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Acoustic Daylight Imaging: Vision in the Ocean

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ABSTRACT

Sound provides a natural means for exploring the ocean, but current sonar systems, as used, for example, in swath-mapping applications, do not provide directly pictorial images of the ocean depths. Such systems are more akin to radar, which relies on travel-time information to map the environment. A new acoustic technique for providing real-time, visual images of the interior of the ocean is being developed, and results from initial experiments at sea provide evidence in support of the concept. The imaging process relies on ambient noise, or "acoustic daylight," as the source of illumination, the underlying idea being analogous to photography in the atmosphere with daylight illuminating the subject. An object in the noise field scatters the incident sound, and the scattered field is focused with an acoustic lens to form an image on an array of transducers. After signal processing, the acoustic image is displayed as a pictorial image on a television monitor. Acoustic "color," characterizing the spectral reflectivity of the object, could be represented as artificially generated optical color in the display, and a rapid refresh rate could yield moving images much like those from a conventional video camera. Acoustic daylight imaging holds promise for several underwater applications, including mapping the topology and geology of the seafloor.

INTRODUCTION

Daylight is strongly absorbed by sea water: below a depth of a few tens of metres the ocean is enveloped in darkness. Lack of visibility seriously impedes exploration of the ocean depths and is one of the main reasons why activities such as seafloor mapping are so slow and costly. Artificial light sources can be used at depth but, like daylight, are heavily attenuated by the medium, which limits the effectiveness of all forms of optical illumination to very short ranges. Turbidity, which may be severe in shallow environments, exacerbates the problem by reducing the range achievable with optics effectively to zero.

Acoustic techniques for probing the ocean are more promising than light, because sea water is essentially transparent to sound. As demonstrated recently in the Heard Island experiment (Baggeroer and Munk, 1992), sound, under the right circumstances, can be transmitted and detected over oceanic path lengths of tens of thousands of kilometres. Traditionally, acoustics is used in two ways in the ocean: "passive" methods involve simply listening for the sound produced by an object, such as a submarine, whereas "active" systems transmit pulses of sound and listen for returning echoes. Swath-mapping sonar is an example of an active system that is used in an exploratory application, in this case leading to the production of contour or topographic maps of the bathymetry (Macdonald et al., 1993).

Most acoustic systems used for probing the ocean are based on some form of active technology. This is equivalent, in the case of a swath-mapping sonar, for example, to exploring the surface of Earth in pitch darkness using a flashlight; or more accurately, using radar transmissions, which provide travel-time information but no direct visual image. In the circumstances, it is not surprising that ocean exploration is such an arduous activity. Because sonar systems do not yield pictorial images directly, considerable computational effort or a high level of skill and experience is required to interpret their output. Such systems are far from being the underwater equivalent of a conventional photographic or video camera in the atmosphere.

In fact, optical imaging, which is so familiar in the atmosphere, has at present no acoustic analogue in the ocean. Conventional images, as formed by the human eye or a photographic camera, are possible because the presence of an object modifies the ambient illumination by scattering the incident radiation. When the scattered light is focused by an optical lens onto a focal surface (retina or film), an image is created. An essential ingredient in this process is the illuminating field which, under natural conditions in the atmosphere, is daylight. Although it embodies elements and advantages of both, photographic imaging with daylight is neither an active nor a passive technique: the objects being imaged are not intrinsic radiators, nor is the object space illuminated by an artificial light source.

Photography, both still and video, is an extremely effective method of communicating information, as exemplified by the news media, advertising, and television. An analogous acoustic system for creating pictorial images of objects in the ocean could show similar potential. For reasons that may be associated with the evolution of sonar, such a system has never been developed; it is, however, feasible.

ACOUSTIC DAYLIGHT

Ambient noise in the ocean is the analogue of daylight in the atmosphere. Both are incoherent, random fields of radiation propagating in all directions, although the source mechanisms in the two cases are obviously different. The oceanic noise field is produced by numerous natural sources, including breaking waves, bubbles, spray, and precipitation (Kerman, 1988, 1993), in addition to shipping, offshore

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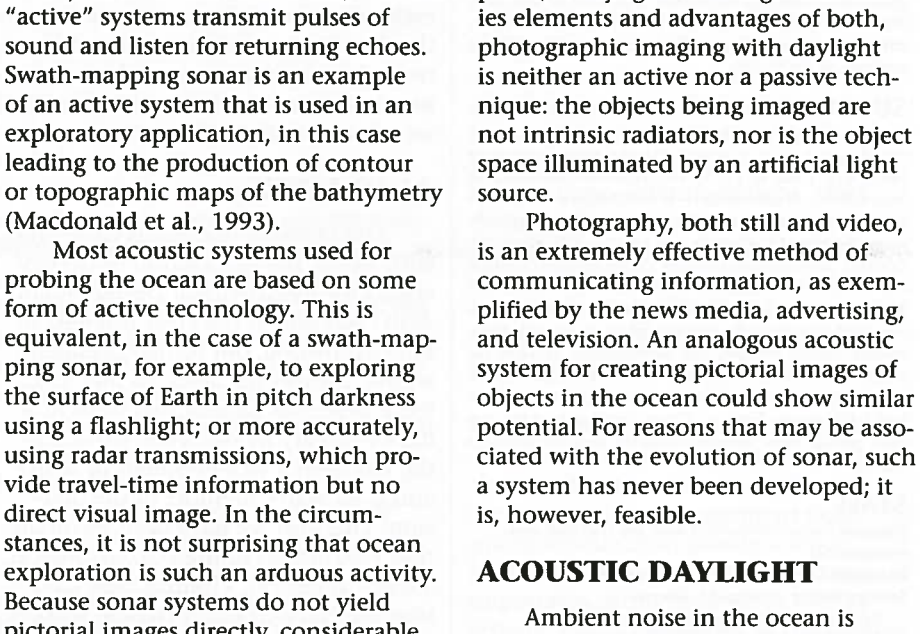

Figure 2. Ambient noise spectra obtained with neoprene-faced targets "on," "off," and absent.

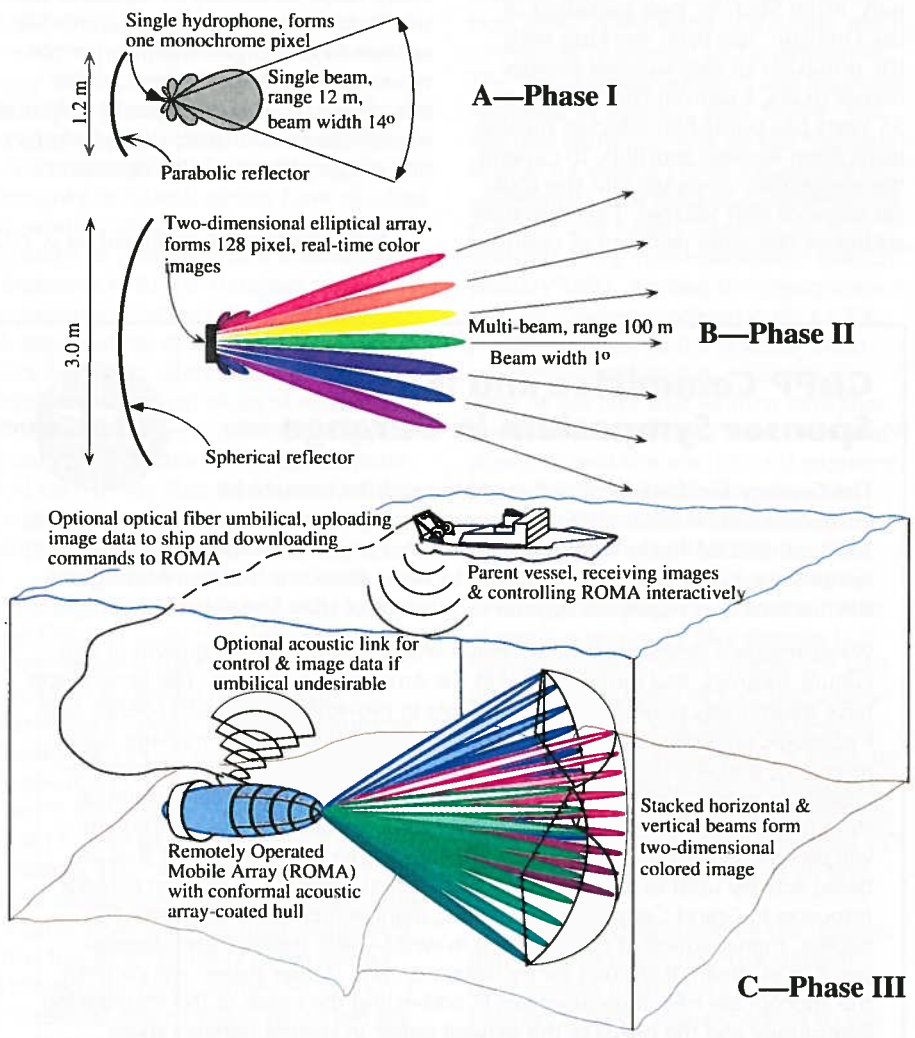

Figure 1. A: Phase I acoustic lens (parabolic reflector with single hydrophone at the focus). B: Phase II acoustic lens (spherical reflector with array of 128 hydrophones in the focal surface). C: Phase III acoustic lens (conformal phased array of 1000 hydrophones on the hull of a remotely operated vehicle).

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Geology: A Truly International Activity

Kevin Burke, Department of Geosciences, University of Houston—Past President, International Division

In the early 1950s at the award ceremony of the Geological Society of London, I recall a tall, handsome, blond young man, a counselor from the Swedish Embassy, standing in for Erik Jarvik, who could not come to collect a medal. In his short speech, he referred to scientists as "the only truly international community," a statement with strong political overtones at that time in Europe. This statement, however, is more applicable than ever to geologists in these times of global politics and global change, when perspectives are continually being altered.

GSA's International Division is active in this changing world in several ways, most of which reflect the energy and enthusiasm of one person or a small number of individuals. Here, I review some of these efforts.

Our division membership is small when compared with the number of GSA members who have international interests. If, in scanning this article, you recognize some activity that you would like to share in or notice some activity that we are missing, think about joining us. Our dues are low, and we try to transfer any balance to a dedicated fund in the GSA Foundation that we hope will eventually allow us to do more of the things that we would like to do.

INTERNATIONAL STUDENTS

Our students committee is the brainchild of Jim Skehan, Division second vice president. The committee has helped Australian and European students arrange field trips in the United States, and it operates a "Geopals" program in which people make a deductible contribution to the Society that enables a named student from abroad to receive one or more of the Society's journals. Lindgren Chyi of the University of Akron assumed responsibility for the students committee while Jim was involved in organizing the Boston Annual Meeting.

With the great influx of students from eastern Europe, Russia, and China, the students committee has some new challenges. A good deal of early effort focused on students from the developing nations in the southern tier; while the problems of those communities have not declined, a whole set of new problems has arisen.

AGID LINKS

The Division maintains close links with AGID, the Association of Geoscientists for International Development. AGID was one of the great interests of Bill Greenwood, our former president, whose unexpected death in July 1992 left a large gap. Sandra Barr from Acadia University in Wolfville, Nova Scotia, has been a vice-president of AGID and is an active member of the division. This year we have been fortunate that Fred Simon of the U.S. Geological Survey in Reston, Virginia, new Division secretary-treasurer (whose work is involved with developing nations) has also agreed to play an informal role in keeping AGID in close touch with the Division.

BOOKS FOR ABROAD

The Division has been collaborating with the Geoscience Information Society on a critical aspect of education in the developing countries. That society has led the way in letting geologists know how best to send technical books and journals to countries where they are needed desperately. Readers of *GSA Today* may recall the publication of a list of names and addresses of organizations that can handle such material. That list appeared in an article by Claren Kidd of the University of Oklahoma in the July 1992 issue. We plan to publish updated versions of this list periodically.

ANNUAL MEETING ACTIVITIES

One of the beliefs of the founders of the Division was that it should be easier for GSA members to learn more about developments in the geological understanding of remote parts of the world. At Cincinnati in 1992, we jointly sponsored a session with the Engineering Geology Division on problems in Latin America and the Caribbean. In 1993 at Boston both a short course on the geology of Asia and sessions on the Himalayas were presented. A short course on the island-arc geology of Japan and a theme session on circum-Pacific geology are planned for the 1994 Seattle meeting. Sponsoring an international field trip in association with the 1995 New Orleans annual meeting is being investigated.

PUBLICATIONS IN FOREIGN LANGUAGES

A topic that has come up at annual meetings of the Division is the publication of papers, particularly on remote and poorly known areas, in a form that is both accessible and comprehensible to members of our Society. To a considerable extent, this happens already through scholarly cooperation between GSA members and colleagues from remote nations. There are also a number of cover-to-cover translation journals. Brian Skinner, past president of the Division, has been working with the publisher of *International Geology Review* (IGR), a journal that for the past 35 years has published selected translations from Russian journals, to expand the geographic coverage and the topical scope of that journal. This initiative addresses the same problem of communication in a different way. Brian and I have agreed to become editors of a reorganized IGR, and I am quite excited about the possibilities. Please contact Brian at Yale University or me at the University of Houston to hear more about this.

LINKS WITH NATIONAL GEOLOGICAL SOCIETIES ON OTHER CONTINENTS

In 1992, the GSA Council approved a set of guidelines, drafted within the Division, addressing ways in which our Society might forge formal and informal links with peer groups on other continents. These guidelines were published in *GSA Today* in September 1992, and additional copies are still available from the executive office in Boulder. With tremendous help from GSA Executive Directory Mike Wahl and his staff, I worked to contact the presidents of several foreign societies as an experiment to see how implementation of these guidelines might be initiated.

We told the presidents of these societies of the GSA Council's decision and sent them copies of the guidelines, suggesting that we would welcome a start in exploring what kinds of cooperation might be both practicable and effective. We have had a good response. Indian, Belgian, British, German, Namibian, Venezuelan, French, Bulgarian, and Swiss societies are among those that have responded. Some of the areas in which collaboration seems possible are simple. For example, the exchange of calendars for a year or more ahead allows societies to publicize each other's activities. You will see evidence of this in the columns of *GSA Today*.

Some of the other kinds of cooperation require individual effort by members. Someone who lives in North America and is a member of both GSA and a national society on another continent can promote collaboration. We are just beginning to identify people who might fill the bill. Any reader who feels that he or she could help and would like to volunteer should contact one of the officers of the Division.

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G&PP Committee and IEE Sponsor Symposium in Durango

The Geology and Public Policy Committee and the Institute for Environmental Education (IEE) will cosponsor a symposium on May 5, 1994, at the GSA Rocky Mountain Section meeting in Durango, Colorado. The symposium, Geoscience Contributions to Water-Resource Decision-Making in the Southwest, is organized by John C. Schmidt of Utah State University.

Water-resource development has been a crucial element of the growth of agriculture, industry, and municipalities in the American Southwest. The geosciences have traditionally played an important role in providing basic earth science and hydrologic understanding that has been used to construct and manage dams, reservoirs, and diversions. In the past 20 years, geoscientists have become increasingly involved in issues concerning management of in-stream values of stream reaches below reservoirs and diversions. Speakers at this symposium will present the results of various approaches within the geosciences that are being actively used to address issues such as management of riparian corridor resources in Grand Canyon National Park, management of endangered fish habitat, management of coarse debris in white-water streams, and development of in-stream flow rules for mountain streams. Other papers will concern the appropriate role of geoscientists in addressing the needs of the engineering community and the needs of the general public in current debates about how these rivers should be managed.

WASHINGTON REPORT

Bruce F. Molnia

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

Women Scientists and Engineers in Government and Industry: What Does the Future Hold?

Women scientists and engineers, already in short supply in the federal government, may be affected disproportionately by the Clinton administration's effort to reduce the size of government by 252,000 employees. Estimates of the number of targeted jobs to be cut from the larger departments and agencies are: Defense—102,000; Treasury—19,000; Veterans Administration—15,700; Agriculture—14,000; Health and Human Services—13,900; Justice—12,500; Interior—9600; Transportation—8500; Energy—4700; Commerce—3800; Environmental Protection Agency—3400; State—3400; Labor—2900; General Services Administration—2900; Housing and Urban Development—2700; Office of Personnel Management—1650; and Education—1600. Additionally, smaller agencies, commissions, and the like would lose about 29,000 jobs. Most cuts would come in fiscal years 1995 through 1997.

Agriculture, Interior, Energy, and Commerce, home to many of the federal government's female scientists and engineers, especially those with earth science expertise, are targeted for a reduction of more than 32,000 jobs. Although the announced target group for a significant percentage of the reduction is mid-level managers—generally middle-aged, white males—the federal government's complicated regulations pertaining to civil service seniority, job protection, and bumping may result in much of the reduction affecting younger women scientists and engineers. Ironically, recent successful efforts to negate decades of gender inequity in federal hiring have resulted in women making up a significant percentage of professional scientists and engineers with less than ten years of government service. Because the final determination of who will lose their jobs may ultimately come down to an equation based on years of service and veteran's preference, reinventing government may take a disproportionate toll on a group that had been identified as potential primary beneficiaries of improvements in government.

An example of how one earth science organization is being affected by the Clinton administration's effort to reinvent government can be seen in the proposed reductions for the U.S. Bureau of Mines (USBM) beginning in fiscal year 1995. President Clinton has requested $150.7 million for USBM in the FY 1995 budget, down $19.7 million (11.5%) from the FY 1994 appropriation. The "keystone" of the FY 1995 changes will be the consolidation of more than a dozen field complexes into five new "Centers of Excellence." The focus of these centers will be environmental remediation, pollution prevention and control, health and safety, materials research partnerships, and minerals information. The Alaska Field Operations Center (offices in Anchorage and Juneau) and research centers in Rolla, Missouri, and Tuscaloosa, Alabama, will be closed. The Intermountain Field Operations Center, the Minerals Availability Field Office, and the Denver Research Center (all in Denver, Colorado), will be consolidated. In all, USBM will lose 211 jobs, decreasing in size by 9.3% from the FY 1994 appropriations level of 2272 full-time-equivalent (FTE) employees to a proposed 2061 FTEs for FY 1995.

Concurrently, in accord with the philosophy of the National Performance Review, USBM will "eliminate at least one management layer" in field and headquarters offices, establish internal and external review processes, increase contracting and partnerships to strengthen research activities, and integrate the functions of the Mineral Institutes into the USBM research program. In FY 1995, the USBM budget for research will be $96.4 million, including a $3.8-million increase in environmental research that is aimed primarily at hazardous waste treatment technologies, particularly in the West. Efforts in minerals and material science will center on industrial process and materials development to promote economic growth and reduce environmental problems.

Two recently released reports also provide some very significant information about the present and future status of women in science and engineering. The first, *Women Scientists and Engineers Employed in Industry: Why So Few?* was released early this year by the National Research Council's (NRC) Committee on Women in Science and Engineering (CWSE). The report summarizes the findings of a CWSE conference held in January 1993. Among the report's revelations: women made up only 12.3% (1988 statistics) of the scientists and engineers employed in industry, in spite of the fact that women compose about 45% of the total work force and about 16% of the science and engineering (S&E) work force. This disparity results largely from women receiving substantially fewer S&E degrees than do men at all academic degree levels. Although the percentage and number of women receiving S&E degrees has increased significantly during the past three decades (40% of S&E bachelor's degrees, 31% of S&E master's degrees, and 28% of S&E doctorates in 1989, up from <24% of S&E bachelor's degrees, <14% of S&E master's degrees, and 8% of S&E doctorates in 1966), women still receive less than one-third of all S&E degrees.

The report documents the barriers that women encounter throughout their careers in industry, starting at the job-search level. Limited access to job information is typical, because common recruitment and hiring practices "make extensive use of traditional networks," which frequently overlook the available pool of qualified women candidates. After starting employment, women commonly encounter paternalism, sexual harassment, allegations of reverse discrimination, gender inequity in assessing production standards, lower pay for equal performance, a "glass ceiling" in job assignments, and open hostility from male co-workers and a male-oriented corporate culture. The report documents that the attrition rate for women scientists and engineers pursuing careers in S&E is more than double that for men and significantly higher than that for other employment sectors. The multiplicity of obstacles and stumbling blocks that the report describes likely is a significant factor contributing to this excessive attrition. Establishing women's networks and developing a productive mentoring system could significantly improve the success of women scientists and engineers in industry; however, conference attendees agreed that "of paramount importance for the retention of women scientists and engineers" is "attention to work-family issues."

The second report, *Pathways for Women in the Sciences: The Wellesley Report, Part I,* prepared by Paula Rayman and Belle Brett and published by the Wellesley College Center for Research on Women, analyzes and documents factors that draw Wellesley College women to the fields of science and mathematics. The study was designed to identify the factors associated with (1) a woman's initial choice to pursue science in college and (2) her retention in the sciences after college. Funded by the Alfred P. Sloan Foundation, the report investigates decision-related factors at three critical junctures in the life of the women participants: when they enter college, when they select a major, and when they make early career decisions. To develop information about initial choice, data were drawn from 534 members of the Wellesley class of 1995 through responses to questionnaires. For information about retention, all science and mathematics graduates were sampled in the classes of 1983–1991

Among its many findings, the study determined that interest in science and mathematics as a career was developed prior to the college years. Few women declared science as a major if they had not expressed an interest in science upon entering college. Most women who were not science majors were not rejecting science; rather, they majored in disciplines that they found more interesting. The report found that women who continue in science are much more likely to prefer subjects with precise answers than subjects with multiple interpretations. Students and alumnae in science were more likely than students in other disciplines to have received encouragement from multiple sources to pursue science. Encouragement from parents is very important—from mothers as well as fathers. About two-thirds of the women in the classes of 1983–1991 who chose careers in science have remained in the sciences.

The authors plan to expand their sample to include science and mathematics graduates in the classes of 1968–1982. Information about the report can be obtained by calling the Wellesley College Center for Research on Women at (617) 283-2500. ■

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engineering activities, and marine mammals (Urick, 1983). An object in the noise field scatters some of the incident radiation, suggesting, by analogy with photography, that the ambient noise could be the basis of an "acoustic daylight" imaging system.

Producing an acoustic daylight image requires an acoustic lens to focus the scattered sound onto a focal surface. The lens could be a reflector, refractor, or phased array. Differences in acoustic intensity across the focal surface constitute the image, making acoustic daylight imaging an incoherent technique that, unlike holography, for example, does not rely on phase information to produce the image. (With a phased array as the acoustic lens, the phasing is important only for steering the beams). Once the acoustic image has been formed, the intensity distribution across the focal surface would be displayed as a familiar pictorial image on a television monitor.

The ambient noise frequencies useful for imaging lie between 5 and 100 kHz, where the upper limit is dictated by the onset of thermal noise arising from thermal agitation of the water molecules (Mellen, 1952). Thermal noise, a localized, microscopic phenomenon, is not a radiating acoustic field and hence cannot be used for imaging. At a frequency of 25 kHz, near the (geometric) center of the operating band, the acoustic wavelength is 6 cm, which is approximately five orders of magnitude greater than the wavelength of visible light. Inevitably, this means that the resolution of acoustic daylight images will be inferior to that of their optical counterparts. In fact, the lower limit of 5 kHz for acoustic daylight imaging is set, rather arbitrarily, at a frequency below which the angular resolution of the lens is deemed to be unacceptably low.

The (dilated) pupil of the human eye is about 10 000 optical wavelengths in diameter, which accounts for the remarkable acuity of human vision. To achieve similar angular resolution with an acoustic daylight system would require an acoustic aperture of the order of 600 m, which is not practical for a variety of reasons. An aperture of 10 m—i.e., approximately 200 acoustic wavelengths, is about the largest that could be achieved in the immediate future. Although not of optical quality, an image from such a system would be by no means unacceptable. Moreover, image enhancement techniques offer the prospect of improving the perceived sharpness of the final image.

At 25 kHz the attenuation of sound in sea water is approximately 4 db/km. Assuming attenuation is the limiting factor, the maximum range of the system will therefore be of the order of 0.5 km. With an aperture of 10 m, the angular resolution would be ~0.4°, corresponding to a linear resolution of 3 m for each point in the image of a target at maximum range. For targets at shorter ranges, the linear resolution scales accordingly; for example, at a range of 100 m the linear resolution at the center frequency is 0.6 m. A further improvement could be achieved by working at a higher frequency—say 75 kHz—where the linear resolution at a range of 100 m is 0.2 m.

INCOHERENT IMAGING

The first in situ acoustic daylight experiments (phase I) were conducted in the Pacific Ocean off Scripps pier in southern California (Buckingham et al., 1992). The acoustic lens used in the experiments was a parabolic reflector of diameter 1.22 m with a single, low-noise hydrophone at the focus. Thus, the system formed a single beam or "look" direction (Fig. 1A), corresponding to just one pixel of an image. The surface of the parabolic dish was faced with neoprene rubber, which is nominally a perfectly soft (pressure-release) reflector at the frequencies of interest. Rectangular targets, also faced with neoprene, were placed in the beam at ranges of approximately 10 m; noise spectra were recorded with the targets "on" (broadside-on and "off") (edge-on) to the lens, as well as entirely absent.

It is clear from Figure 2 that in the "on" position the targets increased the noise level across the band that is of interest here; the targets were visible in the illumination provided by the naturally occurring ambient noise in the ocean. Even in the "off" configuration, the targets could be "seen," in that they produced higher energy noise spectra than were obtained with the targets absent. Although this single-beam experiment is a far cry from acoustic daylight image formation, the fact that the intensity in a single pixel responded to a target in the beam is the first direct evidence that imaging with ambient noise in the ocean is a physically reasonable possibility. Because the technique works with one pixel, it should only be a matter of technology to extend it to many pixels, and many pixels constitute a genuine pictorial image.

Nominally, the difference between the spectral levels observed with the targets "on" and "off" is 3 db. However, the "on" spectra show some interesting structures, as illustrated in Figure 2, where regions of relatively high intensity or "hot spots" can be seen centered around 10, 22, 33, and 47 kHz. Apparently, the targets exhibited a frequency-dependent acoustic albedo, some frequencies being reflected more strongly than others. This effect can be interpreted as "acoustic color," by direct analogy with optical color. Acoustic color could be displayed as "false" optical color in an acoustic daylight image (just as infrared and ultraviolet satellite images are displayed in computer-generated color), thereby providing visually recognizable information about the acoustic properties of the object space.

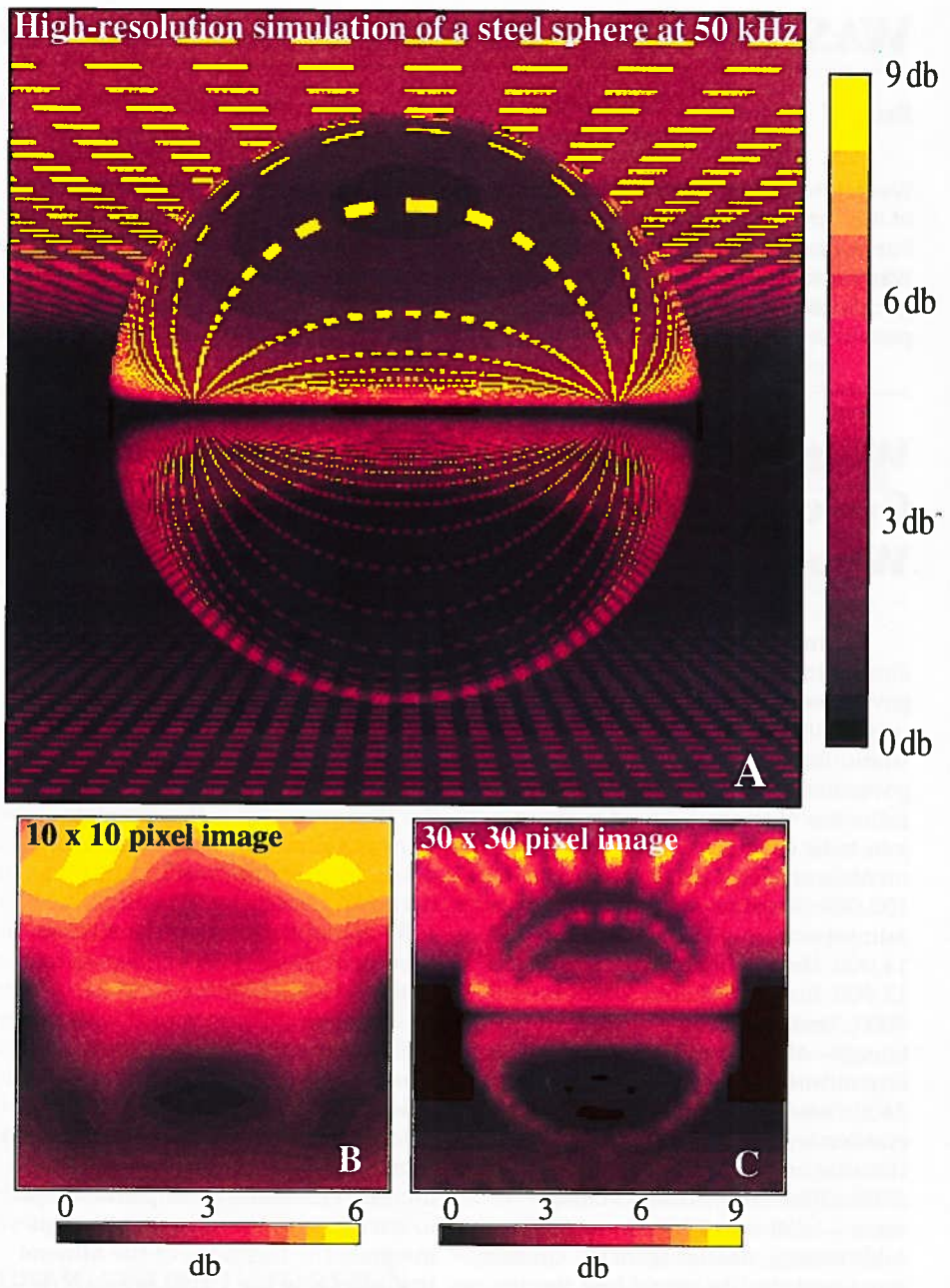

Figure 4. Numerically simulated acoustic daylight image of a steel sphere in shallow water. Breaking waves on the surface are represented as monochromatic sources (bright yellow dashes), with an acoustic frequency of 50 kHz. A: High resolution, with 90 000 pixels. B: Low resolution (phase II), with 100 pixels. C: Intermediate resolution (phase III), with 900 pixels. In all three images, color represents intensity, and dynamic range in each case is indicated by the corresponding color bar.

