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Global Seismic Tomography: A Snapshot of Convection in the Earth

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ABSTRACT

Two new global high-resolution models of the P-wave and S-wave seismic structure of the mantle were derived independently using different inversion techniques and different data sets, but they show excellent correlation for many large-scale as well as smaller scale structures throughout the lower mantle. The two models show that high-velocity anomalies in the lower mantle are dominated by long linear features that can be associated with the sites of ancient subduction. The images suggest that most subduction-related mantle flow continues well into the lower mantle and that slabs may ultimately reach the core-mantle boundary. The models are available from anonymous ftp at maestro.geo.utexas.edu in directory pub/grand and at brolga.mit.edu in directory pub/GSAtoday.

INTRODUCTION

Since forming about 4.5 Ga, planet Earth has been cooling by means of relatively vigorous convection in its interior and by conductive heat loss across the cold thermal boundary layer at the top of the mantle (mainly the oceanic lithosphere). The primary force driving convection is the downward pull of gravity on the cold, dense lithosphere resulting in downwellings of slabs of subducted lithosphere. Understanding the nature of the

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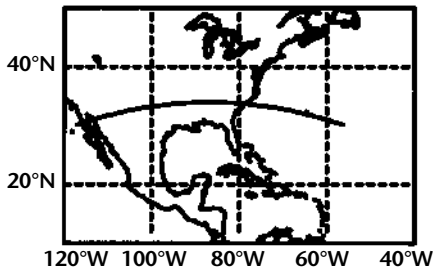

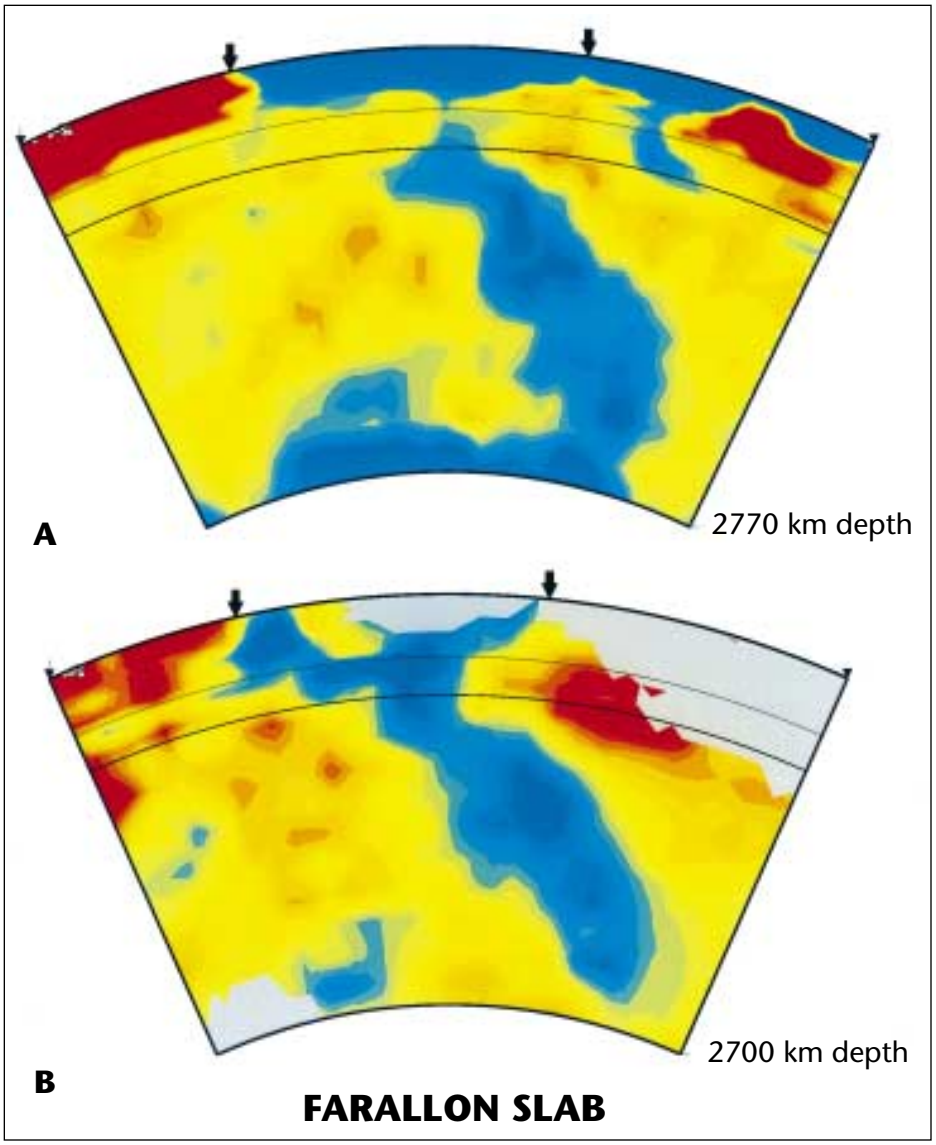

Figure 1. Cross sections of mantle P-wave (A) and S-wave (B) velocity variations along a section through the southern United States. The endpoints of the section are 30.1°N, 117.1°W and 30.2°N, 56.4°W. The images show variations in seismic velocity relative to the global mean at depths from the surface to the core-mantle boundary. Blues indicate faster than average and reds slower than average seismic velocity. The large tabular blue anomaly that crosses the entire lower mantle is probably the descending Farallon plate that subducted over the past ~100 m.y. Differences in structure between the two models in the transition zone (400 to 660 km depth) and at the base of the mantle are probably due to different data sampling in the two studies.

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convective flow is important for deciphering Earth's thermal history, its internal composition, and the differentiation processes that produced the Earth we know today. It is the fundamental process that moves plates and makes mountains. Conversely, the geometry of plates exerts control on the geometry of subduction and therefore Earth convection. A long-standing goal of geophysics has been to determine the convection pattern within Earth's mantle. Despite years of study, several first-order aspects of the mantle flow regime remain controversial (see Silver et al. [1988], Davies and Richards [1992], and Lay [1994] for extensive reviews). In part, this is due to published global maps of seismic aspherical structure of Earth's mantle not having sufficient resolution to track flow trajectories from the surface to the deep mantle.

In the upper mantle (~40 to 660 km depth), downwellings can partially be inferred directly from the shape of the subduction-related seismic zones, but such unambiguous tracers cannot be used at greater depth. Many studies have focused on the behavior of subducted slabs near the upper to lower mantle boundary where deep earthquake activity ceases and a well-defined seismic discontinuity occurs at a global average depth of about 660 km. Near 660 km depth, mantle flow is complex, as a possible viscosity increase accompanies isochemical phase changes in mantle minerals. The 660 km discontinuity may also mark a chemical change that largely prohibits mass flux between the upper and lower mantle. Detailed seismic studies of deep subduction zones suggest that slabs in some arcs descend well into the lower mantle. In other regions, particularly beneath the northwestern Pacific island arcs, evidence exists that some slabs deflect laterally and spread out within the transition zone (Creager and Jordan, 1986; Fischer et al., 1988; Zhou and Clayton, 1990; van der Hilst et al., 1991; Fukao et al., 1992; Ding and Grand, 1994; van der Hilst, 1995) (Fig. 1). Numerical simulations of flow near the 660 km depth boundary that incorporate phase changes (Machetel and Weber, 1991; Tackley et al., 1993; Tackley, 1995; Honda et al., 1993), viscosity stratification (Hager, 1984; Gurnis and Hager, 1988), and possible compositional changes (Christensen, 1988) predict a wide range of flow behav-

Tomography *continued on p. 3*

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ior depending on poorly constrained state parameters.

Another basic issue is the nature of the large-scale flow field in the lower mantle. Local high-resolution seismic studies show that some slab material descends into the lower mantle, but they do not address the ultimate fate of slabs and their effect on the overall convection pattern of the lower mantle.

Global seismic images of the mantle can provide information about the nature of flow in the mantle as they, in principle, provide a snapshot of the entire convection system. A variety of approaches have been employed to map variations in both compressional (P) and shear (S) wave propagation speeds in the mantle. Maps of P-wave velocity have generally been produced using the travel times of P-waves reported by the International Seismological Centre (ISC; see Dziewonski, 1984; Inoue et al., 1990; and Pulliam et al., 1993). By using a wide range of observations, including the periods of the free oscillations of Earth, the phase velocity of surface waves and the travel times of mantle shear body waves, maps of S-wave speed have been found. Recently, Masters et al. (1996), Su et al. (1994), and Li and Romanowicz (1996) have inverted a combination of data types to determine global variations in mantle shear velocity. The model parameterization varies from study to study, because some models use spherical harmonic representations of lateral variations in velocity, whereas others use a block representation. The wavelength of the heterogeneity that can potentially be resolved is limited by block size or the highest order harmonic.

The results of these and other studies have several well-accepted long-wavelength features, including high-velocity "roots" beneath old continents to several hundred kilometers depth and faster than average structure at the base of the mantle associated with the circum-Pacific ring of fire. However, results are still quite variable for the shorter wavelength structure of mantle heterogeneity, particularly at mid-mantle depths. For example, Richards and Engebretson (1992) found that higher than average seismic velocities within the lower mantle occur in regions with long subduction histories, and they concluded that most slabs sink to the bottom of the mantle. In contrast, Wen and Anderson (1995) claimed a high degree of correlation between seismic structure at the top of the lower mantle and subduction history, and concluded that slabs generally remain in the upper mantle. Clearly, such models do not put sufficient constraints on flow fields, because fundamentally different conclusions were reached from similar, very long wavelength images of the mantle. The nature of lower mantle upwellings is even less well understood. Many believe hotspots are plumes ascending from the core-mantle boundary to the surface (Richards et al., 1989), but no seismic model has imaged such a continuous structure.

TWO NEW HIGH-RESOLUTION MANTLE STRUCTURE MODELS

Higher resolution tomographic images of the mantle have not been well accepted, as independent studies show inconsistent results. Here, we present a direct comparison of two new high-resolution models derived by independent groups that for the first time show remarkable agreement, even for short-wavelength structures. A spectacular result of both studies is the detection of long, but relatively narrow linear features in the mid-mantle beneath the Americas (Fig. 1) and southern Asia that can be related to subduction history.

Both models were derived using body-wave data, but the type, selection, and subsequent processing of the data differ fundamentally. The first model used the traveltimes reported to ISC to map the three-dimensional variation in P-wave

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velocity; it is discussed in detail by van der Hilst et al. (1997). The second model used a limited set of multiple-bounce shear waves to map shear-velocity variations in the mantle, following the technique presented by Grand (1994). Both models use blocks with dimensions of a few hundred kilometers to parameterize the models.

The differences in data sampling between the P and S studies are large. An advantage of the S study is the use of multiple bounce seismic phases to study the shallow mantle beneath regions devoid of earthquakes or seismic stations where structures cannot be constrained by direct P- or S-wave data. A disadvantage is that S-wave data are fewer, leading to generally worse resolution than for the P-wave study. The P-wave study has excellent data coverage in subduction zones, owing to the large number of earthquakes in these regions. The very different data coverage in the two studies is an advantage for comparing the models, because common structural features are unlikely to be due to systematic errors common to both studies. In regions where both models have adequate coverage, there is amazing agreement for many short-wavelength (<500 km) structures. Resolution tests of the type presented in other papers (e.g., Grand, 1994; van der Hilst et al., 1997) are not included here, but the correlation between independently derived models is a more rigorous test of the reliability of the images in any case.

The seismic models are displayed side by side at common depths in Figure 2. The discussion below focuses on common features in the deeper mantle where coverage is the most complete.

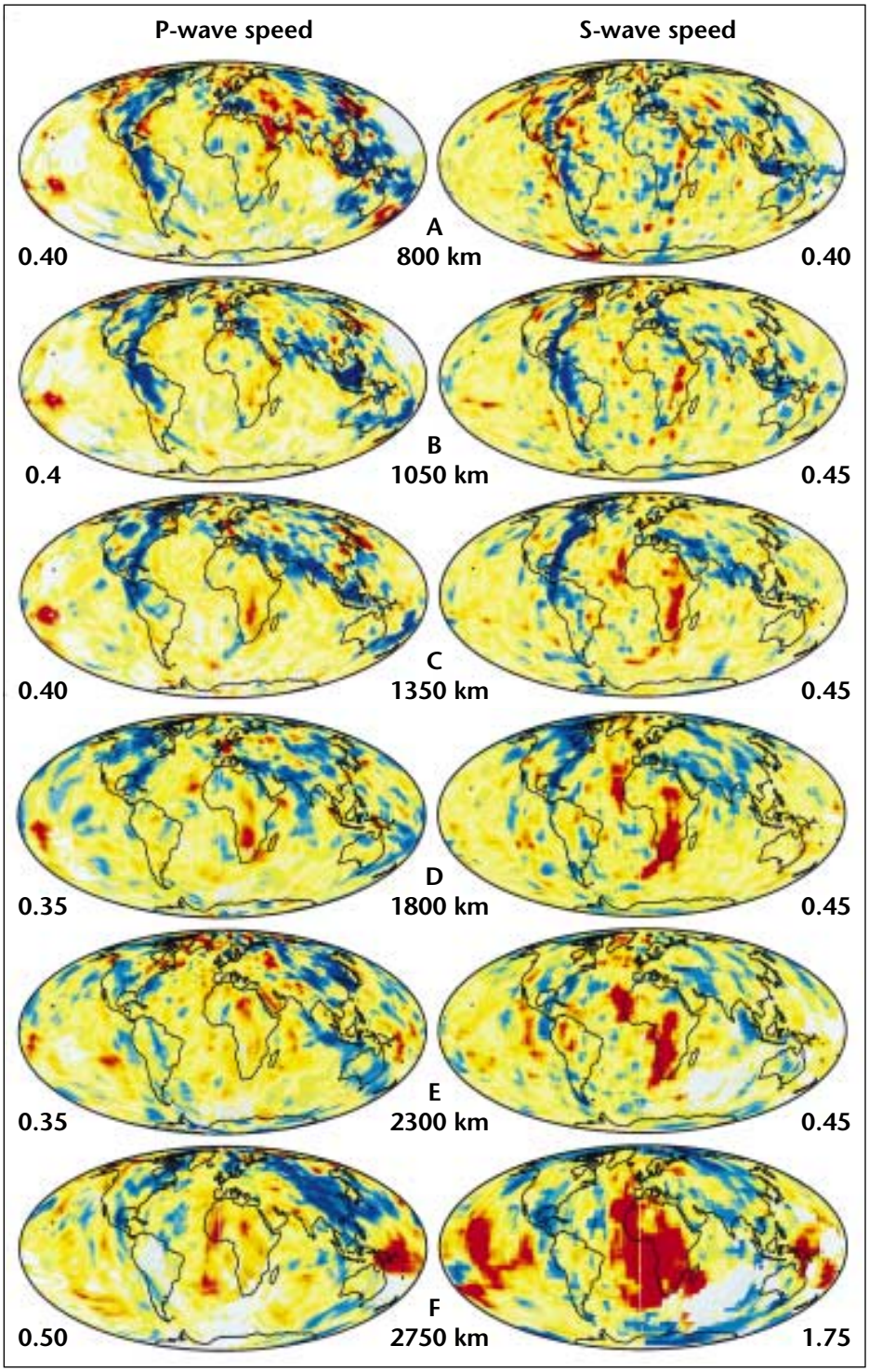

Figure 2. Comparison of P- and S-wave models, showing variations in seismic velocity at given depths through the lower mantle. Numbers at the sides of the images are the maximum anomaly in terms of percentage difference from mean velocity. Blue indicates faster than average, and red indicates slower than average. The white regions have no significant data sampling.

FIRST-ORDER ASPHERICAL P- AND S-WAVE STRUCTURE OF THE MANTLE

Both models show striking high-wave-speed structures in the mid-mantle beneath the Americas and southern Eurasia. The anomalies continue intermittently over distances in excess of 10,000 km with apparent widths of only several hundred kilometers. The two models agree in detail for the anomaly beneath the Americas. At shallow depths (Fig. 2A) the fast anomaly stretches from 30°S to about 50°N beneath the central part of North America. At mid-mantle depths (Fig. 2, B and C), the anomaly extends northward beneath the west coast of Hudson Bay to northern Alaska. In the south, both models show the high-velocity zone ending near 1300 km depth. Finally, in the deeper mantle (Fig. 2, D and E), the single linear structure becomes more diffuse or, perhaps, breaks into two structures. Beneath the western Atlantic, high velocities are continuous with shallower structure. Beneath the western part of North America and off the west coast of South America, a second zone of high velocity can be detected.

The high-velocity zone beneath southern Eurasia also shows complexities in both models. At shallow depths in the lower mantle (Fig. 2A), high velocities are mapped beneath Indonesia and Europe in accord with high-resolution studies (Spakman et al., 1993; Widiyantoro and van der Hilst, 1996). Below 800 km, the band of high velocities becomes progressively more continuous with depth (Fig. 2B). Between 1200 and 1800 km (Fig. 2, C and D) the high-velocity structure is nearly continuous from Indonesia to Europe, although the signature beneath

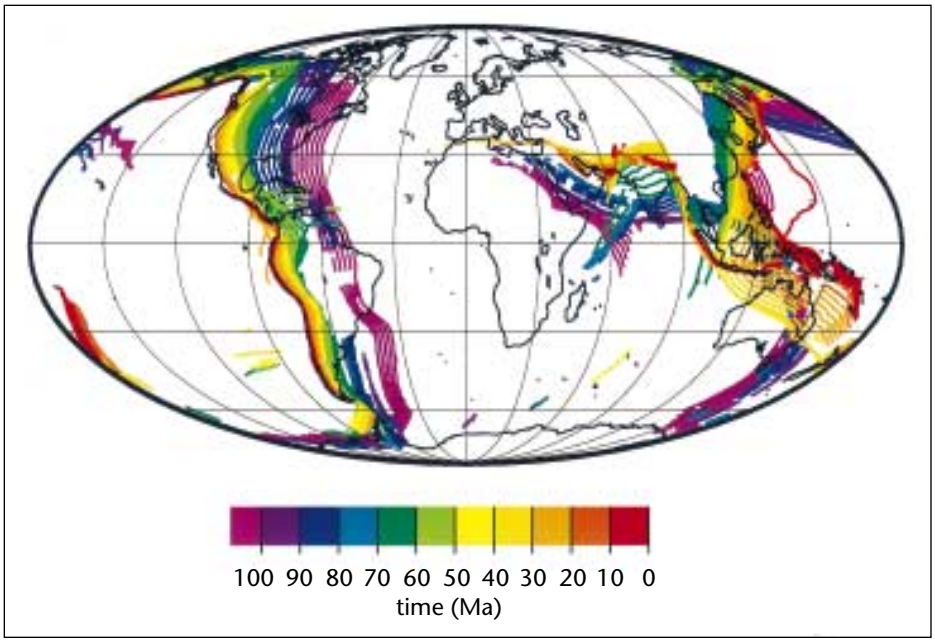

Figure 3. Map showing the location of subduction zones in a hotspot reference frame during the past 110 m.y. The subduction history model was taken from Lithgow-Bertelloni and Richards (1997). Reds show the present locations of convergence; blues show the approximate location of convergence in the past with respect to the present-day location of continents. Note the hiatus in convergence beneath South America from 50 to 100 Ma and the relative youth of many of the subduction zones in the western Pacific.

Indonesia tends to vanish below 1500 km. In the deep mantle, both studies show higher velocities to the south of the shallower structure. The S model shows the anomalous structure continuing farther west than the P model.

Other structures common to the two models include a high-velocity zone in Asia along the 90° meridian in the deep mantle, a patchwork of high-velocity anomalies in eastern Asia, and low-velocity anomalies beneath southern and eastern Africa and parts of the southern Pacific.

The worst disagreement between the two models occurs in regions of poor resolution for one model or the other. These regions are primarily in the Southern Hemisphere and beneath the Pacific Ocean. The S model has limited resolution beneath the western Pacific and southeastern Asia, so that some pronounced anomalies in the P-wave study do not show the same amplitude in the S-wave study. The deepest mantle is less well sampled in the P-wave study, because no core reflected or transmitted waves are used. The comparison at the bottom of the mantle is the most perplexing. Both models (Fig. 2F) have broader structures than in the mid-mantle and agree on a broad high-velocity zone beneath eastern Asia, a sharp contrast between high velocity beneath the Atlantic west of 30°E and low velocity to the east, and generally low velocities beneath Africa, New Guinea, and parts of the southern Pacific. However, the S model shows high velocity at the base of the mantle beneath Alaska and the Arctic Ocean and beneath Europe and Saudi Arabia, whereas the P model shows low velocities.

The model comparisons are important for two reasons. First, agreement of P- and S-wave velocity anomalies in the mid-mantle is consistent with the structures being thermal in origin. The only caveat is at the bottom of the mantle where some notable disagreements could indicate a chemical origin for some seismic signals in the D" (core-mantle boundary) region (see Wysession et al. [1992] and Loper and Lay [1995] for discussion of chemical variation in D"). Second, the comparison builds confidence in tomographic models. Although the important differences need study and model refinement, the mid-mantle agreement between the current versions of our two independently derived models is better than for previous models (see Masters et al. [1996] for comparison of other models). The observation that this is true even on scales of hundreds of kilometers in certain regions is particularly exciting.

