Vol. 9, No. 4 April 1999

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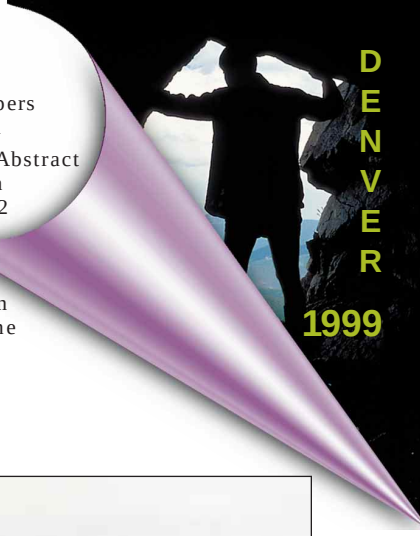
INSIDE



Floods and Sandbars in the Grand Canyon

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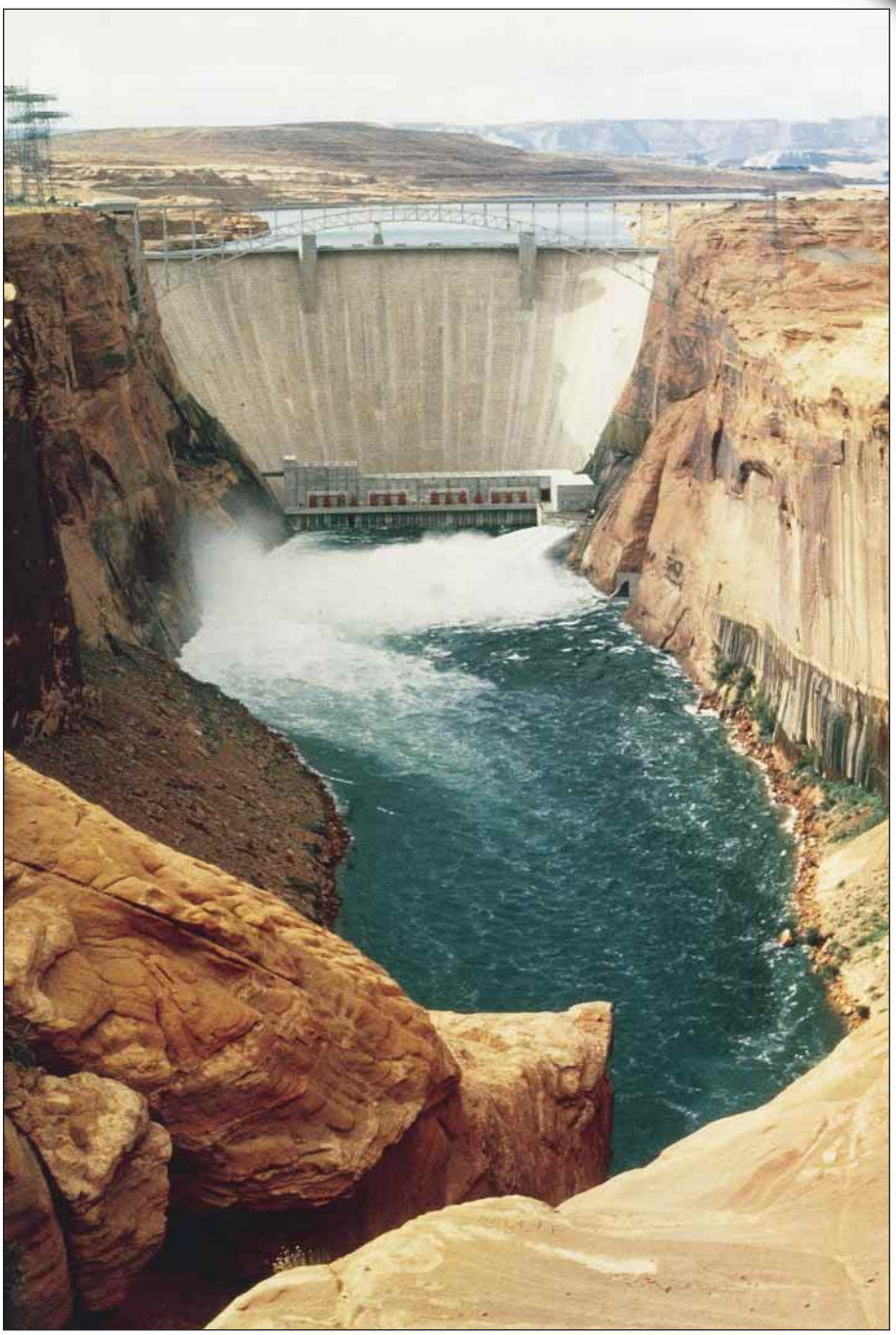
ABSTRACT

Erosion of sandbars and beaches in the Grand Canyon National Park downstream from Glen Canyon Dam has become a major problem that needs to be addressed. Geomorphic and geologic mapping provide a link between sandbar elevations and discharge measurements. This link allows an estimate of discharges that will deposit sand far enough above normal high water to prevent frequent depletions by erosion. The sand is needed to protect habitats and archaeological sites and to maintain beaches used by recreationists. It is proposed that when the Little Colorado is in flood, discharge at Glen Canyon Dam be increased to bring the total discharge to the desired high value. Analysis of the flow records show that such opportunities are presented on the average once in eight years, suggesting that the proposal has a reasonable chance of success.

INTRODUCTION

The Colorado River in the Grand Canyon section in Arizona once fluctuated greatly in its flow. Year-to-year and season-to-season variability was large. Peak discharges ranged from 300 000 cfs (cubic feet per second) to 19 200 cfs, a difference of 16 times. The amount of sediment transported as suspended load was very large. Measurements carried out at the Grand Canyon for the period December 1940 to June 1941 show that, at 50 000 cfs, about 2 000 000 tons were moved per day during the rising stage of the flood,[1] and 500 000 tons during the falling stage, whereas almost 5 000 000 tons per day were moved during the peak of the flood

Grand Canyon *continued on p. 2*



Glen Canyon Dam at high discharge during the June 1983 flood. The dam is 710 ft (216 m) high. The four jets of water issuing from near the lower right corner of the dam are from the outlet works. Releases from the right spillway are hidden by the cloud of mist and spray near the lower left corner of the dam. The left spillway, whose exit is visible a short distance downstream from the outlet-work jets, was inactive when the photo was taken. Discharge from the powerplant is below river level and not visible. Photo courtesy of David L. Wegner

[1]Sediment transported during the rising stage of a flood is much greater than that transported during the falling stage (Leopold and Maddock, 1953).

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February 20, 1999

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Grand Canyon *continued from p. 1*

at ~130 000 cfs (Leopold and Maddock, 1953).

The closure of Glen Canyon Dam in 1963 wrought immense changes in the river. The high peaks were eliminated and the maximum controllable discharge—through power-plant and outlet works—is only ~45 000 cfs (1274 m^3/s). The sediment, so characteristic of the river, is now deposited in the reservoir behind the dam, and the releases are clean and cold. All this materially affected the riparian zone[2] in the Grand Canyon, bringing about changes in erosion, vegetation, and the biotic communities (Johnson, 1991; Stephens and Shoemaker, 1987; Stevens et al., 1995, 1997; Webb, 1996). The annual peak discharges now are usually in the range of 25 000 to 35 000 cfs. Only five times in the 35 years since dam closure has the peak flow in the Grand Canyon equaled or exceeded 45 000 cfs. Such discharges come about when water going over the dam spillways is added to the maximum discharge through power-plant and outlet works.

The curtailment of sediment passage in the canyon has resulted in little replenishment of the sandbars, on which the maintenance of the original riparian community depended. The release of water

Grand Canyon *continued on p. 3*

[2]The zone along a river that is directly affected by the river and its fluctuations.

ENVIRONMENT MATTERS

Enhancing Integrated Science: The Leadership Imperative

Cathleen May, Director, Institute for Environmental Education
Mary Barber, Ecological Society of America
Linda Stanley, U.S. Geological Survey

What factors determine the success or failure of integrated scientific efforts? Are these factors scientific themselves? Social? Cultural? Are they fundamentally dollar-based and administrative? Will collaboration necessarily yield integrated approaches and results? Are there things that organizations can do to enable collaborative efforts among scientists?

The Geological Society of America, the Ecological Society of America (ESA), and the U.S. Geological Survey (USGS) organized a workshop, attended by 24 invited participants and 12 organizers, to investigate these questions. The workshop, "Enhancing Integrated Science" was held November 4–5, 1998, in Reston, Virginia. The participants represented life sciences, earth sciences, economics, social sciences, science administration, and institutional and agency leadership. The results of the workshop illustrate its emergent focus on leadership roles and include a set of "guiding principles" for integrated science, a set of recommendations for the USGS, and a set of recommendations for the larger community of science-enabling organizations and institutions. A summary report, including the results listed above as well as operating definitions, a list of participants, agenda and discussion topics, candid quotes from participants, and an action plan for disseminating the results of the workshop can be found on the USGS Website at: www.usgs.gov/integrated_science/index.html.

The process of organizing the workshop became a microcosm—a real-time illustration of the social and cultural progression by which individuals become a functional collective. A shared vision of the approach to the workshop evolved as individuals came to rely on one another's perspective of the problems we would tackle. Shared responsibility for the products of the workshop evolved as we came to trust each other's contribution during the workshop. These attributes—shared vision, interdependence, and trust—appear to be essential elements of genuine collaboration. Many of the features of the systems in which we work (academic, governmental, or otherwise) are inimical to interdependent, collaborative working relationships. This is not news. Science is a competitive endeavor.

How do we get beyond competition? One of the overarching understandings to emerge from the workshop was that leadership is imperative. If we are to expand the culture of science to include the collaboration so essential to integrated scientific approaches, individuals and institutions alike must embrace the leadership imperative. Only leadership can modify funding structures to remove organizational barriers to collaboration. Only leadership, among the entire scientific community, can expand reward systems to include something other than individual achievement. Leadership is required to ensure that "interdisciplinary" does not come to mean "antidisciplinary." Scientific societies, academic institutions, funding agencies, and federal agencies all share the leadership challenge. Leadership is required to safeguard the pursuit of deep understandings, rigorous methodologies, and technologies of individual disciplines without which we cannot achieve useful understandings of complex natural systems.

N. Metzger and R. N. Zare (*Science*, v. 283, p. 642–643) directly address the leadership imperative by focusing on science policy, "Federal structures . . . strongly militate against interdisciplinary programs cutting across jurisdictional lines." These authors recommend an ambitious interagency approach, funded by Congress through direct appropriations, to bring interdisciplinary research "from belief to reality." In essence, Metzger and Zare challenged Congress and the federal system to actively embrace the leadership imperative.

Even as the Metzger and Zare article reached the community, one federal agency moved to the fore with a bold action to enable interdisciplinary science. In a February 1, 1999, news release, USGS Director Chip Groat proclaimed his agency's "commitment to integrating USGS's scientific disciplines. . ." and announced budget restructuring that includes a line item for integrated science (see www.geosociety.org/science). This action signals, at least in the USGS, federal recognition of the exigencies of organizational leadership to interdisciplinary science.

GSA, ESA, and the USGS will continue their joint efforts to enhance integrated science by following through on the imperatives for organizational leadership we derived through our workshop last November. Some plans for implementation in the near future are contained in the summary report cited above. Long-range planning for collaborative leadership efforts is in the works. If your organization or institution is interested in active leadership to enable interdisciplinary science, please contact us through Cathleen May, (303) 447-2020 ext. 195 or at cmay@geosociety.org.

Grand Canyon *continued from p. 2*

from the dam has been governed by demand for electricity from the power plant. This demand fluctuates widely and quickly, so the discharge in the river has changed radically hour by hour and day by day. Not only has the riparian ecosystem been affected, but a decline in recreational use of the canyon has caused significant commercial loss.

These various effects have become so serious that scientific teams studying the issue have recommended various remedies, including the trial release of water at high controllable discharges to test whether such discharges were sufficient to put in motion sand stored in the bed and in side draws and perhaps build back at least some of the sandbars. In 1996, a "test flood" consisted of the release of 45 000 cfs for a week; in 1997, a discharge of 31 000 cfs for 48 h was designed to transfer from channel bottom to channel margins at least some of the 2.2 million tons of sand and 2.7 million tons of silt and clay that had been delivered to the Colorado River by a sequence of floods on the Paria River (Kaplinski et al., 1998). Both flows deposited sand, to the jubilation of all concerned, but an important part of the deposited volume was subsequently washed away (Kaplinski et al., 1998). Several floods on the Little Colorado River in January and February 1993 brought a large amount of new sand into the Colorado

Grand Canyon *continued on p. 4*

Figure 1. The only tributaries shown in this location map are the Paria and the Little Colorado Rivers, which are pertinent to this paper. Rivers are in blue; stream gages are in orange. The Lees Ferry gage measures the discharge from Glen Canyon Dam. The Cameron gage measures the discharge of the Little Colorado River, except for the relatively small flow from a spring near the confluence with the Colorado River. The Grand Canyon gage measures the combined discharges of the Colorado, Little Colorado, and Paria Rivers, plus the contribution of small tributary streams within the Grand Canyon, and minus seepage and evaporation losses. Oak Cave and Tsegi Wash, in green, are the location of Holocene deposits discussed in the text.

Grand Canyon *continued from p. 3*

River and built conspicuous beaches throughout the Grand Canyon. A year later, these beaches were largely gone (I. Lucchitta, 1994, personal observation).

This paper offers an additional or alternative plan to rebuild the sandbars utilizing floods on the Little Colorado River. The plan is designed in such a way that important parts of the deposition are above the usual moderate peak discharges, so would be less likely to be eroded away.

THE PROPOSAL

A significant amount of sand is brought into the canyon from tributaries entering downstream of the dam, especially the Little Colorado River, which has a large drainage area, more than 26 000 mi^2 (67 340 km^2). The Paria, with an area of 1570 mi^2 (4082 km^2), is helpful (see Fig. 1).

It is proposed that when the Little Colorado approaches a significant flood discharge, the operators at Glen Canyon Dam open penstocks and outlet works so that a combination of high flow from the tributary added to a maximum release from the dam would produce a discharge in the Grand Canyon sufficiently high that its effects may provide on a small scale what the original undammed river accomplished in sand movement and deposition.

This study uses information and data from several disciplines to examine the feasibility of the proposal. Such analysis involves more than the hydrology and hydraulics of the river basin but must perforce deal with the geomorphology of the canyon bottom, which gives an insight into the long-term functioning of the river. Then, in order to estimate what a flood of any size might deposit, it is necessary to analyze in simplified form the various strandlines and terraces, and determine their dates of deposition or renewal.

THE RECENT GEOLOGIC PAST

Extensive and reliably dated Quaternary deposits of the Colorado River in the Grand Canyon go back about 500 000 yr (Lucchitta et al., 1995, 1999), and perhaps about 750 000 yr (Machette and Rosholt, 1991). There have been nine discrete levels of deposition, datable by modern techniques, that are seen in the canyon varying from 10 to 205 m above the present river. Older and higher levels undoubtedly were once present, but have been eroded.

Most deposits consist of remnants of terraces produced by aggradation and underlain by far-traveled river gravel locally intermixed with coarser and more angular debris of local derivation from nearby tributary washes. Taken as a whole, the gravel terraces indicate overall downcutting through the Quaternary, interrupted periodically by aggradation, probably in glacial or late-glacial times. Cobbles greater than 10 cm are common in the gravel, indicating considerable energy and discharge. Tributary rivers and washes mimicked the activities of the main river.

The data show that the Colorado River has cut down an average rate of ~0.4 m/ka for this time interval, within the 0.4–1.09 m/ka range calculated (Lucchitta, 1988) for carving the Grand Canyon as a whole. In reality, this rate averages intervals of aggradation (negative downcutting) with intervals of downcutting at a faster, but unknown, rate. An estimate of the rate at which erosion occurs following a period of aggradation is given by the most recent deposits.

Near-Stream Terrace Levels

The more recent depositional units and sandbars of immediate concern are those that stand at elevations ~10 m or less above the present river. These deposits

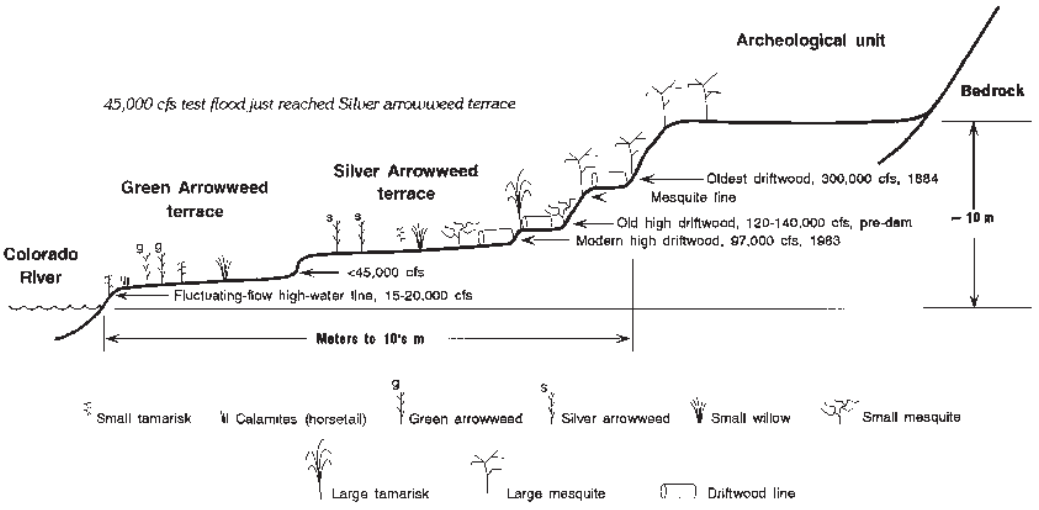

Figure 2. Strandlines and terraces in eastern Grand Canyon. Shown schematically are terrace treads and risers, strandlines marked by driftwood lines, and the vegetation types characteristic of each terrace level.

include the last aggradational terrace, as well as terraces produced during the current period of erosion, which includes the decades since Glen Canyon Dam was built. Geomorphic and geologic studies (Lucchitta and colleagues) provide a general profile of the units in this range, shown in Figure 2.

The archeological unit—the last aggradational terrace—is given this informal name (Lucchitta et al., 1995) because prehistoric Puebloan people lived and farmed on these deposits, leaving abundant evidence of their passage in the form of sites and artifacts of many kinds (Fairley et al., 1994). The unit corresponds in a general way to Hack's (1942, 1945) Tsegi Formation, present in washes tributary to the Colorado River in the southwestern Colorado Plateau. The relation of this formation to Puebloan artifacts and to the present channel is similar to those of the archeological unit, as is the fine grain size. Ages are comparable.

The archeological unit consists of a terrace whose base (strath) is below present river level, and the top (tread) about 10 m above it. The unit is composed predominantly of fine to very fine grained sand. The grain size, excellent rounding, and common frosting of the sand grains suggest derivation from Mesozoic eolian sandstone units abundant on the Colorado Plateau. Far-traveled material is scarce in most places. The sand grades laterally into coarser colluvium derived from local slopes and washes, giving the unit a striped appearance.

The archeological unit commonly is modified by wind action and overlain by resulting eolian deposits. In many places, these deposits bury Pueblo II sites built on top of fluvial material. These relations show that the unit stopped being deposited 800–750 yr B.P., and has been incised ~10 m since that time. The oldest age obtained so far from the unit is 5259–4985 calibrated ^{14}C yr B.P. (Lucchitta et al., USGS data) from a level ~3 m below the top of the unit, and at least 7 m above the base. This suggests that the beginning of deposition may well have been in early Holocene—or even late Pleistocene—time.

Pollen associated with the sediments in Oak Cave, southern Utah (Fig. 1), records the initiation of a regime of heavy summer rains, indicated by the expansion of ponderosa pine, which requires summer rain, and the stripping of interfluve soil mantles, indicated by the waning of sagebrush, which requires deep soil (Lucchitta and others, USGS data). The late Pleistocene to early Holocene age of these sediments either slightly precedes that of the archaeological unit, or corresponds to early deposition of this unit.

These depositional, age, and palynological data are interpreted to indicate regional stripping of soil mantles, with accompanying overloading and aggradation of the regional drainage network resulting in deposition of the archeological unit and correlatives. We prefer the aggradational origin for the unit (the grade of the river increased with time) to the origin proposed by O'Connor et al. (1994), which invokes slackwater deposition from large floods (the grade remained constant), for the following reasons, among others: (1) Deposits correlative with the archeological unit are regionally widespread, and not restricted to the Colorado River and its floods. (2) Deposits of tributaries to the Colorado River are graded to the top of the unit, indicating general aggradation of the drainage network. (3) The unit is present in all types of reaches, not just back-eddy areas downstream from constrictions, where slackwater deposits would be typical.

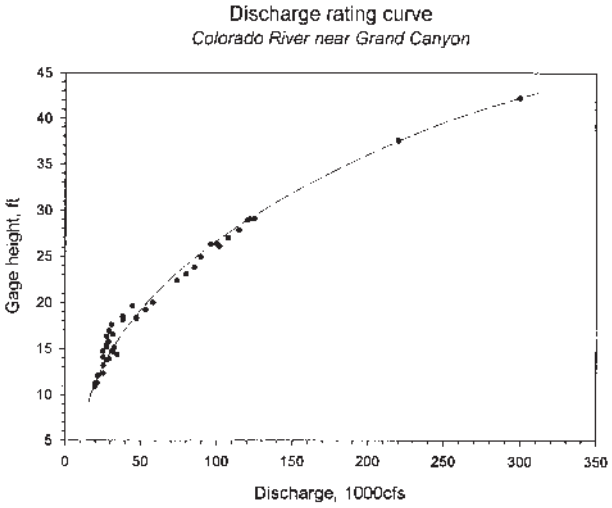

Figure 3. Discharge rating curve, Grand Canyon station. Many of the deviations from the curve are due to measurements being taken on the rising or falling stages of a flood.

The end of alluviation and onset of vigorous downcutting that incised the archeological unit started about 800 yr ago; downcutting has occurred at the high rate of 12.5 m/ka. The significance of these data is that the last period of major aggradation by the Colorado River is represented by the archeological unit, whereas the river has been operating in a regimen of strong downcutting for approximately the past 800 yr, continuing to this day. Glen Canyon dam was built during a strongly erosive regimen.

Among the levels below the archeological unit are two prominent terraces traceable along many reaches of the Grand Canyon. They have been named the Green Arrowweed and the Silver Arrowweed terraces, respectively (Lucchitta et

Grand Canyon *continued on p. 6*

Figure 4. Photo of beach on the Colorado River produced by the 1993 flood of the Little Colorado River. The beach is a short distance downstream from the confluence. The beach must have resulted from the flood on the Little Colorado because no such beaches were present upstream from the confluence, and because the sand contained abundant basaltic detritus. Basalt is common along the course of the Little Colorado River. One year later, the beaches visible in the photograph were virtually gone.

