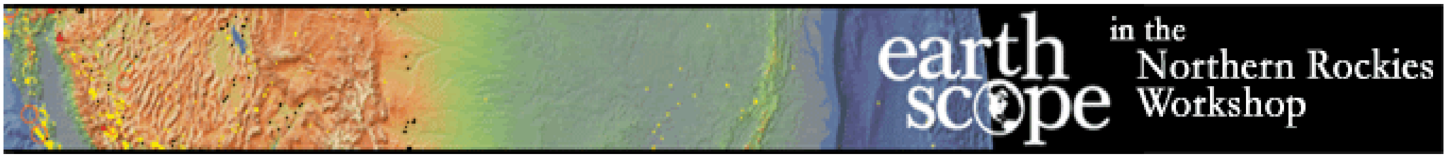

Earthscope in the Northern Rockies Workshop

Co-conveners:

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EarthScope in the Northern Rockies Workshop Report

The Northern Rockies provides the longest record of continental assembly and modification available within the part of North America that will be analyzed within the EarthScope experiment. This region has an incredibly diverse and extensive geologic history that is recorded in rocks that range from ancient (>3.5 Ga) gneisses to the Yellowstone hotspot/Snake River Plain. This portion of the North American continent provides an ideal environment for studying the physical and chemical evolution of the crust-mantle system, because it records multiple generations of crustal evolution involving a variety of tectonic environments (e.g., continent-continent collisions, rifting, sedimentary basin subsidence, convergent margin, and impingement of a mantle plume). The region provides an opportunity, therefore, to examine two of the most challenging problems in the study of the formation and evolution of continental crust: 1) how newly segregated, low-density crust and lithosphere (most commonly formed in island arcs and along continental margins) is integrated into compositionally and structurally mature continents and 2) how this newly formed crust and lithosphere evolves within the continental environment and how its structure and composition influence the subsequent evolution of the continent itself. These are two of the most basic questions in continental crustal evolution because modern continents are clearly not the geochemical or structural equivalent of modern island arcs. In addition, it is clear that inherited Precambrian structural features influence Phanerozoic continental evolution and rheology. To understand the processes by which this lithosphere formed and evolved requires the application of many disciplines (geochemistry, petrology, geophysics, geochronology, etc.). EarthScope resources can play a pivotal role in elucidating the complex history of the Northern Rockies, and thereby add significantly to our understanding of crustal genesis and continental evolution.

In preparation of the installation of EarthScope instruments in the region, the NSF EarthScope program sponsored a workshop entitled ***EarthScope in the Northern Rockies*** 16-18 September 2005 in Bozeman, Montana. Over 80 attendees represented a wide range of organizations, including universities, research organizations, educators (including K-12), state surveys, National Park Service, and the USGS. Representatives from previous regional EarthScope workshops shared summaries of their programs and recommendations for future work. Two independent field trips were also organized around the themes of "Precambrian Crustal Evolution" and "Yellowstone Volcanism and Neotectonics". Both the field trips and the formal workshop proceedings focused on how EarthScope resources could be integrated with existing and future geologic data to reach the primary EarthScope goal of developing a 4-D model of the evolution of the North American continent and its associated lithosphere. The workshop began with tutorials that provided all attendees with information about the capabilities and limitations of EarthScope followed by several updates on our current state of knowledge of crustal evolution, structure, mineral resources, tectonics, and seismicity of the region. In addition, there were two presentations that described the "Geotraverse" approaches to gaining additional insight into crustal/lithospheric structure by combining the Portable Array and USArray, commonly referred to as "densification of the array," and the potential attributes of add-on experiments using active source seismology.

Six separate committees were charged with the task of evaluating the current state of knowledge and developing recommendations for the deployment of EarthScope resources, including possible areas for inclusion in densified swaths or traverses (Figure 1): 1)

Archean/Paleoproterozoic tectonics and crustal evolution, 2) Neotectonics and Yellowstone, 3) Lithospheric structure, 4) Belt basin and Neoproterozoic passive margin, 5) Education and outreach, and 6) Phanerozoic tectonics and magmatism. Each of these working groups prioritized targets for evaluation, which were consistant with the science goals of EarthScope (see www.earthscope.org). The combined results of these committee reports suggest that primary research emphasis should be placed on:

1) Obtaining a better understanding of the lithospheric structure and evolution within and adjacent to the Wyoming Craton. For example, understanding the nature of the Great Falls tectonic zone and Dakota segment of the Trans-Hudson orogen and the Archean cratons (Wyoming, Superior, and Medicine Hat) joined by these mobile belts is critical to understanding the entire temporal range of crustal evolution in the Northern Rockies, North America, and globally. Understanding the tectonic relations between mobile belts and cratons was viewed as fundamental to understanding how older cratons are incorporated into continents in general and Wyoming into Laurentia in particular. These Proterozoic mobile belts were also singled out in terms of their importance in defining regions of later reactivation, mineralization, magmatism, and seismicity.

