Vol. 8, No. 7 July 1998

GSA TODAY

A Publication of the Geological Society of America

INSIDE

Probing the Archean and Proterozoic Lithosphere of Western North America

Deep Probe Working Group

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ABSTRACT

The 1995 western North American Deep Probe seismic experiment, a continental-scale, long-range refraction investigation, extended from the Colorado Plateau to the Archean craton in Canada. The profile crossed the Proterozoic terranes of the southern Rocky Mountains and Colorado Plateau and the southern part of the Archean Wyoming province—a region modified by Phanerozoic tectonism, and the northern part of the Wyoming province and the Archean Hearne province—a region that has been relatively stable since the Archean. Each geologic province has a distinctive crustal type, that of the Wyoming province being the thickest and fastest. In the mantle, the change from low to high upper-mantle seismic velocity that marks the passage from the orogenic plateau to the craton in published teleseismic tomographic images is seen to occur abruptly in the vicinity of the Cheyenne belt, which separates the Proterozoic Rocky Mountain terranes from the Archean Wyoming province. To the south, the upper mantle beneath the southern Rocky Mountains has a well-developed P-wave low-velocity zone like that beneath the Gulf of California spreading system. To the north, the upper mantle beneath the Archean provinces resembles the teleseismic average for the Canadian shield.

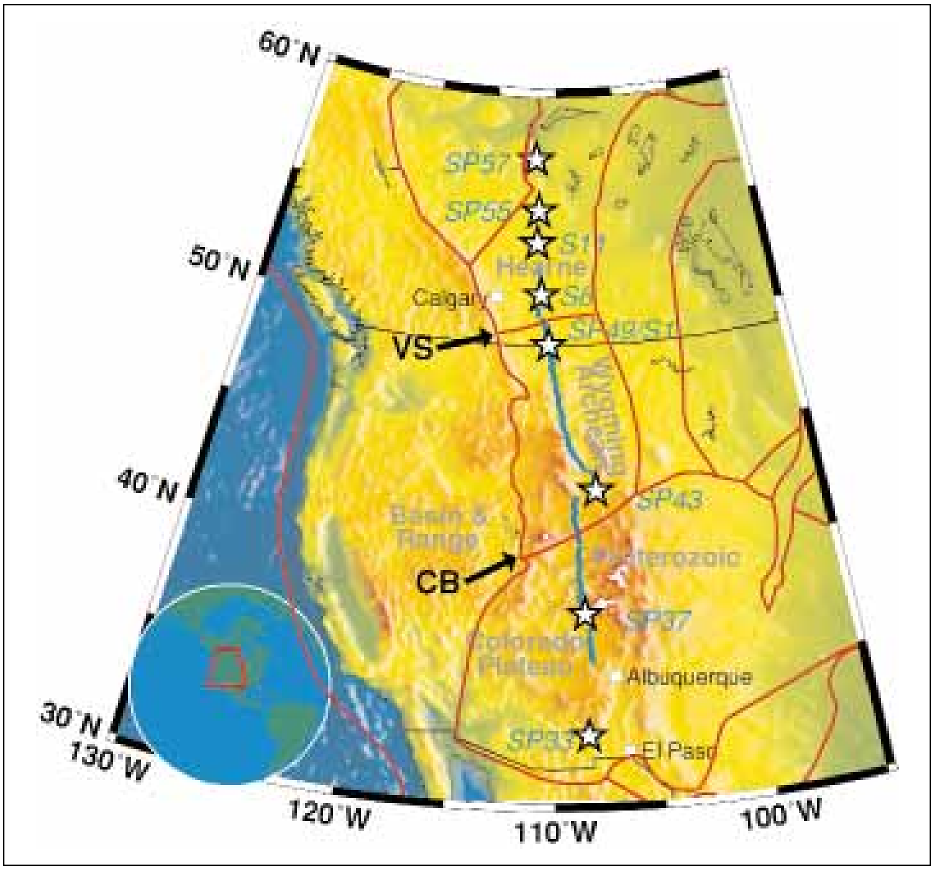

Figure 1. Location map showing the Deep Probe corridor in western North America. Blue line shows seismograph stations occupied for 1995 active-source experiment. SP refers to Deep Probe shotpoints, S to SAREX shotpoints used in this study. Red lines denote borders of major geologic provinces (after Hoffman, 1989). VS—Vulcan structure between Hearne and Wyoming Archean provinces; CB—Cheyenne belt suture between Archean Wyoming province and Proterozoic accreted terranes.

INTRODUCTION

The 1995 Deep Probe investigation is unique among modern seismic refraction studies of western North American lithosphere in scale and spatial sampling (Fig. 1). The study provides seismic observations between the scale of regional reflection or refraction crustal studies and of teleseismic earthquake mantle studies. The Deep Probe corridor approximately follows the 110th meridian, spanning ~29° from north of the U.S.-Mexican border to Great Slave Lake in Canada. From north to south, the profile crosses the Archean Hearne and Wyoming provinces, the Cheyenne belt, and the Proterozoic terranes of the southern Rocky Mountains and Colorado Plateau.

Beginning in the north, the Hearne province of central-south Alberta is the westernmost extension of the Canadian craton. On the basis of basement drill core, gravity, and aeromagnetic studies, the province consists of several Archean domains (Ross et al., 1991). Sedimentary sequences in southern Alberta and northern Montana indicate that the region has been a largely stable topographic high for 1.5 b. y. A prominent crustal feature known as the Vulcan structure could mark the limit with the Wyoming province. The Wyoming province, which is an agglom-

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GSA TODAY

Vol. 8, No. 7 July 1998

GSA TODAY (ISSN 1052-5173) is published monthly by The Geological Society of America, Inc., with offices at 3300 Penrose Place, Boulder, Colorado. Mailing address: P.O. Box 9140, Boulder, CO 80301-9140, U.S.A. Periodicals postage paid at Boulder, Colorado, and at additional mailing offices. **Postmaster:** Send address changes to *GSA Today,* Membership Services, P.O. Box 9140, Boulder, CO 80301-9140.

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Lakewood, Colorado
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Bellaire, Texas
December 28, 1997

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April 12, 1998

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Extended Deadline!

The Penrose Conference on "Strike-slip to subduction transitions on plate boundaries: Tectonic settings, plate kinematics, and seismic hazards," Puerta Plata, Dominican Republic has extended its application deadline to **September 1, 1998.**

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eration of back-arc basins, island arcs, and micro-continental fragments intruded by Late Archean granites, has been largely stable since 2.7 to 2.6 Ga (Houston et al., 1993). The rest of the southwestern U.S. interior consists of Proterozoic island-arc terranes accreted to the southern margin of the Wyoming province between 2.0 and 1.3 Ga (Karlstrom and Bowring, 1988). The Cheyenne belt at the southern boundary of the Wyoming province is interpreted as a Proterozoic crustal suture (Karlstrom and Houston, 1984). The resultant continent known as Laurentia was subjected to Late Proterozic to Early Cambrian rifting that established the limits of the modern North American craton (e.g., Hoffman, 1989).

In the Phanerozoic, the western margin of North America was uplifted and modified by a succession of tectonic events (Burchfiel and Davis, 1975; Ye et al., 1996), only some of which extended into the study area. Of those that did, the Pennsylvanian Ancestral Rockies event affected the Proterozoic terranes south of the Cheyenne belt, producing the Uncompahgre uplift. The Late Cretaceous to mid-Eocene Laramide event produced basement uplifts and deep sedimentary basins throughout the Proterozoic terranes and the southern Wyoming province. Tertiary events in the southern part of the region caused uplift of the Colorado

Lithosphere *continued on p. 3*

Lithosphere *continued from p. 2*

Plateau and produced Basin and Range extension (e.g., Schneider and Keller, 1994).

The goals of the seismic investigation were to determine and contrast the lithospheric structures of the relatively stable Hearne and northern Wyoming provinces with those of the southern Wyoming province and the Proterozoic terranes affected by Laramide events. The seismic data collected provide a continental-scale P-wave velocity model for the crust and upper mantle to depths of ~150 km. We describe two major lateral changes in velocity structure, one in the crust and one in the mantle, which are associated with boundaries between the geological provinces and indicate major differences in lithospheric evolution.

DEEP PROBE SEISMIC OBSERVATIONS AND INTERPRETATION

The Deep Probe experiment consisted of 10 shots detonated at seven shotpoints, recorded by 710 portable refraction seismometers deployed twice at about 1200 sites. Nominal instrument spacing was 1.25 km (Fig. 1; Gorman et al., 1997). Shot size varied from 2400 to 17000 kg of chemical explosive. The recording arrays extended from northern New Mexico to central Alberta. Just prior to our experiment, the Canadian Lithoprobe program conducted the crustal-scale Southern Alberta Refraction Experiment (SAREX), coincident with the Canadian part of Deep Probe. Three shot records from SAREX are included in the analysis here (S1, S6, and S11; Fig. 1).

Seismic Observations: Three Province-Related Seismic Signatures

The fundamental experimental results are illustrated by the records from shotpoint SP43 in central Wyoming, just north of the Cheyenne belt (Fig. 3, see p. 16–17). Markedly different crustal and upper-mantle signals occur north and south of SP43, indicating profound changes in the upper 150 km of the lithosphere over a distance not exceeding 250–300 km. Primary crustal and mantle seismic waves observed include: Pg—upper crustal refractions; Pi—refracted within a lower crustal layer; PmP—reflected from the Moho; and Pn and related phases—refracted beneath the Moho. Travel times and amplitudes of these waves constrain crustal thicknesses and crustal and mantle seismic velocities. An important feature is the source to receiver offset at which Pn becomes a first arrival—the crossover distance—which increases with crustal thickness.

First-order observations on the profile south of SP43 in the Proterozoic terranes of the southern Rockies–Colorado Plateau are that Pn becomes a first arrival at ~200 km offset, has velocities of 7.9–8.0 km/s, and is very weak from the crossover at ~200 km to ~425 km (Fig. 2). Beyond 425 km, Pn amplitude strengthens to offset distances of 800 km. This weak Pn character from 200 to 425 km also occurs on records from SP33 and SP37 in New Mexico and Colorado.

The record for the Archean Wyoming province north of SP43 is dramatically different (Fig. 2). In particular, a Pn crossover at ~260 km indicates a thicker crust, and high-amplitude and high-velocity (8.1–8.4 km/s) Pn phases to offsets of ~800–1000 km indicate a distinct upper-mantle structure. Pn with similar character is seen south of SP49 from the Canadian border to central Wyoming (Fig. 2). More subtle features seen at SP43 north and SP49 south are lower crustal refractions, Pi, with phase velocities of 7.0–7.3 km/s that are first arrivals from 180 to 260 km and clear second arrivals from 260 to 400 km (Fig. 2). Lower-crust events like these are absent in the Proterozoic terranes to the south and the Hearne province to the north.

North of SP49, in the Hearne province, Pn becomes a first arrival at ~210 km with velocities of 8.1–8.2 km/s. The shorter Pn crossover distance (210 km) is also observed on the other shots in the Hearne province, indicating a thinner crust than in the Wyoming province.

Cross Section of Western North America

To interpret the data, we used reflectivity modeling to estimate average one-dimensional velocity structures of the three provinces (Fuchs and Müller, 1971), and two-dimensional ray-tracing and travel-time inversion to estimate two-dimensional crust and upper mantle structure from all shots (Luetgert, 1992; Zelt and Smith, 1992). Due to large distances between shotpoints (~400–600 km) travel-time modeling concentrated on the primary crustal and mantle phases identifiable from shot to shot. For two-dimensional ray-tracing, the starting model used crustal structure estimates from the one-dimensional interpretations, previous seismic studies, and other geological and geophysical data (Prodehl and Lipman, 1989; Pakiser, 1989; Schneider and Keller, 1994; Snelson, 1998). The two-dimensional modeling and inversion allow a more detailed lithospheric picture (Fig. 2), particularly where Moho depth changes by 10 km over lateral distances of ~100 km. Complex sedimentary basins along the profile generate short scale variations in arrival times which were well matched using a near-surface structure developed from published studies and velocity-depth information from 71 well logs (Snelson, 1998; Snelson et al., 1998). From the top of basement down, only small lateral velocity variations within a province were required to fit the data. Long-offset Pn and crustal arrivals allowed determination of mean velocities within a province to ±0.1 km/s and mean depths to the Moho to ~2 km in Pn crossover regions (Fig. 2).

Lithosphere *continued on p. 4*

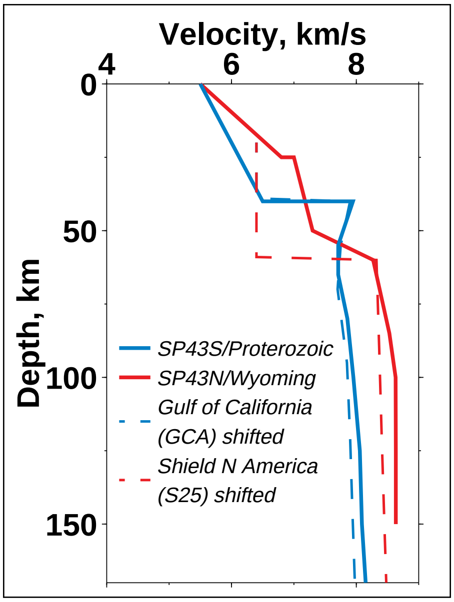

Figure 2. Top: Two-dimensional P-velocity model along Deep Probe corridor. Stars show shots used in this study, gray lines show locations of intracrustal and Moho reflection points. Model depths are best constrained by Pi and Pn refractions that arise in these locations. The one-dimensional velocity profiles derived from reflectivity modeling are superimposed. All velocities shown assume a flat Earth: At 100 km depth they are ~0.15 km/s faster than in a spherical Earth. Bottom: Record sections from SP43, SP37, and SP49 are plotted beneath the shot location with calculated traveltime curves from the model superimposed in red. The blue circles indicate the crossover where Pn becomes the first arrival.

Lithosphere *continued from p. 3*

The main features of the seismic data are exemplified by three simple but very different one-dimensional velocity models that explain the main amplitude relations among the seismic phases and give average crustal and mantle structure within each province (Figs. 2, 3[1]). These are related through the two-dimensional interpretation (Fig. 2). In the south, the Proterozoic crust in the Rocky Mountains and Colorado Plateau is 40 to 45 km thick and shows a linear velocity increase with depth. Most variation in crustal thickness occurs near the boundary with the Wyoming province. In the Archean Wyoming province, crustal thicknesses range from ~40 km at the Cheyenne belt to an average of ~50 km farther north. A high-velocity layer (v_p ~ 7.05–7.30 km/s) occurs in the lower ~25 km of the crust. Crossing the Vulcan structure, Moho depth in the Hearne province shallows to ~40 km. The crust again shows a simple vertical velocity gradient, but with higher velocities than in the Proterozoic crust. Mean crustal velocity in the Southern Rockies and Colorado Plateau is 6.3 km/s, compared with 6.6 km/s in the Wyoming province, and 6.45 km/s in the Hearne province.

On a global scale, the southern Rockies crust is thin and slow compared to average crustal thicknesses and velocities of 42 km and 6.4–6.5 km/s for shields and platforms, and of 46–50 km and 6.4 km/s for orogens (Christensen and Mooney, 1995; Rudnick and Fountain, 1995). The Wyoming province crust is considerably thicker and faster than that of average shields, and faster than, but similar in thickness to orogens. The somewhat thinner Hearne province crust has an average shield velocity.

Variations in amplitude and velocity of the Pn phase indicate extreme differences in the upper mantle along the profile (Figs. 2, 3). North of SP43, the mantle just below the Moho under the Archean provinces has a velocity of 8.1 km/s that increases with depth. There is no evidence of a low-velocity zone. South of SP43, the mantle under the Proterozoic province has a thin lid with velocities of 7.9–8.0 km/s that is underlain by a thick low-velocity zone with a velocity that decreases to 7.75 ±0.1 km/s at 60 km depth. The high-amplitude Pn phase observed in the 425 to 800 km offset range is a turning or reflected phase from a depth of ~90 km or more.

Although determining the width of horizontal transitions between terranes is hampered by shot spacing, fortuitous shot positioning and geologic information allow some inferences to be made. In particular, strong asymmetry of seismic arrivals from SP43 implies a transition zone of less than ~250 km on the southern edge of the Wyoming province. On the northern edge, first-arrival refractions from the lower crust are seen from both the north and the south at SP49/S1; whereas 250 km to the north at S6, strongly asymmetric first arrivals do not include lower-crustal events. This implies that the transition zone between the Wyoming and Hearne provinces is less than 100 km wide.

IMPLICATIONS FOR NORTH AMERICAN EVOLUTION

The scale of the Deep Probe experiment permits comparison with earthquake-derived tomographic images of North America that indicate a transition from fast, cold upper mantle beneath the craton, to slow, hot upper mantle beneath the uplifted North American orogenic plateau (Grand, 1994; Grand et al., 1997; van der Lee and Nolet, 1997). The resolution of the earthquake studies is considerably less—about 500 km horizontally and 100 km vertically.

