LITHOPROBE: A New View of the Continent Beneath Our Feet
Scientific, Economic and Social Contributions

What is *LITHOPROBE*?

Canada's national, collaborative, multidisciplinary Earth science project established in 1984 to develop a comprehensive understanding of how the Canadian landmass and continental margins developed through geological time the last 4 billion years. We are *probing the lithosphere*, Earth's relatively cold, strong, rigid outer shell which is typically 100 km or more thick.

Why *LITHOPROBE*?

To gain a basic understanding of the continent on which we live, from which we derive resources and which generates natural hazards such as earthquakes and volcanoes.

To obtain regional background information useful to mining, petroleum, and other resource industries.

Deploying seismographs in northern BC

How does *LITHOPROBE* work?

Multidisciplinary within the Earth sciences:

- Spearheaded by seismic reflection techniques that are used to image the lithosphere to more than 100 km depth
- Geology, geochemistry, dating of rocks, other geophysics
- Collaborative across Canada:
  - 32 University Earth science departments;
  - 5 offices of the Geological Survey of Canada;
  - 8 provincial/territorial geological surveys;
  - participation from 27 petroleum, 8 base- and precious-metal mining, 8 diamond and 5 uranium companies
- Decentralized research activities
- Study Areas:
  - 10 “transects” were selected to represent globally significant tectonic processes
  - Transects traverse from Vancouver Island to Newfoundland, and from the northern U.S. to the Yukon, NWT and northern Labrador
  - Transects span geological time from 4 billion years ago to the present
- Board of Directors for policy; scientific committees for advice
- Secretariat at University of British Columbia for coordination

Who funds *LITHOPROBE*?

- Natural Sciences and Engineering Research Council of Canada [NSERC]: ~$54M over 20 years
- Geological Survey of Canada [GSC]: ~$27M over 20 years
- Industry and provincial/territorial geological surveys when studies are in their spheres of interest: ~$22M over 20 years
- Other NSERC and other grants to individual scientists; student fellowships: ~$8M over 20 years

Vibroseis trucks generating seismic reflection data near Stewart, BC during the LITHOPROBE SNORCLE transect

The Trans-Canada Crustal Cross-Section

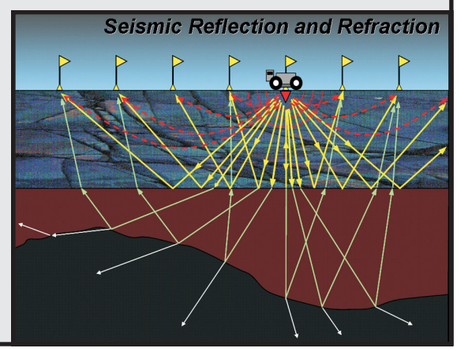
LITHOPROBE

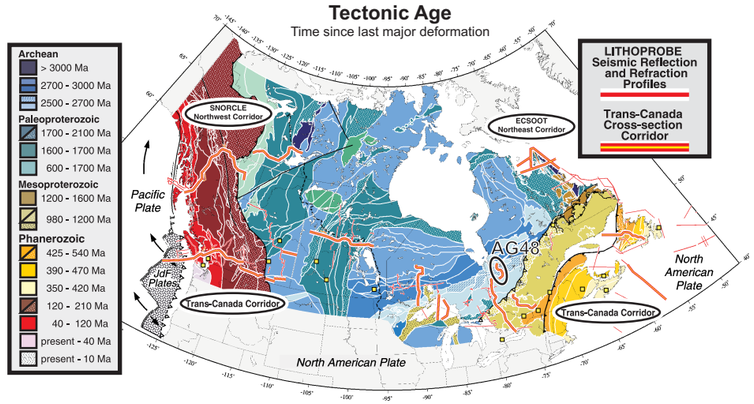
LITHOPROBE focuses multidisciplinary research on a carefully chosen study area. The new investigations are led by seismic profiling that provides structural and compositional information to full crustal depths (and sometimes much deeper). The seismic images provide a framework within which the contributions of other Earth Science disciplines can be more effectively interpreted.
The multidisciplinary approach involves virtually all branches of solid Earth Science including
- geology
- geophysics
- geochemistry
- geochronology

Seismic Methods

a) Seismic Reflection
Sound vibrations generated by vibroseis trucks reflect off of material interfaces that have contrasting properties. This reflected energy is recorded at the surface and used to produce detailed images of the structure of the crust and upper mantle (see middle panel below).

b) Seismic Refraction
Vibrations generated by explosive sources (or the vibroseis trucks) are recorded at distances up to 800 km. These waves are "bent" (e.g., red dashed lines in schematic figure) by gradual changes in rock properties. The data are used to generate models that constrain structural, compositional, and thermal properties. The lower panel below displays models of the speed (km/s) the sound waves travel through the Earth.