In a second experiment with the phase I acoustic lens, the neoprene-faced targets were replaced with a vertical screen of bubbles, all of nominally the same size (radius of 0.3 mm). Bubbles are well known to be resonant systems, with a resonance frequency that varies inversely with the bubble radius (Minnaert, 1933). For the bubbles forming the screen, the resonance frequency was about 11 kHz. The bubbles were produced by attaching an air compressor to a hose pipe along which small holes had been pierced with a fine needle. The hose pipe was laid on the seafloor well below the beam of the acoustic reflector to ensure that the bubbles were acoustically quiescent as their buoyancy carried them upward through the beam. (On closure, a bubble undergoes radial oscillations for several milliseconds, during which time it acts as a brief but effective narrow-band source of sound [Longuet-Higgins, 1993]. After the oscillations have decayed, the bubble is in equilibrium with its surroundings and remains mute for the remainder of its existence).

It can be seen from Figure 3 that with bubbles present the spectrum exhibits a pronounced peak centered close to 11 kHz. Because they are quiescent within the beam, this peak cannot be attributed to the initial pulses of sound made by the bubbles at closure, although it is consistent with the resonant nature of the bubbles: each bubble is excited by the incident (broadband) ambient noise and is driven into radial oscillation around the resonance frequency. The bubble then reradiates sound uniformly in all directions (Devin, 1959), the spectrum of which shows a narrow peak centered on the bubble resonance frequency. This scattered field is responsible for the observed peak in the noise spectrum in Figure 3. Because the sizes of the bubbles constituting the screen were almost certainly distributed about the nominal diameter, the observed noise peak is a superposition of individual resonance peaks and hence is considerably broader than the resonance peak of a single bubble. On the basis of these observations, it appears that the spectra shown in Figure 3 constitute further evidence in support of the concept of acoustic daylight imaging.

The phase I experiments, with the single-beam lens, are now complete, and construction of a multielement acoustic lens (phase II) is in progress (Fig. 1B). Again, the lens is a reflector but with the single sensor replaced by an array of 128 hydrophones in the focal surface. The geometry of this arrangement is such that each sensor element corresponds to a single beam, thus providing 128 pixels in the final image. In passing, it is interesting to note that this phase II lens, which forms multiple beams through the geometrical disposition of the dish and transducer array, is an unusual example of sonar system design, although it has an analogue in the long-focal-length mirror lens that is popular for conven-

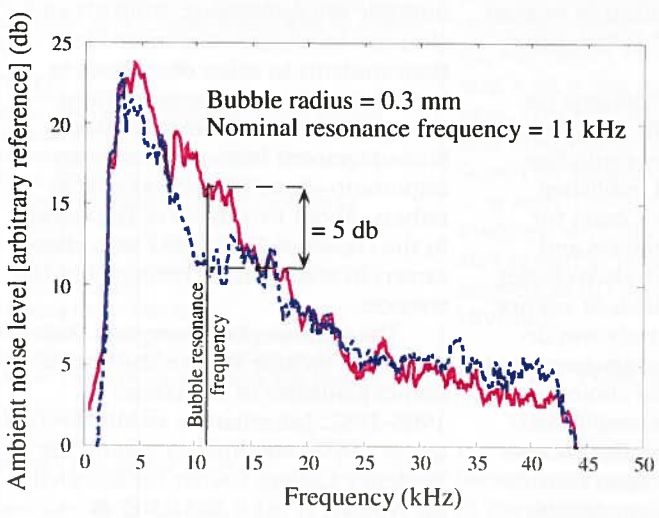

Figure 3. Ambient noise spectra obtained with (dashed blue line) and without (solid red line) the bubble screen as target. Note the peak in the spectrum around 11 kHz when the bubbles are present.

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Vision *continued from p. 100*

tional photography. Looking further into the future, the reflector will be replaced with a phased array of about 1000 elements (phase III), perhaps mounted on the hull of a remotely operated vehicle (Fig. 1C). Such a design would provide relatively high resolution images of 1000 pixels and a mechanical "zoom" capability achieved through the mobility of the platform.

Even with as many as 1000 channels, each corresponding to a pixel, it should be possible to achieve a rapid refresh rate in real time, allowing moving images to be created. Acoustic daylight imaging would then be the direct analogue of video photography, giving rise to moving, color pictures originating in ambient sound rather than ambient light.

THEORETICAL MODELING

Although the idea of incoherent imaging with ambient noise is appealing and the analogy with optical imaging provides an intuitive basis for understanding the physical processes involved, it is difficult to quantify the imaging process. Several questions are of interest, including the effect of the anisotropy of the noise on the image. This issue was not clarified by the phase I experiments because of difficulties in measuring the directionality of the noise field, although circumstantial evidence suggests that Scripps pier itself acted as a significant noise generator.

To address the question of anisotropy, a full wave-theoretic analysis (Buckingham, 1993) of acoustic daylight imaging has been developed in which the target is assumed to be a spherical object with pressure-release (i.e., acoustically soft) surface. Concentric with the target sphere is a noise sphere of infinite radius on which the acoustic sources are distributed. The directionality of the noise field is controlled by selecting the area of the noise sphere covered by the sources. The acoustic lens is modeled as a line array of hydrophones at half-wavelength spacing, arranged endfire-on (i.e., radially) to the target sphere. A central feature of the analysis is the derivation of a new, closed-form approximation for the Green's function of the field scattered from the pressure-release sphere. This approximation makes the statistical analysis of the field tractable, allowing a solution to be developed in a form that is easy to evaluate on a desktop computer.

The response of the line array to the scattered field is expressed in terms of a "visibility" function, V, defined as the ratio in decibels of the total field (incident plus scattered) to the incident field alone. This is essentially the quantity that was measured in the original phase I experiments. Provided the contrast is sufficient, say, with positive value (front lighting) greater than 3 dB or negative value (back lighting) less than –3 db, the object should be visible against the background.

Theoretically, the visibility is fairly insensitive to the anisotropy of the noise under front lighting conditions, showing values of several decibels, which is consistent with the observations in the phase I experiments. This is encouraging, because it implies that the acoustic daylight imaging technique is robust in that it does not depend critically on the detailed structure of the noise field. Under strong backlighting conditions, the visibility function goes strongly negative (in decibels), indicating that the object is in silhouette. The onset of shadowing, as predicted by the wave-theoretic theory, is consistent with arguments based on simple geometrical (ray acoustics).

NUMERICAL SIMULATION

Whereas the analytical theory provides a quantitative estimate of acoustic daylight imaging, it does not yield simulated pictorial images. To remedy this situation, a numerical model has been developed (Potter, 1993), based on Kirchoff-Helmholtz scattering and a far-field assumption, that simulates the process of acoustic daylight imaging. Objects of various shapes and acoustic properties, illuminated by realistic noise fields, can be handled by the computer code to provide images that should be representative of a working acoustic daylight system.

The object in the foreground in Figure 4A, generated from the model, is a steel sphere with a diameter of 1 m, located in a shallow ocean channel. The perspective is that of an observer, at the same depth as the target sphere, who is looking horizontally along the channel; overhead is the sea surface and below is the seafloor. In this example, the acoustic illumination is provided solely by monochromatic surface sources (bright yellow, parallel dashed lines), with a frequency of 50 kHz, representing one spectral component of naturally generated sound from breaking waves. (Thus, there is no "acoustic color" in Figure 4, in the sense discussed above in connection with Figure 2. The color in Figure 4 represents intensity at a single frequency).

A great deal of visual information about the acoustic properties and geometrical form of the target, as well as the geo-acoustic character of the environment, is contained in Figure 4A. At present, such images are unfamiliar, and the information they contain requires interpretation. However, of all the human senses, vision is the most highly developed, the human eye-brain combination having evolved to become remarkably efficient at recognizing visual cues. As our experience with acoustic daylight images grows, the acoustic messages contained therein, as exemplified by Figure 4A, should become as recognizable as the optical information in a conventional photograph.

In Figure 4A, the intense, bright yellow surface sources can be seen below (dull red), reflected in the bottom. The source lines are mapped as arcs onto the surface of the sphere, thereby giving a visual indication of the shape of the target. If the sphere were pitted or otherwise flawed, then the imperfection would show up as a deformity in the mapped curve; if the object were, say, ellipsoidal, the mapped lines would be correspondingly elongated. These mappings, of course, are specular reflections of the sources in the surface of the target. In the ocean, the actual surface sources would be more randomly distributed than those shown in Figure 4A, but this would not affect the overall level of the illumination significantly, although it would change the detailed structure of the reflections from the target. Nevertheless, shape information could be gleaned visually from these more random mapped reflections in much the same way as in the present example.

Apart from the specular reflections, the shape of the object in Figure 4A is also apparent from subtleties in shading. When the image is first viewed, the shading is perhaps the main factor that identifies the object as a sphere. Shape inferred from shading is, of course, commonplace when one views a photograph, but it is only just being exploited in the latest computer-generated swath-mapping sonar displays (Nishimura and de Moustier, 1993). Acoustic daylight imaging offers shading as a natural, intrinsic feature of the new technique.

The seafloor in Figure 4A has been modeled as a fast-fluid sediment with a critical grazing angle of 28° (for sound incident from above). Thus, noise rays with grazing angles less than 28° are totally reflected from the bottom, whereas rays with higher grazing angles penetrate the interface and are lost to the water column. With such a bottom, relatively little acoustic energy travels upward at grazing angles steeper than 28°. This is indeed evident in Figure 4A from the dark shadow on the lower half of the sphere. The edge of this shadow, which is very sharply delineated, corresponds precisely to the critical grazing angle of the seafloor.

Straight along the channel, on either side of the equator of the sphere, the image is almost black, indicating that very little noise travels horizontally. This is consistent with the fact that most of the energy propagating in the horizontal originates in far distant surface sources and thus is subject to severe attenuation. When we look slightly above the horizon the surface becomes brighter, an effect that continues progressively with increasing elevation, until the nearby, overhead sources appear brightest of all.

In addition to the pronounced shadowing, attenuation, and reflection effects, the image in Figure 4A shows some subtle features that relate to the acoustic properties of the sphere itself. (Although steel is obviously a hard material, the sphere is not a perfectly rigid body, nor is it a perfect reflector of sound). Thus, even this simple example of acoustic daylight imaging contains an abundance of information, making interpretation of the image an interesting and challenging task.

A further factor that complicates interpretation is reduced resolution in real acoustic daylight images. The resolution of the simulated image in Figure 4A is artificially high, at 90 000 pixels, a number that could probably not be achieved in practice. Figure 4B shows the same image but degraded to 100 pixels, which is close to the quality expected of the phase II system currently under construction. No image enhancement has been applied in this case, except for a simple interpolation between pixels which introduces some smoothing. Obviously, the sharpness of the high-resolution image has been lost and the dynamic range has been reduced, but the most prominent features of Figure 4A have been retained. For instance, the dark shadow on the lower hemisphere can still be seen, the bright waistline is apparent, and the shading on the upper half of the sphere is also evident. Nevertheless, it would be desirable to see some improvement in image quality, at least to the level where the shape of the target could be recognized unequivocally.

When the number of pixels is increased by almost an order of magnitude, to 900, corresponding to the

Vision *continued on p. 102*

Vision *continued from p. 101*

planned phase III system, the acuity of the image is improved significantly and the dynamic range is retained (Fig. 4C). The target is easily recognizable as a sphere and all the important details in the high-resolution image of Figure 4A are visible with only slight degradation of quality. This degree of fidelity should be achievable with a practical acoustic daylight imaging system.

ACOUSTIC COLOR

Looking to the future, computer-generated color in the display of the phase II and phase III systems will be used to represent the acoustic spectrum in each pixel of an image. With this scheme, the spectral content of a pixel is determined by three factors: the acoustic reflectivity of the corresponding point in the object space (see Fig. 2), the spectral shape of the sources, and attenuation associated with both the medium and the boundaries. Of these, the acoustic reflectivity corresponds to the intrinsic (optical) color of an object as viewed in white light. The noise sources in the ocean are not white but they are broad-band (unlike the monochromatic sources in the artificially generated Fig. 4A), showing a spectrum that rolls off approximately as (frequency)$^{-2}$. Thus, low frequencies predominate in oceanic ambient noise, providing illumination that is acoustically "pink." This shift toward "acoustic red" is further accentuated by attenuation, which increases approximately as (frequency)^{n}, where n = 1 or 2, depending on the mechanism involved.

Attenuation does not have a direct analogue in the atmosphere, because light in the visible region of the spectrum is not significantly absorbed. (A related phenomenon is a red sunset, which occurs because blue light is scattered by particulate matter in the atmosphere). In the ocean, on the other hand, even the lowest frequencies will be attenuated over sufficiently long ranges, giving rise to regions of an acoustic daylight image that will appear dark. (Recall that the dark regions on the horizon in Figure 4A are an effect of attenuation.) In applications of acoustic daylight imaging, it may well be possible to turn absorption to advantage since it yields visual information about the acoustic properties of the ocean environment.

GEOPHYSICAL APPLICATIONS

Acoustic daylight imaging has naval, industrial, and geophysical applications; potentially it is useful whenever vision in the ocean is required. In the geophysical arena, an obvious application of the new technique is high-resolution topographic mapping of the seafloor. Assuming that the "camera" was mounted on a mobile platform such as a fish or remotely operated vehicle, allowing it to operate within 100 m of the bottom, a spatial resolution of approximately 0.6 m per pixel could reasonably be expected, with 1000 pixels composing the image. The images would be processed in real time, with a refresh rate of 10 Hz or faster, and would show color characterizing the acoustic properties of the seafloor. In brief, moving, color images of the seafloor would be produced.

Although such performance is for the future, available evidence indicates the feasibility of the technique. An interesting feature of acoustic daylight imaging, which distinguishes it from most sidescan mapping sonar, is its broad-band nature. A frequency bandwidth of over a decade is the factor that allows color to be introduced into the images. Although artificially produced, the color correlates with the frequency-dependent acoustic properties of the object space. Through this color facility, acoustic daylight images of the seafloor may yield, in addition to bottom topography, information on the composition of the basement. For instance, the acoustic reflectivity of a porous sediment is strongly dependent on frequency, whereas that of a consolidated basement is not. The different colors of these two types of bottom material in acoustic daylight images could act as a discriminator, providing an indication of their respective geologic properties.

CONCLUSIONS

Simple experiments in the ocean support the concept of imaging with naturally generated ambient noise, a conclusion that is consistent with theoretical and numerical models of the new imaging technique. Because it provides vision in the ocean, several potential applications exist for acoustic daylight imaging, including geophysical surveying of the seafloor. For two reasons, attenuation in the ocean and reduced angular resolution, the system is effective only over short ranges, of up to about 0.5 km. Within its operating envelope, the acoustic daylight technique should produce images that show (visual) color determined by three factors: the spectral shape of the noise, the degree of attenuation in the ocean, and the acoustic reflectivity of the object space. Because acoustic daylight images can be refreshed rapidly, the final effect should be much like a conventional, moving video image on a television monitor, but with somewhat inferior resolution.

Improvements in angular resolution could be achieved by increasing the aperture of the acoustic lens; apart from being prohibitively costly, such an aperture would make the underwater camera unduly cumbersome. An alternative approach lies with image enhancement algorithms, running in real time to produce images with improved acuity. Automated image recognition is a related problem, which for some geophysical applications may be important; for example, automatic classification of seafloor by topography or geology could prove useful. Neural networks, operating on raw data or extracted feature vectors rather than the acoustic daylight images themselves, may satisfy this requirement. Algorithms dedicated to the enhancement and recognition of acoustic daylight images are currently being considered.

ACKNOWLEDGMENTS

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OFFICERS OF THE DIVISION

Bruce Molnia of the U.S. Geological Survey in Reston (and *GSA Today* Forum editor), is currently president of the Division. Pinar Yilmaz of Exxon Production Research Company, Houston, is first vice-president and will succeed Bruce for a one-year term as president in October 1994. John Oldow of Rice University has just completed a four-year term as our resourceful secretary-treasurer, passing the baton to Fred Simon. As mentioned, Jim Skehan has started his term as second vice-president and will become division leader at the November 1995 New Orleans meeting. I, having stepped down at the Boston (1993) meeting, join Brian Skinner in the ranks of past presidents.

FUTURE OF THE DIVISION

This short article has aimed to give readers some idea of the kinds of things that the International Division has been doing during the four years of its existence. Our future holds prospects of continuing in the same directions and branching out in new ways. Working with other GSA Divisions, which we have done, is an area where additional opportunities certainly exist. I am sure our officers would be glad to hear your suggestions. Field trips to other continents, more work with students visiting North America, and grasping the opportunities that arise as new nations emerge and existing nations become more accessible are all in our dreams.

The Division's diversity embraces some responsibilities that I am beginning to think might be better handled in other ways. Specifically, I refer to the kinds of functions that are filled in many national societies by a foreign secretary. As far as I know, GSA has never had such a person, and the reason may well be that we are a continental and supranational society. Nonetheless, a foreign secretary to deal with national societies on other continents (Antarctica, as always, being the exception) could be very helpful. The kind of person I envisage would be a distinguished senior member of the society, perhaps a past president or officer. He or she would hold office for perhaps five to seven years and work with the president and Council on links with peer societies and international bodies. The key to a foreign secretary's function is continuity in office; a one-year appointee cannot become familiar with the issues, and especially the diverse ways of doing business, which are the essence of international relations. This is an idea that I would like to see discussed widely in the Society. ■

GSAF UPDATE

Robert L. Fuchs

New Support for Student Travel Grants

One of the most popular GSA and Foundation programs for the past seven years has been student travel grants. Administered by GSA's six Sections, the program provides money to assist students attending Section meetings and the GSA annual meeting. Award parameters may vary among the Sections, but generally recipients must be enrolled in a geology program at a college or university within the Section. Also, preference may be given to students presenting papers (oral or poster) at the meetings.

Financially, the Foundation provides one-for-one matching grants to each Section for their expenditures, by reimbursing the Section each year for 50% of the money it spends in student travel support. From inception in 1988 through the end of 1993 the Foundation has paid out a total of $16,500 to GSA Sections under this program.

Recently, Robert N. Ginsburg of the Rosenstiel School of Marine and Atmospheric Science at the University of Miami made a five-year pledge to the Second Century Fund, the annual contributions to be used for student travel grants to GSA annual meetings. Ginsburg, a former member of the GSA Council, said when making the pledge, "I can't think of a better way to support young geologists and encourage their entry into the scientific community. For many members, the intercommunication that takes place at technical meetings is a principal benefit of GSA membership. Certainly the effect of this exchange on students can be even more far-reaching. And there is a lot of benefit for the dollar—not too many of our students ride in the front of the airplane and stay in the presidential suite. They commandeer vans and go triple or quadruple in hotel rooms. Geology students have the ability to make a little money go a long way, but they need us to provide that money."

If you would like to make a contribution to the GSA Foundation that will go a long way in benefiting geology, consider student travel grants. Use the accompanying coupon to send your gift, or call us in Boulder to discuss a longer term pledge to the Second Century Fund for Earth-Education-Environment that can be designated to this purpose.

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New Fund Supports Volcanology Research

The Lipman Research Fund has been established at the GSA Foundation to support student research grants in volcanology and petrology in the western United States and Alaska. This fund is a gift of the Howard and Jean Lipman Foundation and is a part of GSA's Second Century Fund for Earth-Education-Environment.

Recently, GSA received a five-year extension of the National Science Foundation matching grant for student research. Under the terms of this renewal, NSF will provide up to $100,000 for the student research grants program each year, at the rate of $1 for every $2 from GSA and the Foundation. Therefore, the Lipman Research Fund is timely because the dollars it provides will be augmented by NSF funding.

When arrangements for this new fund were completed, Lipman Foundation President and GSA Fellow Peter W. Lipman reflected on his own experience with GSA's student research grants program. "When I was a graduate student, the award of a research grant proved to be a major milestone in my studies. The money enabled me to obtain chemical analyses that were critical to the successful completion of my thesis and for which, at that time, I did not have funds available."

The GSA Committee on Research Grants meets in April each year. In 1993, the Committee awarded $257,882 to 178 recipients.

Pooled Income Fund 1993 Results

The GSA Foundation Pooled Income Fund generated a cash return of 6.3% and a total return of 11.7% in 1993. The cash return is down 10% from the 1992 return of 7.0%, but the total return is up 44% from the 1992 total return of 8.1%. These results are in line with the year's falling interest rates and higher bond prices.

At the end of 1993 the Pooled Income Fund net asset value was $214,744, double that of the prior year end. The fund's holdings included Warburg Pincus Fixed Income and Global Fixed Income Funds, Steinroe Income Fund, and some corporate bonds.

The Pooled Income Fund is a deferred gift mutual fund for GSA members and friends, whereby benefactors receive income for life. Following the donor's death, his or her portion of the fund becomes part of the foundation's endowment, and the income is then used in support of GSA programs and activities. If you would like to learn more about this estate and retirement planning technique that benefits Earth and geology, please send us the accompanying coupon, or call the Foundation office—(303) 447-2020, ext. 154. ■

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Robert H. Dott, Jr.—Chair, 1993–1994; Fernando Ortega-Gutiérrez, 1992–1994; James W. Horton, Jr., 1993–1995; Morris W. Leighton, 1993–1995; Keros Cartwright, 1994–1996; John E. Costa—Editor, *Bulletin;* Arthur G. Sylvester—Editor, *Bulletin;* David M. Fountain—Editor, *Geology;* Henry T. Mullins—Editor, *Geology;* Richard A. Hoppin—Editor, Memoirs and Special Papers; David Schleicher—Editor, Maps and Charts; Bruce F. Molnia—Forum Editor, *GSA Today;* Eldridge M. Moores—Science Editor, *GSA Today;* Richard Arnold Davis—Chair, *Treatise on Invertebrate Paleontology* Advisory Committee; Conferee: F. Michael Wahl—Executive Director

Committee on Research Grants
Raymond V. Ingersoll—Chair, 1992–1994; Darryll T. Pederson, 1992–1994; Ben A. van der Pluijm, 1992–1994; Mary L. Droser, 1994–1996; Peter C. Patton, 1994–1996; Sheila J. Seaman, 1994–1996; *NSF Conferee:* Thomas O. Wright

***Treatise on Invertebrate Paleontology* Advisory Committee**
Richard Arnold Davis—Chair, 1993–1996; Ronald R. West, 1991–1994; F. Michael Wahl, Executive Director

Committee on the Young Scientist Award (Donath Medal)
Genevieve Atwood—Chair, 1994–1996; Sharon Mosher, 1992–1994; Frank S. Spear, 1992–1994; John C. Behrendt, 1993–1995; Leonard F. Konikow, 1993–1995; R. Douglas Elmore, 1994–1996

Ad Hoc Geosphere Alliance Committee
William S. Fyfe—Chair; Fred A. Donath; William L. Fisher; Robert D. Hatcher, Jr.; Susan W. Kieffer; Raymond A. Price; E-an Zen

Ad Hoc Committee on Membership Services
Arden L. Albee—Chair; Genevieve Atwood; Kenneth E. Kolm; Marie E. Morisawa; Karen L. Prestegaard; John M. Sharp, Jr.

GSA Member of the American Geological Institute (AGI) Member Society Council
David A. Stephenson—Vice-President

GSA Member of the AGI Education Advisory Committee
Edward E. Geary—Coordinator for Educational Programs

GSA Member of the AGI Government Affairs Program Advisory Committee
M. Gordon Wolman, 1991–1994

GSA Representatives to the American Association for the Advancement of Science (AAAS)
Section E—Geology and Geography: J. Thomas Dutro, Jr., June 1, 1985–February 23, 1997; *Section W—Atmospheric and Hydrospheric Sciences:* John G. Weihaupt, July 1, 1988–February 23, 1997

GSA Representatives to the AAAS Consortium of Affiliates for International Programs (CAIP)
Bruce F. Molnia—President, GSA International Division; F. Michael Wahl—GSA Staff Liaison

GSA Representatives to the North American Commission on Stratigraphic Nomenclature (NACSN)
G. B. Morey, 1991–1994; Donald L. Baars, 1992–1995; Lee C. Gerhard, 1993–1996; Representative-elect: James O. Jones, 1994–1997 (term begins during the NACSN 1994 fall meeting in Seattle)

GSA Representative to the *Treatise* Editorial Advisory and Technical Advisory Boards of the Paleontological Institute
Richard Arnold Davis

GSA Delegate to the Circum-Pacific Council
Robert L. Fuchs, May 2, 1984–

GSA Representatives to the Joint ASCE-GSA-AEG Committee on Engineering Geology (American Society of Civil Engineers, Association of Engineering Geologists)
Jeffrey R. Keaton, July 1, 1991–June 30, 1994; John D. Rockaway, July 1, 1990–June 30, 1996

GSA Representative to the U.S. National Committee on Tunneling Technology
Charles A. Baskerville, July 1, 1992–June 30, 1995

GSA Representative to the U.S. National Committee on Scientific Hydrology
David A. Stephenson, 1990–; Bruce B. Hanshaw (alternate)

GSA and AASG Selection Committee for the John C. Frye Memorial Award in Environmental Geology (Association of American State Geologists)
Frank E. Kottlowski—Chair, AASG representative; John P. Kempton, GSA representative, 1990–1994; Diane L. Conrad, AASG representative ■

Association of Earth Science Editors Calls for Nominations for Outstanding Publication Award

The Awards Committee of the Association of Earth Science Editors solicits nominations for AESE's Outstanding Publication Award. Given for the first time in 1993, this award is designed to recognize an outstanding earth-science publication—book, map, journal, or other individual publication, including those produced electronically—that has been recently published. This award recognizes the publication based on the quality of its editing, design, illustration, writing, production cost-per-copy, and overall effectiveness in achieving its publication goal. The primary aim of this award is to recognize excellence in publication, taking into account goals and production constraints.

Nominations for the AESE Outstanding Publication Award must be received by June 1, 1994, to be eligible for consideration. Each nomination should provide necessary supporting material. Nominations will be screened by the AESE Awards Committee, which will make recommendations to the AESE Executive Committee, which will make final decisions.

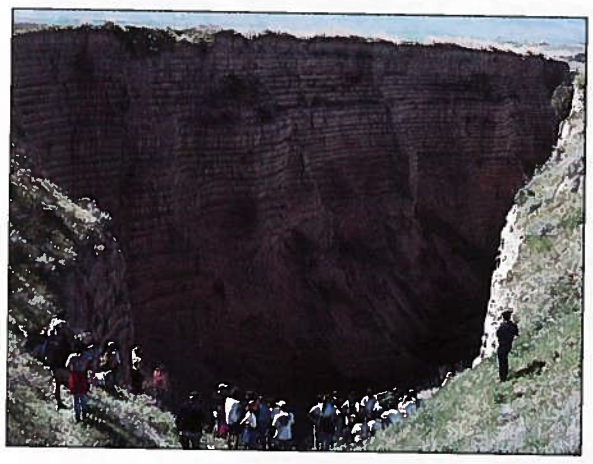
Nominations and supporting materials should be submitted to Elsa Kapitan Mazzullo, AESE Awards Committee, Mitchell Energy Corporation, P.O. Box 4000, The Woodlands, Texas 77387-4000, fax 713-377-5885. Questions about the award should also be sent to this address.

Geological Society of America

Seattle
at the leading edge

1994 ANNUAL MEETING

SEATTLE, WASHINGTON • OCTOBER 24–27



Geology *At the Leading Edge* is the scientific theme of the Seattle meeting. The theme draws emphasis both to the geographical position of Seattle, situated on the leading edge of a convergent plate margin, and to the application of "leading edge" theoretical approaches and technological advances to the elucidation of geological problems. Theme sessions and symposia will be offered not only on aspects of Pacific Rim and convergent margin geology, but also on a wide range of contemporary environmental and hydrogeological topics. An outstanding program of scientific sessions, field trips, continuing education courses, and exhibits is organized around this theme.

Seattle: The Emerald City – Seattle is a city of splendid views. No matter which direction you travel, there are mountains, forests, or stretches of salt and fresh water. Flanked by the Cascade Range to the east and the Olympic Mountains to the west, the city occupies an isthmus between Puget Sound, an 80-mile long arm of the Pacific Ocean, and freshwater Lake Washington. Seattle is known these days for its rich and active cultural life, delicious foods and fresh roasted coffees, and strong ties to the Pacific Rim. Seattle has changed a lot since the last time GSA met in Seattle in 1977. Join us in the Northwest this October and experience the appeal of this unique destination. On behalf of the Annual Meeting Committee, we look forward to seeing you in Seattle.