Southern Rocky Mountains–Colorado Plateau: Proterozoic Accreted Terranes

Given its location within a region of Laramide tectonism, the crust in the southern Rockies–Colorado Plateau is surprisingly simple: little lateral velocity variation and no vertical layering. Its 40 to 45 km thickness is insufficient to explain present regional elevations (e.g., Sheehan et al., 1995). Going deeper, the upper-mantle velocity profile is comparable to that of Walck (1983) for the Gulf of California part of the East Pacific Rise spreading system (Fig. 3), in that both show low-velocity zones just beneath the Moho. The low-velocity zone beneath the southern Rockies likely represents the buoyant mantle needed to support the topography, and is deeper and thicker than its equivalent in the Colorado Plateau–Basin and Range transition zone in Arizona (Benz and McCarthy, 1994). To the east, a range of seismic methods (e.g., Sinno and Keller, 1986; Keller et al., 1990; Slack et al., 1996) indicates low velocities in the uppermost mantle of the Rio Grande Rift. Grand's (1994) teleseismic observations show low velocities in the mantle extending from the East Pacific Rise through the southwestern United States. The Deep Probe results show that regional low-velocity mantle extends northward to the Cheyenne belt.

Wyoming Province: Thick Archean Crust

The crust is thicker and faster in the Wyoming province than in the Proterozoic terranes, with a high-velocity lower-crustal layer occurring in most of the province. The transition from thin (40 km) to thick (50 km) crust occurs in the southernmost 150 km of the province. It is unclear how the Laramide tectonism that affected parts of the province modified the Archean crust. Nothing in our results indicates a Laramide influence unless the entire lower crustal layer is a Laramide feature. The seismic velocity model (Fig. 2) indicates a thick lower crust and uniform upper-mantle structure beneath Laramide uplifts in Wyoming and southern Montana as well as the plains of Montana and southern Alberta.

Although the Archean crust in this part of the Deep Probe profile is ~10 km thicker than the global average for shields and platforms (Christensen and Mooney, 1995), it is not the only cratonic region with a high-velocity lower crust (Rudnick and Fountain, 1995). High velocities like these are compatible with mafic garnet granulite or hornblendite compositions, such as are found among northern Montana xenoliths (Reed et al., 1993), or with intermediate-composition crust that is mixed with eclogite, pyroxenite, or dunite.

After adjustment for crustal thickness, the upper-mantle model for the Archean Wyoming province is comparable to the average Canadian shield P-wave profile (S25 in Fig. 3) derived from teleseismic P-wave observations by LeFevre and Helmberger, (1989). The similarities of the two profiles, derived from different types and scales of seismic data, indicate a similarity between Wyoming province and Canadian shield upper mantle.

Vulcan Structure and Hearne Province

The crustal boundary between the Wyoming and Hearne provinces appears to lie close to the Vulcan structure in southern

[1] Figure 3 is on p. 16–17.

Alberta. This structure is covered by younger sedimentary sequences, and is thus delineated by gravity, magnetic, and seismic data (Kanasewich et al., 1969). It is a target for Lithoprobe's Alberta Basement Transect (Ross et al., 1997). North of the Vulcan structure, the crust is like average Archean crust. No strong vertical or lateral variations are seen with the exception of a slight thinning to the north. Despite crustal differences with the Wyoming province, the Hearne province has a similar mantle.

Some Unanswered Questions

We are left with questions related to the development of the crust-mantle system along the profile. Is the thick high-velocity lower crust in the Wyoming province due to original Archean assembly, Laramide tectonism, or neither? If the lower crust is the result of Archean formation, why is the Hearne province different? Has its lower crust been delaminated or incorporated into the upper mantle through eclogitization (Nelson, 1991)? If the lower crust beneath the Wyoming province resulted from lower crustal flow during the Laramide, why is the crust to the south so different? A global compilation of Precambrian seismic structure (Durrheim and Mooney, 1994) shows Archean crust to be generally thinner and to have lower velocity crust than Proterozoic crust. This pattern is opposite to that seen in the Wyoming province and the Proterozoic terranes to the south.

CONCLUSIONS

The Deep Probe experiment provides a continental-scale model of crust and upper-mantle compressional velocity to depths of ~150 km along a transect crossing three distinct geologic provinces. Each province has a distinct crustal type. The Wyoming province has an unusual 25-km-thick high-velocity lower-crustal layer, whereas the Hearne province crust is more typical of an Archean shield. The crust in the southern Rockies–Colorado Plateau is relatively simple, and it is thinner than expected from its elevation and Phanerozoic contractional tectonic history.

The lithospheric mantle structure differs profoundly between the relatively stable Archean mantle in the north and a mobile, tectonically active upper mantle in the south, likely modified by Laramide and more recent tectonism. The transition between the two mantle structures is laterally abrupt, lying close to a Proterozoic-age crustal suture despite episodes of more recent tectonism.

ACKNOWLEDGMENTS

We thank the 100 volunteers who helped deploy seismographs, the IRIS/PASSCAL Instrument Center, and the Geological Survey of Canada (GSC) Instrumentation Group, who achieved an almost perfect data collection record. We thank especially Ed Criley, Grey Jensen, and Tom Burdette of the USGS and Tim Cartwright and Peter Carroll of Lithoprobe for assistance with shotpoints. Phelps-Dodge Tyrone, Inc., permitted use of a copper mine as a shotpoint. We thank numerous private landowners, as well as state, provincial, and federal agencies in the United States and Canada for land access, in particular the U.S. Forest Service, the New Mexico Department of the Environment, the U.S. Bureau of Land Management, and Canadian Forces Bases Suffield and Cold Lake. We thank Michael Milstein of the *Billings Gazette* for accurate coverage of the experiment. We thank reviewers Eric Erslev, Ron Bruhn, Walter Mooney, and especially *GSA Today* editor Sue Kay for many improvements to the manuscript. This research was supported by the National Science Foundation Continental Dynamics Program, EAR-94109021, EAR-9706841, AFOSR Grant F49620-J-0438, the Lithoprobe Project [funded by the Geological Survey of Canada and the Natural Sciences and Engineering Research Council of Canada (NSERC)], and NSERC research grants.

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Manuscript received February 20, 1998;
accepted May 12, 1998 ■

WASHINGTON REPORT

Bruce F. Molnia

Washington Report provides the GSA membership with a window on the activities of the federal agencies, Congress and the legislative process, and international interactions that could impact the geoscience community. These reports present summaries of agency and interagency programs, track legislation, and present insights into Washington, D.C., geopolitics as they pertain to the geosciences.

PROTECTING AMERICA'S CRITICAL INFRASTRUCTURES: PDD 63

On May 22, 1998, the White House issued Presidential Directive 63 (PDD 63) calling for a national effort to assure the security of eight of the United States' increasingly vulnerable and interconnected infrastructures, several of which are deeply connected to the earth sciences. PDD 63 builds on October 1997 recommendations of the President's Commission on Critical Infrastructure Protection (PCCIP). The PCCIP, established in July 1996 by Presidential Executive Order 3010, is the first national effort to address the vulnerabilities created in the new information age. The commission was tasked to formulate a comprehensive national strategy for protecting U.S. infrastructures from physical and "cyber" threats. Specifically, the PCCIP's mission is to "Determine and categorize the range of threats to critical infrastructures; identify vulnerabilities within and among critical infrastructures; find and assess options for protecting infrastructures, assuring continuation and restoration of service; develop a strategy for protecting critical infrastructures; and recommend an implementation plan for protective and assurance measures, including the policy, legislative and other changes required."

The 18 member PCCIP, chaired by Robert T. Marsh, an aerospace industry executive, includes senior representatives from private industry, government, and academia. An advisory committee consisting of industry leaders provides counsel to the commission, and a steering committee, made up of cabinet-level officials, reviewed the commission's report before forwarding it to the President. Commission members were divided into five teams, representing the eight critical infrastructures. Each team evaluated the growing risk, threats, and vulnerabilities within its sector. A threat was defined as "Anyone with the capability, technology, opportunity, and intent to do harm. Potential threats can be foreign or domestic, internal or external, state-sponsored or a single rogue element." Terrorists, insiders, disgruntled employees, and hackers were included in the profile.

The PCCIP noted that most of the nation's vital services are delivered by private companies. This creates a significant challenge in determining where the responsibility of protecting critical infrastructures falls. The commission addressed this challenge by bringing representatives from the private and public sectors together to assess infrastructure vulnerabilities and to develop assurance strategies for the future. The Commission consulted with over 6,000 representatives from the private and public sectors, including industry executives, security experts, government agencies, and private citizens.

The PCCIP report defines the eight critical infrastructures as systems whose incapacity or destruction would have a debilitating impact on the defense or economic security of the nation. The report deals with the following infrastructures: telecommunications, electrical power systems, gas and oil production, storage and transportation, banking and finance, transportation, water supply systems, emergency services, and continuity of government services.

Telecommunications are defined as the networks and systems that support the transmission and exchange of electronic communications among and between end-users (such as networked computers). Electrical power systems are defined as the generation stations, transmission, and distribution networks that create and supply electricity to end-users so that end-users achieve and maintain nominal functionality, including the transportation and storage of fuel essential to that system. Gas and Oil Production, Storage, and Transportation are defined as the holding facilities for natural gas, crude and refined petroleum, and petroleum-derived fuels, the refining and processing facilities for these fuels, and the pipelines, ships, trucks, and rail systems that transport these commodities from their source to systems that are dependent upon gas and oil in one of their useful forms. Banking and finance are defined as the retail and commercial organizations, investment institutions, exchange boards, trading houses, and reserve systems, and associated operational organizations, government operations, and support entities, that are involved in all manner of monetary transactions, including its storage for saving purposes, its investment for income purposes, its exchange for payment purposes, and its disbursement in the form of loans and other financial instruments. Transportation is defined as the aviation, rail, highway, and aquatic vehicles, conduits, and support systems by which people and goods are moved from a point-of-origin to a destination point in order to support and complete matters of commerce, government operations, and personal affairs. Water supply systems are defined as the sources of water, reservoirs and holding facilities, aqueducts and other transport systems, the filtration and cleaning systems, the pipelines, the cooling systems, and other delivery mechanisms that provide for domestic and industrial applications, including systems for dealing with waste water and fire fighting. Emergency services are defined as the medical, police, fire, and rescue systems and personnel that are called upon when an individual or community is responding to a public health or safety incident where speed and efficiency are necessary. Continuity of Government Services is defined as those operations and services of governments at federal, state, and local levels critical to the functioning of the nation's systems, i.e., public health, safety, and welfare.

The sector teams and their industries included: Information & Communications —telecommunications, computers & software, Internet, satellites, and fiber optics; Physical Distribution—railroads, air traffic, maritime, intermodal, and pipelines; Energy—electrical power, natural gas, petroleum, production, distribution, and storage; Banking and Finance—financial transactions, stock and bond markets, and the Federal Reserve; and Vital Human Services—water, emergency services, and government services.

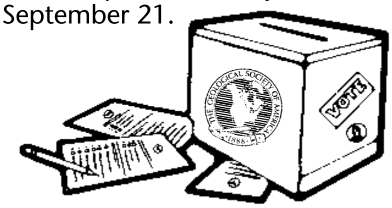
PDD 63 is the culmination of an intense, interagency effort to evaluate the PCCIP's recommendations and produce a workable and innovative framework for critical infrastructure protection. The President's policy sets a goal of a reliable, interconnected, and secure information system infrastructure by the year 2003, and significantly increased security to government systems by the year 2000.

This will be accomplished by:

- Immediately establishing a National Center to warn of and respond to attacks;
- Ensuring the capability to protect critical infrastructures from intentional acts by 2003;
- Addressing the cyber and physical infrastructure vulnerabilities of the Federal government by requiring each department and agency to work to reduce its exposure to new threats;
- Requiring the Federal government to serve as a model to the rest of the country for how infrastructure protection is to be attained;
- Defining a National Infrastructure Protection Center (NIPC), to be located at the Federal Bureau of Investigations (FBI), which will fuse representatives from FBI, Department of Defense, U.S. Secret Service, Department of Energy, Department of Transportation, the intelligence community, and the private sector in an unprecedented attempt at information sharing among agencies in collaboration with the private sector. The NIPC will also provide the principal means of facilitating and coordinating the Federal Government's response to an incident, mitigating attacks, investigating threats, and monitoring reconstitution efforts;
- Establishing a national coordinator whose scope will include not only critical infrastructure but also foreign terrorism and threats of domestic mass destruction (including biological weapons);
- Establishing Information Sharing and Analysis Centers, to be set up by the private sector in cooperation with the federal government and modeled on the Centers for Disease Control and Prevention;
- Establishing a Critical Infrastructure Assurance Office which will provide support to the National Coordinator's work with government agencies and the private sector in developing a national plan. The office will also help coordinate a national education and awareness program, and legislative and public affairs;
- Establishing a National Infrastructure Assurance Council drawn from private sector leaders and state and local officials to provide guidance to the policy formulation of a national plan;
- Seeking voluntary participation of private industry to meet common goals for protecting critical systems through public-private partnerships;
- Protecting privacy rights and seeking to utilize market forces.

VOTE!

Attention, voting members: your vote is an important part of the management process! The 1998 GSA ballot to elect officers for 1999 and councilors for the term 1999–2001 will be mailed with the annual report in August. Ballot and *signed* proxy must be postmarked by September 21.



Opposition to this commission surfaced with the release of the 1996 Executive Order and focused on invasion of privacy issues. One group commented that the order's creation of a Department of Justice Infrastructure Protection Task Force was equivalent to the formation of an American Gestapo. ■

1999 Officer and Councilor Nominees

Council announces the following officer and councilor candidates. Biographical information on all candidates will be mailed with the ballot to all voting members in August.

PRESIDENT (1999)
Gail M. Ashley, Piscataway, New Jersey

VICE-PRESIDENT (1999)
Mary Lou Zoback, Menlo Park, California

TREASURER (1999)
David E. Dunn, Richardson, Texas

COUNCILOR (1999–2001), POSITION 1
Mary J. Kraus, Boulder, Colorado
Noel P. James, Ontario, Canada

COUNCILOR (1999–2001), POSITION 2
Claudia J. Mora, Knoxville, Tennessee
Rob Van der Voo, Ann Arbor, Michigan

COUNCILOR (1999–2001), POSITION 3
Carol Simpson, Boston, Massachussetts
Jane Selverstone, Albuquerque, New Mexico

COUNCILOR (1999–2001), POSITION 4
John J. Clague, Vancouver, British Columbia
Stephen G. Wells, Reno, Nevada

American Association of Stratigraphic Palynologists is Newest GSA Associated Society

The GSA Council has approved Associated Society status for the American Association of Stratigraphic Palynologists (AASP). AASP was founded in 1967 to promote the science of palynology and to foster the spirit of scientific research. These purposes have been expanded beyond stratigraphic applications of palynology to include: environmental applications such as high-resolution modeling of aquifers and groundwater flow, and remediation of contaminated waste sites; Quaternary paleoclimatic reconstructions as a record for global warming as reflected by the effects of greenhouse gases through their influence on Earth's flora and its floral record; the use of palynology in charting the migration pathways of insects; palynology as a tool in archaeological reconstructions; palynology in conjunction with geology as an integral part of forensic science; and the use of palynology in paleoenvironmental reconstructions in strata of all ages.

According to the GSA Bylaws (Article XI), "Any national or international society that has aims consistent with those of The Geological Society of America, that is, the advancement of the science of geology, may, with the approval of the Council, associate itself with the Society for the purpose of cooperation in annual, sectional, or divisional meetings, in publications, or in other appropriate ways."

AASP has nearly 800 members in the United States and abroad. The association holds an annual meeting and also provides materials designed to enhance the knowledge of its members.

Officers for 1998 are President Rolf Mathews, President-Elect Christopher N. Denison, Past President Gordon D. Wood, Secretary-Treasurer David T. Pocknall, and Managing Editor David K. Goodman.

Governor Honors GSA Fellows

GSA 1998 President Victor R. Baker, Robert W. Hatcher (professor of geology at the University of Tennessee and 1993 GSA president), Kentucky State Geologist Donald C. Haney, and Gerald M. Friedman, professor of geology at Brooklyn College, were designated Honorary West Virginians at the GSA Southeastern Section meeting in March. West Virginia Governor Cecil H. Underwood presented certificates to the four GSA Fellows in recognition of outstanding accomplishments and meritorious service. The 1998 Southeastern Section meeting was in Charleston, West Virginia. The award is the highest honor given by the state to nonresidents.

Right to left: Vic Baker, Bob Hatcher, Don Haney, and Gerry Friedman display their Honorary West Virginian certificates at the Southeastern Section meeting.

