

The LITHOPROBE Trans-Canada Lithospheric Cross-Sections: A Plate-Scale View of Continental Assembly

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Introduction

A continental-scale synthesis of more than two decades of coordinated multidisciplinary Earth science research has yielded a lithospheric-scale cross-section of the entire North American continent. The Lithoprobe Trans-Canada Profile and two additional profiles through northern Canada provide a unique perspective at a continental scale. The cross-sections were developed to be useful for teaching purposes and the non-specialist audience, as well as for the research community. The interpreted profiles illuminate the assembly of the North American continent and highlight the lithospheric structures generated as collision and accretion builds continents. For the more advanced audience, relationships between orogens are emphasized and the display permits visual comparisons to be made regarding structure and tectonic development.

Construction of the Cross-Sections

The Lithoprobe project coordinated study on ten targeted areas, or transects (Figure 1). These carefully selected corridors are not only representative of Canadian geology, but they provide examples of globally significant tectonic processes. The resulting dataset represents new information from remnants of nearly every kind of tectonic regime. The geologic history of the entrained rocks spans the Present to the Mesoarchean (4.0 billion years ago (Ga)). Each Lithoprobe transect involved the full spectrum of surface-based geological investigations integrated with seismic reflection and other remote-sensing geophysical tools that provided the critical constraints for structure at depth. The structures displayed in the lithospheric cross-sections are primarily based on seismic data. However, the regional geometry and the interpretations of the structure and tectonic processes rely on all the geological, geochemical, and geophysical data available for that region. The broad-scale synthesis provided by the lithospheric cross-sections relies on this foundation and on the current published interpretations.

The transects (and their internal components) were designed such that they could be linked directly or by projecting along strike (Figure 1). The southern eight Lithoprobe transects are used to assemble the trans-Canada lithospheric cross-section, a 6000 km-long corridor that traverses southern Canada at 45-55°N. The interpreted profile extends to the base of the lithosphere, reaching approximately 270 km depth beneath the cratonic core of the continent. The profile crosses the Juan de Fuca ridge off the west coast, Vancouver Island, the Cordillera of British Columbia and Alberta, the prairies of Alberta and Saskatchewan, the exposed Canadian Shield of Manitoba, Ontario and Québec and the Great Lakes, and extends across the Gaspé peninsula to Newfoundland and the Atlantic Ocean basin. Major tectonic domains traversed include the active Cascadia subduction zone, the Cordilleran, Albertan, and Trans-Hudson orogens, the Superior Province, the Keweenawan rift, the Grenville and Appalachian orogens, and the Atlantic passive margin. Two northern transects yield two additional cross-sections (Figure 1). The northwestern cross-section represents a 2000 km-long corridor that extends from the Pacific plate west of Haida Gwaii (Queen Charlotte Islands, BC) to Yellowknife (NWT) (54-63°N). The profile crosses the Cordilleran, Wopmay, and Slave orogens. In Canada's northeast, a 1600 km-long corridor crosses northern Québec and Labrador and

continues down Labrador's east coast (52-61°N). The profile crosses the New Québec and Torngat orogens, the Nain craton, and the Makkovik and Grenville orogens. The large-scale display incorporates Earth curvature and emphasizes how plate collisions and accretions have sequentially stacked orogen upon orogen such that one forms basement to the next. The stacking and wedging of the orogens is remarkably similar across the continent despite the range of complexity and age of the lithosphere involved.