Darrel S. Cowan
General Chairman

REGISTRATION and FULL DETAILS: June issue *GSA Today*

Abstracts Due July 6 — For Abstracts Forms (303) 447-8850

Preregistration due September 16 — Registration and Housing Forms available June 1

Program, Registration, and Lodging Information — (303) 447-2020 or 1-800-472-1988

Associated Societies — Association for Women Geoscientists ◆ Association of American State Geologists ◆ Association of Geoscientists for International Development ◆ Cushman Foundation ◆ Geochemical Society ◆ Geoscience Information Society ◆ Mineralogical Society of America ◆ National Association of Black Geologists and Geophysicists ◆ National Association of Geology Teachers ◆ National Earth Science Teachers Association ◆ Paleontological Society ◆ Sigma Gamma Epsilon ◆ Society of Economic Geologists ◆ Society of Vertebrate Paleontologists

TECHNICAL PROGRAM

Seattle
at the leading edge

Call for Papers and Announcement of Symposia and Theme Sessions

ABSTRACT DEADLINE: JULY 6

JOINT TECHNICAL PROGRAM COMMITTEE: AUGUST 5–6. The JTPC selects abstracts and determines the final session schedule. Speakers will be notified within 14 days following that meeting.

The JTPC consists of approximately 40 geoscientists representing each of the associated societies and GSA divisions participating in the technical program. The JTPC chairs, nominated by the Seattle Annual Meeting Committee and approved by the GSA Council, also serve a four-year term on GSA's ongoing Program Committee, which oversees all technical program activities.

Daily technical session schedule: September issue of *GSA Today*. If you are not a member, please call, fax, or write us, and we will gladly send you the schedule.

1994 Technical Program Chairs

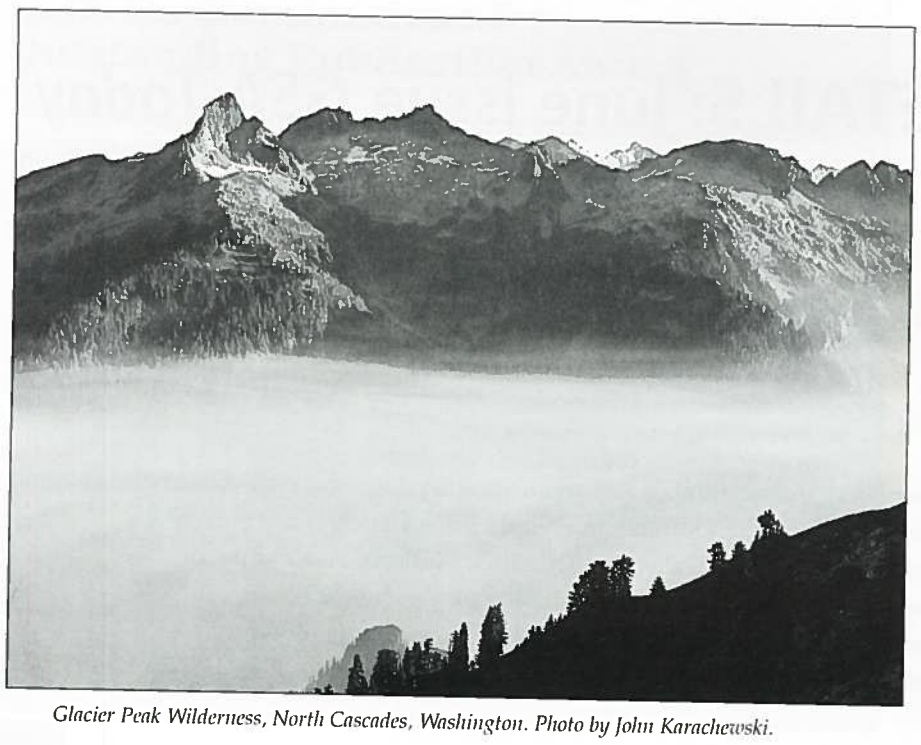
Chairman
Mark S. Ghiorso
Dept. of Geological Sciences
University of Washington
Mail Stop AJ-20
Seattle, WA 98195
Phone: (206) 685-2482
Fax: 206-543-3836
E-mail: ghiorso@fondue.geology.washington.edu

Co-Chair
Thomas Dunne
Dept. of Geological Sciences
University of Washington
Mail Stop AJ-20
Seattle, WA 98195
Phone: (206) 543-7195
Fax: 206-543-3836
E-mail: dunne@geology.washington.edu

At the Leading Edge: Scientific Theme for Seattle

Geology *At the Leading Edge* is the scientific theme of the Seattle meeting. The theme draws emphasis both to the geographical position of Seattle, situated on the leading edge of a convergent plate margin, and to the application of "leading edge" theoretical approaches and technological advances to the elucidation of geological problems. Theme sessions and symposia will be offered on aspects of Pacific Rim and convergent margin geology, with particular emphasis on the utilization of new technology.

The 1994 Annual Meeting Committee is sponsoring the Keynote Symposium entitled *The Birth and Death of a Plate* which will include invited talks on topics such as arc volcanism, kinematics of plate motion, accretionary wedges, and evolution of ocean ridge spreading centers. Speakers will illuminate these issues with results from remote sensing, geodesy, seismic imaging, experimental studies of geologic materials, and computational advances in modeling geologic systems. The 1994 Program Committee will have several, more informal evening sessions aimed at bringing attendees up-to-date on new techniques such as GIS (Geographical Information Systems), GPS (Global Positioning System), and major nationally funded research projects such as the Continental Drilling Program. The 1994 GSA Annual Meeting in Seattle promises an exciting opportunity to discuss important geologic questions in a nontraditional way.



Glacier Peak Wilderness, North Cascades, Washington. Photo by John Karachewski.

GSA's Institute for Environmental Education

In cooperation with the Geology and Public Policy Committee, IEE will sponsor its third Annual Environmental Forum on Sunday afternoon, October 23. The forum is entitled *Crucial Environmental Issues: Fear and Loathing at the Leading Edge*. Speakers will address four topics: earthquakes and earthquake prediction; low-level radioactive waste disposal; contaminant hydrogeology; and geologic factors affecting habitat loss and modification.

Earthquakes are arguably the natural disaster that most fascinates and frightens the public, and the demand for reliable earthquake prediction creates a situation that geological scientists must address. Disposal sites for low-level radioactive waste is an issue that can lead to an inflamed and fearful public, but the geoscientist can contribute by helping the public question key assumptions that affect site selection. Ground-water contamination is a major concern throughout the world. The forum will address serious questions facing the geoscientist/engineer that affect the cost and effectiveness of proposed solutions. The causes and rates of species decline are widely debated, and the ability to make effective decisions on endangered species protection and land use depends on properly defining the debate. Discussion will focus on the geoscientist's role in this process.

In addition to the Forum, IEE will also sponsor or cosponsor with GSA divisions several theme sessions in the technical program. These are identified with the global symbol IEE.

Mineralogical Society of America 75th Anniversary

GSA congratulates its colleagues at MSA on 75 years of serving the geosciences, and has noted the MSA sessions with a special logo. MSA and the local program committee are cosponsoring a special symposium in honor of this anniversary. Speakers will focus upon the current advances and changing trends in mineralogical research. Additional special events and programs in celebration of the anniversary are planned.

Abstract Submittal Guidelines

1994 Abstract Forms Availability

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

The required 1994 abstract form will be used as camera-ready copy for publication. Abstracts are limited to 250 words with a minimum 10-point font size. Please read the instructions on the abstract form. Your abstract may be rejected if the instructions are not followed.

Only ONE Volunteered Abstract May Be Submitted

Submit only one volunteered abstract as speaker or poster presenter for discipline and/or theme sessions. Multiple submissions as speaker-presenter for volunteered abstracts may result in rejection of *all* abstracts. Note that this limitation does not apply to, nor does it include, invited contributions to symposia.

Presentation Modes

Oral Mode—This is a verbal presentation before a seated audience. The normal length of an oral presentation is 15 minutes, including time for discussion. Projection equipment consists of two 35 mm projectors, one overhead projector, and two screens.

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

Papers for discipline sessions may be submitted in either oral or poster mode. However, because of the homogeneous topic, papers for theme sessions are to be submitted only in the mode noted in the theme description. If the abstract is submitted in the incorrect mode, the abstract will NOT be considered for the theme session, but will automatically be considered for a discipline session instead.

Presentation Formats

Format	*Abstracts*
◆ Symposia	Invited by the convener
◆ Theme Sessions	Volunteered for a topic announced *before* the abstracts deadline
◆ Discipline Sessions	Volunteered for a specific scientific discipline, and organized by topic *during* the JTPC meeting

Invited Papers (Symposia)

Abstracts are to be sent directly to the convener by July 6. The convener who extended the invitation to speakers is responsible for obtaining two independent reviews of each abstract, and for sending the reviews and the abstracts to GSA headquarters prior to the JTPC meeting. *A preliminary symposium schedule will be available from headquarters by May 15.*

S1. **Keynote Symposium: Birth and Death of a Plate.**
1994 GSA Annual Meeting Committee. George W. Bergantz and Kenneth C. Creager, University of Washington.

Douglas R. Toomey, University of Oregon
Magma generation at oceanic ridges

Ronald M. Clowes, University of British Columbia
Geophysical character of the Cascadia margin

Xavier Le Pichon, Ecole Normale Supérieure
Sediment and fluid budgets at continental margins

E. Wesley Hildreth, U.S. Geological Survey, Menlo Park
Arc magmatism

Julie D. Morris, Washington University, St. Louis
Time scales and geochemical signatures of arc magmas

Leigh H. Royden, Massachusetts Institute of Technology
Mountain building: Mechanics of upper plate deformation

Larry J. Ruff, University of Michigan
Mega-thrust earthquakes and environmental considerations

Kenneth C. Creager, University of Washington
Fate of the subducted slab

S2. **Plate Motion and Displacement Partitioning in the Circum-Pacific Orogenic Belts.**
International Division. Basil Tikoff and Christian Teyssier, University of Minnesota; John Oldow, Rice University.

S3. **New Frontiers in Active Tectonics Science.**
Structural Geology and Tectonics and *Geophysics Divisions.* George H. Davis, University of Arizona; J. Bernard Minster, Scripps Institution of Oceanography, San Diego.

S4. **Tectonic Geomorphology, Depositional Processes, and the Depositional Record.**
Sedimentary Geology Division. Douglas Burbank, Massachusetts Institute of Technology.

S5. **Geology and the Postindustrial Society.**
1994 GSA Annual Meeting Committee. George D. Klein, New Jersey Marine Science Consortium, Fort Hancock.

S6. **Meyer Symposium: Maintaining Compatibility of Mining and the Environment.**
Society of Economic Geologists and *1994 GSA Annual Meeting Committee.* George Brimhall and Lewis Gustafson, University of California, Berkeley.

S7. **Advances in Silica Geochemistry.**
Mineralogical Society of America. Peter J. Heaney, Princeton University; Patricia Dove, Georgia Institute of Technology.

S8. **Mineralogical Society of America 75th Anniversary Symposium.**
Mineralogical Society of America and *1994 GSA Annual Meeting Committee.* W. Gary Ernst, Stanford University.

S9. **Frontiers of Mineral Surface Geochemistry: A Symposium in Memory of Andrew J. Gratz (1962–1993).**
Mineralogical Society of America and *Geochemical Society.* Michael F. Hochella, Jr., Virginia Polytechnic Institute and State University.

S10. **The Dreiss Symposium: Recent Trends in Studies of Coupled Hydrodynamic, Tectonic, and Thermal Processes.**
Hydrogeology Division. Mark Person, University of Minnesota.

S11. **Hydrology and Active Volcanism: At the Leading Edge.**
Quaternary Geology and Geomorphology Division. John E. Costa and Richard Waitt, U.S. Geological Survey, Vancouver, Washington.

S12. **Regional Economic Geology of the Northern Cordillera.**
Society of Economic Geologists. Eric S. Cheney, University of Washington.

S13. **Historical Investigations of Extraterrestrial Events and Causes in Earth History.**
History of Geology Division. Joanne Bourgeois, University of Washington; Mott T. Greene, University of Puget Sound.

S14. **Cataclysms and Catastrophes: The Planetary Perspective.**
Planetary Geology Division. Odette B. James, U.S. Geological Survey, Reston.

S15. **Evolutionary Paleobiology.**
Paleontological Society. Douglas H. Erwin, National Museum of Natural History, Smithsonian Institution.

S16. **Military Geology in War and Peace.**
Engineering Geology Division. James R. Underwood, Jr., Kansas State University; Peter L. Guth, U.S. Naval Academy.

S17. **Pyrolysis Techniques for Source Rock Evaluation—Twenty Years Later.**
Organic Geochemistry Division of the Geochemical Society. Colin Barker, University of Tulsa; Steven Larter, The University (Newcastle upon Tyne).

S18. **Origin of Compositional Characteristics in Tertiary Coals: Paleoecology, Paleobotany and Palynology.**
Coal Geology Division. Thomas D. Demchuk, Amoco Production Co., Houston, Texas; Timothy A. Moore, Geological Survey of Wyoming, Laramie; Jane C. Shearer, Foundation for Research in Science and Technology, Wellington, New Zealand.

S19. **The Late Cretaceous Marine and Continental Record of Global Climate Change.**
Cushman Foundation. Enriqueta Barrera, University of Michigan; Brian T. Huber, Smithsonian Institution.

S20. **Use of Archaeology for Dating Geologic Events.**
Archaeological Geology Division. Margaret J. Guccione, University of Arkansas.

S21. **Changing Gateways: The Impact of Technology on Geoscience Information Exchange.**
Geoscience Information Society. Barbara E. Haner, University of California, Riverside.

S22. **Recent Advances in Geoscience Education—The Leading Edge of Undergraduate Instruction and Research.**
National Association of Geology Teachers and *National Science Foundation.* John C. Palmquist, Lawrence University.

S23. **Marine Trace-Element Biogeochemistry and the Sedimentary Record.**
Geochemical Society. Lee R. Kump and Michael A. Arthur, Pennsylvania State University.

S24. **The Geological Profession's Response to National Priorities in Science Education.**
Geoscience Education Division. Robert Ridky, University of Maryland at College Park.

S25. **Annual Environmental Forum: Crucial Environmental Issues: Fear and Loathing at the Leading Edge.**
Institute for Environmental Education. Patrick L. Abbott, San Diego State University.

S26. **SGE Student Research.**
Sigma Gamma Epsilon. Charles J. Mankin, Oklahoma Geological Survey. POSTER.

S27. **Where Geology Matters: Past, Present, and Future.**
GSA Committee on Geology and Public Policy. Emery T. Cleaves, Maryland Geological Survey; Donald C. Haney, Kentucky Geological Survey.

Volunteered Papers

This format includes all abstracts that are not specifically invited for a symposium. Each paper will have a minimum of three reviews. Two types of sessions are available:

1. Discipline Sessions

Papers are submitted to ONE scientific discipline. The JTPC representatives organize the papers in sessions focused on this one discipline, e.g., hydrogeology, geochemistry.

2. Theme Sessions

Papers are submitted to a specific *pre-announced* title and to ONE scientific category. Theme sessions are interdisciplinary; each theme may have as many as three categories from which authors may choose ONE. After each theme description below, the categories are identified by name and number as they appear on the 1994 Abstract Form.

Theme submissions must include:

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

Submit only in the mode indicated in description

If the abstract is submitted in the incorrect mode, the abstract will NOT be considered for the theme session, but will automatically be considered for a discipline session instead.

Role of theme advocate

Each theme session has been proposed by an advocate. *Advocates may not invite speakers; however, advocates may encourage colleagues to submit abstracts, with the understanding that there is no guarantee of acceptance.*

All abstracts will be evaluated by three appropriate JTPC reviewers in the discipline for which they are submitted; a fourth review will be provided by the theme advocate. During the August 5–6 JTPC meeting, the designated JTPC representative (in consultation with the theme advocate) will organize theme sessions from the abstracts approved for presentation.

Theme Topics

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

T1. **Liquefaction Hazard Mapping and Mitigation.**
W. Paul Grant, Shannon & Wilson, Inc., Seattle, Washington.

The Pacific Rim has the potential for significant damage from earthquake induced liquefaction, particularly from a subduction earthquake. Mitigation of this hazard requires identifying susceptible areas and developing effective construction techniques. This theme session will provide a forum for discussion of liquefaction mapping strategies and case histories of effective liquefaction mitigation. ORAL.
Engineering Geology (5), Geoscience Information (11).

T2. **Speciation, Mobility, and Bioavailability of Metals in Mining Wastes.**
Mineralogical Society of America. David Frank and Roseanne M. Lorenzana, U.S. Environmental Protection Agency, Seattle, Washington.

Processing of ore deposits from convergent plate margins produces wastes with elevated concentrations of metals and metalloids. Environmental mobility and biological uptake may also be altered. This theme session brings together interdisciplinary studies involving mineralogical characterization and geochemical speciation of solid and liquid mining wastes and their biological effects. ORAL.
Environmental Geology (6), Geochemistry, Aqueous/Organic (7), Mineralogy/Crystallography (16).

T3. **The Role of Geology in Characterization, Contaminant Transport, and Remediation of Hazardous Waste Sites.**
Institute for Environmental Education. Daniel Clayton and Kathy Goetz Troost, Shannon & Wilson, Inc., Seattle, Washington.

The integration of geologic site characterization with exposure assessments and remediation technology is of fundamental importance in successfully remediating contaminated subsurface soils and ground water. This session is a forum for case histories where innovative geological and hydrogeological studies have been instrumental in assessing contaminant migration pathways and selecting remedial strategies. ORAL.
Engineering Geology (5), Environmental Geology (6), Hydrogeology (13).

T4. **Surprises for Society.**
GSA Geosphere Alliance Committee. Susan Kieffer, University of British Columbia.

Humans as individuals, or as societies with governing institutions, are little prepared for nonintuitive events, or for events rare in their experience. This session will be dedicated to describing, in socially and economically relevant terms, events that are rare compared to human experience, but for which the geologic record and our interpretations of it are relevant. These include processes that have a statistically significant chance of happening on the 100–1000 year time scale, and/or processes that might be more rare but influence our interpretation of everyday phenomena. Examples might be: any nonlinear phenomenon; large meteorite impacts as analogs for nuclear winter; geologic extinctions as lessons in biodiversity; relations between rare volcanic eruptions and climate changes; and processes on other planets and their lessons for Earth. Implications for current societal problems must be addressed. ORAL.
Environmental Geology (6), Hydrogeology (13), Quaternary Geology/Geomorphology (25).

T5. **The Geological Basis of Wild Salmon Ecology.**
Institute for Environmental Education. David R. Montgomery and Thomas Dunne, University of Washington.

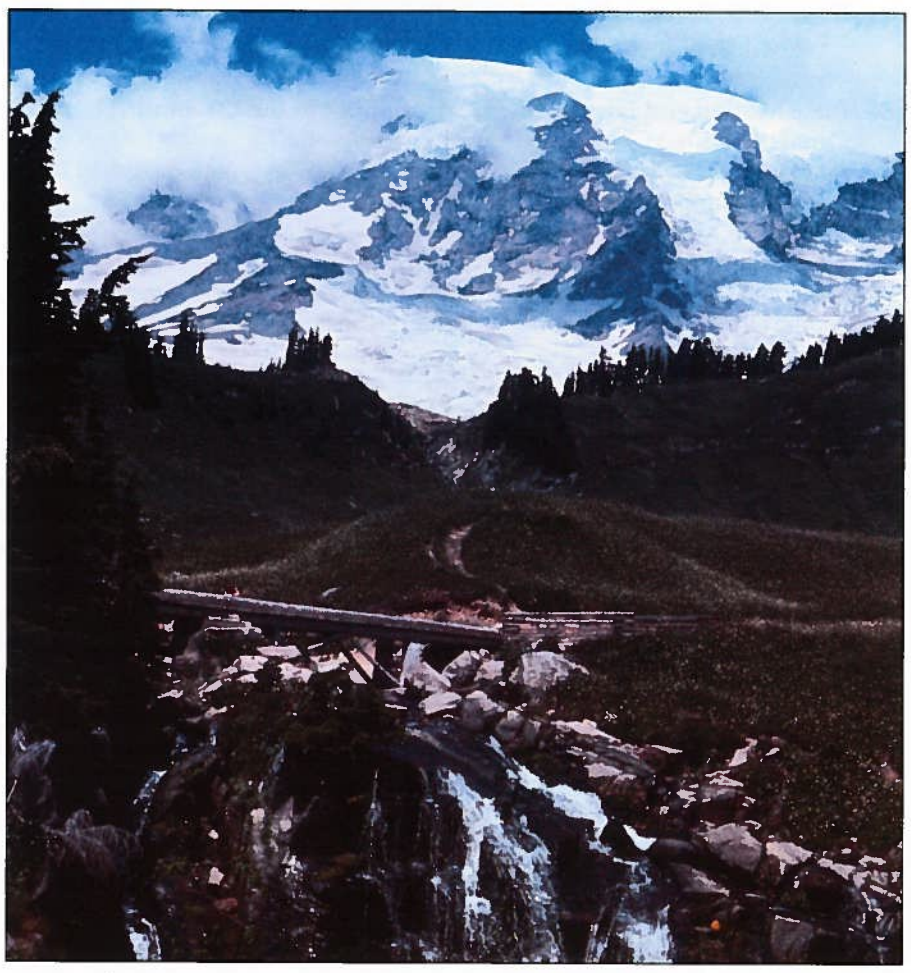
The recent national focus on the need to manage regional-scale mountain landscapes to protect the habitat of wild salmon, spotted owls, and other species raises the question of whether geological studies can provide understanding to assist with the task of managing landscape for biodiversity. The theme session will use the habitat of the Pacific salmon as a focus for addressing this question. Abstracts are sought on how the processes of landscape assembly and evolution provide the basis for ocean currents, climate and its fluctuations, estuarine conditions, drainage basin hydrology, and channel and floodplain morphology that have allowed the Pacific salmon to exploit an extensive and varied range. ORAL.
Environmental Geology (6), Quaternary Geology/Geomorphology (25).

T6. **Environmental Geology: The Voice of Warning.**
Institute for Environmental Education. Monica E. Gowan, GeoLogic, Bellingham, Washington.

The geoscientist's grasp of complex geoenvironmental issues carries a responsibility to raise public awareness of the risks of natural hazards, resource availability and consumption, and the impacts of human activities. This session will focus on how geologists can contribute to developing a citizenry informed on the geology relevant to environmental issues. ORAL.
Engineering Geology (5), Environmental Geology (6), Hydrogeology (13).

T7. **Environmental Geology: The Voice of Reason.**
Institute for Environmental Education. Monica E. Gowan, GeoLogic, Bellingham, Washington.

Geoscientists routinely use reasoning processes that test data reliability and relevance, probabilities, and causal relations. These skills can help clear public confusion over verity, risk, and consequences. This session will examine how geologists can assist the public and decision makers in developing rational perspectives that incorporate relevant geoscience in environmental debates. ORAL.
Engineering Geology (5), Environmental Geology (6), Hydrogeology (13).



Paradise Trail, Mt. Rainier National Park, Washington. Photo by John Karachewski.

Sea stacks in Jurassic rocks of Sooes terrane, Point of Arches, west coast of Olympic Peninsula, Washington. Photo by Eric S. Cheney.

T8. **Geochemistry of Contaminant Transport.**
L. Edmond (Ted) Eary, Sciences International, Inc., Kennewick, Washington; George R. Holdren, Battelle Pacific Northwest Labs, Richland, Washington.

Contaminant transport through geologic media is affected by biological and chemical redox, solubility, and sorption reactions. Knowledge of these processes is critical for assessing migration potential. This session brings together researchers with theoretical, field, and modeling expertise to develop a unified framework for describing geochemical processes that affect contaminant migration. ORAL.
Environmental Geology (6), Geochemistry, Aqueous/Organic (7), Hydrogeology (13).

T9. **Urban, Suburban, and Rural—Environmental Geology at the Leading Edge.**
Quaternary Geology and Geomorphology Division and *Institute for Environmental Education*. Duncan Foley, Pacific Lutheran University, Tacoma, Washington.

This session will focus on environmental aspects of the interface between geology and society. Urban, suburban, and rural areas along the "leading edge" are affected by multiple environmental issues including geologic hazards (earthquakes, volcanoes, landslides, floods, and tsunamis), resource development, waste disposal, and water shortages. Geological input is critical in handling such issues in these areas of rapid development. ORAL.
Engineering Geology (5), Environmental Geology (6), Quaternary Geology/Geomorphology (25).

T10. **The Management of Contaminated Sites in Near-shore Marine and Estuary Environments.**
Theresa Henson, Shannon & Wilson, Inc., Seattle, Washington.

Many coastal urban environments in the U.S. contain sites where industrial activities affect the near-shore zone. Representatives include military installations, wood treatment plants, municipal landfilling, and harbors. Numerous such sites are currently being investigated to determine their potential impact on the marine environment. This session will provide a forum to discuss remediation resulting from an integration of a broad spectrum of disciplines: geology, hydrology, fisheries, wetlands, wildlife biology, ecological and human health risk assessment, environmental chemistry, and engineering. ORAL.
Environmental Geology (6), Hydrogeology (13), Marine Geology (14).

T11. **Stable Environmental Isotope Application in Ground-water Systems.**
Hydrogeology Division. Noel C. Krothe, Indiana University; Roy F. Spalding, University of Nebraska.

The theme presentations will describe the current status of the theory and application of stable isotopes of hydrogen, helium, carbon, nitrogen, oxygen, and sulfur to the understanding of ground-water processes. The application of stable isotopes in areas of environmental concern such as degradation of ground-water quality associated with industries, waste repositories, waste treatment, and agriculture will be highlighted. ORAL.
Environmental Geology (6), Geochemistry, Aqueous/Organic (7), Hydrogeology (13).

T12. **Hydrothermal Systems Evolution in the Cascade Range.**
Hydrogeology Division. Lisa Shevenell, Nevada Bureau of Mines and Geology, University of Nevada at Reno; Jules Friedman, U.S. Geological Survey, Denver.

Although considerable research has been conducted on active hydrothermal systems throughout the Cascade Range, little is known about the genesis of Cascade geothermal systems. Is there evidence of an integrated system? What is the most applicable heat-flow model? Are there significant hydrothermal resources? The objective of this session is to present studies on the localization, distribution, and temporal changes in individual volcano-related and other hydrothermal systems. ORAL.
Geophysics/Tectonophysics (10), Hydrogeology (13), Volcanology (32).

T13. **Relation of Depositional Environments to Chemical and Physical Heterogeneity within Sedimentary Aquifers.**
Hydrogeology Division and *SEPM (Society for Sedimentary Geology)*. Matthew J. Davis, University of New Hampshire; George N. Breit, U.S. Geological Survey, Denver.

Heterogeneity of the physical and chemical properties of many sedimentary aquifers is controlled largely by the processes of deposition. This session will focus on the relation between depositional processes and the resulting spatial variation of chemical and physical properties of aquifers that impact solute transport and water quality. ORAL.
Geochemistry, Aqueous/Organic (7), Hydrogeology (13), Sediments, Clastic (28).

T14. **Geologic Significance of Microbial Processes.**
Hydrogeology Division. Philip C. Bennett, University of Texas at Austin; Frank Chapelle, U.S. Geological Survey, Columbia, South Carolina.

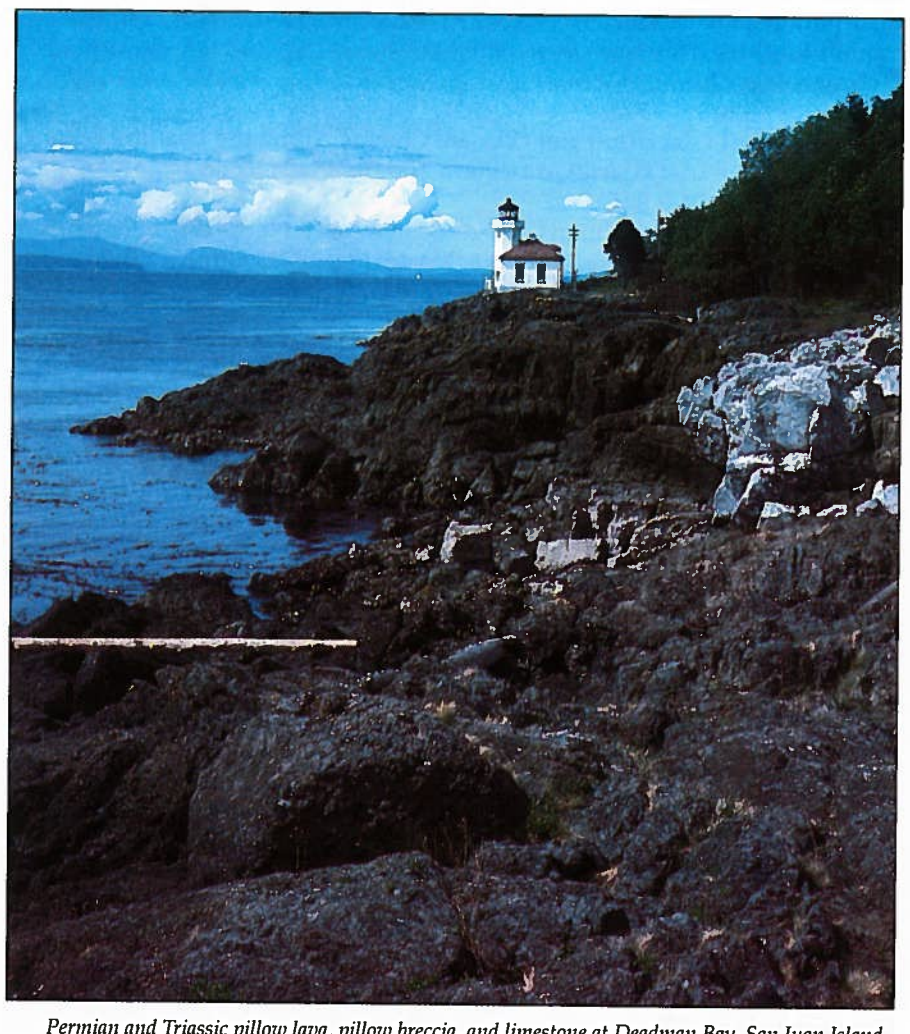
Geoscientists are becoming increasingly aware of the powerful role that microorganisms play in geologic processes. Rather than being passive inhabitants of the subsurface, microbes are key factors in the diagenetic alteration of sediments and rocks, and in the accumulation of some metal ores. This session will focus on the geologic significance of microbial processes in the lithosphere, examining the role of microbes as geologic agents. ORAL.
Environmental Geology (6), Geochemistry (7), Hydrogeology (13).

