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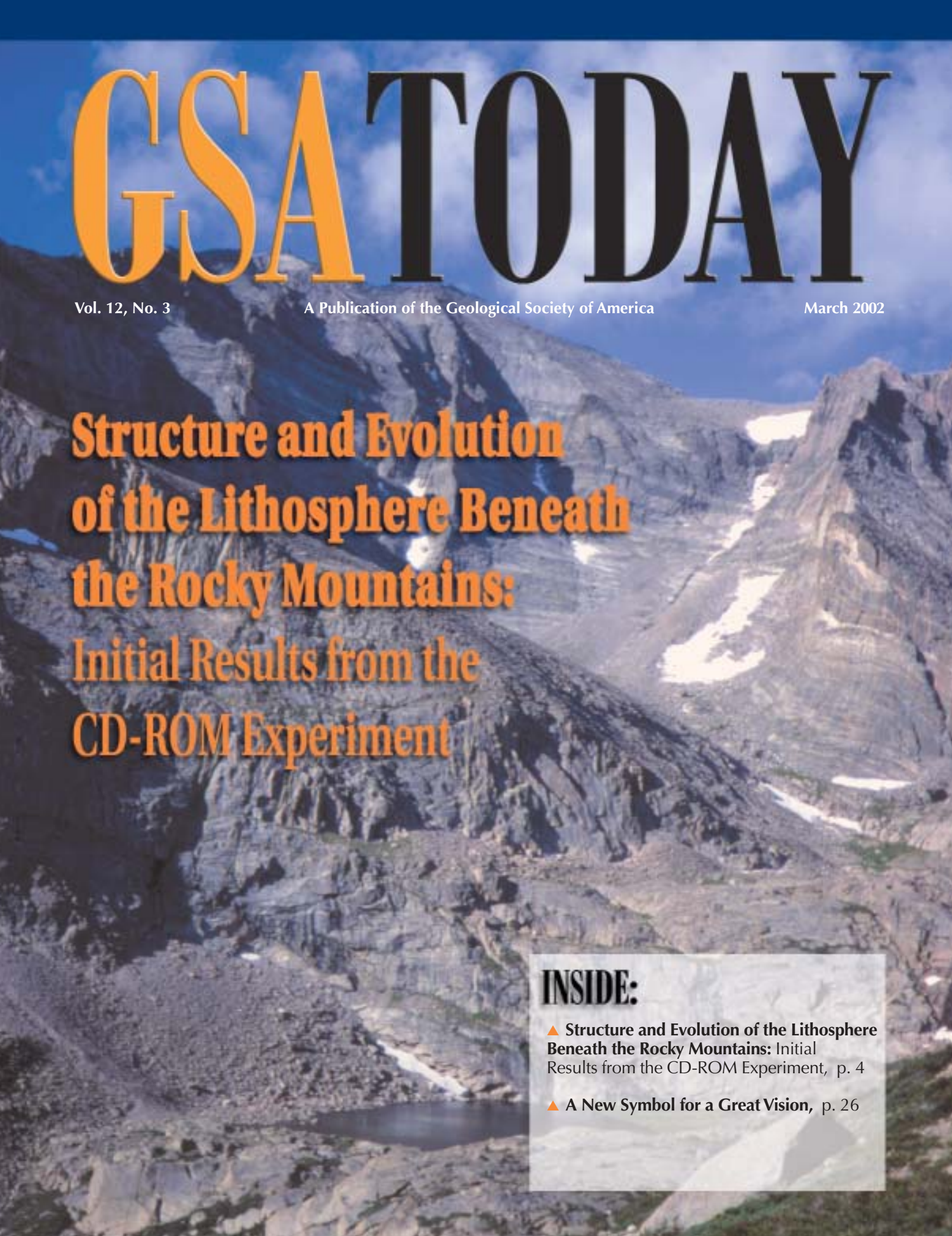
Structure and Evolution of the Lithosphere Beneath the Rocky Mountains: Initial Results from the CD-ROM Experiment



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science article

On the cover: Long's Peak, Colorado. Photo by K. Karlstrom. See "Structure and Evolution of the Lithosphere Beneath the Rocky Mountains: Initial Results from the CD-ROM Experiment," p. 4–10.

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Structure and Evolution of the Lithosphere Beneath the Rocky Mountains: **Initial Results from the CD-ROM Experiment**

CD-ROM Working Group*

ABSTRACT

An integration of new seismic reflection, seismic refraction, teleseismic, and geological data provides insights into the nature and evolution of the lithosphere along a transect extending from Wyoming to New Mexico. Perhaps the major issue in interpreting the seismic data is distinguishing lithospheric structures that formed during Precambrian growth and stabilization of the continent from those that record Cenozoic tectonism. Tomographic data show that the upper mantle, to depths of >200 km, contains several dipping velocity anomalies that project up to overlying Proterozoic crustal boundaries. Our integrated studies define crustal sutures that are congruent with the dipping mantle domains, and we interpret these crust and mantle features as the signatures of Proterozoic paleosubduction zones. Proposed sutures are the Cheyenne belt, Lester-Farwell Mountain area of northern Colorado, and Jemez lineament. The resulting thick Proterozoic lithosphere was part of North America by 1.6 Ga, and has remained both fertile and weak as shown by repeated deformational and magmatic reactivations from 1.4 Ga to present. Proterozoic lithosphere of Colorado and New Mexico differs from lithosphere beneath the Archean core of the continent, possibly in thickness but most important by its strongly segmented nature, its long-term fertility for magmatism, and its relative weakness, expressed as a tendency to be reactivated. Throughout much of the southern Rocky Mountains, seismic refraction data have delineated a 10–15 km thick, 7.0–7.5 km/s mafic lower crustal layer. The base of this layer (Moho) varies from 40 to 55 km in depth. We interpret it to have formed diachronously and by a combination of processes, including original arc development and subsequent magmatic underplating, and to be the product of progressive evolution of the lithosphere.

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INTRODUCTION

The CD-ROM (Continental Dynamics of the Rocky Mountains) experiment is a geological and geophysical study of a transect from Wyoming to New Mexico. The transect obliquely crosses Phanerozoic tectonic provinces (southern Rocky Mountains, Rio Grande rift, Great Plains) and orthogonally crosses northeast-striking structures related to Proterozoic assembly of the crust (Fig. 1). Our goal is to differentiate the lithospheric structures that formed during Precambrian growth and stabilization of the continent from those that record Cenozoic tectonism. CD-ROM integrates a series of coordinated seismic experiments (Keller et al., 1999) and geological studies to delineate crust and upper mantle structure and provide a better understanding of lithospheric evolution and geodynamical processes.

GEOLOGIC AND SEISMIC EVIDENCE FOR THE AGE AND STRUCTURE OF THE ROCKY MOUNTAIN LITHOSPHERE

Figure 1 shows the complex arrangement of Precambrian crustal provinces and younger tectonic elements of the southern Rocky Mountains. Similar to the crustal signature, mantle velocities also show complex patterns between high- and low-velocity domains (Fig. 1). Figure 2 shows a multiscale cross section of the Rocky Mountain lithosphere. One of the most notable features on the cross section is the dramatic lateral velocity variations in the upper mantle. These velocity differences could be interpreted as reflecting temperature differences related to modern asthenospheric convection, and as such, even though the crust is predominantly Proterozoic, the upper mantle under the Rocky Mountains would be interpreted to be essentially Cenozoic. However, here we explore the hypothesis that the lithospheric mantle under the Rocky Mountains, although extensively modified and reactivated by younger events, is primarily Proterozoic in age. This is suggested by the congruence of dipping crust and mantle boundaries with major Proterozoic province boundaries at the surface. By this hypothesis, the observed seismic velocity variations reflect a complex overprinting, where Proterozoic compositional and mechanical heterogeneities influenced Cenozoic mantle magmatism and lithosphere-asthenosphere interactions.

One of the most profound tectonic boundaries in the Rocky Mountain region is the Cheyenne belt (Fig. 1), a crustal manifestation of the suture between Archean crust and juvenile 1.8–1.7 Ga Proterozoic island arc crust (Hills and Houston, 1979). New seismic reflection images of the crust (Fig. 2B) confirm that the Cheyenne belt dips south under the Proterozoic Green Mountain arc (Condie and Shadel, 1984), consistent with north-verging thrusting of Proterozoic rocks over Archean crust (Karlstrom and Houston, 1984; Chamberlain, 1998). However, reflection data (Morozova et al., 2002) show that the deeper crust is characterized by tectonic inter-wedging similar to other sutures between old continents and younger arcs (Cook et al., 1998) rather than subparallel, south-dipping shear zones. We speculate that the north-dipping reflections from the Farwell Mountain area (Fig. 2B) project through generally unreflective lower

crust to coincide with a thrust-offset Moho seen in teleseismic receiver function images, and with the top of a high-velocity mantle anomaly (blue anomaly of Fig. 2D) that dips north under the Archean (Dueker et al., 2001). Our present interpretation is that Proterozoic oceanic lithosphere was underthrust beneath Archean crust during late stages of accretion of the Green Mountain arc but never developed into a self-sustaining subduction system, as shown by the absence of an associated volcanic arc to the north above it. This is similar to subduction polarity reversal taking place as the Banda arc accretes to Australia (Snyder et al., 1996). A series of south-dipping reflections (Lester Mountain suture) near the Farwell Mountain structure are interpreted as a suture zone between the 1.78–1.76 Green Mountain arc and the 1.75–1.72 Rawah arc-backarc complex (Fig. 2B). Dismembered ophiolitic fragments crop along this boundary zone.

The Aspen anomaly (Dueker et al., 2001) is an enigmatic low-velocity mantle anomaly that lies beneath the Colorado Mineral belt. (It is imaged by regional-scale studies and occupies part of the blank area of Figure 2D.) The Colorado Mineral belt is a northeast-striking zone defined by: a Proterozoic shear zone system (McCoy, 2001); a suite of Laramide-aged plutons and related ore deposits (Tweto and Sims, 1963); a major gravity low (Isaacson and Smithson, 1976); low-crustal velocities; and high heat flow (Decker et al., 1988). The presence of Laramide plutons here suggests that the mantle in this region was modified during the early Cenozoic and the high heat flow suggests continued, young heat sources.

The Jemez lineament (Fig. 1) marks the surface boundary between 1.8 and 1.7 Ga crust of the Yavapai province (to the north) and 1.65 Ga crust of the Mazatzal province (Wooden and DeWitt, 1991; Shaw and Karlstrom, 1999). New reflection data (Magnani et al., 2001, Eshete et al., 2001; Fig. 2A) show south-dipping middle crustal reflections that project toward a south-dipping boundary between fast (south) and slow (north) mantle that extends to great depth (>200 km; Fig. 2). Based on these relationships, we interpret the Jemez lineament to mark a Proterozoic suture zone that localized Cenozoic magmatism.

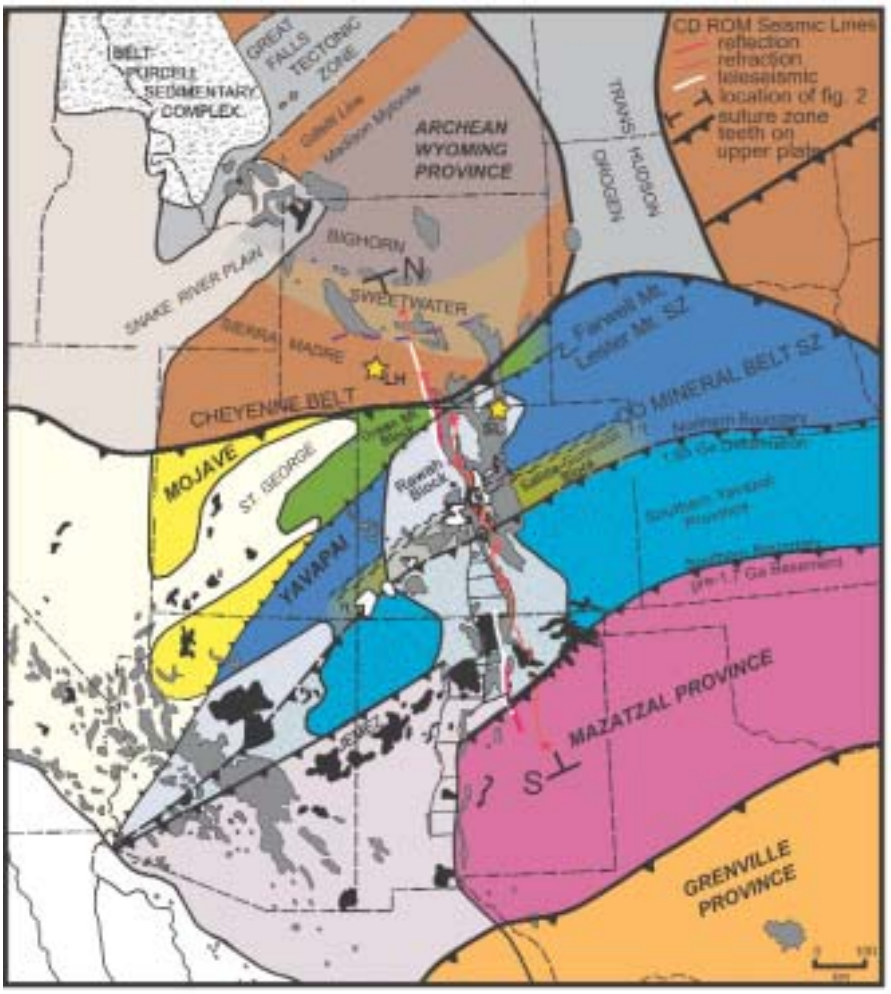


Figure 1. Geologic elements of southwestern North America showing Continental Dynamics of the Rocky Mountains (CD-ROM) reflection, refraction, and teleseismic lines. Precambrian provinces strike northeast, Laramide uplifts (gray) strike north-south, Laramide plutons (white) and Neogene volcanic fields (black) strike northeast. Locations of xenolith localities are shown as yellow stars. LH—Leucite Hills; SL—State Line district. Lithospheric mantle has lower velocity toward plate margin; area of lighter color represents regions underlain by low-velocity mantle, probably containing partial melt (from Dueker et al., 2001). In the Rocky Mountain–Colorado Plateau region, fingers of this hot mantle penetrate older lithosphere along northeast-striking zones; these areas are producing basaltic melts as shown by young volcanics along Yellowstone, St. George, and Jemez zones.