STUDENT NEWS AND VIEWS

Brian Exton, *University of Texas at Austin*

Student News and Views provides GSA membership with commentary on matters relating to undergraduate and graduate students in the geosciences. The Correspondent for Student News and Views welcomes comments and suggestions, sent to stumatts@geosociety.org.

Effective Posters: The Five-Minute Tour

The time is drawing near for geologists of all types to descend on Toronto for the 1998 GSA Annual Meeing, and many of you may be presenting posters for the first time. I thought of submitting this particular column for the September issue, but the earlier you begin planning your poster, the better your results (and feedback) are likely to be. The idea of a column on helpful hints for designing posters is also fresh in my mind because I just presented one of my own posters at a GSA Penrose Conference. In preparing for that meeting, I discovered how few articles there were on this topic, and how widely the suggestions varied. Some of you have given posters before, and probably consider yourselves experts by now. We may learn from our mistakes, but we can always improve. Although this topic may be of interest primarily to the novice poster presenter, a broader audience may benefit as well by heeding some of these suggestions.

Spatial Circumstances

The content of your poster will largely be determined by the amount of space you are given. For most meetings, this is 4' by 8', and you should use as much of it as possible without overcrowding. Your first inclination might be to fill half of this space with text and half with graphics. A better approach would be to limit your text to about one-fourth of the space and maximize the impact of your graphics. Remember that a poster session is more than just abstracts and authors—it is a graphically oriented method for increasing *active discussion* of research.

Step One: Picture This

As your first step, make a list of the photographs, figures, and data tables you would need if you were to create a poster describing your research *using graphics only*. This may seem difficult or impossible to do, but it will force you to focus on the essential elements of your work. The bulk of your time will then be spent collecting or creating these images. Be sure to write simple captions for each and every graphic.

Step Two: Divide and Conquer

Think of your poster as an argument to convince others that what you have done is important (you will certainly encounter others who agree to disagree about your methods or results). Although there's no substitute for knowing your subject matter, being well organized can help you survive the critical eye. Lead the viewer step by step through your research by dividing the poster into discrete elements. Traditional wisdom holds that, at a minimum, you should include title, abstract, introduction, methodology, results, and conclusions. Depending on the stage of your research, however, you may also want to include sections on future research plans, questions for discussion, etc. Be sure to leave white space between sections, so that each stands alone. Text size is also very critical. It must be large enough to be read at a distance, because if you attract a crowd, it may be difficult to get close to your poster. Generally this means a font size greater than 100 points for your title, and greater than 18 points for the body of your poster's text.

Step Three: Some Assembly Required

There are several approaches to assembling your final poster. Perhaps the most common is to wait until the meeting, and then pin your text and graphics blocks to the bulletin board provided for you. For a more polished look, you may want to assemble the poster at home on pre-cut matte board, available from most art supply stores and framing galleries. But the days of scissors and spray adhesive are coming to an end. At the conference I attended recently, perhaps one-third of all posters were printed as single sheets using high-quality color plotters. Popular programs for creating your poster this way include Microsoft Powerpoint and Adobe Illustrator. Before you attempt the electronic method you should become familiar with the software. Depending on which you choose, the learning curve can have a steep initial slope. More important is to know the capabilities of your computer system, because large graphics files embedded in your poster will mean a very large file size, often several megabytes. Be sure your computer is connected directly to the final printer—otherwise you will have to FTP the file to one that is connected or carry the file on a Zip disk or other high-density diskette.

In many ways, presenting a poster is much harder than giving a talk. Over the course of the session, you will probably talk much more than 20 minutes and will have to answer many more questions than the few allowed after a talk. Make it obvious that you are the author and not just another viewer. Actively engage each person who approaches your poster. Rehearse a brief summary of your research that you can present to those in a hurry. And finally, don't be afraid to highlight areas that are not totally worked out, since this is where you might get the most benefit from feedback. It's better to have several people standing next to your poster discussing ways to improve the study than to be standing all alone.

Posters can be as individual as their presenters. After all, no one else has the same perspective of your research or understands the particular question that you are asking. This diversity of style may also reflect personal preference in regard to graphic design. On the other hand, poster sessions, as informal as they seem, are probably the method by which an overwhelming proportion of technical information is passed during meetings, so the way in which they are designed deserves more than a passing glance. In this case, five minutes may just be enough! ■

A Funny Thing Happened on the Way to Retirement

by Robert L. Fuchs

Since I am receiving monthly checks from the Social Security Administration, I believe I am now entitled to write "retired" on forms asking for one's occupation. But in getting to this version of the Holy Grail, there were some annoyances to deal with, and a significant revelation to ponder. One of the annoyances involved actually getting the first check from SSA—a sordid story unto itself. Call me if you would like to know the gory details.

The revelation concerned distributions from qualified retirement plans such as an IRA, Keough, SEP, 401(k), or pension. At the time they are made with pre-tax dollars, retirement contributions are tax deferred. Therefore, except for any after-tax contributions you might have made, amounts withdrawn from any of the plans *are taxable at regular income rates, not at long-term capital gain rates*.

That's right! All that impressive growth attributable to rising market values that most of us have witnessed in our retirement assets could be taxed at federal rates of 39.6% or more (not including state and local taxes) when we start periodic withdrawals or take a lump-sum distribution. This is nearly double the 20% long-term capital gain rate enacted in 1997.

Furthermore, if you die with assets still in your plans, your plan beneficiaries will continue to bear these tax pains. The same tax rates apply to beneficiary withdrawals as to retiree withdrawals. Unlike a bequest from other estate assets, which can be tax free to the recipient, the remainder interest of an IRA has baggage—the liability for the deferred, unpaid tax on the income originally invested *plus* the appreciation on the investments.

Fortunately, with some planning, now the tax disadvantage can be minimized. The Internal Revenue Service has approved bequests of retirement plans to qualified charities, such as the GSA Foundation, and the charities are exempt from taxation on subsequent distributions.

An example can illustrate the opportunity. A GSA member with a $50,000 IRA and personal assets valued at $150,000 wishes to bequeath $50,000 each to a nephew and to the GSA Foundation. Assignment of the IRA to the nephew would require him to pay the accumulated tax liability on the value in excess of the member's original contribution. The net value of the bequest could be reduced to $30,000 after taxes. Alternatively, by making the GSA Foundation the beneficiary of the IRA and paying the nephew's bequest from other estate assets, both transfers can be made free of taxation and realize the full $50,000 benefit for each.

Owing to these potentially onerous tax liabilities, taking the extra estate planning time and care to anticipate the problem can pay big dividends to your beneficiaries. Most financial institutions such as banks, brokers, insurance companies, and retirement plan administrators have forms enabling you to change the beneficiary designations of your retirement assets. It's worth a call to inquire about the procedures.

Returning to my situation, I have an IRA that can be used for charitable bequests. So the GSA Foundation is now a beneficiary of my IRA, and bequests to family members will be paid from other assets in my estate. With its 110-year history of serving the interests of geology professionals, its extensive scientific and educational agenda, and its long-term and reliable performance in managing its own assets, GSA is a worthy beneficiary of its members' philanthropy.

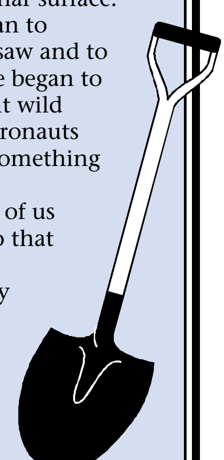
A college development officer once told me that he didn't think much of IRA gifts to his organization. His reasoning was that, upon retirement, individuals would rapidly deplete their IRAs, and the college's residual interest would likewise dissipate. Not necessarily so!

I've heard it said that 90% of 90-year-olds still have 90% of their IRAs. I can't vouch for the accuracy of the statement, but on the basis of personal contacts in recent years, I can say that many senior GSA members admit to having much larger personal estates than they expected to have in retirement. IRAs and similar qualified retirement plans constitute a significant share of these estates. If you find yourself at risk of incurring big tax bills from the existing status of your retirement accounts, you may wish to consider integrating gifts to the GSA Foundation in your estate planning. I invite you to call the Foundation office (at 303-447-2020) for further information about how you may make these profitable changes. ■

Digging Up the Past

During the first lunar landing, 29 years ago, almost 70 of us were at a geology summer field camp near Park City, Utah. Gathered around the television set, we were quiet as Armstrong and Aldrin descended to the lunar surface. But as the crew began to describe what they saw and to name rock types, we began to chatter, and we went wild when one of the astronauts announced seeing something that looked "like anorthosite"! Those of us who were witness to that event of events in humankind's history will never forget it. Those of us who are geologists have it etched in stone!

—*John C. Jens*



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About People

Student Associate **Richard Ashmore**, Lamar University, Beaumont, Texas, was selected as one of 20 college students from across the country for *USA Today's* 1998 All-USA College Academic Team. The American Association of Petroleum Geologists also named Ashmore its first convention scholar, for the 1998 AAPG annual meeting.

Fellow **George D. Klein** has relocated his consulting firm, now called SED-STRAT Geoscience Consultants, to Houston Texas.

ENVIRONMENT MATTERS

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Geoecology: Emerging Direction or Buzz Word?

Cathleen L. May, Outsource Options, Inc., P.O. Box 833, Gunnison, CO 81230

Geoecology, geobiology, geomicrobiology, Earth-system science: Does this terminology represent new avenues of inquiry, or just a recent hatch of buzz words? If employing such terms helps to increase awareness of geology's critical role in environmental problem-solving and sustainable ecosystem management, then I for one will buzz persistently. These new terms represent more than fashion, however. The theme "Earth System Summit" and much of the content of GSA's 1997 Annual Meeting in Salt Lake City suggest that fresh scientific insight and integration of diverse approaches are largely responsible for new usage of terms like "geoecology" as well as new terms like "Earth-system science." As decision-makers at all levels of society grapple with issues of environmental degradation, sustainable land use, global climate change, and declining biodiversity, the need for scientific information about the structure, function, and evolution of complex natural systems grows. Geologists are beginning to respond to these needs through research that elucidates critical linkages between geological, biological, and ecological components of complex natural systems. So while the "geo" in geoecology may not be "new," its contribution to the emerging emphasis on systems-level inquiry is.

Earth System Science and Geoecology

"Earth-system science" is an inclusive concept that comprises social systems as integral components of the dynamic processes of Earth. Current usage of the term "Earth-system science" implies integration of earth, life, atmospheric, planetary, and social sciences to identify systemic relationships of global aspect. Earth-system science explicitly considers historic, current, and future anthropogenic influences.

"Geoecology" focuses on the current state of complex natural systems as understood through direct observation (as compared to "geobiology," which focuses on the historic record of relationships between geology and biology viewed through proxy evidence). The term "geoecology" has been used for decades by soils scientists to describe the study of relationships between soils and vegetation. My usage of the term expands on this concept to include the study of all relationships between geology, in its fullest sense, and the structure and function of modern ecosystems. In my introductory remarks for GSA's sixth annual Environmental Forum at the 1997 Annual Meeting, I emphasized the contingent relationships (see below) that emerge at the interface of the geological and biological components of ecosystems.

Geoecology as an Emerging Application

Geoecology looks for congruence and coincidence between geological elements and processes and ecological elements and processes. As described above, it then seeks out dependent relationships between these elements and processes. Geological parameters upon which ecosystem structure and function are dependent at the level of the whole system are "geoecological contingencies."

To describe what I mean by "geoecological contingency," I use a unique and relatively simple system that occurs on the Colorado Plateau. Hanging gardens are isolated and distinct "island ecosystems" that occur on canyon sidewalls and headwalls in the incised drainage system of the plateau. Two geoecological contingencies prescribe the occurrence and persistence of the hanging-garden habitat, and the ecosystem it supports—the presence of a perennial groundwater seep and protective headward-concave geomorphology. These two contingencies subsume lithologic, stratigraphic, hydrologic, structural, and geomorphic factors that together determine the occurrence of seeps and the geomorphologic features they create. Protective geomorphology and groundwater seeps allow the accumulation of colluvium on steep slopes, and a constant supply of water below the fluvial (erosional) threshold. These habitat parameters are boundary conditions for occurrence and persistence of the distinctive hanging-garden community, and are direct consequences of the two geoecological contingencies. Characteristic geomorphology that indicates the occurrence of these habitat boundary conditions can be identified, with practice, by using topographic and geologic maps, aerial photographs, and even satellite imagery. Furthermore, the geologic controls on habitat characteristics (e.g., shape, size, soil properties) are so conservative across the system that one can reliably anticipate variations in the hanging-garden community on the basis of geologic factors alone (May, 1998; May et al., 1995).

Geoecological contingencies are conceptually appealing to me as a scientist interested in the hierarchical structure and function of naturally occurring systems. As a scientist directly involved with land and resource management issues for many years, however, I find that the elegance of geoecological contingency also represents immediate utility. Episodic change aside, the geologic components of ecosystems are more conservative across time and space than the biological components. When we can identify higher-order geologic boundary conditions upon which ecosystem function is contingent, we are capturing information at a level useful to decision-makers. That is, understanding geoecological contingency can allow us to anticipate agents that force directional change and/or system collapse. If these are anthropogenic in origin, we may choose to avoid them or to use them, as societal values dictate.

For example, erosion of colluvial soil on a hanging garden decreases the habitat available to support its endemic species. Human foot traffic and grazing are the two observed anthropogenic causes of erosion. Diverting seep discharge away from a hanging garden can collapse the system. Aquifer drawdown may affect the occurrence and distribution of hanging gardens at local to regional scales. Such information is quite valuable to those responsible for maintaining viable habitat for endemic and threatened and endangered species. The most critical information necessary to prevent anthropogenic impact on this habitat is geologic. This information is readily accessible and can be applied to conservation efforts in advance of more complete knowledge of the species' biology and ecology.

The geoecology of hanging gardens is a simplistic case study. The speakers in the 1997 GSA Environmental Forum, "Concepts in Geoecology: Applying New Knowledge at the Interface of the Life and Earth Sciences," presented examples of geoecological concepts across the full range of temporal and spatial scales, and at varying levels of complexity. Keynote speaker Steven Stanley suggested, for example, that total available magnesium is a parameter that has determined the abundance and ecological importance of different calcareous reef-building taxa over 500 million years. This parameter appears to have been contingent on variability in spreading rates at mid-ocean ridges. Evolutionary biologist James Patton showed how the complex patterns of ecologic heterogeneity and taxonomic diversity in the Amazon Basin are contingent on a historic template of landform evolution and a "dynamic geological past (and present)." Karen Prestegaard discussed an integrated approach to field experiments at the scale of stream reaches. Besides generating explicitly geological, hydrological, and ecological data, these efforts are revealing the contingent relationships among streambed heterogeneity, primary productivity, and benthic ecology. Bruce Douglas showed how hydrologic budgets and total energy balances vary between the upper and lower parts of a single watershed, contingent upon bedrock geology and structure. In the accompanying theme session on geoecology, 14 authors presented technical papers that specifically linked geology to ecological processes. Again, the research represented a full range of temporal and spatial scales. For speakers' abstracts, see GSA *Abstract with Programs*, v. 29, no. 6, p. A21–22 and A65–68.

Is geoecology emerging as a research focus? I note several positive indicators. One was the remarkable participation by the audience throughout last year's Environmental Forum. Toward the end of the last panel discussion period, at least six theme session advocates described the geoecological relevance and complementary nature of technical papers that would be presented during the meetings in Salt Lake City. This suggests that with minor prompting and a few good examples, earth scientists from all subdisciplines can easily see themselves and their research as directly applicable to ecological questions and problems. Another indicator was that 14 papers in the geoecology technical session came from eight different geological subdisciplines. An informal survey of the presenters showed that each felt that the relevance of their work would be showcased under the "geoecology spotlight" and might not be appreciated within their own subdiscipline. Two recent pieces in *GSA Today* caught my attention for their geoecological relevance: Antony Berger's "Environmental Change, Geoindicators, and the Autonomy of Nature" (*GSA Today*, January 1998) and Donald Runnells's "Investigations of Natural Background Geochemistry—Scientific, Regulatory, and Engineering Issues" (Environment Matters, *GSA Today*, March 1998). The upcoming GSA Annual Meeting in Toronto includes a theme session on Hydrogeologic Controls on Ecosystems. Other indicators come from some of the primary consumers of geoecological information. For example, the Forest Service ran its sixth annual in-service field course in Geology and Ecosystem Management this past summer. Demand for the course has outstripped the agency's ability to accommodate requests for admission, which are now received from other government agencies. Who wants to take this course? Mostly ecologists and administrators responsible for implementing sustainability strategies on public lands.

What Now?

In his endnote address to last year's Environmental Forum, Dennis Fenn (chief of the Biological Resources Division of the USGS) confirmed that both environmental problem solving and long-term goals such as ecosystem health and sustainable land use require integrative, coordinated research among disciplines and immediately applicable scientific information at a level useful to decision-makers.