THE FATE OF SLABS

The linear high-velocity features in the mid-mantle can be associated with past subduction sites. At shallow depths (Fig. 2A), there is a clear correlation of high wave speed with present subduction sites, especially for the P model. Many high-velocity zones near 700 km depth can be connected to seismically imaged upper mantle slabs (van der Hilst et al., 1991; Fukao et al., 1992; Spakman et al., 1993; Ding and Grand, 1994; van der Hilst, 1995; Widiyantoro and van der Hilst, 1996). At greater depths, the correlation of high wave speed and present subduction zones is less obvious. However, slabs that have penetrated deep into the lower mantle must have subducted when subduction zones were not all in their present locations. Figure 3 shows past convergence regions as a function of time in a hotspot reference frame. Note that in the past, the Farallon plate was subducting farther east, and convergence of the ancient Tethyan sea was occurring south of Asia. The two large, linear high-velocity anomalies correlate well with this history, as the deeper parts of the anomalies are located near more ancient subduction sites. Agreement is especially good at mid-mantle depths.

The continuity of long, narrow high-velocity zones from the upper mantle to depths in excess of 1500 km in regions of ancient subduction is convincing evidence for large-scale flow of subducted slabs into the deep mantle. Assuming that the mid-mantle fast anomalies are slabs implies that upon reaching about 700 km depth, slabs sink nearly vertically through the lower mantle. Using these results and plate reconstructions, one can estimate slab sinking rates. The significant linear anomaly that extends to about 1300 km depth beneath western South America in both models can be used in this way. Because subduction beneath South America appears to show a hiatus from about 50 to 100 Ma, Grand (1994) argued that the bottom of the anomaly represents the leading edge of the slab subducted 50 Ma. Using an upper mantle subduction rate of 10 cm/yr implies an average lower mantle slab descent rate of 1–1.5 cm/yr. This slow rate implies significant slab deformation in the deeper mantle in accord with the 300–600-km-wide linear features that we interpret as slab. The decrease in slab descent rate implies increased resistance to subduction with depth consistent with an increase in viscosity with depth (see Gurnis and Hager, 1988) or an endothermic phase change near 660 km depth (see Tackley, 1995).

Seismic structure in the deepest mantle (Figs. 2E and F) is unlike that in the mid-mantle. In particular, long linear features are absent, and correlations between high-velocity structures and old subduction sites are less clear. However, there is also less certainty in the location of subduction further in the past. Furthermore, there is a growing consensus that viscosity increases in the deepest mantle (Forte and Mitrovica, 1996; King and Hager, 1994; Peltier and Jiang, 1996; Bunge and Richards, 1996), and this may cause lateral smearing of descending slab.

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Note that the high-velocity mid-mantle structures all lie above broad high-velocity zones near the base of the mantle (especially in the S model). Moreover, some vertical mantle cross sections make a case for a connection between mid-mantle slab structure and heterogeneity just above the core-mantle boundary (Fig. 1). Even though the nature of flow between the mid-mantle and its bottom is not yet completely resolved, it is likely that the very long wavelength fast regions in D" (core-mantle boundary) are the ultimate resting place for subducted lithosphere.

We have shown how two ancient subduction systems, the south Asian and western Americas regions, can be associated with large linear mid-mantle seismic anomalies. The P model also shows high seismic velocity in the deep mantle associated with subduction along the Tonga-Kermadec trench. The S model shows little anomaly, which can be explained by very poor resolution. The long history of convergence along the western Pacific has not resulted in a clear continuous mid-mantle anomaly. Along the east coast of Asia, high velocities exist in the upper part of the lower mantle (<900 km) and in the deepest mantle (>1800 km). In the mid-mantle there is little slab signature. Instead, the data are consistent with a discontinuous patchwork of high-velocity anomalies, only some of which are vertically continuous over a large depth range. Interpretation is difficult owing to the complex tectonic development of the region. Northwestward subduction along the ancient Japan and Kurile trenches predates westward subduction along the Izu-Bonin and Mariana trenches which started at about 45 Ma. Subduction in the latter trenches could have been strongly influenced by rapid oceanward trench migration (van der Hilst and Seno, 1993). Despite the absence of linear features, several studies provide evidence for deep slab penetration into the lower mantle beneath some western Pacific island arc segments (Jordan, 1977; Creager and Jordan, 1986; van der Hilst et al., 1991, 1997). If the seismic models are accurate, the nature of cold downwelling beneath northwestern Pacific arcs is different from that elsewhere. The models are consistent with local intermittent flow into the lower mantle, as seen in numerical simulations by, for instance, Machetel and Weber (1991) and Tackley et al. (1993) and discussed by van der Hilst and Seno (1993).

Our seismic models show high-velocity sheets beneath most subduction zones that correlate with at least the past 100 m.y. of subduction. We interpret this as evidence that most subducted lithosphere descends into the deepest lower mantle and possibly reaches the bottom of the mantle. Alternative explanations, such as that subduction zones are preferentially located over existing lower mantle downwellings or that slabs subducting in the shallower mantle trigger lower mantle downwellings without actual flow into the lower mantle, seem unlikely. If lower mantle downwellings exist irrespective of surface tectonics, regions of relatively recent convergence, such as the Marianas and South America, should have lower mantle anomalies that extend as deep as those in regions of more continuous subduction. This is not the case. Slabs in the upper mantle in these regions are equally unlikely to have had enough time to cool the lower mantle sufficiently to cause the large, deep seismic anomalies observed. Furthermore, if slabs remain stagnant in the top of the lower mantle or the transition zone for a long time, far broader seismic anomalies would be expected in the transition zone than observed (Jordan et al, 1993; Puster and Jordan, 1997). Slab deflection has been observed locally (Zhou and Clayton, 1990; van der Hilst et al., 1991; Fukao et al., 1992) but is unlikely to be a widespread phenomenon in the present Earth. Slab deflection could be important on time scales shorter than the characteristic time for mantle-wide overturn (Christensen, 1996; van der Hilst et al, 1997).

UPWELLINGS

Our new high-resolution global seismic models show a pattern of high-wave-speed anomalies consistent with most lower mantle downwelling being associated with subducting slabs. The nature of mantle upwelling is far less obvious, but a few prominent slow seismic anomalies are apparent in our models in the deep mantle. The major deep-mantle slow anomaly is a structure beneath southern Africa from the base of the mantle to near 1000 km depth. This feature is also seen in the models of Masters et al. (1996), Su et al., (1994), and Li and Romanowicz (1996). Other generally slow anomalies also seen in most global models are beneath the southwestern Pacific, parts of the East Pacific Rise, the eastern Atlantic near Cape Verde, and the Atlantic near Iceland. Unlike the fast anomalies, these structures are more pronounced at great depth and tend to fade above 1000 km depth.

Upward return flow from the lower to upper mantle is thus not obvious in our seismic images. If this is the case, deep slow anomalous mantle may not rise to shallow depths, and return flow may be diffuse and close to adiabatic. However, imaging of upwellings is more difficult than imaging the long slabs forming the downwellings. First, upwellings likely occur in aseismic regions and are not as well sampled by seismic data, in particular in the shallow mantle. Second, use of first arrivals of seismic waves causes a natural bias toward fast anomalies, because annealing of wavefronts creates a tendency to underestimate slow anomaly amplitudes. Finally, upwellings can be overlooked if they are cylindrical, as suggested by Bercovici et al. (1989), and become more focused as they ascend.

DISCUSSION

The two seismic models presented are the most ambitious to date with respect to resolution on a global scale. There are still large gaps in data coverage, but the ability to produce independent models that agree in such detail for large volumes of the mantle marks a milestone in imaging the effects of dynamic processes in the earth. High-velocity anomalies in the mid-mantle are dominated by long, thin structures associated with subduction. The most likely interpretation is that these structures are slabs penetrating to at least 1600 km depth. In some regions there is evidence for downwelling to even greater depth. The generally excellent correlation between P- and S-wave anomalies indicates that they are probably caused by temperature variations. Some significant differences between the P- and S-wave models require further study, although in many cases differences can be attributed to poor resolution in one or both models. The proportionality between P- and S-wave velocity expected from a thermal origin may break down in some parts of the mantle, and, in particular, the disagreement in the D" layer could signal chemical heterogeneity. Better models are within reach, given the large amount of high-quality seismic data becoming available. Such models can reduce uncertainty in plate reconstructions and can help resolve questions such as: What is the nature of upwellings within the deep mantle? Are there truly gaps in subducted slab within the lower mantle, as appears to be the case beneath East Asia? Do slabs continue to the core-mantle boundary, if so, how? What is the cause for the apparent difference in P and S velocity structure in the deepest mantle?

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GSA Today Science Co-Editor Appointed

Molly F. Miller, Vanderbilt University, is a new science co-editor of *GSA Today*. She will work with the continuing science co-editor, Suzanne M. Kay (Cornell University). Both have been appointed for a three-year term, 1997–1999.

Molly F. Miller

Miller's broad-based research uses the modern and ancient relations between soft-bodied, bottom-dwelling animals and the enclosing sediment to identify long-term changes in benthic communities and to reconstruct (integrating sedimentologic data) ancient depositional environments and paleogeography. Currently she is using biogenic structures in otherwise sparsely fossiliferous rocks in the Transantarctic Mountains to document the response of freshwater animals to climate change following late Paleozoic glaciation.

As a Sigma Xi national lecturer, Miller gives talks on Antarctic earth science and its importance. She has edited a book of earth-science activities for K–12 teachers and has also served as GSA Southeastern Section chair. She holds degrees from the College of Wooster (B.A.), George Washington University (M.S.), and UCLA (Ph.D.). At Vanderbilt she is a professor of geology and holds a Chair of Teaching Excellence.

GSA Today science editors are charged to obtain high-quality, focused articles that collectively reflect and summarize current topics and discoveries in the earth sciences. All submissions, whether solicited or volunteered, are reviewed; most require revision before acceptance.

"*GSA Today* is an ideal vehicle for presenting the newest ideas on emerging developments to a broad earth science audience," Miller said. "I look forward to being part of the process."

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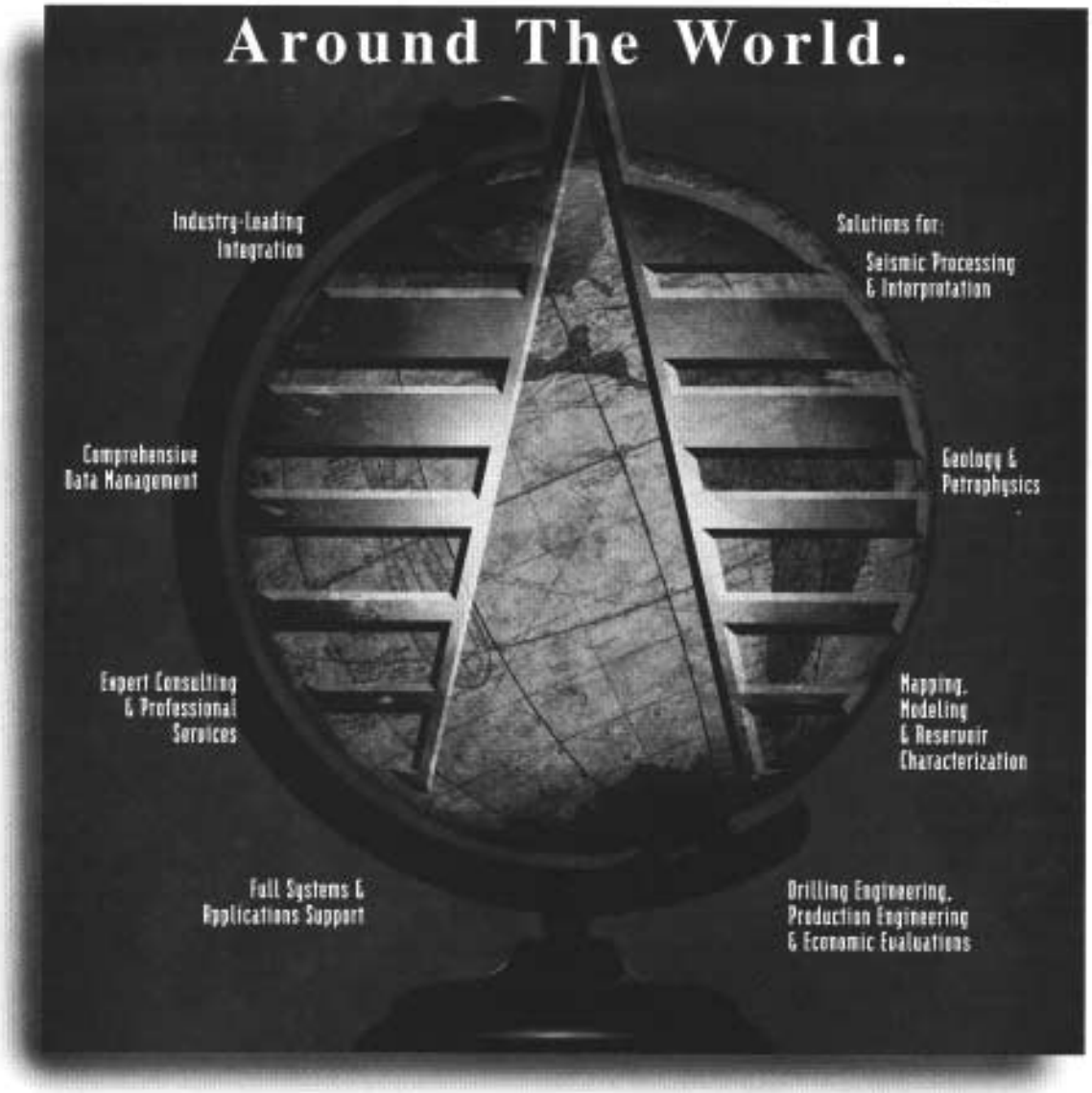

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WASHINGTON REPORT

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. In future issues, Washington Report will present summaries of agency and interagency programs, track legislation, and present insights into Washington, D.C., geopolitics as they pertain to the geosciences.

1997 Is the "International Year of the Coral Reef"

> *"Pollution, overfishing, and overuse have put many of our unique reefs at risk. Their disappearance would destroy the habitat of countless species. It would unravel the web of marine life that holds the potential for new chemicals, new medicines, unlocking new mysteries. It would have a devastating effect on the coastal communities from Cairns to Key West, Florida—communities whose livelihood depends upon the reefs."*
>
> —Bill Clinton, President of the United States, August 1996

The National Oceanic and Atmospheric Administration (NOAA) has declared 1997 as the International Year of the Coral Reef (IYOR). United States government agencies and more than 50 other organizations from around the globe have sanctioned the IYOR to raise awareness of the value of coral reefs and the challenges that they face.

The IYOR resulted from efforts by conservation groups and others, concerned about the state of the world's reefs, who urged governments, scientists, environmental organizations, and the private sector to join together in addressing the following challenges: (1) execute a major program of public education about coral reefs; (2) scientifically assess the conditions of coral reefs worldwide; and (3) collaborate with governments, local communities, and other reef managers to develop and implement plans for the sustainable use of irreplaceable reef resources. IYOR, the result, is a partnership of nations and organizations to protect and sustainably use fragile coral-reef resources worldwide.

The U.S. framework for the IYOR and the goals of the U.S. Coral Reef Initiative were unveiled February 24 by representatives from the Departments of Commerce and State. A national public awareness campaign was also presented to focus attention on the state of the nation's reefs, and 1997 was declared the "International Year of the Coral Reef" as a means to bring attention to these unique and beautiful ecosystems that today face grave dangers from a variety of threats, many of them human-caused. NOAA literature states, "The stakes are high: two-thirds of the earth's coral reefs are dying. It is estimated that 10 percent of the earth's coral reefs have already been degraded beyond recovery. A much larger percentage is now threatened. Human activities are among the major cause of reef decline."

"Coral reefs are some of the earth's most diverse ecosystems, full of plants and animals with biomedical applications that we've only just begun to explore," said Commerce Secretary William M. Daley. "They are important protection for coastal communities from storms and wave damage and the foundation for thousands of jobs and billions of dollars for coastal communities."

In 1995, many of the same individuals supporting the IYOR helped put together the International Coral Reef Initiative (ICRI), which issued a strong call to action. Directed at governments, the ICRI encouraged countries and other partners to develop national and local initiatives to reverse the decline of reef ecosystems and thereby enhance the well-being of the communities that depend on them. The U.S. was one of the first nations to develop a national Coral Reef Initiative. More than 75 of the 100 nations with coral reefs have since begun such initiatives. Many of the threats to coral reefs are human-caused. Land-based pollution and sedimentation can quickly kill off an entire reef ecosystem. Overfishing and destructive fishing practices involving cyanide and dynamite are also threatening coral reefs.

"The United States is a leader in efforts to save coral reefs," said Timothy Wirth, undersecretary for global affairs at the State Department. "Just three short years ago, I announced the International Coral Reef Initiative, a partnership of governments, scientists and private interests aimed at protecting, managing, and monitoring coral reef resources. The Initiative has grown rapidly from a small group of founding partners to a large consortium in which more than 75 countries participate. In the United States, the national and international efforts are inextricably entwined. The Departments of State and Interior and NOAA in the Department of Commerce are integral to efforts to stop the destruction of coral reefs."

NOAA is the primary federal agency within the United States charged with the stewardship of domestic coral reefs. In keeping with the call to action in the ICRI, NOAA has developed an action plan to build on existing activities and help fill the gaps in the overall U.S. effort to protect and wisely use coral reefs. NOAA's contributions address three priority areas of the U.S. Coral Reef Initiative: (1) science for improved management; (2) solutions for conservation and sustainable development; and (3) improved information and outreach.

"We must seize this window of opportunity and act to ensure there are coral reefs for the next generation," said NOAA Administrator D. James Baker. "We don't know everything there is to know about these unique communities, but we do know we must act now to ensure they survive. That is why in addition to its policy initiatives, NOAA, along with its partners, is launching a national awareness campaign to educate the public on the state of the coral reefs and let them know there are things they can do."

This year-long campaign for reef awareness is titled "Coral Reefs: the Rainforests of the Sea." Joining with the National Fish and Wildlife Foundation, the American Association of Zoos and Aquariums, the Earth Communications Office, diver Jean-Michel Cousteau, the Professional Association of Dive Instructors, and the artist Robert Lyn Nelson, NOAA is launching this national effort to bring the reality of coral reef decline to the public.

The first aspect of the campaign is a poster featuring a composition called "Planetary Choir," by Nelson. The poster became available in aquarium and zoo gift shops and in participating dive shops around the country in March. The awareness campaign will also include a series of public service announcements that will be unveiled later this year. As of late February, a coral-reef hotline, which provides more information about how to protect reefs, was made available to the public. This hotline, 1-888-coral reef, is sponsored by ECO, the Earth Communications Office, and is made possible in large part by

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ENVIRONMENT MATTERS

Institute for Environmental Education

Improving the Nation's Environmental Research System

Daniel Sarewitz, *Director, GSA Institute for Environmental Education*

A brief report assessing the state of federally funded environmental research and development (R&D) programs has recently been issued by the Carnegie Commission on Science, Technology and Government. The report concludes that the government's environmental R&D system is excessively fragmented among numerous agencies and jurisdictions, and that this fragmentation is a severe obstacle to developing the scientific information base necessary for effective protection of the nation's environment.

Given the current government focus on budget balancing, and the highly partisan nature of congressional debate over the environment, the Carnegie report recommends a number of low-cost, uncontroversial measures that could begin to address the problems in the R&D system, as excerpted below.

"The framework of federal environmental laws, regulations, and R&D programs established in the United States over the past three decades is in need of comprehensive reform. This framework came about in an *ad hoc* manner, as individual laws were passed to address specific issues deemed urgent at a particular time, such as air and water quality, toxic-waste disposal, and the protection of endangered species. Many, perhaps most, of these laws have had measurably positive impacts on the nation's environment, yet the weakness of the existing framework has become increasingly apparent. This weakness can be traced to numerous sources, including a lack of strategic coordination among diverse programs, an inconsistent and overly rigid regulatory structure, an excessive focus on remediation rather than prevention, and a neglect of basic environmental monitoring.

"At the core of any effort to reform the nation's system of environmental protection is the need to provide the high-quality technical information upon which the design and implementation of sound policies depend. The federal government's environmental R&D system is generally seen to be unequal to the task. The reasons for this failure are varied and include a lack of strong leadership in the coordination of environmental R&D, a research agenda that is not well matched to the scale and scope of the environmental challenges facing the nation, and the need for more effective environmental assessment.…

"The Commission recommends that substantial effort be spent on developing credible environmental indicators.

"The nation needs quantitative indicators of the state of the nation's environment that are analogous to widely used economic indicators such as gross domestic product, unemployment rates, and balance of payments. Just as it took years to develop and test many of the economic indicators now in use, so it will take substantial time and intellectual effort to develop reliable environmental indicators. Indeed, the President's Council on Sustainable Development has taken preliminary steps in this direction. To ensure that adequate attention and resources are focused on the delineation of credible indicators, the White House, through its Council on Environmental Quality and Office of Science and Technology Policy, should authorize and support the establishment of study groups, composed of environmental policy experts and leading environmental scientists from outside and within the government; their goal would be to develop a suite of scientifically credible and policy-relevant environmental indicators. Such indicators might include measures of atmospheric and oceanic conditions (for example, urban and stratospheric ozone levels, changes in coastal nutrient levels); ecological trends (for example, indicator species population and ecosystem productivity); earth-surface processes (for example, erosion rates of arable soil); public health (for example, incidence of waterborne infection); land-use patterns (for example, rates of wetland loss); and water quality (for example, levels of toxic substances in drinking water supplies as recently established as an indicator by EPA).

