

A New Look at Evolutionary Rates in Deep Time: Uniting Paleontology and High-Precision Geochronology

Samuel A. Bowring, Department of Earth, Atmospheric and Planetary Sciences, Massachusetts Institute of Technology, 54-1124, 77 Massachusetts Avenue, Cambridge, MA 02139, sbowring@mit.edu.
Douglas H. Erwin, Department of Paleobiology, MRC-121, National Museum of Natural History, Washington, DC 20560, erwin.doug@nmnh.si.edu



Figure 1. The Permian-Triassic boundary at Meishan, China, showing dates for the ash beds described in Bowring et al. (1998). The end Permian mass extinction is recorded within the last 1 m below the lowest ash bed (left). This ash bed lies about 10 cm below the Permian-Triassic boundary as defined on the basis of conodonts, and just below the major isotopic excursion. The upper two ash beds are in Lower Triassic strata.

ABSTRACT

It is now possible to routinely determine the age of 200–600-m.y.-old volcanic rocks interlayered with fossil-bearing deposits to uncertainties of less than 1 m.y. with uranium-lead zircon geochronology. This level of precision, coupled with the recognition that volcanic ash beds are much more common in fossiliferous rocks than previously realized, opens new opportunities for the study of evolutionary rates in deep time. It is now possible to constrain rates of evolutionary radiations, mass extinctions, and other evolutionary events as well as evaluate potentially diachronous biostratigraphic boundaries. For example, a combination of detailed biostratigraphic and chemo-

stratigraphic data with new U-Pb zircon dates for the late Neoproterozoic and Early Cambrian has demonstrated that the soft-bodied Ediacaran fossils immediately underlie the Cambrian, that the base of the Cambrian is much younger than previously recognized, and that the Cambrian explosion lasted 10 m.y. or less. Other recent studies have shown the Middle and Late Cambrian each lasted only about 10 m.y., suggesting that the duration of the included trilobite zones was similar to those of Jurassic ammonites. Recent data from the Late Permian and earliest Triassic of south China now constrain the duration of the most profound mass extinction in the history of life to less than 1 m.y. Collaboration between paleontologists

and geochronologists offers the prospect of accurately assessing the rates of evolutionary processes, from speciation to evolutionary radiations and mass extinctions, throughout the Phanerozoic.

"How fast, as a matter of fact, do animals evolve in nature? That is the fundamental observational problem that the geneticist asks the paleontologist" (Simpson, 1944).

INTRODUCTION

Answers to Simpson's question about evolutionary rates have generally lacked precision, particularly for the pre-Cenozoic. Although many paleontological

Evolutionary Rates *continued on p. 2*

TORONTO

See titles/
authors
database
— [http://www.
geosociety.org](http://www.geosociety.org)

Technical Program
Schedule
— page 19

1998
Annual Meeting
Preregistration
Deadline
— September 18

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

Copyright © 1998, The Geological Society of America, Inc. (GSA). All rights reserved. Copyright not claimed on content prepared wholly by U.S. Government employees within the scope of their employment. Permission is granted to individuals to photocopy freely all items other than the science articles to further science and education. Individual scientists are hereby granted permission, without royalties or further requests, to make unlimited photocopies of the science articles for use in classrooms to further education and science, and to make up to five copies for distribution to associates in the furtherance of science; permission is granted to make more than five photocopies for other noncommercial, non-profit purposes furthering science and education upon payment of a fee (\$0.25 per page-copy) directly to the Copyright Clearance Center, 222 Rosewood Drive, Danvers, MA 01923 USA, phone (978) 750-8400, <http://www.copyright.com>; when paying, reference *GSA Today*, ISSN 1052-5173. Written permission is required from GSA for all other forms of capture, reproduction, and/or distribution of any item in this publication by any means, including posting on authors' or organizational Web sites, except that permission is granted to authors to post the abstracts only of their science articles on their own or their organization's Web site providing the posting includes this reference: "The full paper was published in the Geological Society of America's news-magazine, *GSA Today*, [include year, month, and page number if known, where article appears or will appear]." GSA provides this and other forums for the presentation of diverse opinions and positions by scientists worldwide, regardless of their race, citizenship, gender, religion, or political viewpoint. Opinions presented in this publication do not reflect official positions of the Society.

SUBSCRIPTIONS for 1998 calendar year: Society Members: *GSA Today* is provided as part of membership dues. Contact Membership Services at (800) 472-1988, (303) 447-2020 or member@geosociety.org for membership information. Nonmembers & Institutions: Free with paid subscription to both *GSA Bulletin* and *Geology*, otherwise \$50 for U.S., Canada, and Mexico; \$60 elsewhere. Contact Subscription Services. Single copies may be requested from Publication Sales. Also available on an annual CD-ROM, (together with *GSA Bulletin*, *Geology*, GSA Data Repository, and an Electronic Retrospective Index to journal articles from 1972); \$89 to GSA Members, others call GSA Subscription Services for prices and details. Claims: For nonreceipt or for damaged copies, members contact Membership Services; all others contact Subscription Services. Claims are honored for one year; please allow sufficient delivery time for overseas copies, up to six months.

STAFF: Prepared from contributions from the GSA staff and membership.
Executive Director: *Donald M. Davidson, Jr.*
Science Editors: *Suzanne M. Kay*, Department of Geological Sciences, Cornell University, Ithaca, NY 14853;
Molly F. Miller, Department of Geology, Box 117-B, Vanderbilt University, Nashville, TN 37235.
Forum Editor: *Bruce F. Molnia*, U.S. Geological Survey, MS 917, National Center, Reston, VA 22092
Director of Publications: *Peggy S. Lehr*
Managing Editor: *Faith Rogers*
Assistant Editor: *Vanessa Carney*
Production Manager: *Jon Olsen*
Production Editor and Coordinator: *Joan E. Manly*
Graphics Production: *Joan E. Manly, Leatha L. Flowers*

ADVERTISING: Classifieds and display: contact Ann Crawford, (303) 447-2020; fax 303-447-1133; acrawfor@geosociety.org.

