North American Earth Science Megaproject Continuum, Part 1: LITHOPROBE (1984-2005)

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North American Earth sciences have benefitted from the exceptional output and community-building that resulted from the Canadian LITHOPROBE (1984 to 2005) and U.S. EarthScope (2004 to 2020; see Part 2) programs. LITHOPROBE is an internationally acclaimed research project that was established to study the development of the North American continent from the Paleoarchean to the present and to investigate the varied and complex processes involved in that development. The studies had scientific, economic and social benefits (Clowes 2010). Collaborative, multidisciplinary research was the key to LITHOPROBE's scientific and related successes. Ten study areas, or transects, across Canada focused on tectonic regions that addressed globally significant processes (Fig. 1). Each transect involved a multidisciplinary team of scientists; more than 1500 publications were generated. LITHOPROBE demonstrated the applicability of the high resolution seismic reflection technique to base metal and uranium exploration. In cratonic areas, LITHOPROBE seismic and MT studies provided new information relevant to exploration for diamonds and understanding of the geology and tectonic environments within which kimberlite intrusions occur. On the west coast, LITHOPROBE studies provided data and a framework for better understanding the mega-thrust earthquake hazard in the region. LITHOPROBE established an effective public outreach strategy.

By combining results from the southern eight transects, the LITHOPROBE trans-continental cross-section (including earth curvature) was compiled (Fig. 2). The cross-section is based on near-vertical incidence seismic reflection and refraction / wide-angle reflection data, combined with a broad range of other geophysical, geological, geochemical and geochronological data and their interpretation. It provides a view of the North American continent at a scale that emphasizes relationships between orogens rather than detailed patterns within orogens. Plate collisions and accretions have sequentially stacked orogen upon orogen such that one forms basement to the next. Boundary relationships between adjacent terranes as well as structure within terranes are preserved and sometimes linked from outcrop to Moho by correlating seismic reflections with structures and stratigraphy. The orogens exhibit subcretion (mechanical underplating) as is observed in subduction/accretion zones, mid-crustal tectonic wedging and crustal ramping up a full crustal-scale décollement from the Moho. First-order observations show that these stacked and wedged bivergent orogens are replicated across the continent with remarkable similarity in style despite the range of complexity and age of the orogens involved. Reflections extending from the crust into the uppermost mantle are observed in the majority of orogens, demonstrating that subducted or subcreted lithosphere can remain intact beneath and eventually within cratonic lithospheric mantle. The dynamic nature of the seismic Moho contrasts with the preservation of some crustal structures that extend into lithospheric mantle. Syn- or post-orogenic re-equilibration of the Moho is required; the Moho remains remarkably flat across the entire continent despite the great diversity of overlying topography and crustal properties. The LITHOPROBE seismic data provide convincing evidence that horizontal plate collisional processes played important, if not dominant, roles in the Neoarchean (2.5-2.7 Ga) and perhaps earlier. Detailed scientific results from individual transects are outstanding (see Percival et al. 2012). The talk also will highlight results from one or two specific transects. The focus will be on lithospheric structure and tectonic evolution as revealed by the multidisciplinary studies.

References

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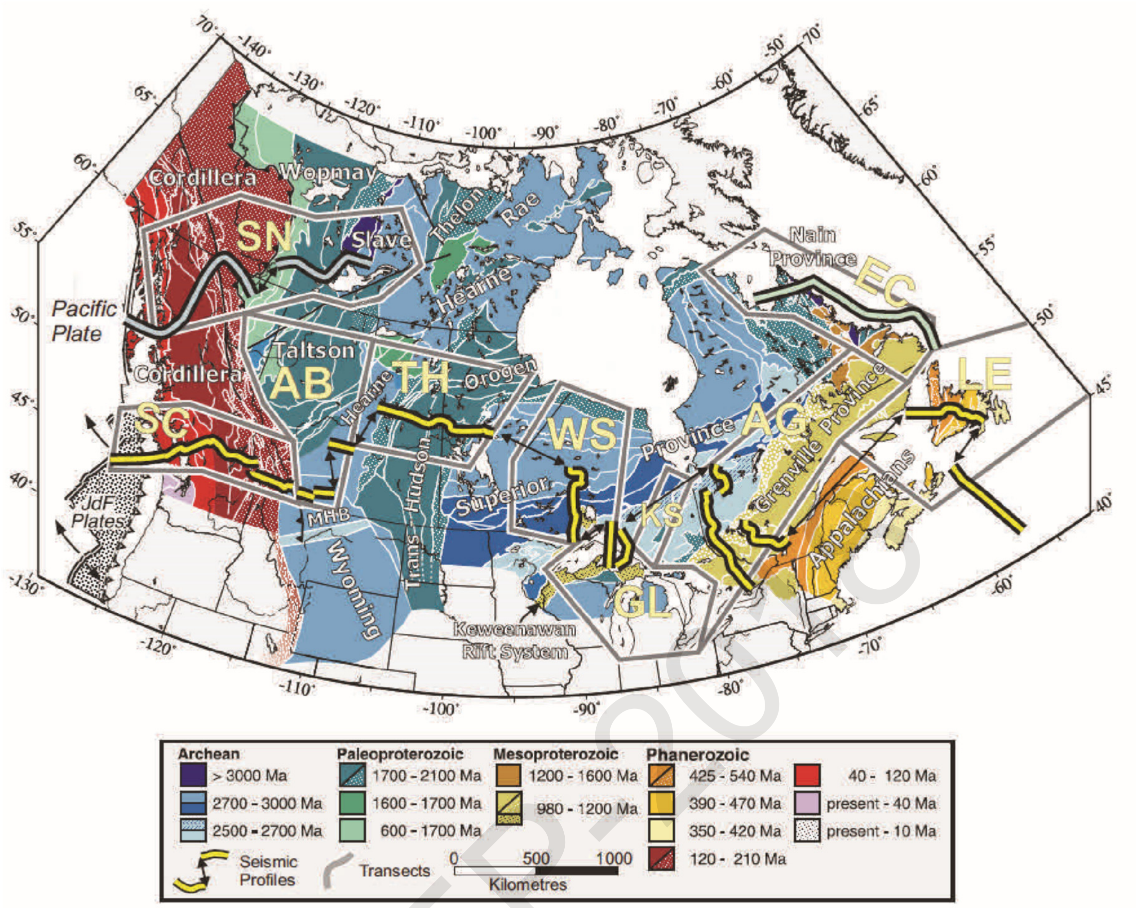