"Study groups would be administered by a prestigious, nonpartisan organization such as the National Research Council. Indicators would be tested and refined each year by the study groups, and the White House would issue an annual Environmental Indicators Report. Indicators would aid in the setting of priorities for environmental research and protection activities by creating a unified, policy-relevant vision of the state of environment and the effectiveness of environmental protection measures over time. New integrative information management technologies will facilitate recognition and analysis of possible indicators.

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a contribution from the Goldman Foundation.

"Corals are the master architects of the planet. Over tens of thousands of years, they have constructed massive reefs and islands that make the pyramids look like children's building blocks," said Cousteau. "But we humans can be immensely destructive. In our ignorance we are harming some of the oldest and most successful life forms on the planet."

NOAA has published a brochure titled "25 Things You Can Do To Save Coral Reefs." It can be found on the Internet on NOAA's Coral Reef Home Page. "From recycling to wise purchasing practices, people can make a difference," said Baker. "We are implementing our policy initiatives, but are issuing a call to action to the American people."

A list of resources that can be found on the NOAA Coral Reef Home Page include: IYOR Activities Completed or Underway; an IYOR brochure; IYOR Tool Kits—Selected Guidelines, Handbooks, and "Tools" for Coral Reef Management; a Coral Reef Education Resource List; IYOR Checklists for Action; government research institutions and scientists, dive and tour operators, schools and teachers, local and national NGOs; ICRI Call to Action; ICRI Framework for Action; and an ICRI Report to the UN Commission on Sustainable Development.

Additional information is available from Matt Stout, NOAA Public Affairs Office, Room 6013, U.S. Department of Commerce, 14th St. and Constitution Ave., NW, Washington, DC 20230, (202) 482-6090. The NOAA coral program e-mail address is: reef@www.rdc.noaa.gov. You can visit NOAA's coral reef home page at http://www.noaa.gov/public-affairs/coral-reef.html. ■

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"The Commission recommends the creation of a National Environmental Database.

"Technological tools now exist for unifying and integrating data generated by disparate programs at numerous agencies. For example, geographic information system (GIS) technologies permit the creation of geospatial digital databases encompassing geological, hydrological, biological, and cultural information and thus allow for analysis of multidisciplinary data sets that were previously incompatible. It is now possible to begin to overcome fragmentation of information and create a 'virtual unity' in the technical knowledge base, perhaps centered around the environmental indicators developed as part of the first recommendation. This unified database does not require centralized management of all environmental databases by one agency; indeed, such centralization would be undesirable. However, a single agency could design and establish linkages between decentralized databases at many agencies, perhaps with policy guidance from the President's National Science and Technology Council. One possible organization to take on this task is the newly consolidated USGS [U.S. Geological Survey] and NBS [National Biological Service], especially in light of the USGS's role in the development of a National Spatial Data Infrastructure and its expertise in GIS applications. GIS creates the further possibility of developing real-time 'decision support systems' for policy makers at the national, state, and local levels.

"The Commission recommends creation of an on-line National Library of Natural Resources.

"Continued advances in information technologies have now made possible the creation of an on-line library that would provide access to non-partisan and quality-controlled scientific information on the environment. An on-line National Library of Natural Resources would provide access to numerous sources of environmental data, information, and assessment, but these sources would be subject to quality control that does not now exist on the World Wide Web. The library would contain environmental information generated by the many components of the federal environmental R&D system and would thus be a mechanism for creating a more unified view of the nation's environmental research effort and knowledge base. This on-line library could be structured so that it is appropriate for a variety of users, ranging from the general public to policy makers to the scientific community. The National Library for Natural Resources should start out simply as a gateway to existing on-line information sources of known high quality. The library could be managed by a single agency with relevant capabilities, such as the National Oceanic and Atmospheric Administration (NOAA) or the USGS, while linking such independent data sources as NOAA's National Data Centers, the USGS's portion of the National Spatial Data Clearinghouse, and, in the future, the National Environmental Database recommended above.

"The cost of such an initiative would be small and would primarily involve the development and implementation of common protocols for structuring information presentation, as well as the creation of linkages among existing information sources. However, given anticipated future budgetary constraints, as well as likely growth in demand for reliable environmental information, the managing agency may wish to consider implementing user fees for library access.

"The Commission recommends the creation of Regional Natural Resource Science Forums.

"Across the country numerous community and issue-specific grass-roots efforts are under way to manage lands and resources. However, too often groups striving to resolve issues and manage their lands and natural resources effectively lack key scientific data and information, moni-

toring, and research required to underpin an informed decision-making process. Natural resources information that would be of use to local and regional land and resource managers is developed and stored by federal, state, tribal, and local governments, universities, nongovernmental organizations, and industry. Regional Natural Resource Science Forums would bring together representatives of these sectors to provide a mechanism for all stakeholders, public and private, to identify what is known, what needs to be understood, and how these needs can be satisfied as they relate to the management of a region's lands and natural resources. These Science Forums could facilitate communication, identification of science capabilities and needs, coordination among stakeholders, and the efficient allocation of resources to address highest-priority issues identified by scientists, land and resource managers, and policy makers at the regional level. Science Forum activities would be supported and enhanced by implementation of the three previous recommendations.

"The Regional Natural Resource Science Forums will succeed only if all major stakeholders share responsibility for their establishment and operation.... Where possible, existing mechanisms and forums should be used to engage regional stakeholders in a dialogue to identify issues and the science needed to adequately support sound decision making. For example, Science Forums could be organized to broaden the geographic scope of existing efforts, perhaps by facilitating linkages among conjugate watersheds....

"Conclusion

"The short-term value of implementing these or similar recommendations lies in the creation of a multiagency, multidisciplinary information infrastructure that overcomes some of the problems created by a fragmented federal environmental R&D system, while facilitating more effective linkages between scientific information and environmental policy making at the national, regional, and local levels. Such initiatives cannot eliminate the fragmentation itself, but they may help to create a more unified perspective on both national environmental priorities and the value of high-quality scientific information on the environment. Over the longer term, this unified perspective can help cultivate a policy environment within which more comprehensive approaches to systemic reform become politically viable. The ultimate goal of such reform should be strong presidential leadership and coordinated planning in environment R&D. Achieving this goal will lay a firm foundation for effective environmental protection in the future."

The full report, *Federal Environmental Research and Development: Status Report with Recommendations,* is a follow-up to a more comprehensive report issued in 1992, *Environmental Research and Development: Strengthening the Federal Infrastructure*. Both documents are available, free of charge, from the Carnegie Commission on Science, Technology, and Government, 437 Madison Ave., 27th Floor, New York, NY 10022. ■

Upcoming IEE-Sponsored Events

The Roy Shlemon Mentors In Applied Geology Program will be held at the North-Central and Cordilleran GSA Section meetings. Shlemon Mentors, leading practitioners in the applied geosciences, present workshops for undergraduate and graduate students on professional and scientific opportunities and challenges in the world of consulting geology. For more information on the North-Central Section program, see the North-Central Section Meeting Final Announcement in the February *GSA Today.* For more information on the Cordilleran Section program, contact Steve Martel, Student Coordinator, Dept. of Geology and Geophysics, University of Hawaii, 2525 Correa Rd., Honolulu, HI 96822, (808) 956-7797, martel@soest.hawaii.edu.

CORRECTION

CORDILLERAN SECTION MEETING

The cost of Cordilleran Field Trip 3—**Petrology and Volcanology of Maui,** to be led by Sinton and Rowland has been increased from $150 to $400. This includes, in addition to all previously stated information, air fare from Honolulu to Maui and from Maui to Kailua Kona. It does not include transportation from the Kona airport to the hotel.

Call For Papers

The theme for the 1997 GSA Annual Meeting is *Global Connections*.
Geoscience depends on making connections that range from closing a gap in mapping a contact to linking trace organic chemicals in an Antarctic meteorite to life on Mars. A global scope is important to geoscience both in the spatial sense, as in plate tectonics, and in the figurative sense of comprehensive interdisciplinary science. A technical program with "Global Connections" thus means being inclusive in terms of geographics and disciplinary representation and focusing on processes and problems that are global priorities. We anticipate that such a program will foster productive connections between geoscientists that are the reason for the meeting.

1997 Annual Meeting Committee

Deadlines

Abstracts due July 8th
Preregistration due September 19th

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Registration and Full Details

See the June issue of GSA *Today*.

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The Geological Society of America

1997 ANNUAL MEETING

Salt Lake City, Utah
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Global Connections

How To Submit Your Abstract

Submit Abstracts via the WWWeb (www.geosociety.org)

Starting on or about May 1, abstracts for this year's Annual Meeting in Salt Lake City can be sent to GSA via the World Wide Web. (Over 40% of the abstracts were submitted electronically in 1996.) **Note that you can send electronic abstracts to GSA only via the Web. They may not be sent by ordinary e-mail.**

For the present, this system will accept only abstracts containing pure ASCII content; no graphics, tables, symbols, Greek, superscripts, etc. may be included. If you must use any of that in your abstract, use the paper form for now. We hope to be able to include non-ASCII material in the future, but for most users the technology for that is not yet in place. However, if your entire content—title, addresses, and abstract body—is pure ASCII and you have access to the Web, the new system will make life much easier by eliminating the more onerous tasks usually connected with preparation of paper forms.

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4. *Complete the personal information on the form, including credit card information for abstracts fee payment* (required for both paper and electronic forms).
5. *Hit the "SEND" button.* You're done! We've included instructions, pull-down lists, and helpful hints on the Web form to save you time and confusion. There's even an error checker to make certain you include all the information we must have.

You are now able to test our new system, strictly on a "get acquainted" basis. Nothing you send via this form before May 1 will be saved at GSA or considered by GSA for the 1997 Annual Meeting. Although you will receive an acknowledgment of receipt on any test abstracts you send, that is just part of the test, too, and is meaningless.

To get acquainted with the form from now until May 1, go to *www.geosociety.org*. There you'll find the link, *"TEST DRIVE* GSA's Web Abstract Form." Just follow the instructions from there. If you discover any glitches in our system during a test, please send a detailed e-mail message to: *pubs@geosociety.org*. Please include your telephone number so we can call if more details are needed. On or about May 1, the TEST DRIVE link will change to *"SUBMIT an Abstract."*

Please submit only one copy of your abstract—either electronic or paper.

Paper Still Works Well

The electronic system has not yet replaced the familiar paper version of GSA's abstract form. Rather, the two systems operate in parallel. Paper forms already have been distributed for 1997, and can be obtained from GSA's Abstracts Coordinator: ncarlson@geosociety.org or call (303) 447-2020, ext. 161.

Paper abstract forms are available from:

- Abstracts Coordinator at GSA headquarters
- Conveners of symposia
- Advocates of theme sessions
- Geoscience departments of most colleges and universities
- Main federal and state survey offices

Only ONE Volunteered Abstract May Be Submitted

Please submit only one volunteered abstract as speaker or poster presenter in discipline and/or theme sessions. Multiple submissions as speaker-presenter *may* result in rejection of *all* abstracts. Since almost all of the abstracts are accepted, this helps avoid speaker-scheduling conflicts and gives everyone an equal opportunity to be heard. Note that this limitation does not apply to, nor does it include, invited contributions to symposia.

Abstracts Fee Initiated

Costs for implementing an electronic abstract submission system, as well as increasing costs for producing the printed *Abstracts with Programs* books, have led to establishment of a **$15 abstract fee** for the GSA Annual Meeting, beginning with the 1997 meeting in Salt Lake City. Implementation of the fee follows the standard set by many other scientific organizations many years ago. The fee must be sent with both paper copy and electronic submissions. *(See the Executive Director's article, February issue of* GSA Today, *page 17).*

Abstracts with Programs

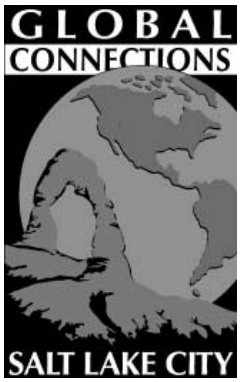
Purchase an advance copy through GSA Membership Services, Publication Sales, or pick up a copy on site in the registration area. The *Abstracts with Programs* is not part of your registration fee. For advance sales, contact Publication Sales, GSA headquarters 1-800-472-1988. Member Cost: $24, Nonmember Cost: $30.

Presentation Modes

Oral Mode—This is a verbal presentation before a seated audience. The normal length of an oral presentation is 12 minutes, plus three minutes for discussion. Projection equipment consists of two 35 mm projectors, one overhead projector, and two screens. Requests for video projection and computer display will be addressed on a case-by-case basis. Please let us know when you submit your paper if you have special presentation needs.

Poster Mode—Each poster session speaker is provided with two horizontal, free-standing display boards approximately 8' wide and 4' high. Precise measurements will appear in the Speaker Guide. The speaker must be present for at least two of the four presentation hours.

Papers for discipline sessions may be submitted in either oral or poster mode. Papers for theme sessions, however, are to be submitted only in the mode noted in the theme description. If a theme abstract is submitted in the incorrect mode, the abstract will be transferred automatically to a discipline session.



Joint Technical Program Committee: August 8–9

The JTPC selects abstracts and determines the final session schedule. Speakers will be notified by August 24. This should be much sooner for abstracts submitted electronically. The JTPC consists of representatives from each of the associated societies and GSA divisions participating in the technical program. The JTPC technical program chairs were nominated by the Salt Lake City Annual Meeting Committee and approved by the GSA Council.

GSA's Institute for Environmental Education

As an issue-driven, nonadvocacy, outreach organization sponsored by GSA, the primary goal of the IEE is to enhance the effective contribution of geoscientists and the geosciences to the resolution of the wide array of environmental problems facing the postindustrial world. IEE's challenge is to be known within and beyond the geoscience community for its capacity to foster nonconfrontational dialogue and productive public outreach on environmental issues. IEE has developed an open network of volunteers who are committed to these goals. IEE also works directly with GSA's Geology and Public Policy Committee. For each Annual Meeting, IEE sponsors unique sessions including symposia and theme sessions, including this year's IEE Annual Environmental Forum: Concepts in Geoecology and Ecosystem Management: Applying New Knowledge from the Interface of the Life and Earth Sciences. Other IEE-sponsored sessions are indicated on the following pages.

Symposia (Invited Papers)

All invited abstracts (electronic and paper) are to be sent to GSA, which will forward the abstracts to the conveners for review.

S1 Ore Deposits through Time.

Society of Economic Geologists. Erich U. Petersen, University of Utah; David Groves, University of Western Australia, Nedlands, Australia.

S2 Organic Perspectives on Geochemical Processes.

Organic Geochemistry Division of the Geochemical Society. John Hedges, University of Washington; Stuart Wakeham, Skidaway Institute of Oceanography.

S3 IEE Annual Environmental Forum: Concepts in Geoecology and Ecosystem Management: Applying New Knowledge from the Interface of the Life and Earth Sciences.

Institute for Environmental Education. Cathleen L. May, USDA Forest Service; Daniel Sarewitz, Geological Society of America; Mary Barber, Ecological Society of America.

S4 Micropaleontology of the Cretaceous Western Interior Seaway: Integration of the Tethyan and Boreal Record.

Cushman Foundation. David H. McNeil, Geological Survey of Canada; Mark Leckie, University of Massachusetts.

S5 Geomicrobiology: Interactions Between Microbes and Minerals.

Mineralogical Society of America. Jill Banfield, University of Wisconsin—Madison; Ken Nealson, University of Wisconsin—Milwaukee.

S6 Exploring Life in the Solar System.

Planetary Geology Division. Cassandra Coombs, College of Charleston; Loren Babcock, Ohio State University.

S7 New Developments in Coal and Coalbed Methane Evaluation and Exploitation.

Coal Geology Division. Brenda Pierce, U.S. Geological Survey, Reston.

S8 Exhumation of High- and Ultrahigh-Pressure Rocks.

Structural Geology and Tectonics Division. Bradley Hacker, University of California, Santa Barbara; Lothar Ratschbacher, Universität Würzburg, Würzburg, Germany.

S9 Engaging the National Science Education Standards.

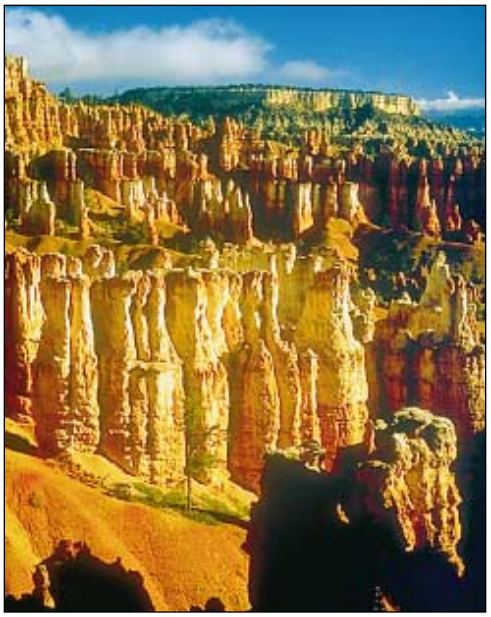
Geoscience Education Division. David W. Mogk, Montana State University.

S10 The Anatomy and Attenuation of Chlorinated Solvent Plumes in Granular Aquifers.

1997 Annual Meeting Committee. John A. Cherry, Waterloo Center for Groundwater Research; David McWhorter, Colorado State University.

S11 Hotspots from the Top Down: What Are They?

Geophysics Division. Eugene D. Humphreys, University of Oregon; Robert B. Smith, University of Utah.



Bryce Canyon National Park. Photo by John Karachewski.

S12 Process from Pattern in the Fossil Record.

Paleontological Society. Frank K. McKinney, Appalachian State University; Jeremy B. C. Jackson, Naturhistorisches Museum, Basel, Switzerland; Scott Lidgard, Field Museum.

S13 Isotopes and Earth Surface Processes.

Quaternary Geology and Geomorphology Division. Paul Bierman, University of Vermont; Eric Steig, University of Colorado at Boulder.

S14 The Costs and Values of Geoscience Information.

Geoscience Information Society. Connie J. Manson, Washington Department of Natural Resources.

S15 Recent Advances in Studying Earth from Space: What Students Should Know.

National Association of Geoscience Teachers. John R. Wagner, Clemson University; Cassandra Coombs, College of Charleston.

S16 Geochemical Records of Hydrologic Response to Climate Change.

Abstract Deadline July 8th

Geochemical Society. Emi Ito, University of Minnesota; Jay L. Banner, University of Texas.

S17 Tectonic, Climatic, and Eustatic Controls on Sedimentation in Continental Rifts.

Sedimentary Geology Division. Greg Mack, New Mexico State University; Michael J. Soreghan, University of Oklahoma.

S18 Archaeological Geology of Arid Environments—Dedicated to the Late Jonathan O. Davis.

Archaeological Geology Division. Rolfe Mandel, University of Kansas.

S19 Sigma Gamma Epsilon Symposium: Student Research and Interdisciplinary Connections.

Sigma Gamma Epsilon. James C. Walters, University of Northern Iowa; Charles J. Mankin, Oklahoma Geological Survey.

S20 Iapetus Ocean, Its Birth, Life, and Death: The Wilson Cycle.

Geophysics Division, International Division, Structural Geology and Tectonics Division, Paleontological Society; in association with *International Geological Correlation Program, Project 376*. Ian W. D. Dalziel, University of Texas, Austin; Mary Droser, University of California, Riverside; Kenneth P. Kodama, Lehigh University.

S21 Geology and Ore Deposits of the Oquirrh and Wasatch Mountains.

Society of Economic Geologists. Geoffrey Balantyne, Kennecott Utah Copper, Bingham Canyon, Utah; David John, U.S. Geological Survey, Menlo Park; Robert W. Shafer, Kinross Gold Corp., Toronto, Ontario.

S22 The Archbishop Ussher Symposium: Quantifying Earth History.

1997 Annual Meeting Committee. Samuel A. Bowring, Massachusetts Institute of Technology.

S23 Predictive Modeling in the Earth Sciences: Application and Misapplication to Environmental Problems.

Institute for Environmental Education. Orrin Pilkey, Duke University; Victor Baker, University of Arizona.

S24 Celebrating 50 Years of the Engineering Geology Division: The Past, Present, and Future of Geoscience in the Public Interest.

Engineering Geology Division. Vincent S. Cronin, University of Wisconsin—Milwaukee.

S25 Advocacy, Ethics, and the Geosciences: Problems of Facts and Values in Environmental Issues.

Institute for Environmental Education and *National Association of Geoscience Teachers*. Paul Pinet, Colgate University; Heather Macdonald, College of William and Mary.

S26 Recent Advances in Chemical Hydrogeology: A Tribute to William Back's 50-Year Career.

Hydrogeology Division. Mary Jo Baedecker, U.S. Geological Survey, Reston; Janet S. Herman, University of Virginia.

