Two issues (Parts I and II) of Rocky Mountain Geology (RMG) are an attempt to summarize the structure and evolution of the continental lithosphere in a Rocky Mountain transect from Wyoming to New Mexico (Fig. 1). After decades of geologic work, our understanding of the complex history of this region is still incomplete. As in many other regions, first-order questions remain about the deep structure, processes of formation, and evolution of the continental lithosphere. Fundamental new insights are most likely to come through integration of a broad range of data, involving close collaboration among geologists, geochemists, and geophysicists.

The Continental Dynamics program of the National Science Foundation has provided funding recently for a collaborative effort in the Rocky Mountains that involves many of the contributors to these theme issues of RMG. Plans for coordinated activities include acquisition of about 600 km of seismic reflection and refraction data (in 1999), passive seismic studies, xenolith studies, and a range of geologic and geochronologic studies. We hope that the papers in the two issues of RMG will promote discussion of the best design for our upcoming seismic experiments. In the longer term, we hope that the planned geologic and geophysical experiments will catalyze a new generation of collaborative research in the Rocky Mountains.

The goal of our research is to understand the growth, stabilization, and reactivation of the lithosphere of southwestern North America. This area represents the juncture of two globally unique tectonic regimes, each of fundamental importance for understanding continental tectonics. Together they represent an unparalleled field laboratory for studies of continental lithosphere. First, a 1200 km-wide, juvenile, Proterozoic orogenic belt records a globally unique episode (between 1.8 and 1.6 Ga) of rapid accretion of continental materials from mantle sources and their assembly to southern Laurentia. One aspect of our studies, therefore, is to evaluate the processes of formation of new continental lithosphere by investigating the deep structure and evolution of major Precambrian province boundaries (Fig. 1). Secondly, the present high elevations of the regional orogenic plateau in the Southwest and in the Southern Rocky Mountains–Rio Grande rift region is the manifestation of Phanerozoic and ongoing modification of Proterozoic lithosphere. Thus another major aspect of our work is to better document present lithospheric structure, how it evolved through time, and the processes of tectonism that affected the interiors of continents.

Although our goals go beyond a single hypothesis, our main testable hypothesis is that lithospheric structure, produced during assembly of the southwestern United States, profoundly influenced the physical and chemical modification of the continental lithosphere during all subsequent tectonism (see paper by Karlstrom and Humphreys). Influence of that ancient assembly continues in the form of ongoing reorganization of small-scale asthenospheric convection and its lithospheric tectonic and magmatic response. Such long-term influences are suggested by the northeast-trending embayments of hot “upwelling” mantle along proposed Proterozoic province boundaries in the Southwest (see cover) and an apparent correspondence of mantle anisotropy and velocity provinces with Precambrian crustal provinces. The Rocky Mountains–Colorado Plateau region is especially important for understanding mantle–crust interactions, because it marks a broad transition from old, cold, unmodified mantle tectosphere of the midcontinent to hot, young, modified mantle of the Basin and Range province (Lerner-Lam et al.). Thus, this is an area in which processes of mantle modification are ongoing and perhaps more readily deciphered. Overall, our investigation is designed to understand interrelationships between lithospheric evolution (using geologic studies), present lithosphere structure (using geophysics), and continental dynamic processes (using modeling).

Papers in the two issues discuss several testable aspects of our hypothesis. For example, we postulate that different mantle provinces exist beneath different crustal provinces (Snelson et al.; Keller et al.), and that a profound and long-lived difference between Archean and Proterozoic lithosphere is involved (Chamberlain; Smithson and Boyd; Lester...
Figure 1. Proterozoic rocks and boundaries of the North American Southwest, adapted from Karlstrom and Bowring (1993, fig. 7). The Wyoming province contains Archean crust. The Mojave province contains Archean crustal material incorporated into Proterozoic crust. The Yavapai province contains 1.75-Ga juvenile volcanic-arc crust. The Mazatzal province contains 1.65-Ga crust. The Grenville province contains 1.4- to 1.1-Ga crust. Stippled zones are transitions between provinces. Proposed seismic reflection lines are: (1) the Cheyenne belt; (2) a proposed Yavapai-Mazatzal boundary in southern Colorado; and (3) the Jemez lineament, which corresponds to a proposed Mazatzal-Yavapai province boundary in New Mexico.
and Farmer). Our geologic studies suggest that boundaries between Proterozoic orogenic provinces may be more complex and cryptic than those between the Archean and Proterozoic provinces. Thus, we highlight the importance of multidisciplinary geologic research to study the processes and products of Proterozoic crustal assembly (e.g., studies include: Shaw and Karlstrom; Read et al.; Williams et al.; Foster et al.; Barinek et al.) and for constraining parameters of the planned seismic studies. Following assembly of the continent, thermochronologic studies suggest that rocks underwent slow cooling (Marcoline et al.) and that different tectonic blocks had unique cooling histories. Different blocks also had different magmatic histories, presumably because of variations in bulk compositions and because some boundaries were repeatedly important as zones of melt migration (Karlstrom and Humphreys).

The post-assembly history of blocks suggests an interplay between “active” (asthenosphere-driven) and “passive” (lithosphere-influenced) processes within the craton during the late Proterozoic and Phanerozoic, culminating with lithospheric thinning in the Cenozoic. Cenozoic geologic history is discussed in a synthesis of geomorphology and fission-track studies in the Southern Rocky Mountains (Pazzaglia and Kelley) and in a review of the Rio Grande rift (Keller and Baldridge). Another important aspect of our Continental Dynamics project is reprocessing seismic data from industry, including an example from southern New Mexico (Chang et al.). Toward a test of these various hypotheses, the western United States is an ideal place to combine geophysical investigations of crust and mantle with studies of crustal exposures and xenoliths. The general goal is to characterize the evolution of lithospheric provinces and boundaries in four dimensions from the time of accretion to the present.

To some extent, this Continental Dynamics-Rocky Mountain project emulates and builds upon the highly successful interdisciplinary approach of the Canadian Lithoprobe project. The project complements the ongoing Canadian–U.S. Deep Probe experiment that targets the mantle of the western United States. Our three-year investigation will study lithospheric boundaries within the Rocky Mountain transect. Following the Lithoprobe model, the project brings together a critical mass of investigators from 15 institutions to document processes of assembly and modification of crustal and mantle provinces along a transect more than 1000 km in length. Because of the challenge of simultaneously studying lithosphere assembly along northeast-trending boundaries and its disassembly along north- to northwest-striking boundaries, our approach involves a three-dimensional array of geophysical studies linked together at strategic tie points and integrated with diverse geologic investigations. In particular, we will undertake an integrated set of large-scale seismic experiments using state-of-the-art data acquisition techniques. Satellite data, computerized image processing, digital terrain models, GIS analysis, and other modern visualization schemes will be employed to create a data base suitable for integrated analysis.

The major components of our project are: (1) crustal reflection and refraction experiments across key boundaries (Fig. 1; e.g., the Archean–Proterozoic boundary exposed at the Cheyenne belt and the intra-Proterozoic boundaries exposed in southern Colorado and northern New Mexico); (2) teleseismic recording to image modern mantle structure in the Rocky Mountains region; (3) geologic and geochronologic studies of exposed rocks along the transect to understand evolution of boundaries; (4) xenolith studies to reconstruct the compositional and physical properties of lithosphere under different provinces; and (5) modeling studies aimed at putting our results into a general framework for understanding lithosphere dynamics. We will attempt to provide some of the most detailed images ever attained of the three-dimensional structure of accreted crust and mantle fragments, and we will place these images into a tectonic context by concurrent geologic studies.

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