anywhere on Earth. In contrast to the formation of the Superior crust, the continental collision was protracted, with contraction occurring over an interval of at least 100 million years and, if the Shawinigan pulse is included in the continental collision, for perhaps twice as long. Contraction was, however, not continuous and large regions of the continental margin that had been deeply buried during the Ottawa pulse were rapidly unroofed before renewed shortening during the Rigolet pulse. Unroofing of the deeply-buried rocks was achieved probably by a combination of extrusion and orogenic collapse, with extrusion better developed, or at least more evident, in the eastern Grenville, where it may have been aided by the presence of a lateral ramp in the subsurface.

The studied region of the Grenville transect is characterised by uniformly southeast-dipping structures, the majority of which developed through the northwestward propagation of thrusts. There is a well-developed and generally consistent younging of metamorphic ages towards the foreland, consistent with a normal sequence of forelandward propagation of a large-scale orogenic wedge. The general absence of out-of-sequence thrusting, and particularly the development of new thrusts in front of the region most affected by the Ottawa pulse, rather than re-thickening of the region, is one of the more surprising observations from the study, given that there is widespread evidence for orogenic collapse following the Ottawa pulse. If this is a general feature of orogens, it would provide support for our suggestion that orogenic collapse strengthens the lithosphere because of cooling and strengthening of the lower crust.

Although orogenic collapse following the Ottawa pulse of the Grenvillian orogeny was important, the process appears to have been far less dramatic and perhaps on a much smaller scale following the Rigolet pulse. There is widespread evidence for a strong lower crust near the Grenville Front in the later stages of the Grenvillian orogeny. Only in the westernmost part of the province is there some suggestion that the lower crust deformed through widely-distributed plastic flow. Elsewhere there are normal faults that cut and offset the Moho (Section C) and thick roots beneath the Grenville Front (Section D). These features presumably result from superposition of the Grenvillian collision on continental crust that was old and cool. It is surprising that this lower crust remained cool throughout the Rigolet pulse, and raises the question of whether there was indeed substantial crustal thickening at that time. High grades of metamorphism are generally considered indicative of crustal thickening, but they are equally explicable by tectonic extrusion. The absence of substantial crustal thickening during the Rigolet pulse could then explain the apparently limited ensuing orogenic collapse. Establishing the relative importance of extrusion and orogenic collapse for the rapid unroofing of deeply-buried rocks in collisional zones is one of the major challenges for future studies in this and other collisional orogens.

Reference: Abitibi-Grenville LITHOPROBE synthesis volume, *Editors, Ludden, J. N. and Hynes, A.,* Canadian Journal of Earth Sciences, vol ##, 2000 (In press).