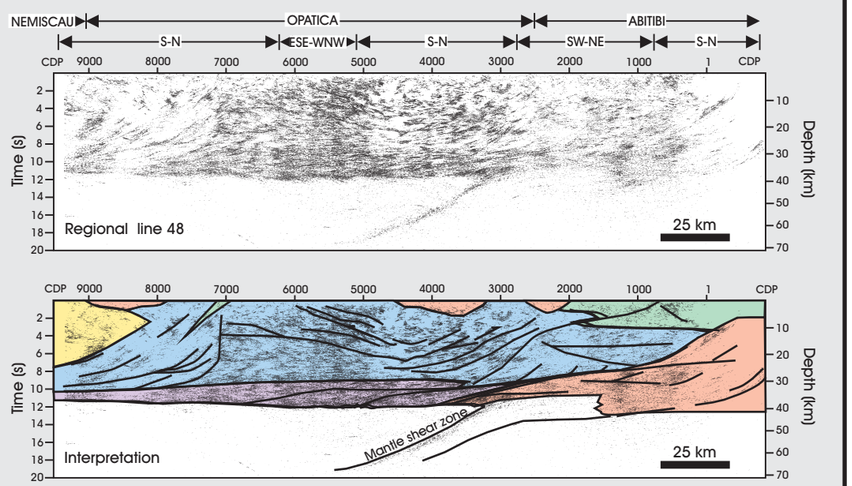




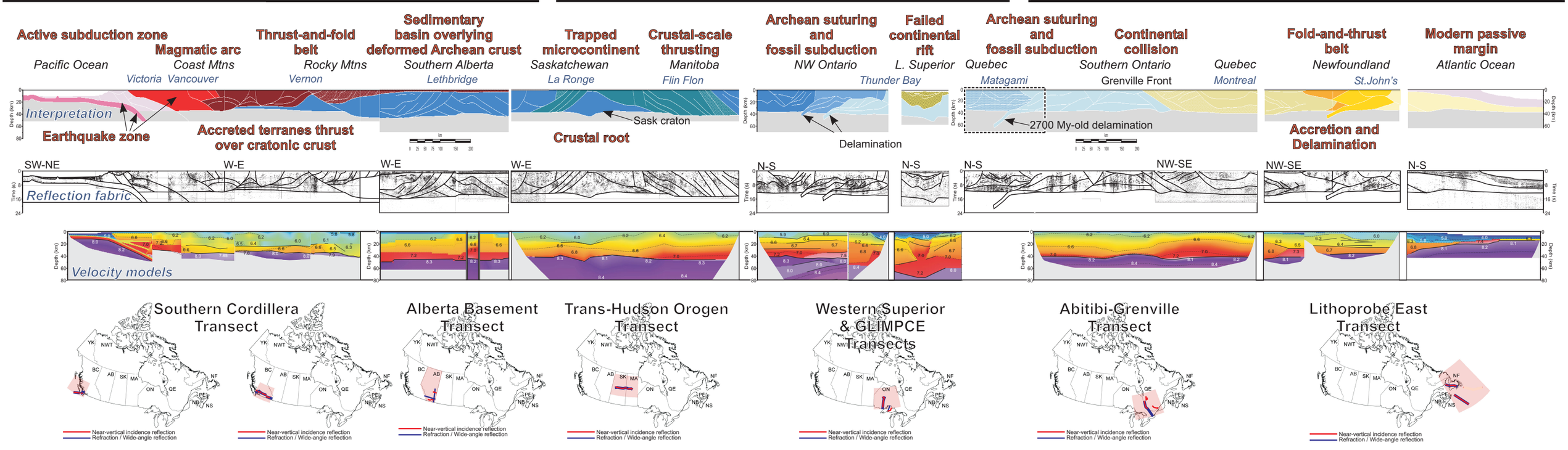
How does the Earth change over time? How are continents formed? How do those processes affect us?

LITHOPROBE's work over the past two decades has had a major impact on our understanding of Canada's geological and tectonic history, as well as of the global processes that drive the evolution of our planet. Eight of the ten study areas link to form a grand transect that spans the continent. Although the seismic profiles do not appear to trace a continuous line across the country, the offsets vanish when fault zones, rock ages, and tectonic linkages are considered.

The map divides Canada into general "tectonic age", the time since the last episode of major deformation. LITHOPROBE seismic lines are shown with those lines highlighted that are used for the Trans-Canada crustal cross-section. The cross-section below includes seismic reflection, seismic refraction, and interpreted profiles. The profiles span 4 billion years of crustal evolution and emphasize the large-scale pattern of sequential collisions that result in deformation and continental growth.