T15. **Computational Hydrology and Data Visualization and Animation.**
Hydrogeology Division. Edward A. Sudicky, Waterloo Centre for Groundwater Research, University of Waterloo, Ontario, Canada; Frank W. Schwartz, Ohio State University.

The goal of this special session is to explore the science and applicability of exciting visualization and animation technologies in ground-water geology. Beyond fundamental questions of how to extract information from multidimensional data that comes from process-oriented, fluid-flow and mass-transport models or from large-scale experiments, the session will examine the future of these techniques in "digital" journals, hydrogeological education, and the legal arena. ORAL.
Computers (3), Hydrogeology (13).

T16. **Leading Edge Applications of Earth Science Modeling and Visualization.**
COGEOINFO (Commission on the Management and Application of Geoscience Information). A. Keith Turner, Colorado School of Mines; Frank A. D'Agnese and Claudia C. Faunt, U.S. Geological Survey, Denver.

This session explores recent advances in three-dimensional (3-D) geoscience computer modeling and visualization. Presentations will address the evaluation of regional and global problems by these 3-D tools in conjunction with process-response and numerical simulation models. Recent increases in vol-



Permian and Triassic pillow lava, pillow breccia, and limestone at Deadman Bay, San Juan Island, Washington. Photo by Darrel S. Cowan.

ume and complexity of geoscience data sets have resulted in concerns about data availability and quality. Therefore, presentations will also discuss data quality assurance, management and integration methods for structural geology, stratigraphy, engineering geology, and hydrogeology. ORAL.
Computers (3), Engineering Geology (5), Hydrogeology (13).

T17. **Integration of Hydraulic and Geochemical Approaches in Vadose Zone Transport Studies.**
Hydrogeology Division and *Institute for Environmental Education*. Scott W. Tyler, Desert Research Institute, Reno, Nevada; Bridget R. Scanlan, Bureau of Economic Geology, University of Texas at Austin.

The emerging role of the vadose zone in ground-water recharge and contaminant transport studies has led to the development of new hydraulic and geochemical indicators of soil water movement. These indicators too often present conflicting data on both the direction and magnitude of subsurface water flux. The objectives of this session are to explore integration and conflict resolution of these hydraulic and geochemical indicators to better understand vadose zone processes. The session should be of interest to hydrogeologists and geochemists working on recharge and contaminant transport studies related to site characterization of proposed waste disposal facilities and remediation of contaminated sites in a variety of climates and terranes. ORAL.
Environmental Geology (6), Geochemistry, Aqueous/Organic (7), Hydrogeology (13).

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

T18. **Methods for Quantifying Unsaturated Permeability, Retardation, and Other Transport Properties in Rock, Soil, and Sediment.**
Judith Wright, Battelle-Pacific Northwest Labs, Richland, Washington; James L. Conca, Washington State University.

This theme session focuses on an interdisciplinary approach to determining unsaturated subsurface transport in soils, sediments, and rocks. Comparison of new and established techniques will show how to achieve a more complete characterization and understanding of subsurface transport and water-substrate interactions. Abstracts are requested from investigators utilizing various empirical methods and modeling techniques including classical laboratory and in situ field studies, new direct-measurement technologies, and multidimensional modeling. POSTER.
Environmental Geology (6), Geochemistry, Aqueous/Organic (7), Hydrogeology (13).

T19. **Description and Measurement of Constitutive Relations Governing Fluid Flow in Variably Saturated Media.**
Hydrogeology Division. Martinus Th. van Genuchten, U.S. Salinity Laboratory, Riverside, California; Robert J. Lenhard, Battelle-Pacific Northwest Labs, Richland, Washington.

Important parameters for modeling fluid flow in variably saturated media are the constitutive relations between fluid saturation, relative permeability, and fluid pressure. This theme session addresses the description, measurement, and scaling of the constitutive relations governing multiphase fluid flow. The session will also focus on the development and testing of statistical pore-size distribution, percolation–pore-network, and other theoretical or empirical models for these relations. ORAL.
Hydrogeology (13).

T20. **Records of Glaciation and Climate Change Along the Leading Edge During the Last Glacial Maximum and the Pleistocene-Holocene Transition (20–8 ka).**
Donald T. Rodbell, Union College, Schenectady, New York; P. Thompson Davis, Bentley College, Waltham, Massachusetts; Geoffrey O. Seltzer, Byrd Polar Research Center, Ohio State University.

The purpose of this theme session is to evaluate glacial and climatic records from the cordillera of North and South America. We solicit papers that document (1) the timing and magnitude of the last glacial maximum, (2) the climatic conditions that prevailed during the last glacial maximum, (3) the mode and style of the last deglaciation, and (4) the occurrence of high-frequency and large-magnitude climatic oscillations during the last glacial-interglacial transition. Principal proxy records of interest are radiocarbon-dated moraines, lacustrine sediments, and pollen spectra. Our goals are the identification of regional patterns of climatic change and the compilation of a paleoclimatic database along a north-south transect to test models of global climatic forcing. ORAL.
Quaternary Geology/Geomorphology (25).

T21. **The Last Interglacial: Timing and Environment.**
Daniel R. Muhs, U.S. Geological Survey, Denver; Tom Hamilton, U.S. Geological Survey, Anchorage.

The last interglacial period has been cited as a possible analog for a future climate under an increased-CO_2 "greenhouse" effect, with temperatures and sea level higher than the present. Papers with last-interglacial coral reef, calcite vein, paleosol, pollen, ice core, deep-sea core, or other records for North America are invited for this theme session. ORAL.
Paleoceanography/Paleoclimatology (17), Quaternary Geology/Geomorphology (25).

T22. **Paleoclimate Records from Arctic Lakes and Estuaries.**
Gifford Miller, University of Colorado, Boulder.

The Arctic plays a key role in the global climate system, primarily due to strong feedback mechanisms related to the extent of permanent snow and ice sheets, and the distribution of permanent and seasonal sea ice in the Arctic Ocean and adjacent marginal seas. How changes in these conditions influence the rest of the climate system, and conversely how changes that occur outside the Arctic impact the Arctic remain obscure. An international effort to develop high-resolution time series of environmental change for the past 20 ka for the circum-Arctic regions is now well under way, including GCM modeling. A review of results to date would be appropriate and of wide interest to the earth science community. ORAL.
Paleoceanography/Paleoclimatology (17), Quaternary Geology/Geomorphology (25).

T23. **Correlation of the Marine and Terrestrial Paleoclimatic Record of the Eastern North Pacific and Western United States.**
James V. Gardner, U.S. Geological Survey, Menlo Park; Walter E. Dean, U.S. Geological Survey, Denver.

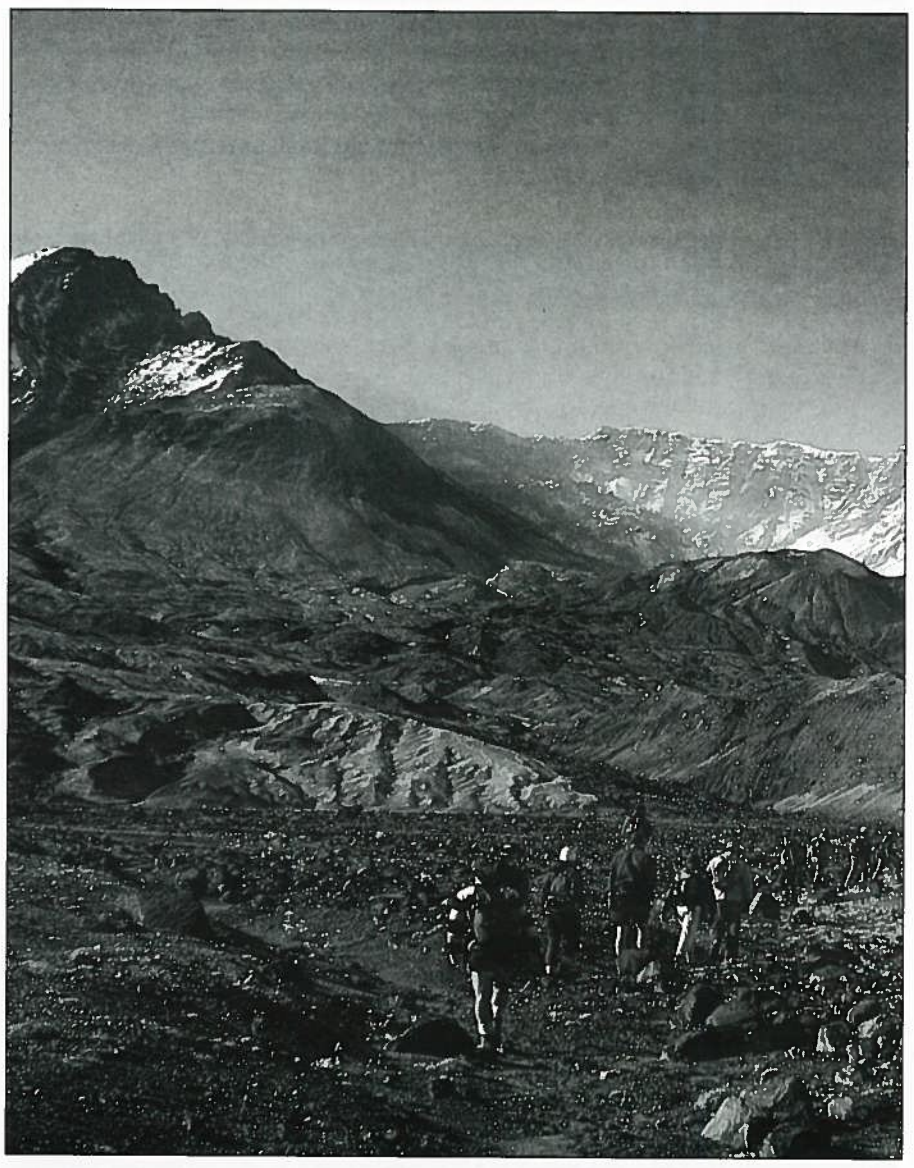
This theme session will include results of high-resolution studies of the past 100,000 years from marine and terrestrial paleoclimatic records of the western margin of North America. The focus will be on the last glacial-interglacial cycle, the last deglaciation, and major climate events. POSTER.
Micropaleontology (15), Paleoceanography/Paleoclimatology (17), Quaternary Geology/Geomorphology (25).

T24. **Tectonics and Landforms Around the Pacific Rim.**
Arthur L. Bloom, Cornell University; Thomas Dunne, University of Washington.

The session will combine the experience of geologists who use landforms to define patterns and rates of crustal deformation with others who study the mechanics of landform evolution affected by tectonism. Abstracts are invited that report insights resulting from geophysical and geochronological techniques, remote sensing, and the acquisition and processing of topographic data, as well as on traditional field methods. ORAL.
Quaternary Geology/Geomorphology (25), Tectonics (31).

T25. **The Juneau Icefield: A Half Century of Geoscience Education, Research, and Professional Training in the Alpine and Glacial Environment.**
National Association of Geology Teachers and *Quaternary Geology and Geomorphology Division*. Brian B. Tormey, Pennsylvania State University; P. Jay Fleisher, State University of New York, Oneonta; Ann M. Tallman, Foundation for Glacier & Environmental Research, Richland, Washington.

More than 2800 students, scientists, and field technicians have participated in a program of field activity centered on the Juneau Icefield, southeastern Alaska. Initiated in 1946, the program has provided education and field



Don Swanson leads a University of Washington Geological Sciences field trip into the crater of Mt. St. Helens in September 1992. Photo by Stephen C. Porter.

training in scientific techniques and methodology in a uniquely stimulating environment. An international staff of renowned scientists has participated in programs for graduate, undergraduate, and precollege students with interests in field-oriented glaciological research. The results form a pedagogical bridge between education and research that has successfully prepared scientists and educators for the challenges of their respective careers. ORAL.
Geology Education (9), Quaternary Geology/Geomorphology (25).

T26. **Quaternary Dating Methods.**
Milan Pavich, U.S. Geological Survey, Reston; Paul Bierman, University of Vermont.

Significant developments in Quaternary dating methods over the past decade include: accelerator mass spectrometry, measurements of cosmogenic isotopes, high-resolution mass spectrometry such as $^{39}Ar/^{40}Ar$ analysis of single crystals and $^{235}U/^{231}Pa$ analysis of young mafic volcanics, and isothermal plateau annealing of glass shards for fission-track dating. The session will showcase applications of these methods to time-stratigraphic, geomorphic, and active tectonic problems. ORAL.
Quaternary Geology/Geomorphology (25), Stratigraphy (29).

T27. **Late Quaternary Evolution of the Eastern Aleutian Arc: Volcanoes, Earthquakes, Glaciers, and Shorelines.**
Mark Molinari, Dames and Moore, Seattle, Washington; Lou Gilpin, University of California, Santa Cruz.

The Gulf of Alaska margin of the eastern Aleutian arc is a huge area that is affected by episodic events of both subduction-related tectonic processes, such as volcanic eruptions and the megathrust earthquake cycle, and climate-controlled glacio-eustatic interactions. The goal is to bring researchers together from various disciplines (i.e., tectonic, volcanic, glacial, and climatic fields) in order to better understand the processes of landscape evolution and consider possible feedback mechanisms between the various processes. ORAL.
Geophysics/Tectonophysics (10), Quaternary Geology/Geomorphology (25), Volcanology (32).

T28. **Learning in Small Groups: Using Collaborative Activities to Teach Geology.**
National Association of Geology Teachers. R. Heather MacDonald, College of William and Mary; Ann Bykerk-Kauffman, California State University at Chico.

This session will explore ways in which small groups' activities are used in geology and earth science courses at all levels (precollege to graduate school). We are interested in descriptions of specific small-group collaborative assignments; discussions of how such activities can be integrated into classes (especially large-enrollment classes); and evaluations of the effectiveness of such activities for student learning. ORAL.
Geology Education (9).

T29. **Advances in the Geology and Metallogeny of Gold Deposits.**
Mineralogical Society of America and *Society of Economic Geologists.*
Michael Rasmussen, Echo Bay Exploration, Inc., Spokane, Washington.

This theme session will focus on developments germane to gold mineralization. Papers may (1) discuss theoretical or experimental results, (2) present regional syntheses of geological, geochemical, and/or geohydrological data, or (3) describe gold occurrences that depart from established deposit models or which require genetic reinterpretation. ORAL.
Economic Geology (4), Geochemistry, Other (8), Petrology, Igneous (21).

Photo courtesy of Seattle–King County Convention and Visitors Bureau.

T30. **Boron: Mineralogy, Petrology, and Geochemistry in Earth's Crust.**
Mineralogical Society of America. Edward S. Grew, University of Maine; Lawrence M. Anovitz, University of Arizona.

Boron has been shown to be a critical indicator of the fate of subducted oceanic crust, and being strongly hydrophilic, it has enormous potential as a tracer of fluids in a variety of geologic environments. An improvement in instrumentation has much facilitated the analysis of boron and its isotopes. Papers on all aspects of boron research are welcome: experimental, field, mineralogy, petrology, instrumentation, and geochemistry. ORAL.
Geochemistry, Other (8), Mineralogy/Crystallography (16), Petrology, Experimental (20).

T31. **Advances in Silica Geochemistry.**
Mineralogical Society of America. Peter J. Heaney, Princeton University; Patricia Dove, Georgia Institute of Technology.

Silica minerals serve as indicators for a variety of geologic processes, ranging from meteorite impacts to gold mineralization. Advances in sol-gel processing and zeolite synthesis have increased the importance of silica as an industrial material. This theme session will survey the most recent advances in understanding the atomic-scale behavior of silica minerals in response to temperature, pressure, and time. ORAL.
Geochemistry, Aqueous/Organic (7), Geochemistry, Other (8), Mineralogy/Crystallography (16).

T32. **Phase Transformations: Mechanisms and Kinetics of Mineral Reactions.**
Mineralogical Society of America. Bradley Hacker, Stanford University; Steven R. Bohlen, U.S. Geological Survey, Menlo Park.

Phase transformations play key roles in the evolution of Earth. Melting and crystallization produce continents and ocean basins, subduction is driven by formation of eclogite from gabbro, and energy resources rely on the formation of hydrocarbons and geothermal systems. With the equilibrium phase relations of many geologic materials well understood, the time is ripe for a theme session to showcase "leading edge" experimental, theoretical, and field investigations of phase transformations. ORAL.
Geochemistry, Other (8), Geophysics/Tectonophysics (10), Petrology, Experimental (20).

T33. **Magmatic Evolution of Circum-Pacific Arc Systems.**
Mineralogical Society of America. Robert J. Stern, Center for Lithospheric Studies, University of Texas at Dallas.

The evolution of convergent margins differs from those of other plate margins in reflecting rapid crustal thickening, with consequences for magmatic evolution and tectonics. In this theme session, we focus on the evolution of magmatic compositions in response to different external effects, such as age of the system, and the age and nature of the crustal substrate and subducted lithosphere. ORAL.
Geochemistry, Other (8), Petrology, Igneous (21).

T34. **Volcanic Hazards and Disasters in Human History.**
Archaeological Geology Division. Floyd W. McCoy, Windward College, University of Hawaii; Grant Heiken, Los Alamos National Laboratory.

Volcanism has been a dominant influence in human history, affecting climate change and facilitating both the destruction and the preservation of human artifacts. This decade is designated for a focus on volcanic hazards. Abstracts are invited on the geologic and archaeological record of volcanic processes that have affected societies. ORAL.
Archaeological Geology (1), Volcanology (32).

T35. **Volatiles and Volcanoes.**
Society of Economic Geologists. Robert Symonds, U.S. Geological Survey, Vancouver, Washington.

Degassing magma beneath volcanoes releases volatiles that interact with volcano-hydrothermal systems. If passively degassed or explosively injected into the atmosphere, these magmatic gases also play a major role in volcano-atmospheric interactions. This interdisciplinary session will explore magma degassing and the role(s) of magmatic volatiles in volcano-hydrothermal and volcano-atmospheric interactions. ORAL.
Environmental Geology (6), Geochemistry, Other (8), Volcanology (32).

T36. **Geological Mapping of Terrestrial Planets: Use (and Abuse?) of Remotely Sensed Data.**
Planetary Geology Division. George E. McGill, University of Massachusetts.

Remotely sensed data are being increasingly used to prepare geologic maps and to infer chemical or physical properties of exposed bedrock and surficial materials on Earth and other planetary bodies. This session will accept presentations on (1) results of mapping using remotely sensed data, and (2) the promise and limitations of such techniques in geological research. ORAL.
Planetary Geology (23), Remote Sensing (26).

Nisqually Glacier icefall on Mt. Rainier. Photo by Stephen C. Porter.

T37. **Impacts and Extinctions.**
Paleontological Society. Peter Ward, University of Washington.

The rapidly evolving research linking bolide impacts with global mass extinctions has undergone several new, major developments. First, the Chicxulub structure is now unambiguously shown to be an impact crater of huge size, and it has been reliably dated at 65 Ma, or coincident with the K-T mass extinction. Second, the Manson Crater in Iowa, previously thought to date to 65 Ma, has recently been shown to be 72 Ma, and an impact layer of this age has been found in the Western Interior. Finally, new work on Triassic rocks has shown abundant evidence of impact at the end of the Triassic. These topics, as well as new information on "kill curves" derived from studies of impacts, will be explored in this theme session. ORAL.
Paleontology/Paleobotany (18), Planetary Geology (23), Stratigraphy (29).

T38. **New Perspectives on Faunal Stability in the Fossil Record.**
Paleontological Society. Kenneth M. Schopf and Linda C. Ivany, Museum of Comparative Zoology, Harvard University.

Motivated by the recent documentation of "coordinated stasis" in several Paleozoic ecosystems, we invite papers that address the question of long-term faunal stasis and coordinated turnover in the fossil record. Studies of within-basin faunal composition over a period of millions of years (at the species or genus level) are encouraged, as are theoretical discussions of the behavior of ecosystems over geologic time scales. This session will emphasize the importance of integrating ecological and environmental factors within evolutionary theory. ORAL.
Micropaleontology (15), Paleontology/Paleobotany (18), Stratigraphy (29).

T39. **Tectonic and Climatic Influences on the Neogene Paleobiology of West-Central Nevada.**
Howard E. Schorn, Museum of Paleontology, University of California, Berkeley; Scott W. Starratt, U.S. Geological Survey, Menlo Park.

This theme session will focus on the role of tectonics and climate in the composition and diversity of the Neogene micro- and macro-floras and faunas in west-central Nevada. Major changes in floral and faunal composition occurred in the Great Basin during the Neogene. Were these changes the result of global climate variations or local and regional changes resulting from the structural development of the Basin-and-Range physiographic province? ORAL.
Paleoceanography/Paleoclimatology (17), Paleontology/Paleobotany (18), Tectonics (31).

T40. **Evolution of Reef Biotas Along Active Plate Margins.**
Paleontological Society. Constance M. Soja, Colgate University; Rodney Watkins, Milwaukee Public Museum.

This theme session will give paleontologists the opportunity to discuss the geologic occurrence of reefs that formed adjacent to oceanic islands or along convergent plate margins. Presentations will amplify models pertaining to reefs by exploring the influence of tectonic activity on reef evolution from the Precambrian to the Holocene. ORAL.
Paleontology/Paleobotany (18), Sediments, Carbonates (27), Tectonics (31).

T41. **Teaching Paleontology.**
Paleontological Society and *National Association of Geology Teachers.* Carl V. Mendelson, Beloit College; H. Allen Curran, Smith College.

Paleontology is a rapidly expanding field that has changed immensely over the past 20 years. How can we keep pace with those changes? Which parts of the "old paleontology" should we exclude from our courses? Which parts of the "new paleobiology" should we incorporate? How can teachers help place paleontology "at the leading edge?" Contributors should prepare posters illustrating successful approaches to teaching paleontology, including field and lab exercises, computer applications (e.g., theoretical morphology, cladistics), discussion sessions, term projects, and specialized courses. POSTER.
Geology Education (9), Paleontology/Paleobotany (18).

T42. **Educating Paleontologists for the Next Millenium: Evolution and Revolution.**
Paleontological Society. Gary D. Rosenberg, Indiana University/Purdue University, Indianapolis.

Education of paleontology professionals needs to change by a quantum leap in an era when the demand for paleontologists in universities, museums, government, and industry is waning. What kinds of paleontologists are most successful now, and what kinds will be needed in the future? Contributors may present data showing how paleontologists can avoid extinction as either pure or applied scientists in a climate of otherwise deteriorating employment. ORAL.
Geology Education (9), Paleontology/Paleobotany (18).

T43. **Pliocene Climates—Sea Levels and Ice Volumes.**
Detlef A. Warnke, California State University at Hayward.

The evolution of Pliocene climates, including sea-level and ice-volume changes, is a hotly debated topic. Divergent views exist, particularly on climatic evolution of the early Pliocene, but there are also areas of agreement. Papers on these subjects are often scattered through three or more sessions. Therefore, it would be fruitful to bring them together in one session for presentation of data and exchange of ideas. POSTER.
Marine Geology (14), Paleoceanography/Paleoclimatology (17), Stratigraphy (29).

T44, T45. **Scientific Results of the Continental Drilling Program: Creede Caldera, Newark Rift Basin, Manson Impact Structure.**
Philip M. Bethke, U.S. Geological Survey, Reston; Dennis V. Kent and Paul E. Olsen, Lamont-Doherty Earth Observatory; David J. Roddy, U.S. Geological Survey, Flagstaff.

These two theme sessions will describe the objectives, operations, and interdisciplinary scientific results of the U.S. scientific drilling programs in (1) the moat of the Creede caldera, San Juan Mountains, Colorado; (2) the Newark Rift Basin, New Jersey; and (3) the Manson impact structure, Iowa. Oral presentations (to be submitted to theme T44) will summarize major areas of investigation. Poster presentations (to be submitted to theme T45) will provide detailed documentation and/or will describe additional scientific results or descriptions of drilling and logging operations. T44: ORAL, T45: POSTER.
Geochemistry, Other (8), Geophysics/Tectonophysics (10), Sediments, Clastic (28).

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

T46. **Teaching Structural Geology.**
Structural Geology and Tectonics Division and *National Association of Geology Teachers.* Jan Tullis, Brown University.

Many of us have experimented with different approaches to teaching structural geology, including discussion formats, writing assignments, special labs, demonstrations, computer or field exercises, student-originated projects, etc. This theme session is envisioned as a forum where people can share new approaches and materials that have worked well for them; it is focused on modes of teaching and learning rather than course content per se. ORAL.
Geology Education (9), Structural Geology (30).

T47. **Quantitative Analysis of Joints and Faults: New Approaches to Field, Laboratory, and Modeling Studies of Rock Fracture.**
Michael R. Gross, Florida International University.

New approaches to the analysis of joints and faults have shed considerable light on brittle deformation in Earth's upper crust. This session will focus on recent advances in field, laboratory, and computer techniques employed to investigate the fracture mechanics of rock, including the influence of material properties on rock fracture; fracture spacing, distribution, and propagation;

local and regional stress fields associated with joints and faults; process zones; and inferring paleostress history from fracture arrays. ORAL.
Geophysics/Tectonophysics (10), Structural Geology (30), Tectonics (31).

T48. **Cascadia Subduction Zone.**
Harvey Kelsey, Humboldt State University; Robert Schuster, U.S. Geological Survey, Denver; Brian Atwater, U.S. Geological Survey, University of Washington.

The purpose of this theme session is to provide an update on the structural setting and Quaternary history of earthquakes west of the Cascade crest. The session should be of interest to engineers as well as earth scientists. ORAL.
Quaternary Geology/Geomorphology (25), Stratigraphy (29), Tectonics (31).

T49. **Cascadia Convergent Margin: Forearc Tectonics.**
J. Casey Moore, University of California, Santa Cruz; Roy Hyndman, Pacific Geoscience Centre, Geological Survey of Canada.

Marine investigations of the Cascadia convergent margin demonstrate the close linkage of tectonic, thermal, and hydrologic processes. On-land work provides complementary and longer term perspectives on tectonic processes in this forearc. This theme session will integrate results from seismic reflection, submersible, and ODP drilling studies offshore, with structural, metamorphic, and neotectonic investigations on land. ORAL.
Marine Geology (14), Geophysics/Tectonophysics (10), Tectonics (31).

T50. **Puget-Sound–Georgia Strait: 140 Million Years of Tectonics.**
James W. H. Monger, Geological Survey of Canada.

The influence of past tectonic activity on features active today in this region must be looked at on both sides of latitude 49°N. Wrangellia–southwest Coast Belt crust found north of the border is not (or barely?) represented south of it; this seems to be mostly the result of Cretaceous tectonics. Does this difference affect younger, through-going tectonic features such as the depression containing Georgia Strait and Puget Sound, or the differing earthquake pattern north and south of the border? ORAL.
Structural Geology (30), Tectonics (31).

View southeast from Obstruction Peak Ridge, Olympic National Park, Washington. Photo by John Karachewski.

T51. **Tilt vs. Translation and the Late Cretaceous Tectonics of Western North America.**
George Gehrels and Bob Butler, University of Arizona.

The debate about tilt vs. translation centers on whether paleomagnetic data from Cretaceous rocks in western North America record >2000 km of northward transport or northeast-side-up tilt and <1000 km of displacement. The debate has important implications for reconstructing pre-Tertiary paleogeography and for understanding the genetic links between terrane accretion, plate motions, and orogenesis. ORAL.
Geophysics/Tectonophysics (10), Structural Geology (30), Tectonics (31).

T52. **Baja British Columbia: Evaluation of Large-scale Northward Transport of the Northern Cordillera in Late Cretaceous to Early Tertiary Time.**
Paul J. Umhoefer, Northern Arizona University; Ted Irving, Pacific - Geoscience Centre, Geological Survey of Canada.

The Baja B.C. hypothesis has been controversial since its inception. It has important implications for tectonics from Mexico to Alaska and as a case study of an oblique-convergence orogeny. The hypothesis seeks to describe the interactions between oceanic plates and North America during the Laramide orogeny. The session will focus on paleomagnetic data, evidence from large faults, and the derivation of sedimentary and volcanic sequences and plutonic suites. ORAL.
Geophysics/Tectonophysics (10), Tectonics (31).

T53. **Convergent and Transform Processes at the Leading Edge of the Northern Pacific Rim.**
Sarah Roeske, University of California, Davis; Jinny Sisson, Rice University; Terry Pavlis, University of New Orleans.