We all recognize that geology underpins ecosystems, directly or indirectly, at all spatial and temporal scales. The fundamental concepts of geoecology are not new. Their current relevance lies in the fact that they generate information "at a level useful to decision-makers." Certainly most geologists are not going to become ecologists to achieve such goals. Ecologists are not prone to ask geologists to help them describe the parameters of the system they are researching. Each discipline must pursue its specializations deeply to achieve the best possible understanding. Geoecology is not a blending of the superficial aspects of either science. It is an avenue for synthesizing our deeper understandings and making them relevant to the larger goals of Earth-system science. It requires an active attempt by geologists of all specializations to make their knowledge available. A cab driver in Washington, D.C., with whom I conversed while attending the GSA Geology and Public Policy Committee meeting in April put it most succinctly: "Everybody knows it's all rocks under there. It all starts from the ground up."

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Penrose Conference , August 17–22, 1999

Marine Eocene-Oligocene Transition

During the Eocene-Oligocene transition, a critical period in earth history, the "greenhouse" conditions of the middle Eocene were gradually replaced by the "icehouse" conditions of the early Oligocene. In the past 20 years, enormous strides have been made in our understanding of the global climatic changes of the Eocene and Oligocene, especially in the pelagic marine record of the world.

The focus of the GSA Penrose Conference, "The Marine Eocene-Oligocene Transition," August 17–22, 1999, will be to synthesize our current understanding of the deep marine and pelagic record of Eocene-Oligocene climatic and biotic events, and then to relate that synthesis to the shallow marine records of various continents, especially North America. The site of the conference, Evergreen State College, Olympia, Washington, in the beautiful forests of the Olympic Peninsula, will allow us to take a mid-meeting field trip to fossiliferous Eocene and Oligocene outcrops in the area, and to collect fossils from both sides of the Eocene-Oligocene boundary. Excellent fossil records of the bivalves, gastropods, echinoids, and foraminifera (as well as other marine groups) are known from the Gulf Coast, Atlantic Coast, and Pacific Coast, but for decades, their correlation to the global time scale was very imprecise. New correlations using magnetic and isotopic stratigraphy have greatly enhanced our cross-comparisons among the Atlantic, Gulf, and Pacific coasts. These data will allow us to consider changes in diversity and ecology in shallow-marine organisms throughout the entire late Paleogene, and correlate those events precisely to the global time scale and its record of climate. In addition, many of these shallow marine sediments will have also yielded a stable isotope record for the first time, allowing direct comparison with the global isotopic signal. Thus, we invite specialists in late Paleogene fossils, stratigraphers, isotope geologists, paleoclimatologists, and anyone else with important data on this time interval to apply.

The sessions will update the stratigraphic context for the Atlantic, Pacific, and Gulf Coasts, and then analyze the isotopic and paleontological records of each of these regions. Questions to be considered are: How did diversity and turnover change through the 12 m.y. (49–37 Ma) of the middle Eocene? Do climatic and/or biotic changes appear to have occurred gradually or in a stepwise fashion through this interval? Do participants' databases show a dramatic extinction at the end of the middle Eocene (37.0 Ma)? Are there any events correlated with the mid–late Eocene (35.5–36.0 Ma) impacts now documented from the Chesapeake Bay area and Siberia? Are there indications of a dramatic cooling in the earliest Oligocene (33.0 Ma)?

The conference is limited to 80 participants. We encourage interested graduate students to apply; some partial student subsidies will be available. The registration fee, which covers lodging, meals, field trips, and all other conference costs except personal incidentals, is not expected to exceed $700. Participants will be responsible for transportation to and from the conference site.

Co-conveners are ***Donald Prothero,*** Dept. of Geology, Occidental College, Los Angeles, CA 90041, (213) 259-2557, fax 213-259-2704, prothero@oxy.edu; ***Linda Ivany,*** Museum of Paleontology, University of Michigan, Ann Arbor, MI 48109, (313) 763-9253, ivany@umich.edu; ***Elizabeth Nesbitt,*** Burke Museum of Natural History and Culture, University of Washington, Box 343010, Seattle, WA 98195, (206) 543-5949, lnesbitt@u.washington.edu.

The application deadline is February 15, 1999. If you wish to participate send a letter of application to Donald Prothero (address above), including a brief statement of interests, the relevance of your recent work to the themes of the meeting, and a proposed title of your presentation (oral or poster; poster preferred). Invitations will be mailed to participants by March 15, 1999. ■

LETTERS

Big Tough Ediacarans

Narbonne (1998) has continued to promote the idea that Ediacaran fossils (Vendobionta) were soft-bodied animals by suggesting that their remarkable preservation in quartz sandstone was facilitated by microbial mats, which created a "death mask" of the fossils. His illustration of a specimen of *Spriggia* on a large rip-up carbonaceous film (Narbonne, 1998, Fig. 10) is an important new piece of evidence in the controversy concerning preservation of these problematic fossils. Like other recently discovered Vendobionta (Crimes et al., 1995; Crimes and Fedonkin, 1996), Narbonne's carbonaceoous film with an undistorted *Spriggia* reveals the extraordinary rigidity of these fossils. It also is evidence that sessile mats with Ediacaran fossils could be transported from shallow to deep water. The rigidity of Ediacaran fossils and associated matlike organisms is quite unlike jellyfish, pond scums, or unmineralized microbial mats of my experience.

Arguments such as those presented by Narbonne for microbial preservation of Ediacaran fossils still require a microbial consortium of unusual rigidity and toughness, comparable to those of lichens with their structural chitin (Retallack, 1994, 1997). Recent discovery of exquisitely preserved Devonian lichens is stimulating workers to reexamine a variety of permineralized Precambrian fossils as possible lichens (Taylor et al., 1997).

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Lichens They Are Not

Retallack continues to promote his idea that the Ediacara biota consisted entirely of lichens (Retallack, 1994), an interpretation that has already been criticized by Waggoner (1995). In addition to Waggoner's many objections, modern lichens are photosynthetic and nonmarine, whereas Ediacaran fossils were exclusively marine and occur in life position in probable deep-slope and fan deposits

Letters *continued on p. 15*

Sign Up Now!

Birdsall-Dreiss Distinguished Lecturer for 1999 Announced

Stuart Rojstaczer, Duke University, will be the 1999 Birdsall-Dreiss Distinguished Lecturer. He will speak on one of three topics by request from interested institutions. All talks are aimed at audiences broadly interested in the earth sciences.

Rojstaczer received a B.S. degree from the University of Wisconsin, an M.S. from the University of Illinois, and a Ph.D. from Stanford University. Formerly a research hydrologist with the U.S. Geological Survey, he has been at Duke University since 1990. At Duke, he serves as an associate professor of geology, environment and engineering, and as director of the Center for Hydrologic Science. He has published numerous research articles on a wide range of topics involving subsurface fluid flow and is the author of *Gone for Good: Tales of University Life After the Golden Age* (Oxford University Press, 1999).

To request a visit to your institution during this tour, go to http://www.aas.duke.edu/cgi-bin/geo/birdsall_dreiss.pl, where you will find an easy to use web-based request form, or contact Stuart Rojstaczer directly (Division of Earth & Ocean Sciences, Duke University, Box 90230, Durham, NC 27708, (919) 684-3159, fax 919-684-5833, stuart@duke.edu). We are particularly interested in including liberal arts colleges in the itinerary. The Hydrogeology Division pays transportation expenses; the host institution is expected to provide for the lecturer's local expenses.

TALK TOPICS

• Geysers: Why Are They So Rare and What Might They Indicate About Deformation in Areas of Active Tectonics?

Geysers are admired for both their beauty and rarity. Historical data, some of which are undoubtedly of questionable quality, indicate that variations in geyser and hydrothermal system behavior are partly controlled by tectonic deformation and may even provide clues to preseismic behavior near plate boundaries. We present a model of geyser mechanics that serves to explain why geysers are rare relative to other hydrothermal features, such as fumaroles and warm springs. We also present the first comprehensive effort to monitor geyser activity in the Old Faithful region of Yellowstone National Park over a lengthy (one year) time period. The data indicate that geyser behavior can be sensitive to small elastic deformation. Thus, historical accounts of unusual geyser activity associated with regional seismic events may reflect local elastic deformation induced by regional tectonism, and may not be as far-fetched as generally thought.

• Truly Useful Prediction of Subsurface Contaminant Transport: Can We Ever Have Enough Data?

The threat of contamination of well water is a world-wide problem, and the future costs associated with clean-up of contaminated aquifers or containment of contamination potentially will cost trillions of dollars. In order to assess the risk of contamination and devise effective clean-up strategies, it is imperative that we be able to predict rates and directions of contaminant movement. Understanding spatial variability and scaling of permeability is a key to predicting contaminant transport in the shallow subsurface. Conventional testing of permeability is generally done at too large a scale and at a resolution too coarse to allow for truly useful prediction of contaminant transport in the preponderance of cases. Our successes and failures in prediction of contaminant transport indicate that improvements in prediction will depend heavily on improving methods of imaging the permeability of the subsurface rather than improving our mathematical models of contaminant transport.

• Faults and Fluids: What Can We Learn About Brittle Failure in the Crust From Shallow Subsurface Hydrology?

Groundwater at depth has been hypothesized to play an important role in fault generation and fault motion. The temptation has been to assume that shallow subsurface hydrology is sometimes significantly coupled to deep-seated geologic and hydrologic processes in and around fault zones. Monitoring of shallow subsurface hydrology in areas of active tectonics can provide valuable information about crustal behavior. During aseismic periods, we can quantitatively use pore-fluid pressure to monitor elastic deformation near and within faults. The response of shallow groundwater and surface water to earthquakes also gives us information on the state of stress in the near surface and the susceptibility of the near surface to brittle failure. But evidence for significant coupling between shallow and deep hydrology is generally lacking. Evidence of the interaction between faults and fluids is currently heavily dependent on geophysical imaging and geological examination of exhumed fault zones. If we wish to significantly improve our understanding of the interaction between faults and fluids at depth, we will likely need to monitor hydrology at seismogenic depths directly. ■

Letters *continued from p. 14*

below the euphotic zone (see Narbonne, 1998, and references therein). Retallack's argument that these could not have been deep-marine because the deposits in Newfoundland include "red beds" (actually red shales) and those in the Mackenzie Mountains have a "calcareous composition" (Retallack, 1994, p. 537–538) ignores the fact that red mud and carbonates are the two most characteristic sediments on the deep sea floor of modern oceans (Kennett, 1982; Stow et al., 1996).

Retallack's view that no modern bacterial and algal mats are rigid or tough is perplexing in light of an extensive literature to the contrary (e.g., Gerdes et al., 1993; Krumbein et al., 1994).

Most important, the tremendous disparity in body plans, composition, and symmetry evident in the Ediacara biota suggests that attempts to shoehorn these organisms into any single taxonomic group is inappropriate, and may hinder our understanding of their paleobiology.

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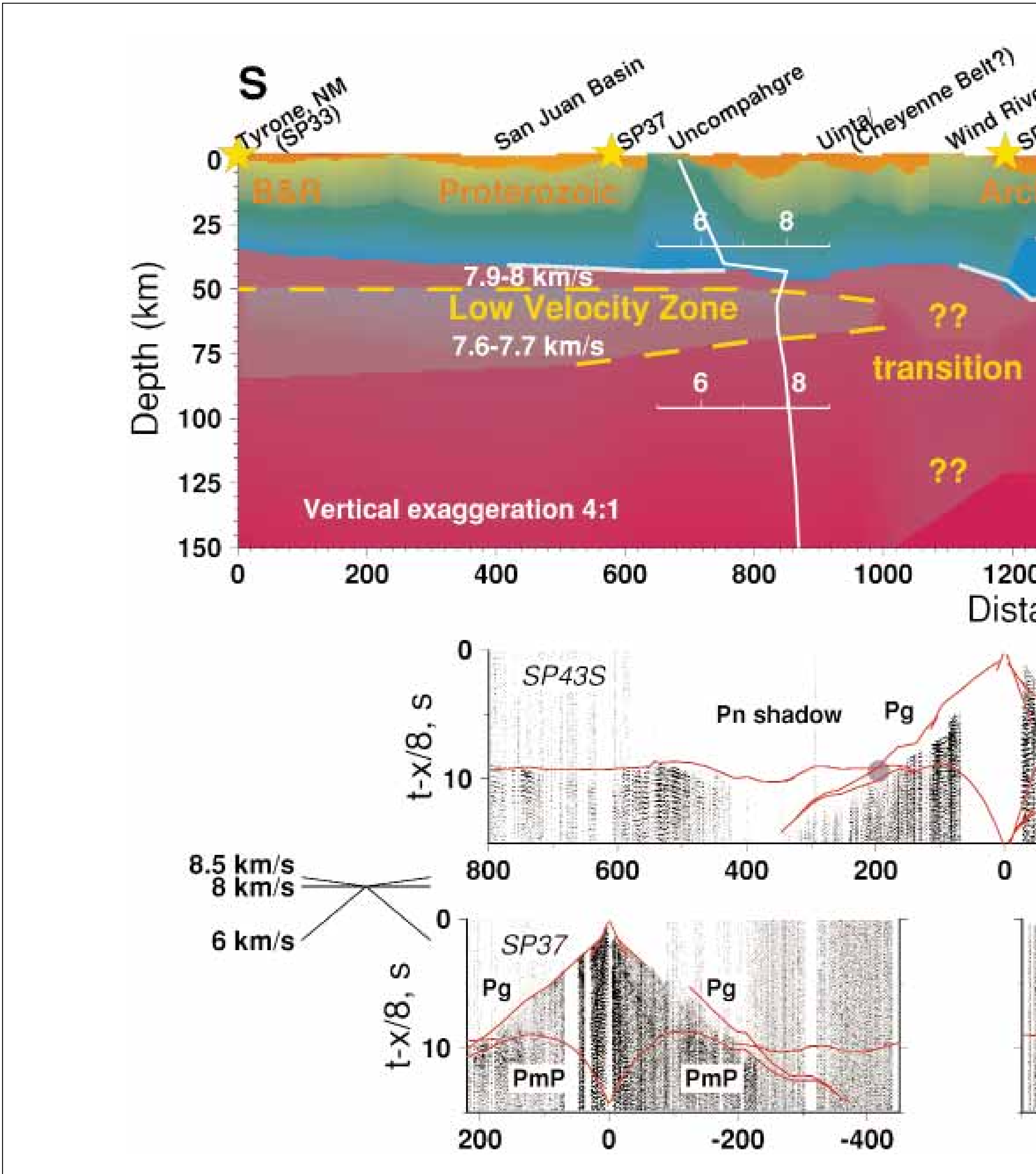
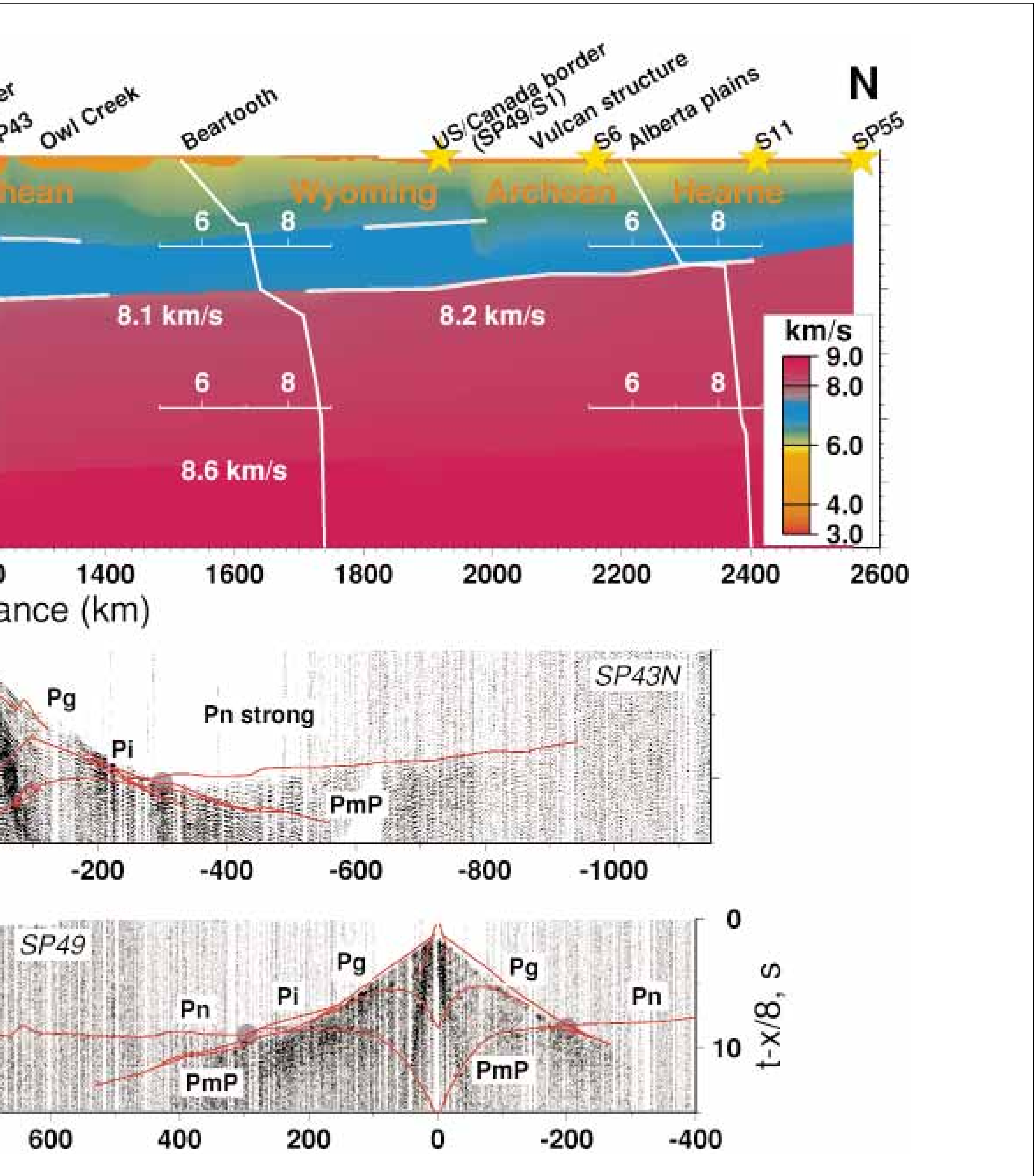


Probing the Archean and Proterozoic Lithosphere of Western North America, by Deep Probe Working Group (p. 1–5, this issue)

Figure 3. One-dimensional velocity profiles from reflectivity modeling of Deep Probe data compared with those determined previously from earthquake observations. The Proterozoic is compared with model GCA for the Gulf of California (Walck, 1983) and the Wyoming province with model S25 for shield North America (LeFevre and Helmberger, 1989). In each case, the earthquake profiles are shifted vertically so that Moho depths match those in our model.