Issues of this publication are available as electronic Acrobat files for free download from GSA's Web Site, <http://www.geosociety.org>. They can be viewed and printed on various personal computer operating systems: MSDOS, MSWindows, Macintosh, and Unix, using the appropriate Acrobat reader. Readers are available, free, from Adobe Corporation: <http://www.adobe.com/acrobat/readstep.html>.

This publication is included on GSA's annual CD-ROM, *GSA Journals on Compact Disc*. Call GSA Publication Sales for details.
Printed in U.S.A. using pure soy inks.



50% Total Recovered Fiber
10% Postconsumer

IN THIS ISSUE

A New Look at Evolutionary Rates in Deep Time: Uniting Paleontology and High-Precision Geochronology	1	1998 Annual Meeting—Toronto	
In Memoriam	2	Late-Breaking Research Sessions	17
Correction	2	Program Calendar	19
About People	3	Short Courses	24
New IEE Director	3	Grad School Information Forum	25
GSA Thanked for Books	8	Student Breakfast	25
Notice of Open Council Meeting	8	Call for Proposals—Denver 1999	25
Washington Report	10	1999 Section Meetings	
Earth Science Week	11	South-Central	27
GSAF Update	12	Northeastern	28
Energy for the 21st Century	12	Southeastern	31
Rock Stars: J. W. Dawson	14	GSA Awards Research Grants	33
New Congressional Science Fellow	16	<i>Bulletin</i> and <i>Geology</i> Contents	35
		Future GSA Meetings	36
		Classifieds	37
		Calendar	39

In Memoriam

Saul Aronow Beaumont, Texas May 15, 1998	Laurence B. James Folsom, California June 8, 1998	Mark Springett Boulder, Colorado July 16, 1998
Robert E. Barnett Washington Court House, Ohio	Louis Pavlides College Park, Maryland April 8, 1998	Leonard R. Wilson Norman, Oklahoma July 15, 1998
Bruce B. Hanshaw McLean, Virginia July 18, 1998	Grover Reinbold Reno, Nevada April 24, 1998	

CORRECTION: July Science Article

The illustration in the center of the July 1998 issue (p. 16 and 17) is Figure 2 (not Figure 3) of the paper "Probing the Archean and Proterozoic Lithosphere of Western North America" by Deep Probe Working Group. The Figure 2 caption on p. 4 should be on p. 16, and the Figure 3 caption on p. 16 should be on p. 4.

On p. 3, leftmost column, the fourth line under the head Seismic Observations: Three Province-Related Seismic Signatures should be: Cheyenne belt (Fig. 2; see p. 16–17), and the footnote at the bottom of the leftmost column on p. 4 should be: Figure 2 is on p. 16–17.

Evolutionary Rates continued from p. 1

issues have revolved around evolutionary rates, the inadequacies of the geologic time scale have generally precluded their resolution. Yet, accurate determination of rates is critical to answering important questions: How does the rate of speciation vary in different environments? How long do stable community assemblages persist? How much time is involved in evolutionary radiations or postextinction recoveries? How rapidly do species and communities respond to climatic and other environmental changes? And perhaps most significant, have these rates changed through the Phanerozoic? Without good data on the amount of time involved in these events, any determination of rate must be suspect.

Rates of some evolutionary and geologic processes can be determined from the Cenozoic with some precision by means of a variety of techniques (e.g., climatic cyclicity, paleomagnetic reversals; Hilgen et al., 1997). However, farther back in the geologic record, the precision with which we can resolve events decreases, the accuracy of the geologic time scale degrades, and the reliability of information used to assess evolutionary rates falls dramatically. Consequently, much of our current knowledge of rates of change is based on interpolation of absolute time between a few well-constrained tie points used to construct relatively imprecise geologic time scales (e.g., Harland et al., 1990), often with the additional assumption that equal thicknesses of rock represent equal amounts of time.

About People

GSA Fellow Daniel Jean Stanley, National Museum of Natural History, Washington, D.C., was chosen by Italian universities to receive the Golden Trident Medal, a first for a North American scientist. He was also inducted as a member of Italy's Accademia Internazionale di Scienze e Tecnica.

GSA Fellow Julia Ann Tullis, Brown University, Providence, Rhode Island, will receive the 1998 Outstanding Educator Award from the Association for Women Geoscientists Foundation.

NEW DIRECTOR FOR IEE

Cathleen May has joined the headquarters staff at GSA as the Director of the Institute for Environmental Education. Cathleen previously directed the national paleontological resources management program for the U.S. Forest Service. More recently, she has consulted to government and professional societies on resource management and legislative issues, and to the entertainment industry on issues of scientific accuracy and literacy.

May earned undergraduate degrees in geology and in secondary science education at the University of Wyoming and her doctorate in integrative biology at the University of California at Berkeley. Her primary research has focused on macroevolutionary patterns in the terrestrial Triassic, particularly as recorded in northwest Argentina, and on geocological contingency in modern ecosystems. May brings to the IEE her long-standing commitment to the crucial role of the geosciences in building scientific literacy, environmental problem-solving, and Earth-system science. Contact May regarding the IEE and its programs at cmay@geosociety.org, or IEE administrative support person Stacey Ginsburg at sginsbur@geosociety.org.