SEISMIC AND GEOLOGIC EVIDENCE FOR THE NATURE OF THE LOWER CRUST

This section examines seismic and geologic data from the crust, including new geophysical and xenolith data, and highlights the importance of understanding crust-mantle interactions through time. Figure 2B shows a crustal velocity model that is based on the detailed CD-ROM refraction line (Rumpel et al., 2001; Snelson, 2001). The refraction data show appreciable topography on the Moho and a crust that varies from ~40 to 55 km thick. A notable feature is a high-velocity (7.0–7.5 km/s), variable-thickness (10–15 km), lower crustal layer beneath the Proterozoic terranes. These velocities are consistent with a dominantly mafic composition. The presence and geometry of this layer are well documented by both wide-angle reflection and refraction data, as well as by receiver function analysis. This zone appears unreflective on all of the seismic reflection lines.

Xenoliths have been recovered from the Stateline diatremes in the Proterozoic crust of northern Colorado and from highly potassic lavas from the Leucite Hills in the adjacent Archean crust of

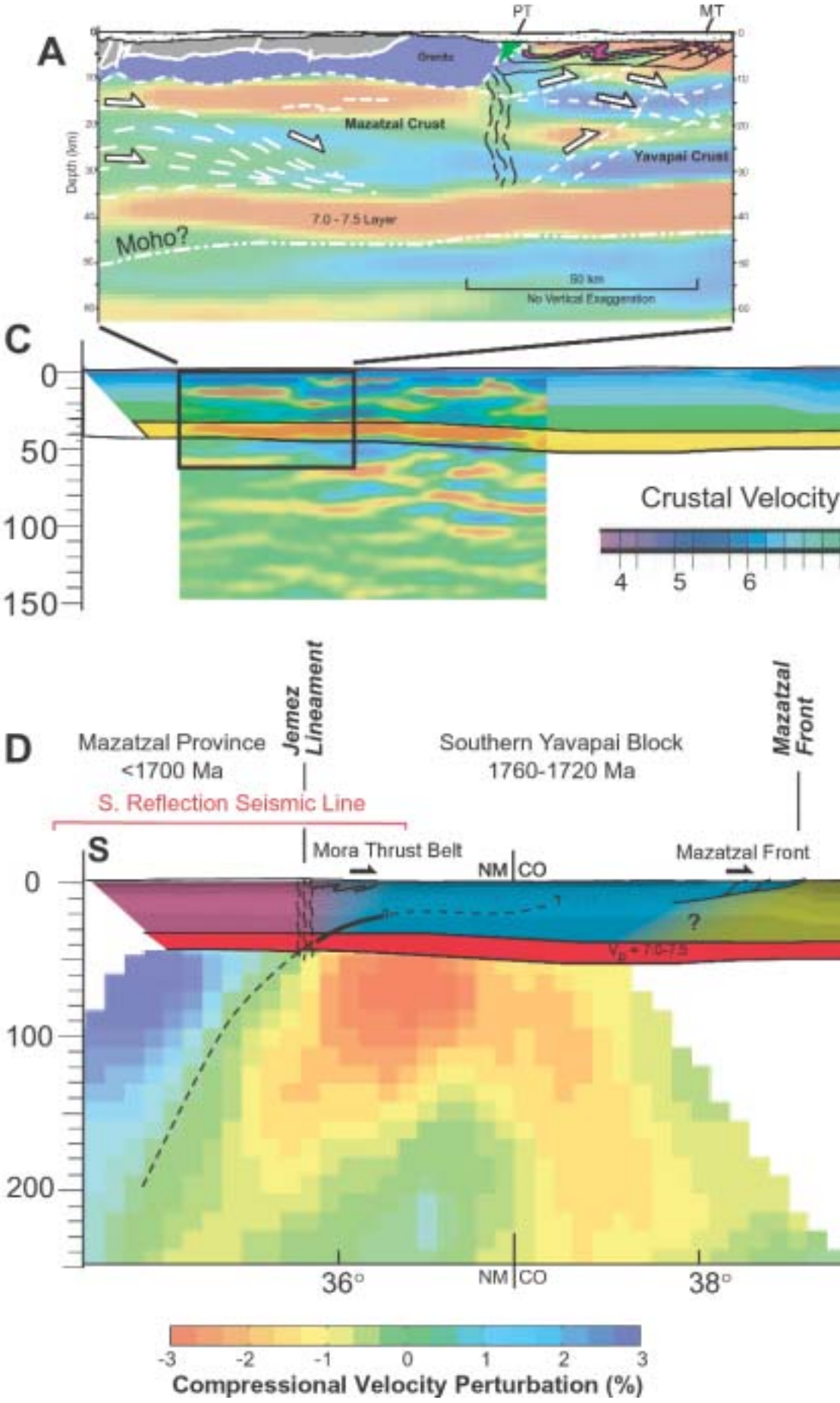
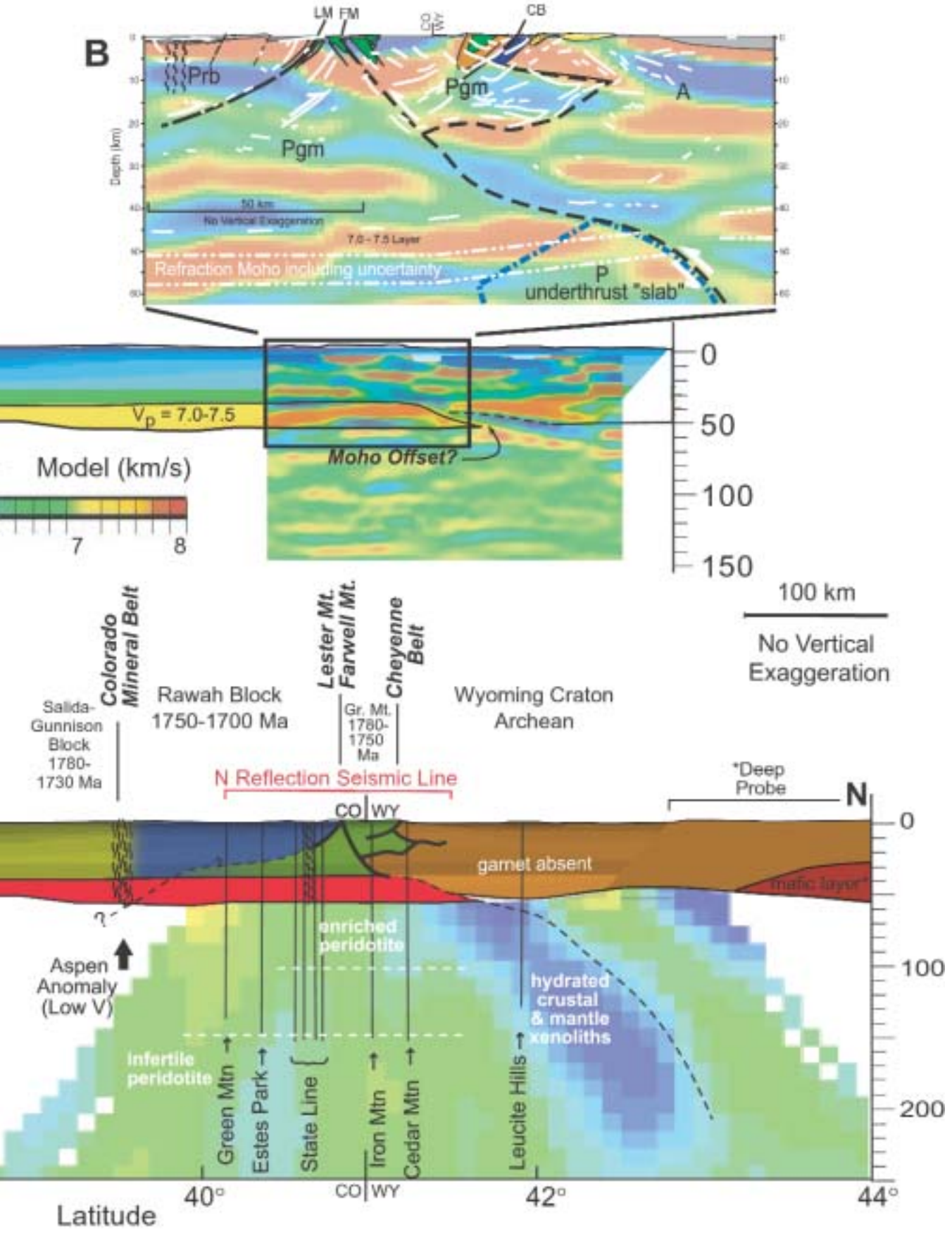


Figure 2. Synthesis of Continental Dynamics of the Rocky Mountains (CD-ROM) results. **A.** Line drawing of CD-ROM Jemez lineament reflection line (Magnani et al., 2001; Eshete et al., 2001) superimposed on receiver function image of Dueker et al. (2001). In receiver function images, red areas represent positive velocity gradients (velocity increases downwards) and blue areas represent negative velocity gradients. Jemez lineament separates oppositely dipping reflection systems. On basis of geologic correlations, we suggest that south-dipping reflections represent a ~1.65 Ga paleo-subduction zone and north-dipping reflections represent a ~1.4 Ga extensional shear zone system. MT—Mora thrusts; PT—Pecos thrust. **B.** Line drawing of CD-ROM Cheyenne belt reflection line (Morozova et al., 2002) superimposed on receiver function image of Dueker et al. (2001); dashed blue line represents high-velocity body imaged by tomography (2% contour). A—Archean lithosphere; P—Proterozoic lithosphere; Pgm—Proterozoic Green Mountain block; Prb—Proterozoic Rawah block; CB—Cheyenne belt; FM—Farwell Mountain zone; LM—Lester Mountain zone. **C.** Results from CD-ROM refraction experiment; interfaces at Moho and top of 7.0–7.5 km/s layer are well resolved by wide-angle reflections and refractions (Rumpel et al., 2001; Snelson, 2001); receiver function images (Dueker et al., 2001) are superimposed on refraction model and show good agreement for mafic lower crustal layer. **D.** Generalized geologic cross section superimposed on P-wave tomographic image of Dueker et al. (2001). Crustal structures in Cheyenne belt and Jemez lineament areas are generalized from seismic reflection data (above) with solid lines representing well-defined reflections. Locations of xenolith pipes shown as vertical lines. Dipping elements in tomographic image, combined with overlying crustal structures, are interpreted to be Proterozoic suture zones and North American lithosphere is interpreted to extend to >200 km depth.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southern Wyoming (Figs. 1 and 2). Lower crustal xenoliths from the Archean side (from depths of ~30 km; 0.8–1.0 GPa) consist of relatively felsic hornblende-pyroxene gneisses (without garnet); they typically display a weak-to-strong foliation primarily defined by amphibole. These, and the mantle xenoliths from this locality, are more hydrated than the Proterozoic xenoliths to the south, perhaps compatible with a position above an underthrust oceanic slab (Fig. 2B). In contrast, the lower crustal xenoliths from the Proterozoic lithosphere (from depths of ~40 km; 1.2 GPa) contain little fabric and include garnet, two-pyroxene granulites, and rare eclogites, consistent with derivation from the thick, relatively dry, high-velocity mafic layer. Proterozoic lower crustal xenoliths record a more complex history than Archean xenoliths. U-Pb zircon geochronology of Archean xenoliths yields dates that are similar to the crystallization ages of rocks exposed at the surface (ca. 2.6–2.7 Ga). In contrast, xenoliths from the Proterozoic side are ca. 1.65–1.7 Ga meta-igneous rocks that contain igneous and metamorphic zircons that yield a range of ages: Devonian (presumed to be the age of kimberlite eruption), ca. 500 Ma, 1370–1420 Ma, 1640–1750 Ma (the dominant population), and Archean (grains as old as 3.1 Ga). The xenolith data indicate that crust and mantle provinces across the Cheyenne belt are distinct lithospheric entities that date back to the time of assembly (Eggler et al., 1987).

REACTIVATION AND DIFFERENTIAL UPLIFT OF PROTEROZOIC LITHOSPHERE

Geologic studies indicate that the Proterozoic lithosphere south of the Cheyenne belt was repeatedly reactivated, whereas the Archean lithosphere has been relatively stable (Karlstrom and Humphreys, 1998). Following protracted assembly of the lithosphere from 1.78 to 1.65 Ga, the first major reactivation event took place ~1.4 Ga and involved widespread bimodal magmatism and intracontinental transpressional deformation (Nyman et al., 1994). This event pervasively affected the Proterozoic lithosphere but essentially terminated at the Cheyenne belt.

In situ electron microprobe U-Pb dating of monazite (Williams et al., 1999) helps document the importance of recurrent movements, and hence persistent weakness, within the Colorado Mineral belt (Shaw et al., 2001). Monazite geochronology from shear zones indicates two protracted, ca. 100 m.y. long, orogenic episodes (1.72–1.62 Ga and 1.45–1.35 Ga), each consisting of numerous pulses of deformation, plus 1.1 Ga Paleozoic and Laramide movements (Allen, 1994). Ar-Ar data (Karlstrom et al., 1997; Shaw et al., 1999) corroborate previous documentation (Chamberlain and Bowring, 1990; Bowring and Karlstrom, 1990; Hodges and Bowring, 1995) that discrete crustal blocks throughout the southwestern United States show very different cooling histories due to differential uplift in the Mesoproterozoic and Neoproterozoic, controlled in part by accretionary structures. New fission-track studies demonstrate post-Laramide differential uplift across the Colorado Mineral belt (Kelley and Chapin, 2002). These data confirm and extend the hypothesis of Tweto and Sims (1963) that the Colorado Mineral belt was a long-lived zone of weakness in the lithosphere.