Both convergent and transform tectonic events have shaped the leading edge of the northern Pacific Rim during the Late Cretaceous through Eocene. We are soliciting abstracts from a broad range of disciplines that address tectonic processes that occurred at this plate boundary, from the Kodiak Islands to northern Oregon. We particularly encourage presentation of regional syntheses that relate offshore tectonic events to geologic events inboard from the plate margin. ORAL.
Petrology, Igneous (21), Sediments, Clastic (28), Tectonics (31).

T54. **Geophysical Studies of the Continental Margin, Western North America.**
Walter D. Mooney, U.S. Geological Survey, Menlo Park.

Geophysical studies of the continental margin of North America have provided new insights into the evolution of this transform-subduction regime. This session will focus on recent marine and land investigations, from Mexico to Alaska, that have provided new constraints on the processes that have formed and modified this diverse and complex continental margin. POSTER.
Geophysics/Tectonophysics (10), Marine Geology (14), Tectonics (31).

T55. **Late Mesozoic Basins in the North American Cordillera: Constraints on Terrane Accretion and Translation.**
Sedimentary Geology Division. J. Brian Mahoney, University of British Columbia; John Garver, Union College, Schenectady, New York; Ralph Haugerud, U.S. Geological Survey, University of Washington.

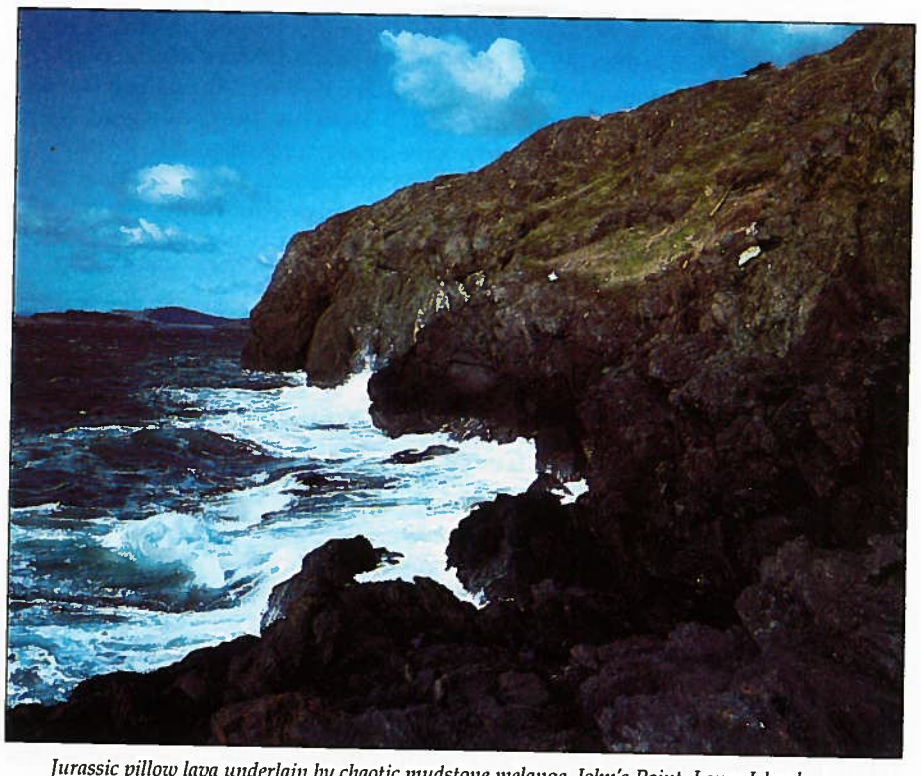
The paleogeographic setting of Jurassic and Cretaceous basins in the North American Cordillera and the limits thus placed on terrane amalgamation and latitudinal translation are particularly important because of conflicting views of the tectonic evolution of the Cordillera. This theme session will focus on the paleogeography, provenance, tectonic setting, and stratigraphic correlation of Jurassic and Cretaceous basins in the North American Cordillera, and their bearing on the location and timing of terrane accretion and magnitude of subsequent translation. Especially important are the paleogeographic relations, if any, between outboard basins of the northern Cordillera, outboard basins of the southern Cordillera, and the North American craton. ORAL.
Sediments, Clastic (28), Stratigraphy (29), Tectonics (31).

T56. **Geology of the Coast Ranges of Oregon and Washington: New Discoveries.**
Richard J. Stewart, University of Washington.

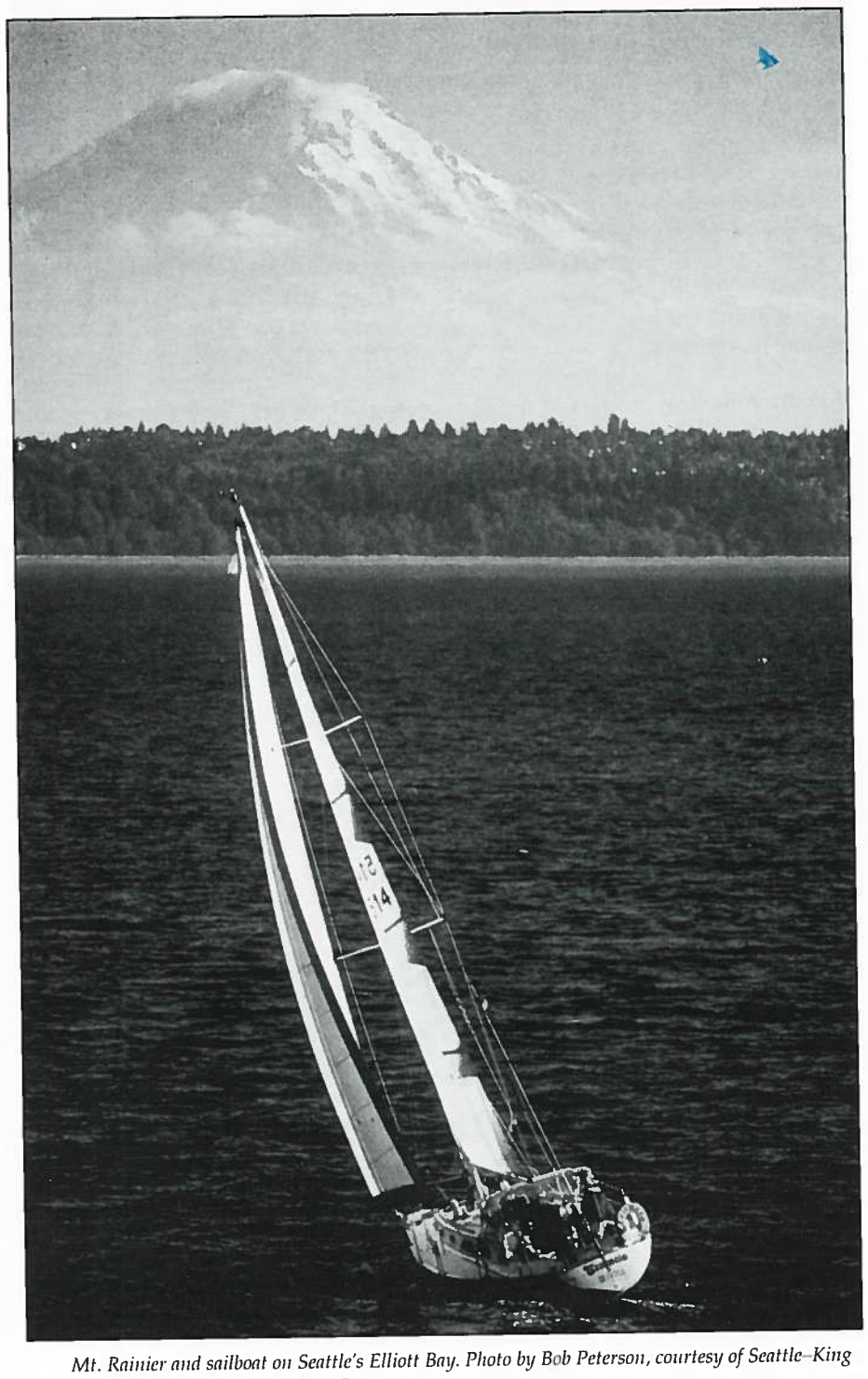
This theme session will focus on the latest developments in the geology of Tertiary-age rocks in the Coast Ranges of Oregon and Washington, and adjacent parts of northern California, western British Columbia, and southern Alaska. The geology of early Tertiary rocks in this region is dominated by the interactions of allochthonous terranes, whereas younger Tertiary rocks record deposition in several basins, the uplifted and eroded parts of which are now exposed on this segment of the Pacific Rim. Papers that incorporate the best and most recent data on terrane interactions, biostratigraphy, paleomagnetism, and radiometric dating are specifically encouraged. ORAL.
Stratigraphy (29), Structural Geology (30), Tectonics (31).

T57. **Birth and Life of an Island Arc at a Leading Edge—The Geologic Development of Japan.**
International and *Structural Geology and Tectonics Divisions*. Tim Byrne, University of Connecticut; Asahiko Taira, University of Tokyo.

Island arcs, and convergent plate boundaries in general, represent one of the most tectonically active environments on Earth. The Japanese island arc is no



Jurassic pillow lava underlain by chaotic mudstone melange, John's Point, Lopez Island, Washington. Photo by Darrel S. Cowan.



Mt. Rainier and sailboat on Seattle's Elliott Bay. Photo by Bob Peterson, courtesy of Seattle–King County Convention and Visitors Bureau.

exception, and during the last few decades this plate boundary has been studied extensively by many scientists, including Japanese, French, American, Australian, and British geologists. As a result, the Japanese islands arguably represent one of the best studied convergent plate boundaries in the world. In this session we welcome contributions that will both broaden the base of general knowledge about the Japanese "leading edge" and, at the same time, provide an integrated framework for more detailed studies of convergent plate boundaries. ORAL.
Marine Geology (14), Tectonics (31), Volcanology (32).

T58. **Active Arc-Continent Collision in Taiwan.**
Structural Geology and Tectonics Division. Neil Lundberg, Florida State University; Louis Teng, National Taiwan University; Donald Fisher, Pennsylvania State University; Jean Crespi, University of Connecticut.

The Luzon island arc is actively accreting to the Asian passive continental margin, building the island of Taiwan as an active fold-and-thrust belt. This session will present results of current research on this active convergent system, which has been used to exemplify collisional processes and to inspire models of mountain building. We welcome contributions from field-based, analytical, and/or modeling investigations that provide new information on processes operating in the Taiwan subduction-collision system. ORAL.
Geophysics/Tectonophysics (10), Structural Geology (30), Tectonics (31).

T59. **Geologic Evolution of the Tian Shan Orogenic System, Central Asia.**
Stephan Graham, Stanford University; An Yin, University of California, Los Angeles.

The Tian Shan orogenic system, stretching 2500 km across Asia, originated as a Paleozoic accretionary fold belt, yet Himalayan deformation has produced topographic relief of 7 km within the Tian Shan during the Cenozoic, despite its position in the center of Asia. This theme session explores recent advances in understanding the evolution of this complex orogenic belt. ORAL.
Geophysics/Tectonophysics (10), Structural Geology (30), Tectonics (31).

T60. **Rheological and Structural Evolution of Contractional Orogenic Belts.**
Phyllis Camilleri, University of Wyoming.

This theme session will focus on theoretical to field-oriented studies on (1) the origin and implications of fabrics and small-scale structures developed within active thrust sheets, (2) metamorphic processes within thrust sheets, (3) flexure of footwalls to thick thrust sheets, and (4) rheological models of contractional orogenic belts. ORAL.
Petrology, Metamorphic (22), Structural Geology (30), Tectonics (31).

T61. **Dating Deformation.**
William J. Dunlap, University of California, Los Angeles; Jerry F. MacLoughlin, University of Michigan.

The application of geochronometers to deformed rocks has demonstrated the potential for the direct dating of deformational events and structural features. We welcome contributions pertaining to all aspects of the dating of deformational events; dating structures such as shear zones, faults, and foliations; and experimental studies on the effect of deformation on isotopic systems. ORAL.
Geochemistry, Other (8), Structural Geology (30), Tectonics (31).

T62. **Precambrian and Phanerozoic Terrane Accretion: Contrasts and Similarities.**
Kent C. Condie, New Mexico Institute of Mining and Technology; Peter J. Coney, University of Arizona.

Terrane accretion has been recognized for some time as an important mechanism in the growth of Phanerozoic continental crust. In recent years it also has been suggested that terrane accretion was important in the Precambrian. To more fully understand continental growth and evolution, it is important to see if Phanerozoic-style terrane accretion occurred in the Proterozoic and the Archean. To do this, it is critical that discussion occur between the Phanerozoic and Precambrian "terrane" groups, particularly if we hope to identify real changes in terrane accretion with time. ORAL.
Precambrian Geology (24), Tectonics (31).

T63. **Precambrian Orogens: Tectonic Setting and Crustal Architecture.**
Ben A. van der Pluijm, University of Michigan; Timothy M. Kusky, Boston University.

Preserved lithotectonic assemblages and the crustal architecture of Precambrian orogens are indicative of Precambrian tectonic style. This theme session will address such topics as structural and temporal evolution, P-T-t paths, paleogeography, ophiolites, and other characteristics of Precambrian orogens worldwide, and their possible contrasts with modern belts. ORAL.
Precambrian Geology (24), Structural Geology (30), Tectonics (31).

T64. **Relations Between Diagenesis and Deformation.**
Sedimentary Geology Division. Richard Behl, University of California, Santa Barbara.

Sediments undergo postdepositional changes in fabric, composition, mineralogy, cementation, and pore-water chemistry which modify the style and thresholds of tectonic and burial deformation. In turn, deformation can influence the rates and pathways of diagenesis by modifying porosity, permeability, and grain-to-grain stresses. These interrelations span a range of scales from stylolites to septarian concretions, from brecciated cherts to accretionary complexes. POSTER.
Sediments, Carbonates (27), Sediments, Clastic (28), Structural Geology (30).

T65. **Perspectives on Desert Surface Processes.**
Planetary Geology Division. Ted A. Maxwell, National Air and Space Museum, Smithsonian Institution; Leslie M. McFadden, University of New Mexico.

Over the past decade our understanding of desert surfaces has been advanced from orbital information, new dating techniques, and new interpretations of the physical and chemical processes that make up desert pavements and varnish. This theme session is designed to combine research results that involve both remote sensing and ground-based studies on the origin and evolution of desert surfaces. Contributions are solicited that deal with sediment transport, deposition, and soil development; dating as applied to arid region sediments, near-surface chemistry, and extraterrestrial arid land processes. In addition, papers on the use of arid region vegetation to understand the underlying geology are encouraged. ORAL.
Planetary Geology (23), Remote Sensing (26), Sediments, Clastic (28).

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

T66. **Cenozoic Sequences on Passive Margins: A Triad of Processes.**
Sedimentary Geology Division. Kenneth G. Miller, Rutgers, The [New - Jersey] State University; Gregory S. Mountain, Lamont-Doherty Earth Observatory.

Recognition of stratal surfaces provide an objective means of dividing the stratigraphic record into sequences (bounded by unconformities) and parasequences (bounded by flooding surfaces). A triad of processes controls the development of sequences and parasequences: sea-level change, tectonics, and climate change (particularly as it affects sediment supply). This theme session will focus on the timing and development of Cenozoic sequences and parasequences. We invite papers on any passive margin or epicontinental sea that address the interaction of these three processes in developing the stratigraphic record. ORAL.
Marine Geology (14), Paleoceanography/Paleoclimatology (17), Stratigraphy (29).

T67. **West Coast Salt Marshes: Stratigraphy, Sea-Level Change, and Seismic Events.**
Roger Byrne, University of California, Berkeley; Scott W. Starratt, U.S. Geological Survey, Menlo Park.

Recent detailed sedimentological and micropaleontological studies of coastal salt-marsh deposits have demonstrated enormous potential for understanding both gradual and geologically instantaneous changes in late Holocene sea level. Methods tested in coastal salt-marsh deposits on passive margins have recently been applied to salt-marsh deposits on the West Coast of North America with varying degrees of success. This theme session will focus on the use of micropaleontology and stratigraphy in unraveling the complex interaction between eustatic changes and local tectonic events in salt-marsh deposits. ORAL. Environmental Geology (6), Quaternary Geology/Geomorphology (25), Stratigraphy (29).

T68. **Evolution on the Atlantic Coastal Plain—Sedimentology, Stratigraphy, and Hydrogeology.**
Marylin P. Segall, University of South Carolina.

Mesozoic to Cenozoic evolution of the Atlantic coastal plain has resulted in a thick sequence of fluvial, marginal marine, and marine deposits. Each unit is characterized by unique physical characteristics that were either inherited at the time of deposition or modified by postdepositional processes. The goals of this multidisciplinary session are to (1) relate the evolution of the southeastern Atlantic coastal plain to globally observed phenomena; (2) define the various depositional sequences as they relate to modern land usage (water supply, nuclear waste disposal, engineering properties and hazards); and (3) delineate innovative technologies that can be used to address old problems. ORAL. Environmental Geology (6), Sediments, Clastic (28), Stratigraphy (29).

FIELD TRIPS

Seattle at the leading edge

The Pacific Northwest offers a magnificent opportunity to study a wide variety of geologic settings, processes, and problems: far-traveled terranes and their deformation, active subduction tectonics and arc volcanoes, deposits of colossal floods and huge flood-basalt flows, forest geomorphology (part of the politically hot old-growth issue), forearc sedimentation, radioactive waste hydrogeology, and many more. The field trip program is designed to take advantage of this diversity, covering ground from southwest Idaho to Honolulu and into southern British Columbia but focusing on Washington and northern Oregon. Come join one or more of these excursions to see how much has been learned since GSA last met in Seattle 17 years ago.

Trips start and end in Seattle unless otherwise indicated. With lower airfares on Saturday night stayover flights, you can pay for a pre- or postmeeting field trip with the savings!

The trips are led by active researchers and are technical in nature, although students are strongly encouraged to attend. Some will require moderate walks or climbs, and others have specific requirements noted below. Always bring rain gear and cool weather garments to enjoy Pacific Northwest weather! Please check with the trip leader if you have any questions.

Trip costs are subject to change before registration begins in June, but they are not expected to change significantly. If you register for only a field trip, you must pay a $25 nonregistrant fee in addition to the field trip fee. This fee may be applied toward meeting registration if you decide to attend the meeting.

For further information, contact the individual trip leader or the 1994 Field Trip Chair, Don Swanson, U.S. Geological Survey, c/o Dept. of Geological Sciences, AJ-20, University of Washington, Seattle, WA 98195, (206) 553-5587 (both voice and fax), E-mail: donswan@geology.washington.edu, or Co-chair, Ralph Haugerud, at the same address, (206) 553-5542 (voice), 206-553-8350 (fax), E-mail: rah@geology.washington.edu.

Premeeting

Island and Coastal Hydrogeology of Hawaii.
October 17 (evening)–21. Clifford Voss, U.S. Geological Survey, 431 National Center, Reston, VA 22092, (703) 648-5885, and Frank Peterson. Trip starts in Hilo and ends in Honolulu, with one free day (October 22) before flying to Seattle. Trip will visit active volcanoes on the island of Hawaii and underground water tunnels on Oahu. Cost: $500, exclusive of airfare to and from Hawaii. **Note: Due to hotel reservation deadlines, those interested in this trip must sign up and submit a $50 deposit to GSA by April 29, 1994. Contact Becky Martin at GSA, (303) 447-2020, for further information or to make a reservation.**

Geomorphology and Stratigraphy of the Great Last-Glacial Missoula Floods in Central Washington and the Columbia River Gorge.
October 18 (evening)–23. Richard B. Waitt, U.S. Geological Survey, 5400 MacArthur Blvd., Vancouver, WA 98661, (206) 696-7558, and Jim O'Connor. Trip starts in Portland and ends in Seattle. Cost: $400.

Late Cretaceous and Early Tertiary Orogeny in the North Cascades.
October 19 (late afternoon)–23. Ralph Haugerud, U.S. Geological Survey, Dept. of Geological Sciences, AJ-20, University of Washington, Seattle, WA 98195, (206) 553-5542, and E. H. Brown, Bryan Kriens, Michael McGroder, and Rowland Tabor. Cost: $420.

Volcanic, Sedimentary, and Structural Evolution of the Oregon-Idaho Graben, Southeast Oregon and Southwest Idaho.
October 20–23. Michael Cummings, Dept. of Geology, Portland State University, P.O. Box 751, Portland, OR 97207-0751, (503) 725-3022, and Jim Evans and Mark Ferns. Trip starts in Boise, Idaho and ends in Seattle. Cost: $350.

Sedimentary, Volcanic, and Tectonic Framework of Tertiary Marine Forearc Basins and the Mist Gas Field, Northwest Oregon.
October 20–23. Alan R. Niem, Dept. of Geosciences, Oregon State University, Corvallis, OR 97331-5506, (503) 737-1233, and Brian McKnight and H. Jack Meyer. Cost: $340.

Quaternary Stratigraphy, Soils, and Neotectonics of the Western Olympic Peninsula.
October 21–23. Frank Pazzaglia, Dept. of Geology and Geophysics, Yale University, P.O. Box 6666, New Haven, CT 06511, (203) 432-3155, and Glenn Thackray. Cost: $220.

Pluton Emplacement During Cretaceous Mid-Crustal Contraction: Mount Stuart Batholith, North Cascades.
October 21–23. Robert B. Miller, Dept. of Geology, San Jose State University, San Jose, CA 95192-0102, (408) 924-5025, and Scott Paterson and Lawford Anderson. Cost: $260.

Vents and Basalt Flows of the Columbia River Basalt Group.
October 21–23. Stephen P. Reidel, Geosciences, Westinghouse Hanford Company, MSIN H6-06, P.O. Box 1970, Richland, WA 99352, (509) 376-9932, and Terry L. Tolan and Melvin H. Beeson. Trip starts in Pasco, Washington and ends in Seattle. Cost: $260.

Sequence Stratigraphy of the Eocene-Oligocene Transition: Examples from the Nonmarine, Volcanically Influenced John Day Basin.
October 21–23. Erick A. Bestland, Dept. of Geological Sciences, University of Oregon, Eugene, OR 97403, (503) 345-3470, and Gregory J. Retallack. Trip starts in Portland and ends in Seattle. Cost: $250.

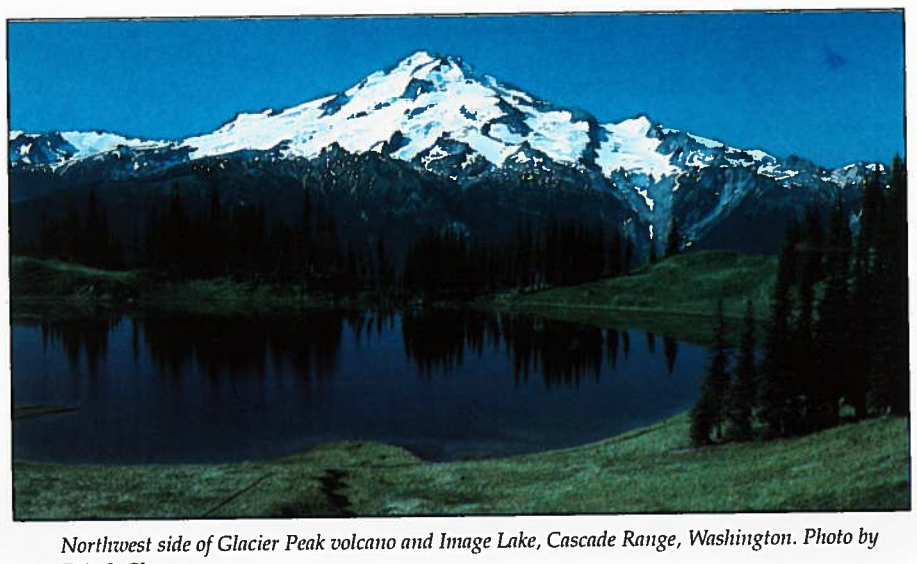
Earth, Water, Trees, and Fish: Geomorphology and Land-Use Problems in the Forested Mountains of the Pacific Northwest.
October 21–23. Matthew J. Brunengo, Washington Dept. of Natural Resources, Division of Geology, P.O. Box 47007, Olympia, WA 98504-7007, (206) 902-1433. Cost: $260.

Tectonostratigraphy of the Crescent Terrane and Related Rocks, Olympic Peninsula, Northwest Washington.
October 21–23. Scott Babcock, Dept. of Geology, Western Washington University, Bellingham, WA 98225, (206) 650-3592, and Dave Engebretson. Cost: $260.

Mid-Tertiary Volcanism East of Mount Rainier: Fifes Peaks Volcano-Caldera and Bumping Lake Pluton–Mount Aix Caldera.
October 22–23. Paul E. Hammond, Dept. of Geology, Portland State University, P.O. Box 751, Portland, OR 97207-0751, (503) 725-3387, and Keith A. Brunstad and John F. King. Some rugged walking with loose footing in wilderness areas. Cost: $160.

Mount Rainier, a Decade Volcano.
October 22–23. Patrick Pringle, Washington Dept. of Natural Resources, Division of Geology, P.O. Box 47007, Olympia, WA 98504-7007, (206) 902-1433. Cost: $180.

Low-tide outcrop along Columbia River east of Astoria, Oregon, with evidence for earthquake-induced subsidence about 300 years ago. Photo by Roger Lewis.



Northwest side of Glacier Peak volcano and Image Lake, Cascade Range, Washington. Photo by Eric S. Cheney.

Holocene Tectonics in Western Washington.
October 22–23. Robert C. Bucknam, U.S. Geological Survey, Denver Federal Center, Box 25046, Denver, CO 80225, (303) 273-8566, and Brian F. Atwater. Rainsuits and hip waders required (inexpensive stocking-foot waders will suffice); canoes will be used for part of the trip. Cost: $140.

Tertiary Coals of Western Washington.
October 22–23. Michael Brownfield, U.S. Geological Survey, Denver Federal Center, Box 25046, Denver, CO 80225, (303) 236-7767, and Ronald Affolter, Samuel Johnson, and Romeo Flores. Hard hat, steel-toed boots, and safety glasses required if participants want to leave mine bus while in coal mines. Cost: $160.

Geoarcheology of Sites on San Juan Island, Washington.
October 22. Julie K. Stein, Burke Museum DB-10, University of Washington, Seattle, WA 98195, (206) 685-2282. Cost: $80.

Postmeeting

Geology and Tectonic Evolution of the Southern Coast Belt, B.C.
October 27 (evening)–29. James W. H. Monger, Cordilleran Division, Geological Survey of Canada, 100 West Pender, Vancouver, B.C. V6B 1R8, Canada, (604) 666-6743, and J. Murray Journeay. Trip ends in Vancouver, British Columbia. Papers required for border crossing. Cost: $225.

The 1980 (Mostly) and Earlier Explosive Eruptions of Mount St. Helens Volcano.
October 27 (evening)–30. Richard B. Waitt, U.S. Geological Survey, 5400 MacArthur Blvd., Vancouver, WA 98661, (206) 696-7558. Trip ends in Portland. Cost: $300.

Geologic Transect Across the Tertiary Cascade Volcanic Arc, Southern Washington.
October 27 (evening)–30. Donald A. Swanson, U.S. Geological Survey, Dept. of Geological Sciences, AJ-20, University of Washington, Seattle, WA 98195, (206) 553-5587, and Russell C. Evarts. Cost: $300.

Geology of Seattle and Vicinity.
October 28–29. Richard W. Galster, Consulting Engineering Geologist, P.O. Box 908, Edmonds, WA 98020, (206) 542-2596, and William T. Laprade. Cost: $50 (exclusive of overnight expenses in Seattle).

Fault-Zone Structures and Solution–Mass-Transfer Cleavage in Late Cretaceous Nappes, San Juan Islands.
October 28–29. Darrel S. Cowan, Dept. of Geological Sciences, AJ-20, University of Washington, Seattle, WA 98195, (206) 543-4033, and Mark Brandon and Jeffrey Feehan. Cost: $180.

Paleogene Cold Seeps and Macroinvertebrate Faunas in Forearc Sequences of Oregon and Washington.
October 28–29. Elizabeth Nesbitt, Geology Dept., Thomas Burke Memorial Museum, University of Washington, Seattle, WA 98195, (206) 543-1856 or 6776, and Kathleen Campbell and James Goedert. Cost: $170.

Geohydrologic Setting of the Hanford Site, South-Central Washington.
October 28–29. Kevin A. Lindsey, Geosciences, Westinghouse Hanford Company, MSIN H6-06, P.O. Box 1970, Richland, WA 99352, (509) 376-9932, and Stephen P. Reidel, K. R. Fecht, Janet L. Slate, A. G. Law, Ann M. Tallman, and Jon Lindberg. U.S. citizenship required. Trip ends in Richland, Washington, with easy access to Tri-Cities airport in Pasco. Cost: $160.

Migmatites to Fault Gouge: Fault Rocks and the Structural and Tectonic Evolution of the Nason Terrane, North Cascade Mountains.
October 28–29. Jerry F. Magloughlin, Dept. of Geological Sciences, 1006 C.C. Little Building, University of Michigan, Ann Arbor, MI 48109-1063, (313) 764-1435. Cost: $160.

Pleistocene Geology of the Puget Lowland.
October 28–30. Don J. Easterbrook, Dept. of Geology, Western Washington University, Bellingham, WA 98225, (206) 650-3583, and Derek Booth and David Dethier. Cost: $260.