Cathleen May

For Paleozoic and Mesozoic rocks, high-precision U-Pb geochronology of zircons can be exploited to yield uncertainties of 1 m.y. or less. The continued refinement of chemical separations of U and Pb from zircon and the improvement of mass spectrometry allow high-precision analyses of single grains of zircon containing as little as 10 picograms (10^{-12} g) of radiogenic Pb (Mundil et al., 1996; Bowring et al., 1998). The ultimate test of the resolving power of the technique occurs when multiple volcanic horizons are interlayered with fossil-bearing rocks and the calculated ages do not violate stratigraphic order.

The integration of geochronology, paleontology, and chemostratigraphy has revolutionized our knowledge of several important episodes in geologic history, including the sudden major increase of animals during Neoproterozoic to Cambrian time and, most recently, the most extensive mass extinction in the history of life, the end-Permian event (Fig. 1).

EVOLUTIONARY RATES

Although Simpson (1944) identified and focused on the importance of determining fine-scale evolutionary rates, he was handicapped by lack of data on absolute dates. Kurten (1959) found that rates of morphological change in Pleistocene mammals exceeded mammalian evolutionary rates during the Tertiary. Subsequent work has established that these higher rates were an artifact: Evolutionary rates are inversely related to time scale. The shorter the time period studied, the faster the observed rates of change, whether the object of study is morphology (Gingerich, 1983, 1993), or sedimentation (Sadler, 1981). This is simply because slow long-term rates are difficult to measure over the short term and because fast long-term rates are generally unsustainable over

the long term. Since evolutionary rates are strongly dependent upon the interval of time over which they are measured, they can only be meaningfully compared when the same time scale is used (Gingerich, 1993; Foote, 1994).

More recently, the determination of precise evolutionary rates has faded from current paleobiological research in favor of identification of large-scale macroevolutionary patterns. This is in part because temporal resolution has been too coarse to allow evaluation of finer-scale processes (Campbell and Marshall, 1987). Recent developments in geochronology suggest that it is time for a new examination of the issue of evolutionary rates, at the scale envisioned by Simpson (1944).

GEOCHRONOLOGY

Since stratigraphic thickness cannot be simply extrapolated to geologic time, a large number of high-precision ages from interstratified volcanic ash beds are required in order to evaluate rates of geological change. In the past 10 years there has been a dramatic increase in the number of studies concerned with calibration of the time scale (e.g., Tucker et al., 1990; Tucker and McKerrow, 1995; Claoue-Long et al., 1991; Mundil et al., 1996; Tucker et al., 1998). The U-Pb method applied to zircons separated from stratabound volcanic layers is a powerful method for dating sedimentary rocks because it exploits two independent decay schemes ($^{238}\text{U} \rightarrow ^{206}\text{Pb}$ and $^{235}\text{U} \rightarrow ^{207}\text{Pb}$) within each zircon sample. This method provides independent age information and a test for the degree to which the systems were closed following crystallization. If a closed system has been maintained, the two U-Pb dates ($^{238}\text{U}/^{206}\text{Pb}$ and $^{235}\text{U}/^{207}\text{Pb}$) and the Pb-Pb date ($^{207}\text{Pb}/^{206}\text{Pb}$) for a zircon analysis should be the same within uncertainties and are referred to as concordant.

The past 15 years have seen marked improvement in high-precision isotope dilution-thermal ionization mass spectrometry (IDTIMS) U-Pb dating of zircons (Krogh, 1982; Parrish and Krogh, 1987). This is largely the result of being able to analyze small amounts of zircon that may contain as little as $10\text{--}25 \times 10^{-12}$ g of radiogenic Pb. This capability is the result of low analytical blanks ($0.5\text{--}2.0 \times 10^{-12}$ g of common Pb) and improvement in mass spectrometry, especially ion-counting techniques. Although these methods have revolutionized our understanding of how geological time is distributed in the rock record, only recently has the full potential of this technique begun to be realized. High precision for its own sake is often not an efficient strategy. We feel that the calibration of evolutionary rates is an example of a problem that requires the maximum resolving power of the U-Pb technique. For example, Tucker et al. (1990) showed through high-precision zircon geochronology that the mean duration of Ordovician graptolite zones is 1–2 m.y. and recognized that with this approach, evolutionary rates of Paleozoic fauna could be evaluated. Hughes (1995) used available U-Pb geochronology to constrain durations of Silurian graptolite zones; the range was 0.44–1.43 m.y.

Calibration of the Time Scale

Geochronometric calibration of a relative, chronostratigraphic time scale is straightforward. Ideally, a volcanic rock is found very close to the point in a stratigraphic section chosen as the global stratotype for the boundary between two geologic intervals, and the volcanic rock contains a mineral, such as zircon or monazite, for which a precise crystallization age can be determined. Such ideal situa-

Evolutionary Rates *continued on p. 4*

tions are uncommon, and so calibration requires dating rocks elsewhere in sections that can be correlated to the stratotype by means of bio-, chemo-, and magnetostratigraphy. The late Neoproterozoic-Cambrian boundary, for example, is defined as a point in rock in a section located in southeastern Newfoundland (Landing, 1992), but no volcanic rocks are present at or in close proximity to the boundary (Myrow and Hiscott, 1993; Landing, 1992). Consequently, the age of the boundary can be calibrated only through correlation with other sections that contain datable volcanic rocks in close proximity to the boundary.

It is a useful exercise to consult your favorite time scale to see how the age of a particular boundary was determined. The chronostratigraphic time scales that we all depend on (Harland et al., 1990; Shergold, 1995; Gradstein et al., 1995) typically assign an absolute age for a biostratigraphic boundary that reflects averaging of several, often imprecise age determinations and estimates; in many cases the uncertainty is several million years. As the geochronological resolution and the number of calibration studies has increased dramatically in the past ten years, existing time scales have been rendered inadequate, especially for the Paleozoic (Fig. 2).