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The extent and style of Phanerozoic reactivation of Proterozoic lithosphere were different between the Proterozoic and Archean lithospheric sections. For example, Ancestral Rocky Mountain uplifts formed almost exclusively south of the Cheyenne belt. Laramide deformation partially reactivated older boundaries in both areas, but minor fault analyses show a major change in style of Laramide to Holocene faulting across the Cheyenne belt. In the Archean lithosphere, paleostrain data indicate one or two directions of Laramide faulting and minimal subsequent deformation. In the Proterozoic lithosphere, data locally indicate three stages of Laramide faulting and three stages of Neogene faulting suggesting reactivations of a weaker Proterozoic crust (Koenig-Koenig, 2002).

NEOGENE TECTONICS ACCOMPANIES REGIONAL DENUDATION

A provocative hypothesis is that the mantle structures that we have imaged seismically may have distinct topographic manifestations. A combined topographic-thermochronologic study by Pazzaglia and Kelley (1998) demonstrated that the mean local relief, mean elevation, and thermochronologically determined exhumation history vary systematically across both the Cheyenne belt and Jemez lineament. Furthermore, geomorphic studies suggest that there is contemporary uplift associated with the youthful magmatism concentrated along the Jemez lineament (Wisniewski and Pazzaglia, 2002). Here, the Canadian River has a distinct convexity or bulge in both its long profile and terrace profiles where it crosses the Jemez lineament and has a rate of incision about two times greater than similar reaches upstream or downstream of the lineament. Thus, in spite of the numerous complex processes that combine to shape landscapes, correlations such as this suggest that deep lithospheric structure exerts important controls on today's topography.

DISCUSSION OF PROCESSES OF STABILIZATION AND EVOLUTION OF CONTINENTAL LITHOSPHERE

Cratons are stabilized by thick lithospheric mantle that extends to depths of >250 km and moves through weaker convecting asthenosphere. These mantle "keels" resist becoming incorporated into the asthenosphere because they are buoyant owing to the presence of strongly melt-depleted peridotite (Jordan, 1988). North America is an interesting case study because it contains one of the thickest mantle keels on the planet, and western North America (e.g., from the Canadian shield to the Pacific plate margin) contains the largest mantle-velocity gradient on Earth (Grand, 1994; Van der Lee and Nolet, 1997). Gradation from fast (cratonic) to slow (orogenic) upper-mantle velocity structure occurs over a remarkably short distance in the Rocky Mountains (Henstock et al., 1998) and this is therefore an important area to study the evolution of mantle structures.

In addition to the complexity resulting from the Proterozoic assembly of the continent, understanding the Rocky Mountain transect (Wyoming to New Mexico) requires consideration of Cenozoic modifications to the lithosphere. Some workers have postulated that the mantle had been largely removed (Bird, 1988) or preserved to moderate depths (70–100 km; Livicarri and Perry, 1993) by shallow-angle subduction of the Farallon slab in the Laramide. Further, many workers have postulated an upwelling of asthenosphere-to-shallow depth (even to the base of the crust) following removal of the Farallon slab that caused the ignimbrite flare-up (e.g., Humphreys, 1995). However, if the Proterozoic lithosphere is thicker, as we suggest, another possibility is that, rather than complete removal, the upper mantle was modified by a combination of Cenozoic events, including hydration above a Laramide flat slab and lithosphere-asthenosphere interactions that caused the ignimbrite flare-up and Neogene magmatism and high heat flow. If the low-velocity upper mantle in the southern Rocky Mountain region is old and essentially intact (e.g., below the Colorado Mineral belt and Jemez lineament), then this mantle, although hot and weak and perhaps being invaded by asthenosphere-derived melts, has not yet been entrained in the convecting asthenosphere. Thus, one important unresolved question is the depth extent of western North American lithosphere and the relative contributions of modern thermal differences and ancient compositional heterogeneity in the present velocity structure.

Another issue is to explain the distinctive Proterozoic lithosphere. The recurrent reactivation of the Proterozoic lithosphere suggests long-lived weakness, relative to Archean lithosphere. We speculate that this fundamental difference is a result of the style of accretion. The Proterozoic orogen was rapidly assembled from oceanic terranes with no major continent-continent collisions, in contrast to much of the Archean and Proterozoic lithosphere to the north. The Proterozoic lithospheric mantle appears to be distinct mechanically because it is buoyant, thick, and strongly segmented. Thus, even prior to the Laramide event, this lithosphere may have been pervasively hydrated during Proterozoic subduction-accretion processes associated with assembly of numerous small bits of juvenile lithosphere, similar to the ongoing accretion of Indonesian oceanic terranes to Australia. Possibly, it is this spatially variable hydration that originally gave rise to the compositional domains imaged in today's mantle.

The genesis of the high-velocity lower crustal layer is not well understood, but it probably had a complex origin involving multiple episodes of segregation of crustal cumulates, concentration of refractory residues of partial melting, and addition of underplated and/or intruded material. In the Proterozoic part of the CD-ROM cross section (Fig. 2D), we suggest that the 7.0–7.5 km/s lower crustal layer may in part be a record of a series of mantle depletion events that extracted basaltic melt from the lithospheric mantle and transferred it to the vicinity of the existing Moho, creating a lower crustal layer that is mafic but that may also contain some ultramafic material. If so, the Moho and the lower crustal layer are younger than the assembly structures and provide a record of changing crustal thickness. The lower crustal layer is remarkably featureless on regional reflection profiles and lies below well-developed bright reflectivity that we interpret to be a record of Proterozoic plate tectonics. Our hypothesis is that today's thick Proterozoic crust grew in part by underplating and addition of mafic intrusive bodies of a variety of ages. Based on thinning of the lower crustal layer just north of the Cheyenne belt, the relative lack of Proterozoic overprinting of Archean lower crust to the north, and volumetrically minor Phanerozoic magmatism in the Archean lithosphere, this process seems to have preferentially affected the Proterozoic lithosphere. A key time for such underplating was ca. 1.4 Ga. Petrogenetic models suggest that the large volume of ~1.4 Ga granitic magmatism in the middle crust was related to melting of rocks with a tholeiitic basalt composition (Frost and Frost, 1997), implying that an enormous volume of mafic rock may reside in the lower crust. However, only a single 1.4 Ga metamorphic zircon has been found so far in the Proterozoic lower crustal xenoliths, and the geochronological and Nd isotopic data from mafic lower crustal xenoliths throughout the southwestern United States indicate that these xenoliths were derived primarily from 1.7 Ga crust. Thus, another major unresolved problem is to understand the role of mafic underplating in forming the lower crustal layer and restructuring the Moho.

SUMMARY

The combined geophysical and geologic data from the CD-ROM experiment provide a high-resolution, multiscale image of the lithosphere of the Rocky Mountain region. This image supports the hypothesis that the lithospheric architecture of the southwestern United States produced during Proterozoic assembly of juvenile terranes provided the template for today's lithospheric structure. The integrated data set indicates that the Cheyenne belt, the Farwell-Lester Mountain zone, and the Jemez lineament, and their corresponding velocity anomalies in the mantle (to >200 km), are controlled by Paleoproterozoic subduction zones that were active during collisions of juvenile terranes. A variable-thickness, high-velocity lower crustal layer forms the base of the crust under all of the Proterozoic provinces investigated along the CD-ROM corridor. This and the appreciable Moho topography are interpreted to be, at least in part, younger than the sutures and the result of underplating that took place at 1.7, 1.4, and 1.1 Ga and more locally at several times in the Phanerozoic. Additional geochronological, isotopic, and physical property investigations of crustal xenolith populations will be required to test this hypothesis. Two provocative and testable hypotheses concerning lithospheric evolution are: (1) the lithospheric mantle in the southern Rocky Mountains preserves old subduction structures, is thick (>200 km) and has been persistently weak, and (2) the lowermost crust is a record of progressive evolution of the lithosphere and has grown through several underplating and/or intrusive events.

ACKNOWLEDGMENTS

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DIALOGUE

Sharon Mosher

A Collective Vision for the Future: GeoJournals, an Online Aggregate of Fully Interlinked Geoscience Society Journals

***Sharon Mosher**, Past President, GSA*

The future of geoscience society journals is at a turning point, and the path taken will profoundly influence the geosciences. In planning for the future, GSA has been working with the American Association of Petroleum Geologists, the Society for Exploration Geophysicists, the Mineralogical Society of America, and SEPM—Society for Sedimentary Geology to explore publishing scientific literature in a way that will make it more accessible and easily usable for professional scientists, students, and all members.

One of the primary purposes of scientific societies is to disseminate scientific research. For publications, students and professionals increasingly rely on electronically available literature, in many cases almost exclusively. Many journals are interlinked and searchable, providing benefits not possible through print publications. To continue our mission of disseminating scientific research results in the future and to preserve past scientific literature, it is imperative that geoscience societies publish online, convert past issues to electronically searchable formats, and integrate their journals into a common aggregate.

Readers want the ability to go seamlessly between journals—to click on a reference in the paper they are reading and be taken instantaneously to the referenced paper, regardless of the journal. When doing research, we are usually interested in a topic, not in a specific journal article. When we see a reference that looks as if it will give us the information we want, we would like to be able to easily access that article. If it isn't what we are looking for, we want to go back to the original article easily and keep reading. If it is, we want to be able to use the new article to continue moving through the literature until we find everything of importance to us. When reading an article for its content, it would be great to be able to check whether the references really do support the arguments. Certainly, instances of misquoting should decrease if this is easily checked! In addition, we want to be able to search all of the geoscience literature for a specific topic and to easily access the results of our search. Through the Web, we have learned to expect easy linking and searching; commercial publishers have shown that such expectations are reasonable. Many geoscience societies now have their journals online, and some have search and/or interlinking capabilities within their own set of publications, but this limited accessibility does not meet our growing expectations.

Our collective vision is to create an electronic geoscience publication aggregate with a wide disciplinary breadth that will include the peer-reviewed, high-quality publications of geoscience societies, both nationally and internationally. Within this aggregate, references would be fully interlinked and all content will be searchable. We also want to make back issues of all geoscience society publications available online and to have them fully linked with the current literature. Citation statistics show that citing of articles increases for 5 to 7 years and then gradually declines. Thus, cross-linking of references to back issues and the ability to search and easily link to them is important. Plus, electronic access to past literature is crucial to its continued use in the future.

Initially, the aggregate would be composed of journals, but eventually would include books, maps, and as much available digital geoscience data as possible. The site should be the first and last place to search for publicly available, high-quality, noncommercial, digital geoscience data. We envision major societies working in partnership to spearhead the formation of the aggregate and to help bring smaller societies online with support from industry and other sponsors. When combining our efforts, we can also merge our growing technological abilities to make articles interactive—published with three-dimensional images, data sets, or maps with multiple layers that can be manipulated by the reader.

An electronic geoscience publication aggregation will increase the value of geoscientific society publications to the greater geoscience community and make them more accessible to a wider audience (i.e., industry, developing countries, scientists in different disciplines), thereby resulting in a much greater readership. We believe that formation of such an aggregate is an essential step in meeting our mission of disseminating scientific research results in the future and that this aggregation will have *the* most powerful impact on our science in many decades.

GSA Foundation Establishes New Fund

I am pleased to announce the establishment of the **GeoCorps America™ Fund** within the Foundation. GeoCorps America is a GSA outreach program that places geoscientists on public lands.

Through the GeoCorps America program, GSA is striving to increase the presence of geoscientists on public lands, which will increase the permanent hiring of geoscientists and enhance the transfer of geoscience knowledge to land managers and the public. This program also raises public awareness of the importance of geoscience in the lives of Americans.

This program offers geoscientists at all levels unique experiences and brings these scientists' knowledge to public lands in the United States. Every year, millions of visitors enter our national parks and forests, often with little or no knowledge about the local geology. These public lands are ideal classrooms for educating the public about earth science. Additionally, public lands have needs requiring geoscience expertise that may not be readily available to land managers. GeoCorps America aims to ensure that more public lands have the scientific resources they need. Program participants are placed in 10- to 12-week positions serving in areas such as resource management, research, interpretation, and education. These participants represent a broad range of expertise, from undergraduate and graduate students to professors, earth science teachers and consultants to retired geoscientists.

GeoCorps America grew out of a partnership between GSA and the National Park Service. When established in 1996, the program sent two geoscientists to national parks. Now, GSA collaborates with the National Park Service and the U.S. Forest Service and will send up to 36 geoscientists to different national parks and national forests in 2002.

For more information:

- Visit the GeoCorps Web site, www.geosociety.org/science/geocorps/aboutgc.htm.
- Contact Karlon Blythe, Program Officer, kblythe@geosociety.org, (303) 357-1036.

Most memorable early geologic experience

In my first year out of college, I served as field assistant to Ira Joralemon, John Gruner, Lewis Weeks, and Walter Bucher.

—Richard H. Olson

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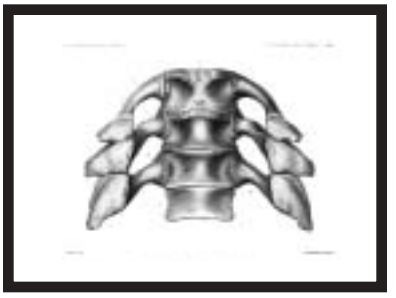
Collector's Corner #1

Brian and Cathy Skinner have donated two original lithographs to the Foundation. These collector-quality items are being offered for sale to GSA members. Each 18 × 24 inch lithograph has been mounted, framed, and is in excellent condition.

O.C. Marsh collected the fossils in the 1870s, and the lithographs were prepared in the 1880s in New Haven in preparation for the publication of a series of monographs. Marsh published several monographs on dinosaurs and John H. Ostrom and John S. McIntosh described the circumstance surrounding the famous Marsh collections. Some of the lithographs became part of their Yale Press book, *Marsh's Dinosaurs.* However, there never has been a monograph on *Stegosaurus* that presented these remarkable illustrations.

The value of each framed lithograph is estimated at $200. The Foundation is accepting bids and hopes the vertebrate paleontologists or collectors of unique geology memorabilia will find these offerings of interest. The minimum bid is $100 each. For further information, please contact the Foundation office at (303) 357-1054 or drussell@geosociety.org.