Figure 1. Simplified tectonic element map of Canada showing location of the ten Lithoprobe transects and three lithospheric cross-sections. Double-headed arrows show the along-strike offsets used in compiling the 6000 km-long trans-continental crosssection (Fig. 2). Thin white lines identify domains within the major tectonic units. Transect abbreviations are: AB – Alberta Basement, AG – Abitibi-Grenville, EC – Eastern Canadian Shield Onshore-Offshore (ECSOOT), GL – Great Lakes International Multidisciplinary Program on Crustal Evolution (GLIMPCE), KS – Kapuskasing Structural Zone, LE – Lithoprobe East, SC – Southern Cordillera, SN – Slave-Northern Cordillera Lithospheric Evolution (SNORCLE), TH – Trans-Hudson Orogen, WS – Western Superior. Other abbreviations: JdF – Juan de Fuca, MHB – Medicine Hat Block

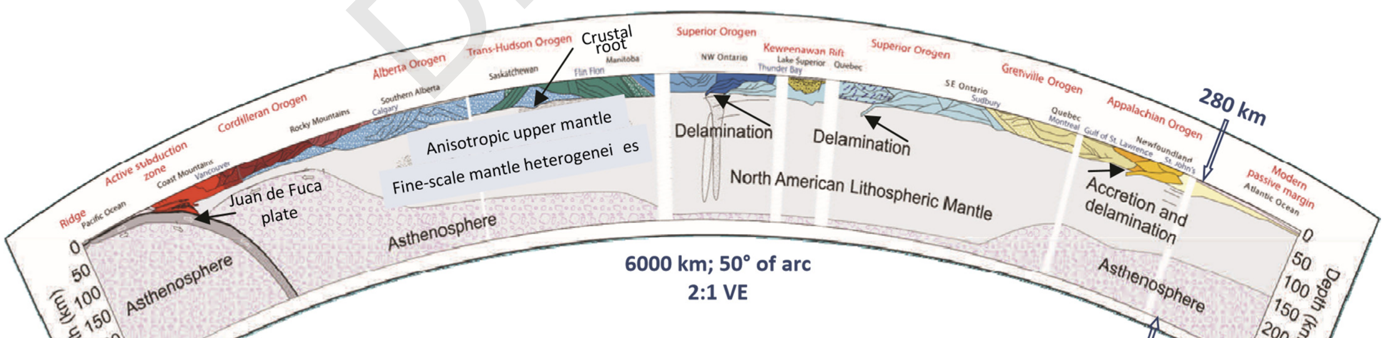

Figure 2. The Lithoprobe Trans-North America cross-section. The interpretation represents a synthesis of published work and is based on seismic reflection profiles and related geophysical and geological information along the seismic profiles (yellow) in Fig. 1. Colors indicate tectonic age (see Fig. 1). Dark blue and black lines represent major reflective or compositional boundaries inferred from seismic data. Anisotropic and/or heterogeneous structure in the lithospheric mantle are identified where observed. In the western Superior Orogen, teleseismic velocity and resistivity anomalies in the lithospheric mantle are denoted by narrow vertical shaded ovals. The teleseismic dataset revealed lateral compositional changes in the lithospheric mantle that corresponded closely with the orogenic boundary and possible subduction and delamination that were inferred from the active-source dataset. Estimates of lithospheric thickness are based on the work of Shapiro and Ritzwoller (2002) and Artemieva (2009).