Methods

Pb analyzed from zircon samples is a mixture of radiogenic and common Pb. Radiogenic Pb is produced by the decay of U in the zircon crystal. A small amount of common Pb is sometimes incorporated into the zircon when it crystallizes, and common Pb is added to the sample via sample processing (analytical blank). When calculating a date for a zircon, one must subtract the common Pb from the total Pb, and in doing so, one must assume a composition of both the blank and any indigenous common Pb. In general, the uncertainties associated with making blank and common Pb corrections can be minimized with large radiogenic Pb/common Pb ratios, which generally scale with sample size. Sources of systematic error may include error in spike calibration and uncertainty in the decay constants for uranium. These later uncertainties would apply to all analyses done in a particular lab; although they might affect absolute age determinations, the relative age differences between beds are not affected. Systematic errors can be a problem when comparing dates obtained by different methods.

Resolution of time with uncertainties of 1 m.y. or less in volcanic rocks provides a special set of problems. The most significant is the ability to distinguish small amounts of Pb loss and/or inheritance. It is common in airfall ash deposits to find

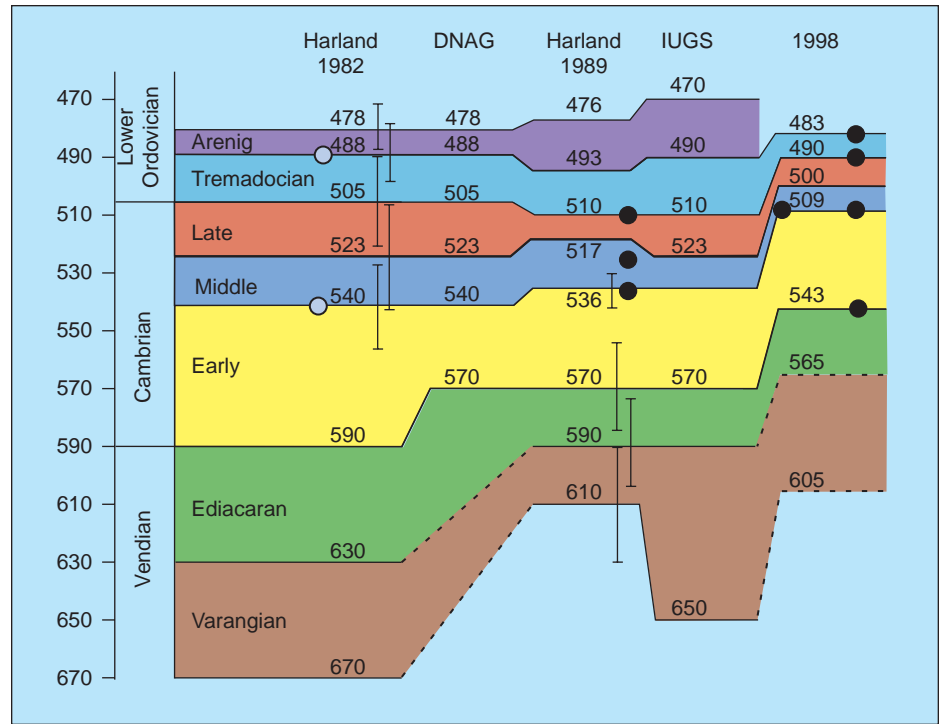


Figure 2. Changing views of late Neoproterozoic–Early Ordovician time. The estimated boundary dates shown are from Harland et al. (1982), the Decade of North American Geology (DNAG) in 1983, Harland et al. (1990), the International Union of Geological Sciences (IUGS; Cowie and Bassett, 1989), and the latest evidence (1998) discussed in this paper. The open circles represent poorly constrained geochronologic tie-points and the black circles better-constrained tie-points. Error bars are shown for the Harland et al. time scales. Note that the Manykaian stage was added to the Cambrian in 1992, and that the subdivisions of the late Neoproterozoic have not been firmly established.

zircon grains, probably incorporated into the eruption column, that are identical in morphology to the indigenous population, but which can be <1 to >10 m.y. older (Landing et al., 1998). This problem can be minimized by analyzing single grains of zircon. A zircon crystal's size and its concentration of radiogenic Pb ultimately determine whether or not single-grain analysis is feasible. One seeks as high a ratio of radiogenic to common Pb as possible for each analysis. In this way, the uncertainty on all three dates ($^{206}\text{Pb}/^{238}\text{U}$, $^{207}\text{Pb}/^{235}\text{U}$, and $^{207}\text{Pb}/^{206}\text{Pb}$) is low (0.1%–0.5%), and the difference between the $^{206}\text{Pb}/^{238}\text{U}$ and $^{207}\text{Pb}/^{235}\text{U}$ dates can be evaluated for inheritance of slightly older grains and/or Pb-loss. In the case of complex zircons, it is often necessary to relax precision requirements so as to be able to analyze a single grain or grain fragment. It is this trade-off that requires the super-high-resolution ion microprobe (SHRIMP) to rely on the $^{206}\text{Pb}/^{238}\text{U}$ date when determining the age of Paleozoic zircons (e.g., Claoue-Long et al., 1995).

In the best-case scenario, a statistically significant cluster of concordant analyses is obtained for each sample, and weighted mean $^{206}\text{Pb}/^{238}\text{U}$, $^{207}\text{Pb}/^{235}\text{U}$ and $^{207}\text{Pb}/^{206}\text{Pb}$ dates are calculated. More commonly, a suite of zircons is discordant and defines a linear array that intersects concordia. In these cases, uncertainty in

the age of the zircons can be calculated for the intersection of the discordant array with the concordia curve (Ludwig, 1980), or, more often, the weighted mean of the $^{207}\text{Pb}/^{206}\text{Pb}$ dates can be used (e.g., Tucker et al., 1998; Bowring et al., 1993). When this approach is used, the minimum uncertainty in age is generally 1–2 m.y. There is no question that the best results are obtained from concordant zircons, and in older rocks they become increasingly difficult to find. Our technique could be termed the "brute force" approach. We typically attempt to analyze a minimum of 5–10 fractions of zircon for each ash bed to assess our reproducibility and to reduce errors in the age (this does not include the analyses that show evidence for inheritance, severe Pb loss, high common Pb, etc.). The test of our approach is to analyze multiple samples of the same horizon, as well as different beds in stratigraphic order (Grotzinger et al., 1995; Bowring et al., 1998).