Lithograph 1. *Stegosaurus aramatus* from the Morrison Formation. Five images: cranium in dorsal, ventral, and mid-sagittal sections. Endocranial cast in dorsal and lateral views. This is specimen 4936 of the National Museum of Natural History (USNM), collected in 1877. Because of the importance of the cranial portion of this dinosaur, a version can be found as Plate #4, p. 254, in *Marsh's Dinosaurs.*



Lithograph #2. *Stegosaurus ungulatus* from the Morrison Formation. Single image of a sacrum in ventral view. This is specimen 1857 in Yale's Peabody Museum and was collected in 1879. A representation is found as Plate #22, p. 277, in *Marsh's Dinosaurs.*

In the Spotlight

GSA and a number of other societies involved in the earth sciences collaborate on GSA Annual and/or Section Meetings, where the societies help develop scientific programs, Penrose Conferences, publications, issues of public policy or education, and professional development. "In the Spotlight" features these GSA Associated Societies. For information on how to become an Associated Society, contact gsa@geosociety.org.

The Paleontological Society—Looking to the Future While Studying the Past

***Patricia H. Kelley**, President*

As the Paleontological Society approaches its first centennial, its vitality is demonstrated by a host of exciting new ventures and continuing services to its membership and to the geoscience community and beyond.

The society's mission is to advance the science of paleontology through our publications, meetings, funding opportunities, and outreach programs. We publish two journals: the *Journal of Paleontology*, which, on the eve of its 75th birthday, remains the international outlet for research on all groups of fossils and especially systematic studies; and *Paleobiology*, which recently celebrated 25 years of publishing research on the biological aspects of paleontology, including evolution, extinction, and the geographic and stratigraphic distribution of fossils. This year, we became one of the first geoscience societies to publish our journals online; they can be accessed through the BioOne consortium (www.bioone.org/bioone/?request=index-html) or our stand-alone site, www.psjournals.org. Our newsletter *Priscum*, which keeps our membership apprised of current activities and opportunities, is also available online at the society's Web site, www.paleosoc.org.

In addition to our publications, professional meetings are crucial to disseminating paleontological research and to providing networking opportunities. We sponsor exciting topical sessions, field trips, and short courses at GSA annual meetings, at each GSA Section meeting (through the six regional Paleontological Society sections), and at other cosponsored meetings (e.g., the North American Paleontological Convention, held every four years). Our annual GSA short courses are free (!) and provide an overview of topics ranging from specific groups of fossils to paleontological methods to the evolution-creation contrversy.

As a forward-looking society, the Paleontological Society is committed to its student members, particularly through our student Grants-in-Aid Program. This year, through the efforts of the Paleontological Society Student Representative, we provided a new venue for students and young professionals to network at the annual GSA meeting. The society has a strong international membership, with members in more than 40 countries. The Paleontological Society International Research Program (PalSIRP) Sepkoski Grants program continues to support research by paleontologists in Eastern Europe and republics of the former Soviet Union. To further our international involvement, we recently added a speaker outside the United States to our Distinguished Lecturer program and developed an agreement with the United Kingdom–based Palaeontological Association to provide reciprocal discounts on publications. We also welcome membership from amateur paleontologists, and each year, in addition to our awards for achievement by professionals, we honor an amateur who has furthered the field of paleontology with the Strimple Award.

Paleontology fascinates the young (three-year-olds who can barely talk seem to have no problem pronouncing *Tyrannosaurus rex*) and old. The Paleontological Society has a multifaceted outreach program that encompasses other geoscientists, K–12 teachers, and the general public. Paleontological Society Distinguished Lecturers are available for college speaker series; each lecturer has international stature in paleontology and is an excellent speaker who can communicate the excitement of paleontology to a general geoscience audience. We serve the K–12 community by hosting inexpensive workshops at annual and regional GSA meetings on such topics as "Learning from the Fossil Record" and "Evolution: Investigating the Evidence." We recently copublished a booklet with the American Geological Institute called *Evolution and the Fossil Record*. Aimed at K–12 teachers, this booklet also was distributed to legislators and school systems and is now online at www.agiweb.org/news/evolution. Our free brochures on topics ranging from careers in paleontology to various fossil groups are very popular with the general public.

Please visit our Web site at www.paleosoc.org to see the exciting activities of a forward-looking society dedicated to advancing the study of the past for the understanding of our future!

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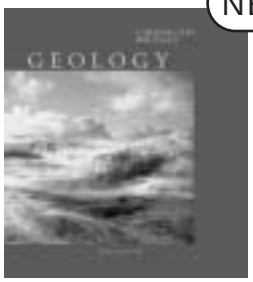

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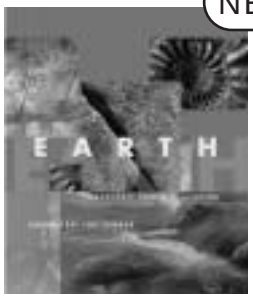

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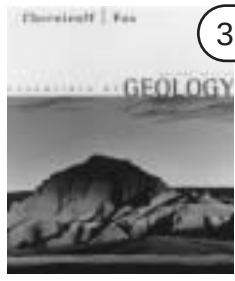

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ROCK STARS

Arthur Holmes as a young man in his early 20s. This photo was probably taken in 1912 when Holmes joined the Geological Society of London.

Arthur Holmes with Maggie, his first wife, and Geoffrey, his second son, in Durham, ca. 1930.

Arthur Holmes: An Ingenious Geoscientist

Cherry L. E. Lewis, *University of Bristol, England*

From an early age, Arthur Holmes (1890–1965) recalled seeing the date of creation—4004 B.C.—written in the family bible. "I was puzzled by the odd '4,'" he wrote. "Why not a nice round 4000 years? And why such a very recent date? And how could anyone know?" The latter question set him thinking, for at the turn of the twentieth century, there was no numerical geological time scale and the "age of the Earth" controversy was at its peak: The physicist Lord Kelvin had calculated the age to be around 20 million years; the majority of geologists demanded at least 100 million years, whilst religious dogma required only 6000 years.

A Bright Boy

Born in Gateshead, the industrial heartland of northeast England, Holmes came from a modest, staunchly Methodist background. At age 15, he gained first-class honors in the School Certificate examinations. In the sixth form, he encountered Mr. McIntosh, who introduced his pupils to the *Popular Lectures and Addresses* of Lord Kelvin. He also familiarized them with the work of the Swiss geologist Edward Suess, whose first volume of his great synthesis, *The Face of the Earth*, had recently been translated into English. Holmes later remarked how the inspirational Mr. McIntosh and these two works were largely responsible for the direction his life took, for it was at school that his interests in physics and geology were born. At 17, he won a scholarship to study physics at the Royal College of Science (later Imperial College) in London where, in his second year, he took a course in geology. Against the advice of his physics tutors, he decided to become a geologist.

Radioactivity had been discovered in 1896 and was causing much excitement. By 1904, Ernest Rutherford had determined the first radiometric date, utilizing the discovery that helium was generated in the decay process. Unfortunately, owing to the problem of helium leakage, these early dates were only minimum values, so Holmes decided to combine his interest in physics and geology in the search for an alternative technique. Building on Bertram Boltwood's work, which indicated that lead might be the final decay product of uranium, Holmes performed the very first uranium-lead analysis *specifically determined* for age-dating purposes. It yielded 370 Ma for a Devonian rock. Aged only 21, he had embarked on his lifetime's quest "to graduate the geological column with an ever-increasingly accurate time scale." In April 1911, the paper was read to members of the Royal Society while Holmes was in Mozambique.

Mozambique

Living in London on his scholarship of only £60 ($100) a year, Holmes continually struggled to make ends meet, so at 21, he took a job prospecting for minerals in Mozambique. After six months, nothing of value was found, and Holmes became so ill with malaria that a notice of his death was telegraphed home. Fortunately, he recovered and immediately caught the boat home where he began writing to geologists such as du Toit and Sederholm, requesting material for dating purposes: "My two chief objects are the formation of a geological time scale and also the correlation of the various members of the Pre-Cambrian rocks in different parts of the world." "Geologising" in Mozambique initiated his lifelong interests.

As a demonstrator at Imperial College, Holmes advanced the infant science of geochronology almost single-handedly. But after isotopes were discovered in 1913, the difficulties of chemically determining the several isotopes of lead meant that progress was slow. Much of this early work was done in collaboration with his best friend from school, Bob Lawson, with whom Holmes shared a passion for physics and music. For almost 30 years, the two friends collaborated on many projects. "I want to discuss it with you…and ask your help in the maths involved," was a typical appeal from Holmes, but Lawson rarely gained the credit he deserved.

The Age of the Earth

Following publication of Holmes' famous book *The Age of the Earth* in 1913 (Harper & Brothers) in which he estimated the Earth's age to be 1600 Ma, Holmes, still only 23, became recognized as the world's authority on the subject. Despite this, opposition from established geologists entrenched in a belief that the Earth was 100 Ma was formidable. Holmes recalled one such occasion during a talk being given at the Geological Society of London in 1915:

> I was being violently attacked by the reader of a paper who insisted that the Age of the Earth must be less than 100 million years old. In the discussion that followed I had occasion to refer to the isotopes of lead, then newly discovered. But isotopes did not seem to have been heard of in that audience. The reader of the paper insisted that all atoms of lead must have the same atomic weight, and I found myself in an exasperated minority of one.

Burma

Holmes remained a demonstrator at Imperial College throughout World War I, but by 1920, with a wife and young son to support, he could no longer afford the luxury of research. He took a job as chief geologist to an oil company in Burma, but again the venture proved unsuccessful and the underfunded company failed to pay its employees. Two years later, Holmes returned to England, bankrupt and devastated by the death of his young son from dysentery. Unable to get a job, he opened a shop selling far-eastern knick-knacks, but he never lost sight of his dream. Eventually, in 1924, following the birth of another son, he was offered the headship of the new geology department being opened at Durham University. His was a department of one.

Continental Drift

On returning from Burma in 1922, Holmes found that the age of the Earth controversy had largely been settled and even the most conservative geologist accepted the long time scale demonstrated by his dating work. But that debate had been replaced by another: continental drift. While many Europeans considered that the geological evidence strongly supported the theory, the majority were still unable to accept it due to a lack of understanding about *how* continents moved around the globe. Holmes, however, was one of a small group convinced from the start of the theory's validity. His work on radioactivity, geological time, and petrogenesis had led him to a profound understanding of processes in the Earth's interior. Consequently, he was the first to propose that incredibly slow-moving convection currents in the mantle caused continental breakup, seafloor formation, crustal assimilation, and continental drifting. Despite his theories being ignored, he still taught them to his students for the next 30 years.

Holmes remained at Durham for 19 years and established himself as "one of the few English geologists with ideas on the grand scale," as Reginald Daly described him. In 1932, continuing his search for a simple dating technique, he proposed a "new key to petrogenesis" that described the principle now known as *initial ratios*. Unfortunately, to illustrate his ideas, he used an assumed radiometric decay scheme ($^{41}K/^{41}Ca$), which later proved incorrect. Consequently, this fundamental idea that today underpins isotope geochemistry, was also ignored for 30 years.

Principles of Physical Geology

Following the death of his wife in 1938, Holmes married Doris Reynolds, also a geologist, with whom he found great happiness. During World War II, he wrote his world-famous textbook with its final chapter on continental drift. *Principles of Physical Geology* (Thomas Nelson & Sons) influenced generations of geologists, but by the time it was published in 1944, Holmes had been appointed Regius Professor of Geology at Edinburgh University. It was there, despite his declining health, that he completed some of his most important work on the age of the Earth, the geological time scale, the Precambrian, and the geology of Africa—those lifelong interests triggered by his trip to Mozambique.

With ideas far ahead of his time, Holmes was a deep thinker and philosopher about the really big geological problems. Many honors were heaped upon him, including the Wollaston and Penrose medals in 1956, and the Vetlesen Prize in 1964, but at no presentation was his work on continental drift ever mentioned. In fact, Holmes was considered something of a maverick for his persistent belief in the theory, and it was as "Father of the Geological Timescale" that he was commended.

Holmes lived just long enough to see the dawn of plate tectonics. In 1963, the theory of seafloor spreading was proposed, validating his theories by then almost forgotten. In 1965, the second edition of his *Principles of Physical Geology* was published, only months before he died. In it he modestly noted that "mantle currents are no longer regarded as inadmissible." Today, Holmes is acclaimed as one of the most important geoscientists of the twentieth century.

Further Reading

Lewis, C.L.E., 2001, Arthur Holmes' Vision of a Geological Timescale, *in* Lewis, C.L.E., and Knell, S., eds., The Age of the Earth: from 4004 B.C. to A.D. 2002: London, Geological Society [London], Special Publications 190, p. 121–138.

Lewis, C.L.E., 2000, The Dating Game, Cambridge University Press.

"Rock Stars" is produced by the GSA History of Geology Division. Editorial Committee: Michele Aldrich, Robert Dott (editor of this profile), Robert Ginsburg, and Gerard Middleton.

Arthur Holmes and Doris Reynolds, his second wife, in the field, ca. 1940.

UPCOMING DEADLINES

Nominations for the **John C. Frye Environmental Geology Award*** are due March 31, 2002. Nominations for the following national awards are due April 30, 2002: **William T. Pecora Award, National Medal of Science, Vannevar Bush Award**, and **Alan T. Waterman Award**. Details and nomination procedures for these awards are posted at www.geosociety.org. Go to "About Us," then to "Awards and Medals." You may also contact Leah Carter, (303) 357-1037, lcarter@geosociety.org, Grants, Awards, and Medals, P.O. Box 9140, Boulder, CO 80301-9140, or see the October and November issues of *GSA Today*.

For details on the following awards, see the January issue of *GSA Today* or visit www.geosociety.org. Go to "About Us," then "Divisions."