Grand Canyon *continued from p. 5*

al., 1995), from the local flora found there when the studies were carried out (Fig. 2). All levels below the archeological unit have been created and refurbished by floods during the historic period.[3] Lines of flood debris and driftwood are found in consistent relations to treads and risers of the terraces, as shown in Figure 2. The younger (and lower) strandlines of large driftwood include abundant worked wood and artifacts such as cans. Plastic objects are common in the 1983 strandline, but very rare in the pre-dam 120 000–140 000 cfs strandline. In pre-dam time, beaches and strandlines produced by lesser floods tended to be modified or destroyed by the higher floods, so they cannot be recognized easily. Floods greater than 120 000–140 000 cfs were rare; the 1884 flood of 300 000 cfs (8490 m^3/s)[4] is marked locally by deposits and a strandline composed of large rotten logs, scarce worked wood, and a few artifacts that include no plastic items. The 97 300 cfs (2755 m^3/s) flood of 1983, which marks the greatest post-dam discharge, is represented by a sand terrace and a drift line composed chiefly of fresh, relatively small wood and modern artifacts, including abundant plastic items. The various strandlines were surveyed by total station (Lucchitta et al., 1995, and USGS data).

The test flood of 1997 covered only the Green Arrowweed terrace. The 1996 test flood reportedly just reached the lower end of the Silver Arrowweed terrace (various sources, personal communications). Subsequent discharges have removed a considerable volume of the sand deposited by the test floods (personal observations by Lucchitta in 1998; Kaplinski et al., 1998; and Hazel et al., 1999).

Relation of Terraces to Floods

The geomorphic terraces must be placed within a hydrologic context. This is best done by relating the levels of the terraces to the discharge rating curve, which correlates gage height with discharge. The best gaging station to use for this purpose is that at Grand Canyon, near Bright Angel Creek. Measurements by current meter at this station began in 1921, but a reliable estimate of 300 000 cfs at Lees Ferry was also obtained for the flood of July 8, 1884 (see above).

A plot of the rating curve (Fig. 3) shows that there has been no progressive change during the period of record. The rating curve for Grand Canyon is a reasonable approximation of the action of the river in the canyon and, combined with the general cross section provided by geomorphic studies, is used here to represent the relation of terrace heights to discharge.

From Figure 3, it can be seen that a discharge of about 55 000 cfs, corresponding to a gage height of 19 to 20 ft (6 m), is required for water to reach a significant part of the Silver Arrowweed terrace. However, an appreciable deposit of sand probably will require 65 000 to 70 000 cfs and a gage height of about 22 ft (7 m). Such a deposit would be relatively durable because it would be well away from the lower step of the terrace, and thus from the erosive action of the river.

In the 35 years since the dam began controlling the flow, only six events equaled or exceeded the 45 000 cfs of the 1996 "test flood" and of these, only two were significantly higher, 58 400 on June 15, 1965, and 96 200 cfs on June 29, 1983. All events exceeding 45 000 cfs required a contribution from the spillway of the dam.

The Little Colorado River can provide the 10 000 to 25 000 cfs needed to raise the maximum controllable outflow from the dam (45 000 cfs) to the required discharge. The floods of the Little Colorado in January and February 1993 indicate that not only is such a contribution possible, but that such floods also bring much sand into the Grand Canyon. The peak discharge of these floods was 18 200 cfs at Cameron, the sixth largest in the period of record. On March 3, a few weeks after the peak, the magnificent beaches (Fig. 4) produced by these floods lined the length of the river from the Little Colorado River confluence to at least as far as Diamond Creek, Mile 226 (Lucchitta and colleagues, personal observations).

ON THE POSSIBILITY OF RESTOCKING SAND ON THE BEACHES

In contrast to the test "floods," which essentially mined the sand in the channel of the Colorado River—a depletable resource—or redistributed sediment brought in by floods on the Paria—which are puny compared to the sediment transported by the Colorado River in pre-dam times—the Little Colorado flood introduced enough new sand to form beaches the length of the river below the confluence (Fig. 4), in addition to the sand that remained in the channel or made its way to Lake Mead. Such floods provide an opportunity for restocking beaches in the Grand Canyon downstream from the confluence.

First, one must achieve a combined Colorado–Little Colorado River discharge sufficient to keep sand entrained rather than allowing it to settle in the channel, and this discharge must be maintained long enough to build adequate beaches. Second, the discharges must attain a high enough stage to park the sand where it will not be readily eroded by the river in its normal modern flows.

In the period of record, seven days of the highest peak discharges (> 18 000 cfs) of the Little Colorado at Cameron included four that increased the discharge at Grand Canyon enough to overflow the Silver Arrowweed terrace. These four occurrences in the 50 years of measurement means one occurrence about every 12 years.

Alternatively, one may estimate the possible contribution by counting the number of days when the daily flow near Cameron exceeded 10 000 cfs. The daily flow often is high on two to four successive days, which would mean little attenuation by channel storage. In the 50 years of record, there were six such occurrences, two of which were not identical with the seven analyzed above. Thus, there appears to be the possibility of six useful events in 50 years, or one in eight years on the average.

The concept is that the flow of the Little Colorado River be monitored at the most downstream gaging station at Cameron, Arizona. When the discharge reaches a high enough level, the operator of Glen Canyon Dam would, on short notice, increase the discharge through power-plant and outlet works to the maximum capacity of 45 000 cfs. A direct radio link from gage to dam would make the opportunity practical. Furthermore, advance notice of a possible peak at Cameron could be obtained from careful observation of the gages on the Little Colorado River upstream of Cameron.

Given the potential for useful events to occur on average once in eight years, it is quite within reason that the high flow of the Little Colorado River could be made to coincide with a release of 45 000 cfs from Glen Canyon Dam, resulting in the deposition of abundant sand at a substantial elevation above present river grade, within the Silver Arrowweed terrace. In this position, sand would have considerable durability, probably enough to last until the next restocking event.

The proposal discussed here pertains to a geological process—the restocking of beaches. However, it is well known that proper managing of the Grand Canyon involves a complex and often contradictory interplay of geological, biological, and other considerations (Schmidt et al., 1998). All of these must be considered when making management decisions. Nevertheless, the proposal attempts to recreate—to the extent possible now that the dam is built—the sediment transport and river stage characteristics of the pre-dam river. These are the conditions to which the Grand Canyon ecosystem was originally adjusted.

[3]Defined here as the time interval, starting in 1884, for which observational information is available.

[4]This discharge is based on the observed level reached by the flood at Lees Ferry—within the orchard of Lee's Lonely Dell Ranch. In the 1920s, a profile was surveyed from this level to the river, allowing determination of the channel cross section during the flood. This, in turn, led to an evaluation of the flood discharge.

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Seismology and Education: The IRIS Education and Outreach Program

Catherine Johnson, IRIS Education and Outreach Program Manager

Incorporated Research Institutions for Seismology (IRIS)

The past few years have seen an enormous growth in innovative and non-traditional educational efforts in the geosciences at universities and colleges nationwide. From individual faculty member efforts, to department-level restructuring, to national programs, these changes have been driven by many factors, including the need to make the geosciences accessible to a diverse student audience, and by a recognition of the importance of communicating scientific research to a wider population than the traditional scientific peer group. Science and technology centers and geoscience consortia can make unique contributions to education at all levels because of their focused science objectives, yet often broad institutional membership.

The Incorporated Research Institutions for Seismology (IRIS) is a consortium of 90 U.S. institutions and more than 20 foreign affiliates. Research programs at IRIS member institutions contribute to seismological research and education, earthquake hazard mitigation, and verification of the Comprehensive Test Ban Treaty. IRIS has extensive expertise in the collection, archiving and dissemination of seismic data through its three long-standing programs: the Global Seismographic Network (a global network of permanent seismic stations), the Program for Array Seismic Studies of the Continental Lithosphere (PASSCAL, an instrument pool of portable seismometers for use in regional experiments) and the Data Management System (DMS).

In 1997, IRIS launched a fourth program: the Education and Outreach (E&O) program. The philosophy underlying the E&O program is that it should target a broad audience through both formal (K–graduate) and informal (adult and public) educational programs, but activities should be focused in that they should draw on IRIS's strengths—access to seismological data, computer resources, organizational structure, and widespread membership. These strengths allow IRIS to make some unique contributions to education and outreach through seismology, complementing existing E&O programs in the earth sciences and in earthquake engineering. Through broad, user-friendly access to seismic data, IRIS can support inquiry-based instruction in the K–16 classroom as incorporation of real data into earth science curricula allows students to learn science by doing science. The integration of real-time seismic data into interactive exhibits can be used to spark public interest in earthquakes, seismology, and related earth science in informal settings such as museums. The nationwide distribution of IRIS member institutions facilitates E&O initiatives of both national and local scope. Activities at the national level provide the opportunity for coordination and for wide visibility and dissemination of resources. Further realization of these programs at the local level is crucial to achieving a lasting, positive impact on educators, students, and the public. Local programs can also foster links between the research and education communities and enhance the quality of science education at all levels. The IRIS E&O program encourages and supports the involvement of all its member institutions and other institutions in a wide variety of education and outreach efforts, thus enabling many individuals to participate. Such participation is vital: the IRIS E&O staff consists of one program officer, and the program relies heavily on the volunteer efforts of individuals within the IRIS community. The success of IRIS E&O to date owes much to the present and past members of the Education and Outreach committee.

In April 1998, IRIS E&O held a workshop bringing together individuals from the seismological and science education research communities, K–16 educators, and representatives of other earth science organizations with education and outreach programs. The discussions and outcomes of that workshop form the basis for a medium- to long-range planning document for the E&O program, to be published later this year. The Education and Outreach Program Plan not only describes the mission, goals and objectives of the E&O program, but sets these in the context of current needs in K–12 and higher and informal education and in the context of existing earth science education and outreach programs. It is our intent that this document will be useful to a wide audience of earth science educators, researchers within the IRIS community, and those involved in other education and outreach programs.

A Washington D.C. public high school class learns about seismology and plate tectonics during a visit to the IRIS museum exhibit, on display in the lobby of the American Association for the Advancement of Science building to celebrate Earth Science Week, 1998.

IRIS Education and Outreach Core Activities

IRIS E&O activities fall into two main groups: those that contribute to the ongoing core of the program and additional

specific, often collaborative, finite-duration projects. Central to all our efforts is the development, publication, and dissemination of hard-copy and Web-based materials useful for teaching seismology and related earth science at a variety of levels. Hard-copy materials include posters, one-page information sheets and teaching modules developed for K–12 teacher workshops. Our Web site provides up-to-date information on the E&O program and contains resources useful for teaching at the K–12 and undergraduate levels. These resources include electronic versions of some of our hard-copy materials and an image archive (see below). One of the objectives of the E&O program is to develop tools to enable nonspecialists to easily access and use seismic data via the Web.

The core activities of the E&O program will obviously develop and evolve with time, but in general they encompass K–12 education through professional development opportunities for teachers, undergraduate education through research opportunities for students and through professional development for undergraduate faculty, and public education through our Web site and through collaborations involving museums and science centers. Although activities related to graduate education have not been emphasized over the past year, it is hoped that the IRIS E&O program will impact graduate education in the geosciences through workshops emphasizing communication of science to nonspecialists and through opportunities for graduate students to participate in the development and field testing of IRIS E&O materials. Below, I highlight areas of focus over the past years in K–12 education and undergraduate education that serve as examples of IRIS E&O activities.

K–12 Education

Workshops for K–12 teachers compose a major educational effort (see table) and are typically run either in conjunction with national education meetings (such as the National Science Teachers Association meeting) or on a more local level through IRIS member institutions. To encourage research seismologists to participate in K–12 educational activities, the E&O program runs a one-day workshop for about 20 seismologists from IRIS member institutions at the annual IRIS meeting, demonstrating inquiry-based, K–12 level activities in seismology and providing information on how to organize and implement a successful teacher workshop. The intent is that during the following year, each attendee runs a workshop for approximately 20 local teachers at the home IRIS institution. IRIS E&O provides the resources for these follow-up workshops. This approach has the potential to reach large numbers of teachers and to foster links between IRIS institutions and local K–12 communities.

Through a separate but related initiative, IRIS E&O hopes to positively impact the teaching of earth science in under-resourced schools in urban and rural areas. IRIS has been collaborating with Teach For America (TFA), a national organization through which college graduates pursue two years of teaching in under-resourced schools across the nation. IRIS E&O ran short workshops demonstrating inquiry-based teaching modules in seismology and related earth science, at TFA's East Coast regional conference last year. An expansion of these efforts is planned to include workshops at the TFA pre-service training institute in Houston this summer.

Museum displays are excellent vehicles for K–12 education in a less formal environment. Over the past two years IRIS E&O has developed three similar interactive museum exhibits—one display is on tour with the Franklin Institute's Powers of Nature exhibit, one display is at IRIS headquarters, and one display is at the New Mexico Museum of Natural History and Science. Educational programs scheduled to coincide with particular museum displays provide opportunities for further learning.

NATIONAL-LEVEL PROFESSIONAL DEVELOPMENT WORKSHOPS FOR K–12 TEACHERS AND UNDERGRADUATE FACULTY DURING 1998 AND 1999

Meeting	Date	Attendees
Teach For America (TFA) East Coast Conference	March 1998	15 TFA teachers (K–12)
National Science Teachers Association Meeting	April 1998	28 K–12 teachers
IRIS Annual Workshop: Software	July 1998	20 college and university researchers
National Science Teachers Association Meeting	March 1999	~25 K–12 teachers
IRIS Annual Workshop: Seismologists Learning to Teach the Teachers	June 1999	~25 research seismologists
Teach For America (TFA) Summer Institute	July 1999	Up to ~75 TFA pre-service teachers (K–12)
Geological Society of America	October 1999	~25 college and university faculty
American Geophysical Union	December 1999	~25 college and university faculty

Undergraduate Education

Many faculty (both at IRIS institutions and non-IRIS institutions) have expressed interest in new and innovative approaches to undergraduate teaching and in increased research experiences for undergraduates. In response, IRIS E&O is currently pursuing activities in four main areas.

First, a summer internship program, begun in 1998, provides the opportunity for undergraduates from both IRIS and non-IRIS institutions to pursue a summer research project (either in the field or the lab) with a seismologist from an IRIS institution. As part of the internship program, IRIS E&O provides funds for each intern to present a paper at a national geoscience meeting such as GSA's or AGU's.

Second, IRIS E&O is encouraging the sharing of resources suitable for teaching at the undergraduate level. Last year, E&O committee member Michelle Hall-Wallace ran a workshop at the annual IRIS meeting highlighting software packages appropriate for use in undergraduate seismology classes. In collaboration with the University of British Columbia, IRIS E&O has developed an Image Archive facility on its Web site. This facility serves as a resource for high-quality figures useful for undergraduate-level classes illustrating topics not adequately covered in traditional texts. The Image Archive will provide an excellent mechanism for storing figures illustrating recent research developments in seismology, allowing faculty to include current material in even introductory-level undergraduate classes.

Third, IRIS E&O is planning regular professional development workshops for undergraduate faculty to be held in conjunction with national geoscience meetings. For faculty without extensive background in seismology, workshops will emphasize content knowledge, using seismology and related earth science modules, and other IRIS products that support inquiry-based teaching. For undergraduate faculty with a significant background in seismology, workshops will emphasize inquiry-based teaching modules and illustrations of how active learning techniques can be implemented in earth science classes.

Fourth, IRIS is working toward the generation of a new membership category, that of academic affiliate, to encourage involvement in IRIS by colleges whose primary focus is education rather than research. Several liberal arts and community colleges have expressed an interest in participating in IRIS in such a capacity,

SAGE Remarks *continued on p. 10*

SAGE Remarks *continued from p. 9*

and it is hoped that the academic affiliates program will be formalized by the end of 1999.

Participating in the IRIS Education and Outreach Program

Participation in the E&O program by a broad community is strongly encouraged. Ways in which you can participate include running K–12 teacher workshops, encouraging your undergraduate students to apply to the internship program, submitting materials to the Image Archive, and participating in the development, field testing, and evaluation of educational materials. Last, but not least, we welcome feedback on current and past activities and suggestions for new initiatives.

The IRIS E&O Web site is at http://www.iris.washington.edu/EandO.

For more information on the IRIS Education and Outreach Program contact catherine@iris.edu. ■

New Service for *Geology* and *Bulletin* Authors

GSA now offers a service that enables authors to place their *Geology* and *Bulletin* articles on their Web sites. Each journal article is available to the author(s) as an electronic file that duplicates the printed paper version in every detail. The file can be viewed using Adobe Acrobat, a widely used, free viewer, and is read-only to maintain its integrity. The file is also printable.

This service is free to authors who are GSA members. Nonmember authors will be charged $40 per article to cover production costs.

CALL FOR NOMINATIONS

Farouk El-Baz Award for Desert Research

Thanks to the generosity of GSA Fellow Farouk El-Baz, the Quaternary Geology and Geomorphology Division has established the Farouk El-Baz Award for Desert Research. It will provide annual cash awards for outstanding work in this field by earth scientists. Any scientist may be nominated for this award, and applicants need not be geologists or U.S. citizens. Documentation of published research results that significantly advance our knowledge of deserts must accompany the nominations, which are to be sent to Division Coordinator, Professional Development Group, Geological Society of America, 3300 Penrose Place, or P.O. Box 9140, Boulder, CO 80301-9140. Nominations will be considered by the Quaternary Geology and Geomorphology Division award committee.

Nomination deadline: May 31, 1999

El-Baz, director of the Center for Remote Sensing at Boston University, said, "The award is intended to encourage young scientists to strive for excellence in desert research.... Deserts have not received as much attention by geologists as other types of landforms; that is why we need to encourage and reward arid-land studies."

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WASHINGTON REPORT

Bruce F. Molnia, bmolnia@erols.com

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

The Debate about a National Institute for the Environment

This year is the tenth anniversary of a growing effort to establish a National Institute for the Environment (NIE). Spearheaded by the Committee for the National Institute for the Environment (CNIE), a nonprofit organization that carries out educational activities and limited advocacy, the proposal has received significant support from the academic community and scientific professional societies. However, the National Science Foundation (NSF) refrained from endorsing the concept, and the National Science Board (NSB) has established a Task Force on the Environment to perform its own detailed assessment and to assist the NSF "in defining the scope of its role with respect to environmental research, education, and assessment, and in determining the best means of implementing activities related to this area." The NSB has dual responsibilities as the national science policy advisory body to the President and the Congress, and the governing body for the NSF.

According to its sponsors, the NIE would be a nonregulatory science institute with a mission "to improve the scientific basis for making environmental decisions." It would provide a major role for stakeholders in defining questions and setting priorities; assessing environmental knowledge on an ongoing basis and identifying issues of critical importance where information is needed; funding peer-reviewed research in the natural and social sciences, engineering, economics, and other fields as required to understand environmental issues; communicating environmental information through an electronic, National Library for the Environment; supporting public education and sponsoring training for future environmental scientists and professionals; integrating knowledge assessment, research, information dissemination, and education and training into a comprehensive scientific approach to improving the scientific basis for making decisions on environmental issues; and supporting its work through competitively awarding grants to the most qualified individuals and institutions, wherever they are.

Committee and Endorsement

The effort to create the NIE began in 1989 with a meeting of 50 scientists, environmentalists, and policy experts led by Stephen Hubbell of Princeton University and Henry Howe of the University of Illinois, Chicago. Hubbell and Howe currently serve as the chair and vice chair of the CNIE Board of Directors. The work of the CNIE is funded by private and corporate foundations, universities, and individual members, and through the CNIE Associates Program.

During the past decade, CNIE has held numerous meetings to discuss the need for the application of more science for the understanding of environmental issues and to discuss ways to better link science to policy. More than 9,000 scientists, educators, former elected officials, and environmental, business, and civic leaders have participated. The result has been the development of the mission statement and list of anticipated activities presented above, and the development of a widely circulated proposal for the establishment of the NIE.

To date, more than 450 organizations have endorsed the establishment of the NIE. These include: more than 250 universities, more than 30 business groups and chambers of commerce, nearly 100 scientific professional societies and academies of science, more than 50 environmental organizations, and more than a dozen state and local government organizations. In the last Congress, nearly 100 House members cosponsored a National Institute for the Environment Bill.

In 1993, 1994, 1996, and 1997, bipartisan legislation was introduced in Congress to establish the NIE as a new independent agency of the federal government. In each instance, no enabling legislation was enacted. Discussions also focused on the possibility of creating an Institute as a Congressionally chartered body outside the government, but funded through the NSF. On July 8, 1997, the House Appropriations Committee declared that it "has been impressed by the proposal for a nonregulatory National Institute for the Environment with a mission to improve the scientific basis for making decisions on environmental issues...." It then directed the NSF "to study how it would establish and operate such an institute, including the potential cost of such an institute, and report to the Committee by April 1, 1998."

The NSF did prepare a report as directed. In April 1998, it issued a report stating that the NSF "is eager to expand its role" in environmental research and education, assessment of research, and dissemination of environmental education. However, it did not "study how it would establish and operate" such an institute. Instead, it reviewed activities currently supported by the NSF and other federal agencies that parallel those of the proposed NIE.

Task Force Formed

On March 19, 1998, the NSB approved a resolution (NSB-98-65) in which it noted the need for expanded environmental research, education, and assessment. The resolution stated that the NSF has a legitimate role in these activities, and that this role can be exercised most constructively in the context of a strategy coordinated by the White House agencies and the National Science and Technology Council (NSTC). In August 1998, the NSB Resolution (NSB-98-161) established a Task Force on the Environment to assist the NSF in defining "the scope of its role with respect to environmental research, education, and assessment, and in determining the best means of implementing activities related to this area." The task force reports to the Committee on Programs and Plans (CPP), chaired by Jane Lubchenco. NSF Assistant Director for Geosciences Robert Corell is also a member.

The task force was charged with: developing guidance for the NSF at the policy level that will be used for designing an appropriate portfolio of activities, consistent with the overall NSTC strategy, the goals of the NSF Strategic Plan, and activities of other agencies and organizations that support related programs. It will complete a report, with final recommendations, and submit it to the NSB before a May 5–7, 1999, meeting.

The task force has the interim objectives of hearing from multiple invested communities and gathering information for their deliberations. Therefore, the task force plans four parallel activities: (1) consideration of present activities at the NSF, including an inventory of programs by the Life and Earth's Environment Working Group; (2) analysis of report recommendations; (3) analysis of program histories at the NSF to answer the questions: What has worked and what has not, and why?; and

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Cordilleran Section Meeting Field Trips

May–June 1999

Because of space constraints in the Cordilleran Section 1999 meeting announcement in March *GSA Today*, field trip descriptions were omitted. Descriptions below give only the first leader. For more information and detailed descriptions, see the Cordilleran Centennial Web site: http:// socrates.berkeley.edu/~earthres/GSApage.html.

Because many field trip opportunities are easily accessible from the San Francisco Bay area, site of the meeting, one-day trips are emphasized in order to afford participants maximum opportunity to sample the diverse geology of the region.

Premeeting:

1. Sierra Nevada Gold Deposits. Two days, Sat.–Sun., May 29–30. Also postmeeting. David Lawler, (510) 549-9694, lawler@webb-net.com. Limit: 20. Cost: $265. All meals included.

Active placer and lode mines in the northern Sierra Nevada (bedrock and economic aspects). The Alleghany Mine District contains world-class lode gold deposits hosted in ultramafic, metasedimentary, and metavolcanic sequences exposed in the highly dissected drainages of the Yuba River.