S27 Late Ordovician Mass Extinction—Silurian Recovery and Associated Perturbations of Global Earth Systems.

1997 Annual Meeting Committee and *Paleontological Society*. Stanley C. Finney, California State University, Long Beach; William B. N. Berry, University of California, Berkeley; Walter C. Sweet, Ohio State University.

S28 Environmental Mineralogy: Science and Politics.

1997 Annual Meeting Committee. George D. Guthrie, Jr. and David L. Bish, Los Alamos National Laboratory.

S29 Global Connections: Environmental Justice in the Americas and Abroad.

National Association of Black Geologists and Geophysicists and *Institute for Environmental Education*. Wesley Ward, U.S. Geological Survey, Flagstaff; Daniel Sarewitz, Geological Society of America.

S30 Deciphering Exhumation from the Sedimentary Record.

1997 Annual Meeting Committee. Mark T. Brandon, Yale University; John I. Garver, University of Waikato, Hamilton, New Zealand.

S31 Geologic Mapping: Past, Present, and Future.

History of Geology Division and *Association of American State Geologists*. Paul R. Seaber, Desert Research Institute; Robert Fakundiny, New York Geological Survey; Robert Michael Easton, Ontario Geological Survey.

Hot Topics at Noon

Popular Scientific Debate & Lunch
Monday through Thursday, October 20–23 from 12:15 to 1:15 p.m. at the Salt Palace Convention Center.

- ***The New Grand Staircase—Escalante National Monument:*** Environmental Preservation vs. Resource Exploitation vs. Tourism.
- ***Geoscience Curricula in the Universities for the 21st Century:*** How Should Academia Respond to Industry and Government Trends?
- ***Nuclear Waste Disposal Strategies:*** What are the Geological and Geopolitical Hazards?
- ***"Dubiofossils" in Martian Meteorites:*** Is (or Was) There Life on Other Planets?

Discipline and Theme Sessions (Volunteered Papers)

Discipline Sessions

Papers are submitted to ONE scientific discipline. The JTPC representatives organize the papers in sessions focused on this discipline—for example, hydrogeology or mineralogy.

Theme Sessions

Papers are submitted to a specific preannounced title and to ONE scientific category. Theme sessions are interdisciplinary; each theme may have as many as three categories from which authors may choose ONE. After each theme description below, the categories are identified by name and number as they appear on the 1997 Abstract Form. **PLEASE SUBMIT ONLY IN THE MODE AND CATEGORIES INDICATED** in the description (oral or poster). An abstract submitted in the incorrect mode will be transferred automatically to a discipline session.

Example Submission

Theme Submissions Must Include:

- Theme number—**T18**
- Key words of the theme title—**Methods for Quantifying Unsaturated Permeability**
- One category—**Environmental Geology** (#6 on abstract form)
- Mode for the session—**Poster**

Role of Theme Advocate

Each theme session has been proposed by an advocate. Advocates may not invite speakers; however, they may encourage colleagues to submit abstracts, with the understanding that there is no guarantee of acceptance. JTPC representatives, in consultation with the theme advocates, will organize theme sessions by August 9.

Potash Trail, Canyonlands National Park. Photo by John Karachewski.

Theme Topics

Please check the correct mode of the theme session—poster or oral. If the abstract is submitted inaccurately, the abstract will be transferred automatically to a discipline session.

T1 Geologic Mapping and GIS: Digital Map Production, Methods of Publication, and Expanded Uses of the Data.

Larry N. Smith and Karen W. Porter, Montana Bureau of Mines and Geology.

Geographic Information Systems became important in production of geologic maps in the past decade. Methods to produce maps conforming to national mapping standards are varied and are being refined. This is a forum where methods for producing "classical" geologic maps and geologic point, areal, and/or volumetric databases can be shared. POSTER.

Computers (3), Stratigraphy (30), Structural Geology (31).

T2 Plutons, Volcanoes, and Ore Deposits.

Society of Economic Geologists. David John, U.S. Geological Survey, Menlo Park; Robert W. Shafer, Kinross Gold Corp., Toronto, Ontario; Geoffrey H. Ballantyne, Kennecott Utah Copper, Bingham Canyon, Utah.

This session will examine the relationships between magmatism and hydrothermal ore deposits in a variety of tectonic settings. It will continue the theme of the symposium "Geology and Ore Deposits of the Oquirrh and Wasatch Mountains," to be held the same day. ORAL.

Economic Geology (4), Petrology, Igneous (21), Tectonics (32).

T3 Geomicrobiology: Interactions Between Microbes and Minerals.

Mineralogical Society of America. Jill Banfield, University of Tokyo; Ken Nealson, University of Wisconsin—Milwaukee.

Recent studies reveal enormous microbial diversity in geologically important environments. Microorganisms mediate mineral precipitation and dissolution. Conversely, mineralogical and geochemical factors dramatically influence microbial community structure and evolution. This theme session will complement the MSA short course and symposium, which will focus on the links between microbial and geochemical processes near Earth's surface. ORAL.

Environmental Geology (6), Geochemistry, Other (8), Mineralogy/Crystallography (16).

T4 Hydrogeology of Landslides.

Engineering Geology Division. Robert A. Larson, Los Angeles County Department of Public Works.

The session on infiltration of water into and percolation of water through landslides of all types will include modeling, theoretical aspects, dewatering, monitoring, effect on activation and rate of movement, and case histories. Papers on debris flow generation and rainfall thresholds for initiating failure of previously stable slopes are appropriate. ORAL.

Engineering Geology (5), Hydrogeology (13), Quaternary Geology/Geomorphology (26).

Buckskin Gulch, Paria Canyon Primitive Area. Photo by John Karachewski.

T5 Trace Metals in the Environment: Sources, Transport, and Fate—A Tribute to Ernest E. Angino.

International Association of Geochemistry and Cosmochemistry. David T. Long, Michigan State University; Gunter Faure, Ohio State University.

Understanding the behavior of trace metals in the environmental is a global concern. All media (air, water, sediments) are involved. This session will address our understanding and lack of understanding of the geochemistry of trace metals in the environment including their sources, transport, and fate. The session is a special tribute to Ernest E. Angino, who has been a pioneer in this field. ORAL.

Environmental Geology (6), Geochemistry, Aqueous (7), Geochemistry, Other (8).

T6 Concepts in Geoecology and Ecosystem Management: Applying New Knowledge from the Interface of the Life and Earth Sciences.

Institute for Environmental Education. Cathleen L. May, USDA Forest Service; Kenneth Kolm, Colorado School of Mines.

Successful restoration and protection of ecosystems requires development and application of geoecological principles. This session will explore how the feedback between geologic and biological processes influences ecosystem dynamics, with an emphasis on work that defines the physical parameters of ecosystem function and structure. ORAL.

Environmental Geology (6), Paleontology/Paleobotany (18), Quaternary Geology/Geomorphology (26).

T7 Conservation Geology: Restoring and Maintaining Earth's Ecosystems.

Institute for Environmental Education. Abraham Springer, Northern Arizona University.

Geologists are now often faced with the task of conservation rather than exploration and extraction of natural resources. This includes restoring or maintaining the structure and function of geologic systems and processes for humans and other species. Topics will include conservation and restoration of riparian areas and wetlands, restoration of surface- and ground-water quality and quantity, and landscape restoration. ORAL.

Environmental Geology (6), Hydrogeology (13), Remote Sensing (27).

T8 Plume Tails and Continental Lithosphere: A Multidisciplinary Approach to the Snake River Plain and Other Continental Plume Tracks.

John Shervais, University of South Carolina; Craig White, Boise State University; Bill Bonnichsen, Idaho Geological Survey.

The Snake River Plain of southern Idaho is a rare example of plume tail migration through continental lithosphere. This theme session will develop a multidisciplinary approach to the effects of plume track migration on volcanism, tectonism, sedimentation, and lithospheric structure, focusing primarily on the Snake River Plain, but also including other possible examples of plume tail activity in other continental settings. ORAL and POSTER.

Petrology, Igneous (21), Stratigraphy (30), Volcanology (33).

T9 Submarine Plateaus and Hotspot Islands, Young and Old: Identification and Role in Continental Growth.

Kent Condie, New Mexico Institute of Mining and Technology; Dallas Abbott, Lamont-Doherty Earth Observatory.

Interdisciplinary theme session focusing on the characteristics, identification, origin, and role of submarine plateaus and hotspot islands in continental growth. We solicit papers characterizing geological, geochemical, and geophysical features of submarine plateaus and hotspot island chains; papers that compare and contrast such plateaus and hotspot chains with oceanic crust, island arcs, and continental margin arcs; and papers that document the tectonics of recent events of submarine plateau and hotspot island accretion at active trenches. Approaches to recognizing greenstones of any age that may represent fragments of submarine plateaus or hotspot island chains are also relevant. ORAL.

Please check the correct mode — poster or oral

Geochemistry, Other (8), Geophysics/Tectonophysics (10), Tectonics (32).

T10 Isotopic Mapping: The "0.706 Line" Twenty Years Later—A Tribute to Ronald W. Kistler.

Allen F. Glazner, University of North Carolina, Chapel Hill; Drew S. Coleman, Boston University; G. Lang Farmer, University of Colorado at Boulder.

Over 20 years ago Kistler and Peterman proposed the Sr "0.706 line" as a proxy for the western edge of the North American craton. In this session we will examine use of isotopic data in investigating the composition and structure of continental lithosphere worldwide. ORAL.

Geochemistry, Other (8), Petrology, Igneous (21), Tectonics (32).

Coyote Wash, Escalante Primitive Area. Photo by John Karachewski.

T11 Earth Science Education for Pre-service Teachers.

National Association of Geoscience Teachers and *National Earth Science Teachers Association.* Karen Havholm, University of Wisconsin—Eau Claire; Frank Ireton, American Geophysical Union.

What should every future teacher know about earth science? How should we educate future elementary, middle, and high school teachers in earth science? What are appropriate content and skills to teach? What are the most effective teaching methodologies? If you work with pre-service teachers, come share your insights. ORAL.

Geology Education (9), Public Policy (25).

T12 Approaches to Undergraduate Teaching of Geophysics.

Keck Geology Consortium and *National Association of Geoscience Teachers.* Robert J. Lillie, Oregon State University; Kevin Pogue, Whitman College.

Undergraduate courses in geophysics present the challenge of teaching quantitative techniques to students who are visual learners. This session presents methods used to engage students in the use of geophysical observations and interpretations as part of their geology curriculum. ORAL.

Geology Education (9), Geophysics/Tectonophysics (10).

T13 Earth System Science Laboratories for the Introductory Undergraduate Level.

Geoscience Education Division. Lisa K. Barlow, University of Colorado at Boulder.

An introductory Earth system science course is becoming a standard offering in many geoscience departments. Our focus is on complementary laboratories. This session will provide a forum for classroom educators and government agencies preparing modules on selected topics to share experiences in development and implementation of Earth system science laboratories. ORAL.

Environmental Geology (6), Geology Education (9).

T14 Concepts of Mapping in Geoscience Education.

National Association of Geoscience Teachers. Andy R. Bobyarchick, University of North Carolina, Charlotte; Carolyn Elliott, South Iredell High School, Statesville, North Carolina.

The concept of mapping includes observation, organization, interpretation, and visualization. These skills are essential for critical thought and for learning the process of transforming data into information. This theme session engages producers and users of maps to illustrate mapping and maps as tools for learning. ORAL.

Geology Education (9), History of Geology (12).

T15 Field-based Investigations on School or Campus Sites: Examples That Work.

National Association of Geoscience Teachers. P. Geoffrey Feiss, University of North Carolina, Chapel Hill; Florence Gullicksen, SW Guilford High School, High Point, North Carolina; Nancy West, University of North Carolina, Chapel Hill.

Teaching geology and related earth sciences requires field-based observational experiences. Instructors, however, encounter logistical and scheduling problems with taking students offsite. This session describes successful field projects by instructors at all levels who use schools and campuses for observation-based instruction. POSTER.

Environmental Geology (6), Geology Education (9).

T16 Great Geological Vacations in North America—How They Can Enhance Geoscience Literacy.

National Association of Geoscience Teachers and *National Earth Science Teachers Association.* Steven C. Semken, Navajo Community College; Lauret E. Savoy, Mount Holyoke College.

Over the centuries, spectacular natural landscapes of North America have drawn attention from Native Americans, explorers, and tourists. How can such features be used to improve public geoscience literacy? We seek exemplary travelogues or ideas for practical field experiences organized to teach interpretive, historical, and environmental geoscience to nongeoscientists. ORAL and POSTER.

Archaeological Geology (1), Environmental Geology (6), Geology Education (9).

T17 Paleoseismology: Contributions to and Issues in Evaluating Seismic Hazards.

Ivan G. Wong and Susan Olig, Woodward-Clyde Federal Services, Oakland, California.

Our understanding of earthquake processes has changed dramatically as paleoseismology has evolved and been increasingly applied in fault studies. Thus, the ability to characterize active faults has also improved significantly, allowing for more accurate evaluations of seismic hazards. This session will focus on seismic hazard issues that paleoseismology has not only attempted to address, but has also raised. ORAL.

Geophysics/Tectonophysics (10), Quaternary Geology/Geomorphology(26), Tectonics (32).

T18 Geoscience Information Issues in a Rapidly Evolving Environment.

Geoscience Information Society. Connie J. Manson, Washington Department of Natural Resources.

The geoscience information world is evolving at an ever-increasing pace. This session will present updates on the triumphs of Internet connectivity, new patterns of information use, the impacts of administrative decisions, the developments in preservation technologies, and other issues in the geoscience information profession. ORAL.

Geoscience Information (11).

T19 Geologic Mapping: Past, Present, and Future.

Paul R. Seaber, Desert Research Institute; Robert Fakundiny, New York Geologic Survey; Robert Michael Easton, Ontario Geological Survey.

Changing principles, theories, philosophies, and concepts have generated a variety of geologic mapping types and techniques. It is important to clarify mapping practices and thought processes to understand and interpret existing geologic maps. These sessions will examine how mapping techniques and principles evolved in relation to changing geological thought and how maps were, are, and will be used. ORAL and POSTER.

History of Geology (12).

T20 Linking Fault Zone Architecture and Quantitative Fluid Flow Studies.

Craig Forster, University of Utah; James P. Evans, Utah State University.

Detailed studies of fault zones are resolving how geometrical factors might influence fluid flow in and near faults. Quantifying the hydraulic significance of faults, however, requires lab studies, in situ permeability tests, or fluid-flow simulations. We invite posters that make direct quantitative links between fault zone architecture and fluid-flow processes to determine the impact of faults on modern and ancient fluid-flow processes. POSTER.

Hydrogeology (13), Petroleum Geology (19), Structural Geology (31).

The full daily technical session schedule appears in the September issue of *GSA Today* and at www.geosociety.org. If you are not a GSA member, please contact us, and we will gladly send you the schedule after September 1.

T21 Hydrogeology of Diagenesis.

Matthew Davis, University of New Hampshire; Richard B. Wanty, U.S. Geological Survey, Denver.

Diagenesis involves fluid flow, solute transport, and water-rock interactions. This session explores recent developments in quantitative hydrologic and coupled models to study diagenetic processes and products. Abstracts should describe uses of hydrologic and/or geochemical models to test hypotheses about diagenetic processes or construct well-constrained conceptual models. ORAL.

Geochemistry, Aqueous (7), Hydrogeology (13), Sediments, Clastic (29).

T22 Hydrogeology of Continental Rift Systems.

Hydrogeology Division. Ward Sanford, U.S. Geological Survey, Reston; Mark Person, University of Minnesota.

Continental rift basins frequently contain ore and/or hydrocarbon deposits. Many also are the sites of growing populations with increasing ground-water needs (e.g., Rhine Valley and Rio Grande Rift). This session will focus on how fluid flow, basin geometry, stratigraphy, faulting, and heat flow affect the genesis and utilization of these natural resources. ORAL.

Hydrogeology (13), Petroleum Geology (19), Structural Geology (31).

Abstract Deadline July 8th

T23 Regional Ground-water Flow and Hydrochemistry of Basins of Internal Drainage.

Joseph S. Gates, U.S. Geological Survey, Salt Lake City, Utah; James R. Harrill, Pal Consultants, Inc., Carson City, Nevada.

This session will discuss development of concepts of regional ground-water flow, and how these flow systems relate to hydrochemical facies, in and adjacent to large basins of internal drainage, generally in arid areas. The model is the Great Basin in the Basin and Range province of western Utah. ORAL.

Geochemistry, Aqueous (7), Hydrogeology (13), Quaternary Geology/Geomorphology (26).

T24 Approaches to Understanding Ground-water Flow and Contaminant Transport in Carbonate Aquifers.

Carol Wicks, University of Missouri; Ira D. Sasowsky, University of Akron.

This session will focus on innovative approaches for predicting and understanding ground-water flow and solute transport through carbonate aquifers. These aquifers, many highly heterogeneous, owing to karstification, are very susceptible to contamination. Research that relies on the use of conceptual, bench-scale, numerical, or geochemical models will be emphasized. ORAL.

Hydrogeology (13), Geochemistry, Aqueous (7).

T25 Recent Advances in Density-dependent Fluid Flow and Solute Transport.

Robert A. Schincariol, Western University of Ontario; E. A. Sudicky, University of Waterloo; F. W. Schwartz, Ohio State University.

This special session highlights recent experimental and theoretical advances in variable density flow in geologic media. We are particularly interested in issues of convective mixing and dispersion, and in case studies that illustrate these processes at the field scale. Both plume-related problems and natural phenomena will be considered. ORAL.

Environmental Geology (6), Geochemistry, Aqueous (7), Hydrogeology (13).

T26 Hydrochemistry of Poorly Confined Aquifer Systems.

Hydrogeology Division. Brian G. Katz, U.S. Geological Survey, Tallahassee; Carl I. Steefel, University of South Florida.

Great strides have been made using naturally occurring tracers, microbiological techniques, and solute-transport modeling to better understand how biogeochemical processes affect the water quality of aquifer systems in natural and contaminated settings. This session will integrate findings from a broad spectrum of disciplines to describe hydrochemical processes in poorly confined aquifer systems. ORAL.

Geochemistry, Aqueous (7), Geochemistry, Other (8), Hydrogeology (13).

T27 Investigations of Transport Processes in Fractured Rock Using Ground-water Tracers.

Hydrogeology Division. Lucy C. Meigs, Sandia National Laboratories; Gerilyn Moline, Oak Ridge National Laboratory.

Ground-water tracers provide valuable insights into the complex flow and transport processes in fractured rock around the world. This theme session will focus on studies utilizing both introduced and natural tracers to evaluate important processes such as matrix diffusion, sorption, and colloid transport. ORAL and POSTER.

Environmental Geology (6), Geochemistry, Other (8), Hydrogeology (13).

T28 Progress in Dating Young Ground Water.

Hydrogeology Division. L. Niel Plummer, U.S. Geological Survey, Reston; Robert Poreda, University of Rochester.

Tritium and helium isotopes, chlorofluorocarbons, and other atmospheric tracers are being used to date ground water recharged at the 0 to 50 year time scale. This theme session highlights recent advances in development of techniques for dating young ground water and presents recent applications of ground-water dating from a wide range of hydrogeologic environments. ORAL.

Environmental Geology (6), Geochemistry, Aqueous (7), Hydrogeology (13).

Colorado River, Canyonlands National Park. Photo by John Karachewski.

T29 Isotopic Tools for Detection of the Origin and/or Fate of Environmental Contaminants.

Hydrogeology Division. Barbara Sherwood Lollar, University of Toronto; Jun Abrajano, Memorial University of Newfoundland.

Isotopic analyses can be cost effective for resolving problems in environmental geochemistry and hydrogeology. Compound-specific-isotope analysis and continuous flow techniques are revolutionizing the application of isotopes to numerous priority compounds including petroleum products and dissolved organic contaminants. We solicit examples of the use of isotopes to identify the source of contaminants or to monitor their transformation and attenuation. ORAL.

Environmental Geology (6), Geochemistry, Aqueous (7), Hydrogeology (13).

T30 Role of Natural Organic Matter in Solute Fate and Transport.

William P. Johnson, University of Utah; Paul Westerhoff, Arizona State University.

This session will explore the mechanisms by which natural organic matter mediates the partitioning, transport, degradation, and biodegradation of solutes in aquatic systems. Both inorganic (i.e., metals, radionuclides) and organic solutes, as well as aquatic and dissolved natural organic matter, will be discussed, in both surface and subsurface settings. ORAL.

Environmental Geology (6), Geochemistry, Aqueous (7), Hydrogeology (13).

T31 Hydraulic Properties and Diagenetic Processes of Municipal Solid Waste.

Peter J. Hutchinson, The Hutchinson Group, Ltd., Murrysville, Pennsylvania.

The purpose of this theme session is to explore waste mass diagenesis and hydraulic properties. Municipal solid waste is subjected to biogeochemical and settling processes. The degradation of waste mass after disposal may be analogous to certain natural geologic processes. ORAL.

Environmental Geology (6), Geochemistry, Aqueous (7), Hydrogeology (13).

T32 Dense, Nonaqueous Phase Liquids (DNAPL), Migration and Remediation in Fractured Rock.