- **Don J. Easterbrook Distinguished Scientist Award,* Quaternary Geology and Geomorphology Division:** Nominations due by April 1, 2002, to Debbie Harden, harden@geosunl.sjsu.edu, San Jose State University, One Washington Square, San Jose, CA 95192-0102.
- **Farouk El-Baz Award for Desert Research,* Quaternary Geology and Geomorphology Division:** Nominations due by April 1, 2002, to J. Steven Kite, jkite@wvu.edu, Dept. of Geography, West Virginia University, 223 White Hall, P.O. Box 6300, Morgantown, WV 26506.
- **Laurence L. Sloss Award for Sedimentary Geology,* Sedimentary Geology Division:** Nominations due by March 1, 2002, to Paul Karl Link, Secretary, Sedimentary Geology Division, Dept. of Geology, Box 8072, Idaho State University, 1400 E. Terry, Pocatello, ID 83209-8072.

* Funds supporting these awards are administered by the GSA Foundation.

LOG ON FOR LETTERS

Letters to *GSA Today* on the following topic are posted at www.geosociety.org/pubs/gsatoday/letters.

— *GSA Evolution and Creationism Position Statement*

GSA has a new look on the Web! We've improved speed and navigation, and, as always, we welcome your comments.

www.geosociety.org

What are Those Shlemon Mentor Programs at Section Meetings All About?

Karlon Blythe, *Program Officer*

Held exclusively for students at GSA Section Meetings, the Shlemon workshops focus on topics of great interest to students who are contemplating the pursuit of a job in the consulting field. Mentors who are practicing applied geoscientists volunteer their time to share insights on the consulting industry and practical tips about how to secure those types of positions with students who are evaluating their post-graduation job options. Don't be surprised when these mentors share information that you have never heard before.

A Shlemon Mentor Program in Applied Geoscience will be offered at each 2002 Section Meeting. The workshops are informal and lend themselves to interactive questions and answers. Additionally, these workshops always include lunch as a bonus. These workshops are made possible by the Roy J. Shlemon Fund, administered by the GSA Foundation. Be sure to preregister for this workshop held at the GSA Section Meeting near you. Registration is free or minimal cost, but you'll want to make sure you have a seat, as attendance is limited.

Places and dates for the spring 2002 Shlemon Mentor workshops:

Cordilleran Section	Shlemon Mentor Program, Tues., May 14, 11:30 a.m.–2 p.m., CH2M Hill Alumni Center, Oregon State University, Corvallis, Oregon. Free.
Northeastern Section	Shlemon Mentor Program, Mon., March 25, 11:30 a.m.–1:30 p.m., Suffolk Room, Sheraton Springfield Hotel, Springfield, Mass. Cost: $5.
Rocky Mountain Section	Shlemon Mentor Program, Tues., May 7, 11:30 a.m.–1:30 p.m., Brian Head Room, Sharwan Smith Center, Southern Utah University Campus, Cedar City, Utah. Free.
South-Central Section	Shlemon Mentor Program, Fri., April 12, 11:30 a.m.–1:30 p.m., Sul Ross University Center, Alpine, Texas. Free.
Southeastern and North-Central Sections	Shlemon Mentor Program, Thurs., April 4, and Fri., April 5, 11:30 a.m.–1:30 p.m., Hyatt Regency Hotel, Lexington, Kentucky. Free.

For additional information, please contact Karlon Blythe, kblythe@geosociety.org, (303) 357-1036.

GEOLOGY from THE HILL:

A Challenging Beginning

Chester F. (Skip) Watts, *2001–2002 GSA–U.S. Geological Survey Congressional Science Fellow*

Before coming to Washington, I was told by folks who are "in the know" that this would be a year that would "open my eyes" and "change my life." After all, becoming a congressional staff member, totally immersed in the legislative process and helping to shape public policy, was certain to make me more politically aware as a scientist and as a citizen. I was eager to jump right in and do my part to help change the world for the better. No one foretold, however, that terrorist attacks less than two weeks after my arrival would dramatically change the entire world and drastically divert the attention of those working on Capitol Hill. This is a challenging time in Washington, and I feel fortunate to be here right now. So for this first article, I chose to describe the unexpected events and unusual early days of my fellowship year and my transition from the world of geology to the world of politics. In later articles, I will describe the great need that exists for each of us to become involved, even in little ways, in matters of public policy and geoscience education.

To set the stage, I accepted a position on the personal staff of Senator Joseph Lieberman, Democrat from Connecticut. It is an honor to be working in his office. Senator Lieberman is a respected member of the Senate Armed Services Committee as well as a member of the Environment and Public Works Committee. He also serves as chairman of the Senate Governmental Affairs Committee. Needless to say, the office is a very busy place. Normally located in the Hart Senate Office Building, presently closed for anthrax decontamination, we now operate from cozy (i.e., crowded) improvised workspaces in borrowed office hallways on Capitol Hill. By the time this goes to press, I have every hope that all of the Senate office buildings will once again be open for business as usual.

For me, this all began as a rather modest interest in public policy related to natural hazards and safety. I was encouraged by a former fellow to apply for the GSA–USGS Congressional Science Fellowship so that I could experience more of the public policy building process. I applied, not really expecting to be chosen. Yet on September 5, 2001, I happily found myself sitting in the Washington, D.C., auditorium of the American Association for the Advancement of Science (AAAS) along with nearly 100 other science fellows, ready to begin two weeks of orientation in preparation for a year of government service. Sponsored by various other professional science and engineering societies and by some government agencies, these fellows include biologists, physicists, chemists, astronomers, engineers, doctors, dentists, and veterinarians, to mention only a few. Many were already assigned to positions in such places as the Department of State, the Department of Justice, the U.S. Agency for International Development, the Department of Defense, and the National Institutes of Health. Thirty-five of us were congressional fellows and would take positions as staff members in the House of Representatives or Senate, working for specific committees or on the personal staffs of members of Congress.

I cannot say enough about the AAAS orientation provided each year for science fellows. I sometimes describe it as the "You are There" version of a college government class. The political world of Washington, D.C., has its own history, protocols, and vocabulary. We were introduced to all of it in a whirlwind of illustrious guest speakers, workshops, and site visits. Orientation topics too numerous to fully list here included such all-time favorites as "Where Does Science Fit in Public Policy," "Why You'll Never Understand the Policy Process Unless You Understand the Budget," and "Reflections on 53 Years of Science and Technology Policy."

Some titles admittedly seemed a bit dry at first glance, yet they each contained a flood of interesting and useful information. I was not terribly surprised to learn, for example, that there have been just a few noteworthy times in American history when the federal government dramatically sought the counsel of scientists and increased the resources available for science research and/or education. The first came during the Civil War, when President Lincoln established the National

Chester F. "Skip" Watts

Academy of Sciences specifically to investigate and respond to scientific questions, initially of a military nature, for the edification of government officials. During World War II, tremendous resources were pumped into science and engineering research for the development of radar, aircraft blind landing systems, sonar, and nuclear weapons, to mention only a few. And in 1957, Russia's entry into the space age with the launch of Sputnik I prompted Congress to authorize far-reaching new programs in science education and space exploration.

In recent years, the general consensus among scientists is that Congress and the president tend to pay very little attention to science when developing public policy. The thought is that, in government, a convincing anecdotal story will generally win out over a myriad of detailed studies, and policies seem to develop based more on ideologies than on scientific thought. So it did bring at least some sense of satisfaction to many when the media quoted President Bush as saying something like, Bring me scientists! as the war on terrorism, and especially the war on anthrax, really got under way. And that was accompanied by the Department of Defense issuing a Broad Agency Announcement, seeking proposals for the development and application of new science and technology useful in detecting and combating terrorist threats at home and abroad. But despite this renewed attention to science in response to threats, the need to push for good scientific thought in building public policy will no doubt remain.

At the Eisenhower Executive Office Building, we met with the White House Science Advisor's Chief of Staff and were briefed on the history of science advice to the president. At the National Press Club, we learned of science applications in the Judicial Branch. Pentagon staff provided insight into science and technology at the Department of Defense. And the staff of the Congressional Research Service of the Library of Congress detailed the role of the service in addressing the information needs of all members of congress and their staffs.

As the terror attacks began on September 11, our training schedule placed us at the Library of Congress, across the street from the Capitol Building. With the Pentagon already hit and another plane believed to be headed to Washington, everyone on Capitol Hill was evacuated to the streets. Traffic was in gridlock and the subway was closed. I chose to hike to the Pentagon, just four miles away, and was allowed only to watch as fire and rescue crews worked under heavy police and military protection.

The days that followed saw changes on Capitol Hill unparalleled since World War II. The biggest issue facing Congress before the attacks was protecting the Social Security surplus, balancing it against President Bush's tax refunds, and allocating reasonable funding to education, health care, science research, defense, and the like. Following September 11, priorities quickly changed to bailing out airlines, combating terrorism, and strengthening defense and homeland security. The focus of AAAS orientation lectures and informal discussions switched to foreign policy related to terrorism, chemical and biological weapons, and how governments can deal with crises. With a special reception in the Capitol Building for new congressional fellows, the orientation period came to a close, and it was time to go to work.

Many of the congressional offices that had specifically requested fellows were now operating in crisis mode. Some staffs were so busy dealing with issues on a minute-to-minute basis that there was simply no time to bring in and incorporate new fellows to help out. And then the anthrax letters began to appear. The Hart Senate Office Building was suddenly closed. Staff members there left behind files, case histories, address books, calendars, and even personal belongings. Through perseverance and creativity, new workspaces were squeezed into other buildings. It was not easy, but the Senate continued to function. That was the environment into which I finally stepped. By the time I joined other staff members in their makeshift office, they had secured two phones and three computers for seven people, and personal workspace was literally a chair and our laps. Amazingly, not a single person was complaining and not a single person wanted to be somewhere else.

Early in orientation, we were told that science expertise is generally limited in most congressional offices. Fellows might be asked to work on most any issues involving science and technology, including some not directly related to our specific disciplines. I have been fortunate to become involved in some geology-related projects with the Department of Interior and the Department of Defense. And, I was asked by one congressional office to work on air force technology and defense issues. The variety of things going on is exciting. As things settle down, a major focus for me will be working on broadband issues and possibly helping to shape the exciting future of high-speed Internet.

It will come as no surprise to most of you that geology is playing a significant role in many aspects of the war on terrorism. From the geotechnical evaluation of the World Trade Center foundations and New York City infrastructure, to the caves and battlefields of Afghanistan, geologic knowledge is being put to the test. Some can be shared and some cannot. But I haven't talked to a geologist yet who hasn't looked carefully at the Bin Laden videos and speculated on their geologic setting and location. And I'm proud to say that the USGS is providing valuable data to the armed services. Soon will come relief and reconstruction efforts in the rebuilding of Afghan infrastructure—airports, roads, dams, and hospitals. Perhaps most important of all will be providing adequate clean water in an already drought-stricken region. The importance of geology in helping to set right that which has gone terribly wrong cannot be treated lightly.

I want to thank GSA and the USGS for making this opportunity available to me. I also want to thank former Congressional Science Fellows Dave Verardo and Rachel Sours-Page for their help and encouragement. In closing, I leave you with some simple thoughts. The public elects the officials. Let's all do our best to educate the public. This is a great country.

Submitted for publication by Chester F. Watts, 2001–2002 GSA–USGS Congressional Science Fellow, with the understanding that the U.S. government is authorized to reproduce and distribute reprints for governmental use. The one-year fellowship is supported by GSA and by the USGS, Dept. of the Interior, under Assistance Award No. 1434-HQ-97-GR-03188. The views and conclusions contained in this document are those of the author and should not be interpreted as necessarily representing the official policies, either expressed or implied, of the U.S. government. ▲

OCEAN GEOSCIENCE LECTURES

The Joint Oceanographic Institutions/U.S. Science Advisory Committee (JOI/USSAC) Distinguished Lecturer Series brings the results of Ocean Drilling Program research to students at the undergraduate and graduate levels and to the earth science community in general. JOI/USSAC is accepting applications from U.S. colleges, universities, and nonprofit organizations to host talks given by the speakers listed below during the 2002-2003 academic year. Applications are available online at www.joiscience.org/USSSP or from: JOI, Inc., 1755 Massachusetts Avenue, NW, Suite 700, Washington, DC 20036-2102; tel (202) 232-3900; email tdonoghue@joiscience.org. **Applications are due April 5, 2002.**

The Subduction Squeegee
Dr. Barbara Bekins, U.S. Geological Survey

Extreme Climates and Frozen Methane: The Global Carbon Cycle with Gas Hydrates
Dr. Gerald R. Dickens, Rice University

Windows on Subduction Zone Processes
Dr. Patricia Fryer, University of Hawaii

The Icy Poles or the Muggy Equator: What Drives Natural Climate Change?
Dr. Alan Mix, Oregon State University

The Ups and Downs of Determining Ancient Sea Level Change
Dr. Gregory Mountain, Lamont Doherty Earth Observatory

Life in Marine Sediments: Probing the Limits of Earth's Deep Biosphere
Dr. David C. Smith, University of Rhode Island

2002 GSA Section Meetings

THE GEOLOGICAL SOCIETY OF AMERICA

NORTHEASTERN SECTION
March 25–27
Sheraton Springfield, Springfield, Mass.
Information: Sheila Seaman, (413) 545-2822, sjs@geo.umass.edu.

SOUTHEASTERN AND NORTH-CENTRAL SECTIONS
April 3–5, 2002
Hyatt Regency Hotel and Lexington Civic Center, Lexington, Ky.
Information: John D. Kiefer, kiefer@kgs.mm.uky.edu, or James C. Cobb, cobb@kgs.mm.uky.edu, (859) 257-5500.

SOUTH-CENTRAL SECTION
April 11–12, 2002
Sul Ross State University Center, Alpine, Texas.
Information: Kevin Urbanczyk, (915) 837-8110, kevinu@sulross.edu.

ROCKY MOUNTAIN SECTION
May 7–9, 2002
Southern Utah University Campus, Cedar City, Utah.
Information: Robert Eves, (435) 586-1934, eves@suu.edu.

CORDILLERAN SECTION
May 13–15, 2002
Oregon State University, Corvallis, Oregon.
Information: Robert S. Yeats, (541) 737-1226, yeatsr@geo.orst.edu.