Owl Creek
Beartooth
US/Canada border (SP49/S1)
Vulcan structure
S6
Alberta plains
S11
SP55
N
Wyoming
Archean
Hearne
8.1 km/s
8.2 km/s
8.6 km/s
km/s
9.0
8.0
6.0
4.0
3.0
1400
1600
1800
2000
2200
2400
2600
SP43N
Pg
Pn strong
Pi
PmP
-200
-400
-600
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-1000
SP49
Pg
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t-x/8, s
0
10
600
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200
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-200
-400

Penrose Conference Report

Linking Spatial and Temporal Scales in Paleoecology and Ecology

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The GSA Penrose Conference , "Linking Spatial and Temporal Scales in Paleoecology and Ecology," was held in Solomons, Maryland, May 14–18, 1998. This conference was cosponsored by the Paleontological Society and the Ecological Society of America. It brought together 76 paleoecologists and ecologists from eight countries to consider how ecological interpretation and synthesis are affected by the spatial and temporal scale at which data are collected and models are constructed. This conference provided an exciting venue for members of the earth and biological sciences communities to look for common scientific ground, and to identify interdisciplinary research directions that will cross the traditional boundaries between the fields of paleontology and ecology. Owing to the diverse background of the participants, the conveners organized the meeting around a series of activities intended to maximize cross-disciplinary interaction. Field trips, dedicated poster sessions, and panel discussions were emphasized throughout the meeting, whereas formal talks were used primarily to introduce general topics and provide fodder for conversation.

The first day of the conference was an all-day field trip examining the Virginia Coastal Reserve–Long Term Ecological Research Site (LTER), located along the barrier islands, coastal marshes and beaches of eastern Virginia, on the Delmarva Peninsula. This trip was organized by Bruce Hayden, and run by John Porter, Ray Dueser, Aaron Mills, Linda Blum, Bob Christian, and Michael Fenster. The premeeting field trip served to introduce the themes of the conference, through an understanding of the evolution of the coastal ecosystem of Virginia at varying temporal and spatial scales, and through discussion of how physical processes (tectonism, eustasy, and sediment supply) interact with ecosystem development at varying scales. The formation of an Eocene impact crater, centered on what is now southern Chesapeake Bay, set the stage for subsequent ecological events, whose effects are still being felt today. A combination of long-term relative subsidence in the southern Delmarva Peninsula associated with crater-induced structures, along with both low sediment supply and eustatic sea-level rise, is creating a rapid modern relative sea-level rise of ~3mm/yr along this coast. A primary function of the Virginia Coastal LTER is to monitor the effect of this sea-level rise, as it induces forest die-backs, transgressive salt marsh migration, and the formation of new storm flooding surfaces in what were previously forested coastal regions. Field trip participants also saw how human-induced change (changing agricultural methods and conversion of economic bases) is playing out in the context of this environmental change. In the afternoon, the field trip moved south, across the Chesapeake Bay Bridge to Cape Henry. Here, less than 50 km south of the LTER sites, a progradational Holocene coastline is developing, under the combined influence of considerably greater sediment input and lower subsidence rates. Formation of a succession of shoreward-migrating beach ridges has sequentially caused the development of bald cypress swamps in the swales between ridges. Changes in the scale and rate of landscape evolution during beach migration has caused vegetational zones to also migrate at varying rates.

Day two of the conference marked the beginning of the formal sessions. Convener Andy Cohen introduced the background and themes of the conference. Ecological processes occur over a vast range of spatial and temporal scales, and it is increasingly evident that our perception of how these processes and changes play out is dependent on the scales at which we observe them, as well as our scientific and cultural differences. "Deep Time" (i.e., pre-Quaternary) paleoecologists, Quaternary paleoecologists, and neoecologists collect observations and generate theory at variable scales and with variable information bases. Can these observations be synthesized by common methodology and theory, or are there fundamental discontinuities crossing between scales? The morning's speakers confronted these issues through introductions to the various approaches to ecological understanding employed today. Mike Rosenzweig gave an introduction to large-scale ecological patterns and our current understanding of what these patterns signify in terms of dynamics at the regional and global level. Advances in statistical methods have greatly improved our ability to assess patterns of diversity in biotas, particularly with regard to species that are relatively rare. Convener Jim Brown presented a series of neoecological data sets gleaned from a variety of temporal and spatial scales, in an attempt to clarify for the paleoecologists in the audience the complexities in understanding pattern and its mechanistic interpretation. Richard Bambach gave participants an overview of the fossil record. He framed this discussion around a dichotomy of those processes and patterns that are familiar to both paleoecologists and neoecologists, and those that are only evident from the vantage point of long time intervals that paleoecologists can observe. Karl Flessa attacked the thorny question of temporal resolution in the fossil record. Paleoecology is only recently moving away from a long interlude of hand wringing over the problems taphonomy and time averaging of fossil faunas pose for paleoecology, to a realization that the fossil record can be resolved much better than traditionally thought and that time averaging isn't all bad news. Roy Plotnick discussed the roles of models and modeling in paleoecology, considering their potential for providing linkages between scales. He also showed the importance of a solid grounding in biological understanding in which to embed the development of theory, and the misinterpretations that may await modelers who don't have this grounding.

Poster presentations that followed the morning talks emphasized the general theme of data acquisition in paleoecology and ecology. Posters provided an opportunity for participants to better understand the nature of data sets from fields in which they may have had little prior experience, as well as seeing how such data are manipulated statistically by other fields. Posters emphasized a wide variety of ecological subjects, including patterns of diversity or community structure data at varying scales, taphonomic effects of scaling interpretations, and body-size dynamics at varying scales and their relationship to evolution and climate. Two panel discussions were convened following each of the poster sessions of the day. Panel discussions allowed a different group of participants than those who had just spoken or presented posters to comment on what had been presented and to field questions from the general audience. This activity, which continued throughout the meeting, proved a highly successful and stimulating way to generate excitement about what had been covered up to that point. There was a buzz in the air following the first day's panel sessions, as participants recognized the great potential for cross-disciplinary research efforts that might arise by linking the perspectives of paleoecologists and ecologists around common research questions. For example, participants pondered how analogous time and space really are in ecology, whether time averaging is really a problem or, in fact an opportunity, what other types of issues besides diversity we should be considering in terms of temporal and spatial scaling, and at what conceptual levels paleoecology and ecology might interact. That evening, Jim Reichman from the National Center for Ecological Analysis and Synthesis (NCEAS) gave an after-dinner talk on how his center works, and its eagerness to entertain innovative proposals for sabbatical visits and collaborative workshops spanning the boundary between paleoecology and ecology.

On the third day, the conference moved to a detailed discussion of community structure and stability. Participants got down to considering major and contentious issues concerning the dynamics of diversity change and community structure over varying time and space scales. Linda Ivany and Carl Brett presented their case for coordinated stasis in the fossil record. This idea postulates that large assemblages of marine benthic organisms evolve at about the same time, co-occur over millions of years, and then simultaneously undergo extinction. Ivany reviewed evidence from the Devonian of New York and the Eocene of the U.S. Gulf Coast that suggests that benthic assemblages persisted over 1–8 Ma time intervals, even in the face of sea-level fluctuations. Mark Patzkowsky argued against the coordinated stasis model based on his work on similar Paleozoic ecosystems. In the Ordovician of the eastern United States he finds that species turnover largely corresponds to pulses of environmental change, and that significant extinction and origination events are not always simultaneous. Background turnover within stratigraphic units seems to be much higher than what has been reported by Brett, Ivany, and others. These divergent views lead to the question of how common patterns of individualistic vs. coordinated change really are, and to what extent our perception of these patterns are regulated by the temporal resolution of individual data sets and the episodicity of environmental change. Russ Graham and Steve Jackson both made a case for individualistic responses in explaining community composition in the Quaternary, in particular the occurrence of "no modern analog" biotas. Graham argued for using the Quaternary as a bridge between the deep paleoecological record and modern ecology. He noted that in the Quaternary, temporal resolution is now good enough that although he can't say that two individuals of co-occurring "no-analog" species saw each other "eyeball to eyeball," they can be linked within 50 years in time. Both Graham and Jackson emphasized that patterns of individualistic change should not be confused with a notion of random association. Jackson argued for a greater understanding of potential yet unrealized niche space in organisms that may well explain these "anomalous" communities. Fred Grassle gave the conferees a fascinating glimpse into the species diversity and community composition in the deep sea. Although our understanding of this environment is limited by the difficulties involved in obtaining broad spatial and temporal coverage, it is evident that deep-sea organisms are highly diverse and their distributions very patchy. Even small-scale environmental heterogeneities, such as the deposition of a log, can create habitat patches with distinctive characteristics that persist for many years.

Afternoon posters and panel sessions and the evening lecture continued exploring the themes of structure and stability, with greater attention to details of changes across scale boundaries. Questions tackled included: (1) Do "rules" exist in ecology, either within scales or transcending scale boundaries? (2) How analogous are time and space in ecology? (3) How does scaling affect our understanding of other issues such as body size structure in communities? (4) To what extent do terminological differences impede understanding between ecologists and paleoecologists? This point was illustrated by Joan Roughgarden in a discussion of the meaning of "stability." Jack Sepkoski discussed patterns of global marine biotic organization, building on his earlier compilation analyses of Phanerozoic diversity patterns. He presented the problems of decomposing Phanerozoic marine diversity as a "chicken or egg" problem. Are the dominant controls at the local or regional level building up to creating a global pattern, or are there global controls on diversity that filter down to the local level? Both panel discussions and informal conversations on this day and the next day generated a lively discussion of specific research questions that might be usefully pursued by small working groups as followups to the conference, and the general excitement level surrounding this discussion led many to view the Penrose conference as but the first step in what could become an ongoing dialog among ecologists and paleoecologists with similar research question interests. There was considerable discussion of how working groups might continue the dialog through a series of NCEAS-type workshops.

A field trip on the fourth day to the well-known Miocene Calvert Cliffs, led by Patricia Kelley and Susan Kidwell, provided an opportunity for the participants to consider, on the outcrop, many of the scaling, data collection, and taphonomic issues confronting paleoecologists that had been discussed over the last few days. Kidwell and Kelley gave detailed talks on the depositional setting of the marginal marine and shelf outcrops visited, the taphonomic context of the fossils (which varies in significant ways related to sea-level fluctuations along the Atlantic coastal margin), and the paleoecological problems currently or previously under study. The Miocene deposits of this region have been the focus of intensive investigations on the interface between ecology and evolution, most notably concerning processes of predator-prey interactions over time, and the tempo and mode of evolutionary change. Ecologists attending the meeting with little prior paleoecological experience gained a great deal of insight into the practical considerations of sampling.

An evening lecture on the fourth day by Mark Westoby looked at ecomorphic classification schemes for plants and plant communities. Westoby put forward a new classification scheme which characterizes various aspects of total leaf size, plant height, and seed size. The expression of all of these features involves fundamental ecological compromises across environmental gradients of moisture and nutrient availability. Some, though probably not all of these variables, could in principle be measured for fossil plants, thereby extending the comparative value of Westoby's scheme from strictly between floras or regions to cross time periods.

On the final day of the conference the theme of relationships between scales was more thoroughly explored. Joan Roughgarden looked at the evidence for linkage across scales in the recruitment and growth of intertidal barnacle communities. She demonstrated that local or patch scales of benthic intertidal adult barnacle and starfish interactions are strongly mediated by the vastly different scale over which planktonic barnacle larvae are dispersed and subsequently recruited to the benthos as adults. The latter results from oceanic current circulation and migration of Ekman transport systems with respect to the coastline. David Jablonski looked at the evolution of onshore to offshore trends in the origination of major benthic invertebrate biotas. He asked what upward or downward effects may influence this pattern. After showing that these patterns are not artifactual, resulting from taphonomic biases, he proceeded to demonstrate that the dynamics of invasion at the higher, ordinal level differ in substantive ways from what is observed at lower hierarchical levels. Bill DiMichele discussed some of the scaling problems involved in understanding the evolution of terrestrial floras. Ecomorphic exploration of plant form and habitat preference on the broadest levels are strongly linked to phylogeny in plants. Although turnover may occur at lower taxonomic scales during the evolution of a flora, the fundamental character of a plant community with respect to more inclusive clades remains remarkably stable over long geologic time intervals. Community assembly "rules" may change through the history of a clade, and incumbency limits the degree to which new floras can invade an ecosystem. Arnie Miller reviewed the nature of the global Ordovician radiation of marine invertebrates, moving from global down to regional scales. Miller showed that an apparent global diversification event, when dissected into its component parts, is actually a composite of regions with highly variable rates of diversification, possibly driven by profound differences in tectonic setting of the various continents.

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Selling Science

David J. Verardo, 1997–1998 GSA Congressional Science Fellow

I had two experiences at work that changed my perspective on our profession. In the first instance, I was listening to the chairman of a science and technology department talk to congressional staff about the importance of federal funding for research and development. Actually, he was lecturing more than talking. This was not surprising given his position as an academic. It was, however, frustrating that after 30 minutes he had not gotten to the point despite some gently leading questions intended to steer the session in a productive direction. The experience got me thinking about how scientists communicate the importance of science.

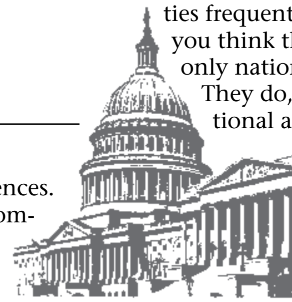
On another occasion, I watched two scientists give a briefing on ecosystem restoration in another legislator's office. They did a masterful job of briefing the staff. You could see by body language, and hear by the nature of the questions asked, that connections were being made in the staff person's mind between geology and ecology. She was understanding how the geosciences were basic to studies of Earth, and how the lens of geologic time provided a unique perspective on ecosystem reconstruction by showing how the environment looked in the absence of historical records. I thoroughly enjoyed watching the interaction. At the end of this highly informative meeting, when asked what the legislator's office could do for scientists, the answer was, "Nothing, we just wanted to let you know what we were doing in your area." What?! It seemed to me the scientists had missed the chance, at the invitation of the congressional staff, to explain how the office could help with the research effort. When I questioned the scientists on this point, they said they were not lobbyists and were constrained by their organization from engaging in such activities. Once again, I thought about how scientists communicate with decision-makers. Specifically, how can we effectively sell science so that we get what we want?

When I relayed these stories to a veteran salesman, he told me that in the first instance, the professor was only interested in his viewpoint—no "sale" potential. In the second instance, the scientists had made the "sale" by showing how the research benefited both the legislator and the scientists, but had not closed the deal by "asking for the order" (i.e., asking for assistance).