2. Accretionary Tectonics of the western Sierra Nevada. Three days, Sun.–Tues., May 30– June 1. Richard A. Schweickert, (702) 784-6901, richschw@unr.edu. Limit: 40. Cost: $300. Breakfast, lunch included.

Tectonics and crustal evolution of the western Sierra Nevada metamorphic belt between Sonora and Auburn. New and published data on stratigraphy, structure, terranes, timing of deformation and metamorphism, and current tectonic models.

3. Sutter Buttes Volcano. Two days, Mon.–Tues., May 31–June 1. Brian Hausback, (916) 278-6521, hausback@csus.edu. Limit: 30. Cost: $180. Breakfast, lunch included.

The Pleistocene Sutter Buttes pushed up through and deformed a great thickness of Upper Cretaceous through Pliocene sediments. We will examine field relationships of volcanic rocks exposed at the Buttes, visit quarry exposures, and hike into the interior of the dome complex. The Buttes are entirely on private land and can be visited only by prior arrangement.

4. Geology and Wines of Napa Valley. One day, Tues., June 1. David G. Howell, (650) 329-5430, dhowell@octopus.wr.usgs.gov. Limit: 40. Cost: $65.

When you taste the wines of the Napa Valley, you're tasting 100 m.y. of Earth history. The geologic history of the Napa Valley has influenced the topography, climate, and soil that create the microenvironments so well exploited by vintners. The highlight of the trip will be sampling three wines from adjacent vineyards, each with a different soil, that meet in a microenvironmental "triple junction."

5. Classic Subduction Complex: The Franciscan Complex of the San Francisco Bay Area, California. One day, Tues., June 1. Also postmeeting. John Wakabayashi, (510) 887-1796, wako@tdl.com. Limit: 35. Cost: $60.

Several major features of the world's most famous subduction complex. Stops include Baker Beach with its serpentinite and shale matrix melange and high-grade blocks; Marin Headlands chert with a 100 m.y. depositional history reflecting tectonic transport across the Pacific to the subduction zone; Ring Mountain's metamorphics, which give insight into tectonic and thermal processes at the inception of subduction ("counterclockwise" *P-T* path); Schmidt Avenue quarry, which exposes a shear zone critical to understanding mechanisms for blueschist uplift.

6. Neotectonic and Quaternary Geology of the San Gregorio Fault Zone, Santa Cruz and San Mateo Counties, California. One day, Tues., June 1. Gerald E. Weber, (408) 426-1367, jweber@earthsci.ucsc.edu. Limit: 35. Cost: $65.

Geologic evidence used to estimate slip rates and recency of movement along the San Gregorio fault zone. Ben Lomond marine terrace sequence; major fault strands that compose the San Gregorio fault zone at Pt. Año

Cordilleran *continued on p. 14*

Washington Report *continued from p. 11*

(4) input and feedback from invested communities. To provide for the flow of this information, the task force held public events on January 14 in Portland, Oregon, and February 17–18 in Los Angeles, and a town hall meeting on March 8 in Arlington, Virginia.

In order to provide maximum information for its deliberations, the task force has assembled a preliminary listing of environment reports and policy documents to examine and consider, especially with respect to the recommendations they contain. This listing, now numbering about 200 documents, can be viewed at http://www.nsf.gov/nsb/tfe/literature.htm.

The NSF found that some recommendations appeared repeatedly in the listing. These include: (1) the need for cross-disciplinary and interdisciplinary research to address environmental issues; (2) the importance of considering questions at the appropriate temporal and physical scale: emphasis was on long-term and large-scale research needs; (3) the need to include appropriate human components (i.e., economics and social sciences) in environmental research and education activities; (4) the need for research to connect more effectively to decision making (policy, regulatory, and management); (5) the urgency of including educational elements in environmental programs and plans; (6) the need for better coordination among programs; (7) the need to improve predictive capabilities in a variety of environmental areas; and (8) the importance of priority setting by individuals and organizations familiar with research, education, and assessment issues.

Two Directions

So the process continues in two subparallel directions; CNIE continues to believe that the NSF is the proper home for the NIE, so as to provide the scientific attention that will help us to understand and resolve the complex environmental challenges facing the nation and the world. They also believe that the science needed for this effort is both multidisciplinary and interdisciplinary and will require a long-term investment in a mixture of fundamental and applied approaches to science and engineering that builds on, "but is different than the traditional approach of the NSF."

The NSF states that it is committed to environmental research and education in all areas of science and engineering, and that it is eager to expand its role in a manner consistent with overall national goals and with its mission and strategic plan. The NSF adds that for many years it has recognized the need for a robust and dependable scientific and engineering research base on which to make decisions about environmental policy and regulation. Additionally, the needs for reliable assessment of this research, education of the public about environmental issues, and dissemination of environmental information are critically important now and will be in the future. The NSF states that they play an important role in all of these activities, and that it is expanding its support of them by building on its Life and Earth's Environment thematic emphasis. The NSF concludes that the intellectual breadth and quality of this fundamental research and education effort are the keys to its success.

Additional information about both points of view can be found at: http://www.cnie.org/ and http://www.nsf.gov/nsb/tfe/. ■

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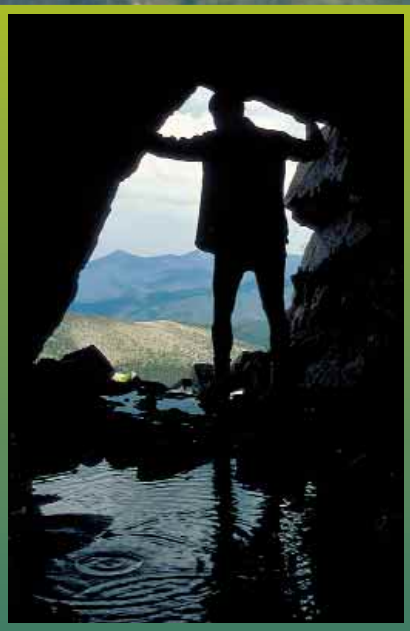

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American Association of Stratigraphic Palynologists • American Institute of Professional Geologists • Association for Women Geoscientists •Association of American State Geologists • Association of Engineering Geologists • Association of Geoscientists for International Development • Council on Undergraduate Research—Geology Division • Cushman Foundation • Geochemical Society • Geoscience Information Society • Mineralogical Society of America • National Association for Black Geologists and Geophysicists • National Association of Geoscience Teachers • National Earth Science Teachers Association • Paleontological Research Institution • Paleontological Society • Sigma Gamma Epsilon • Society of Economic Geologists • Society of Vertebrate Paleontology

We welcome you back to Denver, which hosted the 1996 annual meeting. The proximity of the 1999 GSA Annual Meeting both in space to the Continental Divide and in time to the end of the 20th century inspired the theme of "Crossing Divides." The intent is to celebrate the cross-disciplinary nature of the geosciences and to encourage a scientific program that crosses divides among the various chemical, biological, and physical disciplines of our science. Our hope is that the program will instill in attendees a broadened sense of the contributions geological sciences can make as a discipline and the degree to which an individual's research is linked to many other specialties. An exciting set of field trips, controversial Hot Topics, and a diverse group of exhibitors round out the meeting.

Denver has wonderful cultural attractions, museums, dining, and nightlife. Other reasons to come to Denver are that it has 300 days of sunshine per year (more than San Diego or Miami Beach!) and the largest city park system in the country. In addition to its superlative climate and expansive parks, Denver brews more beer than any other American city. What more could a geoscientist want! We encourage you to come to the meeting early or stay late and enjoy the cultural wonders of the city and natural wonders of the Rocky Mountains. To enhance your visit, we suggest that you find out more about Denver's colorful history, sights and attractions, lodging, and dining, as well as interesting facts about the city at http://www.denvergov.org

Conference goers and their guests can explore the many aspects of Denver's colorful historical past through sites such as the Molly Brown House, the State Capitol on Capitol Hill, and nearby Central City, an old mining town that was once referred to as the "richest square mile on earth."

Denver skyline—Photo courtesy of Denver Metro Convention and Visitors Bureau

Contents

Cover photos by John A. Karachewski: Large photo shows the Continental Divide–Sawatch Range, Collegiate Peaks Wilderness, CO; small photo taken near James Peak, CO

Divisions of GSA

The GSA Divisions enhance the Society's technical, scientific and professional activities. Members are encouraged to participate in all Divisions in which they have an interest. The GSA Divisions are:

Archaeological Geology • Coal Geology • Engineering Geology • Geophysics • Geoscience Education • History of Geology • Hydrogeology • International • Planetary Geology • Quaternary Geology and Geomorphology • Sedimentology • Structural Geology and Tectonics

Pardee Keynote Symposia

Invited Papers

The Pardee Keynote Symposia are made possible by a grant from the Joseph T. Pardee Memorial Fund.

These keynote sessions are special events of broad interest to the geoscience community. They represent topics on the leading edge in a scientific discipline or area of public policy, address broad fundamental problems, are interdisciplinary, or focus on global problems. Selection was on a competitive basis. This year's eight Pardee Symposia were reviewed by a panel of Joint Technical Program Committee (JTPC) representatives and accepted by the Annual Program Committee. (*All speakers are invited.)*

Abstracts Deadline: July 12 Please send all invited abstracts (electronic and paper) to GSA. Abstracts will be forwarded to the conveners for review.

Alpenglow on arete of Precambrian gneiss, cirque at head of Mayflower Gulch, Tenmile Range, CO—Photo by John A. Karachewski

K01 ■ Impact Events: Environmental Consequences and Their Influence on the Origin and Evolution of Life

GSA Planetary Geology Division; Paleontological Society. David A. Kring, Lunar and Planetary Laboratory, University of Arizona, Tucson. ORAL

Based largely on Cretaceous-Tertiary boundary studies, impact cratering is now widely recognized as an important geologic process. This symposium will explore how this type of geologic process can also affect local and regional environments, global climate, and the biologic evolution of Earth.

K02 ■ Human Transformation of the Physical Landscape

GSA Archaeological Geology Division. Lisa E. Wells, Vanderbilt University, Nashville, Tennessee; Patrick Julig, Laurentian University, Sudbury, Ontario. ORAL

Agriculture, grazing, mining, deforestation, and urbanism cause profound changes to Earth's topography, geochemistry, soil, and sediment budget. Humans move more sediment per year than all other processes. Soil erosion impacts both biologic productivity and global climate by changing the carbon cycle, the hydrologic cycle, and eolian dust flux. This symposium will integrate millennial-scale lessons of landscape degradation and conservation into the discussion of modern landscape transformation.

K03 ■ Maintaining a Livable Earth: Conversations Among Concerned Geologists

GSA ad hoc Committee on Critical Issues; Institute for Environmental Education. Jill S. Schneiderman, Vassar College, Poughkeepsie, New York; Susan W. Kieffer, Kieffer Institute for Science-Based Education, Palgrave, Ontario. ORAL

Selected authors of essays for a book for the general public concerning the relevance of geology to environmental decisions will present brief narratives which demonstrate that, without geological knowledge, solutions to environmental problems will not be forthcoming. The symposium will be an interactive session involving extensive discussion with audience members.

K04 ■ Geoscientists in the Legal System: The Challenge for the Next Century

GSA Hydrogeology Division; National Ground Water Association. E. Scott Bair, Ohio State University, Columbus; Steve Wheatcraft, University of Nevada, Reno; David Stephenson, S.S. Papadopulos & Associates, Jackson, Wyoming. ORAL

Keynote speaker Jonathan Harr will describe his observations on the effectiveness of the scientific testimony presented at the Woburn Toxics Trial. A judge, attorneys, and expert geoscience witnesses will present their opinions on the role of science in our legal system and how to be an effective and ethical expert witness. A panel discussion and a question and answer period will conclude the session.

K05 ■ Low-Latitude Precambrian Glaciation: Geochemical, Climatic, and Biological Effects of the Snowball Earth

Joseph L. Kirschvink, California Institute of Technology, Pasadena; Paul F. Hoffman, Harvard University, Cambridge, Massachusetts. ORAL

Precambrian glacial deposits have long been recognized as peculiar, because of climatic indicators indicating sea-level ice within the tropics. This symposium will explore geological, geophysical, climatic, and geochemical constraints on these putative low-latitude glaciations, and some of the biological implications of "Snowball Earth" conditions produced when the oceans freeze over completely.

K06 ■ Globally Warm Climates of the Early Cenozoic: Evidence, Causes, and Biotic Consequences

Paleontological Society. Scott L. Wing, Smithsonian Institution, Washington, D.C.; Lisa C. Sloan, University of California, Santa Cruz. ORAL

Globally warm climates are an enduring geological enigma, pitting our understanding of the processes that generate climate against our interpretation of past conditions based on geological, paleontological, and geochemical data. Speakers in this symposium will discuss recent research that illuminates the possible causes and biotic effects of globally warm climates in the early Cenozoic.

K07 ■ The Case for Steady-State Mountain Belts: Observations, Models, and Implications for Global Tectonics

GSA Quaternary Geology and Geomorphology Division. Peter L. Knuepfer, Binghamton University, Binghamton, New York; Frank J. Pazzaglia, University of New Mexico, Albuquerque. ORAL

It has been suggested that the dynamic and demonstrated interaction between tectonics and topography leads to a "steady-state" mountain range, but what defines steady-state conditions and under what circumstances can they truly be attained? This symposium will focus on reconciling field and model-based studies in defining orogenic steady state. We hope to provide insights of diverse tectonic expressions of topography and the role that steady state processes play in their origin.

K08 ■ New Insights on Organic Metamorphism in the Earth

Group Exploring Organic Processes In Geochemistry. Everett L. Shock, Washington University, St. Louis, Missouri; Harold C. Helgeson, University of California, Berkeley. ORAL

Organic compounds persist at much higher temperatures and pressures than generally thought. Analytical, theoretical, and experimental studies are revealing the reversibility of organic reactions and the pathways through which metastable equilibrium states are reached. This symposium presents evidence that requires rethinking organic geochemical processes throughout the crust and upper mantle.

Discipline and Topical Sessions

Invited and Volunteered Papers

Discipline Sessions

Papers are submitted to ONE scientific discipline. The Joint Technical Program Committee (JTPC) representatives organize the papers in sessions focused on this discipline—for example, environmental geoscience or mineralogy.

Topical Sessions

These sessions are topically focused with a mix of invited and volunteered papers. The sessions are designed to promote the exchange of interdisciplinary, state-of-the-art information. Papers are submitted to a specific session title and to ONE scientific category. Each topical session may have as many as three categories from which authors may choose ONE. After each topical description below, the categories are identified by name and number as they appear on the 1999 Abstract Form. PLEASE SUBMIT ONLY IN THE MODE (oral or poster) AND CATEGORIES INDICATED in the description. An abstract submitted in the incorrect mode will be transferred automatically to a discipline session.

Abstracts Deadline: July 12 Please send all invited and volunteered abstracts (electronic and paper) to GSA. Abstracts will be forwarded to the advocates for review.

ROLE OF SESSION ADVOCATE An advocate has proposed each topical session. Advocates may invite specific papers to ensure a successful and excellent session. Volunteered abstracts are also solicited for all approved topical sessions unless otherwise indicated. JTPC representatives, in consultation with the advocates, will organize topical sessions by early August.

T01 ■ Origins of Carbonate Mounds: Crossing the Divides of Sedimentology, Diagenesis, and Paleontology
David C. Kopaska-Merkel, Geological Survey of Alabama, Tuscaloosa; Douglas W. Haywick, University of South Alabama, Mobile.

Carbonate mounds are unique sedimentological features common during much of the Phanerozoic but unknown in the Holocene. Many mounds exhibit unusual diagenetic fabrics and biologic communities unknown elsewhere. Despite decades of research, mound origins, diagenesis, and paleogeologic significance remain enigmatic. In this session we will explore frontiers of mound research in sedimentology, diagenesis, paleontology, and the interfaces among these disciplines. ORAL and POSTER

Sediments, Carbonates [27], Paleontology/Paleobotany [18]

T02 ■ Geochemical and Isotopic Tracers Applied to Sedimentary Provenance, Drainage Systems, and Related Tectonics
Jonathan Patchett, University of Arizona, Tucson; Chris Holmden, University of Saskatchewan, Saskatoon.

Papers in this session will discuss applications of geochemical (e.g., REE) and isotopic techniques (e.g., Sr, Nd, Pb, including zircons) to the provenance of sedimentary packages in deep basinal, miogeoclinal, foreland, or cratonic environments, and inferences from these studies for drainage systems, mountain belts, continental emergence and submergence, erosional history, and continental juxtapositions. ORAL and POSTER

Sediments, Clastic [28], Geochemistry Other [7], Geochemistry Aqueous [6]

T03 ■ Alloformations, Synthems and Sequences
Ernest A. Mancini, University of Alabama, Tuscaloosa; Lucy E. Edwards, Reston, Virginia; Burleigh Harris, University of North Carolina at Wilmington.

This session will focus on illustrating the merits of utilizing a genetic framework employing alloformations, synthems, or sequences in interpreting the stratigraphic record, on demonstrating the use of unconformity-bounded units in resolving stratigraphic and correlation problems, and on clarifying terminology and definitions used in association with unconformity-bounded units. ORAL

Stratigraphy [29], Sediments, Clastic [28], Sediments, Carbonates [27]

T04 ■ Applied Integrated Stratigraphy in Exploration and Development Geology: New Techniques and Perspectives
Cushman Foundation. Eduardo A. Koutsoukos, PETROBRAS, Rio de Janeiro, Brazil.

This session will focus on innovative techniques pertaining to integrated stratigraphy, and how these can be applied in solving problems of exploration and development in sedimentary basins. These techniques include the development of integrated stratigraphic data sets comprising high-resolution biostratigraphic zonal schemes, ecostratigraphy, magnetostratigraphy, sedimentary geochemistry, sedimentology, sequence stratigraphy, and tectonostratigraphy. ORAL

Stratigraphy [29], Geoscience Information [11], Economic Geology [3]

T05 ■ Effects of Impact Events in the Sedimentary Record
GSA Planetary Geology Division; European Science Foundation (ESF) Impact Program. Christian Koeberl, University of Vienna, Austria; Philippe Claeys, Museum of Natural History, Berlin, Germany.

The study of impact debris in the stratigraphic record is of prime importance to trace accretionary events in the sedimentary record, to identify their origin, and to evaluate their possible role in Earth's biotic and climatic evolution throughout geologic time. Investigations of impact markers in the sedimentary record, especially at various paleontological boundaries, are fundamental to understanding the mechanisms of interaction with the environment. ORAL

Stratigraphy [29], Planetary Geology [22], Geochemistry Other [7]

T06 ■ Faulting and Folding: Crossing the Divide Between 2-D and 3-D.
GSA Structural Geology and Tectonics Division. M. Scott Wilkerson, DePauw University, Greencastle, Indiana; John O. Byrd, Paradigm Geophysical Inc., Houston, Texas.

This session will focus on recent advances in 3-D analysis of fault-related folds (FRFs) in extensional and contractional settings. It is designed as a companion to oral presentations in the morning. Specifically, posters should address: (1) new techniques and/or issues for the 3-D representation, reconstruction, and forward-modeling of FRFs; or (2) carefully documented natural examples or experimental models of zones of complex 3-D deformation within FRFs. ORAL and POSTER

Structural Geology [30], Tectonics [31]

T07 ■ Dates of Faults and Rates of Deformation
GSA Structural Geology and Tectonics Division. Rasoul B. Sorkhabi, Japan National Oil Corporation, Chiba 261-0025, Japan; Ramon Arrowsmith, Arizona State University, Tempe.

A quantitative understanding of the timing of structures, fault rocks, and tectonic events and the rates of deformation processes is crucial to many fields of geology. This multidisciplinary session will focus on the recent progress, problems, and prospects of numerical dating techniques in addressing these issues with case studies and applications (both paleotectonic and neotectonic) and integrative approaches. ORAL

Structural Geology [30], Geophysics/Tectonophysics [10], Quaternary Geology/Geomorphology [25]

T08 ■ Active Faulting and Earthquake Behavior in Complex Orogens: A Multidisciplinary Approach
GSA Structural Geology and Tectonics Division. Karl J. Mueller, University of Colorado, Boulder; John H. Shaw, Harvard University, Cambridge, Massachusetts.

Advances in understanding fault systems and earthquake recurrence in complex orogens suggest important links between fault geometry and stress change over short time intervals (e.g., 0.01–10 ka). This session will combine geologic, geodetic, paleoseismic, and modeling approaches aimed at defining patterns of faulting behavior and characterization of seismic risk. ORAL and POSTER Tectonics [31]

T09 ■ Origin of Orogenic Plateaus: Interactions of Plate Convergence, Mantle Processes, and Surficial Processes in Continental Tectonics
Karl E. Karlstrom, Frank J. Pazzaglia, Mousumi Roy, University of New Mexico, Albuquerque.

The three orogenic plateaus on Earth—Tibetan, Altiplano-Puna, and Cordilleran of North America—are large, relatively flat regions at high elevation within and behind orogenic belts. Understanding these plateaus may take us toward new paradigms that illuminate the role of

Descending talus blocks into Upper Basin, Holy Cross Wilderness, CO—Photo by John A. Karachewski

the asthenospheric mantle and the interactions of surface and deep tectonic processes in continental tectonics. ORAL and POSTER

Tectonics [31], Geophysics/Tectonophysics [10], Structural Geology [30]

T10 ■ Cenozoic Tectonics of the Southern Rocky Mountains in Colorado and New Mexico: Connections with Global Processes

GSA Geophysics Division; GSA Structural Geology and Tectonics Division. Eric A. Erslev, Colorado State University, Fort Collins; G. Randy Keller, University of Texas at El Paso; Anne Sheehan, University of Colorado, Boulder.

This multidisciplinary session will explore the evolution of basement-involved orogens by focusing on the southern Rocky Mountains, which underwent both horizontal shortening and extension in the Cenozoic. Models linking Rocky Mountain deformation and uplift to plate processes will be tested by recent geophysical, structural, stratigraphic, petrologic and geomorphologic studies. ORAL

Geophysics/Tectonophysics [10], Structural Geology [30], Quaternary Geology/Geomorphology [25]

T11 ■ Making Crustal Souffles: High Mountains and Thin Crust in the Sierra Nevada

Stephen K. Park, University of California, Riverside.

Recent geophysical studies have shown that the High Sierra of California is supported by buoyant mantle, rather than a deep crustal root. The evolution of this range from a classic, Andean-style magmatic arc to its present state with no root will be examined in this session. ORAL

Geophysics/Tectonophysics [10], Tectonics [31], Quaternary Geology/Geomorphology [25]

T12 ■ The International Space Station: New Opportunities for Earth Science Research and Education

Cynthia A. Evans, NASA-Johnson Space Center/LMESS, Houston, Texas; Dean B. Eppler; Patricia W. Dickerson, NASA-Johnson Space Center/SAIC, Houston, Texas.

The International Space Station will provide new opportunities for long-term, continuous scientific investigations of Earth to both researchers and educators. This session will highlight the interdisciplinary earth science and educational applications of the imagery database collected by astronauts since Gemini missions and will profile the scientific potential for the station. ORAL and POSTER

Remote Sensing/Geographic Information Systems [26], Geology Education [8], Planetary Geology [22]

T13 ■ Mars, The Next Generation: The Emergent, New Geology of Earth's Neighboring World

GSA Planetary Geology Division. Kenneth S. Edgett, Malin Space Science Systems, Inc., San Diego, California; James W. Rice, Jr., University of Arizona, Tucson.