Seismic reflection images from Line 48 (circled on the map and noted by dashed box below). The seismic image (top panel) and its interpretation (lower panel) of the northern Abitibi belt and the Opatica plutonic belt show the results of a collision of continental crust that occurred 2.7 billion years ago *[Calvert et al., 1995; Ludden and Hynes, 2000]*. The remarkable reflections that extend into the mantle are a fossil signature of subduction and/or crustal delamination. This profile provides direct evidence that plate tectonics has operated since at least the late Archean. The collision helped generate the greenstone belts that host the rich mineral resources of Ontario and Quebec. The colours in the lower panel represent different geological units interpreted from geological, geochemical, and geophysical data.



Prepared by: P. Hammer, A. van der Velden, F. Cook, and R. Clowes

For more information and copies of this poster, see *www.lithoprobe.ca*

LITHOPROBE: Scientific, Economic and Social Contributions

Discovery and exploration

Vast areas of Canada have been mapped from the surface to depths exceeding 100 km.

The collaborative, multidisciplinary approach has yielded great advances in understanding the structure and developmental history of Canada. Applications of these investigations range from resource discoveries to advancements in our understanding of global processes that control the evolution of our planet.

The success of the program has resulted in LITHOPROBE serving as a model for other network projects in Canada and around the world.

Regional information for industry

New and improved understanding of Earth history provides the resource industry with practical and theoretical information that enhances their exploration capabilities.

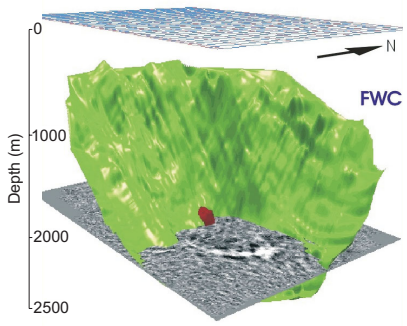
Technological innovation and transfer of science and technology to the private sector

Instrumentation and software developed through LITHOPROBE has been transferred to industry (e.g., seismographs now built by Scintrex Ltd., magnetotelluric recorders now built by Phoenix Geophysics Ltd.).

Demonstration of the applicability of the high resolution seismic reflection technique to mining exploration:

- base-metal exploration in Ontario and Quebec
- mapping diamondiferous kimberlite dykes in the NWT (a scientific and industry first)
- exploration for uranium deposits in northern Saskatchewan.

LITHOPROBE data and interpretations contributed to a petroleum discovery off the west coast of Newfoundland.



LITHOPROBE Trill 3D seismic reflection image from Sudbury, Ontario. Ore body (red) detected.

New resources and mitigation of hazards

LITHOPROBE studies on the west coast of Canada provided data and a framework for better understanding the mega-thrust earthquake hazard in the region. GSC scientists are continuing and extending such research in the region, thus contributing to a much more fundamental understanding of the hazard and how it may affect the region.

Training the next generation of earth scientists

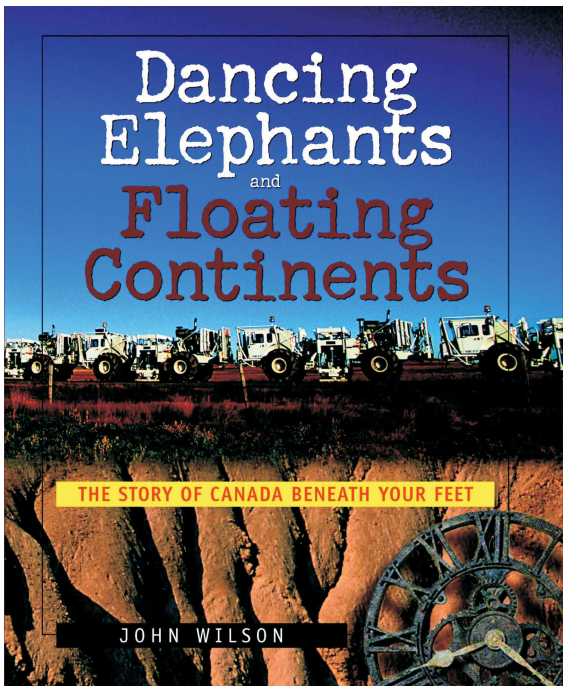
Over 450 graduate and undergraduate students, postdoctoral fellows and research associates have learned their specific skills in an environment of multidisciplinary collaboration.

Education and public awareness of science and technology

Educational material (e.g., posters, image archives, regional fact sheets) developed and used from high schools to universities.

Children's book (ages 9-14), based on results from LITHOPROBE.

Enhanced the visibility and relevance of the Earth sciences.



A new approach to collaborative science in Canada

Fostered an unprecedented degree of cooperation among Earth scientists in universities, federal and provincial/territorial geological surveys, and the mining and petroleum industries.

Spawned a new and healthy atmosphere of scientific cooperation among geologists, geophysicists, and geochemists; enhances results beyond those that could be achieved through any one subdiscipline.

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