Character of Landslides in Western Washington and Oregon.
October 28–30. Tom Kuper, David J. Newton Associates, Suite 400, 1201 S.W. 12th Avenue, Portland, OR 97205, (503) 228-7718, and Scott Burns, Dorian Kuper, and Anne MacDonald. Cost: $260.

Chelan Migmatite Complex.
October 28–30. Clifford A. Hopson, Dept. of Geological Sciences, University of California, Santa Barbara, CA 93106-2314, (805) 961-3471, and Jim Mattinson. Cost: $220.

Sponsored by Society of Economic Geologists

For information contact the trip leader or the SEG field trip chairman, A. James Macdonald, MDRU, Dept. of Geological Sciences, University of British Columbia, 6339 Stores Road, Vancouver, B.C. V6T 1Z4, Canada, (604) 822-4563. Costs are tentative and reflect differential in SEG member/nonmember rates.

Gold Deposits of the Republic Graben, Washington.
October 20–23. Byron R. Berger, U.S. Geological Survey, MS 973, Box 25046, Federal Center, Denver, CO 80225, (303) 236-5533. Trip begins and ends in Spokane, Washington. Cost: $275/$300.

Highland Valley Porphyry Ore Deposits, B.C.
October 21–23. William McMillan, Geological Survey Branch, Ministry of Energy, Mines, & Petroleum Resources, Fifth Floor, 1810 Blanshard St., Victoria, B.C. V8V 1X4, Canada, (604) 952-0444, and Clifford Stanley, MDRU/UBC, Vancouver. Trip begins and ends in Vancouver, British Columbia. Cost: $200/$225.

Cannon Epithermal Au-Ag Mine, Wenatchee, Washington.
October 28–29. Jacob Margolis, Homestake Mining Company, 1375 Greg Street, Sparks, NV 89431, (702) 358-5609, and D. Cameron, Asamera, Wenatchee. Cost: $155/$175.

Mineral Deposits of Vancouver Island, B.C.
October 28–November 1. Colin I. Godwin, MDRU, Dept. of Geological Sciences, University of British Columbia, 6339 Stores Road, Vancouver, B.C. V6T 1Z4, Canada, (604) 822-2804, and Andre Panteleyev, GSB-MEMPR, Victoria. Cost: $985/$1000.

GSA Continuing Education Notes For Sale

Limited supplies of the following short-course manuals or notes remain available from the Cincinnati and Boston Annual Meetings. These may be ordered, while supplies last, through GSA Publication Sales 1-800-472-1988.

1993

SCN020: *GIS and the Geosciences*, by Richard L. Bedell, Jr. ..... $16.50 net

SCN021: *Asia: A Continent Built and Assembled Over the Past 500 Million Years*, by Kevin Burke and A. M. Celal Şengör ..... $27.75 net

SCN022: *Contaminant Hydrogeology: Practical Monitoring, Protection, and Cleanup*, by Christopher M. Palmer and Jeffrey L. Peterson ..... $27.75 net

SCN023: *Fracture Mechanics of Rock*, by Terry Engelder, Michael R. Gross, and Mark P. Fischer ..... $22.75 net

SCN024: *Alternative Pedagogies in Geological Sciences: A Workshop*, by Ann Bykerk-Kauffman, Lauret E. Savoy, and Jill Schneiderman ..... $13.50 net

SCN025: *Application of Sedimentological Information to Hydrogeological Problems*, by Erik K. Webb ..... $11.50 net

SCN026: *Computer Mapping at Your Desk that Really Works*, by Russell A. Ambroziak, Grant R. Woodwell, and Renee E. Wicks ..... $16.50 net

SCN027: *Environmental/Engineering Geology and Land-Use Planning—An Interface Between Science and Regulations*, by Charles W. Welby, Jerome V. DeGraff, and Rhea L. Graham ..... $16.50 net

Prices include shipping and handling; GSA Member discount does NOT apply on 1993 editions. Prepayment is required (check, major credit card, or money order in U.S. funds on U.S. bank).

1992

SCN002: *Paleosols for Sedimentologists*, by Greg H. Mack and Calvin James, 1992 ..... $18.75

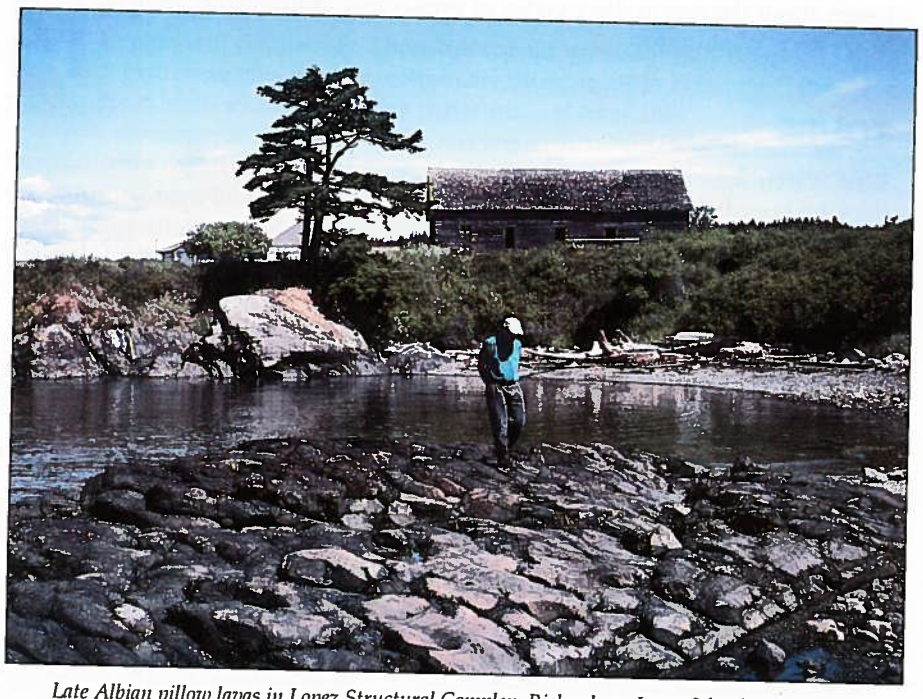
SCN004: *Phase I Preliminary Site Assessments*, by Jeffrey L. Peterson, 1992 ..... $18.75

Prices include shipping and handling; GSA Members deduct member discount. Prepayment is required (check, major credit card, or money order in U.S. funds on U.S. bank).

GSA-Sponsored Continuing Education Courses

Registration information and course descriptions will be published in the *June* issue of *GSA Today*. For additional information contact Edna Collis, Continuing Education Coordinator, GSA headquarters.

Fees will be approximately $150–$175 for the first day and $125–$150 for the second day. If you register for a GSA course only, you must pay a $25 non-registrant fee in addition to the course fee. This fee may be applied toward meeting registration if you decide to attend the meeting. Students will receive a $20 discount on all GSA courses.



Late Albian pillow lavas in Lopez Structural Complex, Richardson, Lopez Island, Washington. Photo by Martin G. Miller.

Tax Deduction: Expenses for continuing professional education (including registration fees, travel, lodging, and meals) undertaken to maintain and improve professional skills are generally tax deductible in whole or in part (Treas. Reg. 1-162-5, Coughlin vs. Commissioner, 203F2d307). Please discuss this directly with a qualified accountant.

Computer-aided Plate Tectonic Modeling Techniques.
October 22–23. Cosponsored by the *Structural Geology and Tectonics Division*. Christopher R. Scotese, University of Texas, Arlington; Malcolm I. Ross, Rice University.

GPS Geodesy and Active Tectonics.
October 22–23. Cosponsored by the *Structural Geology and Tectonics Division*. Michael Bevis, North Carolina State University; Charles Meertens, University Navstar Consortium (UNAVCO).

Phase I Environmental Site Assessments.
October 22–23. Cosponsored by the *Engineering Geology Division*. Raymond C. Kimbrough, Tom Joiner & Associates, Inc.; David R. Gillespie, Desert Research Institute.

Quantitative Sedimentary Basin Modeling.
October 22–23. Cosponsored by the *Sedimentary Geology Division*. Paul L. Heller, University of Wyoming; Chris Paola, University of Minnesota.

Soil and Ground-water Remediation.
October 22–23. Cosponsored by the *Engineering Geology Division*. Jeffrey L. Peterson and Diane M. Lundquist, Enviros, Inc., Sonoma, California.

Applied Ground-water Flow Modeling: Conceptualizing Hydrogeologic Systems and Calibrating Models.
October 23. Cosponsored by the *Hydrogeology Division*. William W. Woessner, University of Montana; Mary P. Anderson, University of Wisconsin.

Computer Applications in Undergraduate Geoscience Courses.
October 23. Cosponsored by the *Geoscience Education Division*. Dorothy L. Stout, Cypress College; Philip Sandberg, University of Illinois.

Computer Mapping at Your Desk That Really Works.
October 23. Grant R. Woodwell, Mary Washington College, Fredericksburg, Virginia; Russell A. Ambroziak and Christine A. Cook, U.S. Geological Survey, Reston.

GIS and the Geosciences.
October 23. Richard L. Bedell, Jr., Homestake Mining Company, Sparks, Nevada.

Geology in Cultural Resource Management.
October 23. Cosponsored by the *Archaeological Geology Division*. E. Arthur Bettis III, Iowa Department of Natural Resources, Geological Survey Bureau; Edwin R. Hajic, Illinois State Museum.

Geomorphic Applications of In Situ–Produced Cosmogenic Isotopes.
October 23. Cosponsored by the *Quaternary Geology and Geomorphology Division*. Paul R. Bierman, University of Vermont; Alan R. Gillespie, University of Washington.

Isotope Hydrology.
October 23. Cosponsored by the *Hydrogeology Division*. Carol Kendall, U.S. Geological Survey, Menlo Park; Neil L. Ingraham, University of Nevada, Las Vegas.

Recognition, Investigation, and Mitigation of Landslides.
October 23. Cosponsored by the *Engineering Geology Division*. Martin L. Stout, California State University, Los Angeles; William R. Cotton, William R. Cotton & Associates, Inc., Los Gatos, California; Michael W. Hart, Consultant, San Diego, California.

Teaching Introductory Earth Systems for Non–Science Majors: An Interactive Approach.
October 23. Cosponsored by the *Geoscience Education Division* and *National Association of Geology Teachers*. Fred N. Finley and V. Rama Murthy, University of Minnesota.

Techniques for Analysis of Rock and Soil Slope Stability.
October 23. Cosponsored by the *Engineering Geology Division*. Chester F. Watts and Robert C. Whisonant, Radford University.

Other Courses and Workshops

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

Writing, Editing, and Referencing Technical Articles.
October 22. Sponsored by the *Geoscience Information Society*, *American Geological Institute*, and *Association of Earth Science Editors*. For information: Julia Jackson, AGI, 4200 King Street, Alexandria, VA 22302, (703) 379-2480, fax 703-379-7563.

Silica: Physical Behavior, Geochemistry, and Materials Applications.
October 22–23. Sponsored by the *Mineralogical Society of America*. For information: MSA Business Office, 1130 Seventeenth Street, N.W., Suite 330, Washington, DC 20036, (202) 775-4344, fax 202-775-0018.

Major Features of Vertebrate Evolution.
October 23, 8:15 a.m. to 5:00 p.m. Sponsored by the *Paleontological Society* and *Society of Vertebrate Paleontology*. For information: Don Prothero, Dept. of Geology, Occidental College, Los Angeles, CA 90041, (213) 259-2557; Robert Schoch, Division of Science, Boston College, 871 Commonwealth Ave., Boston, MA 02215, (617) 353-2886.

GeoRef with Windows Workshop.
October 23, 1:00 to 2:45 p.m. Sponsored by the *Geoscience Information Society*. For information: Marilyn Stark, U.S. Geological Survey Library, MS 914, Box 25046, Denver, CO 80225, (303) 236-1004.

Job Hunting and Career Development Skills for Geoscientists.
October 23, 1:00 to 5:00 p.m. Sponsored by the *Association for Women Geoscientists*. For information: Leuren Moret, 962 South G Street, Livermore, CA 94550, (510) 449-7351.

DataBase Forum.
October 23, 3:00 to 5:00 p.m. Sponsored by the *Geoscience Information Society*. For information: Kimberly Parker, Kline Science Library, Yale University, 219 Prospect St., P.O. Box 208111, New Haven, CT 06511-8111, (203) 432-3443.

Preparing Successful Grant Proposals to Fund Curriculum Innovation in the Geosciences.
October 25, 1:30 to 5:00 p.m. Sponsored by the *National Association of Geology Teachers* and *National Science Foundation*. For information: Judith L. Hannah, Dept. of Geology, University of Vermont, Burlington, VT 05405-0122, (802) 656-0245.

SPECIAL PROGRAMS

Seattle at the leading edge

Graduate School Information Forum

The forum will take place at the Washington State Convention and Trade Center in three sessions from 9:00 a.m. to 5:00 p.m., Monday, October 24, through Wednesday, October 26.

This forum provides a unique opportunity for undergraduate students planning on getting an advanced degree to meet with representatives of graduate schools in an informal setting to discuss interests and explore programs. A list of participating schools will appear in the June and September issues of *GSA Today*.

This year's forum will take place between the poster area and the exhibit hall. Each school will be given use of a 4' x 8' poster board, a table, and four chairs. If your school is interested in participating, contact Matt Ball, GSA headquarters.

Employment Service

GSA will again be offering its Employment Interview Service. Each year, this program provides valuable job-matching opportunities in the geosciences. At last year's meeting in Boston, participating employers conducted nearly 400 interviews with 200 applicants seeking employment!

As in the past, booths will be provided for employers to interview applicants registered with the Employment Service, and GSA staff will be on hand to coordinate the scheduling of interviews. In particular, students completing doctoral and master's theses during 1994 are encouraged to check the job offerings.

See the February issue of *GSA Today* for applicant and employer forms and further information, or contact T. Michael Moreland, Employment Service Manager, GSA headquarters.

Washington State Ferry on Puget Sound. Photo by Bob Peterson, courtesy of Seattle–King County Convention and Visitors Bureau.

Guest Program

Seattle lies on Puget Sound in a spectacular setting between the Olympic and Cascade Mountain Ranges. The city experienced its first economic boom during the Alaska Gold Rush and has since grown into a major northwest port and commercial center, the home of Boeing, Microsoft, and the University of Washington. Within walking distance of the Convention Center, its compact downtown offers sightseeing and cultural opportunities. Highlights include the waterfront, historic district, museums, shops, restaurants, and endless outdoor activities. October's blend of autumnal sun and mild rain make this one of the most beautiful months of the year. Seattle has many rewards for its visitors.

Guests are invited to visit the GSA Hospitality Room in the Sheraton Hotel. Your hosts will be providing a resource center to help you explore *your* interests. Abundant information on Seattle and surrounding areas will be available, as well as details on GSA tours and seminars. Join us for a special reception to welcome you early in the week.

SEMINARS

Welcome to Seattle
Start the week with an insightful introduction to Seattle, from recommended art galleries to insiders' tips on shopping. Learn about the tours and seminars GSA has planned for you.

Old Growth Forest
Understand the conflict between environmental preservation and the logging industry in the Pacific Northwest.

Changes in the Family and Its Social Impact on Life in America
As family structure changes, explore its unavoidable impact on everyday life and how you can best meet the personal challenges.

Earthquakes and Faults of the Pacific Northwest
Learn about the recent discoveries of prehistoric faulting and seismic activity in western Washington.

TOURS

Bird Watching
Back by popular demand, this full-day birding tour of the Puget Sound area will give avid bird watchers a chance to add western species to their "life list."

Victoria Day Tour
Visit the provincial capital of British Columbia, Canada, famed for its Victorian architecture, English flavor, superb anthropological museum, and beautiful protected harbor. Transportation is by the *Victoria Clipper* jet-propelled catamaran.

Seattle City Highlights
This tour will touch briefly on Seattle's most interesting highlights, beginning with historic Pioneer Square, and will include the International District, the University of Washington, the Government Locks, and residential areas. The tour will end with the famous Pike Place Market.

Snoqualmie Falls, Boehm's Candy, Gilman Village
View Snoqualmie Falls as it cascades 268 feet to the canyon below, watch locally famous candy making, and browse through the unique specialty shops at Gilman Village.

Locks and Seattle Harbor
Sailing through the Hiram Chittenden Locks built early in the century, you will learn about the area history and marine activity. If the weather cooperates, plan on enjoying the spectacular scenery surrounding Puget Sound.

Northwest Winery Tour with Lunch at Columbia Winery
Learn about award-winning Northwest wines while visiting two popular wineries—Chateau Ste. Michelle and Columbia. Both tours include tastings of their renowned wines.

INFORMAL TOURS

A city with so much to offer makes tour choices tough! Additional places you might want to visit informally with other guests include Pike Place Market, Pioneer Square, Blake Island State Park/Tillicum Village, Seattle Aquarium, Rainier Brewery, Pacific Science Center, Ye Olde Curiosity Shop & Museum, Boeing Museum of Flight, Bainbridge Ferry, Space Needle, or The Underground.

Evening Highlights

Spirit of Washington Dinner Train with Winery Tour and Tasting
Saturday, October 22

Seattle Repertory Theater and Dinner
Saturday, October 22

Welcoming Party
Sunday, October 23

GSA Presidential Address and Awards Ceremony
Monday, October 24

Alumni Receptions
Monday, October 24

Ferry Ride to Kiana Lodge Salmon Bake
Wednesday, October 26

REGISTRATION

Registration materials available in June GSA Today! The June issue will be the only complete registration issue.

Preregistration Deadline: September 16, 1994

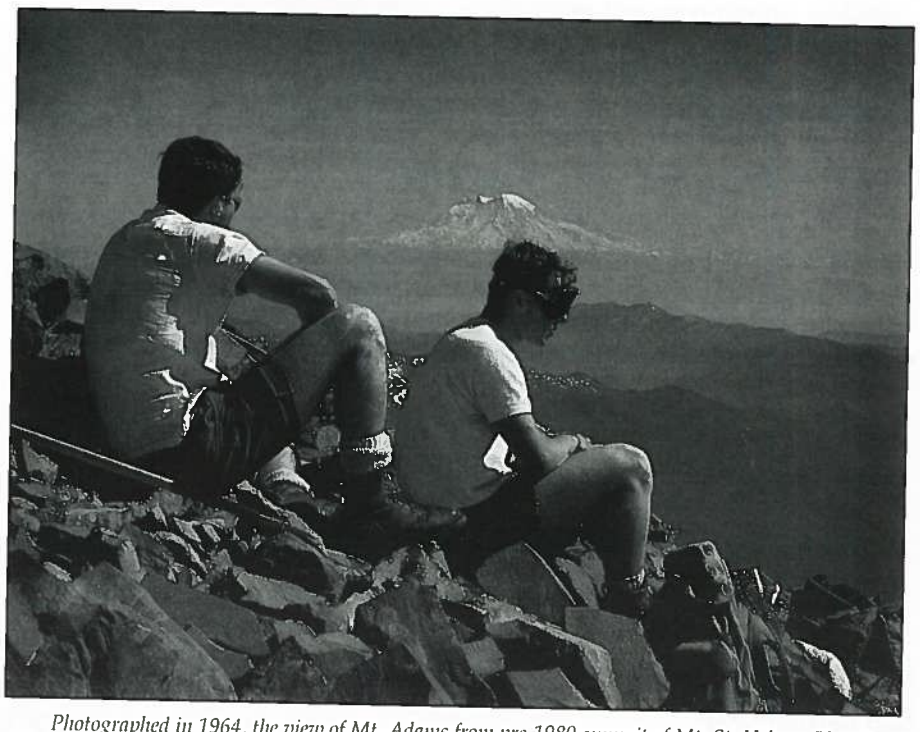
Cancellation Deadline: September 23, 1994

Make plans now to take advantage of the **June** registration opportunity! Events will fill quickly. There are considerable savings on meeting registration fees if you register early. Registration is required for participation in all events. One-day registration is available.

GSA members will automatically receive registration information and forms during the first weeks of June. If you are *not* a member and would like registration forms and further information, please write or call the GSA Registration Coordinator, GSA headquarters. Nonmembers who become GSA members by October 15, 1994, can **pre**register at the member rate. For membership information, contact GSA Membership Services, GSA headquarters.

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

Estimated Registration Fees	Advance	On-Site
Professional Member	$165	$195
Professional Member One Day	$ 98	$ 98
Professional Nonmember	$205	$235
Professional Nonmember One Day	$118	$118
Student Member	$ 65	$ 80
Student Member One Day	$ 40	$ 40
Student Nonmember	$ 85	$100
Student Nonmember One Day	$ 50	$ 50
Field Trip and Short Course Only	$ 25	$ 35
K–12 Teachers	$ 25	$ 35
Guest/Spouse	$ 75	$ 75



Photographed in 1964, the view of Mt. Adams from pre-1980 summit of Mt. St. Helens. Photo by Stephen C. Porter.

Become a GSA Member and Save!

If you are planning to attend this year's Annual Meeting, but are not yet a GSA member, now is the time to join. You will save a substantial amount on your registration fee by paying the member rate—almost exactly the amount you pay to join GSA. That's like joining GSA for free! For membership information, contact T. Michael Moreland, GSA headquarters.

Abstracts with Programs

Purchase an advance copy through GSA Publication Sales or pick up a copy on-site in the registration area. *GSA Abstracts with Programs* is not part of your registration fee. For advance sales, contact Publication Sales, P.O. Box 9140, Boulder, CO 80301, 1-800-472-1988, (303) 447-2020, or fax 303-447-1133. Cost: $22.

Accessibility for Registrants with Special Needs

GSA is committed to making every event at the Annual Meeting accessible to all people interested in attending. If you have special requirements, such as an interpreter or wheelchair accessibility, there will be space to indicate this on the meeting registration form, or you can call Becky Martin, GSA headquarters. Please let us know your needs by September 24.

EXHIBITS

Over 250 Booths Filled With The Latest

- Geologic publications, textbooks, and maps
- Computers and geological software
- Scientific instrumentation
- Microanalysis and photographic equipment
- Geoscience educational supplies and videos
- Gems, minerals, and fossils
- Resource information from environmental, national, and state agencies
- Field supplies and gear
- Earth science program information from major schools and universities

Convenient Exhibit Hall Hours

Sunday, October 23	5:00 p.m. to 8:00 p.m.
Monday, October 24	9:00 a.m. to 5:00 p.m.
Tuesday, October 25	9:00 a.m. to 5:00 p.m.
Wednesday, October 26	9:00 a.m. to 4:00 p.m.

Exhibit Hall, GSA 1993 Boston Annual Meeting. Photo by Vincent Petipas.

TRAVEL AND LODGING

Seattle
at the leading edge

Getting Into and Around in Seattle

By Air. Seattle-Tacoma (SeaTac) International Airport is located 18 miles from the Washington State Convention and Trade Center. The airport is served by most major airlines. The Gray Line Airport Express offers convenient, inexpensive shuttle service from the airport to the downtown hotels.

By Car. Interstate 5 is Seattle's north-south link with Pacific coast cities from Canada to Mexico. Interstate 90 runs east from Seattle to midwestern and eastern United States cities. There is ample, *relatively* inexpensive parking at the Convention Center.

By Bus, Train. Greyhound Bus Lines connect Seattle with major cities in the United States and Canada and south to Tijuana, Mexico. For Greyhound Bus information, call 1-800-231-2222. The METRO (Municipality of Metropolitan Seattle) is a county-wide bus system with a ride-free zone in Seattle's downtown district. AMTRAK serves Seattle, providing passenger service from major United States locations. For AMTRAK information, call 1-800-872-7245.

Student Travel Grants

The GSA Foundation has awarded matching grants up to a total of $3500 each to the six GSA sections. The money, when combined with equal funds from the Sections, is used to assist GSA Student Associates traveling to the 1994 Section Meetings and to the Annual Meeting in Seattle. For information, contact your Section Secretary.

Cordilleran	Bruce Blackerby, (209) 278-2955
Rocky Mountain	Ken Kolm, (303) 273-3932
North-Central	George Hallberg, (319) 335-4500
South-Central	Rena Bonem, (817) 755-2361
Northeastern	Ken Weaver, (410) 554-5532
Southeastern	Mike Neilson, (205) 934-5102

Lodging

Downtown Seattle offers a wonderful convention setting, and most of the GSA hotels are within walking distance of the Washington State Convention and Trade Center. GSA has booked rooms at 13 properties—six within four blocks of the Convention Center and all, except The Edgewater, within one mile of the Convention Center. The properties include a cross section of lodging that should suit a variety of tastes and budgets.

Activities will take place at the Convention Center, as well as GSA's headquarters hotel, the **Sheraton Seattle Hotel & Towers,** and the Stouffer Madison Hotel. The Sheraton is a first-class property within a five-minute walk of the Convention Center. No other hotel in GSA's block matches the Sheraton for accommodations and service.

GSA hotels, single/double rates, and number of rooms blocked:

Sheraton Seattle Hotel & Towers	$128/$142	550 rooms
Stouffer Madison	$122/$132	325 rooms
Downtown Seattle Hilton	$103/$113	150 rooms
Holiday Inn Crowne Plaza	$112/$112	150 rooms
The Warwick	$89/$89	150 rooms
Mayflower Park	$94/$94	125 rooms
Pacific Plaza	$69/$69	100 rooms
WestCoast Camlin	$66/$76	100 rooms
WestCoast Vance	$68/$68	100 rooms
The Roosevelt	$99/$99	100 rooms
Sixth Avenue Inn	$68/$68	85 rooms
WestCoast Plaza Park Suites	$112/$122	75 rooms
The Edgewater	$108/$123	50 rooms
Student Lodging Possibilities:		
Ramada Inn	$72/$72	50 rooms
Quality Inn City Center	$49/$49	35 rooms
Days Inn Town Center	$58/$58	30 rooms
Travelodge, Downtown	$49/$49	30 rooms

The key to getting your first choice is to make your reservation early. Similar to last year, GSA will publish housing information and reservation forms in the **June** issue of *GSA Today.* Because October is one of Seattle's best months for tourism, we highly recommend that GSA meeting attendees get their reservations in *as early as possible.* All hotel reservations must be processed by the Seattle Housing Bureau to get the GSA special rate.

Alternative Lodging

Beating the high cost of lodging is a priority for GSA staff and the 1994 Annual Meeting Committee.

- Check your library copy of the *Hotel and Motel Redbook,* which lists metro properties. Because of the hundreds of properties in the area, GSA cannot provide a complete list.
- Call 1-800-555-1212 or check the Yellow Pages to learn the 800 number for your favorite hotel chains, such as Super 8 Motel or Comfort Inn, which have properties outside the downtown area. You will need to provide your own transportation.

Tourist Information

Seattle Convention and Visitors Bureau
520 Pike Street, Suite 1300
Seattle, WA 98101
(206) 461-5840

Washington State Tourism Division
General Administration Building
Room G-3, AX-13
Olympia, WA 98504
(206) 586-2102

Destination Washington
(Statewide Travel Planning Guide)
1-800-544-1800

Klapatche Park, Mt. Rainier National Park, Washington. Photo by John Karachewski.

COVER PHOTOS:

Top: *North face of Mt. Olympus (left) taken from the summit of Mt. Carrie, Olympic Mountains, Washington. Photo by Richard J. Stewart.*
Inset: *Seattle skyline. Photo courtesy of Seattle-King County Convention and Visitors Bureau.*
Center right: *Mt. Rainier, Washington. Photo by Darrel S. Cowan.*
Lower left: *Slackwater deposits (Touchet beds) of the Lake Missoula catastrophic floods on the Columbia Plateau, Burlingame Canyon near Walla Walla, Washington. Photo by Glenn Thackray.*
Lower right: *The Brothers, Hood Canal, and Olympic Mountains, Scenic Beach State Park, Washington. Photo by John Karachewski.*

Wanted!! More Fellows!!

(If you are a GSA Fellow, please READ this and ACT!)

BILL DICKINSON SEZ: This is your president speaking. We have a genuine GSA Fellowship crisis. Twenty years ago we had a little over 5000 Members and over 3000 Fellows (ratio of Members to Fellows about 60/40). We now have more than 10,000 Members but fewer than 3000 Fellows (ratio of Members to Fellows nearly 80/20). It's clear that people are just not being advanced to Fellowship fast enough (fully half the present Fellows are over 65 years old).

COUNCIL has recently simplified the procedure for Fellowship nominations. Co-sponsors can simply co-sign the form filled out by the sponsor—and away it goes. A Fellowship nomination form is included as part of this issue of *GSA Today* and can be photocopied if you need more.

BILL DICKINSON ALSO SEZ: If you are a GSA Fellow, DO YOUR DUTY and nominate at least one WORTHY junior colleague for Fellowship RIGHT NOW. If every Fellow were to nominate one more person, we would reach the same ratio of Members to Fellows that we had 20 years ago. Let's go for it! We have nothing to lose but the sanity of the Membership Committee! Bury those folks in mail!

Here's How It Works...

A Member of the Geological Society of America is elected to Fellowship in recognition of significant contribution to the science of geology.

A Member can be nominated for Fellowship only by a Fellow of the Society who makes the nomination by completing the Nominating Sponsor's Form. The Nominating Sponsor identifies two other Fellows who agree to sponsor the nomination. However, due to a recent "streamlining" change made by the GSA Council, **these two seconding sponsors are no longer required to submit individual forms.** At least one of these three sponsoring Fellows must be from an organization other than that of the nominee.