It has been more than two decades since we saw a truly "new" Mars. This session will feature new results inspired by data from Mars Global Surveyor—results that are just beginning to change our perspectives on topics including surface composition, interior structure, ancient crust, lakes and oceans, volcanism, sedimentology, and uniquely "martian" geomorphology. A preview of the December 1999 Mars Polar landing site is planned, too. ORAL

Planetary Geology [22], Quaternary Geology/Geomorphology [25], Remote Sensing/Geographic Information Systems [26]

T14 ■ Morphological and Mineralogical Biomarkers for Mars Exploration

GSA Planetary Geology Division; Astrobiology Program of National Aeronautics and Space Administration. John F. Kerridge, University of California, San Diego; J. William Schopf, University of California, Los Angeles; Gene D. McDonald, Jet Propulsion Laboratory, Pasadena, California.

The search for evidence of possible ancient life in samples returned from Mars will require development of robust biomarkers. Such development will be enhanced by fostering interdisciplinary collaboration between the terrestrial-biomarker and planetary-science communities. This session will focus on approaches based upon morphology (e.g., paleontology), and biomineralization. ORAL

Planetary Geology [22], Paleontology/Paleobotany [18], Mineralogy/Crystallography [16]

T15 ■ Beryllium: Mineralogy, Petrology, and Geochemistry

Mineralogical Society of America. Edward S. Grew, University of Maine, Orono.

This session will concern all aspects of the element beryllium in earth sciences, with special emphasis on beryllium minerals and their crystal structures, behavior of beryllium in igneous and metamorphic systems, geochemistry of beryllium, and its cosmogenic isotopes, with applications to understanding tectonic and earth surface processes, and environmental impact of beryllium contamination. ORAL

Mineralogy/Crystallography [16], Geochemistry Other [7], Petrology, Experimental [19]

T16 ■ Uranium: Minerals, Chemistry, and the Environment

Mineralogical Society of America. Peter C. Burns, University of Notre Dame, Notre Dame, Indiana; Robert J. Finch, Argonne National Laboratory, Argonne, Illinois.

Topics covered will include the crystal chemistry, mineral structures, and occurrences of uranium minerals, including experimental uranium mineralogy, geochemical behavior of uranium in a wide range of environments, genesis and distribution of uranium deposits, isotopic systematics of uranium minerals, the role of micro-organisms in the formation of uranium minerals, and environmental aspects, including remediation of contaminated sites and the disposal of nuclear waste. ORAL and POSTER

Mineralogy/Crystallography [16], Geochemistry Other [7], Environmental Geoscience [5]

T17 ■ New Insights into the Giant Butte Hydrothermal Deposit

Mark H.Reed, University of Oregon, Eugene; John H. Dilles, Oregon State University, Eugene.

Studies of deep drill core (to >2 km depth) and surface samples have yielded findings pertaining to faulting and tilting, ages of mineralization and igneous rocks, character of porphyry Cu-Mo veins and alteration, main–stage structure and metal zoning, stable isotopes, fluid inclusion geochemistry, and fluid-rock reaction modeling. ORAL

Economic Geology [3], Geochemistry Other [7], Structural Geology [30]

T18 ■ Application of Advanced Geochemical Modeling to Mining-Related Environmental Issues

Geochemical Society; Mineralogical Society of America. Chen Zhu, Old Dominion University, Norfolk, Virginia; Richard K. Preece, BH Copper, Inc., Tucson, Arizona; David Burden, Robert S. Kerr, Environmental Research Laboratory, Ada, Oklahoma.

Chemical reactions are ubiquitous outcomes of extraction, processing, and disposal of geological materials spanning the mining cycle. Assessment of their long-term impact relies partly on geochemical modeling. However, modeling has met only with limited success. Can we move geochemical modeling to a higher level of sophistication? Papers are solicited on case studies or advancement in theories and techniques on surface adsorption, kinetics, coupled processes, redox reactions, and error analysis. ORAL

Environmental Geoscience [5], Geochemistry Aqueous [6], Hydrogeology [13]

T19 ■ Energy Mix of the Future: Meeting the Needs of Society and a Changing Environment

Peter D. Warwick, Allan Kolker, Energy Resources Program, Reston, Virginia; Michele L. Tuttle, Energy Resources Program, Denver, Colorado.

The energy mix of the future will be determined by a complex interplay of environmental, economic, geologic, and policy factors. This interdiscipli-

Hot Topics at Noon

HOT Debates and HOT Lunch

Monday through Thursday, October 25–28,
12:15 to 1:15 p.m., Colorado Convention Center

- *Climates Change, Get With It!*
  We know that climates vary through time; the question is whether human behavior can alter natural variability. What is the nature of the evidence regarding human impacts on climate?
- *Credibility for Sale: Ethics and the Expert Witness*
  What happens to our credibility if we are being paid to discover evidence for a client? On the other hand, is it ethical to withhold expertise to preserve the myth of "objective" science?
- *Green Accounting in the Marketplace: Calculating the Value of Natural Resources*
  Can the value of ecosystem processes be measured and expressed in dollars? Can this approach aid in cost-benefit analyses of competing land and resources uses?
- *Earth Systems Science: Gaia as Goddess of Insight or Siren of Doom?*
  Some say that systemic approaches to understanding the Earth will yield useful new insights. Others claim that this trend is nothing more than "New Age Environmentalism" in disguise.

nary session will examine the mix by considering the availability of energy resources, alternative energy scenarios, and the constraints associated with sustained energy use in the industrialized and developing world. ORAL

Environmental Geoscience [5], Public Policy [24], Coal Geology [2]

T20 ■ Geology: The Bedrock of the Ecosystem: Biological Uses of Geologic Data

Bruce A. Heise, National Park Service, Lakewood, Colorado.

There is a growing awareness that comprehension of geologic features and processes is critical to understanding an ecosystem as a whole. Papers in this session will discuss the examples and benefits of integrating geologic data into biological studies in topics as diverse as fire management and endangered plant distribution. ORAL

Environmental Geoscience [5], Non-geoscience [33]

T21 ■ New Advances in Mine Site Remediation and Reclamation: Taking a Landscape Perspective

GSA Engineering Geology Division. Anne MacDonald, Exponent, Inc., Boulder, Colorado.

This session will explore advances in engineered landscape components —topography, soil, moisture, nutrients, plants—and their applications for environmentally sensitive and sustainable mine site remediation and reclamation schemes. Topics will include waste material handling; soil, water, and nutrient management; evolution of the post-mining landscape; and site treatment and species selection for revegetation. ORAL

Engineering Geology [4], Environmental Geoscience [5], Quaternary Geology/Geomorphology [25]

T22 ■ Dam Geology: New Science Applied to Old Problems

GSA Engineering Geology Division; Association of Engineering Geology. Robert A. Larson, Los Angeles County Department of Public Works, Van Nuys, California; Kerry D. Cato, Raytheon Infrastructure, Temecula, California.

This session will present the application of state-of-the-art geoscience to dam design, construction, risk assessment, failure, and downstream effects. Flooding, landsliding, and earthquake hazard assessments of dams, as well as the geoscience analysis of the largest dams in the United States currently under design and construction, will be presented. ORAL

Engineering Geology [4], Quaternary Geology/Geomorphology [25], Public Policy [24]

T23 ■ De-icing Salts and Their Effect on Crushed Rock Aggregate

GSA Engineering Geology Division. Peter P. Hudec, School of Physical Sciences, Windsor, Ontario; Robert A. Larson, Van Nuys, California.

This session will address advances in rock durability research, focusing on the thermodynamics of frost deterioration of aggregate under the influence of de-icing salts, and will include papers on: Osmosis or freezing? Why is 3%–5% concentration of most salt-alcohol solutions most destructive? What physical properties of aggregates (pore size, distribution, internal surface area, etc.) influence freeze-thaw breakdown? ORAL

Engineering Geology [4], Economic Geology [3]

T24 ■ Digital Field Mapping and Data Collection

GSA Engineering Geology Division; GSA Structural Geology and Tectonics Division. John H. Kramer, Sonora, California.

Reports from field workers will cross the technical divide from the bi-media era of the 1990s, when paper-based field data were scanned or transcribed, to the era when maps are born digital, collected, edited, stored, transmitted, and processed as blips on chips. ORAL

Engineering Geology [4], Economic Geology [3], History of Geology [12]

T25 ■ Engineering and Environmental Geology: State Geological Surveys and Academic Committees

GSA Engineering Geology Division. Duane A. Eversoll, University of Nebraska, Lincoln; Robert A. Larson, Department of Public Works, Van Nuys, California.

State geological surveys have historically provided invaluable research to the applied fields of engineering and environmental geology. This session will focus on the programs and projects that serve societal needs and that are conducted by the state surveys and associated academic communities. Papers are sought from past and present employees of state surveys and associated academic communities. ORAL

Engineering Geology [4], Environmental Geoscience [5], Public Policy [24]

T26 ■ Expansive Materials Along the Front Range of Colorado: Identification, Clay Minerology, Mapping Programs, and Depth of Wetting Resulting from Development

GSA Engineering Geology Division; Association of Engineering Geologists. Edward O. Church, Wheat Ridge, Colorado.

Expansive materials have severely impacted construction along the Front Range of Colorado. These materials will be discussed with respect to county mapping programs, identification of expansive materials based on bio-stratigraphy and clay mineralogy, and the depth of wetting in these materials due to residential development. ORAL

Engineering Geology [4]

T27 ■ Geologic Input to Public Decision-Making: The Need for Greater Predictive Capability

GSA Engineering Geology Division; Institute for Environmental Education. Jerome V. DeGraff, Clovis, California.

Geologic input to policy issues related to reducing geologic hazard impacts, effective hazardous waste clean-up alternatives, and geologic resource availability is expected to have greater predictive capability. This session will explore geologists' involvement with risk and economic models as well as developing better predicative capabilities for geologic events and conditions. ORAL

Engineering Geology [4], Environmental Geoscience [5], Hydrogeology [13]

T28 ■ Geologic Hazard Mapping: The State of the Art

GSA Engineering Geology Division; Association of Engineering Geologists. Randall W. Jibson; Edwin L. Harp, U.S. Geological Survey, Golden, Colorado.

Losses from geologic hazards have been increasing, and systematic approaches to identify, quantify, and portray geologic hazard and risk are needed to make rational planning and zoning decisions, to plan responses to emergencies, and to project possible losses in different hazard scenarios. This session will provide a forum for experts studying a variety of geologic hazards to share their most recent innovations in hazard-mapping approaches and technology. ORAL

Engineering Geology [4], Public Policy [24], Remote Sensing/Geographic Information Systems [26]

T29 ■ Reactivation of Old Landslides Following Development

GSA Engineering Geology Division; Quaternary Geology and Geomorphology Division. Scott F. Burns, Portland State University, Portland, Oregon; Robert A. Larson, Los Angeles County Department of Public Works, Van Nuys, California.

Old landslides always have a high potential of moving again. In many recent examples, human development on old slides has reactivated them by cutting off the toes, adding loads to the upper slide, and changing the hydrology. There is always loss of property, whether one house or an entire development. ORAL

Engineering Geology [4], Quaternary Geology/Geomorphology [25]

T30 ■ Coastal Geologic Risk: Mapping the Hazards and Influencing Public Policy

David M. Bush, State University of West Georgia, Carrollton; Robert S. Young, Western Carolina University, Cullowhee, North Carolina.

This session will examine geological methods of coastal hazard mapping, risk assessment, and coastal hazard mitigation. The goal is to help bridge the gap between science and public policy. The speakers may concentrate on the physical aspects of coastal hazards, public policy, or case studies. ORAL

Marine/Coastal Science [14], Environmental Geoscience [5], Public Policy [24]

T31 ■ Communication Divides: Perspectives on Supporting Information Bridges in the Geosciences

Geoscience Information Society. Lois Heiser, Indiana University, Bloomington; Charlotte M. Derksen, Stanford University, Stanford, California.

This session will address the issues of the geoscience literature and world-wide data needs. Papers may include research requirements, technology, communications in earth science studies, library collections, or preservation activities. ORAL

Geoscience Information [11], History of Geology [12], Geology Education [8]

T32 ■ Geoscience Ethics Guidelines: A Discussion of Their Development, Utility, and Implementation

David M. Abbott, AIPG Ethics Committee, Denver, Colorado; Jonathan G. Price, University of Nevada, Reno.

This session will begin with a review of the development of the Geoscience Ethics Guidelines. Most of the session will consist of discussions of specific ethical issues presented by the guidelines. Groups of 2–3 talks will allow full development of a topic, including alternative viewpoints. These 30–45 minute sessions will be followed by a full 15 minutes of audience participation and discussion of the topic. This will be a unified, 4-hour session. ORAL

Non-geoscience [33], Public Policy [24], Geology Education [8]

T33 ■ Crossing the Greatest Divide: The Earth Sciences, the Humanities, and the Needs of Society

Robert L. Frodeman, University of Tennessee, Chattanooga; Eldridge M. Moores, University of California, Davis.

Leading scholars from the geosciences, the humanities, and the social sciences will discuss the role of the earth sciences in society. Topics to be treated include: What unique contributions can the earth sciences make to our cultural and political debates? How can we better integrate geologic

information and perspectives into the liberal arts curriculum, and into our culture in general? How are the responsibilities of the scientist to society changing? ORAL

Public Policy [24], History of Geology [12], Non-geoscience [33]

T34 ■ Mission-Driven Geology: Meeting Global Challenges and Society's Needs

M. Lee Allison, Utah Geological Survey, Salt Lake City.

Geologists, as well as all other scientists, need to ensure that science is used to benefit society, and that society supports the scientific establishment. The problems facing geologists are similar all over the world. This session will present examples of how geology is providing solutions and how public support is benefiting the geoscience community. POSTER

Public Policy [24], Non-geoscience [33]

T35 ■ Environmental Justice: Geoecological, Social, and Philosophical Perspectives

Paul Pinet, Colgate University, Hamilton, New York; Paul Reitan, University of New York at Buffalo; Trileigh Stroh, Seattle University, Seattle, Washington.

Geoscientists' perspectives on environmental justice range widely, from appropriate resource allocation, toxic-waste siting policies, and geohazard responsibilities to environmental education and philosophical issues. Our responsibility to Earth and social systems requires that geoscientists share our unique insights to foster short- and long-term success of sustainable and equitable societies. ORAL

Public Policy [24], Geology Education [8]

T36 ■ Preserving Data in the Public Trust: Stewardship of the Record of Past Climates

GSA Quaternary Geology and Geomorphology Division; Institute for Environmental Education; GSA Archaeological Geology Division; National Park Service. Ruthann Knudson, Agate Fossil Beds National Monument, Harrison, Nebraska.

Paleoecological resources such as peat bogs, glacial moraines, complex stratigraphy, and radiocarbon-datable materials contain information important to the development of public environmental policies. Papers in this session will discuss the public trust doctrine and public stewardship of those resources and information, particularly in the context of ongoing discussions of climate change. ORAL

Public Policy [24], Quaternary Geology/Geomorphology [25], Paleoceanography/Paleoclimatology [17]

T37 ■ Crossing Disciplinary Boundaries in the Geosciences: Historical Perspectives

GSA History of Geology Division; History of the Earth Sciences Society [HESS]. Kenneth L. Taylor, University of Oklahoma, Norman; Michele L. Aldrich, Cornell University, Ithaca, New York.

The cross-disciplinary nature of geological science is illuminated by its historical development. This session will explore boundary-crossing as a central theme in the dynamics of change in the earth sciences. Scientists and historians will address this theme through cases of imaginative integrations of perceptions and methods from diverse sciences. ORAL

History of Geology [12], Tectonics [31], Paleoceanography/Paleoclimatology [17]

T38 ■ Monsoons, Tectonics, and Climate Change

GSA Quaternary Geology and Geomorphology Division. David M. Anderson, Boulder, Colorado; Peter DeMenocal, Palisades, New York.

The monsoon on the Asian, Indian, and African continents is a major feature of the tropical atmosphere, and varies on interannual, decadal, and millennial time scales. This session will highlight interdisciplinary research on the causes of monsoon variability on several time scales, using geologic evidence derived from marine and terrestrial sources. ORAL

Paleoceanography/Paleoclimatology [17], Tectonics [31], Quaternary Geology/Geomorphology [25]

T39 ■ Proterozoic Glaciations, Cap Carbonates and Isotopic Excursions: Testing the Snowball Earth Hypothesis

Paul F. Hoffman, Harvard University, Cambridge, Massachusetts; Joseph L. Kirschvink, California Institute of Technology, Pasadena.

Proterozoic snowball Earth hypothesis: Pro or con? Papers in this session will concern stratigraphic, paleomagnetic, climatological, geochemical, paleontological, and sedimentological evidence bearing on the validity of the recently proposed snowball Earth hypothesis for the Paleoproterozoic and Neoproterozoic eras. POSTER

Paleoceanography/Paleoclimatology [17], Precambrian Geology [23], Geochemistry Aqueous [6]

T40 ■ The Tropics Compared: Icehouse and Greenhouse States

Claudia C. Johnson, Indiana University, Bloomington.

This interdisciplinary session will offer a comparative study of the integrated paleobiologic, sedimentologic, climatologic and oceanographic processes operating in the tropics during icehouse and greenhouse worlds. It will focus on empirical data, theory, and/or models to compare and contrast the tropics through the extremes of stable-state climatic conditions. ORAL

Paleoceanography/Paleoclimatology [17], Paleontology/Paleobotany [18], Sediments, Carbonates [27]

Ogliocene and Miocene sedimentary rocks, Pawnee National Grassland, CO—Photo by John A. Karachewski

T41 ■ From Greenhouse to Icehouse: The Marine Eocene-Oligocene Transition

Donald R. Prothero, Occidental College, Los Angeles, California; Linda Ivany, University of Michigan, Ann Arbor; Elizabeth Nesbitt, University of Washington, Seattle.

The Eocene-Oligocene transition was a critical turning point in Earth's climatic history, when the "greenhouse" world of the early Eocene changed into the "ice-ouse" conditions of the early Oligocene. This session will focus on new developments in our understanding of the chronostratigraphy, isotopic changes, and biotic turnover of marine organisms during this interval. ORAL

Paleontology/Paleobotany [18], Paleoceanography/Paleoclimatology [17], Stratigraphy [29]

T42 ■ A Multidisciplinary Study of Coalbed Methane in the Ferron Coals, Utah: An Unusual Resource with Potential for Global Environmental Impact

GSA Coal Geology Division. Charles E. Barker; Timothy Collett, U.S. Geological Survey, Denver, Colorado.

Coals act like activated carbons and sorb large volumes of methane and carbon dioxide, both important greenhouse gases. To further understand the behavior of coalbed gases, a cooperative study was instigated to study coals that have a similar depositional, hydrologic, and thermal history but only locally produce commercial gas. ORAL and POSTER

Coal Geology [2], Environmental Geoscience [5], Geochemistry Other [7]

T43 ■ The Hell Creek Formation and the Cretaceous-Tertiary Boundary in the Northern Great Plains: An Integrated Continental Record of the End of the Cretaceous

Paleontological Society. Joseph H. Hartman, University of North Dakota, Grand Forks; Kirk R. Johnson, Denver Museum of Natural History, Colorado; Douglas J. Nichols, U.S. Geological Survey, Denver, Colorado.

The Hell Creek Formation of the Great Plains is the most thoroughly sampled source of paleontological and geological data used to evaluate changes in nonmarine biotas across the K/T boundary. This topical session provides new studies from Hell Creek and overlying strata in the western Dakotas and eastern Montana. ORAL

Paleontology/Paleobotany [18], Stratigraphy [29], Sediments, Clastic [28]

T44 ■ High-Resolution Stratigraphic Approaches in Paleontology

Paleontological Society. Dana Geary, University of Wisconsin, Madison; Peter J. Harries, University of South Florida, Tampa.

This session will illustrate how state-of-the-art high-resolution stratigraphy can be used to address a wide range of different problems spanning geologic time, depositional environments, and taxonomic groups, as well as how paleontologic data can be effectively integrated with the wealth of other important sources of geologic information. ORAL

Paleontology/Paleobotany [18], Stratigraphy [29], Micropaleontology [15]

T45 ■ Beyond Phylogeny Reconstruction: Tree-Based Analyses in Paleontology

Paleontological Society. Lisa E. Park, University of Akron, Akron, Ohio; Andrew Smith, Natural History Museum, London, UK.

This session will explore the wide variety of questions that can be addressed using a phylogenetic tree as a basis for testing hypotheses in Earth history. Emphasis will be on the many uses to which trees can be put. ORAL

Paleontology/Paleobotany [18], Micropaleontology [15], Paleoceanography/Paleoclimatology [17]

T46 ■ Fire and Geology: Surface Processes and Stratigraphic Records
GSA Quaternary Geology and Geomorphology Division. Mark A. Gonzalez, University of Denver, Colorado; Grant Meyer, Middlebury College, Middlebury, Vermont; John A. Moody, National Research Program, Lakewood, Colorado.

This interdisciplinary (climatology, ecology, geomorphology, hydrology, pedology, stratigraphy) session will examine fire in the geological record. We solicit studies of the types, rates, and magnitudes of geomorphic and hydrological processes following fires; fire recurrence on Holocene time scales; and relations among fire, climate, and land-management practices. ORAL and POSTER

Quaternary Geology/Geomorphology [25], Paleoceanography/Paleoclimatology [17], Environmental Geoscience [5]

T47 ■ Geomorphic and Ecological Responses to Natural and Anthropogenic Disturbances
GSA Quaternary Geology and Geomorphology Division. Jerry R. Miller, Indiana University–Purdue University, Indianapolis; Dru Germanoski, Lafayette College, Easton, Pennsylvania.

The restoration of riparian ecosystems requires an integrated understanding of geomorphic, hydrologic, and ecological processes. This session will focus on the linkages between physical and ecological systems along the riparian corridor, and the interrelated responses of these systems to natural and human-induced disturbance. ORAL

Quaternary Geology/Geomorphology [25], Environmental Geoscience [5], Non-geoscience [33]

T48 ■ Integrated Landscapes: The Colorado Front Range
GSA Quaternary Geology and Geomorphology Division. Ellen E. Wohl, Colorado State University, Fort Collins.

Geologists regard a landscape as the product of processes operating across time and space. This perspective can be broadened by integrating geological studies with the work of other scientists to better understand how landscape history and contemporary events will shape our future. The urbanizing Colorado Front Range exemplifies historic and contemporary human-landscape interactions, and is the focus of this session. ORAL

Quaternary Geology/Geomorphology [25], Environmental Geoscience [5]

T49 ■ Glaciation and Reorganization of Asia's Network of Drainage: The Effects on Late Quaternary Global Change
GSA Quaternary Geology and Geomorphology Division; International Geological Correlation Program (IGCP). Lewis A. Owen, University of California, Riverside; Jim Teller, University of Manitoba, Winnipeg; Nat Rutter, University of Alberta, Edmonton.