RESOLVING THE CAMBRIAN RADIATION

The explosive diversification of higher marine invertebrates in the Early Cambrian is the single most dramatic event documented in the fossil record. Rocks that are late Neoproterozoic in age contain the soft-bodied remains of Edi-

Millions of Years
Before Present

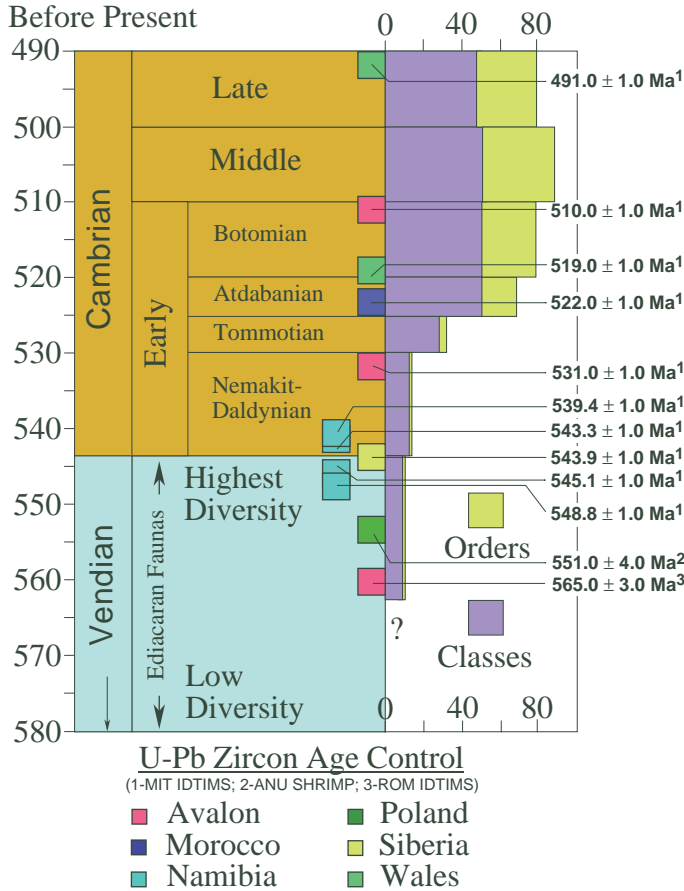


Figure 3. Summary diagram of biostratigraphically and geochronologically well constrained samples that define the late Vendian to Late Cambrian time scale (after Bowring et al., 1993; Grotzinger et al., 1995). Newer data are from: Compston et al. (1995), Landing et al. (1998), and Davidek et al. (1998). MIT IDTIMS is Massachusetts Institute of Technology, isotope dilution-thermal ionization mass spectrometry; ANU SHRIMP is Australian National University, super-high-resolution ion microprobe; ROM is Royal Ontario Museum.

Ediacaran fossils and a small assemblage of skeletonized tubes, as well as recently discovered fossil embryos and sponge spicules (ca. 570 Ma; Xiao et al., 1998; Li et al., 1998). The first Cambrian shelly fossils occur in carbonates near the base of the Manykaian Stage, currently the basal stage of the Cambrian. Trace fossils, skeletal fossils, and spiny organic microfossils diversified rapidly during the ensuing Tommotian and Atdabanian stages, so that by the end of the Atdabanian, most durably skeletonized phyla and classes of marine invertebrates are recognized. Controversy continues over the rapidity of this radiation and the possibility that considerable diversity existed long before the base of the Cambrian, but has not been recognized in the fossil record because of small size or low preservation potential.

Since 1990, U-Pb geochronological studies have constrained the age of the late Neoproterozoic-Cambrian boundary, the duration of diverse Ediacaran fossils, the burst of innovations during the Tommotian-Atdabanian, the Lower-Middle Cambrian boundary, and the Cambrian-Ordovician boundary (Compston et al., 1992, 1995; Bowring et al., 1993; Isachsen et al., 1994; Grotzinger et al., 1995; Landing et al., 1997, 1998; Davidek et al., 1998). Figure 3 is a revised time scale for the Cambrian Period showing the control

provided by U-Pb zircon ages on biostratigraphic boundaries.

Although volcanic rocks are uncommon interbedded with Ediacaran fossils, the fossils generally postdate Varanger-aged glaciogenic rocks (ca. 600 Ma) in eastern North America. In Newfoundland, Benus (1988) reported an age for volcanic rocks immediately overlying Ediacaran fossils at 565 ± 3 Ma. Compston et al. (1995) reported for volcanic rocks from the subsurface of Poland which are correlated with Ediacaran-bearing strata in Ukraine an age of 551 ± 4 Ma. Grotzinger et al. (1995) and Narbonne et al. (1997) have documented Ediacaran fossils including the new genus *Swartpuntia* immediately below the basal Cambrian in Namibia; this deposit is younger than 543.3 ± 1 Ma. Grotzinger et al. (1995) also showed that diverse small shelly fossils overlap with the Ediacaran fossils in Namibia. Although the Cambrian is often viewed as lacking Ediacaran fossils, several exceptions have appeared recently (Crimes et al., 1995; Conway Morris, 1993; Jensen et al., 1998). The lack of any obvious gap between the last Ediacaran fossils and the onset of Cambrian fossils leads to the simple conclusion that the Cambrian explosion is part of a continuous evolutionary radiation that started in the late Neoproterozoic (Grotzinger et al., 1995). The bios-

trigraphically defined boundary does not mark a sudden event or explosion in the diversification of life, but instead serves as an important reference point in an increasingly rich evolutionary record.