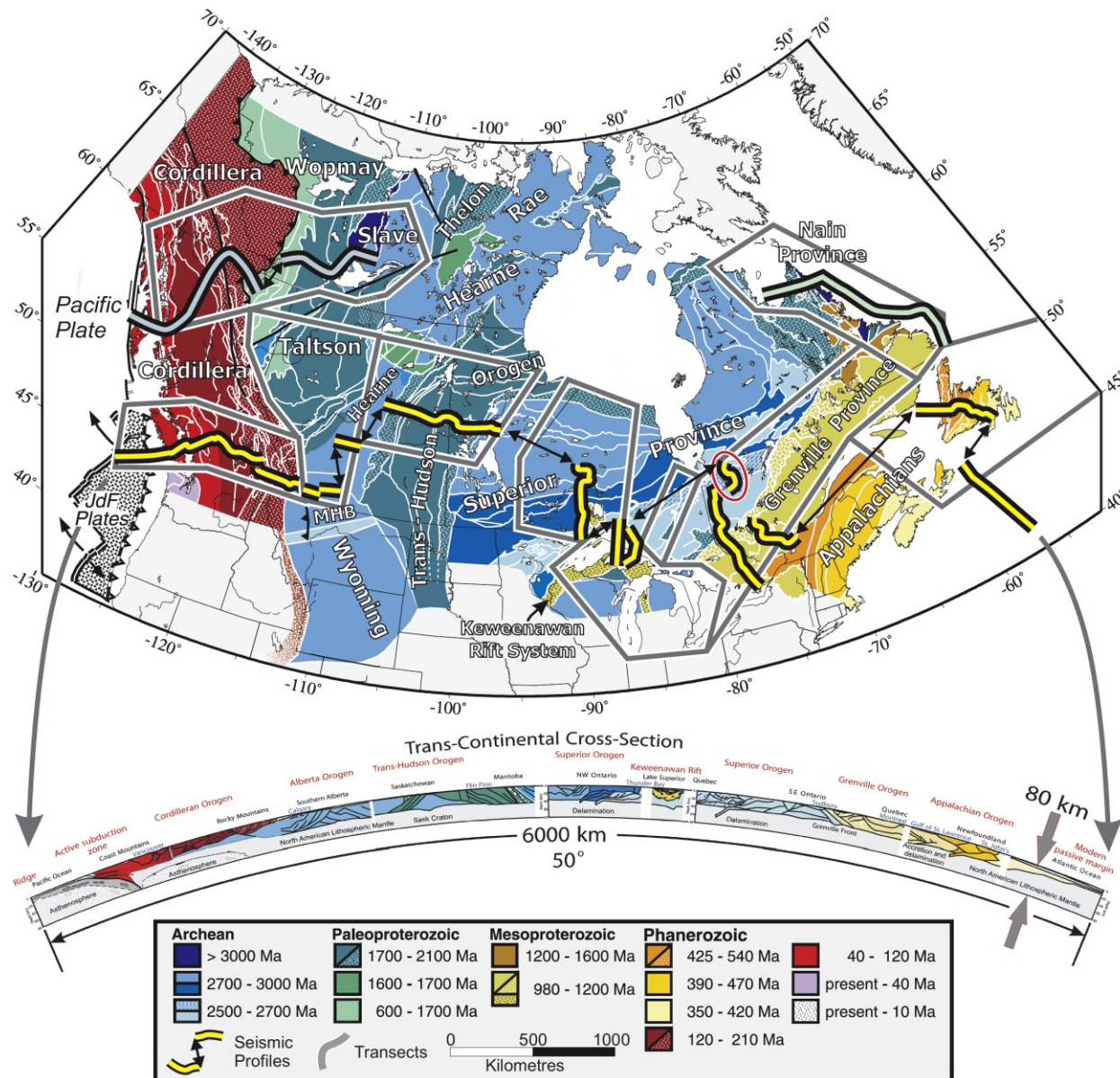


Figure 1: Location of Lithoprobe transects (grey polygons) on a simplified tectonic age map of northern North America. Tectonic age is defined as the time since the most recent episode of tectonic deformation. White lines indicate domain divisions within the major tectonic elements. The locations of the trans-Canada lithospheric cross-section (yellow lines) and the two northern cross-sections (blue/green lines) are noted. The double-headed arrows show the along-strike offsets linking the segments of the profiles. The primary interpreted cross-section, corrected for Earth curvature is shown here at a scale of 2:1. At this scale, features are difficult to identify. Figure 2 provides an enlargement of one small section of the southern profile (red oval).

Observations and Summary

The results of many of the major tectonic events that led to the formation of the North American continent are contained within the cross-sections due to the remarkable preservation of structure in the crust and upper mantle. For example, the data clearly image subducted oceanic lithosphere frozen in place since the early Proterozoic (1.7 billion years (Gy), Northwest Territories) and Neoproterozoic (2.69 Gy, Québec, Figure 2). In contrast, and perhaps equally surprising, is the general absence of crustal roots beneath orogens including the young Cordilleran orogen. Only two clear crustal roots were imaged under the many orogens included in the study (beneath northeastern Labrador and central Saskatchewan). The absence of roots requires the crust-mantle boundary (and Moho) to be a dynamic feature.