The extent and timing of late Quaternary glaciation in Siberia, Tibet, and the bordering mountains and the relation of that glaciation to the re-routing of Asia's north-flowing rivers will be examined to help assess its importance to the continent's hydrological systems and to global climate change. Topics will include glacial geology, geolimnology, paleoceanography, paleohydrology, and general circulation modeling. ORAL

Quaternary Geology/Geomorphology [25], Paleoceanography/Paleoclimatology [17], Stratigraphy [29]

T50 ■ North Atlantic Crossroads: Terrestrial and Marine Environmental Records of Iceland
GSA Quaternary Geology and Geomorphology Division. John T. Andrews, University of Colorado, Boulder.

The area around Iceland is subject to extreme atmospheric and ocean changes; thus, it is ideal for measuring the variability of North Atlantic climate on time scales of the past 100, 1000, and 20,000 years. This session will bring together Icelandic, North American, and European research on historical, glacial, lacustrine, and marine records. ORAL

Quaternary Geology/Geomorphology [25], Paleoceanography/Paleoclimatology [17], Marine/Coastal Science [14]

T51 ■ Landscape Erosion and Sedimentation Modeling
Russell S. Harmon, Engineering and Environmental Sciences Division, Research Triangle Park, North Carolina; William W. Doe, Colorado State University, Fort Collins.

This session will provide an interdisciplinary forum for discussion of different philosophical and technical approaches to soil erosion and deposition and landscape evolution modeling. Approaches could range from those developed from considerations of first-principle soil and water physics and mechanics to those developed empirically according to behavioral or empirical "rules" derived from field observations and measurements. ORAL

Quaternary Geology/Geomorphology [25], Hydrogeology [13], Sediments, Clastic [28]

T52 ■ Geologic and Biologic Evidence for Late Cenozoic Drainage Rearrangements in North America: Implications for Aquatic Biogeography
GSA Quaternary Geology and Geomorphology Division; Smithsonian Institution. Robert Hershler, National Museum of Natural History, Washington, D.C.; Marith C.Reheis, U.S. Geological Survey, Denver, Colorado.

The interplay of tectonics, climate change, and glaciation has greatly modified the configuration of drainage basins and distribution of aquatic species in North America. Advances in dating and techniques for inferring phylogenetic relationships permit new understanding of the timing of drainage change and the migration and evolution and extinction patterns of aquatic species. This session will focus on new geologic and biologic research on drainage changes during the late Cenozoic. ORAL

Quaternary Geology/Geomorphology [25], Non-geoscience [33], Paleontology/Paleobotany [18]

T53 ■ Shallow Subsurface Mapping: Using Geophysics for Geological, Groundwater Resource, and Contamination Studies
GSA Quaternary Geology and Geomorphology Division; GSA Geophysics Division, GSA Hydrogeology Division. Susan E. Pullan, Geological Survey of Canada, Ottawa, Ontario; Peter Haeni, U.S. Geological Survey, Storrs-Mansfield, Connecticut.

Geological mapping, groundwater resource studies, and contamination problems need detailed information on the structure and stratigraphy of shallow subsurface sediments. This session will focus on how geophysics can be used to explore and map the shallow subsurface (upper ~200 m), with an emphasis on applications in Quaternary (particularly glacial) environments. ORAL and POSTER

Quaternary Geology/Geomorphology [25], Geophysics/Tectonophysics [10], Hydrogeology [13]

T54 ■ Subglacial Processes and the Behavior of Ice Sheets
GSA Quaternary Geology and Geomorphology Division. Edward B. Evenson, Lehigh University, Bethlehem, Pennsylvania; Richard B. Alley, Pennsylvania State University, University Park; Daniel Lawson, Cold Regions Research and Engineering Laboratory, Fort Richardson, Arkansas.

This session will focus on how ice-bed interactions and subglacial hydrology influence subglacial processes, including basal-ice and bed deformation, regelation, sliding, and freeze-on, and how these in turn influence glacier flow, glacier dynamics, glacier profiles, glacial erosion, debris entrainment, debris content and transport, and ultimately glacial sedimentation and landform development. ORAL

Quaternary Geology/Geomorphology [25], Hydrogeology [13]

T55 ■ Surficial Three-Dimensional Geologic Mapping: Basic Map Products and Applications
GSA Quaternary Geology and Geomorphology Division; Association of American State Geologists and U.S. Geological Survey National Cooperative Geologic Mapping Program. Richard C. Berg, Champaign, Illinois; Peter T. Lyttle, Reston, Virginia.

This poster session will include examples of surficial geologic maps, particularly those showing the three-dimensional nature of sediments. We also seek examples of how surficial geologic maps have been interpreted for various uses, such as groundwater protection, sand and gravel resources, liquefaction potential, and other applications. POSTER

Quaternary Geology/Geomorphology [25], Environmental Geoscience [5], Geoscience Information [11]

T56 ■ The Case for Steady-State Mountain Belts: Observations, Models, and Implications for Global Tectonics
GSA Quaternary Geology and Geomorphology Division. Frank J. Pazzaglia, University of New Mexico, Albuquerque; Peter L. Knuepfer, Binghamton University, Binghamton, New York.

Do dynamic interactions between geodynamic or tectonic processes and surface processes (and topography) lead to a "steady-state"

Precambrian gneiss/migmatite, Highway 92, Black Canyon of the Gunnison National Monument, CO—Photo by John A. Karachewski

mountain range in compressional orogens? This poster session will focus on field data and modeling studies that present and/or evaluate the validity of the steady state concept at spatial scales from basin-specific to orogen-wide. POSTER

Quaternary Geology/Geomorphology [25], Tectonics [31], Geophysics/ Tectonophysics [10]

T57 ■ Granite Systems and Proterozoic Lithospheric Processes
William R. Van Schmus, University of Kansas, Lawrence; Carol D. Frost, University of Wyoming, Laramie.

Papers are requested relevant to IGCP-426 (Granite Systems and Proterozoic Lithospheric Processes). Topics include, but are not limited to, Proterozoic granite systems from known tectonic settings, processes that formed Proterozoic granite systems, metallogenesis associated with Proterozoic granite systems, and use of granite systems to constrain Proterozoic terrane correlations. ORAL and POSTER

Precambrian Geology [23], Petrology, Igneous [20], Tectonics [31]

T58 ■ Role of Supercontinents in Earth History: Assembly and Dispersal of the Rodinian Supercontinent (1300–750? Ma), and Impacts on Evolution of the Proterozoic Biosphere, Hydrosphere, and Crust-Mantle System
GSA Structural Geology and Tectonics Division. Christopher M. Powell, University of Western Australia, Nedlands; Richard E. Hanson, Texas Christian University, Fort Worth.

This session will examine the profound tectonic, climatic, oceanographic, and biotic changes that occurred in the latter part of the Proterozoic Eon in the context of evolving supercontinent configurations. ORAL

Precambrian Geology [23], Tectonics [31]

T59 ■ Multidisciplinary Studies in Volcanology, Planetary Geology and Economic Geology: A Tribute to 50 Years of Research by Professor Wolfgang Elston, University of New Mexico
Eugene I. Smith, University of Nevada, Las Vegas; James G. Aldrich, Los Alamos National Laboratory, Los Alamos, New Mexico.

During his nearly 50 years at the University of New Mexico, Wolfgang Elston pioneered a multidisciplinary approach to solving geological problems in volcanology, planetary geology, and economic geology. This session is highlighted by keynote speakers in these fields and by a presentation by Elston. We invite Elston's students, colleagues, and others interested in the multidisciplinary linkages among these fields to participate. ORAL and POSTER

Volcanology [32], Planetary Geology [22], Economic Geology [3]

T60 ■ Building the Quantitative Skills of Nonmajors and Majors in Geoscience Courses
National Association of Geoscience Teachers. R. Heather Macdonald, College of William and Mary, Williamsburg, Virginia; LeeAnn Srogi, West Chester University, West Chester, Pennsylvania; Glenn B. Stracher, East Georgia College, Swainsboro.

We welcome contributions on any aspect of quantitative skills in the geoscience curriculum. Topics may include examples of quantitative assignments, strategies for large entry-level courses, ways of integrating quantitative skills throughout the department curriculum, strategies for helping students understand and use mathematics, documentation of success in developing quantitative skills, and campus-wide efforts to promote quantitative literacy. ORAL and POSTER

Geology Education [8]

T61 ■ Undergraduate Research: Strategies for Success
National Association of Geoscience Teachers; Council on Undergraduate Research, Keck Geology Consortium. Jill K. Singer, Buffalo State College, Buffalo, New York; Virginia Peterson, Western Carolina University, Cullowhee, North Carolina; Robert Shuster, University of Nebraska at Omaha.

The increasing role of research experiences in undergraduate education presents faculty with new opportunities and challenges. We encourage submission of papers that address the pedagogical importance of undergraduate research or that present successful strategies for incorporating research experiences into the classroom, directing individual undergraduate projects, or directing group research projects. ORAL

Geology Education [8]

T62 ■ Student Research
Sigma Gamma Epsilon. James C. Walters, University of Northern Iowa, Cedar Falls; Charles J. Mankin, Oklahoma Geological Survey, Norman.

Undergraduate and graduate students are encouraged to share results of their research activities by way of poster presentation. POSTER

Geology Education [8]

T63 ■ Linking Science Research and Education to Improve Undergraduate Geoscience Programs and K–12 Earth Science Teacher Preparation
Frank M. Ireton, American Geophysical Union, Washington, D.C.; Stephanie A. Stockman, Laboratory for Terrestrial Physics, Geodynamics Branch, Greenbelt, Maryland; Edward E. Geary, Geological Society of America, Boulder, Colorado.

This session will highlight some of the undergraduate education reform efforts that are under way with an emphasis on models for success, potential roadblocks, and lessons learned. The conveners invite and encourage organizations and universities that have participated in or are participating in undergraduate geoscience education to contribute to this session. POSTER

Geology Education [8]

T64 ■ Tectonics, Topography, and Climate: The State of the Art in Earth Systems Science Teaching and Research
National Association of Geoscience Teachers. Jeff Niemitz, Dickinson College, Carlisle, Pennsylvania; Yildirim Dilek, Miami University, Oxford, Ohio.

This session will bring together a diverse group of researchers and teachers of earth systems science to present and discuss the feedback relationships among and between tectonic, topographic, and climatic processes and their implementation in the undergraduate and graduate student research and teaching environments. ORAL

Geology Education [8], Tectonics [31], Paleoceanography/Paleoclimatology [17]

T65 ■ Evaluation and Assessment of Multimedia Computer-Assisted Geoscience Education: A Hard Look at What Works and Why
Michael M. Kelly, Northern Arizona University, Flagstaff.

How do we know that the use of multimedia technology in geoscience education works at least as well as traditional teaching techniques? Assessment and evaluation are the keystones to understanding effective use of multimedia as well as the road signs on the path to recommendation or rejection of specific geoscience-teaching software packages. This session encourages exploration of what works and what doesn't in multimedia computer-assisted geoscience education. ORAL

Geology Education [8], Geoscience Information [11], Environmental Geoscience [5]

T66 ■ Successes in Creating Multimedia-Assisted Learning Environments: The Sage on the Stage Versus the Guide on the Side—Yet Another Divide to Cross
National Association of Geoscience Teachers; American Geological Institute. John C. Butler, University of Houston, Houston, Texas; Warren Huff, University of Cincinnati, Cincinnati, Ohio; Michelle Lamberson, University of British Columbia, Vancouver.

This session will include papers that discuss outcomes in using multimedia technologies to create learning environments. We are interested in both long (25 minutes) presentations on "proven" successes and failures, and shorter (15 minutes) presentations. ORAL

Geology Education [8]

T67 ■ Teaching Science By Example: Real Problems, Real Data, All Classes, Every Day
National Association of Geoscience Teachers. Paul Howell, University of Kentucky, Lexington.

This session will examine the diverse strategies used to teach science using real- life problems and data from K–12 to graduate level courses in a variety of geoscience teaching environments. ORAL and POSTER

Geology Education [8]

T68 ■ Successful Assessment Case Studies of Common Concerns in the Geoscience Classroom
National Association of Geoscience Teachers. Dean A. McManus, University of Washington, Seattle; William Prothero, University of California, Santa Barbara.

This session will present descriptions of successful assessment case studies of common classroom concerns in teaching and student learning in the geosciences, with discussion of results after each presentation. ORAL

Geology Education [8]

T69 ■ People and Landscapes: Earth Systems Interpretation in Park Areas
James F. Wood, National Park Service, Lakewood, Colorado; Allyson C. Mathis, National Park Service, Capulin, New Mexico.

National parks and other natural areas are ideal settings for the public to explore relationships among landscape, ecosystems, and people. This session will address how geoscience interpreters and educators can facilitate connections between people and natural systems. ORAL

Geology Education [8]

T70 ■ Teaching Earth Science with Art
Gary D. Rosenberg, Indiana University–Purdue University at Indianapolis; Richard Leo, Cerro Coso Community College, Ridgecrest, California.

Learn how to stimulate your students and deepen your own appreciation of earth science using lessons from art history and the subject matter, materials, and chemistry of art. Your next geology field trip may be to an art museum, your next laboratory an exercise in lithography, etching, morphing, or contemporary music. ORAL

Geology Education [8], History of Geology [12]

T71 ■ Teaching Geologic Time: Methods and Relevance
National Association of Geoscience Teachers. Martin Miller, University of Oregon, Eugene.

This session will explore effective techniques and approaches for teaching different aspects of geologic time and why the concept of deep time is important. Teaching methods will focus on either classroom or field-based instruction. Relevance issues will range from environmental rates and sustainability to the evolution-creation debate. ORAL

Geology Education [8]

T72 ■ Teaching Geology to the Disabled
National Association of Geoscience Teachers. Pranoti M. Asher, Georgia Southern University, Statesboro.

This session will explore the challenges of and strategies for teaching wheelchair bound and hearing- and vision-impaired students in introductory geology courses. POSTER

Geology Education [8]

T73 ■ The Significance of the National Academy of Sciences–National Research Council's National Science Education Standards to the Public Understanding and Future of the Geosciences
National Association of Geoscience Teachers. Bonnie J. Brunkhorst, California State University, San Bernardino; Edward E. Geary, Geological Society of America, Boulder, Colorado; Ramon E. Lopez, University of Maryland, College Park.

This session will present the goals and processes for the NAS/NRC establishment of National Science Standards specifically as significant for the geoscience community. The roadblocks and challenges of Standards implementation will be discussed in the context of the development of the National and California Science Standards. ORAL

Geology Education [8]

T74 ■ Isotopic Records of Microbially Mediated Processes in Natural Environments
Geochemical Society. Chuanlun Zhang; Timothy W. Lyons, University of Missouri–Columbia; Christopher S. Romanek, Savannah River Site, Aiken, South Carolina.

Isotopic fractionations of life-essential elements fingerprint and quantify the roles that microbes play in mediating chemical reactions in natural environments. Recent advances in stable isotope techniques open exciting opportunities for interdisciplinary research involving geology, chemistry, and microbiology, which will expand our understanding of biogeochemical interactions through Earth's history. ORAL and POSTER

Geochemistry Other [7], Geomicrobiology [9], Geochemistry Aqueous [6]

T75 ■ Geomicrobiology and Biogeochemistry
Geochemical Society. Katrina J. Edwards, University of Wisconsin–Madison; Dianne Newman, Harvard Medical School, Boston, Massachusetts.

This session will focus on the interactions among life, geochemical, and mineralogical processes. This includes but is not limited by, mineral formation and degradation, microbially mediated geochemical reactions and conditions, and biogeochemical cycling of elements at all scales. ORAL and POSTER

Geochemistry Other [7], Geomicrobiology [9], Environmental Geoscience [5]

T76 ■ Global Biogeochemical Cycles and Climate
William W. Hay, Christian-Albrechts-University, Kiel, Germany.

This session will explore the effects of global biogeochemical cycles on climate by examining the effects of life processes on the composition of the atmosphere and ocean. How have weathering processes responded to the evolution of life? How have changes of the composition of the atmosphere and ocean affected global climate? ORAL

Geochemistry Other [7], Paleoceanography/Paleoclimatology [17]

T77 ■ The Geology of Geomicrobiology: The Links Between Mineralogy and Microbial Ecology
GSA Hydrogeology Division. Philip C. Bennett, University of Texas at Austin.

There has been growing interest in subsurface microbiology and natural attenuation of organic contaminants. This session invites papers that report on the influence of geology and hydrogeology on the subsurface microbial ecology, and the influence of native subsurface microorganisms on the aquifer geology and hydrogeology. ORAL

Hydrogeology [13], Geochemistry Aqueous [6], Geomicrobiology [9]

T78 ■ Calibration, Inversion, and Uncertainty of Groundwater Models
GSA Hydrogeology Division; International Ground Water Modeling Center, Colorado School of Mines; U.S. Geological Survey, Denver. Eileen P. Poeter, Colorado School of Mines, Golden; Mary C. Hill, U.S. Geological Survey, Boulder, Colorado.

As technology advances and practical tools are developed, the importance of more rigorous model calibration, inversion, and uncertainty analysis is becoming obvious. This session provides an opportunity for presentation and discussion of recent work related to calibration, inversion, and uncertainty evaluation of groundwater models. ORAL

Hydrogeology [13], Environmental Geoscience [5]

T79 ■ Dynamics of Mass Transport in Fractured Rocks and Fine-Grained Sediments: Contributions from Laboratory and Field Analyses to Conceptual and Mathematical Modeling
GSA Hydrogeology Division. Peter R. Jorgensen, University of Copenhagen, Copenhagen, Denmark; William W. Simpkins, Iowa State University, Ames.

How do laboratory and field methods combine to produce valid conceptual and mathematical models for managing of fractured groundwater systems under environmental strain. Specific contributions should focus on field, laboratory, and modeling analyses of flow and contaminant transport, and preferably on combinations of these approaches. ORAL

Hydrogeology [13], Environmental Geoscience [5]

T80 ■ Measurement and Description of Flow and Transport in Highly Heterogeneous Aquifers
GSA Hydrogeology Division. Hongbin Zhan, Texas A&M University, College Station; David A. Benson, University of Nevada, Reno.

Many aquifers are composed of highly heterogeneous material. Studies of flow and transport in those aquifers should consider the nature of the highly variable hydrologic properties. Many previous investigations are based on nearly homogeneous adequate characterization methods and models that are best suited to study flow and transport in aquifers with highly variable properties. ORAL

Hydrogeology [13], Environmental Geoscience [5], Engineering Geology [4]

Institute for Environmental Education

- GSA Institute for Environmental Education (IEE) Annual Environmental Forum: *The Sustainability Challenge II: Water and Human Sustainability*
  Sunday, October 24, 1:00–5:00 p.m.
  Earth is called "The Water Planet" for a reason: liquid water is fundamental to life. Water of life-sustaining quality could easily become the primary limiting resource affecting the global human population in the next century. Indeed, this precious resource has shaped human history through wars large and small, mass human migrations and innumerable demographic shifts, and the distribution of wealth among individuals and nations. The IEE Annual Environmental Forum will examine water as potentially the most fundamental aspect of a sustainable global habitat for human beings.
- Geology and Public Policy Forum: *Creationism vs. Evolution in the Classroom: Should Geoscientists Make a Stand?*
  Wednesday, October 27, 1:30–3:30 p.m.
- From the Outcrop to the Hill: *Report from Kai Anderson, GSA 1998–1999 Congressional Science Fellow*
  Wednesday, October 27, 12:00–1:00 p.m.
- Geology on Public Lands: A User's Guide for Scientists, Citizens, and Industry
  Saturday, October 23, 9:00 a.m.–4:00 p.m.
  Preregistration is required. For further information, contact Cathleen May, Director for Policy and Environmental Issues, (303) 447-2020, ext. 195, cmay@geosociety.org.
- Integrated Science Round Table: *Enabling Integrated Science: The Leadership Imperative,* Co-sponsored by Geological Society of America; Ecological Society of America; U.S. Geological Survey.
  Check the June issue of *GSA Today* for additional information.
- Becoming an Expert Witness: *"Effective Expert Witnessing"*
  Co-sponsored by National Groundwater Association and GSA Institute for Environmental Education
  Preregistration is required. For further information, contact Cathleen May, Director for Policy and Environmental Issues, (303) 447-2020, ext. 195, cmay@ geosociety.org.

T81 ■ Investigations into the Effect of Measurement Scale on Determining Hydraulic Conductivity: Field and Modeling Studies
GSA Hydrogeology Division. Todd W. Rayne, Hamilton College, Clinton, New York; Kenneth R. Bradbury, Wisconsin Geological and Natural History Survey, Madison.

This session will deal with field and modeling investigations of the effect of measurement scale on the determination of hydraulic conductivity. This includes field studies in which a scale effect was detected, studies designed to test this phenomenon, studies designed to create it in model space, and theoretical studies of the effect. ORAL

Hydrogeology [13]

T82 ■ Field-Scale Hydrodynamic and Geochemical Interactions at the Interface of Groundwater and Surface Water
GSA Hydrogeology Division. Thomas C. Winter, U.S. Geological Survey, Lakewood, Colorado; William W. Woessner, University of Montana, Missoula.

This session will focus on transient flow and biogeochemical processes in groundwater from a few to several tens of meters of its interface with surface water. We seek papers describing processes affecting the flow and chemistry of both surface and ground water. We also wish to include research on the hyporheic zone in streams, lakes, and wetlands. We seek papers discussing these processes in a variety of landscapes, including mountainous to riverine, glacial, and coastal. ORAL

Hydrogeology [13], Geochemistry Aqueous [6], Geomicrobiology [9]

T83 ■ From Atrazine to Antibiotics: The Occurrence and Fate of Agricultural Chemicals in the Hydrologic System
GSA Hydrogeology Division. Dana W. Kolpin, U.S. Geological Survey, Iowa City, Iowa; Peter B. McMahon, U.S. Geological Survey, Lakewood, Colorado.

This session will focus on the occurrence and fate in the hydrologic system of chemicals (such as pesticides, fertilizers, antibiotics, and growth hormones) used to enhance crop and livestock production. ORAL

Hydrogeology [13]

T84 ■ Gulf of Mexico Hypoxia: A Multidisciplinary, Multiscale Problem
GSA Hydrogeology Division. Anne E. Carey, University of Alabama, Tuscaloosa; Michael R. Burkart, Iowa State University, Ames.

Debates about Gulf of Mexico hypoxia would benefit from understanding watershed, agronomic, fluvial, and marine processes at microscopic to basin-wide scales. Solutions will only result from multidisciplinary research by geologists, hydrologists, agronomists, soil scientists, microbiologists, and oceanographers. We solicit papers on soil nutrient cycling, watershed inputs, in-stream processes, coastal systems nutrients, temporal and spatial distribution of hypoxia, and role of shelf sediments. ORAL

Hydrogeology [13], Marine/Coastal Science [14], Environmental Geoscience [5]

T85 ■ From Atrazine to Hypoxia to Antibiotics: Occurrence and Fate of Agrichemicals in the Hydrologic System
GSA Hydrogeology Division. Michael R. Burkart, Iowa State University, Ames; Anne E. Carey, University of Alabama, Tuscaloosa.