Bernard H. Kueper, Queens University; Neil Thomson, University of Waterloo.

DNAPLs are common ground-water contaminants in fractured bedrock at many sites throughout North America and Europe. We invite numerical simulation studies, laboratory methods, and case histories focused on DNAPL migration in fractures, DNAPL dissolution, biotic and abiotic transformations, matrix diffusion, remediation methods, and site characterization. ORAL.

Computers (3), Environmental Geology (6), Hydrogeology (13).

T33 Theoretical Molecular Methods in Earth Sciences.

Antonio C. Lasaga, Yale University; David J. Wesolowski, Oak Ridge National Laboratory.

This session will provide a forum for presentation of recent results on the application of various molecular computational approaches, including ab initio or density function methods, and collective behavior treatments such as Monte Carlo and molecular dynamics simulations, to geochemical, geophysical, materials science, and atmospheric processes. ORAL.

Computers (3), Geochemistry, Aqueous (7), Paleoceanography/Paleoclimatology (17).

T34 Applications of Plant Taphonomy to Paleoenvironmental, Paleogeographic, and Paleoclimatic Problems.

Judith Totman Parrish, University of Arizona; Robert A. Gastaldo, Auburn University.

Plant taphonomy has broad applications for reconstructing paleoclimates and paleogeography and for detailed paleoenvironmental analysis. These applications both enhance and, sometimes, conflict with each other. This theme session will provide an opportunity for geologists to evaluate the strengths and limitations of plant taphonomic methods. ORAL.

Paleoceanography/Paleoclimatology (17), Paleontology/Paleobotany (18), Sediments, Clastic (29).

T35 Volcanic Eruptions: From the Deep Oceans to Deep Space.

James Zimbelman, Smithsonian Institution; Tracy Gregg, Woods Hole Oceanographic Institution.

Volcanism is a fundamental process that has modified all solid surfaces in the solar system. Unique environments, ranging from the seafloor on Earth to a vacuum on the Moon, and different eruptive materials influence the emplacement and morphology of volcanic landforms. This session explores volcanic eruptions in these diverse environments. ORAL.

Planetary Geology (23), Volcanology (33).

T36 The Galilean Satellites: Exploring Their Connections.

Planetary Geology Division. Robert Pappalardo, Brown University; Robert Sullivan, Arizona State University.

Galileo data are revealing astounding differences among the geologies of Jupiter's Galilean satellites. This session explores common links among these diverse moons, which might include composition, internal evolution, volcanism, tectonics, cratering, or other characteristics. Through examination of their commonalities, the striking differences among these worlds can be better understood. ORAL.

Geophysics/Tectonophysics (10), Planetary Geology (23), Remote Sensing (27).

T37 Volatiles in Planetary Mantles and Basalts.

Mineralogical Society of America and *Planetary Geology Division.* Charles K. Shearer, University of New Mexico; Clive R. Neal, University of Notre Dame.

Volatiles influence every aspect of magmatism. What roles do volatiles play in magmatic systems in different planetary environments? This session focuses upon: abundance and behavior of volatiles in basalts from the Earth, Moon, Mars, and asteroids, the influence volatiles have on planetary processes, and the volatile content of planetary mantles. ORAL.

Geochemistry, Other (8), Petrology, Igneous (21), Planetary Geology (23).

T38 The Southern Laurentian Late Proterozoic: What Happened?

M. Charles Gilbert, Oklahoma University; Kent C. Nielson, University of Texas at Dallas; W. Randall van Schmus, University of Kansas.

The southern margin of Laurentia in the late Proterozic is poorly constrained geographically, in its geologic history, and in formative tectonic and magmatic processes. This theme session will focus on geochemical and geophysical evidence defining plate boundaries, magma source regions, and tectonism operative during the rifting and collisional events. POSTER.

Geophysics/Tectonophysics (10), Petrology, Igneous (21), Precambrian Geology (24).

T39 The Geosciences in Context: Values, Sustainability, Culture, and Curricula.

Institute for Environmental Education. Paul H. Reitan, SUNY, College at Buffalo; Robert Frodeman, Fort Lewis College; Trileigh Stroh, Seattle University.

The earth sciences today find their work inescapably linked to a larger cultural context. How are we to integrate science and values? What values are implicit within the scientific enterprise itself? What implications does an earth science perspective have for ethics, politics, sustainability, economics, and other

Organ Rock Shale, Southeast Utah.. Photo by Martin Miller.

aspects of our culture? ORAL.

Environmental Geology (6), Geology Education (9), Public Policy (25).

T40 The Sustainability Challenge: A Problem in Geoscience Communication.

GSA Ad Hoc Committee on Critical Issues and *Institute for Environmental Education.* Allison R. Palmer, Cambrian Studies, Boulder, Colorado.

The challenge of attaining global sustainability is often misunderstood by the public and policy makers, because these communities lack knowledge about fundamental geoscientific concepts. This session explores how successful communication of such concepts through dialogue with nonscientists can catalyze public understanding about sustainability and help to stimulate effective social action. ORAL.

Geology Education (9), Public Policy (25).

T41 Natural Background Chemistry and Environmental Decision-making.

Institute for Environmental Education and *International Association of Geochemistry and Cosmochemistry.* Donald D. Runnells and Georgia A. Doyle, Shepherd Miller, Inc., Ft. Collins, Colorado.

The characterization of natural background chemistry affects decision-making in such areas as regulatory affairs, agriculture, epidemiology, risk assessment, water supply, and geochemical exploration. Regulatory and environmental decisions that fail to consider natural background chemistry run the risk of being seriously flawed. This session will bring together people from disciplines and sectors that have a stake in characterizing natural background chemistry. ORAL.

Environmental Geology (6), Geochemistry, Aqueous (7), Public Policy (25).

T42 Geomorphology in Drylands.

Nicholas Lancaster, Desert Research Institute; Steve Reneau, Los Alamos National Laboratory.

New paradigms and techniques that include dating of landforms and surfaces, detailed measurements of processes, and reconstruction of responses of landforms to climate change are changing our view of the dynamics of geomorphic processes in drylands. This session will highlight recent developments in this fast-evolving field of geomorphology. ORAL.

Quaternary Geology/Geomorphology (26), Remote Sensing (27).

T43 The Bonneville Lake Basin from a Global Perspective.

Charles G. (Jack) Oviatt, Kansas State University; Marjorie A. Chan, University of Utah.

This session focuses on new research concerning the Bonneville basin and other hydrologically closed lake basins aimed at understanding regional and global environmental (biosphere-geosphere) dynamics. We especially welcome studies of global linkages of climate, hydrology, stratigraphy, sedimentology, geomorphology, chemistry, and biology, covering time scales of ten to a million years. ORAL.

Quaternary Geology/Geomorphology (26), Sediments, Carbonates (28).

T44 Great Basin Aquatic Geology.

Smithsonian Institution, Utah Geological Survey and *Utah Museum of Natural History.* Donald R. Currey, University of Utah; David B. Madsen, Utah Geological Survey.

This theme session focuses on recent progress in reconstructing the late Tertiary and Quaternary history of Great Basin lakes, marshes, and rivers made using stratigraphy, sedimentology, geochemistry, paleontology, paleolimnology, paleohydrology, paleoclimatology, geochronology, geomorphology, geophysics, and neotectonics. ORAL.

Quaternary Geology/Geomorphology(26), Sediments, Clastic (29), Stratigraphy (30).

T45 Environmental Impacts on Western Rivers.

Institute for Environmental Education and *Quaternary Geology and Geomorphology Division.* Ellen Wohl, Colorado State University.

Human activities in the western United States have impacted rivers since beaver trapping in the early 1800s. Activities within the watershed (lumbering, agriculture) and within the channel (placer mining, flow diversion) alter the movement of water and sediment, causing adjustments in channel morphology. This session addresses the regional cumulative impacts of human activities. ORAL.

Quaternary Geology/Geomorphology (26).

T46 Arroyos: Hydroclimatology, Quaternary Geology, and Riverine Processes.

Quaternary Geology and Geomorphology Division. Robert H. Webb, U.S. Geological Survey, Tucson; Richard Hereford, U.S. Geological Survey, Flagstaff.

Arroyos deeply incised into alluvial fill have long been studied by geomorphologists and archaeologists for their implications for Quatarnary paleoclimatology, paleohydrology, stratigraphy, and human habitations. Now, arroyos are managed for wetlands, flood mitigation, and land use. This session explores current interpretations of arroyo cutting and filling and future stability of these landforms. ORAL.

Archaeological Geology (1), Engineering Geology (5), Environmental Geology (6).

T47 Influence of Geomorphic Processes on Biological Communities.

Institute for Envrionmental Education and *Quaternary Geology and Geomorphology Division.* Karen L. Prestegaard, University of Maryland.

Recent collaborative research indicates the importance of geologic processes to biological communities. This research is important for ecosystem management. Examples of these interactions include the effects of river flow regimes on benthic and fish communities, associations among wetland species and hydrological conditions, and the relationships among hillslope processes and forest ecosystems. This theme session will highlight these and many other collaborative research projects. ORAL.

Environmental Geology (6), Hydrogeology (13), Quaternary Geology/Geomorphology (26).

T48 Feedbacks Between Tectonic and Surface Processes in Orogenesis.

Nicholas Pinter, Southern Illinois University; Douglas Burbank, University of Southern California.

Recent models of mountain-range development hypothesize that orogenesis is a dynamic system responding to powerful feedbacks among tectonics, topography, and erosion. Growing evidence suggests that, in some settings, climate and surface processes may influence topographic and orogenic development as significantly as do tectonic processes. ORAL.

Quaternary Geology/Geomorphology (26), Structural Geology (31), Tectonics (32).

T49 Advances in Deciphering and Modeling Stratigraphic and Depositional Processes of Paleozoic Basins.

Sedimentary Geology Division. Roy D. Adams, University of Utah.

Recent advances in understanding stratigraphic and depositional processes provide new insights into the evolution of sedimentary basins. Application of new process-related concepts—e.g., sequence stratigraphy, process-oriented sedimentology, and computer-modeling—to Paleozoic basins clarifies the interactions of tectonics and eustasy in basin evolution, allows more accurate paleogeographic reconstructions, and revises correlations. ORAL.

Sediments, Carbonates (28), Sediments, Clastic (29), Stratigraphy (30).

T50 Unexplored Microbial Worlds: Evidence from Occurrences of Unique Microbial Sedimentary Structures.

Sedimentary Geology Division. James W. Hagadorn, University of Southern California; Friedrich Pflueger, Yale University; David J. Bottjer, University of Southern California.

Low levels of grazing and bioturbation mediated the preservation of microbial sedimentary structures in the Precambrian. This session will focus on heretofore little-studied Precambrian microbial structures, such as those formed in siliciclastic environments, as well as microbial structures that are restricted to unique marine settings in the Phanerozoic. ORAL.

Paleontology/Paleobotany (18), Sediments, Carbonates (28), Sediments, Clastic (29).

T51 Origin of Mudrocks: Modern Processes and Ancient Examples.

Sedimentary Geology Division. Stephen C. Knowles, University of North Carolina, Chapel Hill; Donald Winston, University of Montana.

Fine-grained sedimentation process research in the past few decades has produced information that could radically change interpretation of mudrock paleoenvironments. This session on modern fine-grained sedimentation and studies of mudrock deposits will provide a forum for discussion between these two, often independent, research communities. ORAL.

Marine Geology (14), Paleoceanography/Paleoclimatology (17), Sediments, Clastic (29).

T52 Impact Deposits in the Sedimentary Record.

Sedimentary Geology Division. Scott W. Hassler, California State University, Hayward; Philippe Claeys, Museum für Naturkunde, Berlin, Germany.

Bolide impacts produce distinctive traces in the sedimentary record: ejecta, tsunami, landslide, and coarse or brecciated deposits. Few such layers are known in comparison with the cratering record; criteria for their identification remain unclear. This session focuses on the search for and description, interpretation, and modeling of sedimentary units related to impact events. ORAL.

Planetary Geology (23), Sediments, Clastic (29), Stratigraphy (30).

T53 New Perspectives on Neoproterozoic Earth History.

Sedimentary Geology Division. Nicholas Christie-Blick, Lamont-Doherty Earth Observatory.

The Neoproterozoic interval (1 Ga to 543 Ma) is one of the most remarkable in the history of our planet. This theme session will draw attention to recent advances in our understanding of the tectonics, ancient climates, paleobiology, paleoenvironments, ocean chemistry, and geochronology of this span. Interdisciplinary papers are encouraged. ORAL.

Precambrian Geology (24), Stratigraphy (30), Tectonics (32).

T54 Records of Paleoclimate and Tectonic Evolution of Continental Interiors: Latest Results from Scientific Drilling and Coring.

Douglas F. Williams and Eugene Karabanov, University of South Carolina; John King, University of Rhode Island.

Scientific drilling in lacustrine basins of continental interiors offers exciting prospects for understanding the interplay between tectonic and paleoclimatic processes during the Cenozoic. Latest results will be presented from multinational scientific drilling in lacustrine basins of central Asia (Baikal Drilling Project) as well as from other continental interiors. ORAL.

Paleoceanography/Paleoclimatology (17), Stratigraphy (30), Tectonics (32).

T55 Deformation Styles, Stacking Patterns, and Stratigraphic Consequences in Foreland Basins.

Peter Schwans, Exxon Exploration Company, Houston, Texas.

Much work has been completed on the relationship of sequence stratigraphy, base level change, and their architectural expression in foreland basin successions. Abundant concerns exist regarding how to distinguish observed stratal patterns generated by tectonism and/or eustasy. This session will discuss the evidence for the interplay of both forcing factors. ORAL.

Sediments, Clastic (29), Stratigraphy (30), Tectonics (32).

T56 The Geologic Record of Three-dimensional Strains in Extended Continental Crust.

Susanne U. Janecke, Utah State University; Kathi K. Beratan, University of Pittsburgh.

Extension of the continental crust is controlled by three-dimensional strains and by strain rates; changes in these variables are reflected in changes in structural and sedimentological patterns. We invite contributions that integrate tectonics, structural geology, and sedimentology, particularly those that document and interpret along-strike variations of rifts and extensional basins. ORAL.

Sediments, Clastic (29), Structural Geology (31), Tectonics (32).

T57 Processes and Mechanics of Fault Nucleation and Growth.

James P. Evans, Utah State University; Ronald L. Bruhn, University of Utah; Atilla Aydin, Stanford University.

This session will bring together field, laboratory, and theoretical treatments of the processes of faulting, including nucleation, propagation, and interaction (segmentation and linkage), to address the evolution of fault zones and their geometrical and physical properties. ORAL and POSTER.

Geophysics/Tectonophysics (10), Structural Geology (31), Tectonics (32).

Salt evaporators, Great Salt Lake. Photo by Martin Miller.

T58 Triassic–Jurassic Structural and Stratigraphic Record of Cordilleran Tectonics: Linking Processes from the Active Margin to the Colorado Plateau.

Structural Geology and Tectonics Division and *Sedimentary Geology Division.* Ronald C. Blakey, Northern Arizona University; Tim Lawton, New Mexico State University; Sandra Wyld, University of Georgia; James Wright, Rice University.

The Triassic-Jurassic of western North America marks initiation of the Cordilleran margin followed by protracted orogenesis. Understanding this critical time of tectonic evolution hinges on linking relations from deformed arc terranes to the undeformed Colorado Plateau. We seek abstracts focusing on stratigraphic and structural relations, paleogeographic reconstructions, and tectonic models. ORAL and POSTER.

Sediments, Clastic (29), Stratigraphy (30), Tectonics (32).

T59 Iapetus Ocean, Its Birth, Life, and Death: The Wilson Cycle.

Geophysics Division, International Division, Structural Geology and Tectonics Division, Paleontological Society; in association with *International Geological Correlation Program, Project 376.* Ian W. D. Dalziel, University of Texas, Austin; Mary Droser, University of California, Riverside; Kenneth P. Kodama, Lehigh University.

Understanding geography, tectonics, and environments of the biologically critical latest Precambrian–early Paleozoic time interval particularly depends on the relations between Laurentia, Baltica, and South America around the Iapetus Ocean basin. Recently an alternative to the classic Wilson cycle has been proposed, prompting a reevaluation of this interdisciplinary problem. Volunteered presentations are sought to complement and expand upon the invited presentations in the symposium on this topic. ORAL.

Geophysics/Tectonophysics (10), Paleontology/Paleobotany (18), Tectonics (32).

T60 Extreme Continental Extension: Examples from Around the World and New Insights from Quantitative Modeling.

International Division. Gabor C. Tari, AMOCO, Houston, Texas; Richard A. Ketcham, University of Texas at Austin.

Some of the fundamental problems associated with extreme continental extension remain unsolved. Although many of these questions have been defined in the western United States, a global perspective is important for separating regional aspects from shared crustal-scale processes. Quantitative modeling of specific localities worldwide helps us identify these commonalities and judge between competing models. ORAL.

Geophysics/Tectonophysics (10), Structural Geology (31), Tectonics (32).

T61 Advances of the Neotectonics in Latin America.

Juan-Carlos Moya, University of Colorado at Boulder; Carlos Costa, Universidad Nacional de San Luis.

This theme session is dedicated to the memory of Carlos Schubert. We invite scientists from Latin America and elsewhere to present new data related to regional styles and geometry of deformation, slip rates, and other quantitative data on the neotectonics of Latin America. ORAL.

Geophysics/Tectonophysics (10), Structural Geology (31), Tectonics (32).

T62 The Coast Shear Zone (Southeastern Alaska and British Columbia), Fundamental Crustal Feature.

Lincoln S. Hollister, Princeton University; John B. Diebold, Lamont-Doherty Earth Observatory.

The Coast shear zone is over 800 km long. Was it the eastern boundary of the Kula plate and thus the exhumed root of a major transcurrent plate boundary? Or was it a postaccretion

response of the lithosphere to changes of relative plate motions? Or a combination? ORAL.
Geochemistry, Other (8), Geophysics/Tectonophysics (10), Structural Geology (31).

T63 Cenozoic Tectonic Evolution of Northern Tibet.

Erich Cowgill, University of California, Los Angeles; Peter Rumelhart, University of California, Los Angeles.

Two modes of Cenozoic deformation in response to the Indo-Asian collision are expressed in northern Tibet: (1) thin-skinned thrusting and intracontinental subduction accommodating north-south shortening, and (2) strike-slip faulting accommodating extrusion. By integrating recent structural, paleomagnetic, geodetic, thermochronologic, and neotectonic investigations, this session will provide new insights into intracontinental deformation related to continental collision. ORAL.
Geophysics/Tectonophysics (10), Quaternary Geology/Geomorphology (26), Tectonics (32).

T64 Paleozoic Tectonics of Western China and Adjacent Areas of Central Asia.

K. D. Apperson, and Robert Ressetar, University of Utah.

Central Asia is a tectonically complex association of lithospheric blocks and shear zones. The recent availability of field and subsurface data from petroleum-producing basins permits us to examine the numerous models advanced for the Paleozoic tectonic history of this area and its role in hydrocarbon and economic mineral occurrences. ORAL.
Stratigraphy (30), Structural Geology (31), Tectonics (32).

T65 Advances in the Geology of Mexico.

José Longoria, Florida International University; Dante J. Moran-Zenteno, Universidad Nacional Autónoma de México; Rogelio Monreal, Universidad de Sonora.

This theme session aims at gathering talks that would view the geology of Mexico in an interdisciplinary framework that would reflect our current understanding of the role that this region plays in making global connections. Geoscientists from all over the world are encouraged to participate irrespective of their field of study. ORAL.
Economic Geology (4), Stratigraphy (30), Tectonics (32).

Special Session

Mars Pathfinder Lander and Rover Mission First Results: Field Geology on Mars

Tuesday, October 21, evening session.
Larry Crumpler, New Mexico Museum of Natural History and Science; Matthew Golombek, Mars Pathfinder Mission Scientist, Jet Propulsion Laboratory

Field geologic studies of Mars will be conducted for the first time this summer by the Mars Pathfinder lander and rover. Mars Pathfinder, launched last December, will land at the mouth of Ares Vallis, an ancient river channel that once drained the highlands of Mars. Imaging and in situ chemical analysis of rocks and soils during the traverse will reveal a new world. This session will present some of the first publicly discussed results from the perspective of mission scientists.

Field Trips

The 1997 GSA Annual Meeting will have a fascinating slate of field trips. Salt Lake City is surrounded by diverse geologic provinces, where abundant recent research has been conducted. As this meeting emphasizes Global Connections, we will be ready with field trips that will be of interest to geoscientists from all disciplines and all parts of the world.

All pre- and postmeeting field trips are technical in nature, one to five days in duration, and led by active field researchers. Professionals and students are strongly encouraged to take advantage of these offerings; lower airfares on Saturday night stay-over flights can reduce the costs associated with field-trip participation significantly.

All trips begin and end in Salt Lake City unless otherwise indicated.