Register online at www.geosociety.org.

*To reward and encourage **teaching excellence** in beginning professors of earth science at the college level, GSA announces:*

The Eleventh Annual Biggs Award

Eligibility Earth science instructors and faculty from all academic institutions engaged in undergraduate education who have been teaching full-time for 10 years or fewer. (Part-time teaching is not counted in the 10 years.)

Award Amount An award of $750 is made possible as a result of support from the Donald and Carolyn Biggs Fund (maintained by the GSA Foundation), the GSA Geoscience Education Division, and GSA's Science, Education, and Outreach Programs. This award also includes up to $500 in travel funds to attend the award presentation at the GSA annual meeting.

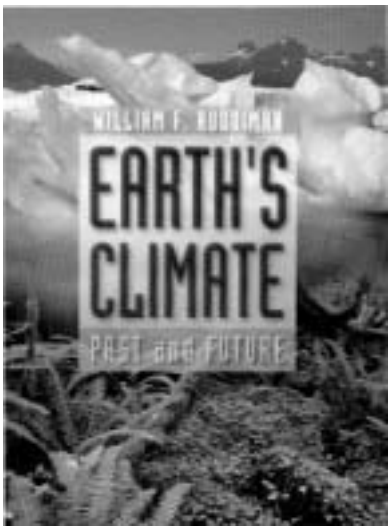
Deadline and Nomination Information Nomination forms for the 2002 Biggs Earth Science Teaching Award are posted at www.geosociety.org (go to "About Us," then "Awards and Medals"). Or, contact Leah Carter, (303) 357-1037, lcarter@geosociety.org. Nominations must be received by May 1, 2002.

Mail nomination packets to:

Leah Carter
Program Officer, Grants, Awards, and Medals
GSA, P.O. Box 9140,
Boulder, CO 80301

for Excellence in Earth Science Teaching

BOOK REVIEW



Earth's Climate: Past and Future

William Ruddiman, W.H. Freeman and Co., New York, 2001, 465 p., $79.

I can think of few if any scientists as well qualified as Bill Ruddiman to write a text on Earth's climate. Who, after all, but a scientist who has worked at the forefront of climate problems for over 30 years and worked with many of the other greats in this field could write such a comprehensive, coherent, and clear text on the subject. As an educator who has taught undergraduate climate change courses for over ten years, I am delighted to have a first-rate text.

Climate change and greenhouse warming have become commonplace expressions in the last few years, but, unfortunately, their currency doesn't reflect a corresponding increase in the public understanding of these complex processes. Among my undergraduates, for example, are some who are unaware of previous global climate changes or how the "greenhouse" works. Yet they want to learn. Climate change is ideal for engaging students in the study of earth science because students do appreciate the dramatic effect it may have on their lives. This book will surely help to make this connection.

It's no accident that *Earth's Climate: Past and Future* is so well adapted to undergraduate use. Ruddiman explains in the preface that he developed the text from teaching notes and outlines he created for his own course on climate change. He makes the subject easier to grasp by breaking it down into five tightly focussed parts, each subdivided into chapters. His expertise as a teacher comes through, because the parts are tied together with recurrent themes such as response time, interactions and feedbacks, and the role of carbon within each time scale.

Graphics in the book are in color and work together so that they carry an easy-to-grasp message. In all of the climate scales, for example, red is warmer and blue is colder, and the colors change through time. Figure 2-16, the general circulation of the atmosphere, is common to meteorology and oceanography texts, but here, high-pressure cells are brown (P<E) and low-pressure cells are green (P>E).

As in most textbooks today, boxes are well in evidence here. They are arranged into four categories: Tools of Climate Science, Climate Interactions and Feedbacks, Climate Debates, and Looking Deeper into Climate Science. This is an attractive way to explain special topics; however, many of them whetted, but did not satisfy my appetite, and additional resources are not provided. For example, Box 10-2, "Antarctic Deglaciation 3 Myr Ago?" in its brevity misses some of the interesting details. Why not direct the reader, whose curiosity may be piqued, to the excellent *GSA Today* articles (*GSA Today*, 1998, v. 8, no. 4: Harwood and Webb, Glacial transport of diatoms in the Antarctic Sirius Group: Pliocene refrigerator, p. 1, 4–8; and Stroeven et al., Atmospheric transport of diatoms in the Antarctic Sirius Group: Pliocene deep freeze, p. 1, 4–5), which provide more background and detail? Similarly, Box 13-1 describing the "Ventilating of the Glacial Ocean" leaves the reader wondering why the ventilation rate is important and the implications of a much slower Atlantic ventilation if Pacific ventilation didn't change.

Overall, this book does an amazing job of synthesizing an overwhelming mass of disparate material. This book is a welcome tool not just for earth science students but public policy makers and those who elect them. I can't wait to hear my students' reactions when I teach a climate course using this outstanding text.

Suzanne O'Connell
Trinity College, Hartford, Conn., and
Wesleyan University, Middletown, Conn.

ANNOUNCEMENTS

MEETINGS CALENDAR

2002

June 15–20	Mineral Surface Reactivity: EuroConference on Models of Mineral Surface Reactivity, Castelvecchio Pascoli, Italy. Information: European Science Foundation, EURESCO Office, 1 quai Lezay-Marnésia, 67080 Strasbourg Cedex, France, euresco@esf.org, www.esf.org/euresco.
Aug. 26–Sept. 3	4th International Workshop on Orogenic Lherzolites and Mantle Processes, Samani, Hokkaidō, Japan. Information: http://earth.s.kanazawa-u.ac.jp/LherzoliteWorkshop2002/.
October 12–17	Natural Waters and Water Technology: EuroConference on Colloids in Natural Waters, Spa, Belgium. Information: European Science Foundation, EURESCO Office, 1 quai Lezay-Marnésia, 67080 Strasbourg Cedex, France, euresco@esf.org, www.esf.org/euresco.
November 20–23	Role of Natural Resources and Environment for Sustainable Development in South and Southeast Asia (NESDA), Dhaka, Bangladesh. Information: Afia Akhtar, Geological Survey of Bangladesh, 153 Pioneer Road, Segunbagicha, Dhaka 1000, Bangladesh, 880-2-418545, afia@agni.com, gsb@agni.com.
December 14–19	Geochemistry of Crustal Fluids: The Role and Fate of Trace Elements in Crustal Fluids, Seefeld in Tirol, Austria. Information: European Science Foundation, EURESCO Office, 1 quai Lezay-Marnésia, 67080 Strasbourg Cedex, France, euresco@esf.org, www.esf.org/euresco. *(Application deadline: September 2002.)*

Send notices to jhammann@geosociety.org. Only new or changed information is published in *GSA Today*. A complete listing is posted in the Calendar section at www.geosociety.org.

About People

The Texas Science Hall of Fame has selected GSA Fellow **Michel T. Halbouty** as a member in recognition of his numerous contributions to the geosciences. The Science Hall of Fame annually recognizes the giants of science in the State of Texas.

Rare Survey of Texas Now on Web

Thanks to a TexShare-funded project by the General Libraries at the University of Texas (UT) at Austin, the Dumble Survey is now on the Web and available to the public.

The Dumble Survey, conducted by state geologist, E.T. Dumble, was mandated in 1888 by an act of the Texas Legislature. This survey—ultimately contained within four annual reports issued from 1889 to 1892, four bulletins, and several special reports—records in detail early firsthand observations of the geology of Texas from its remote corners to its population centers. "What I think is great about this set of documents is the picture it paints of Texas a century ago, facing many of the same challenges we do today, and before half of the state was even fully explored," said Dennis Trombatore, head of the Walter Geology Library at UT Austin.

The survey is still a primary historical document consulted for current work in lignite mining, mineral exploration, land use, and groundwater and aquifer development throughout Texas. The most complete copies of the documents, totaling some 2,700 pages and 35 foldout plates, are located in the Walter Geology Library at UT Austin. Unfortunately, they were printed on low-quality paper and are now crumbling.

These fragile pages, filled with valuable information often difficult to locate because of the way the information was originally organized, are now digitized, indexed, and posted at www.lib.utexas.edu/books/dumble.

A grant from the TexShare TexTreasures Grant Program, plus assistance from the General Libraries and the UT Geology Foundation's Walter Fund, provided the support for the digitization of the materials and the creation of the Web site.

In Memoriam

John C. Butler
Houston, Texas
October 24, 2001

Darryl S. Futrell
Whittier, California

Samuel Epstein
Pasadena, California
September 17, 2001

Y.W. Isachsen
Albany, New York
October 24, 2001

L. Gifford Kessler III
Houston, Texas
December 12, 2001

Louis C. Pakiser Jr.
Denver, Colorado

James A. Pendleton
Boulder, Colorado
December 13, 2001

Deane K. Smith Jr.
University Park,
Pennsylvania
September 7, 2001

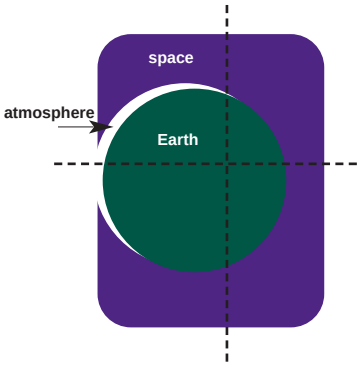
Please contact the GSA Foundation for information on contributing to the Memorial Fund.

A New Symbol

THE GEOLOGICAL SOCIETY OF AMERICA

The new GSA logo is a graphical representation of Earth in space. It reflects the expansion that has taken place within the geological sciences. Geoscience is no longer limited to earthbound, hard-rock geology, but includes planetary geology and the integration of other scientific disciplines such as biology, chemistry, atmospheric science, and oceanography.

The new logo also reflects increased research activity by GSA members outside of North America and the growing number of non-United States–based GSA members. It supports the Society's globalization initiative.



Inside the Design

The **green portion** in the lower half depicts a portion of the globe. Its undifferentiated surface allows for assumed inclusion of the lithosphere, asthenosphere, hydrosphere, and biosphere, along with the many scientific disciplines involved in their study.

The **white area** represents Earth's atmosphere, communicating inclusion of atmospheric sciences.

The **deep purple** at the top represents space and the attendant planetary disciplines that are a vital part of the geosciences.

The **name element** of the mark makes clear that this expanded view of the geosciences is held by the Geological Society of **America**.

While the geosciences have expanded in scope, and GSA as a society has moved beyond the boundaries of North America and hard-rock geology, the name element strongly states both our scientific orientation and our organizational identity.

"The new logo is elegant, classy, modern, and in keeping with the spirit of what GSA represents today, especially the global and planetary reach of its members and programs."

—***Eldridge Moores,*** *Past President and Strategic Planning Committee member, GSA*

What Happens to the GSA Seal?

GSA's seal is widely recognized and respected in the field of geoscience. **It continues to have a role to play at GSA and will not disappear.** As a symbol of GSA's history and longevity, it will continue to be used on GSA medals and awards and will be used for other official purposes.

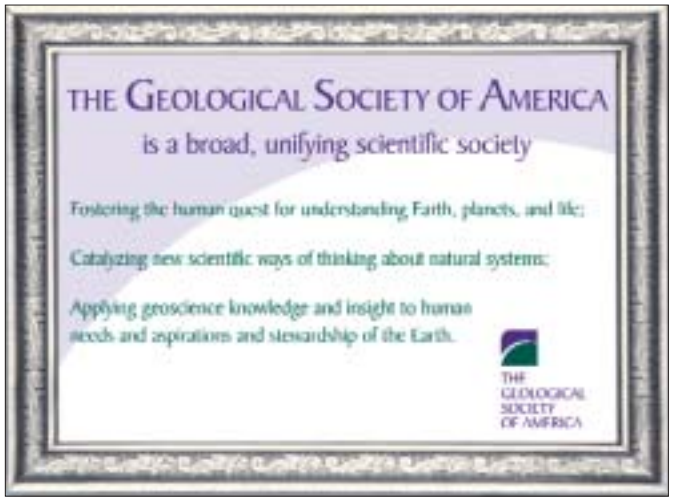
The new logo is intended to support other, more marketing-oriented purposes, such as GSA's efforts to expand its membership and increase meeting attendance. This forward-looking logo reflects the expansion of the geosciences and communicates the strategic direction of GSA in the twenty-first century. It conveys the fact that all geoscientists have a place at GSA.

"I think the traditional seal is a wonderful historical design that we should preserve and continue to use where appropriate, such as on medals and awards, financial reports, and legal documents. The new logo provides a visually attractive symbol for a forward-looking organization; it is in sync with the best of contemporary fine art and design of our times."

—***Peter W. Lipman,*** *GSA Councilor*

SCIENCE ▪ STEWARDSHIP ▪ SERVICE

for a Great Vision



The goal of GSA's organizational identity initiative is to convey the Society's contemporary mission, vision, and values, while continuing to honor its history and longevity. This initiative is one additional step in the implementation of GSA's progressive and forward-looking Strategic Plan.

"The new logo effectively expresses the global nature of our science and GSA's vision. I now find it easier to identify with the new logo than with the Seal."

—***Sharon Mosher,*** *Past President, GSA*

The New GSA Logo:

- **Illustrates** GSA's position as a broad, unifying scientific society.
- **Reflects** the expansion of the geosciences.
- **Communicates** GSA's commitments to globalization and integrative science.
- **Stimulates** discussion of GSA's strategic direction and encourages participation.
- **Represents** GSA favorably in the company of world-class scientific, media, and other organizations.

When used with GSA's tagline—Science, Stewardship, and Service—the logo creates an enormously strong impression. It suggests a broadly based, prestigious organization with values that place it on high ground.

THE GEOLOGICAL SOCIETY OF AMERICA

SCIENCE ■ STEWARDSHIP ■ SERVICE

Beginning this month, the new GSA logo will appear on GSA journals, and you'll see it on the abstract books for the 2002 Section meetings. The logo also will be incorporated into the new GSA Web site design at www.geosociety.org.