As I considered the question of selling, I thought about how, as scientists, we hawk our ideas all the time. With colleagues, we discuss our theories in private over coffee and in public at conferences. We pitch our ideas to clients and company management. We write detailed proposals to funding agencies in support of our research ideas. By and large, we market our science to other scientists. So I thought, how tough could it be to get what we want? I realized, however, that what we think of as selling is actually persuasive arguing; the two are related but not the same. The persuasive argument is crafted from a debate about an issue and revolves around the statement, "My position has merit and this is why." The successful sale centers on the question, "How can we benefit each other?"

When visiting Congress, the emphasis should be on the successful sale as opposed to the persuasive argument. This recognizes that the person you meet in a congressional office is not extensively trained in science and may be ill-suited to evaluate your technical arguments. So instead, focus on selling your idea. The goal is to show how your idea benefits the people of the representative's region, which is, in turn, good for the representative and good for the nation. That is the practical order of interest. Our system of government is carefully designed around the concept of grassroots and is intended to keep the elected representative's focus on the needs of the people. We start with the local and move to the national, and then the international, perspective. The successful sales pitch must be developed within a flexible framework, and the "seller" must be able to sense where the dialogue (not monologue) is going and avoid the urge to stick to a prepared text.

Getting back to the two-scientists example, why is it assumed that providing information and asking for assistance is lobbying, and that this is bad? In essence, lobbying is about providing information and selling ideas. The perception of the lobbyist as doling out money and buying votes is unrealistic. You might be thinking that your organization does not allow lobbying. Well, ask your managers how they define lobbying and who is providing information to decision-makers. Who better to be part of the team that provides this information than those who actually do the scientific and technical work? Many organization's policies regarding communicating with Congress are poorly constrained. I have seen glaring inconsistencies within and among federal and private organizations in policies related to communicating with Congress. It may come as a surprise to learn that universities frequently lobby Capitol Hill, if you think that universities promote only national educational goals. They do, but they have institutional agendas and seek funding for particular university projects. Other science and technical groups are active as well.



The underlying assumption is that communicating with decision-makers is deceptive, just like selling. This notion is limiting. Legislators need reliable information to develop good legislation. Congress is awash in information, but not all of it is reliable. You might think that congressional hearings are the appropriate time for exchanging information. As it turns out, hearings are not the best venue for communicating, because they are highly controlled and choreographed, the consequence being that information flow is restricted.

In the legislative context, the most effective time for sharing information is when legislative ideas are being formed and while minds are open to discovery. Here are some suggestions for communicating with Congress (or other legislative bodies) that foster success in legislative matters.

Suggestion #1: Treat the legislative staff as you would like to be treated yourself. This respects basic human dignity and is professional courtesy.

Suggestion #2: Do your homework on an issue. Know what is important to legislators. What are their views? What is their voting record? What have they said about your issue? Maybe they haven't said anything (on the basis of information available on their Web site or in their local or national offices), so this is a great opportunity to show why your position is a good one for a particular representative. You do not have to be well versed in the details of the legislative process. You are a geoscientist, not a legislative expert. Know enough to be conversant, but speak from your heart about what you feel is important. Empower the staff to help you by conceding your vulnerability. Nothing is as persuasive as passion for one's beliefs.

Suggestion #3: Science is not an entitlement and something to be funded in and of itself. Science is not a distinct category of human activity. It is an activity that serves as the basis of many legislative proposals. In conversations on Capitol Hill, the question is often asked, "What is the science on this (i.e., what is the scientific basis)?" Science has power because it provides order in a chaotic world.

Suggestion #4: Communicate frequently with congressional staff. Call the Washington, D.C., office and find out who

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Selling Science *continued from p. 20*

handles your issues and interests. Write that staff member a personal letter and follow up with a phone call. For a particular issue, provide your thoughts and a potential solution. Maintain contacts even if you do not have any comment at the moment, but do not stalk the staff. Offer to be a resource on science issues. Do not call or write just to complain, and never begin a letter with an insult (this occurs all too frequently). Show your support on a range of issues. In short, develop a professional relationship with the staff.

Suggestion #5: Close the deal. Ask for the legislator's support on your particular issue. Do not badger the staff for a firm answer, but let them know that you are serious about your issue.

Suggestion #6: Lose gracefully. You rarely get all that you want, so do not burn bridges, because you will have to go back across them eventually. America is a big country, but Congress is a small world.

These guidelines seem too simple, too easy, and too obvious to be of value, so they are often ignored. Oddly enough, what drives daily activity on Capitol Hill and, hence, public policy, is the relationships among people. This situation is no different from our personal and professional lives.

Some might be offended at the suggestion that selling science is necessary. They might see it as somehow vulgar or not dignified.They might believe that science's value should be self evident. But Congress is not composed of scientists and engineers. It comprises people whose backgrounds and interests lie elsewhere. Congress is filled with aggressive self-starters who run independent shops supported by one client—the voting public. So, since Members of Congress or their staffs are not, with few exceptions, scientists, then how are they to understand technical issues without your help? Osmosis is not an effective learning strategy, and mind-reading is not a convincing form of communication.

Why not get more scientists on the Hill? Because we eschew science policy as a career path for scientists. Why? Because it is not field or laboratory based and is therefore considered of limited value. This aversion to working with decision-makers is unfortunate and counterproductive since what transpires in the District of Columbia affects future trends in science funding and agency missions. Our profession has been slow to understand that participation is fundamental to success.

The point is that geoscientists are being left behind to harbor some outdated ideas regarding the world. We should take a hard look at our values and our mode of operation. What do we consider to be our core values, and how do we achieve them? Our profession and institutions have changed radically over the years. In industry, companies have shifted to contract workers whose numbers ebb and flow with the economic tide. Within academia, a quiet revolution has occurred. In the period between 1970 and 1993, non–tenure track and part-time faculty positions at four-year colleges increased by 88% and now compose more than 40% of total faculty positions. In this case, industry and academia track closely. What then is the paradigm for today's professional world? Clearly, some of our old ways must go, for they are confining. Ours is a vibrant science that looks to the past for solutions for the present and future. We should not, however, become mired in the past. Instead, we must emphasize our connection to, indeed our underpinning of, other sciences.

In general, science still enjoys healthy respect in the U.S. Congress and in society at large. The time of expansive growth for science, however, is over; this slowdown reflects the fundamental change in today's budgetary and professional landscape. It will take some time to adjust both cognitively and behaviorally; this has already begun. By looking ahead and being adaptable and innovative, however, we can move forward together. ■

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This examination of processes at progressively smaller scales suggests a need to evaluate, in similar detail, the tempo of other presumptively global events such as mass extinctions. Bruce Patterson gave the final talk of the meeting, looking at altitudinal diversity gradients across the Peruvian Amazon. Although data from bird surveys have come to be a sort of benchmark against which biogeographic models are compared, Patterson showed that many other patterns of diversity occur, particularly among small mammals. Spatial ranges and gradients in extant organisms display many properties analogous to the biostratigraphic ranges familiar to paleoecologists. Using his nested subset methodology, Patterson argued that historical factors and differences in dispersal ability, as well as species-area relationships, play a role in structuring mammal distribution patterns.

During the final panel discussion, a consensus arose among the panelists and audience as to the need for continued dialog among paleoecologists and ecologists. Scientists from both disciplines were urged to seek out colleagues with complementary skills to solve scaling problems of mutual interest while simultaneously drawing on the strengths of their respective knowledge. Following on the favored metaphor of the meeting, one conferee suggested that "we had to become polygamous" in developing collaborations among multiple fields. During the conference, participants had made tentative but important steps in learning each others' scientific "languages," critical for sustained dialog. It was widely agreed that the need for such a dialog has never been greater. The combined issues of global change and biodiversity loss on Earth both dramatize the need for understanding processes of diversification, invasion, and extinction at all scales. Our old modus operandi, of making simplistic interpretations of data gleaned from each other's fields, should be replaced by truly collaborative efforts to understand these most serious of environmental problems. This Penrose Conference provided an exciting opportunity for all participants to begin what we hope will become a sustained and fruitful conversation between paleoecology and ecology. ■

Penrose Conference Participants

Simone Alin
John Alroy
Richard Aronson
Gail Ashley
Catherine Badgley
Richard Bambach
Roberto Barbieri
Kay Behrensmeyer
J. Bret Bennington
G. Lynn Brewster-Wingard
Grace Brush
Donna Carlson
Chi-ru Chang
Michael Collins
Sean Connin
Sean Connolly
Kathryn Cottingham
Michael Cuggy
Tamar Dayan
Claudia Del Rio
William DiMichele
Douglas Erwin
Brian Exton
Karl Flessa
Norman Fredericksen
Robert Gastaldo
Russell Graham
Frederick Grassle
Elizabeth Hadly
Lucas Hottinger
John Hunter
Scott Ishman
Linda Ivany
David Jablonski
Stephen Jackson
Christine Janis
Thomas Kammer
Patricia Kelley
Susan Kidwell
Mary Killelea
Michal Kowalewski
Matthew Kosnik
Conrad Labandiera
Kathleen Lyons
Richard Lupia
Christopher G. Maples
Ronald Martin
Brian A. Maurer
Arnold Miller
Richard Norris
Thomas Olszewski
John Pandolfi
Lisa Park
Bruce Patterson
Mark Patzkowsky
Hermann Pfefferkorn
Roy Plotnick
James Reichman
Michael Rosenzweig
Joan Roughgarden
John Sepkoski
Felisa Smith
Cheryl Solomon
Heidemarie Steltzer
Nils Stenseth
Carol Tang
Jessica Theodor
Thomas Therriault
Anne Weil
Mark Westoby
Jack Williams
Scott Wing
Deborah Woodcock
Yaron Ziv

GSA Employment Service

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You may register any time throughout the year. Your name will be provided to all participating employers who seek individuals with your qualifications. If possible, take advantage of GSA's Employment Interview Service, which is conducted each fall in conjunction with the Society's Annual Meeting. The service brings potential employers and employees together for face-to-face interviews. Mark your calendar for the 1998 GSA Annual Meeting in Toronto, Ontario.

To register, complete the application form on page 23, prepare a one-to two-page résumé, and mail it with your payment to GSA headquarters. One-year listing for GSA Members and Student Associates in good standing: $30, nonmembers: $60.

NOTE TO APPLICANTS: If you plan to interview at the GSA Annual Meeting, GSA must receive your materials no later than September 1, 1998. If we receive your materials by September 1, your record will be included in the information employers receive prior to the meeting. Submit the form early to receive maximum exposure! Don't forget to indicate on your application form that you would like to interview in October. Good luck with your job search!

For additional information or submission of forms, please contact T. Michael Moreland, Manager, Membership Services, Geological Society of America, P.O. Box 9140, Boulder, CO 80301, (303) 447-2020, or member@geosociety.org.

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How does it work? Complete the Employer's Request for Earth Science Applicants form on page 24. Remember to specify educational and professional experience requirements as well as the specialty area or areas of expertise your applicant should have. The GSA computer will take it from there.

You will receive a printout that includes the applicants' names, addresses, phone numbers, areas of specialty, type of employment desired, degrees held, years of professional experience, and current employment status. Résumés for each applicant are sent with each printout at no additional charge. For 1998, the cost of a printout of one or two specialty codes is $175. (For example, in a recent job search for an analyst of inorganic materials, the employer requested the specialty codes of geochemistry and petrology.) Each additional specialty is $50. A printout of the applicant listing in all specialties is available for $350. (Specialty codes printed in boldface type are considered major headings. If you request a listing of one of the subspecialties, applicants coded under the major category will be included but not those coded under the other related subspecialties.) If you have any questions about your personalized computer search, GSA Membership Services will assist you.

The GSA Employment Service is available year round. However, GSA also conducts the Employment Interview Service each fall in conjunction with the Society's Annual Meeting (this year in Toronto, Ontario, October 26–29). You may rent interview space in half-day increments from GSA. Our staff will schedule all interviews with applicants for you, the recruiter. In addition, GSA offers a message service, complete listing of applicants, copies of résumés at no additional charge, and a posting of all job openings. ■

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PRESENT EMPLOYER ______________________________

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Will accept employment in: ☐ U.S. only ☐ U.S. with foreign assignments ☐ Either

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101 coal geology
102 geothermal, etc.
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120 Engineering Geology
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200 General Geology
220 Geochemistry
221 organic
222 high temperature
223 low temperature
224 stable isotopes
225 geochronology
250 Geomorphology
300 Geophysics
301 seismic
302 gravity/magnetics
303 seismicity
304 paleomagnetism
320 Hydrogeology
321 hydrochemistry
322 ground water
323 surface water
330 Library
350 Mathematical Geology
351 computer science
352 statistical geology
400 Mineralogy
401 crystallography
402 clay mineralogy
410 Museum (curator)
420 Oceanography
421 marine geology
422 coastal geology
450 Paleontology
451 invertebrate
452 vertebrate
453 micropaleontology
454 paleobotany
455 paleoecology
500 Petroleum Geology
501 exploration
502 subsurface strat.
520 Petrology
521 igneous
522 metamorphic
523 sedimentary (clastic)
524 sedimentary (carb.)
525 experimental
550 Planetology
575 Quaternary Geology
600 Regional Geology
620 Remote Sensing
621 photogeology
622 photogrammetry
630 Science Editing
650 Sedimentology
651 sed. processes
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720 Stratigraphy
750 Structural Geology
751 tectonics
752 tectonophysics
753 rock mechanics
800 Volcanology

Résumé must be attached, ***limited to two pages,*** typewritten on one side only, to be acceptable for reproduction to employers. Include your name, address, and phone number; concise details of work experience; and majors/minors on degrees.

Fee: $30 if you are a Member or Student Associate of GSA in good standing (Member #____________), $60 if you are not a member of GSA. Payment in U.S. funds (check, money order, or charge information ***must accompany form).***

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List the specialty code numbers that you wish to order, or ☐ check here if you want the entire file of applicants in *ALL* specialties.

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- 102 geothermal, etc.
- 103 metallic deposits
- 104 nonmetallic deposits
- 105 mining geology

120 Engineering Geology
150 Environmental Geology
160 Public Education & Communication
200 General Geology
220 Geochemistry
- 221 organic
- 222 high temperature
- 223 low temperature
- 224 stable isotopes
- 225 geochronology

250 Geomorphology
300 Geophysics
- 301 seismic
- 302 gravity/magnetics
- 303 seismicity
- 304 paleomagnetism

320 Hydrogeology
- 321 hydrochemistry
- 322 ground water
- 323 surface water

330 Library
350 Mathematical Geology
- 351 computer science
- 352 statistical geology

400 Mineralogy
- 401 crystallography
- 402 clay mineralogy

410 Museum (curator)
420 Oceanography
- 421 marine geology
- 422 coastal geology

450 Paleontology
- 451 invertebrate
- 452 vertebrate
- 453 micropaleontology
- 454 paleobotany
- 455 paleoecology

500 Petroleum Geology
- 501 exploration
- 502 subsurface strat.

520 Petrology
- 521 igneous
- 522 metamorphic
- 523 sedimentary (clastic)
- 524 sedimentary (carb.)
- 525 experimental

550 Planetology
575 Quaternary Geology
600 Regional Geology
620 Remote Sensing
- 621 photogeology
- 622 photogrammetry

630 Science Editing
650 Sedimentology
- 651 sed. processes
- 652 sed. environments

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750 Structural Geology
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- 752 tectonophysics
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Experience desired (years):

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1. I agree to use this service for valid recruiting purposes.
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Registration information and course descriptions were published in the June issue of *GSA Today*. For additional information, contact Edna Collis, GSA headquarters, ecollis@geosociety.org, or see GSA's Web site, www.geosociety.org.

Fees are given in U.S. dollars

PREREGISTRATION DEADLINE:SEPTEMBER 18 • CANCELLATION DEADLINE:SEPTEMBER 25

1. ■ ANALYSIS OF VEINS IN LOW-TEMPERATURE ENVIRONMENTS—INTRODUCTION FOR STRUCTURAL GEOLOGISTS

Saturday, October 24 and Sunday, October 25, 8:00 a.m. to 5:00 p.m. Metro Toronto Convention Centre. Cosponsored by *GSA Structural Geology and Tectonics Division.* **FACULTY: David V. Wiltschko**, **John W. Morse**, and **Will Lamb,** Dept. of Geology and Geophysics, Texas A&M University, College Station, and **Zachary D. Sharp,** Dept. of Earth and Planetary Sciences, University of New Mexico.

Limit: 40. Fee: $290, students $270; includes course manual and lunch both days. CEUs: 1.6.

2. ■ DEFORMATION MECHANISMS AND MICROSTRUCTURES

Saturday, October 24, 8:00 a.m. to 5:00 p.m., and Sunday, October 25, 8:00 a.m. to 12:00 noon. University of Toronto. Cosponsored by *GSA Structural Geology and Tectonics Division.* **FACULTY: Jan Tullis,** Dept. of Geological Sciences, Brown University; **Christian Teyssier,** Dept. of Geology, University of Minnesota; **Holger Stunitz,** Geology and Paleontology Institute of Basel University, Switzerland.