The use of agrichemicals (nutrients, pesticides, and pharmaceuticals) exposes all parts of the hydrologic system to contamination at scales ranging from individual soils to the Gulf of Mexico. We solicit papers on the processes affecting the fate and occurrence of these chemicals and their transformation products in soils, groundwater, surface water, and marine environments. POSTER

Hydrogeology [13], Marine/Coastal Science [14], Environmental Geoscience [5]

T86 ■ Hydrochemistry of Springs
GSA Hydrogeology Division. Brian G. Katz, Tallahassee, Florida; Carol Wicks, University of Missouri, Columbia.

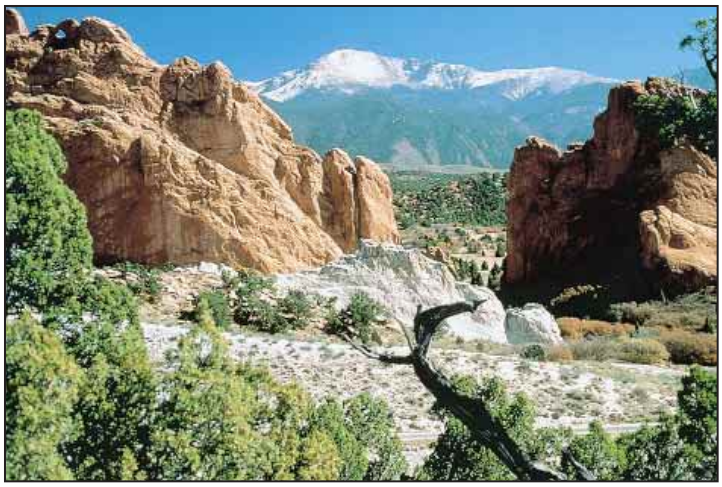
Agricultural activities and other land uses have stressed the quality of spring waters by contributing large quantities of nutrients and other contaminants to groundwater recharge. This session focuses on studies that use biogeochemical, hydrologic, and geophysical methods to characterize the processes that affect the quality of spring waters. ORAL

Hydrogeology [13], Geochemistry Aqueous [6]

T87 ■ Measurement Techniques and Modeling of Spatial and Temporal Variability in Groundwater Recharge in Response to Past, Present, and Future Climates
GSA Hydrogeology Division. Bridget Scanlon, University of Texas at Austin; Alan Flint; Lorrie Flint, Sacramento State University, Sacramento, California.

Recharge measurements are critical for groundwater resources and contaminant transport. This session will include physical (water budget, Darcy's law) and chemical (Cl, ^{3}H, $^{3}H/He$, CFCs, ^{2}H, ^{18}O, Br, dyes) techniques for quantifying recharge at various spatial (point to basin) and temporal (seasonal to thousands of years) scales. Numerical modeling will be discussed. Controls on recharge such as climate (past and future climate, global warming), soil texture, and vegetation will be evaluated. ORAL

Hydrogeology [13], Environmental Geoscience [5]



Garden of the Gods and Pikes Peak—Photo courtesy of Denver Metro Convention and Visitors Bureau

T88 ■ Role of Groundwater Models in Water Rights Disputes: An Evolution in the Understanding of Large-Scale Hydrologic Systems in the Western United States
GSA Hydrogeology Division. Charles B. Andrews, S.S. Papadopulos & Associates, Bethesda, Maryland.

The focus will be on the development and use of models in water rights disputes. Case studies of the use of innovative techniques in high-profile cases will be presented. Emphasis will be on studies where models have been essential for developing a new understanding of the surface water–groundwater relationship and have been used to develop an understanding of aquifer systems in complex geologic settings. Papers on new and innovative modeling techniques for analyzing water rights issues are invited. ORAL

Hydrogeology [13], Engineering Geology [4]

T89 ■ Sustainability of Water Resources in the High Plains
GSA Hydrogeology Division. Marios Sophocleous; Rex Buchanan, Kansas Geological Survey, Lawrence.

The purpose of this session is to stimulate greater interest and involvement by hydrogeologists and others in helping to bring about solutions that will enable both present and future generations to enjoy adequate, good-quality food and water. Additional topics for discussion can include useful hydrogeologic tools that can be used, and how best to provide the needed information to policy makers. ORAL

Hydrogeology [13], Environmental Geoscience [5], Engineering Geology [4]

T90 ■ Hydrologic Resources of Synorogenic Strata
GSA Hydrogeology Division. William E. Sanford, Colorado State University, Fort Collins; Robert G. Raynolds, Kirk Johnson, Denver Museum of Natural History, Denver, Colorado.

Aquifers are being exploited by rapidly urbanizing populations in areas where the water-bearing strata are controlled by depositional patterns reflecting past orogenic activity. In these settings, stratigraphers can provide insight to aid development. Development strategists and public policy makers can benefit from stratal insight! ORAL

Hydrogeology [13], Stratigraphy [29], Tectonics [31]

T91 ■ Low-Recharge Groundwater Systems
Todd F. Battey, Earth Tech, Palmdale, California; John A. Izbicki, U.S. Geological Survey, San Diego, California.

Groundwater systems with limited recharge occur throughout much of southwestern North America and beyond. An understanding of recharge to these precious nonrenewable resources is critical to making sound decisions related to water supply, clean-up, and waste storage. Presentations in this session may focus on new investigative techniques, regional studies, or management implications of low-recharge systems. ORAL

Hydrogeology [13], Environmental Geoscience [5], Geochemistry Aqueous [6]

T92 ■ Sediments in Karst Systems: Processes, Mechanisms, Interpretation
GSA Hydrogeology Division; Karst Waters Institute, GSA Quaternary Geology and Geomorphology Division. Ira D. Sasowsky, University of Akron, Akron,

Ohio; John E. Mylroie, Mississippi State University, Mississippi State; Victor J. Polyak, Texas Tech University, Lubbock.

This session will provide a forum for synthesis of techniques and discussion of new research directions in any aspect of clastic or chemical sediments (speleothems) in karst. Participants are expected from disciplines including: sedimentary processes, paleoclimatology, hydrogeology, surficial processes, mineralogy, paleomagnetism, geochemistry, physics, geomorphology, paleontology, and biology. ORAL and POSTER

Hydrogeology [13], Sediments, Clastic [28], Quaternary Geology/Geomorphology [25]

T93 ■ Impacts of Urbanization on Groundwater Quantity and Quality

GSA Hydrogeology Division. William S. Logan, George Washington University, Washington, D.C.; John M. Sharp, University of Texas at Austin.

Urbanization produces massive physical and chemical disturbances to flow systems, due to changes in demand for groundwater, decreases in recharge, leakage from sewers, runoff from roads, pumping of dewatering wells, and many other phenomena. In this session, we will emphasize studies that integrate several different approaches to document or explain these changes. ORAL

Hydrogeology [13], Geochemistry Aqueous [6], Engineering Geology [4]

T94 ■ Source Protection Planning for Springs and Tunnels: Problems and Solutions

Sue A. Finstick, Bulloch Brothers Engineering, Cedar City, Utah; James H. Martin, Utah Department of Environmental Quality, Salt Lake City.

Protecting the quality of drinking water is an ongoing effort. Numerical modeling to delineate management zones or Wellhead Protection Areas around wells has become commonplace, but these techniques are often not applicable for springs. This session will focus on the problems and solutions in delineating Springhead Protection Areas. ORAL

Hydrogeology [13]

T95 ■ Wetland Hydrology and Geochemistry: The State of the Science

GSA Hydrogeology Division. Donald I. Siegel, Syracuse University, Syracuse, New York.

Wetlands are the hydrologic interface between land, water, and atmosphere. They contain some of the most dynamic ecosystems on terrestrial earth, systems that respond to changes in the hydrology to which they are adapted. This session will present a series of synthesis papers reviewing the most salient aspects of wetland hydrology and geochemistry. ORAL

Hydrogeology [13], Geochemistry, Aqueous [6], Environmental Geoscience [5]

T96 ■ Subsurface Transport, Fate, and Remediation of Nonaqueous Phase Liquid Contaminants in Multicomponent Biogeochemical Systems

GSA Hydrogeology Division. John E. McCray, Colorado School of Mines, Golden; Mark L. Brusseau, University of Arizona, Tucson.

Multicomponent nonaqueous phase liquids and other waste mixtures present a difficult challenge for scientists who endeavor to understand and predict the behavior of subsurface contaminants. This session aims to cross the divides between physical hydrogeology, chemistry, and biology that often impede the study of multicomponent contaminant systems. Theoretical and practical papers related to characterization, transport, remediation, and risk and health assessment are encouraged. ORAL

Hydrogeology [13], Geochemistry, Aqueous [6], Environmental Geoscience [5]

T97 ■ Evolution and Remediation of Acid-Sulfate Groundwater Systems at Reclaimed Mine Sites

GSA Hydrogeology Division. Joseph J. Donovan, West Virginia University, Morgantown; David Atkins, Exponent Environmental Group, Boulder, Colorado.

Mining-related oxidation of sulfide-rich rocks results in the production and transport of sulfate, acid, and metals in the vadose and phreatic zones. Climate, hydrology, transport, and reactions influence the chemistry of resulting flow systems. Innovative lab, field, and modeling approaches are solicited that show promise for prediction and/or control of rates of acid generation and/or neutralization. ORAL

Hydrogeology [13], Environmental Geoscience [5]

T98 ■ Sources, Transport, Fate and Toxicology of Trace Elements in the Environment: A Tribute to Jerome Nriagu

David T. Long, Michigan State University, East Lansing; Gunter Faure, Ohio State University, Columbus.

Papers are invited on the study of trace elements in the environment related to identification of sources, mechanisms of transport by water and air; controls on mobility, the nature and toxicological consequences of transfer through the food chain, and accumulation of toxic elements in sediments and soils. ORAL

Geochemistry, Aqueous [6], Environmental Geoscience [5], Economic Geology [3]

Premeeting Sessions

T99 ■ Janus I: Impact of Research on Mineral Exploration: A Century-Long Retrospective

Society of Economic Geologists. Richard I. Grauch, Denver, Colorado; Richard W. Hutchinson, Colorado School of Mines, Golden.

This session will examine the relationship between research and mineral discovery by comparing and contrasting the major breakthroughs (milestones) in the earth sciences and technology during discoveries in economic geology. This is the predecessor to the year 2000 SEG symposium (Janus II), which will examine the challenges for economic geology research in the next century. ORAL *(All invited papers)*

Economic Geology [3]

T100 ■ The Sustainability Challenge II: Water and Human Sustainability

Institute for Environmental Education; GSA Committee on Critical Issues. Allison R. (Pete) Palmer, Boulder, Colorado; Kenneth E. Kolm, Colorado School of Mines, Golden.

Human sustainability involves a complex interplay between human desires and limits imposed by the atmosphere, biosphere, hydrosphere, and lithosphere. Water quality and quantity are basic to human needs. Assessment of these needs and of water management decisions, including aspects of econometrics and politics, will be addressed. ORAL *(All invited papers)*

Environmental Geoscience [5]

T101 ■ Mission-Driven Geology: Meeting Global Challenges and Society's Needs

M. Lee Allison, Utah Geological Survey, Salt Lake City.

Geologists, as well as all other scientists, need to ensure that science is used to benefit society, and that society supports the scientific establishment. The problems facing geologists are similar all over the world. This session will present examples of how geology is providing solutions and how public support is benefiting the geoscience community. ORAL *(All invited papers)*

Public Policy [24], Non-geoscience [33]

T102 ■ Perspectives on Our Ancestors: Old World and New World Human Populations

Geochemical Society, Organic Geochemistry Division

Michael H. Engel, University of Oklahoma, Norman; Stephen A. Macko, Geochemical Society, University of Virginia, Charlottesville.

Applications of organic geochemical methods for addressing fundamental questions concerning the lifestyles of ancient human populations will be explored. Topics will include the reconstruction of ancient diets, burial practices, trade routes, and genetic relationships based on the analysis of residual organic matter. ORAL *(All invited papers)*

Geochemistry, Other [7], Archaeological Geology [1], Quaternary Geology/Geomorphology [25]

How To Submit Your Abstract

Abstracts Fee: $15 (electronic and paper submissions)

■ Submit Abstract via the Web *(www.geosociety.org)*

On or about May 1, abstracts for the 1999 Annual Meeting in Denver can be sent to GSA via the Web (~72 % of the abstracts were submitted electronically in 1998). Note: electronic abstracts may be sent to GSA only via the Web. They may not be sent by e-mail. The GSA Web abstract system will accept only abstracts containing pure ASCII content (no graphics, tables, symbols, Greek, superscripts, etc.). If you must use non-ASCII characters in your abstract, please use the paper form. Once your abstract is submitted on the Web, you will receive an immediate e-mail confirmation of receipt from GSA, with an abstract number assigned. Please note: There have been problems with some Web client servers cutting off their customers prematurely. The Web page has advice about this and suggestions for use of appropriate browser options.

It's Easy To Submit Electronically

1. *Compose your abstract in your favorite word processor.* Do NOT compose your abstract on-line, because *your server* may disconnect during the time lag.

2. *"Save" the abstract as "text."* This will convert your data into pure ASCII.
3. *Copy and paste* this into the appropriate fields of the GSA Web form.
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 necessary information.

Example Submission

Topical Submissions must include:

- Topical number—T92
- Key words of the topical session title—Sediments in Karst Systems
- One category—Hydrogeology (#13 on abstract form)
- Mode for the session—Oral

Please check the correct mode—oral or poster

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. When you submit your paper, please indicate if you have special presentation needs.

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

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

SUBMIT ABSTRACT ON PAPER

Paper forms have already been distributed for 1999, and can be obtained from the GSA Abstracts Coordinator: Nancy Carlson, ncarlson@geosociety.org or call (303) 447-2020, ext. 161.

Paper abstract forms are available from:

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

YOU MAY SUBMIT ONLY ONE VOLUNTEERED ABSTRACT

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

ABSTRACTS FEE: $15 (electronic and paper submissions)

JOINT TECHNICAL PROGRAM COMMITTEE (JTPC) FINALIZES PROGRAM: *AUGUST 2*

The JTPC selects abstracts and determines the final session schedule. Speakers will be notified in late August. This should be much sooner for abstracts submitted electronically. The JTPC includes representatives from those GSA Associated Societies and Divisions participating in the technical program. The JTPC technical program chairs were nominated by the Denver Annual Meeting Committee and approved by the GSA Council.

Field Trips

Colorado is renowned for field trip opportunities. We encourage meeting attendees to take advantage of a diverse collection of trips, including structural geology, stratigraphy, sedimentology, Quaternary geology, hydro- and environmental geology, and industry-related topics. Some shorter (half-day) trips, quite popular in past years, will show participants local points of geologic interest. Travel plans that include Saturday night stay-over flights can substantially offset field trip costs. Most trips will start and end in Denver. *Please note:* the weather in late October may be a factor in trips in Colorado and adjoining states. The following list is tentative and subject to change. Further details will be given when registration for the meeting begins in June. *For more information, contact the trip leader or the 1999 field trip Co-Chairs: Alan Lester, (303) 492-6172, and Bruce Trudgill, (303) 492-2126, Department of Geological Sciences, Campus Box 399, University of Colorado, Boulder, CO 80309, fax 303-492-2606, alan.lester@colorado.edu, bruce@lolita.colorado.edu.*

Premeeting Trips

- Modern Interpretations of the Geomorphology and Structural Geology in Dinosaur National Monument, as Viewed from the Green River

Monday–Sunday, October 18–24. Jack C. Schmidt, Dept. of Geography and Earth Resources, Utah State University, Logan, UT 84322-5240, (435) 797-1791, fax 435-797-4048, jschmidt@cc.usu.edu; James P. Evans, Dept. of Geology, Utah State University, Logan, UT 84322-4505, (435) 797-1267, fax 435-797-1588, jpevans@cc.usu. edu. Maximum: 16. Cost: $920.

- Cretaceous Hydrocarbon Plays—Southern Colorado

Thursday–Saturday, October 21–23. Cosponsored by *GSA Sedimentary Geology Division.* Paul R. Krutak, Dept. of Geosciences, Fort Hays State University, 600 Park St., Hays, KS 67601-4099, (913) 628-5969, fax 913-628-4096, gspk@fhsu.edu; Maximum: 30. Cost: $290.

- Origin and History of the Heart Mountain Detachment and Associated Structures, Northeast Absaroka Range, Wyoming

Thursday–Sunday, October 21–24. David Malone, Dept. of Geography-Geology, Illinois State University, Normal, IL 61790-4400, (309) 438-2694, fax 309-438-5310, dhmalon@istu.edu; Tom Hauge, Edward Beutner. Maximum: 27. Cost: $375.

- Coal Mining in the 21st Century

Saturday–Sunday, October 23–24. Cosponsored by *GSA Coal Geology Division.* Michael Brownfield, U.S. Geological Survey, MS 972, P.O. Box 25046, Federal Center, Denver, CO 80225, (303) 236-7767, fax 303-236-5888, mbrownfield@usgs.gov; R. Afflotter, E. Johnson, C. Barker. Maximum 20. Cost: $180.

Sand dunes and Sangre de Cristo Mountains, Great Sand Dunes National Monument, CO—Photo by John A. Karachewski

- K/T Boundary in the Raton Basin, New Mexico and Colorado: Evidence for Asteroid Impact

Saturday–Sunday, October 23–24. Cosponsored by *GSA Sedimentary Geology Division.* Charles (Chuck) L. Pillmore, U.S. Geological Survey, MS 913, P.O. Box 25046, Federal Center, Denver, CO 80225, (303) 236-1240, fax 303-236-0214, cpillmor@usgs.gov; Doug Nichols, Farley Fleming. Maximum: 33. Cost: $200.

Fall colors and Lake Creek near Continental Divide, Mt. Hope trail, Sawatch Range, San Isabel National Forest, CO—Photo by John A. Karachewski

- Laramide to Holocene Structural Development of the Northern Colorado Front Range

Saturday–Sunday, October 23–24. Eric A. Erslev, Dept. of Earth Resources, Colorado State University, Fort Collins, CO 80523, (970) 491-6375, fax 970-491-6307, erslev@cnr.colostate.edu; Karl Kellogg, Bruce Bryant. Maximum: 33. Cost: $185.

- 200,000 Years of Climate Change Recorded in Eolian Sediments of the High Plains of Eastern Colorado and Western Nebraska

Saturday–Sunday, October 23–24. Cosponsored by *GSA Sedimentary Geology Division*. Dan Muhs, U.S. Geological Survey, MS 963, P.O. Box 25046, Federal Center, Denver, CO 80225; (303) 236-7919, fax 303-236-5349, dmuhs@usgs.gov; James Swinehart, David Loope. Maximum: 40. Cost: $180.

- Active Salt Tectonics and Collapse in the Eagle Valley and Adjoining Areas of Western Colorado

Sunday, October 24. Robert B. Scott, U.S. Geological Survey, MS 913, P.O. Box 25046, Federal Center, Denver, Colorado 80225, (303) 236-1230, fax 303-236-0214, rbscott@usgs.gov; David Lidke, Bruce Bryant, Mark Hudson, Mick Kunk, Bill Perry, Jim Budahn, Frank Byers. Maximum: 40. Cost: $80.

- Bouncing Boulders, Rising Rivers, and Sneaky Soils: A Primer to Geological Hazards Along Colorado's Front Range

Sunday, October 24. Cosponsored by *GSA Engineering Geology Division*. David C. Noe, Colorado Geological Survey, 1313 Sherman Street, Room 715, Denver, CO 80203; (303) 866-2432; fax 303-866-2461, dave.noe@state.co.us; James M. Soule, Jeffrey L. Hynes. Maximum: 90. Cost: $65.

- Cave of the Winds and Springs of Manitou, Colorado: Geology and Hydrology

Sunday, October 24. Fred Luiszer, Dept. of Geological Sciences, University of Colorado, Boulder, CO 80309, (303) 492-5251, fax 303-492-2606, luiszer@spot.colorado.edu. Maximum: 40. Cost: $85.

- Geological Reconnaissance of Dinosaur Ridge and Vicinity

Sunday, October 24. Norb Cygan, (303) 660-9792, necygan@aol.com; Betty Rall, "T" Caneer, Bob Raynolds, Friends of Dinosaur Ridge, Morrison, Colorado. Maximum: 40. Cost: $70.

- Hydrogeology and Wetlands of the Mountains and Foothills Near Denver, Colorado

Sunday, October 24. Kenneth E. Kolm, Div. of Environmental Sciences, Colorado School of Mines, Golden, CO 80401, (303) 273-3932, fax 303-273-3413, kkolm@mines.edu; John C. Emerick. Maximum: 40. Cost: $80.

- Kimberlites of the Colorado-Wyoming State Line District

Sunday, October 24. Pete Modreski, U.S. Geological Survey, MS 915, P.O. Box 25046, Federal Center, Denver, CO 80225, (303) 236-5639, fax 303-236-5448, pmodreski@usgs.gov; Tom Michalski. Maximum: 26. Cost: $90.

- Walking Tour of Paleontologist G. G. Simpson's Boyhood Neighborhood

Sunday, October 24. Cosponsored by *GSA History of Geology Division*. Leo Laporte, Earth Sciences Dept., University of California, 1156 High St., Santa Cruz, CA 95064, (408) 459-2640, laporte@cats.ucsc.edu. Maximum: 12. Cost: $10.

Half Day—Concurrent with the Meeting

- Geology Tour of Denver Buildings and Monuments

Monday, October 25 or Wednesday, October 27. Cosponsored by *GSA Archaeological Geology Division*. Jack Murphy, Denver Museum of Natural History, Dept. of Earth & Space Sciences, 2001 Colorado Blvd., Denver, CO 80205, (303) 370-6445, fax 303-331-6492. Maximum: 40 (each trip). Cost: $10.

- Tour of the U.S. Geological Survey Mapping and Geologic Facilities, Denver Federal Center

Tuesday, October 26 or Wednesday, October 27. Pete Modreski, U.S. Geological Survey, Box 25046, MS 915, Federal Center, Denver, CO 80225, (303) 236-5639, fax 303-236-5448, pmodreski@usgs.gov; Joseph Kerski. Maximum: 24. Cost: $10.

Postmeeting Trips

- Geological Reconnaissance of Dinosaur Ridge and Vicinity

Friday, October 29. Norb Cygan, (303) 660-9792, necygan@aol.com; Betty Rall, "T" Caneer, and Bob Raynolds, Friends of Dinosaur Ridge, Morrison, Colorado. Maximum: 40. Cost: $70.

- Laramide Minor Faulting and Tectonics of the Northeastern Front Range of Colorado

Friday, October 29. Eric A. Erslev, Dept. of Earth Resources, Colorado State University, Fort Collins, CO 80523, (970) 491-6375, fax 970-491-6307, erslev@cnr.colostate.edu; Steve Holdaway. Maximum: 33. Cost: $85.

- Soil-Geomorphic Relationships Near Rocky Flats, Boulder and Golden, Colorado, With a Stop at the Pre-Fountain Formation of Wahlstrom

Friday, October 29. Peter Birkeland, Dept. of Geological Sciences, University of Colorado, Boulder, CO 80309, (303) 492-6985, fax 303-492-2606, birkelap@stripe.colorado.edu; Ralph Shroba, Penny Patterson. Maximum: 27. Cost: $90.

- South Park Conjunctive Use Project: A Combined Look at Geology and Hydrology in the South Park Basin, Colorado

Friday, October 29. Michael F. McHugh, City of Aurora Water Resources Division, 1450 S. Havana, Aurora, CO 80012, (303) 739-7006, fax 303-739-7604, mmchugh@ci.aurora.co.us; Jim Jehn, Harvey Eastman. Maximum: 40. Cost: $80.