SCIENCE ■ STEWARDSHIP ■ SERVICE

GeoVentures

GeoTrips

Iceland: Fire and Ice

August 1–15, 2002

Scientific leader: Haraldur Sigurdsson, Graduate School of Oceanography, University of Rhode Island. **Guest Lecturer:** Haukur Johannesson, Natural History Institute, Reykjavík, Iceland. This trip will reveal many unaltered and fresh geologic features that can be seen nowhere else on land. Expect to acquire an expanded understanding of volcanoes, hotspots, and rifts. View steep-walled and flat-topped hyaloclastite ridges derived from subglacial eruption, young hyaloclastite islands produced by submarine eruptions, great explosion craters, tephra cones, calderas, blocky obsidian flows, waterfalls descending into the rift valley and, of course, extraordinary glacial panoramas.

Fees and Payment: $3,400 for GSA members; $3,500 for nonmembers. A $400 deposit is due with your reservation and is refundable (less $100) through May 15. Fee is based on double occupancy. The single supplement, based on availability, is an additional $486. Total balance is due May 15. Min.: 20; max.: 40. Included: Classroom programs and materials; field trip transportation, lodging, all meals, guidebook and map. Not included: Airfare to and from Reykjavík, alcoholic beverages, and other expenses not specifically included.

Iceland: A Student Only–Oriented GeoTrip

August 1–15, 2002

Scientific leader: James Reynolds, Brevard College, Brevard, North Carolina. Designed for students *only*, this trip will visit classical geological localities of Iceland on a low-frills budget. Participants will camp and prepare meals in a group kitchen tent. Eighty kilometers of hikes will take us through spectacular volcanic and glacial scenery. The trip begins in Baltimore and will fly to Reykjavík to make a 12-day loop around the country.

Fees and Payment: $2,700 for GSA student members; $2,800 for nonmembers. A $200 deposit is due with your reservation and is refundable (less $100) through May 15. Total balance is due May 15. Min: 20; max: 35. Included: Roundtrip airfare to Reykjavík from Baltimore (currently the gateway city), classroom programs and materials, field trip transportation, lodging, all meals, guidebook and map. Not included: Airfare to and from Baltimore, camping equipment (tent and sleeping bag), alcoholic beverages, and other expenses not specifically included.

GeoHostel

Geology of Coastal Southern Maine

July 13–18, 2002

Limited number of spaces available. Register today!

For complete details on these trips, see the January issue of *GSA Today*, also available at www.geosociety.org/pubs/. Trip details also are posted at www.geosociety.org (go to "Meetings," then to "GeoVentures"). GSA is committed to making GeoVentures accessible to all. If you require special arrangements or have special dietary concerns, contact Edna Collis, GSA Headquarters, (303) 357-1034.

REGISTER TODAY!

Send a deposit to hold your reservation; please pay by check or credit card. You will receive further information and a confirmation of your registration within two weeks after your reservation is received.

	Deposit Per Person	No. of Persons	Total Paid Deposit
Iceland	$400	____	$_____
Iceland (students only)	$200	____	$_____
Maine	$100	____	$_____
		TOTAL DEPOSIT	$_____

Name

Institution/Employer

Mailing Address

City/State/Country/ZIP

Phone (business/home)

Guest Name

GSA Member #

☐ VISA ☐ MasterCard ☐ American Express ☐ Discover

Credit Card # Exp. Date

Signature

MAIL OR FAX REGISTRATION FORM AND CHECK OR CREDIT CARD INFORMATION TO:
2002 GSA GeoVentures, Member Services
P.O. Box 9140, Boulder, CO 80301
fax 303-357-1070 or 303-443-1510

MAKE CHECKS PAYABLE TO: GSA 2002 GeoVentures

CLASSIFIED Advertising

Ads (or cancellations) must reach the GSA Advertising office one month prior. Contact Advertising Department, (303) 357-1053, 1-800-472-1988, fax 303-357-1070, or e-mail acrawford@geosociety.org. Please include complete address, phone number, and e-mail address with all correspondence.

Classification	Per Line for 1st month	Per line for each addt'l month (same ad)
Situations Wanted	$1.75	$1.40
Positions Open	$6.50	$5.50
Consultants	$6.50	$5.50
Services & Supplies	$6.50	$5.50
Opportunities for Students		
first 25 lines	$0.00	$2.35
additional lines	$1.35	$2.35
Code number: $2.75 extra		

Agencies and organizations may submit purchase order or payment with copy. Individuals must send prepayment with copy. To estimate cost, count 54 characters per line, including all punctuation and blank spaces. Actual cost may differ if you use capitals, centered copy, or special characters.

Situations Wanted

Ph.D. in geology w/ 5+ years exper in science research, oil industry, grad & undergrad teaching. Field exper in W. America, Europe, & Greenland. Contact @ (352) 278-3481.

Positions Open

LECTURER IN GEOLOGY
UNIVERSITY OF ILLINOIS AT URBANA-CHAMPAIGN

The Department of Geology at the University of Illinois invites applications for a full-time position as lecturer, beginning fall semester, 2002. This 12-month, non-tenure track appointment is renewable. The successful candidate will teach undergraduate geoscience courses, mostly at the introductory level. Responsibilities will include developing and teaching an introductory geology course that introduces non-science students to mathematical applications. The successful applicant must have a broad knowledge of geoscience and must be able to apply mathematics (algebra, trigonometry, basic statistics, basic calculus) to geoscience. The successful applicant must also be able to demonstrate excellence in teaching, outstanding interpersonal skills, strong motivation, and an ability to play a leadership role in undergraduate geoscience education. We will consider applications from candidates in any geoscience discipline. A Ph.D. is required, and experience with field-based and computer-based instruction is desirable. Maintaining research interests is encouraged. Salary is commensurate with qualifications and experience.

Applicants should submit a vita, transcripts, names of at least three referees, and a letter describing geologic background, teaching accomplishments and interests, and research interests to: Lecturer Search Committee, Department of Geology, 1301 West Green Street, University of Illinois, Urbana, IL 61801.

In the interest of time, applicants should have references sent directly to the Search Committee. Questions can be directed to Prof. Stephen Altaner, (217) 244-1244, altaner@uiuc.edu. For full consideration, applications and references must be received by March 21, 2002. Further information about the department is available at: http://www.geology.uiuc.edu/. Women, minorities, and other designated classes are encouraged to apply. The University of Illinois is an Affirmative Action, Equal Opportunity employer.

FACULTY POSITION, QUEENS COLLEGE, CUNY
SURFACE SYSTEMS AND/OR PROCESSES

The School of Earth & Environmental Sciences invites application for a tenure-track assistant professor position to begin in the 2002 fall semester. A Ph.D. is required and candidates should have research interests and demonstrated abilities (preferably field-based) in some aspect of surface systems and/or processes. It is preferred that candidates have a demonstrated commitment to college teaching and experiences in seeking external funding. Duties will include teaching undergraduate through doctoral courses in quantitative surface systems and/or processes and teaching courses in geoscience and/or environmental sciences; establishing a research program, preferably field-based; supervising student research; interacting with and complementing our other faculty; participating in student advising and curriculum development. The appointment will be at the assistant professor level. The salary level will vary between $32,703 and $57,049 (9 months), depending on experience and qualifications. Letters of application addressing the preferred qualification, a curriculum vitae, transcripts of all degrees, and three letters of reference should be sent to Dr. David Speidel, Chair of the Search Committee, School of Earth & Environmental Sciences, Queens College, Flushing NY 11367-1597. Address questions to Speidel at 718-997-3323/3300 or David_Speidel@qc.edu. For additional information about the department and college, visit the web site: www.qc.edu/EES/. Queens College is an equal opportunity/affirmative action employer.

U.S. GEOLOGICAL SURVEY
CHIEF SCIENTIST
CENTRAL EARTH SURFACE PROCESSES TEAM

The U.S. Geological Survey (USGS) invites applications for the position of Chief Scientist, Central Earth Surface Processes Team, in Lakewood, CO, a suburb of Denver. The Team Chief Scientist, a GS-15 position, supervises a staff of approximately ninety (90) research, technical, and operational personnel; therefore, this position requires strong scientific and human resource leadership abilities combined with demonstrated scientific stature and communication skills. Applicant must have a strong record of publications in refereed scientific literature in problems of regional geologic and tectonic synthesis, paleoseismicity, geomorphology, paleoclimate, hydrogeology, and (or) ecology. Applicant must have broad knowledge of the principles, theories, and modern techniques of research in earth sciences and related fields, to (1) design approaches to solving complex interdisciplinary research problems in two or more of the specific fields mentioned above, (2) implement the highest quality research investigations, and (3) lead a team in multi-disciplinary scientific research projects. The selected applicant will serve as Team Chief Scientist for 3 to 5 years and then should be prepared to fill a research scientist position. The grade as a researcher is determined through a periodic peer review process and is based on demonstrated expertise in conducting complex and innovative research as indicated above.

This is an Interdisciplinary position that may be filled as Supervisory Geologist, GS-1350-15; Supervisory Physical Scientist, GS-1301-15; or Supervisory Biologist, GS-401-15. It is a permanent position with the U.S. Geological Survey and has a salary range of $93,596 to $121,678. The position is located in Lakewood, CO, a suburb of Denver. There are three vacancy announcements, CR-2002-0043, CR-2002-0044, and CR-2002-0045. The announcements are open from 3/4/02 to 3/29/02. Complete qualification information and application procedures can be found online at http://www.usgs.gov/ohr/oars/. **U.S. Citizenship is required.** Contact: Office of Personnel (303) 236-9567. **The U.S. Geological Survey is an equal opportunity employer.**

DEAN OF SCIENCE AND HEALTH CAREERS
OAKTON COMMUNITY COLLEGE

Oakton Community College is seeking a dean who is an innovative academic leader and who will continue a strong tradition of excellence. Applicants should be current in their use of evolving technologies and have a strong interest in non-traditional instructional delivery methodologies.

The dean provides supervision and leadership for 35 full-time faculty, approximately 60 part-time faculty and more than a dozen full- and part-time staff. Programs include biology, earth science, chemistry, physics, physical education, basic nurse assistant training, health information technology, medical laboratory technology, nursing and physical therapist assistant. The division is engaged in multiple federal/state grant programs, which involve both the science and health career faculty and staff.

The dean must have the academic credentials to qualify for a faculty appointment in the division (master's degree required; doctorate preferred) and a record of 3–5 years of progressive leadership in an academic environment. The ideal candidate will have a history of exemplary college-level teaching, familiarity with real-world health care issues and trends, and a profound commitment to enhancing the intellectual and educational atmosphere of the college. We are particularly interested in considering candidates with demonstrable values and integrity, vision, people and communications skills, a commitment to a multicultural environment, and a commitment to both the transfer and career programs within the division.

For more information and an application, visit our Web site at www.oakton.edu.

Oakton Community College is an equal opportunity employer.

KING FAHD UNIVERSITY OF PETROLEUM & MINERALS
DHAHRAN, SAUDI ARABIA

College of Sciences
Earth Sciences Department

The Department of Earth Sciences at King Fahd University of Petroleum & Minerals, Dhahran, Saudi Arabia invites applications for a faculty position at a professor rank in the field of Environmental and Engineering Geology. This position requires someone who is experienced in all aspects of environmental investigations and assessments. Areas of particular interest are interaction of humans with the geologic environment, waste and pollution management, assessing geological hazards and risks, toxic substance control and land use management. Additional requirements are a Ph.D. degree in Environmental Geology / Engineering Geology and at least ten years of industry experience. The successful candidate must be innovative and have the vision and ability to apply advanced scientific and computer techniques to environmental and geological engineering problems. Teaching at the undergraduate and graduate levels and maintaining a strong research program will be expected of the successful candidates.

Salary/Benefits: Two year renewable contract. Competitive salaries based on qualifications and experience. Free furnished air-conditioned on-campus housing unit with free essential utilities and maintenance. The appointment includes the following benefits according to the University's policy: air ticket to Dammam on appointment; annual repatriation air tickets for up to four persons; assistance with local tuition fees for school-age dependent children; local transportation allowance; two months' paid summer leave; end-of-service gratuity. KFUPM campus has a range of facilities including a medical and dental clinic, an extensive library, computing, research and teaching laboratory facilities and a recreation center.

To apply: Mail, fax or e-mail cover letter and detailed resume to:

Dean, Faculty & Personnel Affairs
KFUPM, DEPT. ES-2104
Dhahran, 31261, Saudi Arabia
Fax: 966-3-860-2429
E-Mail: faculty@kfupm.edu.sa or
es.chairman@kfupm.edu.sa

Please visit our website address: http://www.kfupm.edu.sa

INTERDISCIPLINARY SPATIAL ANALYST (GEOLOGIST, PHYSICAL GEOGRAPHER, ECONOMIC GEOLOGIST, BIOLOGIST, ECOLOGIST)

The U.S. Geological Survey is seeking a full-time, permanent spatial analyst in Spokane, Washington. The office conducts interdisciplinary research including spatial analysis of geological, mineral resource, mineral-environmental, lithological, biological, climatic, and other data. We are seeking a highly motivated, intellectually curious individual willing to adapt to new research questions that may be considerably outside their professional training.

The successful candidate will analyze spatial phenomena and construct spatial and temporal models to develop a process-based understanding of earth systems. The candidate must have skill in designing, building, and using spatial and statistical or other mathematical models to analyze spatially referenced data. A level of experience commensurate with a Ph.D. in statistics applied to spatial analysis, earth-sciences, physical geography, biology, ecology, or other natural sciences is desired. Extensive analytical experience using ESRI software is required.

Starting salary will range from $54,275 to $70,555 plus benefits. Must be a U.S. citizen. Applications must be received at USGS, Human Resources Office, 7801 Folsom Blvd., Suite 103, Sacramento, CA 95826 by close of business on April 15, 2002. A description of the position (USGS-W-02-070) can be found at www.usajobs.opm.gov/wfjic/jobs/TO5696.HTM. For additional information, contact Tom Frost at tfrost@usgs.gov. For information on how to apply, contact Julia Ainslow at jainslow@usgs.gov. The USGS is an Equal Opportunity Employer.