2) A second major area of emphasis focused on developing a more complete understanding of the interaction of the ancient lithosphere of the Wyoming craton with the Yellowstone hot spot and associated Snake River Plain volcanism and the shallow subduction regime of the Farallon plate. Whereas the Wyoming craton's interaction with Proterozoic plates produced no craton penetrating magmagtic activity, the Cretaceous-Paleogene passage of the Farallon plate has produced volcanism on the craton margins (e.g., Absaroka volcanic province), but not in the interior of the craton. These interactions offer a globally unique opportunity to learn more about hot spots and relatively recent shallow subduction, and their influences on ancient lithosphere. This are critical aspects of crustal evolution during early earth history when heat generation was much higher and shallow subduction more likely, and should be studied by a combination of seismic and GPS methods in order to obtain the best possible characterization of current interactions.

3) Another area in which EarthScope resources could greatly increase our understanding of lithospheric evolution involves developing a better appreciation of how continental lithosphere accommodated the immense thickness of Belt basin sedimentation. Current estimates of the total thickness of Belt sediment approach 28 km. The rheological (mantle and crust) and structural aspects of accommodating such thicknesses of sediment and its subsequent crustal and perhaps mantle coherence represent a globally unique opportunity to understand the role of sedimentary accretion in continental growth.

4) Reactivation of ancient structures by modern stress regimes was also a major issue of interest that derived from our current understanding of the state of stress in the lithosphere and the relations between this stress and its accommodation by ancient structures and age-province boundaries. For example, the eastern limit of Basin and Range extension and Sevier shortening largely coincides with the edge of Archean lithosphere whereas Laramide deformation impacted the entire craton. Understanding the relations between the deformational events and lithospheric structure and strength is a critical aspect of understanding continental assembly and growth.

5) The nature of boundary between the western edge of Precambrian North America and the Phanerozoic accreted terranes, along with the structural and chemical modifications of the lithosphere associated with the Sevier and Laramide orogenies, are also seen as critical targets for EarthScope research. The batholiths associated with Phanerozoic magmatic arcs and the related orogenic belt impacted the ancient lithosphere of North America more so in the Northern Rockies than perhaps anywhere along the Cordilleran margin. This basement involvement in Cordilleran deformation may have been controlled by the unique ancestral structure of the lithosphere (e.g., structures like the Lewis and Clark line) or the dynamics of terrane collision and accretion along the Idaho suture zone.

6) The Education and Outreach group identified a number of targets of opportunity to serve educators at all levels. Follow-on activities may include use of EarthSope data and data products for preparation of instructional kits, presentations at state science teacher meetings, traveling scientists to visit schools, and adopt a young scientist program. The Wyoming craton and environs attracts millions of environmentally oriented visitors each year and offers tremendous opportunities for informal as well as formal educational programs.

With these considerations in mind, the general sense of the scientific community is that the overall richness of the record of crust-mantle interaction and continental growth in the Northern Rocky Mountains is globally unique and will require a coordinated geological and geophysical approach that includes imaging of crustal as well as mantle structures in conjunction with new mapping, geochemistry, geochronology, and structural geology and tectonic studies along key swaths. For EarthScope, this means that research groups would be best served by working collaboratively to develop proposals that focus on a multi-disciplinary approaches to the swaths in which more closely spaced passive arrays, preferably with some active source component, are used to elucidate key structural elements and boundaries. The ultimate connection of these swaths on a continental scale would provide a quantum leap in our understanding of lithospheric evolution and continental assembly.