- Stratigraphy, Sedimentary, and Paleontology of the Cambrian-Ordovician of Colorado

Friday–Saturday, October 29–30. Paul M. Myrow, Dept. of Geology, Colorado College, Colorado Springs, CO 80903-3294, (719) 389-6790, fax 719-389-6910, pmyrow@cc.colorado.edu; J. Taylor, J. Miller, R. Ethington, R. Ripperdan. Maximum: 30. Cost: $240.

- Geology and Paleontology of the Gold Belt Back-Country Byway: Florissant Fossil Beds and Garden Park Fossil Area

Friday–Saturday, October 29–30. Herb Meyer, National Park Service, Florissant Fossil Beds National Monument, P.O. Box 185, Florissant, CO 80816, (719) 748-3253, fax 719-748-3164, herb_meyer@nps.gov; T. W. (Woody) Henry, Dan Grenard, Emmett Evanoff. Maximum: 30. Cost: $175.

Short Courses

GSA-Sponsored Short Courses

Preregistration Deadline: September 17

Registration information and course descriptions will be published in the June issue of *GSA Today*. For additional information, contact Edna Collis, Professional Development Department, GSA headquarters, ecollis@geosociety.org, or see GSA's Web site, www.geosociety.org.

- Practical Methods in Applied Contaminant Geochemistry: From Characterization to Remediation

Saturday, October 23. Cosponsored by *GSA Hydrogeology Division*. Donald I. Siegel, Syracuse University. Fee: $175, students $155. C.E.U. 0.8.

- Applied Inverse Ground Water Modeling: Why Use Anything Less?

Saturday–Sunday, October 23–24. Cosponsored by *GSA Hydrogeology Division*. Evan R. Anderman, ERA Ground-Water Modeling, LLC, Denver; James O. Rumbaugh, Environmental Simulations, Denver. Fee: $385, students $365. C.E.U. 1.6.

- Digital Mapping Methods: Accurate Digital Data Capture and Analysis for the Field Geoscientist

Saturday–Sunday, October 23–24. Kent Nielsen, Carlos Aiken, University of Texas at Dallas. Fee: $385, students $365. C.E.U. 1.6.

- Introduction to Remote Sensing for Geologic Applications

Saturday–Sunday, October 23–24. Cosponsored by *GSA Planetary Geology Division*. Andrea Gallagher, Research Systems, Boulder, Colorado; Rebecca Dodge, University of Texas at El Paso; K. Eric Livo, U.S. Geological Survey, Denver. Fee: $325, students $305. C.E.U. 1.6.

- Modern Salt Tectonics

Saturday–Sunday, October 23–24. Cosponsored by *GSA Structural Geology and Tectonics Division*. Mark G. Rowan, Rowan Structural Consulting, Boulder, Colorado. Fee: $265, students $245. C.E.U. 1.6.

- 3-D Seismic Interpretation: A Primer for Geologists

Saturday–Sunday, October 23–24. Cosponsored by *GSA Sedimentary Geology Division*. Bruce S. Hart, New Mexico Bureau of Mines and Mineral Resources. Fee: $280, students $260. C.E.U. 1.6.

- Applications of Environmental Isotopes to Watershed Hydrology and Biogeochemistry

Sunday, October 24. Cosponsored by *GSA Hydrogeology Division*. Carol Kendall, Tom Bullen, U.S. Geological Survey, Menlo Park, California. Fee: $210, students $190. C.E.U. 0.8.

- Teaching Earth System History: A Computer-Assisted Approach

Sunday, October 24. Christopher R. Scotese, University of Texas at Arlington. Fee: $175, students $155. C.E.U. 0.8.

Other Courses, Workshops, and Forums

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

- Isotopic Dating of Ore Deposits

Saturday, October 23. Sponsored by *Society of Economic Geologists*. Information: Joaquin Ruiz, Dept. of Geosciences, University of Arizona, Tucson, AZ 85721, (520) 621-4827, fax 520-621-2672, jruiz@geo.arizona.edu, David Lambert, National Science Foundation, 4201 Wilson Blvd., Arlington, VA 22230, (703) 306-1554, dlambert@nsf.gov.

- National Association of Geoscience Teachers Workshop on Preparing Graduate Students for Teaching

Saturday–Sunday, October 23–24. Sponsored by *National Association of Geoscience Teachers, GSA Education, Outreach, and Policy Programs*, with partial support from *National Science Foundation*. Applications should be submitted by August 17, 1999. Applications and Information: Heather Macdonald, Dept. of Geology, College of William and Mary, P.O. Box 8795, Williamsburg, VA 23187, (757) 221-2443, fax 757-221-2093, rhmacd@facstaff.wm.edu.

- Uranium: Minerals, Chemistry, and the Environment

Friday–Saturday, October 22–23. 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://www.minsocam.org.

- The Evolution-Creation Controversy II: Perspectives on Science, Religion, and Geological Education

Sunday, October 24. Sponsored by *Paleontological Society*. Information: Patricia Kelley, Dept. of Earth Sciences, University of North Carolina, Wilmington, NC 28403, (910) 962-7406, fax 910-962-7077, kelleyp@UNCWIL.edu.

- Digital Database Forum

Wednesday, October 27. Sponsored by *Geoscience Information Society*. Information: Adonna Fleming, James A. Michener Library, University of Northern Colorado, Greeley, CO 80639, (970) 351-1530, fax 970-351-2963, acflemi@bentley.uncl.edu.

GSA K–16 Education Program

Join us in Denver for an exciting program with something for everyone—geoscientists, undergraduate and graduate students, and K–16 teachers.

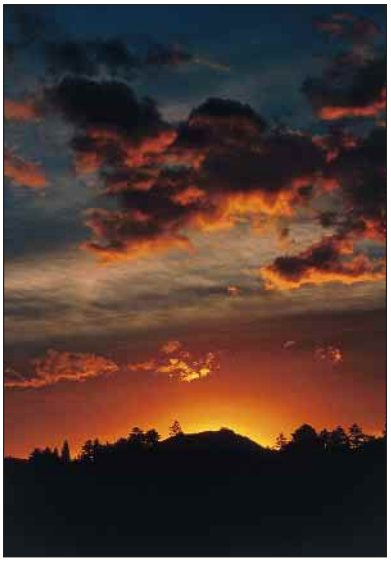
Workshops begin on Saturday and Sunday, so plan to preregister and come early to participate. Our workshops in Denver will include:

- "How to Get Started in Research"
- "Resources Available from the USGS"
- "Exploring the Solar System" for teachers of students with special needs
- "Preparing Graduate Students for Teaching"
- "Exploring Plate Tectonics"
- "Evolution: Investigating the Evidence"
- "Geographic Information Systems"
- "Innovative Course Design for Teaching Undergraduate Geoscience"

Beginning on Monday, October 25, we will also offer a series of dynamic technical sessions, symposia, and forums on a variety of education topics.

Don't forget!

Monday afternoon, GSA and NESTA will host the Earth Science Educators Reception, and we especially invite PEP members! During the reception we will hold our largest Rock Raffle ever, and the Earth Science Information Share-a-Thon. You could be this year's big winner!



Sunrise over Beaver Meadows, Rocky Mountain National Park, CO—Photo by John A. Karachewski

Registration, Travel, and Lodging

Registration

Preregistration Deadline: September 17
Cancellation Deadline: September 24
Registration materials available in June *GSA Today*
June *GSA Today* will be the only complete registration issue.

Estimated Registration Fees

	Advance	On-Site	
	Full Meeting	Full Meeting	One Day
Professional Member	$210	$255	$128
Professional GSA Member (70 or older)	$160	$205	$ 78
Professional Nonmember	$255	$300	$148
Student Associate Member	$ 75	$100	$ 51
Student Nonmember	$100	$125	$ 61
Guest or Spouse (no technical session access)	$ 75	$ 75	n/a
K–12 Professional	$ 25	$ 35	n/a
Continuing Education/ Field Trip Only	$ 35	$ 35	n/a

Costs in U.S. dollars
Final fees will be published in the June issue of *GSA Today*.

Plan now to take advantage of the June registration opportunity. GSA members will automatically receive registration information. If you are not a member and would like registration forms and further information, visit GSA's Web site or contact the Meetings Coordinator, meetings@geosociety.org.

Meeting registration fees have not been established as we go to print. However, for your budgeting and travel authorization requests, please use the estimated pre-registration fees.

MEMBERS PAY LESS! JOIN NOW!

If you join GSA as a 1999 member by October 1, you can register for the meeting at the member rate—while enjoying the other advantages of belonging to the Society. You will save a substantial amount on your registration fee by becoming a member—almost exactly the amount you would pay to join GSA. That's like joining GSA for free!

For further information, contact Member Services at GSA headquarters, member@geosociety.org.

GSA Student Associate Member Travel Grants

The GSA Foundation has awarded $4,000 grants to each of the six GSA sections. The money, when combined with equal funds from the sections, is used to assist GSA undergraduate Student Associates, as well as graduate Student Members, traveling to GSA meetings. For information and deadlines, contact your section secretary.

Cordilleran:	Bruce Blackerby, (209) 278-2955, bruceb@zimmer.csufresno.edu
Rocky Mountain:	Kenneth Kolm, (303) 273-3932, kkolm@mines.edu
North-Central:	Robert Diffendal, Jr., (402) 472-7546, rfd@unl.edu
Northeastern:	Kenneth Weaver, (410) 554-5532, kweaver438@aol.com
South-Central:	Rena Bonem, (254) 710-6806, Rena_Bonem@baylor.edu
Southeastern:	Harold Stowell, (205) 348-5098, hstowell@wgs.geo.ua.edu

Air Travel

Conventions in America (CIA), is the GSA official travel agent. 1025 West Laurel St., Suite 106, San Diego, CA 92101-1254, 1-800-929-4242, fax 619-453-7976, e-mail address: flycia@scitravel. com, Web address: www. scitravel.com, GSA Group #633.

Lodging

GSA has booked rooms at eight properties that offer special convention rates ranging from $80 to $153. The Marriott City Center and Hyatt Regency are co-headquarters hotels for the meeting. Other participating hotels include the Adam's Mark, Brown Palace, Comfort Inn, Embassy Suites, Holiday Inn, and Westin.

Most activities will take place at the Colorado Convention Center, Marriott City Center, and Hyatt Regency. Housing and registration forms will be in the June issue of *GSA Today*.

Special Programs

Employment Interview Service

The Employment Interview Service, together with Round Table Discussions, provides valuable networking opportunities in the geosciences.

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 degrees during 1999 are encouraged to check the job offerings.

See the July 1999 issue of *GSA Today* for applicant and employer forms and additional information, or contact Nancy Williams at GSA headquarters, nwilliams@geosociety.org. Information and forms are also available on the GSA Web site, www.geosociety.org.

Graduate School Information Forum

This forum provides an opportunity for undergraduate students planning to obtain advanced degrees to meet one-on-one with representatives of graduate schools. A list of participating schools will appear in the September issue of *GSA Today*. If your school is interested in participating, contact Tammy White, Exhibits Manager, GSA headquarters, twhite@geosociety.org.

Student Assistants

If you are a student member of GSA and wish to defer some of the cost of attending the Denver Annual Meeting, you may work as an assistant during the meeting. Benefits include registration fee reimbursement (including technical program and exhibits). To receive full benefits, assistants will be expected to work a minimum of 12 hours.

How to Sign Up

Duties will be assigned on a first-come, first-served basis until all positions are filled, giving students in Colorado and surrounding states first choice. If you are interested, send the following information to the e-mail address listed below:

Name • Address • Telephone number • Fax number • E-mail address • Estimate of dates and times you will be available to assist • Name of educational institution you attend • GSA Membership number

Send this information to: Suzanne Larsen, Student Assistant Co-Chair, University of Colorado, Jerry Crall, Johnson Earth Sciences Library, Campus Box 184, Boulder, CO 80309-0184, fax 303-735-4879, suzanne.larsen@colorado.edu

Colorado Convention Center—Photo courtesy of Denver Metro Convention and Visitors Bureau

Exhibits

The 260-booth exposition will showcase more than 170 organizations representing the latest in scientific instrumentation; field supplies and gear; geological publications; laboratory services; gems, minerals, and fossils; geoscience associations; and information on earth science programs at various institutions. Find out more about our current 1999 exhibitors by visiting our Web site, www.geosociety.org/meetings/99.

Exhibitors can reach more than 6,500 influential and key decision-makers from the geoscience community, meeting face-to-face with attendees and developing new customers, increasing sales, and educating current and potential customers on your products and services. For information on becoming an exhibitor, contact Tammy White, Exhibits Manager, GSA headquarters, twhite@geosociety.org. Information is also available on the GSA Web site, www.geosociety.org/meetings/99.

Demo Theater

The GSA Demo Theater offers companies a unique opportunity to present live demonstrations of geoscience products, services, and new technologies in a specially designated area. The presentation schedule will appear on GSA's Web site in August and in the on-site program. If you are interested in showcasing your product, service, or shareware/freeware, contact Tammy White, Exhibits Manager, GSA headquarters, twhite@geosociety.org.

LETTER

Traditional Beliefs and Earth History

I would like to respond to the article by Eric M. Riggs and Dawn G. Marsh, "The Indigenous Earth Sciences Project: Exploring the Synthesis of Southern California Native American Traditional Knowledge and the Earth Sciences" (*GSA Today*, December 1998). I wholeheartedly support efforts to increase participation of Native Americans (and other underrepresented groups) in the earth sciences. Science does not occur in a cultural vacuum, and I think we are all enriched by greater diversity in the cultural backgrounds of our colleagues.

I do offer a word of caution, however, about the goal of enhancing the diversity of approaches to knowledge, and particularly, the incorporation of traditional beliefs in understanding earth systems and history. Riggs and Marsh state, "Preserving and enhancing the diversity of cultures and approaches to knowledge is important for preserving the vitality of science...." I might add: *only* if those approaches fall within the realm of the scientific method. The problem is, traditional beliefs, be they Native American or otherwise, are usually grounded in a different epistemological realm. Such an approach is often incompatible with the scientific method, which, although not perfect, works best for understanding earth systems and history. The conflicts that arise between these two different approaches are long familiar to archaeologists who for some time have been trying to involve Native Americans (as they should) in research and incorporate traditional beliefs in understanding the past. Sometimes the partnership is fruitful, and oral tradition can provide insight into actual geological events (e.g., the Cahuilla flood myth and periodic flooding of the Salton Trough by the Colorado River). However, many times scientific and Native American beliefs are incompatible (case in point is scientists vs. Native Americans in the disagreement about the peopling of the Americas and the ongoing court battle over "Kennewick Man").

True, there are different ways of studying nature and history, but let's not think that by including knowledge based on oral tradition and religion geoscientific understanding will be enhanced. They represent two completely different ways of looking at the world, and I think geology is best served by restricting its "way of knowing" to the scientific method. Yes, we should be proactive in including Native Americans in geology, and we should respect their traditional beliefs, but we should not dilute our discipline by mixing science and religion.

Gary Huckleberry
Washington State University
Pullman, WA 99164-4910

Cordilleran *continued from p. 12*

Nuevo, including recent trench sites; the marine terrace sequence near Pigeon Pt. (west of the fault); geomorphic features associated with faulting, landsliding, and the captured headwaters of Arroyo de los Frijoles; late Pleistocene–Holocene reverse faults; recent sedimentary sequences and liquefaction events; and geomorphic features and evidence from trenching studies.

Postmeeting

7. Mesozoic Convergent Margin of Central California. Four days, Sat.–Tues., June 5–June 8. Raymond V. Ingersoll, (310) 825-8634, ringer@ess.ucla.edu. Limit: 32. Cost: $305. Breakfasts and lunches included.

One of the best locations on Earth to study an ancient convergent margin exposed on land. Stops include the accretionary Franciscan Complex; forearc basement (Great Valley ophiolite) and forearc basin fill (Great Valley Group); the granitic batholith of the Sierra Nevada (plutonic roots of the magmatic arc) exposed in Yosemite Valley; the complex geology of the Foothills metamorphic belt—all the components of the late Mesozoic convergent margin.

8. Economic Geology and Environmental Issues at Mercury-Gold Deposits and the McLaughlin Gold Deposit, California Coast Range. Two days, Sat.–Sun., June 5–6. James J. Rytuba, (650) 329-5418, jrytuba@mojave. wr.usgs.gov. Limit: 35. Cost: $195. All meals included.

Geology and environmental geochemistry of mercury and gold deposits in the northern Coast Range mercury belt. Relationship of thermal springs to mercury deposits and mine drainage; The Geysers geothermal system, Sulphur Bank and Knoxville mercury deposits. Geology and remediation measures, Gambonini mercury mine; environmental restoration at McLaughlin gold mine; evolution of pit lake geochemistry at McLaughlin. Lectures, dinner, and tasting from local wineries included.

9. Sierra Nevada Gold Deposits. Two days, Sat.–Sun., June 5–6. Also premeeting. David Lawler, (510) 549-9694, lawler@webbnet.com. Limit: 20. Cost: $265. All meals included.

See pre-meeting trip 1.

10. San Andreas Fault Zone Near Point Reyes: Late Quaternary Deposition, Deformation, and Paleoseismology. One day, Sat., June 5. Karen Grove, (415) 338-2617, kgrove@sfsu.edu. Limit: 25. Cost: $65.

San Andreas fault where it cuts late Pleistocene coastal deposits and in trenches where it cuts late Holocene deposits. Climatic and tectonic controls on sedimentation and landscape, style and rates of fault deformation, fault zone geometry and evolution. Direct observations and presentations of subsurface well and gravity data. Includes locations not accessible by the general public.

11. Sedimentology and Facies Architecture of High-Density Sediment-Gravity-Flow Deposits, Paleocene, Santa Lucia Range, California. One day, Sat., June 5. Kai Anderson, (650) 723-0507, anderson@pangea.stanford.edu. Limit: 25. Cost: $65.

Sedimentology and stratigraphic architecture of Wagon Caves Rock, a prominent exposure of Paleocene deep-marine sandstones in the Santa Lucia Range; a rare opportunity to investigate both lateral and vertical variability of such sandstones; may be viewed as an exhumed analog for similar sandstones that serve as hydrocarbon reservoirs. Geometric characteristics, lateral and vertical hetereogeneity, and effective reservoir properties of Wagon Caves Rock; field methodologies used to document and represent the sandstones at grain and outcrop scale.

12. Representative Industrial Mineral Mines of the San Francisco Bay Region. One day, Sat. June 5. Don DuPras, (916) 323-0111. Limit: 20. Cost: $65.

Three large construction-related industrial mineral mining operations: one for concrete-grade Pleistocene-Holocene sand and gravel; one for concrete-grade Cretaceous hornblende gabbro; and one in which the Lower Cretaceous Calera Limestone is mined for cement manufacture and aggregate.

13. Earthquakes on the Calaveras Fault: Fact or Fiction? One day, Sat., June 5. Keith Kelson, (925) 256-6070, kelson@lettis.com. Limit: 45. Cost: $65.

Overview of geology, seismology, paleoseismology, and geodetic deformation of Calaveras fault. Classic localities in Hollister show spectacular evidence of surface fault creep; a paleoseismologic site provides a late Holocene slip rate; one or more paleoseismologic sites provides a chronology of large surface ruptures. Earthquake potential of the fault, as interpreted from these sites and the

current understanding of its seismology and geodetic deformation.

14. Geology and Natural History of Coastal Northern California (Tomales Bay, Bodega Bay, and Russian River Regions). One day, Sat., June 5. Jere Lipps, (510) 642-9006, jlipps@ucmp1.berkeley.edu. Limit: 45. Cost: $90. Includes family-style Italian dinner at Union Hotel in Occidental.

Mesozoic terranes, San Andreas fault zone in Tomales and Bodega Harbor, and Pleistocene marine Millerton Formation of Tomales Bay, as well as plant and animal communities. The Mesozoic rocks include accreted turbidite sequences, radiolarian chert, pelagic sediment, and pillow basalt. The Pleistocene deposits, fossiliferous bay sediments deposited 130,000 yr ago, are similar to modern ones. Intertidal communities and quartz diorites, Pleistocene terraces, and beach sedimentation at the UC Bodega Marine Laboratory.

15. Sequence Stratigraphy and Mining History of the Black Diamond Mines Regional Preserve. One day, Sat., June 5. Raymond Sullivan, (415) 338-7730, sullivan@sfsu.edu. Limit: 23. Cost: $65.

Location during 1800s of largest coal mining operation in California. Explore the geology in the underground workings. Shows one of the most complete Tertiary sections in the Coast Ranges. Application and importance of sequence stratigraphy in reinterpreting the stratigraphic relationships of the middle Eocene Domengine formation.

16. Classic Subduction Complex: The Franciscan Complex of the San Francisco Bay Area, California. One day, Sat., June 5. Also premeeting. John Wakabayashi, (510) 887-1796, wako@ tdl.com. Limit: 35. Cost: $60.

See premeeting trip 5.

17. Depositional and Other Features of the Merced Formation in Seacliff Exposures South of San Francisco, California. One day, Sun., June 6. H. Edward Clifton, (281) 293-6775, h-edward.clifton@conoco.dupont.com. Limit: 18. Cost: $60.

Late Pliocene and Pleistocene history of coastal San Francisco area. Depositional facies range from shelf depth to eolian dune and their implications relative to sea-level history and tectonism over the past 2+ m.y. Exposure differs year to year, from fossil remains including a mammoth or mastodon and footprints of diverse Pleistocene mammals, to sedimentary structures formed by ancient earthquakes, and an ash fall that, today, would devastate the Bay Area. Walk along the base of a giant landslide that is activated by earthquakes and El Niño winters.

18. Del Puerto Ophiolite, Its Petrology and Tectonic Setting. One day, Sun., June 6. Robert G. Coleman, (650) 854-3641, coleman@pangea. stanford.edu. Limit: 33. Cost: $65.

Latest Jurassic ophiolite in the eastern Diablo Range, one of the best preserved exposures of the California Coast Range ophiolite. Outcrops of the major ophiolite components, including mantle peridotite, plutonic complex, volcanic rocks, and depositionally overlying sedimentary rocks. Emphasis on petrology, geochronology, and the probable tectonic environment in which this supra-subduction-zone ophiolite formed.

19. Hayward Fault—Source of the Next Big One? One day, Sun., June 6. Sue Hirschfeld, (510) 885-3000, shirsch@gauss.sci.csuhayward.edu. Limit: 42. Cost: $60.

Follow one of the most visible, accessible, and hazardous faults in the world for most of its length along the eastern side of San Francisco Bay; sites provide the latest information on segmentation, the history of earthquake activity, and geologic slip rate; classic sites illustrate geomorphic features and tectonic creep.

20. Hills, Hollows, and Channel Networks: Linking Field Studies and Digital Terrain Modeling. One day, Sun., June 6. William E. Dietrich, (510) 642-2633, bill@geomorph.berkeley.edu. Limit: 30. Cost: $60.