Limit: 30. Fee: $250, students $230; includes course manual, slide set, and lunch on Saturday. CEUs: 1.6.

3. ■ PHASE I ENVIRONMENTAL SITE ASSESSMENTS

Saturday, October 24 and Sunday, October 25, 8:00 a.m. to 5:00 p.m. Metro Toronto Convention Centre. Cosponsored by *GSA Engineering Geology Division.* **FACULTY: Raymond C. Kimbrough,** Tom Joiner & Associates, Inc., Tuscaloosa.

Limit: 30. Fee: $245, students $225; includes course manual and lunch both days. CEUs: 1.6. *Optional exam fee: $90. Optional NREP Study Guide is available for $50.*

4. ■ THREE-DIMENSIONAL SEISMIC INTERPRETATION: A PRIMER FOR GEOLOGISTS

Saturday, October 24 and Sunday, October 25, 8:00 a.m. to 5:00 p.m. Metro Toronto Convention Centre. **FACULTY: Bruce S. Hart,** New Mexico Bureau of Mines and Mineral Resources, Socorro.

Limit: 40. Fee: $240, students $220; includes course manual and lunch both days. CEUs: 1.6.

5. ■ ANALYTICAL METHODS AND APPLICATIONS IN PROVENANCE STUDIES OF LITHIC ARTIFACTS

Sunday, October 25, 8:00 a.m. to 5:00 p.m. University of Toronto. Cosponsored by *GSA Archaeological Geology Division.* **FACULTY: Patrick J. Julig,** Dept. of Sociology and Anthropology, Laurentian University, Sudbury, Ontario; **Darrel G. F. Long,** Dept. of Earth Sciences, Laurentian University, Sudbury, Ontario; **R. G. V. Hancock,** SLOWPOKE reactor facility, Dept. of Chemical Engineering and Applied Chemistry, University of Toronto.

Limit: 30. Fee: $220, students $200; includes course manual and lunch. CEUs: 0.8.

6. ■ APPLICATIONS OF ENVIRONMENTAL ISOTOPES IN GROUNDWATER STUDIES

Sunday, October 25, 8:00 a.m. to 5:00 p.m. Metro Toronto Convention Centre. Cosponsored by *GSA Hydrogeology Division.* **FACULTY: Ramon Aravena,** Dept. of Earth Sciences, University of Waterloo, Ontario; **Ian D. Clark,** Dept. of Geology, University of Ottawa.

Limit: 50. Fee: $190, students $170; includes course manual and lunch. CEUs: 0.8.

7. ■ BUCK ROGERS, FIELD GEOLOGIST: 21ST CENTURY ELECTRONIC WIZARDRY FOR MAPPING AND FIELD DATA COLLECTION

Sunday, October 25, 8:00 a.m. to 5:00 p.m. Metro Toronto Convention Centre. **FACULTY: John H. Kramer,** Condor Earth Technologies, Inc., Sonora, California; **Todd T. Fitzgibbon,** U.S. Geological Survey, Menlo Park, California.

Limit: 35. Fee: $240, students $220; includes course manual and lunch. CEUs: 0.8.

8. ■ DESIGN AND CREATION OF STATE-OF-THE-ART, INTERACTIVE, MULTIMEDIA CD-ROMS FOR USE IN TEACHING GEOLOGY

Sunday, October 25, 8:00 a.m. to 5:00 p.m. University of Toronto. **FACULTY: Parvinder S. Sethi,** Dept. of Geology, Radford University, Radford, Virginia.

Limit: 25. Fee: $230, students $210; includes course manual and lunch. CEUs: 0.8.

9. ■ DETECTING ENVIRONMENTAL EFFECTS USING BENTHIC FORAMINIFERA AND THECAMOEBIANS

Sunday, October 25, 8:00 a.m. to 5:00 p.m. Metro Toronto Convention Centre. Cosponsored by *Cushman Foundation.* **FACULTY: David B. Scott,** Dept. of Earth Sciences, Dalhousie University, Halifax, Nova Scotia; **Eduard G. Reinhardt,** Dept. of Earth Sciences, Dalhousie University, Halifax, Nova Scotia; **Francine M. G. McCarthy,** Dept. of Earth Sciences, Brock University, St. Catharines, Ontario; **R. Timothy Patterson,** Dept. of Earth Sciences, Carleton University, Ottawa, Ontario.

Limit: 30. Fee: $230, students $210; includes course manual and lunch. CEUs: 0.8.

10. ■ GEOTECHNICAL AND ENVIRONMENTAL APPLICATIONS OF TIME DOMAIN REFLECTOMETRY

Sunday, October 25, 8:00 a.m. to 5:00 p.m. Metro Toronto Convention Centre. Cosponsored by *GSA Engineering Geology Division.* **FACULTY: Kevin M. O'Connor,** President, GeoTDR, Inc., Apple Valley, Minnesota; **Charles H. Dowding,** Dept. of Civil Engineering, Northwestern University.

Limit: 50. Fee: $190, students $170; includes course manual and lunch. CEUs: 0.8.

11. ■ TEACHING PRACTICAL HYDROGEOLOGY: HOW TO MAKE DO WITH SCANT "REAL WORLD" DATA

Sunday, October 25, 8:00 a.m. to 5:00 p.m. Metro Toronto Convention Centre. Cosponsored by *GSA Hydrogeology Division.* **FACULTY: Donald I. Siegel,** Dept. of Earth Sciences, Syracuse University.

Limit: 50. Fee: $170, students $150; includes course manual and lunch. CEUs: 0.8.

CALL FOR GSA SHORT COURSE PROPOSALS

Due December 1, 1998

The GSA Committee on Continuing Education invites those interested in proposing a GSA-sponsored or cosponsored course or workshop to contact GSA headquarters for proposal guidelines. Short courses may be conducted in conjunction with all GSA annual or section meetings. We are particularly interested in receiving proposals for the 1999 Denver Annual Meeting or the 2000 Reno Annual Meeting.

Proposals must be received by December 1, 1998. Selection of courses for 1999 will be made by February 1, 1999. For those planning ahead, we will also consider courses for 2000 at that time.

For proposal guidelines or information, contact:
Edna Collis, Continuing Education Coordinator,
GSA headquarters, 1-800-472-1988, ext. 134,
ecollis@geosociety.org

July *BULLETIN* and *GEOLOGY* Contents

The Geological Society of America
BULLETIN
Volume 110, Number 7, July 1998

GEOLOGY
VOLUME 26
NO. 7
P. 579–672
JULY 1998

Forum

1998

October 26–29
Metro Toronto Convention Centre

Sheraton Centre Toronto Hotel

www.geosociety.org/meetings/98

Abstracts due: *July 13*

ASSEMBLY OF A CONTINENT

Call for Papers and First Announcement in the April issue of GSA Today.
Registration and Housing information in the June issue of GSA Today.

GENERAL CHAIRS

Jeffrey J. Fawcett, *University of Toronto*
Peter von Bitter, *Royal Ontario Museum*

TECHNICAL PROGRAM CHAIRS

Denis M. Shaw, *McMaster University*
Andrew Miall, *University of Toronto*

FIELD TRIP CHAIRS

Pierre Robin, Henry Halls
University of Toronto

Travel to Toronto

- Visit the GSA Toronto Web site for links to travel information: www/geosociety.org/meetings/98, then e-mail us if you have any questions: meetings@geosociety.org.

Federal and State Employees

- For the purposes of the GSA meeting, the Toronto destination will be considered nonforeign travel by the U.S. Geological Survey. Just be sure that your name is on the list to go to Toronto. Other federal agencies may also have the same policy. State governments, however, may consider Canada as foreign travel, so please be sure that the GSA Annual Meeting is on the list for "approved" travel.

U.S. Visa Holders

- Get in touch with your consulate NOW. Citizens or permanent residents of other countries must have a valid passport and/or a valid visitors visa and should contact their local Canadian Embassy, Consulate, or High Commission Office for further qualification.

Travel and Immigration Information

- For native-born Americans and/or U.S. citizens, it's really easy! Canadian Immigration only requires either (1) a passport **OR** (2) a birth certificate, supported by photo I.D.
- A permanent resident who is not a citizen is required to possess a 1551 or 1151 form ("Green Card") by both U.S. and Canadian Immigration. This is also easy!

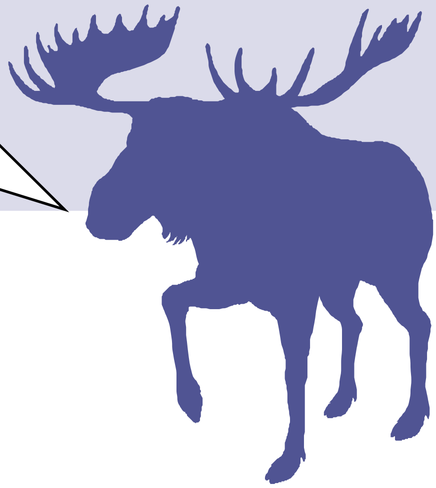
Geological Association of Canada and Mineralogical Association of Canada members welcome to register at the GSA members rate!

TRAVEL GRANTS FOR STUDENT MEMBERS OF GSA

The GSA Foundation has awarded matching grants to the six GSA sections. The money, when combined with equal funds from the sections, is used to assist student members of GSA traveling to GSA meetings. The following sections offer assistance to the Annual Meeting in Toronto. The remaining two sections, Cordilleran and Rocky Mountain, offer assistance to their section meetings. For information and deadlines, contact your section secretary.

- **North-Central:** Robert F. Diffendal, Jr. (402) 472-7546, rfd@unlinfo.unl.edu
- **Northeastern:** Kenneth N. Weaver (410) 554-5532, kweaver438@aol.com
- **South-Central:** Rena M. Bonem (254) 710-2361, Rena_Bonem@baylor.edu
- **Southeastern:** Harold H. Stowell (205) 348-5098, hstowell@wgs.geo.ua.edu

Announcing … Late-Breaking Research Sessions



GSA Annual Meeting
October 26–29, 1998, Toronto, Ontario
Metro Toronto Convention Centre

Exciting new data or breakthroughs over the summer?

Present your work at the GSA Annual Meeting this fall!

Special instructions for submitting an abstract for the Late-Breaking Research Sessions:

- An abstract on late-breaking research may be submitted electronically after September 1 until midnight, September 30, 1998.
- Abstracts may not be submitted on paper or by e-mail; they must be submitted using the Web form: http://www.geosociety.org/meetings/98
- Space will be limited and selection will be based on scientific merit.
- The author must provide a brief explanation of why the abstract deserves consideration after the usual deadline for this meeting.
- The presentation will be **poster mode only**, and will be put with the appropriate discipline poster session. These posters will be advertised as "Late-Breaking Research," with booth number, at session entrances.
- Because of scheduling limitations, the policy is that only one volunteered paper may be presented in either oral or poster mode for the overall meeting. If you already had a volunteered abstract accepted, please do not submit another—even if the second one is "news."

Abstract Fee: For this meeting, a nonrefundable abstract fee of $50 must accompany each Late-Breaking Research abstract submitted. Our Web-template form will ask for credit-card information. We have installed one of the best-known and most respected *secure server* systems for transmission of your credit-card data to fully protect your confidential information.

Schedule: Abstracts will be reviewed by the Technical Program Chairs for 1998 and 1999. Electronic acceptance notices will be sent out the first week in October with the place and time of presentation. The date and time will depend on where your paper best fits scientifically. We will try to provide a time for your paper together with others of similar relevance.

Publication: These abstracts will be published on the Web along with the other annual meeting abstracts, and paper copies will be made available on site in Toronto. They will not be published in the *Abstracts with Programs* volume.

Call for Papers: April and June *GSA Today*

Registration and Housing information: June *GSA Today*

Technical Program Schedule: September *GSA Today* and the Web

Preregistration Deadline: September 18

1999 Denver, Colorado

October 25–28
Colorado Convention Center

General Co-Chairs

Mary J. Kraus, David Budd, *University of Colorado*

Technical Program Chairs

Craig Jones, G. Lang Farmer, *University of Colorado*

Due date for symposia and theme proposals: *January 6, 1999*

Call for Field Trip Proposals

We are interested in proposals for single-day and multi-day field trips beginning or ending in Denver, and dealing with all aspects of the geosciences. Please contact the Field Trip Co-Chairs:

Alan Lester
Department of Geological Sciences
University of Colorado
Campus Box 399
Boulder, CO 80309-0399
(303) 492-6172
fax 303-492-2606
alan.lester@colorado.edu

Bruce Trudgill
Department of Geological Sciences
University of Colorado
Campus Box 399
Boulder, CO 80309-0399
(303) 492-2126
fax 303-492-2606
bruce@lolita.colorado.edu

FUTURE MEETINGS

2000 Reno, Nevada
November 13–16

2001 Boston, Massachusetts
November 5–8

2002 Denver, Colorado
October 28–31

2003 Seattle, Washington
November 2–5

For information on any GSA Meeting call the GSA Meetings Department.

1-800-472-1988 or (303) 447-2020, ext. 113
meetings@geosociety.org

Or see GSA's Web page at http://www.geosociety.org

CLASSIFIED ADVERTISING

Published on the 1st of the month of issue. Ads (or cancellations) must reach the GSA Advertising office one month prior. Contact Advertising Department (303) 447-2020, 1-800-472-1988, fax 303-447-1133, or E-mail:acrawfor@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.

To answer coded ads, use this address: Code # ----, GSA Advertising Dept., P.O. Box 9140, Boulder, CO 80301-9140. All coded mail will be forwarded within 24 hours of arrival at GSA Today office.

Positions Open

HYDROGEOSCIENCE, VIRGINIA TECH

The Department of Geological Sciences at Virginia Polytechnic Institute and State University (Virginia Tech) extends its search for an Assistant Professor (tenure-track) in Hydrosciences.

The successful candidate must have expertise in data collection and quantitative analysis of field observations. Areas of interest include: Environmental geochemistry of natural aquifer systems in sedimentary and fractured crystalline terranes, multiphase fluid flow in aquifer systems using deterministic and stochastic techniques, deterministic/stochastic modeling of fluid-flow systems in petroleum reservoirs.

A Ph.D. is required at the time of appointment. Application closing date is September 1, 1998. Interested applicants should send a letter of interest, curriculum vitae, transcripts, names of three references, a statement of anticipated research and teaching interests, along with a short essay explaining where the applicant would like to see him/herself within the geosciences in the 21st century. Applicants should send their application package to Cahit Coruh, Chairman, Department of Geological Sciences, Virginia Tech, 4044 Derring Hall, Blacksburg, VA 24061-0420; Phone: (540) 231-6894; fax: 540-231-3386; E-mail: coruh@vt.edu. For detailed information about the Department, applicants are encouraged to visit the Department's Home Page at http://www.geol.vt.edu/.

Virginia Tech is an equal opportunity/affirmative action employer.

HARVARD UNIVERSITY
DEPARTMENT OF EARTH & PLANETARY SCIENCES
JUNIOR FACULTY POSITION

The Department of Earth and Planetary Sciences at Harvard University seeks to fill a tenure track position at the assistant or untenured associate professor level. We are interested in candidates who investigate the processes and evolution of the Earth and planets through studies of the physical and chemical properties of rocks, minerals, and melts. The selected candidate will be expected to develop a strong research program and to teach at the undergraduate and graduate levels. Applicants should send a statement of research and teaching interests, curriculum vitae and the names of three referees to Prof. Roberta Rudnick, Chair, Petrology Search Committee, Department of Earth and Planetary Sciences, Harvard University, 20 Oxford Street, Cambridge, MA 02138. Applications should be received by September 15, 1998. We particularly encourage applications from women and minorities. For more information about the department you may visit our web site at: www.eps.harvard.edu.

UCLA
NEOTECTONICS FACULTY POSITION

The Department of Earth and Space Sciences, University of California, Los Angeles, invites applications for a ladder faculty position at the assistant or associate professor level in the general areas of neotectonics, paleoseismology, quantitative geomorphology, and surficial processes. We are particularly interested in candidates who can integrate field observations with one of the following disciplines: (1) quantitative modeling of landform evolution due to interaction of neotectonics and surficial processes, (2) monitoring surface deformation and evolution using space geodetic techniques (e.g., radar interferometry, SPOT imagery, GPS), (3) modeling crustal and mantle dynamics using patterns and histories of Quaternary land surface deformation, (4) earthquake hazard assessments, and (5) Quaternary chronology of land surfaces and dating offset geologic features along active faults. The Department has active programs in monitoring and forecasting of southern Californian earthquakes, the tectonics of Asia and North American Cordillera, mantle dynamics, and planetary sciences. Interested applicants should send a resume, a list of three references, and other relevant documentation to: Neotectonics Search Committee, Department of Earth and Space Sciences, P.O. Box 1567, University of California, Los Angeles, CA 90095-1567.