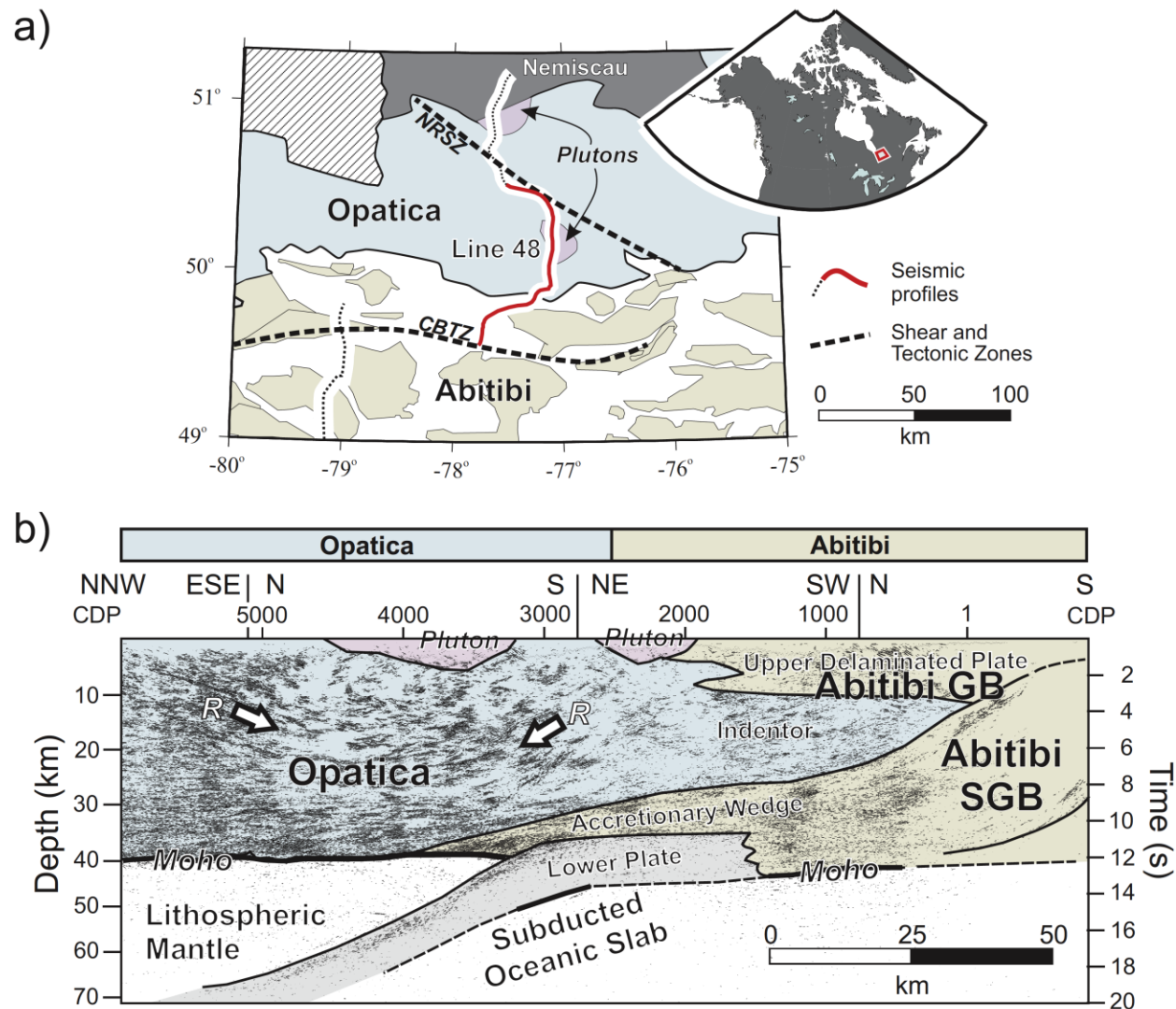


Figure 2: Results from the Abitibi-Grenville transect, southwest Quebec. a) Geological map showing the location of the seismic reflection line (red portion shown in (b)). Location is also shown by red oval in Figure 1. Abbreviations: CBTZ-Casa Berardi tectonic zone, NRSZ-Nottaway River shear zone. b) Migrated near-vertical incidence seismic reflection profile with interpretation (adapted from Calvert et al., 1995) This profile is one of the best images of relict subduction and provides convincing evidence for modern-style plate tectonics back to 2.69 Ga.

The profiles illustrate that the Canadian Shield was formed more than 2.6 Ga through a sequence of collisions of microcontinents and intervening ocean basins and islands. Plate tectonics clearly were an important component to continental evolution to at least that point in Earth history. The profiles also provide a reminder of the power of time and erosion. The massive collisions that assembled Laurentia 1.7-2 Ga (e.g., the Trans-Hudson, Wopmay, Taltson, and Thelon orogens) and later added much of the eastern part of the continent, culminating in the Grenville orogen (1.2-1.0 Ga) would have constructed Himalayan-scale mountain ranges (Figure 1). Now, of course, those former collision zones in the Northwest Territories, Nunavut, the Prairies, and southern Ontario and Québec bear little obvious connection to their previous topography. Another important structure highlighted in the cross-sections is the failed rift zone beneath the Great Lakes that almost split North America in two about 1.1 Ga.

We would like to develop the cross-sections into a resource to be used by educators and the general public. They will be presented in a poster format suitable for a general audience and versions will be made available at www.lithoprobe.ca. More detailed information and references can be found in Hammer et al. (2010).

Acknowledgements

As a project- and continent-scale synthesis of over two decades of research, the cross-sections pull together the superb work done by hundreds of researchers. Unfortunately, it is impossible to give credit here to all who made contributions, but we would like to recognize and thank all those whose work played a role.

References

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