To access the EarthScope in the Northern Rockies workshop program, abstracts, PowerPoint presentations, and posters, please visit the workshop website at: http://serc.carleton.edu/earthscoperockies/index.html

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"The Craton Meets the Hot Spot" Wyoming to Yellowstone: 3.5 Ga of Lithospheric Evolution

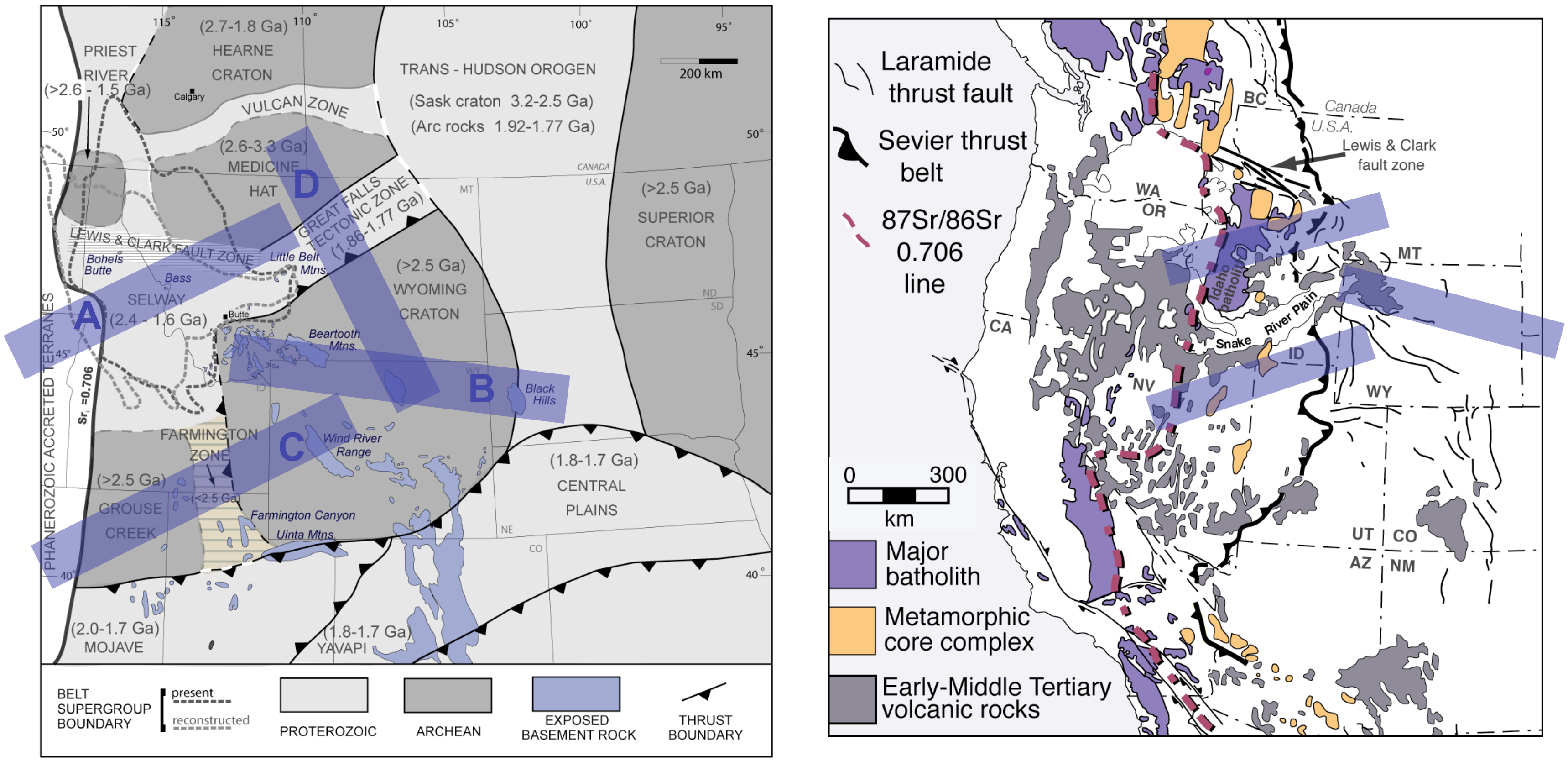

Figure 1. Condensation of transects proposed by the working groups plotted on a basement province map (after Foster et al., in press) and a map of Mesozoic and Tertiary structures (after Coney, 1980). Major geological features crossed by these transects include: Precambrian province boundaries with probable lithospheric extent (Archean Wyoming craton and Medicine Hat block; deep crustal high-P wave velocity layer; Proterozoic Great Falls tectonic zone; Trans-Hudson Orogen; Mojave block; Selway terrane, Grouse Creek block; Farmington zone; Belt basin and Neoproterozoic rifted margin); Phanerozoic accreted terranes; Cretaceous-Eocene Idaho batholith and Boulder batholith; Sevier fold-thrust belt; Laramide foreland structures; Tertiary extension and magmatism; Yellowstone hot spot;Lewis and Clark fault zone; intermontain seismic belt.