Deadline for applications is September 1, 1998. The University of California is an equal opportunity employer.

CRUSTAL SEISMOLOGIST

The Department of Geosciences within the Penn State University's College of Earth and Mineral Sciences (EMS) invites applications for a tenure-track faculty position in the area of Crustal Seismology. Of particular interest are individuals involved in the acquisition, analysis, and innovative use of seismic data (active or passive source) for solving problems in structure, evolution, and active tectonic processes of the crust, earthquake source dynamics, and/or natural hazards.

This position is part of a focused initiative in the area of Geodynamics that includes the potential in the future for up to three additional faculty hires in rheology, crustal geodynamics, and observational crustal deformation. The successful candidate will join a geodynamics group with research activities in seismilogy, lithospheric geodynamics, surface processes, active tectonics, and structural geology. Opportunities exist to participate in our Applied Geosciences program and/or the college-wide Center for Natural Hazards Research in the EMS Environment Institute. Applicants should demonstrate the potential for developing a funded research program and high-quality teaching. A Ph.D. is required at the time of appointment. We expect to fill this position at the Assistant Professor level, but appointment at an Associate Professor level is possible in exceptional cases. The search process begins immediately and will continue until suitable candidates are identified.

Applications should include a complete resume, examples of published work, a statement outlining teaching and research interests, and the names and addresses of at least four (4) individuals who could provide references. Send application materials to: Geosciences Search Chairman, The Pennsylvania State University, Department of Geosciences, 503G Deike Building, University Park, PA 16802. AA/EOE.

STRUCTURAL GEOLOGY – PETROLEUM GEOLOGY
WEST VIRGINIA UNIVERSITY

The Department of Geology & Geography invites applications for a tenure-track faculty position in structural geology. The appointment will be at the level of beginning assistant professor, effective January or August 1999, and the Ph.D. degree is required at the time of appointment.
We are seeking an individual who is adept in both quantitative and field approaches to geological research and teaching. This individual will be expected to collaborate with others in the department and to establish linkages with the petroleum industry. The successful candidate will have demonstrated research capabilities in structural geology and petroleum geology, and he or she should be able to effectively teach undergraduate courses in these two fields and supervise M.S. and Ph.D. students. The candidate should be able to teach a large section of introductory geology and to participate in the team-teaching of our capstone field camp. In addition, the successful candidate must attract external research funding. Additional information is available on-line at http://www.geo.wvu.edu.

Interested candidates should submit a curriculum vitae including a list of publications, grants, a statement of teaching and research interests, transcripts from graduate schools, and contact information for five references to: Dr. Richard Smosna, Chair of Search Committee, Department of Geology & Geography, Box 6300, West Virginia University, Morgantown, WV 26506. Review of applications will begin on September 1, and will continue until the position is filled. West Virginia University is an equal opportunity/affirmative action employer.

THE UNIVERSITY OF NEW BRUNSWICK
ECONOMIC GEOLOGIST

Applications are invited for the CHAIR IN ECONOMIC GEOLOGY to be appointed at the Assistant Professor level. The position is at this time supported for a 4 year term. As a priority position within the Department and Faculty of Science, it is intended to establish the Chair as a tenure-track position at the earliest possible date. Responsibilities will include undergraduate and graduate teaching covering resource exploration, evaluation, and development. The Department of Geology supports Geology, Environmental Geochemistry, and Geological Engineering programs, to which all faculty contribute. The Department is particularly seeking a candidate who can integrate into and complement existing research interests. Candidates must have a Ph.D. at the time of appointment, with a strong background in some aspect of mineral deposits geology (e.g. mineral exploration science, stable isotopes, ore genesis). The successful candidate is expected to develop a research focus on mineral deposits and other economic/resource geology topics through an externally funded research program.

The Department of Geology is involved in rejuvenation of its faculty and anticipates significant opportunities for the successful candidate. Research facilities include microprobe, analytical SEM & TEM, XRD, high-temperature geochemistry lab, AA/graphite furnace/ICP and GIS lab.

Given suitable candidates, the position is available as of July 1, 1998. It is intended to fill the position by January 1, 1999.

In accordance with Canadian immigration requirements, this advertisement is directed to Canadian citizens and permanent residents. Applicants are asked to provide a curriculum vitae, a statement of teaching and research plans, and arrange for three letters of recommendation to be sent directly to: Dr. Joseph C. White, Chair, Department of Geology, University of New Brunswick, 2 Balley Drive, Fredericton, NB E3B 5A3 CANADA.

The University of New Brunswick is committed to the principle of Employment Equity.

THE OHIO STATE UNIVERSITY
DIRECTOR, BYRD POLAR RESEARCH CENTER

The Byrd Polar Research Center (BPRC) enjoys an international reputation as a premier polar and alpine research center with an expanding focus on global enviromental issues. Its mission is to conduct multi-disciplinary research, offer enhanced educational opportunities, and provide outreach activities that build and strengthen OSU's programs in Polar Processes and Earth System Science. This mission is carried out by providing research facilities and expertise complementary to those in OSU's academic departments and by offering a unique interdisciplinary perspective for study of the Earth system and interactions among its components. The BPRC has approximately 40 active scientists conducting research in six major areas: Geology, Glacier Dynamics, Ice Core Paleoclimatology, Polar Meteorology, Remote Sensing, and Environmental Chemistry. In addition, the BPRC has an active Archival Program that preserves important collections such as the papers of Admiral Richard E. Byrd, Sir Hubert Wilkins, and Dr. Frederick Cook. More information about each of these research programs and other Center activities is on the BPRC's Website (http://www-bprc.mps.ohio-state.edu). During the next 5–10 years, BPRC's goal is to continue the pursuit of excellence in existing research programs and increase its national and international recognition in the areas of understanding climate variability, detecting and interpreting changes in modern physical and biological systems, and predicting future environmental changes and their consequences for society. To realize these goals, we envision a growth of the Byrd Center and a broadening of its research focus to provide a more global perspective.

The Director will provide leadership to the Center and will be responsible for its day-to-day operation. A faculty appointment will be made at the appropriate level within one of the affiliated Departments (e.g., Civil and Environmental Engineering and Geodetic Science, Geological Sciences, Geography, Chemistry). The Director will provide leadership in strengthening existing research programs, developing research in new areas, encouraging collaborative activities within the Center and the

University, and fostering relations with current funding agencies (NSF, NASA, NOAA, etc.) as well as actively exploring other funding opportunities. The Director is expected to develop outreach activities within the University, as well as within the local community. The successful candidate should have an established national and international stature in Earth System Science research as evidenced by an outstanding record of recent publications and competitive research funding, and she/he is expected to maintain a vigorous research program. To apply, send a curriculum vitae, a statement of research interest, a description of relevant management experience, and the names of three references to Chair, Search Committee for BPRC Director, Office of Research, The Ohio State University, 208 Bricker Hall, 190 N. Oval Mall, Columbus, OH 43210. The Search Committee will begin reviewing applications immediately and continue until a suitable candidate is found.

The Ohio State University is an equal opportunity/affirmative action employer. Women, minorities, Vietnam-era veterans, disabled veterans, and individuals with disabilities are encouraged to apply.

INFORMATION SERVICES DIRECTOR CENTER FOR EARTHQUAKE RESEARCH AND INFORMATION (CERI) AT THE U. OF MEMPHIS

We seek a creative and enthusiastic person with excellent qualifications to coordinate and implement our public education and outreach programs. The ISD will coordinate activities with other agencies (e.g., The Mid-America Earthquake Center, USGS, IRIS, SCEC). Duties include: developing and presenting public programs about earthquakes; designing and producing brochures and pamphlets; directing the Internet presentation of education and outreach materials about seismic hazards in the central U.S. The ISD is the principal contact for public inquiries to CERI and coordinates information flow to media and response/emergency management officials during earthquake emergencies. Other duties include: writing grant proposals to fund education and outreach activities, and conducting and attending workshops with CERI's customers. The ISD will supervise CERI outreach and education personnel. Applicants should hold a Master's Degree in one of two tracks: 1) Science Education, Communication, Marketing, etc., or 2) Earth Sciences or Engineering. Position requires three years experience dedicated to scientific education, outreach and/or disaster planning, or an equivalent combination of education and experience. Compensation is commensurate with experience and qualifications, and includes an excellent benefits package. The application deadline is July 15, 1998, or until filled. Request application information from the Department of Human Resources, 108 Jones Hall, Phone: (901) 678-2601.

The University of Memphis, Memphis, TN 38152. Equal Opportunity/Affirmative Action Employer.

POSITION OF STATE PALEONTOLOGIST OF UTAH UTAH GEOLOGICAL SURVEY

The Utah Geological Survey (UGS) invites applications for the position of State Paleontologist of Utah (Senior Geologist). This position begins approximately November 1, 1998. Duties of the position include: (1) conduct field surveys, excavations, laboratory research, and curation, and publish results in house and in outside publications; (2) pursue funding and prepare proposals for priority paleontology projects; (3) advise the Director of the UGS on paleontological issues of local, state, and national significance; (4) issue permits for paleontological excavations; and (5) promote the paleontology of Utah through collaboration with other paleontologists, cooperation with Utah museums, support and guidance of amateur organizations, and supervision of volunteers. Preference will be given to individuals with an advanced degree in geology (paleontology specialty) or other earth science degree and experience in excavation and laboratory preparation of vertebrate fossil specimens. The UGS has just completed a new specimen preparation laboratory. Minimum starting salary $34,278 with an excellent benefit package. Submit a resume and Utah Skill Match cover sheet (which can be found at www.ugs.state.ut.us; or obtained from Cheryl Ostlund at (801) 537-3300) to Department of Human Resource Management, 2120 State Office Building, Salt Lake City, UT 84114. On the top right hand corner of the Utah Skill Match cover sheet please enter 8NR9UG in the blank for the source code. In addition, applicants may contact the Department of Natural Resources Human Resource office at (801) 538-7210 to ensure consideration for this position. The State of Utah is an equal opportunity employer.

CALENDAR

Only new or changed information is published in *GSA Today*. A complete listing can be found in the **Calendar** section on the Internet: **http://www.geosociety.org.**

1998 Penrose Conferences

July

July 4–11, **Processes of Crustal Differentiation: Crust-Mantle Interactions, Melting, and Granite Migration Through the Crust,** Verbania, Italy. Information: Tracy Rushmer, Dept. of Geology, University of Vermont, Burlington, VT 05405, (802) 656-8136, fax 802-656-0045, trushmer@zoo.uvm.edu.

September

September 13–17, **Ophiolites and Oceanic Crust: New Insights from Field Studies and Ocean Drilling Program,** Marshall, California. Information: Yildirim Dilek, Dept. of Geology, Miami University, Oxford, OH 45056, (513) 529-2212, fax 513-529-1542, dileky@muohio.edu.

1999 Penrose Conferences

January

January 18–24, **Strike-slip to Subduction Transitions on Plate Boundaries: Tectonic Setting, Plate Kinematics, and Seismic Hazards**, Puerto Plata, Dominican Republic. Information: Paul Mann, Institute of Geophysics, University of Texas, Bldg 600, 4412 Spicewood Springs Road, Austin, TX 78759-8500, (512) 471-0452, fax 512-471-8844, paulm@utig.ig.utexas.edu.

March

March 25–31, **Mid-Cretaceous to Recent Plate Boundary Processes in the Southwest Pacific**, Arthur's Pass, South Island of New Zealand. Information: Suzanne L. Baldwin, Department of Geosciences, University of Arizona, Tucson, AZ 85721, (520) 621-9688, fax 520-621-2672, baldwin@geo.arizona.edu.

June

June 18–24, **Terrane Accretion along the Western Cordilleran Margin: Constraints on Timing and Displacement**, Winthrop, Washington. Information: J. Brian Mahoney, Department of Geology, University of Wisconsin, Eau Claire, WI 54702-4004, (715) 836-4952, fax 715-836-2380, mahonej@uwec.edu.

August

August 17–22, **The Marine Eocene-Oligocene Transition**, Olympia, Washington. Information: Donald R. Prothero, Department of Geology, Occidental College, 1600 Campus Road, Los Angeles, CA 90041, (213) 259-2557, fax 213-259-2704, prothero@oxy.edu.

1998 Meetings

July

July 23–25, **44th Annual Rocky Mountain Mineral Law Institute**, Snowmass Village at Aspen, Colorado. Information: Mark Holland, Rocky Mountain Mineral Law Foundation, 7039 East 18th Ave., Denver, CO 80220, (303) 321-8100, fax 303-321-7657, info@rmmlf.org, http://www.rmmlf.org.

September

September 3–6, 1998, **Earth Stress and Industry—The World Stress Map and Beyond (Euroconference),** Heidelberg, Germany. Information: WSM Euroconference Office, Geophysical Institute, University of Karlsruhe, Hertzstraße 16, 76187 Karlsruhe, Germany, fax: 49 721 71173, wsm@gpiwap1.physik.uni-karlsruhe.de.

September 9–14, **Association of Earth Science Editors–European Association of Science Editors–Council of Biology Editors–GeoInfo VI,** Washington, D.C. Information: Barbara Haner, Science & Engineering Library, 4697 Geology Bldg., University of California, Los Angeles, CA 90095, (310) 825-1055, bhaner@library.ucla.edu, or http://earth.agu.org/editorinfo98.

September 15–18, **Western States Seismic Policy Council, 20th Annual Conference**, Pasadena, California. Information: Western States Seismic Policy Council, 121 Second Street, 4th Floor, San Francisco, CA 94105, (415) 974-6435, fax 415-974-1747, wsspc@wsspc.org.

September 20–23, **Ground Water Protection Council Annual Forum**, Sacramento, California. Information: Ground Water Protection Council, 827 NW 63rd, Ste. 103, Oklahoma City, OK 73116, (405) 848-0690, fax 405-848-0722, ben@gwpc.site.net, http://gwpc.site.net/meetings.htm.

November

November 8–9, **Geology, Mineralogy and Human Welfare** National Academy of Sciences Colloquium, Irvine, California. Information and registration: Edward Patte, National Academy of Sciences, NAS-146, 2101 Constitution Ave., NW, Washington DC 20418, (202) 334-2445, fax 202-334-2153, epatte@nas.edu, http://www2.nas.edu/abstract/20fa.html.

November 11–13, **20th New Zealand Geothermal Workshop**, University of Auckland, New Zealand. Information: Geothermal Institute, University of Auckland, Private Bag 92019, Auckland, New Zealand, fax 64-9-373-7436, geo.wshop@auckland.ac.nz.

1999 Meetings

January

January 24–27, **Conference on Tailings and Mine Waste,** Fort Collins, Colorado. Information: Linda Hinshaw, Dept. of Civil Engineering, Colorado State University, Fort Collins, CO 80523-1372, (970) 491-6081, fax 970-491-3584 or 7727, lhinshaw@engr.colostate.edu. *(Abstracts deadline: June 12, 1998.)*

March

March 1–3, **13th International Conference and Workshops on Applied Remote Sensing,** Vancouver, British Columbia. Information: ERIM Geologic Conferences, Box 134008, Ann Arbor, MI 48114-4008, (734) 994-1200, ext. 3234, fax 734-994-5123, wallman@erim-int.com, http://www.erim-int.com/CONF/conf.html. *(Abstracts deadline: July 13, 1998.)*

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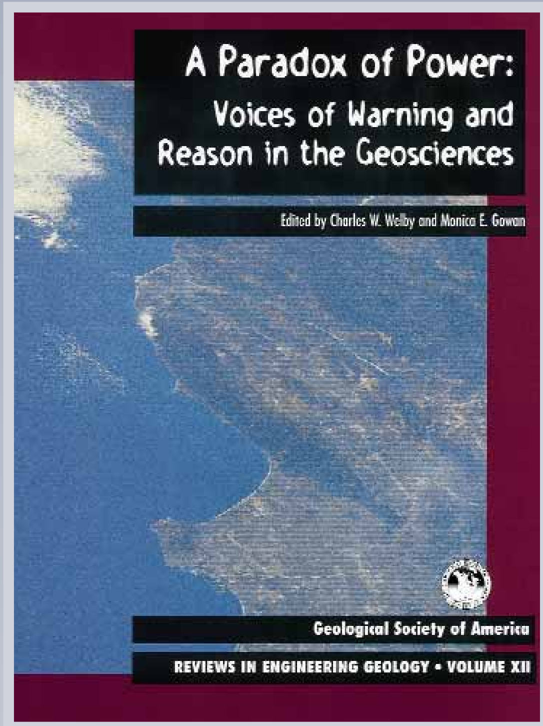
1998 ANNUAL MEETING AND EXPOSITION — **October 26–29, 1998**



EDITED BY
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