A nominee for Fellowship must have at least eight years of professional experience in geology or related fields. Graduate study may be substituted for a maximum of three of those eight years. Nominees for Fellowship ordinarily will be selected from individuals who have been Members for at least one year; however, qualified nonmembers may be nominated for Fellowship.

In addition to professional experience, to meet the standards for Fellowship, the nominating sponsor and nominee *must document the significant contributions* to the science of geology made by the nominee. The nature of the contribution may take many forms, and *it is the responsibility of the nominating sponsor and the nominee to adequately document the individual contribution* so that the Committee on Membership can evaluate the nomination and prepare a recommendation to Council. Examples of ways in which one may make a contribution to the science of geology include (but are not limited to):

A. *Publication of the results of geologic research.* This category should include the development of new data and interpretation of data in some aspect of geology reported in standard publications.

B. *Applied research.* The practical application of geologic knowledge to significant problems concerning geologic resources, natural hazards, and/or environmental problems is an avenue of contribution to the science of geology that may be made by geologists in industry or governmental agencies at all levels.

C. *Training of geologists.* Teaching of geology students in either graduate or undergraduate formal education programs potentially constitutes an important contribution to the science. Furthermore, participation in presentation of specialized training in applied programs, short-courses, etc., may also be recognized. Preparation of educational materials (textbooks, laboratory manuals, short-course guides, field guides, etc.) may also constitute a contribution.

D. *Administration of geological programs.* A wide range of administrative positions provides an opportunity to make a contribution to the geological sciences. These include, for example, administration of distinctive academic programs, leadership of research teams, coordination of research programs, supervision of industrial programs involving application of geologic principles and, in general, supervision of significant numbers of geologists as employees.

E. *Public awareness of geology.* Presentations of geological work to governmental agencies (legislative bodies, courts, committees, etc.) as well as to the public in general may provide the basic support for important advances in geology.

F. *Professional organizations.* Participation in the leadership of professional organizations or major scientific committees may provide for advancement of the science.

G. *Editorial, bibliographic, and library responsibilities.* The dissemination of geologic knowledge contributes to the advancement of the science, and unique activities in these areas may provide qualification for Fellowship.

H. *Other.* The opportunities available to Members of the Geological Society of America to make a contribution to the science of geology are as diverse as geologists and indeed as geology itself. Therefore, a nominee may present to the Committee on Membership activities that do not fit into any of the ordinarily prescribed categories.

This list is not intended to be exclusive or restrictive, but merely a set of examples. Furthermore, the categories listed are not intended to represent any order of importance. These categories are intended to exemplify the most common kinds of activities that nominees or their sponsors present as qualifications for Fellowship. ■

The Geological Society of America
3300 Penrose Place, P.O. Box 9140 • Boulder, Colorado 80301 • (303) 447-2020 • Fax (303) 447-1133

Nomination to Fellowship

Nominating Sponsor's Form

I wish to nominate the following Member of The Geological Society of America for election to Fellowship:
(please print)

Name of Nominee _____

Affiliation and Title _____

Address _____

_____

_____
City State ZIP Country

Telephone number *during business hours* ( ) _____ Fax ( ) _____

Name of Nominating Sponsor _____

Affiliation _____

Signature _____ Date _____

The following two other Fellows of the Society know the professional qualifications of the nominee and by signing this form (or submitting a separate letter or form) acknowledge that they support this nomination ***(please print)***:

1. _____
Name

_____
Affiliation*

_____
Signature

2. _____
Name

_____
Affiliation*

_____
Signature

Note: At least one sponsor must be from an organization other than that of the nominee.

PLEASE REVIEW THE CRITERIA FOR ELECTION TO FELLOWSHIP. From the examples of ways in which one may make a contribution to the science of geology and thereby qualify for Fellowship in the Society, select those categories which most accurately describe the significant contributions of the nominee. On the reverse side of this form, provide your evaluation of the nominee's performance in the area or areas you consider to be the primary contribution to the geological sciences. The Committee will receive a copy of the nominee's résumé and bibliography and does NOT require repetition of the data included on it. The Committee on Membership cannot prepare an effective recommendation to Council unless the nominating sponsor provides a CRITICAL EVALUATION of the ways in which the nominee has CONTRIBUTED SIGNIFICANTLY to the science of geology. For nominees whose major contributions are unpublished, the Committee depends heavily upon the depth and informative character of your evaluation.

Nominee's performance and/or contributions are to be evaluated in the following categories:

- ☐ A. Publication of the results of geologic research
- ☐ B. Applied research
- ☐ C. Training of geologists
- ☐ D. Administration of geological programs
- ☐ E. Public awareness of geology
- ☐ F. Professional organizations
- ☐ G. Editorial, bibliographic, and library responsibilities
- ☐ H. Other

(see other side) 3/94

MEETINGS

GSA Penrose Conferences

April 1994

Triple Junction Interactions at Plate Margins, April 21–26, 1994, Eureka, California. Information: Virginia B. Sisson, Dept. of Geology and Geophysics, Rice University, P.O. Box 1892, Houston, TX 77251-1892, (713) 285-5234; Terry L. Pavlis, Dept. of Geology and Geophysics, University of New Orleans, New Orleans, LA 70148, (504) 286-6797; David J. Prior, Dept. of Earth Sciences, University of Liverpool, P.O. Box 147, Liverpool L69 3BX, UK.

June 1994

Fractured Unlithified Aquitards: Origins and Transport Processes, June 15–20, 1994, Racine, Wisconsin. Information: John A. Cherry, Waterloo Centre for Groundwater Research, University of Waterloo, Waterloo, Ontario N2L 3G1, Canada, (519) 885-1211, ext. 2892, fax 519-746-5644; David M. Mickelson, Dept. of Geology and Geophysics, University of Wisconsin, 1215 W. Dayton St., Madison, WI 53706, (608) 262-7863, fax 608-262-0693; William W. Simpkins, Dept. of Geological and Atmospheric Sciences, 253 Science I, Iowa State University of Science and Technology, Ames, IA 50011, (515) 294-7814, fax 515-294-6049.

1994 Meetings

April

GSA Southeastern Section Meeting, April 7–8, 1994, Blacksburg, Virginia. Information: Lynn Glover, III, and Robert J. Tracy, Dept. of Geological Sciences, Virginia Tech, Blacksburg, VA 24061-0420, Glover's direct (703) 231-6213, fax 703-231-3886, Tracy's direct (703) 231-5980.

Toxic Substances and the Hydrologic Sciences, April 10–13, 1994, Austin, Texas. Information: American Institute of Hydrology, 3416 University Ave. S.E., Minneapolis, MN 55414-3328, (612) 379-1030, fax 612-379-0169.

Transport and Reactive Processes in Aquifers IAHR Symposium, April 11–15, 1994, ETH-Zürich, Switzerland. Information: Th. Dracos or F. Stauffer, Institute of Hydromechanics and Water Resources Management (IHW), ETH-Hönggerberg, CH-8093 Zürich, Switzerland, phone 41-1-377 30 66 or 41-1-377 30 79, fax 41-1-371 22 83.

Mid-America Paleontology Society National Fossil Exposition: Dinosaurs, April 15–17, 1994, Macomb, Illinois. Information: Marvin Houg, 3330 44th St. NE, Cedar Rapids, IA 52402, (319) 395-0577, or Karl A. Stuekerjuergen, RR1, Box 285, West Point, IA 52656, (319) 837-6690.

Extractive Industry Geology, April 17–20, 1994, Sheffield, England. Information: Conference Office, Institution of Mining and Metallurgy, 44 Portland Place, London W1N 4BR, England, phone 44-71-580-3802, fax 44-71-436-5388.

AAPG Hedberg Research Conference, Near-Surface Expressions of Hydrocarbon Migration, April 24–27, 1994, Vancouver, British Columbia, Canada. Information: AAPG Continuing Education Department, P.O. Box 979, Tulsa, OK 74101, (918) 584-2555, fax 918-584-0469.

European Association of Science Editors 5th General Assembly and Conference, April 24–28, 1994, Budapest, Hungary. Information: EASE Secretariat, 49 Rossendale Way, London, NW1 0XB, UK, phone 44-71-388 9668, fax 44-71-383 3092.

Petroleum Source Rocks: Formation, Diagenesis, and Expulsion, April 25–29, 1994, Calgary, Alberta, Canada. Information: Han Wielens, Unocal Canada Exploration Ltd., Box 2120, Calgary, Alberta, Canada T2P 2M4, (403) 268-0370, fax 403-268-0101; Marc Bustin, Dept. of Geological Sciences, University of British Columbia, Vancouver, B.C., Canada V6T 1Z4, (604) 822-6179, fax 604-822-6088; or Steve Calvert, Dept. of Oceanography, University of British Columbia, Vancouver, B.C., Canada V6T 1Z4, (604) 822-5210, fax 604-822-6091.

European Geophysical Society XIXth General Assembly, April 25–29, 1994, Grenoble, France. Information: EGS 94, c/o LGGE BP 96, 38402 St. Martin D'Heres Cedex, France, phone 33-76-82 42 78, fax 33-76 82 42 01, E-mail: egs94@glaciog.grenet.fr.

International Land Reclamation and Mine Drainage Conference, and Third International Conference on the Abatement of Acidic Drainage, April 25–29, 1994, Pittsburgh, Pennsylvania. Information: D. Lowanse, U.S. Bureau of Mines, P.O. Box 18070, Pittsburgh, PA 15236, (412) 892-6708, fax 412-892-4067.

GSA North-Central Section Meeting, April 28–29, 1994, Kalamazoo, Michigan. Information: Alan Kehew, Dept. of Geology, Western Michigan University, Kalamazoo, MI 49008, (616) 387-5495, fax 616-387-5513.

May

GSA Rocky Mountain Section Meeting, May 4–6, 1994, Durango, Colorado. Information: Douglas Brew, Geology Dept., Ft. Lewis College, Durango, CO 81301, (303) 247-7254, fax 303-247-7310.

Geologic Remote Sensing Tenth Thematic Conference, May 9–12, 1994, San Antonio, Texas. Information: ERIM/Thematic Conferences, P.O. Box 134001, Ann Arbor, MI 48113-4001, (313) 994-1200, ext. 3234, fax 313-994-5123, Internet: wallman@vaxb.erim.org.

Midwest Friends of the Pleistocene Annual Meeting, May 13–15, 1994, Cincinnati, Ohio. Information: Tom Lowell, Dept. of Geology, University of Cincinnati, Cincinnati, OH 45226, (513) 556-4165, E-mail: Lowelltv@ucbeh.san.

Evaluation of nominee's performance and/or contributions in those categories selected.
Please continue on separate sheet if necessary.

Describe any other significant activities that do not appear in the preceding categories.

Please send completed form to GSA Membership Services, P.O. Box 9140, Boulder, CO 80301

uc.edu; or Scott Brockman, Division of Geological Survey, Ohio Department of Natural Resources, Columbus, OH 43224, (614) 265-6604.

Geological Association of Canada and Mineralogical Association of Canada Annual Meeting, May 15–18, 1994, Waterloo, Ontario, Canada. Information: Alan V. Morgan, Dept. of Earth Sciences, University of Waterloo, Waterloo, Ontario N2L 3G1, Canada, (519) 885-1211, ext. 3231, fax 519-746-7484.

Pan-American Current Research on Fluid Inclusions (PACROFI V), May 19–21, 1994, Curenavaca, Morelos, Mexico. Information: David A. Vanko, Dept. of Geology, Georgia State University, Atlanta, GA 30303, fax 404-651-1376, E-mail: geodav@gsusgi1.gsu.edu.

National Association of Geology Teachers, Eastern Section Annual Meeting, May 20–22, 1994, Nyack, New York. Information: Michael J. Passow, 296 Central Ave., Englewood, NJ 07631, (201) 871-0846.

■ **Northeast Friends of the Pleistocene Annual Meeting,** May 20–22, 1994, Hazelton, Pennsylvania. Information: Duane Braun, Geography and Earth Science Dept., Bloomsburg University, Bloomsburg, PA 17815, (717) 389-4139.

High-Level Radioactive Waste Management International Conference, May 22–26, 1994, Las Vegas, Nevada. Information: Tom Sanders, Attn: Transactions Office, American Nuclear Society, 555 N. Kensington Avenue, La Grange Park, IL 60525.

Glacial Cycles at High Latitudes, May 29–June 1, 1994, Fjærland, Norway. Information: Berit H. Barkley, Dept. of Geology, P.O. Box 1047 Blindern, 0316 Oslo, Norway, 47-22-856691, fax 47-22-854215.

June

1st North American Rock Mechanics Symposium, June 1–3, 1994, Austin, Texas. Information: NARM Symposium, Continuing Engineering Studies, Cockrell Hall 10.324, University of Texas, Austin, TX 78712; or Priscilla Nelson, (512) 471-5664; or Stephen Laubach, fax 512-471-0140.

Geochronology, Cosmochronology, and Isotope Geology Eighth International Conference (ICOG-8), June 5–11, 1994, Berkeley, California. Information: Garniss H. Curtis, Institute of Human Origins–Geochronology Center, 2453 Ridge Road, Berkeley, CA 94709, (510) 845-4003, fax 510-845-9453.

Fifth International Conference on Ground Penetrating Radar, June 12–16, 1994, Kitchener, Ontario, Canada. Information: GPR '94, Waterloo Centre for Groundwater Research, University of Waterloo, Waterloo, Ontario N2L 3G1, Canada, (519) 885-1211, ext. 2892, fax 519-725-8720.

Seventh International Symposium on the Ordovician System, June 12–16, 1995, Las Vegas, Nevada. Information: Margaret N. Rees, 7th ISOS, Dept. of Geoscience, University of Nevada, Las Vegas, NV 89154-4010, (702) 739-3890, fax 702-597-4064, E-mail: rees@nevada.edu.

■ **Seventh Symposium on the Geology of the Bahamas,** June 16–20, 1994, Bahamian Field Station, San Salvador, Bahamas. Information: Mark R. Boardman, Dept. of Geology, Miami University, Oxford, OH 45056; (513) 529-3230, fax 513-529-1542, E-mail: boardman@miamiu; or Daniel R. Suchy, Bahamian Field Station, Ltd., 270 SW 34th St., Ft. Lauderdale, FL 33315, (305) 331-2520. *(Abstract deadline: April 1, 1994.)*

First International Symposium on Protection and Development of Mountain Environment, June 20–24, 1994, Ponte di Legno, Italy. Information: Man & Mountain '94, c/o Valdepur Service s.r.l., via Seradello 225, 25068 Serezzo (BS), Italy.

Western Society of Malacologists 27th Annual Meeting, June 26–30, 1994, Santa Barbara, California. Information: Henry W. Chaney, Santa Barbara Museum of Natural History, 2559 Puesta del Sol Rd., Santa Barbara, CA 93105, (805) 682-4711, ext. 334, fax 805-569-3170.

July

FORAMS '94: International Symposium on Foraminifera, July 5–9, 1994, Berkeley, California. Information: FORAMS '94, Museum of Paleontology, University of California, Berkeley, CA 94720, (510) 642-1821, fax 510-642-1822.

Earthquake Engineering Fifth U.S. National Conference, July 10–14, 1994, Chicago, Illinois. Information: Claudia Cook, Newmark Civil Engineering Laboratory, University of Illinois, 205 N. Mathews, Urbana, IL 61801-2397, (217) 333-0498.

■ **Geological Indicators of Rapid Change, International Workshop,** July 11–18, 1994, Corner Brook, Newfoundland. Information: A. R. Berger, Chairman, Geo-Indicators Working Group, 528 Paradise St., Victoria, BC V9A 5E2, Canada, (604) 480-0840, fax 604-480-0840.

Basement Tectonics 11th International Conference, July 25–29, 1994, Potsdam, Germany. Information: Onno Oncken, Conference Chairman, Geo-Forschungs Zentrum, Telegrafenberg, D-0-1561 Potsdam, Germany, phone 49-331-310601, fax 49-331-310306.

Society for Industrial and Applied Mathematics Annual Meeting, July 25–29, 1994, San Diego, California. Information: SIAM Conference Coordinator, 3600 University City Science Center, Philadelphia, PA 19104-2688, (215) 382-9800, fax 215-386-7999, E-mail: meetings@siam.org.

August

■ **New Perspectives in the Appalachian-Caledonian Orogen: A Symposium in Honour of Hank Williams,** August 12–13, 1994, (field trip August 14–19), Corner Brook, Newfoundland, Canada. Information: J. Hibbard, MEAS, Box 8208, NCSU, Raleigh, NC 27695, (919) 515-7242, fax 919-515-7802, E-mail: hibbard@meavax.nrrc.ncsu.edu; or C. van Staal, Geological Survey of Canada, 601 Booth St., Ottawa, Ontario K1A 0E8, Canada, (613) 995-4333, fax 613-995-7997, E-mail: vanstaal@cc2sutp.emr.ca.

Clay Minerals Society 31st Annual Meeting, August 13–18, 1994, Saskatoon, Saskatchewan, Canada. Information: Ahmet R. Mermut, Dept. of Soil Science, Saskatchewan Institute of Pedology, University of Saskatchewan, Saskatoon S7N 0W0, Canada, (306) 966-6839, fax 306-966-6881, E-mail: mermut@sask.usask.ca.

West Australian Basins Symposium, August 14–17, 1994, Perth, Australia. Information: Petroleum Exploration Society Australia, Attn.: J. B. O'Reilly/N. K. Guppy, P.O. Box 1102, West Perth, W.A. 6872, Australia, phone 61-9-481-6666, fax 61-9-481-1952.

The South Atlantic: Present and Past Circulation, August 15–18, 1994, Bremen, Germany. Information: South Atlantic Symposium, Barbara Donner, Fachbereich Geowissenschaften der Universität, Postfach 33 04 40, D-28334 Bremen, Germany.

■ **45th Highway Geology Symposium,** August 17–19, 1994, Portland, Oregon. Information: Scott Burns, Dept. of Geology, Portland State University, Portland, OR 97207-0751, (503) 725-3389, fax 503-725-3025. *(Abstracts deadline: April 18, 1994.)*

14th International Sedimentological Congress, Equatorial Gateway in Atlantic Symposium, August 21–26, 1994, Recife, Brazil. Information: Luba Jansa, Bedford Institute of Oceanography, Dartmouth, N.S., Canada B2Y 4A2, (902) 426-2734, fax 902-426-4465, E-mail: jansa@agcrr.bio.ns.ca.

International Geographical Union Regional Conference, Environment and Quality of Life in Central Europe: Problems of Transition, August 22–26, 1994, Prague, Czech Republic. Information: Conference Secretariat, IGU RC 1994, Albertov 6, 128 43 Praha 2, Czech Republic, phone 42-2-24912060, or 42-2-296025, fax 42-2-24915817 or 42-2-296025, E-mail: kucera@prfdec.natur.cuni.cz

International Symposium on Paleoenvironmental History of East and South Asia and Cretaceous Correlation (IGCP 350), Taegu, Korea. Information: Ki-Hong Chang, Dept. of Geology, Kyungpook National University, Taegu, Korea 702-701, phone 82-53-950-5355, fax 82-53-957-0431, E-mail: khchang@bh.kyungpook.ac.kr.

Proterozoic Crustal and Metallogenic Evolution, August 29–September 1, 1994, Windhoek, Namibia. Information: G.I.C. Schneider, Geological Society of Namibia, P.O. Box 699, Windhoek, Namibia, phone 264-61-37240, fax 264-61-228324.

V.M. Goldschmidt Conference, August 29–September 2, 1994, Edinburgh, Scotland. Information: B. Harte or P. Symms, V.M. Goldschmidt Conference 1994, Dept. of Geology and Geophysics, University of Edinburgh, Grant Institute, West Mains Road, Edinburgh EH9 3JW, Scotland, UK.

September

Cyclicity in Global Geology, Australian Geological Convention Symposium, September, 1994, Perth, Australia. Information: Bryan Krapez or C. McA. Powell, Dept. of Geology, University of Western Australia, Nedlands, 6009, Australia.

Prospecting in Areas of Glaciated Terrain—Tenth Conference, September 5–7, 1994, St. Petersburg, Russia. Information: The Conference Office, The Institution of Mining and Metallurgy, 44 Portland Place, London W1N 4BR, England, phone 44-71-580-3802, fax 44-71-436-5388.

Biotic Recoveries from Mass Extinctions, IGCP Project 335, September 5–8, 1994, Plymouth, United Kingdom. Information: Malcom B. Hart, Dept. of Geological Sciences, University of Plymouth, Drake Circus, Plymouth, Devon P1A 8AA, UK, fax 44-745-233-117; or Douglas H. Erwin, Dept. of Paleobiology, NHB-121, Smithsonian Institution, Washington, DC 20560, (202) 357-2053.

International Conference on Arctic Margins, (ICAM '94), September 5–9, 1994, Magadan, Russia. Information: Kirill V. Simakov, North East Science Center, Russian Academy of Sciences, 16 Portovaya St., Magadan, Russia 685000, (907) 474-7219 (USA) or 7-41-3-223-0953 (Russia); or Dennis K. Thurston, Minerals Management Service, 949 E. 36th Ave., Anchorage, AK 99508-4302, (907) 271-6545, fax 907-271-6565.

First International Airborne Remote Sensing Conference and Exhibition: Applications, Technology, and Science, September 11–15, 1994, Strasbourg, France. Information: Robert Rogers, ERIM, Box 13001, Ann Arbor, MI 48113-4001, (313) 994-1200, ext. 3234; fax 313-994-5123.

■ **Illinois Basin Energy and Mineral Resources Workshop,** September 12–

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Meetings *continued from p. 123*

13, 1994, Evansville, Indiana. Infomation: Theola Evans, Kentucky Geological Survey, 228 MMRB, University of Kentucky, Lexington, KY 40506, (606) 257-5500, E-mail: theola@kgs.uky.edu.

Salt Tectonics, September 14–15, 1994, London, England. Information: Ian Alsop, Derek Blundell, and Ian Davison, Dept. of Geology, Royal Holloway, University of London, Egham, Surrey, UK, phone 44-784-443615, fax 44-784-471780. *(Abstract deadline: April 1, 1994.)*

■ **Underground Technology Research Council,** September 16–18, 1994, Chicago, Illinois. Information: John MacDonald, Meeting Chairman, Guy F. Atkinson Construction Company, P.O. Box 428, Enumclaw, WA 98022, (206) 825-1410, fax 206-825-2514; or Frank Kendorski, UTRC Chairman, Morgan Mining & Environmental Consultants, Ltd., 4921 Chase Avenue, Downers Grove, IL 60515, (708) 305-7900, fax 708-305-9841.

Fifth International Mine Water Congress, September 18–23, 1994, Nottingham, UK. Information: Conference Secretary, IMWA Conference, c/o Department of Mineral Resouces Engineering, University of Nottingham, University Park, Nottingham NG7 2RD, UK.

■ **Geomorphology and Natural Hazards,** (25th Annual Binghamton Geomorphology Symposium), September 24–25, 1994, Binghamton, New York. Information: Marie Morisawa, Dept. of Geol. Sciences and Environmental Studies, State University of New York, Binghamton, NY 13902-6000, (607) 777-2837, fax 607-777-2288, E-mail: marieem@bingvmb.cc.binghamton.edu.

■ **Society for Organic Petrology 11th Annual Meeting,** September 25–30, 1994, Jackson, Wyoming. Information: Ron Stanton, U.S. Geological Survey, 956 National Center, Reston, VA 22092, (703) 648-6462, fax 703-648-6419, E-mail: rstanton@ncrds.usgs.er.gov.

■ **Geochemical Event Markers in the Phanerozoic,** final meeting of IGCP Project 293, September 26–28, 1994, Erlangen, Germany. Information: Michael M. Joachimski, Institute of Geology and Mineralogy, University of Erlangen/Nürnberg, Schlossgarten 5, 91054 Erlangen, Germany, 49-9131-852615, fax 49-9131-859295; or Helmut H. J. Geldsetzer, Geological Survey of Canada, 3303-33rd St., N.W., Calgary, Alberta T2L 2A7, Canada, (403) 292-7155, fax 403-292-5377.

12th Australian Geological Convention, September 26–30, 1994, Perth, Australia. Information: Secretary, 12AGC, P.O. Box 119, Cannington, WA 6107, Australia, 61-9-351-7968, fax 61-9-351-3153.

Eco Rio '94, International Symposium on Resource and Environmental Monitoring, September 26–30, 1994, Rio de Janeiro. Information: National Institute of Space Research—INPE c/o Mônica Oliveira, CRI, P.O. Box 515, Av. dos Astronautas, 1758-CEP 12227-010, San José dos Campos, SP-Brazil, phone 55-123-22-9816 or 41-8977, ext. 250, fax 55-123-21-8543 or 22-9325.

October

Association of Engineering Geologists Annual Meeting, October 2–7, 1994, Williamsburg, Virginia. Information: AEG, 323 Boston Post Rd., Suite 2D, Sudbury, MA 01776, (508) 443-4369 or (508) 443-3639.

Federation of Analytical Chemistry and Spectroscopy Societies Annual Conference, October 2–7, 1994, St. Louis, Missouri. Information: FACSS, 198 Thomas Johnson Dr., Suite S-2, Frederick, MD 21702-4317, (301) 846-4797.

■ **International Association for Mathematical Geology Annual Meeting,** October 3–5, 1994, Mont Tremblant, Quebec, Canada. Information: C.-J. Chung, Geological Survey of Canada, 601 Booth St., Ottawa, Ontario K1A 0E8, Canada, (613) 996-3413, fax 613-996-3726, E-mail: chung@gsc.emr.ca.

German Geological Society (DGG) Annual Meeting, October 4–7, 1994, Heidelberg, Germany. Information: Th. Bechstädt and R. O. Greiling, Geologische-Paläontologisches Institut, Ruprecht-Karls-Universität, Im Neuenheimer Feld 234, D-6900 Heidelberg, Germany.

Symposium on Porphyry Copper Deposits from Alaska to Chile, October 5–7, 1994, Tucson, Arizona. Information: Jim Laukes, University of Arizona Extended University, 1955 East Sixth Street, Tucson, AZ 85719-5224, 1-800-955-UofA, fax 602-621-3269, E-mail (Internet): jlaukes.ccit.arizona.edu.

■ **9th National Conference on Hydrogeology and Engineering Geology of Karst Terranes,** October 16–18, 1994, Nashville, Tennessee. Information: James F. Quinlan, Box 110539, Nashville, TN 37222, (615) 833-4324; or Geary M. Schindel, (615) 255-2288. *(Abstract deadline: May 15, 1994.)*

■ **Symposium on the Petroleum Geology and Hydrocarbon Potential of the Black Sea Area,** October 16–18, 1994, Varna, Bulgaria. Information: Liz Lador, Petroconsultants S.A., Information Research Division, P.O. Box 152, 24 Chemin de la Mairie, 1258 Perly, Geneva, Switzerland, phone 41-22-721-1717, telex 413-541-PETR CH, fax 41-22-721-1747. *(Abstract deadline: April 30, 1994.)*

Ninth Annual Conference on Contaminated Soils, October 17–20, 1994, Amherst, Massachusetts. Information: Paul Kostecki, Environmental Health and Sciences, N344 Morrill, University of Massachusetts, Amherst, MA 01003, (413) 545-2934, fax 413-545-4692.

LIRA Workshop on the Ross Orogen: Crustal Structure and Tectonic Significance, October 21–23, 1994, Dallas, Texas. Information: John W. Goodge, Dept. of Geological Sciences, Southern Methodist University, Dallas, TX 75275, (214) 768-4140, E-mail: jgoodge@sun.cis.smu.edu.

November

■ **Carolina Geological Society Annual Meeting and Field Trip,** November 4–6, 1994, Raleigh, North Carolina. Information: Skip Stoddard, Dept. of MEAS, Box 8208, North Carolina State University, Raleigh, NC 27695-8208, (919) 515-7939, fax 919-515-7802, E-mail: stoddard@meavax.nrrc.ncsu.edu.

■ **International Symposium on the Cenozoic Tectonics and Volcanism of Mexico,** November 7–11, 1994, Puerto Vallarta, Jalisco, Mexico. Information: Hugo Delgado Granados, Inst. de Geofísica, UNAM, Circuito Exterior, C.U., Coyoacán 04510, México D.F., phone (525) 622-4145, 622-4119, 622-4124, fax 525-550-2486, Internet: hugo@tonatiuh.igcofcu.unam.mx; or Gerardo Aguirre Díaz, Estación Regional del Centro, Inst. de Geología, UNAM, Apdo. Postal 376, Guanajuato, Gto, 36000, México, phone and fax 524-732-3038.

Geology and Resources of the Eastern Frontal Belt, Ouachita Mountains, Oklahoma, November 15–17, 1994, Poteau, Oklahoma. Information: Neil H. Suneson, Oklahoma Geological Survey, Sarkeys Energy Center, Room N-131, 100 East Boyd St., Norman, OK 73019-0628, (405) 325-3031.

International Geological Correlation Program Project 351, Early Paleozoic Evolution in Northwest Gondwana, November 29–December 7, 1994, Rabat, Morocco. Information: Naima Hamoumi, Dépt. de Géologie, Faculté des Sciences de Rabat, B.P. 1226 RP Rabat, Morocco, phone 212-7-7719-57, fax 212-7-77-42-61, telex 36607 M.

December

Tectonic Evolution of Southeast Asia, December 7–8, 1994, London, UK. Information: Robert Hall, Geological

Meetings *continued on p. 127*

1994 GeoVentures

GEOTRIP

An extraordinary value for a trip with so much variety.