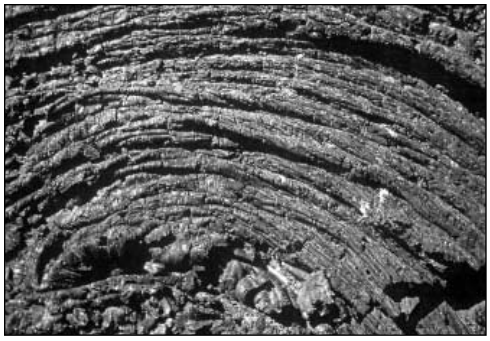
Please note that several of the premeeting field trips, indicated by an asterisk (*), end in Salt Lake City on Saturday night, October 18, so that participants can attend one-day trips or courses on Sunday, October 19.

For more information, contact the trip leader or 1997 Field Trip Co-Chairs: Bart Kowallis, Dept. of Geology, Brigham Young University, P.O. Box 24646, Provo, UT 84602-4646, (801) 378-2467, fax 801-378-8143, bkowallis@byu.edu; or Paul Link, Dept. of Geology, Idaho State University, Pocatello, ID 83209-8072, (208) 236-3846, fax 208-236-4414, linkpaul@isu.edu.

The following list of trips and estimated costs is tentative and subject to change. Further details will be given when registration begins in June.

Pre-Meeting Trips

Late Pleistocene–Holocene Cataclysmic Eruptions at Nevado de Toluca and Jocotitlan Volcanoes, Central Mexico. Tuesday, October 14 through Saturday, October 18. Jose Luis Macias, Instituto de Geofísica, UNAM, Coyoacan 04510, Mexico D.F., Mexico, (52)-5-6224124, macias@tonatiuh.igeofcu. unam.mx; Juan Manuel Espindola Castro, Claus Siebe. This trip originates and ends in Mexico City. Maximum: 22. Cost: $370.



Pahoehoe basalt. Snake River Plain, Idaho. Photo by Martin Miller.

Late Devonian Alamo Impact Event, Global Kellwasser Events, and Major Eustatic Events, Eastern Great Basin, Nevada and Utah. Thursday, October 16 through Sunday, October 19. Charles A. Sandberg, U. S. Geological Survey, Box 25046, MS 939, Federal Center, Denver, CO 80225, (303) 236-5763; John E. Warme and Jared R. Morrow. This trip originates in Las Vegas, and ends in Salt Lake City. Maximum: 40. Cost: $370.

Grand Tour of the Ruby–East Humboldt Metamorphic Core Complex, Northeast Nevada. Thursday, October 16 through Sunday, October 19. Arthur W. Snoke, Dept. of Geology and Geophysics, University of Wyoming, Laramie, WY 82071-3006, (307) 766-5457, fax 307-766-6679, snoke@uwyo.edu; Keith A. Howard, Calvin G. Barnes, Allen McGrew, Brad Burton, Mark Peters, and James E. Wright. Maximum: 40. Cost: $285.

**** Late Ordovician Mass Extinction and Glacio-eustasy—Sedimentologic, Biostratigraphic, and Chemostratigraphic Records from Shelf and Basin Successions, Central Nevada.*** Thursday, October 16 through Saturday, October 18. Cosponsored by *Paleontological Society*. Stan Finney, Dept. of Geological Sciences, California State University—Long Beach, Long Beach, CA 90840, (310) 985-8637, scfinney@csulb.edu; John Cooper and William Berry. Maximum: 30. Cost: $220.

Fiery Furnace, Arches National Park. Photo by John Karachewski.

**** Neotectonics, Fault Segmentation, and Geologic Hazards Along the Hurricane Fault in Utah and Arizona.*** Thursday, October 16 through Saturday, October 18. Cosponsored by *Engineering Geology Division*. Meg Stewart, Dames & Moore, One Blue Hill Plaza, Suite 530, Pearl River, NY 10965, (914) 735-1200; Wanda J. Taylor, Philip Pearthree, Barry Solomon, Hugh Hurlow. This trip originates in Las Vegas and ends in Salt Lake City. Maximum: 26. Cost: $235.

**** Regional Geology of Southeastern Utah, Emphasizing National Parks.*** Thursday, October 16 through Saturday, October 18. Lehi F. Hintze, Dept. of Geology, Brigham Young University, Provo, UT 84602-5111, (801) 378-3918; Hellmut H. Doelling. Maximum: 45. Cost: $230.

**** Sequence Stratigraphy in a Classic Area: Evolution of Fluvial to Marine Architecture in Response to Tectonism and Eustasy, Cretaceous Foreland Basin, Utah.*** Thursday, October 16 through Saturday, October. 18. Cosponsored by *Exxon Production Research Company*. Peter Schwans, Exxon Production Research Company, P.O. Box 2189, Houston, TX 77252, (713) 965-7299, fax 713-965-4114, Peter.Schwans@Exxon.sprint.com; Kirt M. Champion. Maximum: 31. Cost: $240.

**** Stratigraphy and Structure of Sevier Thrust Belt and Proximal Foreland-Basin System in Central Utah: A Transect from the Sevier Desert to the Wasatch Plateau.*** Thursday, October 16 through Saturday, October 18. Cosponsored by *Sedimentary Geology Division*. Timothy Lawton, Dept. of Geological Sciences, New Mexico State University, Las Cruces, NM 88003, (505) 646-4910, tlawton@nmsu.edu; Douglas Sprinkel, Peter DeCelles, Gautam Mitra, Aviva Sussman. Maximum: 29. Cost: $240.

Bimodal Magmatism, Basaltic Volcanic Styles, and Tectonomagmatic Evolution of the Eastern Snake River Plain, Idaho. Friday, October 17 through Sunday, October 19. Scott Hughes, Dept. of Geology, Idaho State University, Box 8072, Pocatello, ID 83209, (208) 236-4387, fax 208-236-4414, hughscot @isu.edu; Richard P. Smith, Steve Anderson. Maximum: 22. Cost: $255.

50th Anniversary of the Discovery of the Ghost Ranch Coelophysis Quarry. Friday, October 17 through Sunday, October 19. David D. Gillette, Utah Geological Survey, P.O. Box 146100, Salt Lake City, UT 84114-6100, (801) 537-3307, fax 801-537-3400, nrugs.dgillett@ state.ut.us; Barry Goldstein, J. Lynett Gillette. Maximum: 30. Cost: $255.

Neoproterozoic Sedimentation and Tectonics in West-Central Utah. Friday, October 17 through Sunday, October 19. Nicholas Christie-Blick and Linda Sohl, Lamont-Doherty Earth Observatory, P.O. Box 1000, Route 9W, Palisades, NY 10964, (914) 365-8546, fax 914-365-2312, ncb@ldgo.columbia.edu. This trip will spend Sunday morning in Big Cottonwood Canyon with the participants of the Proterozoic Tidal Glacial, and Fluvial Sedimentation in Big Cottonwood, Utah trip led by Todd A. Ehlers. Maximum: 20. Cost: $270.

**** New Explorations Along the Northern Shores of Lake Bonneville.*** Friday, October 17 and Saturday, October 18. Charles G. (Jack) Oviatt, Dept. of Geology, Kansas State University, Manhattan, KS 66506, (913) 532-6724, fax 913-532-5159, joviatt@ksu.edu; D. M. Miller. Maximum: 31. Cost: $140.

Structure and Kinematics of a Complex Crater, Upheaval Dome, Canyonlands National Park, Utah. Saturday, October 18 and Sunday, October 19. Ken Herkenhoff, Jet Propulsion Laboratory, MS 183-501, California Institute of Technology, 4800 Oak Grove Drive, Pasadena, CA 91109-8099, (818) 354-3539, fax 818-354-0966, ken.e.herkenhoff@ jpl.nasa.gov; Bryan Kriens, Eugene Shoemaker. Maximum: 43. Cost: $150.

One-Day Premeeting Trips

Saturday, October 18

**** Geochemistry and Hydrology of the Great Salt Lake.*** Cosponsored by *Hydrogeology Division*. Briant Kimball, U.S. Geological Survey, 1745 West 1700 South, Room 1016, Salt Lake City, UT 84104, fax 801-975-3424, bkimball@ usgs.gov; Blair Jones, Kidd Waddell. Maximum: 80. Cost: $50.

Sunday, October 19

Examination of Fault-related Rocks of the Wasatch Normal Fault. James P. Evans, Dept. of Geology, Utah State University, Logan, UT 84322; (801) 797-1273, fax 801-797-1588, jpevans@ cc.usu.edu; W. Adolph Yonkee, Ron Bruhn, William Parry. Maximum: 33. Cost: $50.

Geologic Hazards of the Wasatch Front. Cosponsored by *Engineering Geology Division*. Michael Hylland, Bill Black, Mike Lowe, Utah Geological Survey, P.O. Box 146100, Salt Lake City, UT 84114-6100, (801) 537-3382, fax 801-537-3400, nrugs.mailid.mhylland@state.ut.us. Maximum: 42. Cost: $55.

Lake Bonneville Classic Depositional Shore Features: Geochronology, Geomorphology, Stratigraphy, and Sedimentology. Derald Smith, Dept. of Geography, University of Calgary, Calgary, Alberta, T2N 1N4, Canada, (403) 220-6191; Donald Currey, Charles G. (Jack) Oviatt. Maximum: 52. Cost: $60.

Sequence Stratigraphy and Paleoecology of the Middle Cambrian Spence Shale in Northern Utah and Southern Idaho. W. David Liddell and Scott H. Wright, Dept. of Geology, Utah State University, Logan, UT 84322-4505, (801) 797-1261, davel@cc.usu.edu; Carlton E. Brett. Maximum: 39. Cost: $60.

Proterozoic Tidal, Glacial, and Fluvial Sedimentation in the Big Cottonwood Canyon, Utah. Todd A. Ehlers and Marjorie A. Chan, Dept. of Geology and Geophysics, University of Utah, Salt Lake City, UT 84112, (801) 581-6553, taehlers@mines.utah.edu and machan@mines.utah.edu; Paul Karl Link. This trip will spend Sunday morning in Big Cottonwood Canyon with the participants of the Neoproterozoic Sedimentation and Tectonics in West-Central Utah trip led by Nicholas Christie-Blick. Maximum: 42. Cost: $55.

Half-Day Trip

Concurrent with the Meeting

Bedrock Geology of the Snyderville Basin. Wednesday afternoon, October 22. Cosponsored by *Engineering Geology Division*. James P. Evans, Dept. of Geology, Utah State University, Logan, UT 84322, (801)797-1273, fax (801)797-1588, jpevans@cc.usu.edu; Frank Ashland, Kelly Keighley, W. Adolph Yonkee. Maximum: 33. Cost: $30.

Postmeeting Trips

Bimodal Basalt-Rhyolite Magmatism in the Central and Western Snake River Plain, Idaho and Oregon. Thursday, October 23 through Sunday, October 26. Michael McCurry, Idaho State University, Dept. of Geology, P. O. Box 8072, Pocatello, ID 83209, (208) 236-3960, mccumich@fs.isu.edu; Bill Bonnichsen, Craig White. This trip originates in Salt Lake City and ends at the Twin Falls, Idaho, airport, or in Salt Lake City. Maximum: 30. Cost: $275.

Carbonate Sequences and Fossil Communities from the Upper Ordovician–Lower Silurian of the Eastern Great Basin. Thursday, October 23 through Sunday, October 26. Mark Harris, Dept. of Geosciences, University of Wisconsin—Milwaukee, P.O. Box 413, Milwaukee, WI 53201, (414) 229-5777, mtharris@csd.uwm.edu; Peter Sheehan. Maximum: 31. Cost: $235.

Depositional Sequence Stratigraphy and Architecture of the Cretaceous (Turonian) Ferron Sandstone: Implications for Coal and Coal Bed Methane Resources. Thursday, October 23 through Saturday, October 25. Cosponsored by *Coal Geology Division*. James Garrison, The Ferron Group Consultants, L.L.C.,

Paria Canyon Primitive Area. Photo by John Karachewski.

117 South 200 East, Emery, UT 84522-0117, (801) 286-2377, ferron_group@compuserve.com; T.C.V. van den Bergh, Charles E. Barker, David Tabet. Maximum: 30. Cost: $205.

Extensional Faulting, Footwall Deformation and Plutonism in the Mineral Mountains, Southern Sevier Desert. Thursday, October 23 through Sunday, October 26. Drew S. Coleman, Dept. of Earth Sciences, Boston University, 675 Commonwealth Avenue, Boston, MA 02215, (617) 353-5511, dcoleman@bu.edu; J. Douglas Walker, John M. Bartley, David E. Price. Maximum: 24. Cost: $230.

Fluvial-Deltaic Sedimentation and Stratigraphy of the Ferron Sandstone. Thursday, October 23 through Saturday, October 25. Cosponsored by *Sedimentary Geology Division*. Paul B. Anderson, Consulting Geologist, 807 E. South Temple, Suite 101, Salt Lake City, UT 84102, (801) 364-6613; Thomas C. Chidsey, Jr., nrugs.tchidsey@email.state.ut.us. Maximum: 20. Cost: $195.

Hinterland to Foreland Transect through the Sevier Orogen, Northeast Nevada to Southwest Wyoming: Structural Style, Metamorphism, and Kinematic History of a Large Contractional Orogenic Wedge. Thursday, October 23 through Sunday, October 26. Phyllis Camilleri, Dept. of Geology and Geography, Austin Peay State University, Clarksville, TN 37044, (615) 648-7454, camillerip@apsu01.apsu.edu; Jim Coogan, Peter DeCelles, Allen McGrew, Michael Wells, W. Adolph Yonkee. Maximum: 29. Cost: $315.

Quaternary Geology and Geomorphology, Northern Henry Mountains. Thursday, October 23 through Saturday, October 25. Cosponsored by *Engineering Geology Division* and *Quaternary Geology and Geomorphology Division*. Ben Everitt, Utah Division of Water Resources, Box 146201, Salt Lake City, UT 84114-6201, (801) 538-7282, nrwes.beveritt@state.ut.us; Bob Anderson, Alan Howard, Andy Godfrey. Maximum: 19. Cost: $245.

Triassic and Jurassic Macroinvertebrate Faunas of Utah: Field Relationships and Paleobiologic Significance. Thursday, October 23 through Saturday, October 25. Cosponsored by *Paleontological Society*. Carol M. Tang, University of California Museum of Paleontology, Valley Life Sciences Bldg., University of California, Berkeley, CA 94720, (510) 642-8690, carolt@ucmp1.berkeley.edu; David J. Bottjer. Maximum: 21. Cost: $195.

Triassic-Jurassic Tectonism and Magmatism in the Mesozoic Continental Arc of Nevada: Classic Relations and New Developments. Thursday, October 23 through Sunday, October 26. Sandra Wyld, Dept. of Geology, University of Georgia, Athens, GA, 30602, (706) 542-2652, swyld@gly.uga.edu; James E. Wright. This trip originates and ends in Reno, Nevada. Maximum: 20. Cost: $275.

High, Old, Pluvial Lakes of Western Nevada. Friday, October 24 through Sunday, October 26. Marith Reheis, U.S. Geological Survey, MS980, Federal Center, Box 25046, Denver, CO 80225, (303) 236-1270, mreheis@greenwood.cr. usgs.gov; Roger Morrison. This trip originates and ends in Reno, Nevada. Maximum: 22. Cost: $205.

Lower to Middle Cretaceous Dinosaur Faunas of the Central Colorado Plateau: A Key to Understanding 35 Million Years of Tectonics, Sedimentology, Evolution and Biogeography. Friday, October 24 through Sunday, October 26. Jim Kirkland, Dinamation International Society, 550 Jurassic, Fruita, CO 81521, (970) 858-7282, dis@gj.net; Brooks Britt, Donald Burge, Frank De Courtin, Tim Lawton. This trip originates in Salt Lake City and offers participants the option of ending in Grand Junction, Colorado, on Sunday, October 26 or in Salt Lake City on Monday, October 27. Maximum: 40. Cost: $240.

Mississippian Stratigraphy and Paleotectonics of the Antler Foreland, Eastern Nevada and Western Utah. Friday, October 24 through Sunday, October 26. N. J. Silberling, 1235 Estes St., Lakewood, CO 80215, (303) 233-4551, slbrlng@msn.com; J. H. Trexler, Jr., K. M. Nichols, P. W. Jewell. Maximum: 20. Cost: $300.

Sponsored by Association for Women Geoscientists

Antelope Island, the Great Salt Lake, and Ancient Lake Bonneville. Sunday, October 19. Genevieve Atwood. For information: Sandy Eldredge, Perspectives, P.O. Box 521788, Salt Lake City, UT 84151-1788, (801) 537-3325, nrugs.seldredge@state.ut.us. Cost: $50, includes transportation and lunch.

Sponsored by Society of Economic Geologists

Geology and Ore Deposits of the Oquirrh and Wasatch Mountains, Utah, with Visits to the Bingham, Melco, and Mercur Mines. Thursday, October 23 through Saturday, October 25. Geoffrey H. Ballantyne, Manager of Geological Services, Kennecott Utah Copper, P.O. Box 192, Bingham Canyon, UT 84006, (801) 569-7361, fax 801-569-7365; David John, U.S. Geological Survey, (415) 329-5490. Maximum: 55. Minimum: 30. Cost: $150, includes guidebook and lunches. Contact trip leaders for information.

Special Events

Preliminary List of Evening Activities

Look for detailed descriptions and pricing information in the June issue of *GSA Today*.

- **Saturday, October 18**
  Salt Lake City Theatre and Dinner
  Tour of Local Micro Brewery
- **Sunday, October 19**
  Welcoming Party
  (meeting registration required)
  Dinner and Behind the Scenes Tour—
  Utah Museum of Natural History
- **Monday, October 20**
  GSA Presidential Address & Awards
  Alumni Receptions
- **Wednesday, October 22**
  B'earthday Celebration

Fun Run

John Bartley of the University of Utah is organizing a casual run tentatively scheduled for Wednesday, October 22. There will not be a formal sign-up for this event. Further information will follow in June.

GSA Goes Global!

International Surveys Invited for '97 Meeting

Join Us For This International Event

- The Salt Lake City Organizing Committee has invited geologists from national geological surveys around the globe to participate in an international program in conjunction with the 1997 Annual Meeting.
- The program will include a technical poster session on global geology, exhibits on new geological or environmental developments in various countries, and a hosted reception that will be attended by your international colleagues, program sponsors, business and industry representatives, and government officials.

Here's an opportunity to meet and talk geology with your colleagues from around the world.

Be Part of the World That's Coming to Salt Lake City!

Sponsored by: GSA International Division, U.S. Geological Survey, Association of American State Geologists, U.S. Department of Energy, and State of Utah.
Corporate sponsorship is available.
For more information please contact Diane Conrad, Chair of the International Program Committee, (801) 799-2160 or E-mail 103046.1313@compuserve.com.

Professional Horizons: Continuing Education Programs

GSA -Sponsored Continuing Education Courses

Registration information and course descriptions will be published in June GSA *Today*. For additional information, contact Edna Collis, Continuing Education Coordinator, GSA headquarters, ecollis@geosociety.org, or see GSA's Web site, www.geosociety.org.

Fees will be approximately $150–$175 for the first day and $125–$150 for the second day. Students will receive a discount on all GSA courses.

Analysis of Veins in Sedimentary Rocks—An Introduction for Structural Geologists. Saturday, October 18 and Sunday, October 19. Cosponsored by *Structural Geology and Tectonics Division*. David V. Wiltschko, John W. Morse, Will Lamb, Texas A&M University; Danny Rye, Yale University. C.E.U. 1.6.

Techniques of Geostatistical Estimation and Simulation Applied to Environmental Geology. Saturday, October 18 and Sunday, October 19. Cosponsored by *Engineering Geology Division*. Sean A. McKenna and Christopher A. Rautman, Sandia National Laboratories, Albuquerque. C.E.U. 1.6.

Three-Dimensional Velocity and Displacement—Field Modeling of Upper-Crustal Deformation. Saturday, October 18 and Sunday, October 19. Cosponsored by *Structural Geology and Tectonics Division*. Steven F. Wojtal, Oberlin College; Basil Tikoff, Rice University. C.E.U. 1.6.

Applications of Environmental Isotopes to Solving Hydrologic and Geochemical Problems. Sunday, October 19. Cosponsored by *Hydrogeology Division*. Carol Kendall and Thomas D. Bullen, U.S. Geological Survey, Menlo Park. C.E.U. 0.8.

Preregistration Deadline — September 19

Buck Rogers, Field Geologist: 21st Century Electronic Wizardry for Mapping and Field Data Collection. Sunday, October 19. Cosponsored by *History of Geology Division*. John H. Kramer, Condor Earth Technologies, Inc., Sonora, California; Todd Fitzgibbon, U.S. Geological Survey, Menlo Park. C.E.U. 0.8.

Dynamical Systems Modeling for Undergraduate Education: From Coleman Coolers to Computers. Sunday, October 19. Cosponsored by *National Association of Geoscience Teachers*. Alexandra Moore, Hartwick College; Louis Derry and Andrew Kurtz, Cornell University. C.E.U. 0.8.

Environmental Issues at Modern and Historic Mining Sites. Sunday, October 19. Donald D. Runnells, Clint Strachan, Ed Redente, and Tom Shepherd, Shepherd Miller, Inc., Fort Collins, Colorado. C.E.U. 0.8.

Geology of Coal Bed Methane: The Perspective from Basin and Thermal History Studies. Sunday, October 19. Cosponsored by *Coal Geology Division*. Charles E. Barker, U.S. Geological Survey, Denver; Andrew R. Scott and Roger Tyler, Bureau of Economic Geology, University of Texas at Austin. C.E.U. 0.8.