Review past and ongoing research on processes controlling runoff, erosion, and landscape form in the grass and brush lands of Marin County. Detailed studies of runoff generation mechanisms, the cycle of colluvial accumulation and discharge in hollows, controls on channel network development, and linkages between soil production and transport, results of digital terrain modeling. ■

Environmental & Engineering Geoscience Contents

April *BULLETIN* and *GEOLOGY* Contents

The Geological Society of America
BULLETIN
Volume 111, Number 4, April 1999

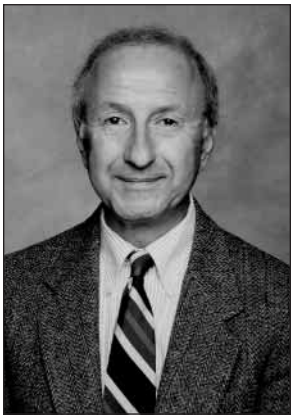
GEOLOGY

VOLUME 27
NO. 4
P. 289-384
APRIL 1999

GSAF UPDATE

Donna L. Russell, Acting Director of Annual Giving

Roy J. Shlemon Establishes Scholarship Fund for Engineering Geology



Roy J. Shlemon, vice chair of the GSA Foundation Board of Trustees, has made a gift to the Foundation to establish the Roy J. Shlemon Fund for Engineering Geology. The purpose of the fund is to support students in the field of Engineering Geology; it will be directed by the GSA Engineering Geology Division.

Roy Shlemon, Foundation trustee since 1996, and GSA member for 29 years, is a consulting geologist and principal of Roy J. Shlemon & Associates, Inc., Newport Beach, California. He previously established the Shlemon Mentors Program, to counsel geology students about opportunities in applied geoscience.

Shlemon earned degrees from Fresno State College, the University of Wyoming, and the University of California, Berkeley (Ph.D.). He has held teaching and/or research positions at the University of California (Davis), Louisiana State University, Stanford, UCLA, and California State University (Los Angeles).

In making this gift, Shlemon pointed out that today's engineering geologist should be well versed in many disciplines, particularly Quaternary geology, geomorphology, and soil stratigraphy. He hopes that the engineering scholarship supported by this new fund will encourage study of traditional engineering in general and of application of multidisciplinary techniques in particular.

Foundation News

The Trustees have announced that Donna L. Russell has accepted the position of Acting Director of Annual Giving. This appointment recognizes her added responsibilities in addition to serving as secretary-treasurer for the Foundation. ■

Donors to the Foundation, January 1999

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2000 Annual Meeting Reno, Nevada

November 13–16
Reno-Sparks Convention Center

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Due Date for Pardee Keynote Symposia and Topical Proposals:
January 5, 2000

For More Information:
Call: (303) 447-2020 or 1-800-472-1988
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Call for Field Trip Proposals

We are interested in proposals for single-day and multi-day field trips beginning or ending in Reno, and dealing with all aspects of the geosciences.

Please contact the Field Trip Co-Chairs:

Mary Lahren
University of Nevada, Department of Geological Sciences, Mackay School of Mines, MS 172, Reno, NV 89557-1038, (775) 784-6610, fax 775-784-1833, lahren@mines.unr.edu

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FUTURE GSA MEETINGS

2001 Boston, Massachusetts, November 5–8
2002 Denver, Colorado, October 28–31
2003 Seattle, Washington, November 2–5

Have Enough Abstracts Forms for the 1999 GSA Annual Meeting?

If not ... request them NOW.

(303) 447-2020, ext. 161
E-mail: ncarlson@geosociety.org

For electronic abtract submission Information is available April 15 on the GSA home page at http://www.geosociety.org.

Remember Deadline for receipt at GSA is *July 12*.

1999 GSA SECTION MEETINGS

ROCKY MOUNTAIN SECTION — April 8–10, 1999, Pocatello, Idaho. Information: Scott S. Hughes, Dept. of Geology, Idaho State University, 785 South 8th Ave., Pocatello, ID 83209-8072, (208) 236-4387, hughscot@fs.isu.edu.

NORTH-CENTRAL SECTION — April 22–23, 1999, Champaign-Urbana, Illinois. Information: Dennis R. Kolata, Illinois State Geological Survey, 615 East Peabody Dr., Champaign, IL 61820, (217) 244-2189, fax 217-333-2830, kolata@isgs.uiuc.edu.

CORDILLERAN SECTION — June 2–4, 1999, Berkeley, California. Information: Doris Sloan, Dept. of Geology & Geophysics, University of California, Berkeley, CA 94720-4767, (510) 642-3703, sloan@socrates.berkeley.edu. *Preregistration deadline: April 30, 1999.*

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continued from p. 19

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Digging Up the Past

"A 47-year career (1931–1978) with USGS—what a fantastic time to have worked in geology!"

—Kiguma J. Murata

GeoTrip

From Pacific Islands to Snake River Rapids: The Geology of Hells Canyon, Oregon and Idaho

June 17–25, 1999 • 9 days, 8 nights

Scientific Leader: *Tracy Vallier, Lewis-Clark State College, Lewiston, Idaho*

Field trip leader *Tracy Vallier* began his studies in Hells Canyon 35 years ago and recently completed a guidebook, *Islands and Rapids: A Geologic Story of Hells Canyon,* published by Confluence Press, Lewis-Clark State College, Lewiston, Idaho. Tracy retired in 1997 from the U.S. Geological Survey, where he worked as a marine geologist with interests in island arcs and deep-sea processes. Before joining the USGS, Tracy taught at Indiana State University and worked with the Deep Sea Drilling Project at Scripps Institution of Oceanography. He taught at Whitman College in Walla Walla, Washington, during autumn 1998, and he is now an adjunct professor at Lewis-Clark State College in Lewiston, Idaho.

Description

One hundred miles of rugged outcrops are exposed in Hells Canyon of the Snake River between Oxbow, Oregon, and the mouth of the Grande Ronde River in Washington. In the deepest major river canyon in the lower 48 states, the Snake River flows more than 8,000 feet below the highest peak of the adjacent Seven Devils Mountains. Explore the viscera of an Early Permian through Middle Jurassic volcanic massif that formed along the magmatic axis of the Blue Mountains island arc. See the dike zones that crystallized beneath the volcanoes, visit volcano-root plutons, study the Permian, Triassic, and Jurassic strata that include a 500-meter-thick Upper Triassic limestone, and put your hand on the Permian-Triassic unconformity. Review the evidence that the pre-Tertiary rocks are exotic to North America. Lava flows of the Miocene Columbia River Basalt Group that overlapped the exotic terrane now perch on canyon rims and, in places, line the steep canyon walls near river level. The canyon is growing deeper as uplift outpaces stream erosion. Landslide, slump, avalanche, alluvial fan, terrace, Bonneville flood, and Mazama ash deposits chronicle the late Quaternary and Holocene. Indian and European histories complement the geology and add to the breadth of the trip. This is an exceptional hiking and rafting trip for the physically fit person to see Hells Canyon and to learn about its geology. June is a beautiful time to visit the canyon, and the weather should be cooperative. Bears, cougars, wild sheep, turkeys, eagles, deer, and elk are among the animals that might be seen. Bring a bathing suit and fly rod if inclined to swim or fish.

Hells Canyon. *Photo by Tracy Vallier.*

Fee and Payment *GSA Member: $1,400 Nonmember: $1,500*

Based on 17 people. The trip may cost more if there are fewer registrants. A $200 deposit, due with your reservation, is refundable through April 1, 1999, less $50 processing fee. Total balance due May 1, 1999. Minimum age: 21.

Included: All meals beginning with dinner on June 17 and ending with lunch on June 25. Transportation by bus from Boise to Halfway and from Heller Bar back to Boise. All river equipment including tents, dry bags, sleeping bags, sleeping pads, and geological reading materials, including, *Island & Rapids—A Geologic Story of Hells Canyon,* by your leader, Tracy Vallier.

Not included: Airfare to and from Boise, Idaho.

GeoHostel

Geology of the Lewis and Clark Expedition—The Three Forks of the Missouri River to the River of No Return, Montana and Idaho

SOLD OUT

REGISTER TODAY!

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

Name

Institution/Employer

Mailing Address

City/State/Country/ZIP

Phone (business/home)

Guest Name

GSA Member #

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CALENDAR

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

1999 Penrose Conferences

June

June 21–27, Terrane Accretion along the Western Cordilleran Margin: Constraints on Timing and Displacement, Winthrop, Washington. Information: J. Brian Mahoney, Dept. of Geology, University of Wisconsin, Eau Claire, WI 54702-4004, (715) 836-4952, fax 715-836-2380, mahonej@uwec.edu.

August

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

2000 Penrose Conferences

March

March 27–31, Volcanic Rifted Margins, Royal Holloway University of London, Egham Surrey, UK. Information: Martin Menzies, Dept. of Geology, Royal Holloway, University of London, Egham Hill, Egham, Surrey TW20 OEX, UK, phone 44-1784-443105, fax 44-1784-471780, menzies@gl.rhbnc.ac.uk. See May 1999 *GSA Today* for meeting details.

1999 Meetings

April

April 21–23, 21st Urban Data Management Symposium, Venice, Italy. Information: www.udms.net.

May

May 4–8, Institute on Lake Superior Geology 45th Annual Meeting, Marquette, Michigan. Information: Robert Regis, Department of Geography and Earth Science, Northern Michigan University, 1401 Presque Isle Ave., Marquette, MI 49855, (906) 227-1176, fax 906-227-1621, rregis@nmu.edu, www.geo.mtu.edu/great_lakes/ilsg.

May 17–19, Third International Conference on Seismology and Earthquake Engineering, Tehran, Iran. Information: SEE-3 Organizing Committee, P.O. Box 19395/3913, Tehran, Iran, phone 98-21-283-1117-9, fax 98-21-229-9479, see3@dena.iiee.ac.ir, www.iiee.ac.ir/see3/index/htm.

June

June 9–15, MINETIME 99, 5th World Technology Exhibition, Düsseldorf, Germany. Information: German Mining Association, MINETIME Congress, Postfach 12 02 80, 63044 Bonn, Germany, phone 49-228-54002-0, fax 49-228-54002-35, or contact Messe Düsseldorf North America, 150 Michigan Ave., Suite 2920, Chicago, IL 60601, phone (312) 781-5180, fax 312-781-5188, www.mdna.com.

June 13–17, Geo-Engineering for Underground Facilities, Urbana-Champaign, Illinois. Information: Carol Bowers, Geo-Institute of ASCE, 1801 Alexander Bell Drive, Reston, VA 20191-4400, (703) 295-6352, fax 703-295-6351, cbowers@asce.org, www.ceps.uiuc.edu/3rdGeoInstitute/index.html.

June 14–15, 3rd Annual Workshop on Continental Scientific Drilling, Hilo, Hawaii. Information: Theresa Fall, DOSECC, 423 Wakara Way, Suite 300, Salt Lake City, UT 84108, (801) 585-9687, fax 801-585-3540, tfall@egi.utah.edu, www.dosecc org.

June 21–22, The Geology of Today for Tomorrow—A Satellite Conference of the World Conference on Science, Budapest, Hungary. Information: János Halmai, Hungarian Geological Society, Pf. 433, H-1371 Budapest, Hungary, phone 36-1-2517770, fax 36-1-3561215, mail.mft@mtesz.hu, www.mafi.hu/mft/alap.html.

August

August 16–20, Operationalization of Remote Sensing, Enschede, Netherlands. Information: Organizing Committee 2nd International Symposium Operationalization of Remote Sensing, Loes Colenbrander, c/o ITC, P.O. Box 6, 7500 AA Enschede, Netherlands, phone 31-53-4874534, fax 31-53-4874466, colenbrander@itc.nl, www.itc.nl/ags/symposium.htm.

August 24–27, International Symposium on High Altitude and Sensitive Ecological Environmental Geotechnology, Nanjing, China. Information: Eleanor Nothelfer, Lehigh University, 13 E. Packer Ave., Bethlehem, PA 18015-3176, (610) 758-3520, fax 610-758-6405, esn0@lehigh.edu; or Baojun Wang, Department of Earth Sciences, Nanjing University, Nanjing 210093, China, phone 86-25-3596220, fax 86-25-3302728, shibin@public1.ptt.js.cn.

September

September 26–30, Society for Organic Petrology 16th Annual Meeting, Salt Lake City, Utah. Information: Jeff Quick, Utah Geological Survey, 1594 West North Temple, Suite 3110, Salt Lake City, UT 84114-6100, (801) 537-3372, fax 801-537-3400, nrugs.jquick@state.ut.us, www.tsop.org.

October

October 1–3, New York State Geological Association 71st Annual Meeting, Fredonia, New York. Information: Gordon Baird, SUNY College at Fredonia, Department of Geosciences, Fredonia, NY 14063-1198, (716) 673-3303, fax 716-673-3347, baird@oak.ait.fredonia.edu.

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

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Positions Open

POSTDOCTORAL POSITION
PURDUE UNIVERSITY

The Laboratory for Applied Experimental Geophysics at Purdue University has an opening for a postdoctoral research associate in the area of laboratory investigation of pore scale imaging and relative permeability upscaling. The primary research will be to perform laboratory measurements of pore geometry, relative permeability, and other parameters necessary for testing current scaling theories for applying laboratory measurements of multiphase flow to the field scale studies. Interested candidates should show demonstrated excellence in laboratory techniques. The research associate will be involved with the construction and fabrication of equipment, the use of low pressure equipment at low temperatures, the performance of relative permeability measurements, imaging, and image analysis. Minimum qualifications: A Ph.D. in hydrology, rock mechanics, geology, physics, chemistry, mechanical engineering, drilling engineering, or a comparable discipline. Please send a letter of interest and your resume by e-mail to Prof. Pyrak-Nolte at pyrak@physics.purdue.edu. Purdue University is an equal opportunity/affirmative action employer. Women and minorities are encouraged to apply.

TEMPORARY TEACHING POSITION IN GEOSCIENCES
UNIVERSITY OF VIRGINIA

The Department of Environmental Sciences at the University of Virginia invites applications for a one-year temporary teaching appointment as Lecturer in Geosciences. Responsibilities each semester will include introductory physical/environmental geology, an additional undergraduate course, and a seminar course at the undergraduate or graduate level. Preference will be given to candidates holding a Ph.D. degree with a specialization in surface processes who can offer courses in coastal processes, geomorphology, or soils. The department is an interdisciplinary community of process-oriented scientists representing atmospheric sciences, ecology, geosciences, and hydrology. Therefore, the ability to offer geosciences courses with ties to the other areas will be beneficial.

Applicants should include one-page statements on their research and teaching interests and experience, a curriculum vitae, and names and contact information of three references. Preference will be given to applications received before April 30, 1999. Applications should be sent to: James N. Galloway, Professor and Chair, Department of Environmental Sciences, University of Virginia, Clark Hall, Charlottesville, VA 22903.

We encourage applications of individuals from underrepresented groups. The University of Virginia is an Equal Opportunity/Affirmative Action Employer.

PALEOBIOLOGY AND PALEOECOLOGY
UNIVERSITY OF ARIZONA

The Department of Geosciences has a one-year sabbatical replacement position as a Lecturer available in the general fields of paleobiology and paleoecology for the 1999/2000 academic year. We seek an individual who demonstrates the ability to be a capable instructor, who is active in research and who demonstrates the capability to provide guidance to and interaction with a dynamic group of graduate students in paleobiology. The successful candidate will be expected to be involved in the teaching of one introductory level course in an appropriate field and to offer a graduate course or seminar in his/her area of specialization. A Ph.D. or equivalent in a relevant discipline is required. Offered salary, not exceeding $30,000, is dependent upon experience. Review of applications will begin on April 20; position will remain open until filled. Candidates should submit a curriculum vitae and a list of three references (including addresses and phone numbers) to Joaquin Ruiz, Chair, Department of Geosciences, University of Arizona, Tucson, AZ 85721 USA. Please refer to Job #14466. The University of Arizona is an EEO/AA employer-M/W/D/V.

LECTURER / PROGRAM COORDINATOR
IN ENVIRONMENTAL STUDIES
UNIVERSITY OF PITTSBURGH

The University of Pittsburgh Department of Geology & Planetary Science seeks a Lecturer/Program Coordinator for its program in Environmental Studies. This non-tenure track faculty position will have an initial appointment of one year, renewable for a three-year period. Teaching responsibilities include instruction in geology and environmental science, with an emphasis on written and oral communication. As Environemntal Studies Coordinator, the successful candidate would establish and run an internship program, advise undergraduate majors, and provide additional educational and administrative support. A Ph.D. in geology or related field of study is required. Review of applications will begin on May 1, 1999, with a target start date of July 1. Send resume, a summary of teaching and related experience, and names/telephone numbers of four references to the Environmental Studies Recruitment Committee, Department of Geology and Planetary Science, 321 EH, University of Pittsburgh, PA 15260-3332. The University of Pittsburgh is an Equal Opportunity Affirmative Action Employer.

SEPM SEEKS EXECUTIVE DIRECTOR

The Society for Sedimentary Geology (SEPM) seeks candidates for the position of Executive Director. SEPM, founded in 1926, is an international society with 5000 members from 23 countries. The Society's primary purpose is to encourage research in sedimentary geology and disseminate that information through journals, special publications, research conferences, and international congresses. The Executive Director is responsible for managing the Society's programs, crafting a vision in partnership with the Executive Council composed of scientists, and proactively seeking opportunities to further the Society's goals. The Executive Director has the responsibility of implementing the Society's program in cooperation with the Society's Business Manager who oversees daily operations of a twelve person staff at SEPM's headquarters in Tulsa, Oklahoma. Candidates for Executive Director must have an advanced degree in geology, Ph.D. preferred, with experience in scientific publications, program management and team supervision. Experience in facilitating teamwork involving technical professionals and support staff will provide a competitive advantage. Applicants should send their letter of interest, resume, and the names (include phone number and e-mail address) of three references to: SEPM Executive Director Search Committee, via e-mail to negeeslin@sepm.org, or by surface mail to SEPM Headquarters, 1731 East 71st Street, Tulsa, OK 74136-5108. Evaluation of submitted resumes will begin June 15, 1999, and will continue until the position is filled. SEPM is an equal opportunity employer.

ASSISTANT SCIENTIST
ILLINOIS STATE GEOLOGICAL SURVEY

Position will involve the hydrogeologic characterization, evaluation, and monitoring of wetland mitigation sites associated with highway construction. Bachelor's degree in geology or appropriately related field with four years of professional experience, or Master's degree as above with two years experience is the minimum requirement. Requires travel that will include extended overnight stays as well as the ability to perform field work. Valid driver's license is required. Salary Range: $28,600-$31,500. Closing date: 04/30/99. Contact walston@isgs.uiuc.edu or 217-244-2401 Illinois State Geological Survey, 615 East Peabody Dr., Champaign, IL 61820. AA/EEO/ADA Employer.

Consultants

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Opportunities for Students

Graduate Study in Structure and Stratigraphy, Baylor University. There is an anticipated opening for a Ph.D. student in the Department of Geology at Baylor University to study the structural and stratigraphic evolution of salt minibasins in southern Louisiana. The project will involve workstation-based interpretation of 3-D and/or 2-D seismic data, development of a sequence stratigraphic framework for the area, and construction of structurally balanced 3-D computer models. Applicants should have an M.S. in Geology or Geophysics, and experience with UNIX is helpful but not required. A more complete project description is available at http://www.baylor.edu/~geology/gradproject.html. It is anticipated, subject to funding, that the position will exist for 3 years as a Research Assistantship, starting in September 1999 or January 2000. Salary will be $20,000/year plus full tuition. For information or application please contact Dr. Mike Hudec, Baylor University, Department of Geology, P.O. Box 97354, Waco, TX 76798-7354; (254)710-6898; e-mail michael_hudec@baylor.edu.

Paleontology Field Program Opportunities. The Museum of the Rockies offers opportunities for students (ages 15 and over) to participate in week-long paleo field programs that offer a broad range of field experiences at several different fossil sites. Each session provides instruction in current dinosaur paleontology research, Rocky Mountain geology, and many opportunities to participate in work in progress including excavating dinosaur fossils and gathering geological data. Week-long sessions begin June 7. For more information, call the Museum at (406) 994-6618 or write to the Paleo Field Program, Museum of the Rockies, 600 W. Kagy Blvd., Bozeman, MT 59717.

Electronic Abstracts Submission
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Abstracts Due
July 12

Preregistration Due
September 17

Registration and Housing Information
June *GSA Today*

Program Schedule
September *GSA Today* and the Web

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For more detailed and up-to-date information, check out the 1999 GSA Annual Meeting Web site at www.geosociety.org/meetings/99

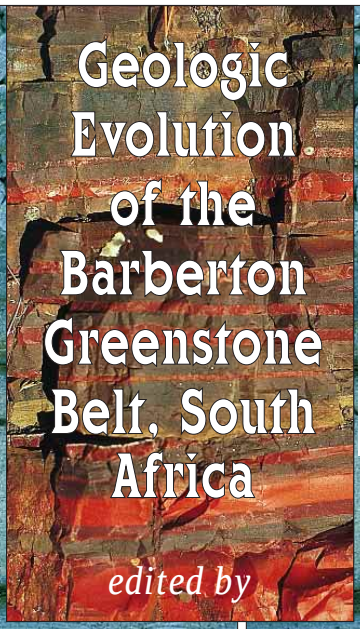
1999 ANNUAL MEETING AND EXPOSITION October 25–28, 1999

HIMALAYA
MOUNTAIN ROOTS TO MOUNTAIN TOPS
AND TIBET

edited by Allison Macfarlane, Rasoul Sorkhabi, Jay Quade, 1999

More than 30 international authors contributed to the first Himalaya-Karakoram-Tibet (HKT) Workshop held in America. The 11th HKT Workshop, held April 1996 in Flagstaff, Arizona, was a logical outcome of an increasing involvement of North American geologists in the studies of the Himalaya and Tibet over the past two decades. One of the prominent features of this 21 chapter volume is the integration of both "hardrock"and "softrock" geology, paleotectonic and neotectonic history, and endogenic (tectonic) and exogenic (geomorphic) processes in the Himalaya. Fully refereed, seven articles cover the Tibet, Trans-Himalaya, and Tethys unit. The High Himalayan Crystalline zone is the subject of another eight chapters; the final six chapters cover the Himalayan Foreland and its sediments, structures, and landforms.

SPE328, 336 p., softcover, 1 large plate, indexed, ISBN 0-8137-2328-0, $70.00, Member price $56.00



Donald R. Lowe and Gary R. Byerly, 1999

The Barberton Greenstone Belt contains the oldest well-preserved volcanic and sedimentary rocks known on Earth and provides a unique window on surface environments, biological evolution, and crustal development 3,550 to 3,200 m.y. ago. This volume presents a systematic account of the geology of the Barberton Belt and its implications for interpreting surface conditions and processes on early Earth. The subjects include stratigraphy, structural divisions, sedimentary geology, and biological materials of the entire belt; mafic and ultramafic volcanic rocks and their petrogenesis; the sedimentology and volcanology of ultramafic volcaniclastic units; the depositional and tectonic setting of the oldest known foreland basin sediments of the overlying Fig Tree Group; and the petrology and tectonic implications of the upper syntectonic quartzose clastic sediments of the Moodies Group. An interpretative summary of the overall evolution of the Barberton Belt concludes the book.

SPE329, 324 p., softcover, indexed, ISBN 0-8137-2329-9, $60.00; Member price $48.00

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