Calgary to Vancouver: Transect across the Southern Canadian Cordillera: A Cross Section through a Convergent Margin

15 days, 16 nights: August 13–27, 1994

Scientific Leaders:

J. Murray Journeay, J.W.H. Monger, Randall R. Parrish, *Geological Survey of Canada*
J. Brian Mahoney, *University of British Columbia*
Philip S. Simony, Deborah A. Spratt, *University of Calgary*

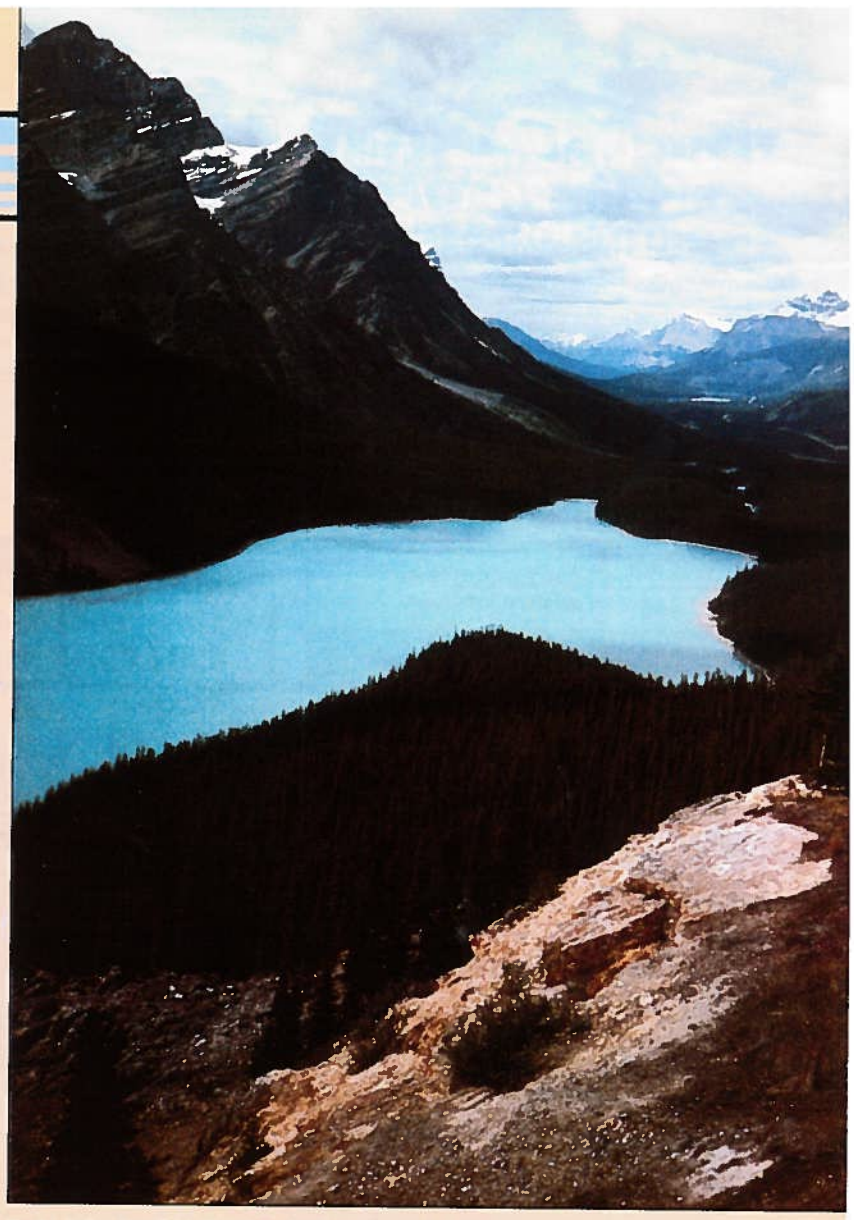
Itinerary

This trip is an extraordinary geological excursion across the southern Canadian Cordillera, from Calgary, Alberta, to Vancouver, British Columbia. Participants will journey through the Canadian Rocky Mountain fold-and-thrust belt, the Omineca metamorphic complex and Mesozoic arc assemblages, sedimentary basins, and plutonic complexes of the accreted terranes. The trip will focus on the tectonic evolution of the region and will emphasize the current level of understanding and areas of current research. As with all GeoTrips, the daily itinerary is planned with both the geologist and nongeologist in mind.

Physical Requirements, Transportation, Lodging, Meals

The leaders have planned several extensive day hikes. Persons in good physical health with the ability to hike several miles uphill are encouraged to consider this trip; however, bus will be the primary transportation mode. Also included will be day trips by raft, horseback, jeeps, and jet boat or helicopter. Lodging (double occupancy) will be in comfortable hotels or inns. All meals, including a final farewell dinner, are included, with the exception of the arrival night, "the on-your-own day," and the departure morning.

Orientation is the evening of August 13. Departure is the morning of August 28. The arrival point is Calgary, and the end point is Vancouver. For most departure points there is a modest differential for the airfare from Vancouver back to Calgary or the continuing airfare from Vancouver to your home destination. Call Cain Travel Group and ask for Robyn Langerak if you want an estimate: 1-800-346-4747, 8:30 a.m. to 5:30 p.m. MST, Monday through Friday.



Peyto Lake, Banff National Park, Canada. *Mark Duvall*

Fee and Deposit Cost: Member: $2300. Nonmember: $2450.
Inclusive of meals, lodging, transportation or horseback ride, jetboat or helicopter overview, half-day raft trip, and farewell dinner. Airfare is not included.
Based on 24 people. The trip may be slightly more if fewer register. If you have previously traveled on a GSA GeoTrip, the nonmember surcharge will be waived. $200 deposit is due with your reservation, and is fully refundable through April 30 less a $50 processing fee. Total balance due: June 15. Minimum age: 21. Limit: 30 persons.

GEOTRIP

Great value for an exceptional trip!

Rim to River: Moab, Canyonlands, and Cataract Canyon

7 days, 8 nights: May 28–June 4, 1994

Scientific Leaders: **Kenneth Kolm and John Emerick,** *Colorado School of Mines*
John A. Campbell, *Ft. Lewis College*

Itinerary

May 28, Saturday—Travel day to Moab. Orientation at 7:30 p.m.
May 29, Sunday—La Sal Mountains. Paradox Valley overview. Lodging in Moab.
May 30, Monday—Arches National Park and vicinity. Lodging in Moab.
May 31–June 3, Tuesday–Friday—Hike to the River on Upheaval Trail. Hiking in Canyonlands including Powell's Overlook and the Maze District. Tent camping.
June 4, Saturday—Rafting Cataract Canyon. Hike in Dark Canyon. Sunset overflight of Canyonlands and return to Moab for farewell dinner at Mi Vida.
June 5, Sunday—Travel day.

Fee and Deposit

Estimated Cost: GSA Member: $1220. Nonmember: $1370.
Based on 24 people. May be more if there are fewer registrants. If you have previously traveled on a GSA GeoTrip, the nonmember surcharge will be waived.
Total balance due: April 1. Minimum age: 21. Limit: 24 persons.

Fee includes all meals except dinner on the arrival day and breakfast on the departure day; comfortable van transportation; double-occupancy lodging in Moab; five days of rafting; tents, sleeping bags, and pads when camping; geological reading material and guidebook; sunset overflight of Canyonlands; and, of course, the final dinner at Mi Vida.

Not included is airfare to and from Grand Junction, Colorado, or transfer to Moab, Utah. We will arrange for an optional group pick-up and return. The cost is about $20 each way (100 miles).

Air Transportation

Air transportation can be arranged by Cain Travel Agency in Boulder, 1-800-346-4747, Monday through Friday, 8:30 a.m. to 5:30 p.m. MST. Please ask for Robyn Langerak.

GEOHOSTEL

Scenic Geology and Natural History of the Central Colorado Rocky Mountains

Western State College, Gunnison, Colorado

5 days, 6 nights: June 25–30, 1994

Scientific Leaders: **Kenneth E. Kolm** and **Gregory S. Holden,** *Colorado School of Mines*

Itinerary—*All trips begin and end in Gunnison.*

Saturday, June 25
7:00 to 9:00 p.m.—Welcoming Reception.
Sunday, June 26
8:00 a.m. to 5:00 p.m.—Geological Sequence of Central Colorado.
Monday, June 27
8:00 a.m. to 1:00 p.m.—Geology of the Gunnison Valley.
Tuesday, June 28
8:00 a.m. to 5:00 p.m.—Geology of the Northern Rio Grande Rift.
Wednesday, June 29
8:00 a.m. to 12 noon—Features of Calderas and Ash Flow Tuffs of the San Juan Volcanic Field.
1:00 p.m. to 7:00 p.m.—Optional afternoon field trip to the Great Sand Dunes.
Thursday, June 30
8:00 a.m. to 5:00 p.m.—Lake City Tour.
The Farewell Party begins at 7:00 p.m.

Fee and Deposit

Cost: GSA Member: $480. Nonmember: $530.
$100 deposit, due with your reservation; refundable until April 30, less $20 processing fee. Total balance due: May 1. Minimum age: 21. **Limit:** 32 persons.

Fee includes classroom programs and materials, field trip transportation, lodging for 6 nights (single-occupancy, or double for couples, dormitory rooms), breakfast and sack lunch daily through Thursday, tram rides, and welcoming and farewell events. **Not included** are transportation to and from Gunnison, Colorado, transportation during hours outside class and field trips, meals, and other expenses not specifically included.

For More Information and Registration Call: Matt Ball or Edna Collis at (303) 447-2020 or 1-800-472-1988

April *BULLETIN* and *GEOLOGY* Contents

Are you missing out? If you're not a *Bulletin* or *Geology* subscriber, you may miss the articles listed below. Subscribe today and receive all 1994 issues, even if you've already paid your 1994 dues. Call Membership Services today at 1-800-472-1988.

The Geological Society of America
BULLETIN
Volume 106, Number 4, April 1994

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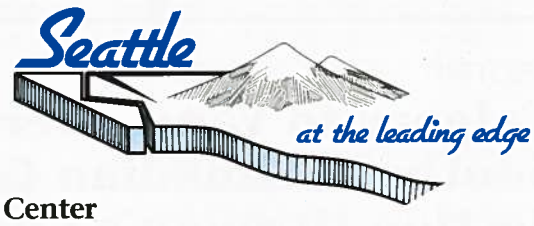
GSA ANNUAL MEETINGS

■ 1994



Seattle, Washington
October 24–27
Washington State
Convention and Trade Center
Seattle Sheraton Hotel

General Chairman: ***Darrel S. Cowan***
Technical Program Chairmen: ***Mark S. Ghiorso, Thomas Dunne***
Field Trip Chairman: ***Donald A. Swanson***

All of these chairmen are located at the Dept. of Geosciences, University of Washington, Seattle, WA 98195, (206) 543-1190, fax 206-543-3836.

For information call the GSA Meetings Department, 1-800-472-1988 or (303) 447-2020.

Call for Papers: See page 105 in this issue— Themes, Symposia, Field Trips, and Continuing Education.

■ 1995

New Orleans, Louisiana, November 6–9
Ernest N. Morial Convention Center, Hyatt Regency New Orleans

General Chairman: ***William R. Craig, University of New Orleans***
Technical Program Chairman: ***Laura Serpa, University of New Orleans***
Call for Field Trip Proposals: *Please contact the Field Trip Chairmen listed below.*

Whitney Autin
Louisiana Geological Survey
P.O. Box G, University Station
Baton Rouge, LA 70893-4107
(504) 388-5320

Duncan Goldthwaite
4608 James Drive
Metairie, LA 70003
(504) 887-4377

For general information call the GSA Meetings Department, 1-800-472-1988 or (303) 447-2020.

■ FUTURE

Seattle	October 24–27	1994
New Orleans	November 6–9	1995
Denver	October 28–31	1996
Salt Lake City	October 20–23	1997

For general information on technical program participation (1994 or beyond) contact Sue Beggs, Meetings Manager, GSA headquarters.

GSA SECTION MEETINGS

■ 1994

Southeastern Section, Virginia Polytechnic Institute and State University, Blacksburg, Virginia, April 7–8, 1994. Lynn Glover, III and Robert J. Tracy, Department of Geological Sciences, Virginia Tech, Blacksburg, VA 24061-0420, Glover's direct (703) 231-6213, Tracy's direct (703) 231-5980, fax 703-231-3886. *Abstract Deadline was December 1, 1993.*

North-Central Section, Western Michigan University, Kalamazoo, Michigan, April 28–29, 1994. Alan Kehew, Department of Geology, Western Michigan University, Kalamazoo, MI 49008, (616) 387-5495, fax 616-387-5513. *Abstract Deadline was January 6, 1994.*

Rocky Mountain Section, Fort Lewis College, Durango, Colorado, May 4–6, 1994. Douglas Brew, Department of Geology, Fort Lewis College, Durango, CO 81301, (303) 247-7254, fax 303-247-7310. *Abstract Deadline was January 13, 1994.*

■ 1995

Northeastern Section, Radisson Hotel, Hartford, Connecticut, March 20–22.
Southeastern Section, Knoxville Hilton Hotel, Knoxville, Tennessee, April 6–7.
North-Central and South-Central Sections, University of Nebraska, Lincoln, Nebraska, April 27–28.
Rocky Mountain Section, Montana State University, Bozeman, Montana, May 18–19.
Cordilleran Section, University of Alaska, Fairbanks, Alaska, May 24–26.

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Positions Open

THE UNIVERSITY OF READING

Professorship of Sedimentology and Directorship of the Postgraduate Research Institute for Sedimentology. Applications are invited for the post of Director of the Postgraduate Research Institute for Sedimentology recently vacated by Professor J.R.L. Allen, FRS.

Candidates should be earth scientists with an international reputation in sedimentology in the broad sense, and should be able to provide research leadership and direction across the range of the Institute's activities, particularly as they interact with cognate departments in the Centre for Earth and Atmospheric Sciences.

A Research Fellowship, for five years, funded from the University's Research Endowment Trust, will be established in connection with the Professorship.

Further information may be obtained from the Registrar, Room 213, Whiteknights House, P.O. Box 217, The University, Whiteknights, Reading RG2HAH. Telephone 44 (0) 734 318 112; fax 44 (0) 734 874722.

The closing date for applications is 30 April 1994.

FACULTY POSITION
SOUTHERN OREGON STATE COLLEGE
GROUNDWATER GEOLOGIST

The Geology Department at Southern Oregon State College invites applications for a tenure-track faculty position (nine-month academic year appointment beginning September 16, 1994) in Groundwater Geology. The position requires the Ph.D. and is at the Assistant or Associate Professor rank. The individual selected should have strengths in hydrogeology, mineralogy-lithology, and chemistry. Teaching assignments include developing professional and popular course sequences in surface and groundwater hydrogeology; general undergraduate lecture and laboratory courses; and a professional mineralogy-lithology sequence. The successful candidate is expected to continue externally funded research and develop cooperative efforts in hydrogeology with local agencies. Applicants should forward curriculum vitae, descriptions of teaching and research interests and names of three referees to Professor Monty Elliott, Chair, Dept. of Geology, Southern Oregon State College, 1250 Siskiyou Blvd., Ashland, OR 97250. Southern Oregon State College is an Equal Opportunity/Affirmative Action Employer. Women and people of diverse racial, ethnic, and cultural backgrounds are encouraged to apply. Position will remain open until filled, but preference will be given to applications received before May 15, 1994.

DIRECTOR/EARTH SCIENTIST

The Foundation for Glacier and Environmental Research, based in the Pacific Northwest, invites applications for Director of its major field teaching and research programs, conducted annually on the fifth largest ice field in North America, the Juneau ice field, Alaska. Excellent field facilities and infrastructure exist.

We seek an earth scientist with a background in research and teaching and experience in mountain and arctic environments. Ph.D., excellent leadership, organization and communication skills and strong commitment to field training and graduate, undergraduate, and secondary education required. Ability to continue and enhance the current program's philosophy with creativity and vision necessary. Successful record in grant-writing and fund-raising desired.

Please submit letter of application, resume, and three letters of reference to Chair, Search Committee, Box 241003, Douglas, AK 99824-1003. Applications accepted until position is filled.

The Foundation is an equal opportunity/affirmative action employer.

DIRECTOR, OCEAN DRILLING PROGRAM

Joint Oceanographic Institutions, Inc. is seeking qualified candidates to fill the vacancy of Director, Ocean Drilling Programs. By agreement with the U.S. National Science Foundation, the Director is responsible for administrating the Ocean Drilling Program on behalf of its 18 partner nations. The Director is also responsible for the management of U.S. science programs affiliated with ODP. Term of the appointment is open, but the current phase of ODP runs through 1998 with an anticipated extension to 2003, and it is anticipated that the successful candidate could serve through the renewal period. Necessary minimum qualifications for the position include a Ph.D. in the ocean or geosciences, 10 years experience in research with extensive grants and contracts administration experience, and a willingness to relocate to Washington, D. C. Desirable additional qualifications include familiarity with the ODP and NSF funding procedures,and a desire to integrate scientific drilling better into ongoing ocean sciences initiatives. The position requires extensive domestic and international travel and is available immediately. The Acting Director is not a candidate. An application letter, including a complete CV and names of 6 references, should be addressed to: Director of Administrative Services, Joint Oceanographic Institutions, Inc., 1755 Massachusetts Ave., N.W., Suite 800, Washington, D. C. 20036-2102. Review of applications begins 1 April and will continue until the position is filled. JOI, Inc. is an equal opportunity/affirmative action employer.

PUBLIC INFORMATION & EDUCATION SPECIALIST (RESEARCH ASST)

Assist in developing and operating a public education and information program for the KS Geological Survey; communicate with lay citizens, policy-makers, and educators. Start on or about June 18, 1994. Required: Bachelor's or graduate degree in an earth science or in another natural science with significant coursework in an earth science; exp writing non- and semi-technical materials for public; teaching exp; excellent written & oral communication skills. Application deadline: May 13, 1994, postmark. For full application requirements & job description contact S. Cox, KS Geological Survey, Univ. of KS, 1930 Constant Ave., Lawrence KS 66047; (913) 864-3965. KU is an EO/AA employer.

Opportunities for Students

Planetary Tectonics/University of Nevada, Reno. Applications are invited from outstanding students for graduate work on the tectonics of Mars, with emphasis on faulting and rock mechanics. Support is currently available for qualified students with interest and/or aptitude in photointerpretation, planetary science, and structural geology. This research associateship offers a generous stipend with tuition and fees. UNR is located in a setting ideal for related field work and world-class recreation.

Students interested in the above research opportunity should contact Dr. Richard Schultz, Department of Geological Sciences, Mackay School of Mines/172, University of Nevada, Reno, NV 89557-0138; (702) 784-4318; fax 702-784-1766; E-mail, schultz@mines.unr.edu.

Student Travel Grants. The GSA Foundation will award matching grants to each of the six GSA Sections to assist students wishing to travel to GSA Section and Annual meetings. For applications contact individual Section secretaries. For Section information, contact GSA (1-800-472-1988).

Meetings *continued from p. 124*

Sciences, University College, Gower St., London WC1E 6BT, UK, phone 44-784-443592, fax 44-71-387-1612, E-mail (Internet): robert.hall@ucl.ac.uk.

Symposium on Inverse Problems: Geophysical Applications, December 12–14, 1994, Yosemite Fish Camp, California. Information: SIAM Conference Coordinator, 3600 University City Science Center, Philadelphia, PA 19104-2688, (215) 382-9800, fax 215-386-7999, E-mail: meetings@siam.org. *(Abstract deadline: April 25, 1994.)*

1995 Meetings

April

Geological Society of South Africa Centennial Geocongress, April 3–7, 1995, Johannesburg, South Africa. Information: Congress Secretariat, Centennial Geocongress, P.O. Box 36815, Menlo Park, 0102, South Africa, phone and fax 27-12-47-3398.

Geological Society of Nevada Symposium III: Geology and Ore Deposits of the American Cordillera, April 10–13, 1995, Reno, Nevada. Information: Bob Hatch, Chairperson, Geological Society of Nevada, P.O. Box 12021, Reno, NV 89510, (702) 323-4569, fax 702-323-3599.

■ **Third International Symposium on In Situ and On-Site Bioreclamation,** April 24–27, 1995, San Diego, California. Information: Betty Weaver, Symposium Coordinator, The Conference Group, 1989 West Fifth Ave., Suite 5, Columbus, OH 43212-1912, toll-free (U.S. and Canada) 800-783-6338, or (614) 424-5461, fax 614-488-5747. *(Abstract deadline: July 1, 1994.)*

May

Water Resources at Risk, May 14–18, 1995, Denver, Colorado. Information: Helen Klose, American Institute of Hydrology, 3416 University Ave., S.E., Minneapolis, MN 55414, (612) 379-1030.

17th International Geochemical Exploration Symposium, Exploring the Tropics, May 15–19, 1995, Townsville, Queensland, Australia. Information: Russell Myers, 171GES, National Key Centre in Economic Geology, James Cook University, Townsville, Q4814, Australia, phone 61-77-814486, fax 61-77-815522.

Geological Association of Canada–Mineralogical Association of Canada Joint Annual Meeting, May 17–19, 1995, Victoria, British Columbia, Canada. Information: Chris Barnes, General Chair, SEOS, University of Victoria, P.O. Box 1700, Victoria, B.C. V8W 2Y2, Canada, fax 604-721-6200.

1995 World Geothermal Congress, May 18–31, Florence, Italy. Information: George Frye, Executive Director, International Geothermal Association, LBL 50C, Rms. 106–108, One Cyclotron Road, Berkeley, CA 94720, (510) 486-4584, fax 510-486-4889.

July

■ **Seventh International Williston Basin Symposium,** July 23–25, 1995, Billings, Montana. Information: W. Kipp Carroll, General Chairman, (406) 245-2367. *(Abstract deadline: July 15, 1994.)*

August

Tectonics and Metallogeny of Early/Mid Precambrian Orogenic Belts, August 28–September 1, 1995, Montreal, Canada. Information: J. A. Percival, Geological Survey of Canada, 601 Booth St., Ottawa, Ontario K1A 0E8, Canada, (613) 995-4723, fax 613-995-9273, E-mail: jpercival@601C.gsc.emr.ca, or J. N. Ludden, Dept. de Géologie, Université de Montréal, CP 6128, Succ. A, Montréal, Québec H3C 3J7, Canada, (514) 343-7389, fax 514-343-5782, E-mail: luddenj@ere.umontreal.ca.

Third Hutton Symposium: The Origin of Granites, August 28–September 2, 1995, College Park, Maryland. Information: Michael Brown, Dept. of Geology, University of Maryland, College Park, MD 20742, (301) 405-4082, fax 301-314-9661.

October

■ **Fifth International Conference on Seismic Zonation,** October 17–19, 1995, Nice, France. Information: Earthquake Engineering Research Institute, 499 14th St., Suite 320, Oakland, CA 94612-1902, (510) 451-0905, fax 510-451-5411; or Association for Earthquake Engineering, Domaine de Saint-Paul, BP 1, 78470 Saint-Rémy-lès-Chevreuse, France, 30-85-22-03, fax 30-52-75-75.

Send notices of meetings of general interest, in format above, to Editor, *GSA Today*, P.O. Box 9140, Boulder, CO 80301.

Abstract Forms Available Now

GSA Annual Meeting

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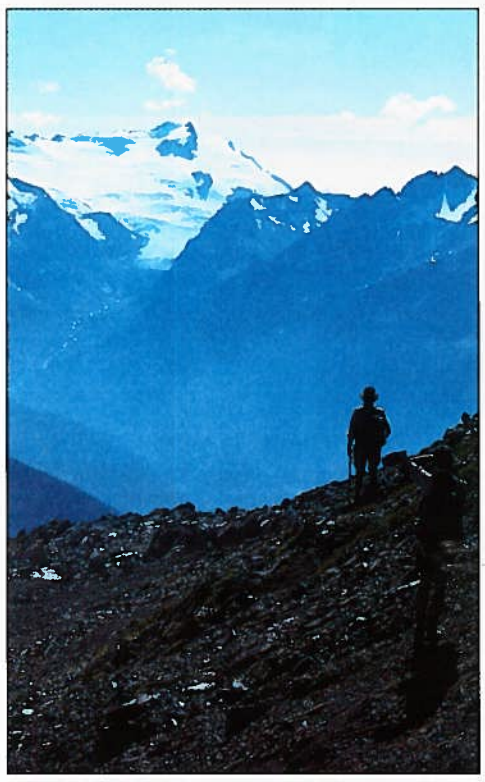


- **Abstract Deadline: July 6**
  See page 105
- **Preregistration Deadline: September 16**

Registration and Housing Forms available in June *GSA Today*

Recently Released from GSA

Processes Controlling the Composition of Clastic Sediments

by Mark J. Johnsson and Abhijit Basu, 1994

Compositional data from clastic sediments commonly provide the only available constraints to the composition of eroded land masses. Studies of orogenic development, paleotectonic and paleogeographic relationships, and regional correlation may depend on the interpretation of such data. This volume addresses the complex partitioning processes operating during pedogenesis, erosion, transport, and deposition and how they interact to determine the compositions of modern and ancient clastic sediments. The 20 papers are organized into sections dealing with lithology/tectonics, chemical weathering, mechanical controls on sediment composition, and specific depositional systems. Two preview papers provide a comprehensive overview and a look at recent geochemical advances in studies of provenance.

SPE284, 352 p., paperback, indexed, ISBN 0-8137-2284-5, $75.00

Modern and Ancient Coal-Forming Environments

edited by J. C. Cobb and C. B. Cecil, 1993

The peat origin of coal has long been known, but specific processes of peat accumulation have not been clearly identified. This is primarily because peat accumulates in a wide variety of environments, not all of which produce coal formations of economic value. This volume addresses the origin of coal and coal-bearing strata and presents climate and doming in peat deposits as important factors. Data, observations, and interpretations from modern peat deposits in North American deposits of Pennsylvanian age are presented. The concepts of climatic control and doming discussed in this volume are sure to contribute to better understanding of coal geology, as the cyclothem and deltaic concepts did in the past.

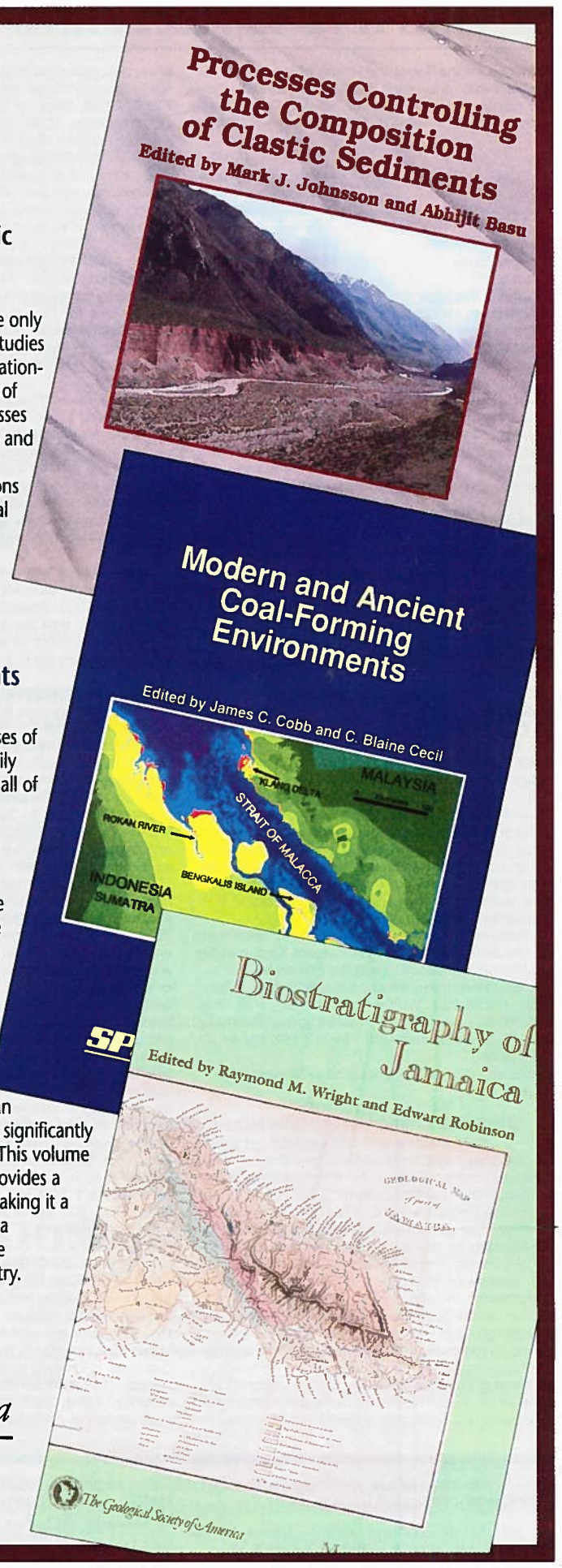
SPE286, 202 p., paperback, ISBN 0-8137-2286-1, $52.50

Biostratigraphy of Jamaica

edited by Raymond M. Wright and Edward Robinson, 1994

Although Jamaican biostratigraphy has been studied for more than 150 years, in the past two decades intensified field work there has significantly advanced our understanding of this important Caribbean island. This volume includes primarily descriptive articles, very clearly presented. It provides a taxonomic and photographic key to the Jamaica marker fossils, making it a useful reference work for academia, research, and industry, and as a supplemental textbook. It also is an invaluable source book on the Cretaceous and Paleogene biostratigraphy of a low-latitude country.

MWR182, 504 p., hardbound, indexed, 0-8137-1182-7, $118.75



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