Carbon isotope stratigraphy is an essential tool for correlating latest Neoproterozoic rocks. Globally, many stratigraphic sections have yielded very similar fluctuations in carbon isotopes (Kaufman et al., 1997; Narbonne and Knoll, 1994). This pattern of isotopic variation provides an independent framework for correlation between sections and allows, in some cases, calibration of the isotopic shifts by dating volcanic layers. In Namibia, Grotzinger et al. (1995) showed that an isotopic interval known as the +2 plateau has a duration of about 5–6 m.y. and coincides with occurrence of the most diverse Ediacaran assemblages.

Temporal calibration of past global events, correlated using bio-, chemo-, and magnetostratigraphic data sets, is possible only with the precise absolute age control offered by U-Pb zircon dating of volcanics interlayered within sedimentary sequences. This temporal framework has important implications for our understanding of biological diversification and its possible links to contemporaneous tectonic, biogeochemical, and climatic changes. Exciting problems remain unresolved. What is the lower boundary of the Ediacaran faunas? Can we resolve time sufficiently during the late Neoproterozoic to identify distinct assemblages of fossils or migration between different biogeographic regions? Will additional data on the Manykaian Stage allow better temporal constraints on the gradual expansion of the small shelly fossils? Is the distribution of Ediacaran organisms diachronous?

NEW RESULTS FOR THE MIDDLE CAMBRIAN-EARLY ORDOVICIAN

Trilobites dominate Middle and Late Cambrian marine assemblages in both species diversity and numbers of specimens. Rapid speciation in trilobites has allowed biostratigraphers to divide the Middle Cambrian of Laurentia into six biostratigraphic zones, and the Upper Cambrian into seven (but see Geyer and Palmer, 1995). A detailed examination of the evolutionary patterns underlying trilobite history during this time reveals a more interesting pattern, however. In 1965 A. R. Palmer recognized a series of five larger biostratigraphic units, each beginning with a small number of trilobite families unrelated to those in underlying rocks. He traced the rapid diversification of these families across several biostratigraphic zones; the resulting diverse assemblage was finally eliminated by a mass extinction, and the cycle was repeated.

Evolutionary Rates *continued on p. 6*

These extinction events cross a variety of facies and, significantly, are not associated with lithological changes (Palmer, 1965, 1979, 1984; Stitt, 1971, 1975; Thomas, 1995). These biomere events, as Palmer termed them, also affect brachiopods, conodonts, and other taxa.

The causes of these events have been the subject of considerable debate; some authors have favored shelf-wide declines in water temperature (Stitt, 1971, 1975), perhaps associated with an incursion of anoxic water (Palmer, 1984). Others have favored a model tied to sea-level rise and a migration of deep-water taxa into near-shore environments (Westrop and Ludvigsen, 1987). Testing these alternative explanations and determining how quickly the extinctions and the subsequent adaptive radiations took place require tight constraints on time. The DNAG time scale, similar to other time scales of that vintage (Fig. 2), depicts a Middle Cambrian of 17 m. y. and a Late Cambrian of 18 m. y., yielding an average duration of a biostratigraphic zone of 2.8 m. y. and 2.6 m. y., respectively, with biomes averaging 7 m. y.

High-precision geochronology, while not yet to the level of the Cambrian radiation, has already changed this picture considerably. With the Ordovician boundary at about 490 Ma (Davidek et al., 1998) and the base of the Middle Cambrian at 509 Ma (Landing et al., 1998), the 13 trilobite zones of the Middle and Upper Cambrian now have an average duration of 1.5 m. y. and the biomes average 4 m. y. The trilobite zones are not of equal duration—those early and late in each biome are generally shorter (Shergold, 1995), but the length of these zones now approaches that of Jurassic ammonites, and the rates of speciation, migration, and overturn are all very high. Improved geochronology may help resolve intercontinental problems (e.g., Geyer and Palmer, 1995) and, if the appropriate circumstances are identified, may be combined with biogeographic information and phylogenetic analysis to determine rates of immigration at the base of biomes.

RATES OF THE END-PERMIAN MASS EXTINCTION

The Paleozoic ended at 251 Ma with the most severe mass extinction of the Phanerozoic. An estimated 85% of all marine species disappeared during the Late Permian, along with about 70% of land vertebrates and a significant number of plants and insects (Erwin, 1994; Retallick, 1995). The next largest mass extinction, at the close of the Ordovician, was only half as large. The end-Permian mass extinction eliminated the major marine communities of the Paleozoic, and in its

aftermath an entirely new suite of communities developed which, in many ways, continue to dominate modern oceans.

The causes of this extinction have long been enigmatic, in part because marine sections spanning the critical interval are relatively rare. Over the past decade, considerable advances have been made, and paleontologists, working together with geochemists and others, have established several important aspects of this extinction. Anoxia is present in both deep-ocean (Isozaki, 1997) and shallow-ocean sections (Wignall et al., 1996) across the Permian-Triassic boundary, the latter during a time of marine transgression. Analyses of carbon isotope patterns across the boundary show multiple, brief, negative excursions (Holser and Schonlaub, 1991; Wignall et al., 1996), and are found in both marine and terrestrial sections, demonstrating that extinctions were essentially simultaneous in both realms. There is no evidence for glaciation near the boundary, but there is growing evidence for some degree of global warming in the earliest Triassic. Finally, the mass-extinction patterns are consistent with the effects of poisoning by massive amounts of CO₂ (Knoll et al., 1996).