ASSISTANT PROFESSOR, ONE-YEAR REPLACEMENT MINERAL/PETROLOGY, BATES COLLEGE

The Department of Geology at Bates College invites applications for one-year sabbatical leave replacement, beginning fall 2002, in the general area of mineralogy/petrology (ig., sed. or met.). Teaching responsibilities for the year include an introductory physical geology course with two lab sections, a sophomore/junior level course in mineralogy with lab, a junior/senior-level seminar course in petrology with lab, and thesis advising duties for senior geology majors. Applicants should have a Ph.D. by the time of appointment and should submit a letter of application, curriculum vitae, three letters of reference, transcripts, and proposed course syllabi to the address below via mail. Complete applications must be postmarked by April 1, 2002. Bates College is a highly selective liberal arts college of approximately 1,600 students, located in Maine, 2.5 hours north of Boston. More information about the college and Department of Geology can be seen on our Web page: http://www.bates.edu/.

Assistant Professor of Geology Search (#R2314), c/o Bates College Academic Services, 2 Andrews Road, 7 Lane Hall, Lewiston, ME 04240.

Bates College values a diverse college community and seeks to assure equal opportunity through a continuing and effective Affirmative Action program.

CANADA RESEARCH CHAIR UNIVERSITY OF SASKATCHEWAN ENVIRONMENTAL EARTH SCIENCES—SYNCHROTRON RADIATION

An outstanding individual is required to establish research excellence in the application of synchrotron radiation in the area of environmental earth sciences at the University of Saskatchewan. He/she will have access to the new Canadian Light Source (CLS), a 3rd generation synchrotron facility scheduled to begin operation in early 2004. The CLS is located on the University of Saskatchewan campus, a short walk from the Department of Geological Sciences. A technical description of the facility and beamlines under construction can be found at www.cls.usask.ca/research/beamline.shtml.

The University invites applications from outstanding individuals to be nominated for either a Tier One or Tier Two Canada Research Chair (www.chairs.gc.ca). The successful candidate will also hold a tenurable faculty appointment in the Department of Geological Sciences. The department has 15 full-time faculty, including two endowed research chairs in geochemistry. The analytical infrastructure in the department is one of the finest in North America, with MC-ICP-MS, laser ablation quadrupole ICP-MS, TIMS, IRMS, electron microprobe, SEM, XRD, and trace-metal clean room (www.usask.ca/geology/).

The University of Saskatchewan is a publicly funded institution, established in 1907. It has over 19,000 degree students, 4,500 employees, an operating budget of approximately $200 million and receives research funds in excess of $100 million. It offers a full range of programs, both academic and professional, in 13 colleges, including a full range of health sciences. The City of Saskatoon, with a population of about 210,000, offers an abundance of parks and recreational and cultural facilities on the banks of the South Saskatchewan River and is in close proximity to pristine lakes, forests, and a national park.

This position has been cleared for advertising at the two-tiered level. Applications are invited from qualified individuals regardless of their immigration status in Canada. The University of Saskatchewan is committed to Employment Equity. Members of designated groups (women, Aboriginal people, people with disabilities, and visible minorities) are encouraged to self-identify on their applications.

We will begin reviewing applications on March 31, 2002, and continue until a suitable candidate is found.

For additional information, please contact: Dr. Jim Basinger, Head, Department of Geological Sciences, University of Saskatchewan, 114 Science Place, Rm 114 Geology, SASKATOON, SK S7N 5E2 CANADA; ph.: (306) 966-5684; fax: (306) 966-8593; e-mail: jim.basinger@usask.ca.

FACULTY POSITION IN GEOBIOLOGY RENSSELAER POLYTECHNIC INSTITUTE

The Department of Earth and Environmental Sciences solicits applications for an anticipated tenure-track faculty position in the general field of geobiology, including the areas of geomicrobiology, microbial geochemistry, biomineralogy, biogeochemistry, and mineral-surface studies. We are particularly interested in the application of molecular biology to the understanding of natural and engineered geochemical systems. This position is part of a major new initiative in biotechnology at Rensselaer involving numerous faculty hires in several disciplines. We expect the successful applicant to develop multidisciplinary research that integrates with one or more of our existing program strengths in biogeochemistry, stable isotope geochemistry, environmental geochemistry and biology, hydrogeology and Origins of Life.

Applicants should have a Ph.D. or equivalent degree, a demonstrated record of innovative research, and an ability to inspire and educate undergraduate and graduate students. The level of appointment is assistant professor, but a more senior appointment will be considered for especially qualified candidates. Review of applications will begin immediately and the search will remain open until the position is filled.

Applicants may send a letter of application, curriculum vitae, and the names, addresses (including e-mail), and telephone numbers of at least three persons who can provide letters of reference to Frank S. Spear, Chair, Department of Earth and Environmental Sciences, JRSC 1C25, Rensselaer Polytechnic Institute, 110 8th Street, Troy, New York, 12180 USA.

Rensselaer Polytechnic Institute is an Affirmative Action, Equal Opportunity Employer—women and minorities are especially encouraged to apply.

CALL FOR PROPOSALS
EXXONMOBIL UPSTREAM RESEARCH COMPANY

ExxonMobil Upstream Research Company is divesting its experimental modeling laboratory. The laboratory consists of: (1) A motorized apparatus designed to simulate detached and basement-involved tectonic processes, and (2) A tilting refrigerated table for the simulation of salt tectonics. This equipment was part of an application-driven research program at the former Mobil Technology Company. We intend to continue this program with a qualified academic partner, and hence wish to solicit proposals for the donation of this equipment for use in a program of mutual scientific interest and benefit. It is possible that the equipment will be divided between two institutions. Applicants must be permanently affiliated with a 501(c)(3) academic institution, to which the equipment will be permanently designated. There must be a commitment to house and maintain the laboratory for a specified duration. To preapply, please send a curriculum vitae, recent publications, and a brief statement regarding your experimental background & research interests to eric.a.schmidtke@exxonmobil.com by April 1, 2002. If basic criteria are met, a package of equipment specifications and maintenance requirements will be sent. Full proposals will be due June 1, 2002.

UNIVERSITY OF NEW ORLEANS
ENVIRONMENTAL SIMULATIONS
IT INITIATIVES POSITIONS

Deltaic Framework Geology and Subsidence Processes, Assistant Professor. The Department of Geology and Geophysics within the College of Sciences at the University of New Orleans (UNO) seeks qualified applicants for a tenure-track position at the rank of assistant professor. This position will hold a joint appointment in the multidisciplinary Pontchartrain Institute for Environmental Sciences also within UNO's College of Sciences. This position is supported by the Louisiana Board of Regents Information Technology Initiative within the UNO College of Sciences for the Targeted Research Area of Environmental Simulation. The successful candidate must have a proven track record in the environmental simulation of subsidence processes at time scales ranging from the Quaternary through the Tertiary. Special preference is given to qualified applicants with environmental simulation experience in subsidence processes and the geologic framework of the Mississippi River delta plain. The successful applicant is expected to develop a research and educational program focused on the evolution and subsidence of the Mississippi River Delta plain as it relates to New Orleans, the Pontchartrain Basin, Louisiana's coastal land loss crisis, and the economic development of this region. The salary is budgeted for 9 months and start-up funds are negotiable. A full benefits package is provided by UNO, which is a member of the Louisiana State University System. UNO is an equal opportunity employer.

Send resume and 3 letters of recommendation to: Department Chair, Dept. of Geology & Geophysics, University of New Orleans, 2000 Lakeshore Drive, New Orleans, LA 70148. Application closing date: March 15, 2002.

UNIVERSITY OF NEW ORLEANS
ENVIRONMENTAL SIMULATIONS
IT INITIATIVES POSITIONS

Coastal Processes: Waves, Tides, and Storm Surges, Assistant Professor. The Department of Geology and Geophysics within the College of Sciences at the University of New Orleans (UNO) seeks qualified applicants for a tenure-track position at the rank of assistant professor. This position will hold a joint appointment in the multidisciplinary Pontchartrain Institute for Environmental Sciences also within UNO's College of Sciences. This position is supported by the Louisiana Board of Regents Information Technology Initiative within the UNO College of Sciences for the Targeted Research Area of Environmental Simulation. The successful candidate must have a proven record in the environmental simulation of modern coastal processes. Special preference is given to qualified applicants with environmental simulation experience as it relates to storm surges and coastal hydrodynamics within the Mississippi River delta plain. The successful candidate is expected to develop a research and education program focused on the hurricane risk to New Orleans and the coastal land loss and water quality crisis as it relates to the Pontchartrain Basin and the Mississippi River delta plain, and the economic development of this region. The salary is budgeted for 9 months and start-up funds are negotiable. A full benefits package is provided by UNO, which is a member of the Louisiana State University System. UNO is an equal opportunity employer. Send resume and 3 letters of recommendation to: Department Chair, Dept. of Geology & Geophysics, University of New Orleans, 2000 Lakeshore Drive, New Orleans, LA 70148. Application closing date: March 15, 2002.

Opportunities for Students

Research and Teaching Assistantships Available for Fall Semester 2002 at Temple University: Research and teaching assistantships are available for the fall term (September 2002) in our Masters Program in Geology at Temple University. The 2-year Masters Program offers advanced courses and thesis research opportunities in environmental geology, hydrogeology, geochemistry, environmental geophysics, cyclic stratigraphy, soil science/paleosols, K/T boundary studies, and materials science. Financial support for every student includes stipend, book allowance and full tuition for 2 years. **Research assistantships** and/or **summer support** are available for studies in karst hydrology and volcanology monitoring. Graduates of our program have an excellent record of employment and acceptance into doctoral programs. For information and applications please write, call or e-mail Edwin J. Anderson, Department of Geology, Temple University, Philadelphia, PA 19122; tel. (215) 204-8249, fax (215) 204-3496, e-mail andy@astro.temple.edu. Applications will be accepted until these positions are filled. Please visit our Web site at http://www.temple.edu/geology for additional information.

Graduate Fellowship in Sedimentary Geology, MIT. Potential Ph.D. students are invited to apply for a three-year Graduate Research Fellowship in the Department of Earth, Atmospheric, and Planetary Sciences, Massachusetts Institute of Technology. Student stipend and tuition are fully supported. The research focus will center on quantification of facies scaling relationships, in an effort to evaluate sedimentologic process and stratigraphic response. The successful candidate should have a keen interest in stratigraphically oriented field mapping of carbonate rocks and a desire to work with digital acquisition technologies. Field sites will include the Canning Basin (Devonian, Western Australia) and Oman (Cretaceous, Proterozoic). Graduate Admissions applications should be submitted to MIT, along with a letter of intent to be copied to Professor John Grotzinger (grotz@mit.edu). John Grotzinger, MIT, Department of Earth, Atmospheric, and Planetary Sciences, 77 Massachusetts Avenue, 54-816, Cambridge, MA 02139, (617) 253-3498.

Photo by John Karachewski. Flatirons in Boulder, Colorado.

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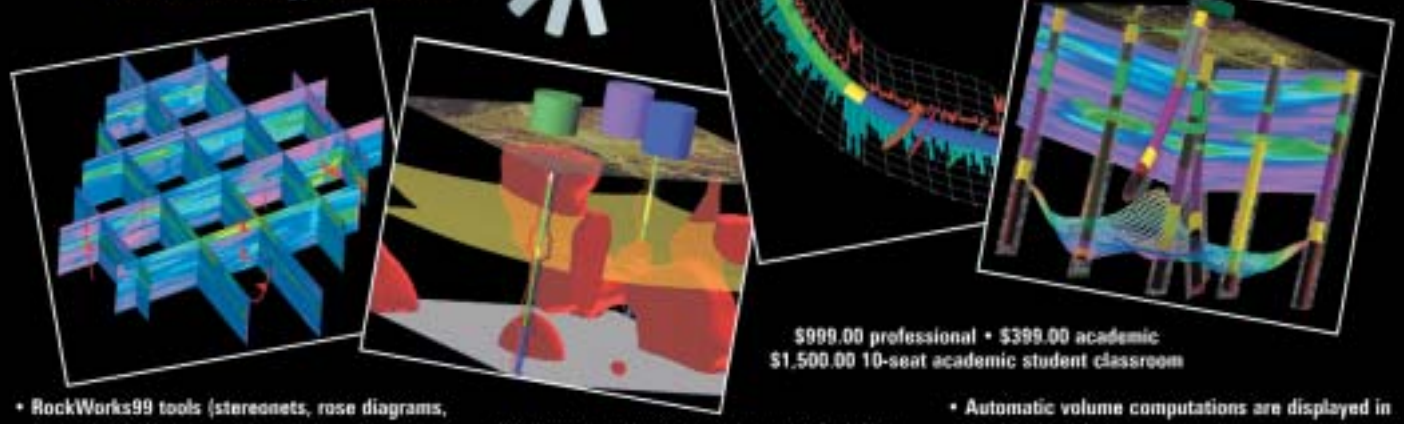

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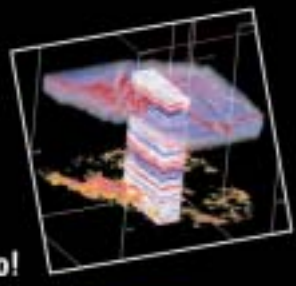

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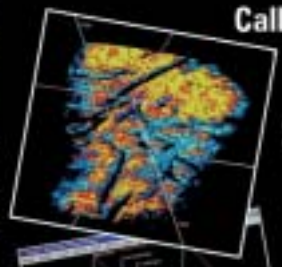

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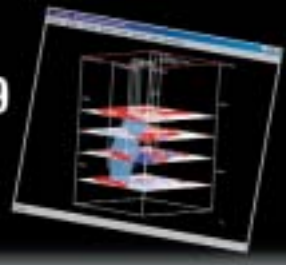

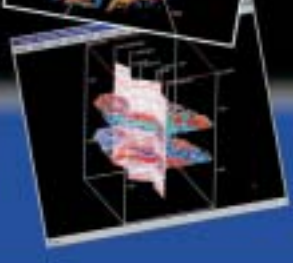

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