Geomorphic Applications of In Situ–Produced Cosmogenic Isotopes. Sunday, October 19. Cosponsored by *Quaternary Geology and Geomorphology Division*. Paul R. Bierman, University of Vermont; Alan R. Gillespie, University of Washington. C.E.U. 0.8.

Multidimensional Computer Visualization in the Geosciences. Sunday, October 19. Paul Morin, University of Minnesota; Mark McBride, Groundwater Metrics, Silver Springs, Maryland. C.E.U. 0.8.

Paleosols for Sedimentologists. Sunday, October 19. Cosponsored by *Sedimentary Geology Division*. Greg H. Mack and H. Curtis Monger, New Mexico State University. C.E.U. 0.8.

Practical Remote Sensing for Geology. Sunday, October 19. Cosponsored by *Quaternary Geology and Geomorphology Division*. James M. Ellis, Chevron Overseas Petroleum, Inc., San Ramon, California. C.E.U. 0.8.

Other Courses & Workshops

Registration and information can be obtained from the contact person listed for each course.

Ore Genesis and Exploration: The Roles of Organic Matter. Friday, October 17 and Saturday, October 18. Sponsored by *Society of Economic Geologists*. Information: Richard M. Kettler, University of Nebraska, Dept. of Geology, Lincoln, NE 68588, (402) 472-0882, fax 402-472-4917, rkettler@unlinfo.unl.edu; or Thomas Giordano, Dept. of Geological Sciences, Box 3AB, New Mexico State University, Las Cruces, NM 88003-8001, (505) 646-2511, fax 505-646-1056, tgiordano@nmsu.edu.

Geomicrobiology: Interactions Between Microbes and Minerals. Saturday, October 18 and Sunday, October 19. Sponsored by *Mineralogical Society of America*. Information: MSA Business Office, 1015 18th St., N.W., Suite 601, Washington, DC 20036, (202) 775-4344, fax 202-775-0018, j_a_speer@minsocam.org, or visit the MSA home page: http://geology. smith.edu/msa/msa.html.

National Association of Geoscience Teachers Workshop on Innovative and Effective Techniques for Teaching Geoscience. Saturday, October 18. Sponsored by *National Association of Geoscience Teachers, National Science Foundation Undergraduate Faculty Enhancement Program*, and *GSA SAGE Program*. Information: R. Heather Macdonald, Dept. of Geology, College of William and Mary, Williamsburg, VA 23187, (757) 221-2443, fax 757-221-2093, rhmacd@facstaff.wm.edu.

Clastic Facies and Sequence Stratigraphy for Graduate Students Only. Saturday, October 18 and Sunday, October 19. Sponsored by *Exxon Production Research Company*. Information: Morgan Sullivan, Exxon Production Research Company, 3120 Buffalo Speedway, Houston, TX 77098, (713) 966-6396, fax 713-965-4114.

Geobiology of Echinoderms. Sunday, October 19. Sponsored by *Paleontological Society*. Information: Johnny Waters, Geology Dept., University of West Georgia, Carrollton, GA 30118, (770) 836-6479, fax 770-836-4373, jwaters@westga.edu; or Christopher G. Maples, National Science Foundation, 4201 Wilson Blvd., Arlington, VA 22230, (703) 306-1551, fax 703-306-0382, cmaples@nsf.gov.

Preparing Successful Grant Proposals to Fund Curriculum Innovation and Programmatic Change in the Geosciences. Sunday, October 19. Sponsored by *National Association of Geoscience Teachers* and *National Science Foundation*. Information: Robert W. Ridky, Division of Undergraduate Education, National Science Foundation, Room 835, 4201 Wilson Blvd., Arlington, VA 22230, (703) 306-1669, fax 703-306-0445, rridky@nsf.gov.

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GSA's SAGE Program for K–16

SAGE (Science Awareness through Geoscience Education) invites you to join us in Salt Lake City for an outstanding K–16 Education Program. Our program has something for everyone: geoscientists, students, park personnel, and K–16 teachers. Plan to preregister and come to the premeeting workshops: Innovative and Effective Teaching, Exploring the Solar System, Project WET (where scientists and educators have the chance to learn from each other), and Exploring Marine Geology. There will also be a premeeting workshop on Grant Writing and a Continuing Education workshop on Computer Modeling with classroom applications. On Monday, workshops on maps, Geographic Information Systems, and fossils will round out the workshop schedule. Monday also marks the beginning of technical sessions, symposia, and forums on a variety of education topics. As usual, we will have our annual Earth Science Educators Reception, complete with the wild and crazy Rock Raffle and an Earth Science Educator's Share-a-Thon.

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Forums

Digital DataBase Forum. Sunday, October 19. Sponsored by *Geoscience Information Society*. Information: Vivienne Roumani-Denn, 230 McCone Hall, University of California, Berkeley, CA 94720, (510) 643-7041, vroumani@library. berkeley.edu.

Coalition for Earth Science Education (CESE) Open Forum. CESE will host a special evening session to discuss the outcomes of the Second International Conference on Geoscience Education. Among the principal outcomes of the conference will be the determination of the global state of Earth System education. Panelists will include recipients of an NSF conference grant stipend. Panel moderators will be John R. Carpenter, University of South Carolina, and M. Frank Watt Ireton, American Geophysical Union.

Geology and Public Policy Forum. Wednesday, October 22. The GSA Committee on Geology and Public Policy will conduct a forum on local earth science policy outreach. What is the role of a geologist with respect to the needs of community, and how can a geologist become involved with critical earth science issues locally? Our panelists will share their successes and failures and help guide the GSA membership into the local policy arena.

Exhibits

Exhibiting at GSA is a cost-effective way to reach a targeted buying audience of over 6000 geoscientists in only 3-1/2 days. The exhibition hall will be filled with more than 250 booths representing the latest: geological publications; geological software; scientific instrumentation; microanalysis and photographic equipment; geoscience educational supplies; gems, minerals, and fossils; resource information from environmental, national, and state agencies; field supplies and gear; and information on earth science programs at major institutions. Please visit GSA's Web site (www.geosociety.org) to browse an on-line product and services listing of current exhibitors. For information on becoming an exhibitor, please contact Matt Ball, GSA headquarters, mball@geosociety.org.

Watch for details on extended hours for the GSA Bookstore.

Special Programs

Employment Interview Service

GSA will again be offering its Employment Interview Service. Each year, this program provides valuable job-matching opportunities in the geosciences. At last year's meeting in Denver, participating employers conducted over 500 interviews with nearly 250 applicants seeking employment!

As in the past, booths will be provided for employers to interview applicants registered with the Employment Service, and GSA staff will be on hand to coordinate the scheduling of interviews. In particular, students completing doctoral and master's theses during 1997 are encouraged to check the job offerings.

See the July 1997 issue of GSA *Today* for applicant and employer forms and further information, or contact T. Michael Moreland, Employment Service Manager, GSA headquarters, tmorelan@geosociety.org. Information is also available on GSA's Web site, www.geosociety.org, in the Membership Services section.

GSA Demo Theater

This year GSA is offering a unique opportunity for demonstrations of products and services at the Annual Meeting. The theater will be located just inside the exhibit hall and will feature a variety of demonstrations which will take place in 30-minute blocks designated for these categories: Products and Services, CD-ROMs, Commercial Software, Shareware or Freeware. A schedule of presentations will appear on GSA's Web site in August and in the on-site *Program*.

Shareware and Freeware developers may demonstrate for free and are encouraged to participate. Commercial demonstrations will be charged a reasonable fee, $100–$200, and you do not have to be an exhibitor to participate. If you are interested in demonstrating in any of the above categories, please contact Matt Ball, mball@geosociety.org or (303) 447-2020, ext. 141, or see GSA's Web site for information and an online form, www.geosociety.org.

Child Care

GSA will be providing child-care services in the convention center during the meeting. The cost will range from $3.00 to $4.50 per hour, based upon a four-hour minimum. Preregistration is recommended; however, on-site registration will be available at a higher rate per hour. Further information and forms will be provided in the June issue of GSA *Today*.

Guest Program

A hospitality room will be provided at the Salt Palace Convention Center for registered guests to meet, enjoy refreshments, and get information on Salt Lake City and surrounding areas. Formal and informal tour information will also be available. Guest registration includes an exhibit hall pass, but does not give access to technical sessions. (A guest can obtain a temporary pass to see a spouse or friend present his/her paper.)

Preliminary List of Organized Tours Open to All GSA Registrants

Look for detailed tour descriptions and pricing information in the June issue of GSA *Today*.

- Fossil Butte National Monument and Fossil Fish Quarry
- Tabernacle Choir Broadcast and Brunch
- Birding Trip
- City Tour
- Genealogy Workshop at Family History Library
- Park City Silver Mine Adventure and 2002 Olympic Park
- Historic Walking Tour
- Great Salt Lake Cruise and Antelope Island
- Kennecott Open-pit Mine and Concentrator
- Historic Park City—Museums, Shopping, Lunch

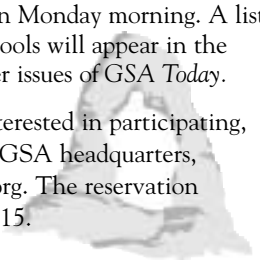
Informal Tours

In addition to the tours listed above, you might enjoy visiting other Salt Lake City attractions with fellow guest attendees. Plan to sign up for these informal, self-guided tours in the hospitality room.

Graduate School Information Forum.

Monday, October 20 through Wednesday, October 22. This forum provides a unique opportunity for undergraduate students who are planning to obtain an advanced degree to meet with representatives of graduate schools in an informal setting to discuss interests and explore programs. New this year is a student reception that will take place in this area on Monday morning. A list of participating schools will appear in the June and September issues of GSA *Today*.

If your school is interested in participating, contact Matt Ball, GSA headquarters, mball@geosociety.org. The reservation deadline is August 15.



Registration, Travel and Lodging

Deadlines

Preregistration: September 19, 1997
Cancellation: September 26, 1997

June GSA *Today* will be the only complete registration issue. Make plans now to take advantage of the June registration opportunity! **Events will fill quickly.** There are considerable savings on registration fees if you register early. Registration is required to participate in events, including courses and field trips. One-day registration is available on-site Sunday to Thursday.

GSA members will automatically receive registration information and forms during the first weeks of June. If you are not a member and would like registration forms and further information, please contact the GSA Registration Coordinator, GSA headquarters, meetings@geosociety.org or visit GSA's Web site.

Meeting registration fees have not been established as we go to print. However, for your budgeting and travel authorization requests, please use the ***estimated preregistration fees*** below. Final fees will be published in the June issue of GSA *Today*.

Members Pay Less ... Join Now!

If you are not yet a GSA member, now is the time to join. Nonmembers who become GSA members by October 1, 1997, can preregister at the member rate. You will save a substantial amount on your registration fee by paying the member rate—almost exactly the amount you would pay to join GSA. That's like joining GSA for free! For further information, contact Membership Services at GSA headquarters, member@geosociety.org.

Accessibility for Registrants with Special Needs

GSA is committed to making every event at the 1997 Annual Meeting accessible to all people interested in attending. If you have special requirements, such as an interpreter or wheelchair accessibility, there will be space to indicate this on the meeting registration form, or you can contact Becky Martin, GSA headquarters, bmartin@geosociety.org. If possible, please let us know your needs by September 26.

Travel

GSA's official travel agent, Travel King, is committed to obtaining the best possible fares for GSA Annual Meeting travelers. Advance bookings with Saturday night stayovers are the best route to lowest fares. However, as with all airline reservations, please use caution regarding change and cancellation penalties that accompany low-fare tickets. This applies especially to field trip and continuing education participants, whose trip or course may be canceled after the Sept. 19 preregistration deadline. Call Travel King at 1-800-458-6398 or trvlking@indra.com for a reservation or more information.

The Salt Lake International Airport is 7 miles from downtown. Nearly all downtown hotels offer free transportation to and from the airport. Those that do not are serviced by low-cost shuttle services.

GSA Student Associate Member Travel Grants

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 GSA Student Associates traveling to GSA meetings. The following sections offer assistance to the Annual Meeting in Salt Lake City. The remaining two sections offer assistance to their section meeting. For information and deadlines, contact your section secretary.

- **North-Central:** George Hallberg (319) 335-4500, ghallber@uhl.uiowa.edu
- **Northeastern:** Kenneth Weaver (410) 554-5532, kweaver@aol.com
- **South-Central:** Rena Bonem (817) 755-2361, bonemr@baylor.edu
- **Southeastern:** Harold Stowell (205) 348-5098, hstowell@wgs.geo.ua.edu

Lodging

GSA has booked rooms at 13 properties that offer special convention rates ranging from $62 to $110 single, and $62 to $120 double. A block of 550 rooms is reserved at the Little America Hotel, which, as headquarters, will host most social and business events. Other participating hotels include the Marriott, Best Western Salt Lake Plaza, Olympus Best Western, Hilton, Holiday Inn Downtown, Shilo Inn, Quality Inn City Center, Crystal Inn, Wyndham, Embassy Suites, Inn at Temple Square, and the Peery Hotel. In addition, several lower cost properties will be available to student registrants.

Most activities will take place at the Salt Palace Convention Center, Little America, Marriott, and Wyndham.

Special Note Another large convention is overlapping with GSA from October 16 to 19. If you plan to arrive during the premeeting weekend, we **strongly recommend** you make reservations now. Housing information and the reservation form are available on the GSA Web site, or contact Becky Martin, GSA headquarters, bmartin@geosociety.org. All hotel reservations must be processed by the Salt Lake City Housing Bureau to obtain GSA special rates. Deadline for hotel reservations is September 19.

GSA Shuttle

Most Salt Lake City hotels are walking distance from the Convention Center and from each other. However, GSA will provide daytime shuttle service between the outlying GSA-selected hotels and the Convention Center throughout the week. Service will be extended to all GSA hotels during the evening hours.

Estimated Registration Fees	Advance Full Meeting	On-Site Full Meeting	One Day
Professional Member	$195	$235	$118
Professional Nonmember	$235	$275	$138
Student Associate Member	$ 70	$ 90	$ 45
Student Nonmember	$ 90	$110	$ 55
Guest or Spouse *(no technical session access)*	$ 70	$ 70	n/a
K–12 Professional	$ 25	$ 35	n/a
Continuing Education/Field Trip Only Fee	$ 35	$ 35	n/a

Call for Nominations

The EDUCOM Medal

The EDUCOM Medal was established in 1994 to improve the quality of the undergraduate learning experience and to promote the effective use of information technology in higher education. Each year, Educom partners select disciplinary societies, whose representatives select a winner. This year, Educom has chosen GSA as a partner in selecting an individual who has made a significant contribution to transforming undergraduate learning in geology through information technology. Educom will provide the winner with a check for $2,500, a silver medal, a bronze desk statue, and travel expenses to participate in the awards presentation at the Educom annual meeting October 28–31 in Minneapolis, Minnesota.

Eligibility

Awards are made to individuals rather than to the institution, publisher, or organization to which they may belong. The award program is limited to technological applications used by undergraduate students and includes all forms of information technology used in undergraduate instruction, e.g., computer software, telecommunications networks, video applications, etc. To be considered for an award, the technological application should:

- address a significant pedagogical problem fundamental to the discipline (e.g., sustainable and scalable applications would be more favorably regarded than those representing a singular effort applicable in only one instructional setting);
- provide an innovative solution offering clear advantages over other techniques (e.g., alternative instructional delivery models or new instructional environments that incorporate information technology which may offer advantages over traditional instructional models in such areas as increasing student access to and acquisition of a particular subject matter, improving the cost-effectiveness of undergraduate instruction, encouraging collaborative learning, or enhancing communication between students and faculty);
- demonstrate substantial impact on improved student learning (e.g., demonstrations of substantial impact may include evidence of accelerated learning, significant numbers of students affected, improved learning outcomes, or increased cost-effectiveness compared to traditional approaches).

How To Nominate

Nominations for the award must include:

- a brief biographical sketch, such as used in *American Men and Women of Science* and *Who's Who in America*,
- supporting letters from five scientific educators in addition to the person making the nomination,
- a summary of the candidate's contribution to the transformation of undergraduate learning in geology through information technology, with special attention to the critera listed above.

The deadline for receipt of nominations at the office of the Executive Director, is **June 15, 1997.** Send nominations to: Donald M. Davidson, Jr., Geological Society of America, P.O. Box 9140, Boulder, CO 80301.

GSAF UPDATE

Valerie G. Brown, *Director of Development, GSA Foundation*

From the Ground Up

Spring is here … or at least is a lot closer than it was a month ago! For those of us in wintry climes, spring is relief from short days and long coats. In any clime, spring symbolizes revitalization and growth.

Organizations, too, have their seasons, and the past several years have been a springtime at GSA. Invigorated by challenges affecting the geosciences—environmental concerns, educational needs, professional changes—GSA considered how its strengths and resources might contribute to meeting the challenges. In past articles, I've summarized some of the intiatives resulting from these considerations.

April being also tax month, when we all wish for a break, let's focus on the deductible donations that enable the initiatives and demonstrate the importance of your gifts.

Sloss Gift

Last November, GSA lost a dear and dedicated friend, Larry Sloss. During their lifetimes, Larry and his late wife, Marion, made several significant contributions to the GSA Foundation's Pooled Income Fund, which paid them income on their investment. With Larry's death, the donation is converted to a permanent endowment generating unrestricted revenue to be applied at the discretion of GSA's leadership.

At the time of his death, Larry was the William Deering professor emeritus of Geological Sciences at Northwestern University, having served on that faculty since 1947. In his 40 years as an academic, Larry was a noted mentor, nurturing countless students from aspiration to achievement. Similarly, GSA's unrestricted funds are often allocated to new projects, providing the seed money required to achieve the growth and accomplishment that attract outside donations. GSA is honored that Larry selected GSA to help perpetuate his dedication to enterprise.

Mann Gift

Last December, another dedicated GSA friend who is still alive and thriving made a significant contribution that is another and equally valuable investment in the future. John Mann and his wife, Carol, created the Mann Mentorships in Applied Hydrogeology. The Mann gift will provide funding for lectures, workshops, and symposia, bringing distinguished experts in hydrogeology together with students, scientists, and public policy makers to improve their familiarity with this essential specialty.

In a long and exceptional career, John has been a focal contributor to water policy, conservation, and use. Over the past 40 years his expertise, committed both to education and to consulting, has measurably influenced decisions and development. His wisdom has been applied to 72 cases of water litigation, to educating leadership for the Los Angeles Department of Water and Power, to providing water for the city of Cairo, and to saving a granite quarry on the Isle of Guernsey. Sponsoring programs in such an accomplished name will be an enduring source of pride for GSA.

This months's bumper sticker:
Money is the root of all excellence. ■

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Digging Up the Past

Most memorable early geologic experience: Work in Montana on the Devonian and Mississippian with Larry Sloss was the highlight of my early career.