How did these events interact to trigger this mass extinction? The age of the Permian-Triassic boundary at the classic Meishan section between Shanghai and Nanjing, China was determined to be ca. 251 Ma (Claoue-Long et al., 1991; Renne et al., 1995), but knowing the age of the boundary without additional age constraints provides no reliable estimates of the duration of the extinction. On the basis of rock thickness and the number of biostratigraphic zones, a variety of estimates have been offered for the duration of the Late Permian stages, ranging between 2 and 10 m. y.

Recently, in conjunction with Jin Yugan and his colleagues at the Nanjing Institute of Geology and Paleontology, we have used the techniques described above to date a series of ash beds (Fig. 1) in south China that bracket the Permian-Triassic boundary and are well constrained biostratigraphically (Bowring et al., 1998). Because our results are tied to previous biostratigraphic and chemostratigraphic studies, they are of immediate significance beyond south China, and they provide the first constraints on the rapidity of the extinction and the association between the extinction and the related environmental changes. In particular, Bowring et al. (1998) showed that in the Meishan section, a sharp spike in $\delta^{13}\text{C}_{\text{carb}}$ of -6‰ occurred in less than 160 000 yr and perhaps as little as 10 000 yr (using the dates to calculate accumulation rates within this section). The latest Permian extinction occurred in less than 1 m. y. and could be coincident with the isotopic shift. At the

moment, the geochronological resolution of the extinction pattern is more detailed than the paleontological resolution. Further paleontological studies employing the statistical methods could help to sort out the rapidity of the extinction and help to constrain possible mechanisms. Models for the extinction that involve changes related to aggregation of Pangea at that time (e.g., Faure et al., 1995) seem incompatible with the rapid pulse of extinction. The rapidity implies events at the 100 000 yr level, compatible with proposed oceanographic changes (e.g., Knoll et al., 1996) such as overturn or even bolide impact (Bowring et al., 1998). More work on the fine-scale texture of the extinction and associated geochemical changes is required to further constrain the mechanisms of extinction. Outstanding issues are whether the terrestrial extinction occurred at the same time as the marine, and whether the extinction was globally synchronous. With the ability to resolve time at the 200 000–300 000 yr level, this question is of extreme importance.

Following the biggest extinction in Earth history, life recovered dramatically, although in a fundamentally different world. The recovery period of the Early Triassic provides an opportunity to quantify rates of rapid diversification into a relatively barren ecosystem following the end-Permian extinction. A comparison of evolutionary rates and paleobiogeographic controls may be the best analog to the Cambrian radiation. Comparisons of this sort should help us to better understand the general processes involved in extinctions and recoveries throughout Earth history.

NEW DIRECTIONS FOR THE STUDY OF EVOLUTIONARY RATES

The integration of high-resolution U-Pb geochronology and detailed paleontology offers a bright future to understanding rates of a variety of evolutionary processes. Thin layers of volcanic ash, interbedded with fossiliferous rocks, are more common than is often recognized, and correlations can be made to sections that lack volcanics by using biostratigraphy and chemostratigraphy. In addition, accumulation rates can be precisely evaluated when bracketed by abundant ashes, allowing much-improved resolution. Ideally, when volcanic rocks are regularly interspersed between fossil-bearing layers, reproducibility and precision can be evaluated by dating multiple ash beds within a single stratigraphic sequence.

This linkage between paleontology and geochronology allows us to address several evolutionary questions, especially those that move beyond simple taxonomic approaches. In Precambrian rocks, there is potential for calibrating major branch points or nodes in the tree of life

and comparing these estimates to those derived from analysis of molecular data through molecular clocks. The spectacular morphometric data on Cambrian and Ordovician trilobites produced by Foote (1993) is an excellent example for which high-resolution geochronology could document quantitative rates of morphological change from the Cambrian through the Ordovician radiation and extinction (rather than simply changes in the number of taxa). For this interval, the database is good enough that biogeographic effects could be examined as well. When coupled with high-resolution chemostratigraphy, the approach described in this paper will allow exploration of how subtle changes in climate or ocean chemistry are manifested in the evolutionary record.

Critical to understanding the diversification of life is an accurate chronology of life as preserved in the fossil record. Armed with an accurate chronology, we can begin to evaluate evolutionary rates by merging information on taxonomic, phylogenetic, and morphologic evolutionary patterns. Further, this approach offers the prospect of a more rigorous synthesis of data on molecular evolution and paleontology. When chronology is coupled with chemostratigraphic data, we can begin to understand the linkages between environmental change and evolution and to examine the distribution of time in the rock record with precision.

ACKNOWLEDGMENTS

Supported by the Exobiology Program of NASA, the Walcott Fund of the Smithsonian Institution, and the National Science Foundation (EAR 94-0618). High-precision U-Pb geochronology at MIT is possible because of the hard work of M. Martin, M. Schmitz, K. Davidek, D. Hawkins, and C. Isachsen. We thank Mark Martin and Liz Valiulis for producing the figures.