—Wilson M. Laird

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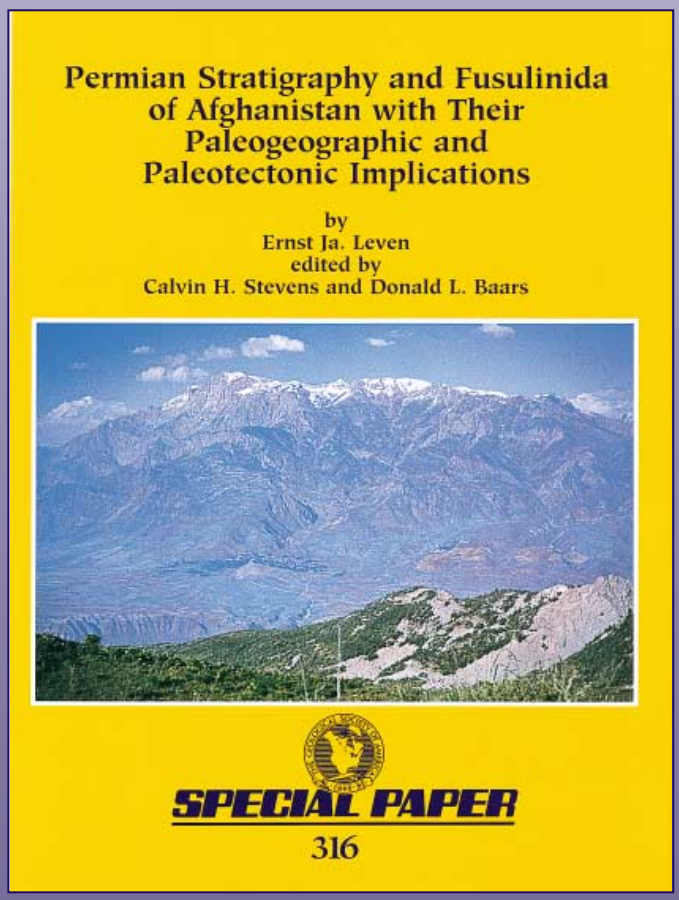

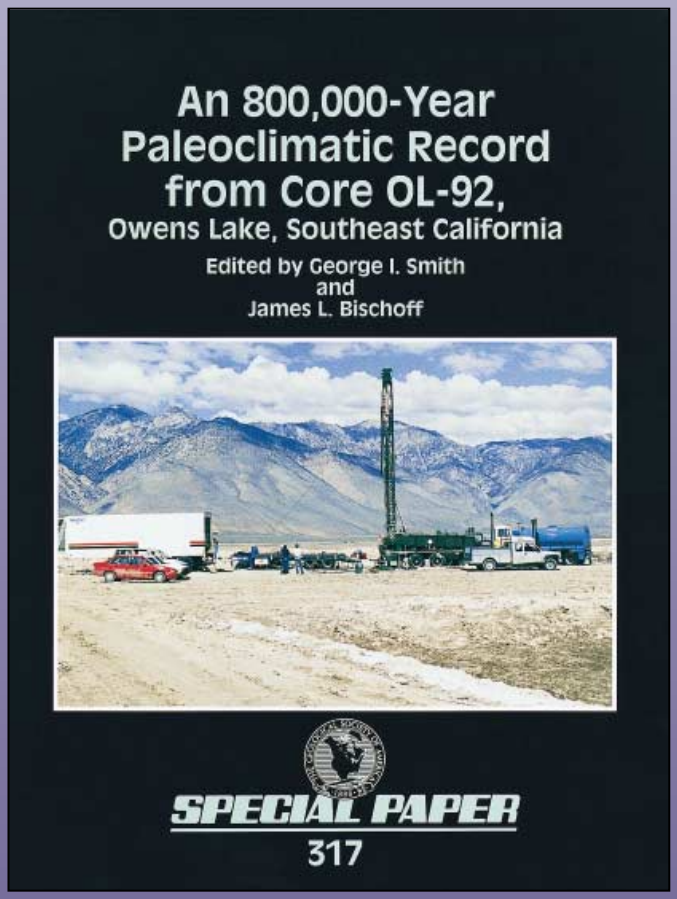

An excellent overall study of the Permian Stratigraphy and fusulinid faunas of Afghanistan. All of the major stratigraphic sequences there are correlated with those of the adjacent Pamirs and are described, as are one new genus and 41 new species and subspecies of Permian fusulinid. These data are used to postulate that Afghanistan and the Pamirs consist of fragments of numerous diverse depositional basins that were crushed together during collision of the Indostanian and Laurasian plates. In the northern part of the region, fusulinid faunas and facies indicate that tropical conditions existed throughout the Permian. In the south, however, cold and then cool conditions in the Early Permian appear to have been followed by tropical conditions in the Middle Permian. The authors propose that this demonstrates the distance of convergence during the Early Permian must have been at least the width of one climatic belt.

SPE316, 138 p., ISBN 0-8137-2316-7,
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A need for more lacustrine records that document late Quaternary climates in the now-arid western North America led to a U.S. Geological Survey-funded core-drilling project on Owens Lake, southeast California. The resulting 323-m-long core records lake fluctuations since 800 ka. This volume describes how they are revealed by variations in the CO^3 and organic-C percentages, pore-water isotopic content, composition of clay-sized materials, magnetic susceptibility, and fossils (diatoms, ostracodes, mollusks, fish, and pollen). Sediment ages are based on ^{14}C data, measured mass-accumulation rates, and paleomagnetic variations. The recorded wet and dry climatic cycles are about 100 ka long. Although their distribution in time is similar to those of deep-sea and other records that largely reflect paleotemperatures, the maxima and minima of the wet and dry cycles differ in age from correlative inflections in paleotemperature records by an average of 15 ka.

SPE317, 172 p., indexed, ISBN 0-8137-2317-5,
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1997

Salt Lake City, Utah, October 20–23
Salt Palace Convention Center
Little America Hotel

Abstracts due: ***July 8***

General Chair: ***M. Lee Allison,*** *Utah Geological Survey*

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John Bartley, Erich Petersen, *University of Utah*

Field Trip Chairs:
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Paul Link, *Idaho State University*

Both technical program proposals and field trip deadlines have passed.

Call for Papers and First Announcement on p. 13 of this issue.

1998

Toronto, Ontario, Canada, October 26–29
Metro Toronto Convention Centre
Sheraton Toronto Centre Hotel and Towers

General Chair:
Jeffrey J. Fawcett, *University of Toronto*

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Due date for symposia and theme proposals: ***January 2, 1998***

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1999—Denver, Colorado, Oct. 25–28
2000—Reno, Nevada, Nov. 13–16
2001—Boston, Massachusetts, Nov. 5–8
2002—Denver, Colorado, Oct. 28–31

SECTION MEETINGS

1997

NORTH-CENTRAL SECTION, May 1–2, The Concourse Hotel, Madison, Wisconsin. Information: Thomas J. Evans, Wisconsin Geol. & Nat. History Survey, 3817 Mineral Point Rd., Madison, WI 53705, (608) 263-4125, tevans@facstaff.wisc.edu. *Preregistration Deadline: March 28, 1997.*

CORDILLERAN SECTION, May 21–23, Kona Surf Resort and Convention Center, Kailua-Kona, Hawaii. Information: Ralph Moberly, Department of Geology and Geophysics, University of Hawaii, 2525 Correa Road, Honolulu, HI 96822, (808) 956-8765, ralph@soest.hawaii.edu. *Preregistration Deadline: April 18, 1997.*

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FIELD TRIP

June 10–15, 1997

NORTH ISLAND, NEW ZEALND

(Wanganui and East Coast Basins)

The Best Textbook of Outcrop Sequence Stratigraphy in the World

A 5 day field trip to study the classic cyclothemic (sequence) stratigraphy of the New Zealand Plio-Pleistocene.

- View 5th and 6th order depositional sequences representing isotope stages 100-5 (2.5-0.1 Ma)
- Visit: Wanganui Basin (shelf sequences); Hawke's Bay (shelf and marginal marine sequences, wine trail); Wairarapa (slope/shelf sequences)

LEADERS: Prof. Bob Carter, Dr Steve Abbott, Dr Tim Naish

Interested in attending?

Contact us for a detailed trip outline by email (tim.naish@jcu.edu.au) or fax (+61-77-81-2515). Scheduling of this trip is contingent on the number of participants. Trip dates may therefore be rescheduled by negotiation.

1997 Penrose Conferences

April

April 24–30, **Paleocene-Eocene Boundary Events in Time and Space,** Albuquerque, New Mexico. Information: Spencer Lucas, New Mexico Museum of Natural History, 1801 Mountain Road NW, Albuquerque, NM 87104, (505) 841-2873, fax 505-841-2866, E-mail: lucas@darwin.nmmnh-abq.mus.nm.us.

September

September 10–15, **Faults and Subsurface Fluid Flow: Fundamentals and Applications to Hydrogeology and Petroleum Geology,** Albuquerque and Taos, New Mexico. Information: William C. Haneberg, New Mexico Bureau of Mines and Mineral Resources, New Mexico Institute of Mining and Technology, 2808 Central Ave. SE, Albuquerque, NM 87106, (505) 262-2774, fax 505-255-5253, E-mail: haneberg@nmt.edu. For more information, see http://www.nmt.edu/~haneberg/Fluids.html.

September 23–28, **Tectonics of Continental Interiors,** Cedar City, Utah. Information: Michael Hamburger, Department of Geological Sciences, Indiana University, Bloomington, IN 47405, (812) 855-2934, fax 812-855-7899, E-mail: hamburg@indiana.edu.

1997 Meetings

August

August 24–28, **Classical Karst,** Lipica, Slovenia. Information: Karst Research Institute ZRC SAZU, Titov trg 2, SI 6230 Postojna, Slovenia, phone 386-67-24-781 or 22-457, fax 386-67-23-965, IZRK@ZRC-SAZU.SI.

September

September 1, **Spatial Interpolation Comparison '97.** Information: Gregoire Dubois, gregoire.dubois@jrc.it, http://java.ei.jrc.it/rem/gregoire/SIC97/intercomp.html.

September 7–19, **Ice Physics in the Natural and Endangered Environment,** Acquafredda di Maratea, Italy. Information: Ice ASI, Applied Physics Laboratory, University of Washington, 1013 NE 40th St., Seattle, WA 98105-6698, natoice@apl.washington.edu, http://www.apl.washington.edu/natoice/natoice.html.

September 12–14, **Recoveries '97,** final meeting of UNESCO IGCP Project 335, Biotic Recoveries from Mass Exctinctions, Prague, Czech Republic. Information: Petr Cejchan, Geological Institute, Academy of Sciences, Rozvojova 135, CZ 165 02 Praha 6 Lysolaje, Czech Republic, recovery@gli.cas.cz, http://www.gli.cas.cz/conf/recovery/recovery.htm; or Petra Hovorkova, Recoveries '97, Eurocongress Centre, Budejovicka 15, CZ 140 00 Praha 4, Czech Republic.

September 20–25, **Polar Regions and Quaternary Climate: Quaternary Climate–Interhemispheric Coupling,** Acquafredda di Maratea, Italy. Information: J. Hendekovic, European Science Foundation, 1 quai Lezay-Marnesia, 67080 Strasbourg Cedex, France, phone 33-388-76-71-35, fax 33-388-36-69-87, euresco@esf.org, http://www.esf.org/euresco.

September 26–28, **New York State Geological Association 69th Annual Meeting,** Clinton, New York. Information: David G. Bailey, Dept. of Geology, Hamilton College, Clinton, NY 13323, (315)859-4741, fax 315-859-4741, dbailey@hamilton.edu, http://www.library.csi.cuny.edu/dept/as/geo/nysga.html.

November

November 3–5, **International Conference and Sino-American Symposium on the Tectonics of East Asia,** Chungli, Taiwan. Information: Ching-Hua Lo, Dept. of Geology, National Taiwan University, Taipei, Taiwan, lo@sun03.gl.ntu.edu.tw, fax 886-2-3636095, http://fermat.geol.uconn.edu/info/taiwan; or Jean Crespi, Dept. of Geology and Geophysics, University of Connecticut, Storrs, CT 06269, (860) 486-0601, crespi@geol.uconn.edu. *(Abstract deadline: July 1, 1997)*

Send notices of meetings of general interest, in format above, to Editor, *GSA Today,* P.O. Box 9140, Boulder, CO 80301, E-mail: editing@geosociety.org.

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Positions Open

GEOMORPHOLOGY POSITION

The Department of Geosciences at the University of Arizona invites applications for a tenure-track appointment in geomorphology. The position will be available by January, 1998. Salary will be based upon qualification. A Ph.D. or equivalent degree is required.

We seek applicants with strong backgrounds in the area of surficial processes and landscape evolution. Preferences will be given to candidates with a strong record of publication and demonstrated effectiveness in obtaining research funding. A strong commitment to excellence in undergraduate and graduate education is essential, and preference will be given to candidates with demonstrated teaching ability.

The selection process will begin May 15, 1997 and continue until the position is filled. Interested applicants should submit a curriculum vitae, a statement of research and teaching interests, and a list of at least three references with addresses, e-mail, phone, and fax numbers to: Professor Joaquin Ruiz, Chairman, Department of Geosciences, The University of Arizona, Gould-Simpson Building, Room 208 P.O. Box 21007, Tucson, Arizona 85721-0077 PH: (520) 621-4327.

The University of Arizona is an EEO/AA/ADA compliance employer. Women and minorities are particularly encouraged to apply.

THE UNIVERSITY OF AKRON
VISITING ASSISTANT PROFESSOR

The Department of Geology seeks applications from qualified persons to fill a 9-month position starting August 25, 1997 and ending May 15, 1998. Applicants must hold a Ph.D. in geology or related geoscience field. The successful candidate will teach introductory geology courses and in the general area of stratigraphy/sedimentology. Prior college teaching experience is preferred.

In addition to teaching, the Department seeks a candidate having compatible research interests with current faculty members. For a description of interests and information on the department, visit http://www.uakron.edu/geology/.

Compensation includes a salary of $35,000 and benefits. Applications including 3 references and complete vitae should be sent to: Dr. Lisa Park; Dept. of Geology; University of Akron, Akron, OH 44325-4101; fax: 330-972-7611; phone: 330-972-7630. U of A is an EO/AA Employer. Application deadline: April 15, 1997, or until position is filled.

VALDOSTA STATE UNIVERSITY

The Department of Physics, Astronomy, and Geology invites applications for a tenure-track Assistant Professorship in Geography. A.B.D. with Masters degree required; Ph.D. preferred. We seek an individual with evidence of excellence in teaching, who will be responsible for introductory level courses in physical geography, as well as upper-level courses in one or more of the following areas: climatology, biogeography, hydrology, and/or soil science. Applicants should demonstrate commitment to quality undergraduate teaching, dedication to research involving undergraduates, and potential to contribute to program development. VSU offers a B.S. with a major in Environmental Geography, recently approved by the Board of Regents of the University System of Georgia. The program is enjoying strong growth in enrollment. VSU also offers B.S. degrees in Physics and in Astronomy, and a minor in Geology, as well as a program in Engineering with transfer to Georgia Tech. Women and minorities are particularly encouraged to apply. Salary is commensurate with qualifications. Starting date is September 1, 1997. Submit letter of application, curriculum vitae,and three letters of recommendation by April 30, 1997. Apply to Dr. Dennis Marks, Head, Department of Physics, Astronomy, and Geology, Valdosta State University, Valdosta, Georgia 31698-0055.

FACULTY POSITION
GEOLOGICAL ENGINEER
SOUTH DAKOTA SCHOOL OF MINES AND TECHNOLOGY

The Department of Geology and Geological Engineering is seeking to fill a tenure-track position at the Assistant or Associate Professor level in geological engineering. The successful candidate will be required to teach undergraduate and graduate classes in geological engineering. The candidate is expected to develop a funded research program in support of the M.S. and Ph.D. degree programs. The Ph.D. is required, and it is preferable that the candidate has practical experience, and is registered as a Professional Engineer or Engineer-in-Training. Salary will be commensurate with qualifications and experience.

Send vitae, letter of application, and three letters of reference to: Dr. Colin J. Paterson, Chairman, Dept. of Geology and Geological Engineering, South Dakota School of Mines & Technology, Rapid City, SD 57701. Information on the university and department, located in the beautiful Black Hills, is at the following web address: http://www.sdsmt.edu/campus/mineral/geology/geolhp.htm. Address inquiries to paterson@silver.sdsmt.edu, phone (605) 394-2461, fax 605-394-6703. Applications will be reviewed beginning April 20, 1997, and will continue until a suitable candidate is hired.

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GEOLOGICAL DATABASE ADMINISTRATOR
ODNR, DIVISION OF GEOLOGICAL SURVEY

The Ohio Department of Natural Resources, Division of Geological Survey seeks applications for the full-time permanent position of Geological Database Administrator (Class title: Administrative Assistant 3).

The major responsibilities of the position are to design, implement, and oversee the Division's computer-database systems, and formulate and implement database standards for geologic maps, data, and records. Database systems will be built in both Oracle v.7.x and Microsoft Access. Requires interaction with consultants and vendors in design and implementation of some systems. Will work closely with geologists, computer-aided mapping, GIS personnel, and the USGS National Geological Map Database Program to integrate all database needs. Databases will have links to CAD (Microstation) and GIS (MGE & Arc/Info) applications. Close cooperation required with end users for establishment of design needs and customization of input and reporting forms. The position also oversees systems maintenance, tuning, backup, and security.

The appointment will begin about July 1, 1997, and have a starting salary of $34,486. U.S. CITIZENSHIP IS REQUIRED! A background in geology is preferred but not essential. Application deadline is May 17, 1997. For futher information on how to apply for this position, please contact Dennis Hull, Assistant State Geologist, at (614) 265-6596 (fax: 614-447-1918; e-mail: dennis.hull@dnr.state.oh.us) or visit the Division's website at http://www.dnr.state.oh.us/odnr/geo_survey/.

Consultants

LOOKING FOR A HOME FOR YOUR COLLECTION? Museum curator provides advice or referrals to departments, companies or individuals seeking to sell or donate collections of minerals, rocks, ores, fossils, geobooks, etc. Contact: A. Sicree, 122 Steidle, University Park, PA 16802, (814) 865-6427; sicree@geosc.psu.edu.

Services & Supplies

LEATHER FIELD CASES. Free brochure, SHERER CUSTOM SADDLES, INC., P.O. Box 385, Dept. GN, Franktown, CO 80116.

Opportunities for Students

Fossil Butte National Monument Paleontological Internship, June 1–August 30, 1997. The two primary activities will be fossil collection and preparation.

Fossil Butte National Monument is currently involved in the active collection of fossils at two localities: one within Monument boundaries provides data for evaluating a near-shore paleoenvironment and the changes within it over time; the other locality is in deeper-water sediments and represents different flora and fauna, as well as the opportunity to investigate a larger area stratigraphically.

Sufficient volume of fossil material is collected from these localities to require a dedicated effort towards their preparation in order to collect additional data not readily evident in field examination. Fossil preparation requires diligence, patience and attention to detail along with the mastery of air scribe and airbrasive equipment.

This position is funded by the Geologic Resources Division through the Student Conservation Association. Call SCA at (603) 543-1700 for applications. For more information contact Peter Ambrose, Park Paleontologist, Fossil Butte National Monument (307) 877-4455, e-mail: peter-ambrose@nps.gov.

Graduate Research Opportunities. Applications are invited for graduate students to join our program in Geomechanics. One or two new positions are anticipated for qualified MS or Ph.D. students starting in August, 1997, in the areas of planetary structural geology or rock fracture mechanics, subject to availability of funds. The successful applicants will possess strong academic skills, be highly motivated, and have demonstrated prior experience in research. Applicants for the position in planetary geology must also have background and/or experience in planetary science. Related attributes include good field and interpersonal skills with proficiency in computer applications. For information contact Prof. Richard Schultz, Geomechanics–Rock Fracture Group, Department of Geological Sciences/172, Mackay School of Mines, University of Nevada, Reno, NV 89557-0138; schultz@mines.unr.edu; for information on specific program areas visit http://unr.edu/homepage/schultz.

1997 Geological Society of America Annual Meeting and Exposition

Salt Lake City, Utah
October 20–23

Electronic Abstracts Submission
Page 14

Abstracts Due
July 8

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September 19

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June GSA *Today*

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September GSA *Today* and the Web

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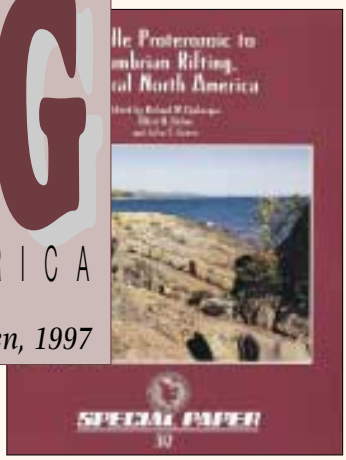
MIDDLE PROTEROZOIC TO CAMBRIAN

RIFTING

CENTRAL NORTH AMERICA

EDITED BY

R. W. Ojakangas, A. B. Dickas, and J. C. Green, 1997

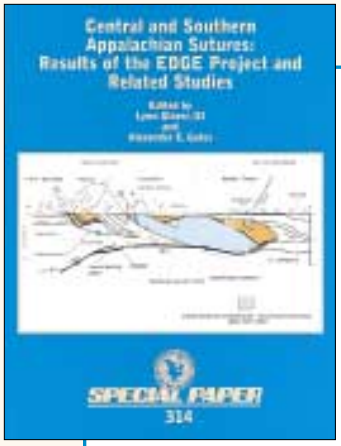


Most of these papers, presented at the Tenth International Basement Tectonics Conference, deal with a wide variety of aspects of the 1.1 Ga Midcontinent Rift System of North America, including tectonics, strain analysis, sedimentology, geophysics, and economic geology, and how they interrelate. The remaining contributions concern other rift-related structures and rock units in the North American midcontinent that date from the time of rifting into the Cambrian. Many of the significant features described in this book are buried under Paleozoic and Quaternary strata and are known chiefly from geophysical surveys and scattered drilling. These papers provide new insights and interpretations for the foundations of the U.S. continental midsection.

SPE312, 328 p., paperback, indexed, ISBN 0-8137-2312-4. Nonmembers $100.00; GSA Members $80.00

CENTRAL AND SOUTHERN APPALACHIAN SUTURES

RESULTS OF THE EDGE PROJECT AND RELATED STUDIES



edited by L. Glover, III and A. E. Gates, 1997

In 1962 Harry Hess's *History of Ocean Basins* gave a mechanism and a measure of credibility to the ancient hypothesis of continental drift. The new model has been successful in explaining Mesozoic and Cenozoic tectonics; therefore, it is remarkable that today there exists no general agreement on the number, age, and location of older Appalachian sutures. This volume contributes to understanding these sutures. Topics include: the nature of metavolcanic Carolina-Avalon terrane and its problematic western boundary in the Piedmont of central Georgia; the Cambrian(?) emplacement of Carolinian rocks against Laurentia in southern Virginia; and reactivation of the southern Virginia suture as a major zone of crustal weakness that moved during every subsequent tectonic event. Two papers argue against a suture in the Blue Ridge and suggest that the Laurentian plate boundary is the central Piedmont suture. A regional paper interprets the "Taconic"-Carolinian suture and the Laurentian margin through the central Appalachians and offshore continental margin.

SPE314, 142 p., ISBN 0-8137-2314-0. Nonmembers $50.00; GSA Members $40.00

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