REFERENCES CITED

- Benus, A. P., 1988, Sedimentological context of a deep water Ediacaran fauna (Mistaken Point Formation, Avalon Zone, eastern Newfoundland): *New York State Museum Bulletin*, v. 463, p. 8-9.
- Bowring, S. A., Grotzinger, J. P., Isachsen, C. E., Knoll, A. H., Pelechaty, S., and Kolosov, P., 1993, Calibrating Cambrian evolution: *Science*, v. 261, p. 1293-1298.
- Bowring, S. A., Erwin, D. H., Jin, Y. G., Martin, M. W., Davidek, K., and Wang, W., 1998, Geochronology of the end-Permian mass extinction: *Science*, v. 280, p. 1039-1045.
- Campbell, K. S. W., and Marshall, C. R., 1987, Rates of evolution among Paleozoic echinoderms, in Campbell, K. S. W., and Day, M. F., eds., *Rates of evolution*: London, Allen & Unwin, p. 61-100.
- Claoue-Long, J.-C., Zhang, Z., Ma, G., and Du, S., 1991, The age of the Permian-Triassic boundary: *Earth and Planetary Science Letters*, v. 105, p. 182-190.
- Claoue-Long, J.-C., Compston, W., Roberts, J., and Fanning, C.-M., 1995, Two Carboniferous ages: A comparison of SHRIMP zircon dating with conventional zircon ages and $^{40}\text{Ar}/^{39}\text{Ar}$ analysis, in *Geochronology, time scales and global stratigraphic correlation*: SEPM Special Publication 54, p. 3-21.
- Compston, W., Williams, J. L., Kirschvink, J. L., Zhang, Z., and Ma, G., 1992, Zircon U-Pb ages for the early Cambrian time scale: *Geological Society of London Journal*, v. 127, p. 319-332.
- Compston, W., Sambridge, M. S., Reinfrank, R. F., Moczydlowska, M., Vidal, G., and Claesson, S., 1995, Numerical ages of volcanic rocks and the earliest faunal zone within the late Precambrian of east Poland: *Geological Society of London Journal*, v. 152, p. 599-611.
- Conway Morris, S., 1993, Ediacaran-like fossils in Cambrian Burgess Shale-type faunas of North America: *Paleontology*, v. 36, p. 593-635.
- Cowie, J. W., and Bassett, M.G., 1989, Global stratigraphic chart: Episodes, v. 12, supplement.
- Crimes, T. P., Insole, A., and Williams, B. P. J., 1995, A rigid-bodied Ediacaran biota from Upper Cambrian strata in Co. Wexford, Eire: *Geological Journal*, v. 30, p. 89-97.
- Davidek, K., Landing, E., Bowring, S. A., Westrop, S. R., Rushton, A. W. A., Fortey, R. A., and Adrain, J., 1998, New Uppermost Cambrian U-Pb date from Avalonian Wales and the age of the Cambrian-Ordovician boundary: *Geological Magazine*, v. 135 (3), p. 303-309.
- Erwin, D. H., 1994, The Permo-Triassic extinction: *Nature*, v. 367, p. 231-236.
- Faure, K., de Wit, M. J., and Willis, J. P., 1995, Late Permian global coal hiatus linked to ^{13}C -depleted CO_2 flux into the atmosphere during the final consolidation of Pangea: *Geology*, v. 23, p. 507-510.
- Foote, M., 1993, Discordance and concordance between morphological and taxonomic diversity: *Paleobiology*, v. 19, p. 185-204.
- Foote, M., 1994, Temporal variation in extinction risk and temporal scaling of extinction metrics: *Paleobiology*, v. 20, p. 424-444.
- Geyer, G., and Palmer, A. R., 1995, Neltneriidae and Holmiidae (Trilobita) from Morocco and the problem of Early Cambrian intercontinental correlation: *Journal of Paleontology*, v. 69, p. 459-474.
- Gingerich, P. D., 1983, Rates of evolution: effects of time and temporal scaling: *Science*, v. 222, p. 159-161.
- Gingerich, P. D., 1993, Quantification and comparison of evolutionary rates: *American Journal of Science*, v. 293-A, p. 453-478.
- Gradstein, F., Agterberg, F. P., Ogg, J. G., Hardenbol, J., van Veen, P., Thierry, J., and Huang, Z., 1995, A Triassic, Jurassic, and Cretaceous time scale, in *Geochronology, time scales and global stratigraphic correlation*: SEPM Special Publication 54, p. 3-21.
- Grotzinger, J. P., Bowring, S. A., Saylor, B. Z., and Kaufman, A. J., 1995, Biostratigraphic and geochronologic constraints on early animal evolution: *Science*, v. 270, p. 598-604.
- Harland, W. B., Cox, A. V., Llewellyn, P. G., Tickton, C. A., Smith, A. G., and Walters, R., 1982, *A geological time scale*: Cambridge, UK, Cambridge University Press.
- Harland, W. B., Armstrong, R. L., Cox, A. V., Craig, L. E., Smith, A. G., and Smith, D. G., 1990, *A geological time-scale 1989*: Cambridge, UK, Cambridge University Press.
- Hilgen, F. J., Krijgsman, W., Langereis, C. G., and Lourens, L. J., 1997, Breakthrough made in dating of the geological record: *Eos*, v. 78, p. 285-289.
- Holser, W. T. and Schonlaub, H. P., eds., 1991, *The Permian-Triassic boundary in the Carnic Alps of Austria (Gartnerkofel Region)*: *Abh. Geol. B. A.* 45:1-232.
- Hughes, R. A., 1995, The durations of Silurian graptolite zones: *Geological Magazine*, v. 132, p. 113-115.
- Isachsen, C. E., Bowring, S. A., Landing, E., and Samson, S. D., 1994, New constraint on the division of Cambrian time: *Geology*, v. 22, p. 496-498.
- Isozaki, Y., 1997, Permo-Triassic boundary superanoxia and stratified superocean: Records from lost deep sea: *Science*, v. 276, p. 235-238.
- Jensen, S., Gehling, James G., and Droser, M. L., 1998, Ediacara-type fossils in Cambrian sediments: *Nature*, v. 393, p. 567-569.
- Kaufman, A. J., Knoll, A. H., and Narbonne, G. M., 1997, Isotopes, ice ages, and terminal Proterozoic earth history: *National Academy of Science Proceedings*, v. 94, p. 6600-6605.
- Knoll, A. H., Bambach, R. K., Canfield, D. E., and Grotzinger, J. P., 1996, Comparative earth history and Late Permian mass extinction: *Science*, v. 273, p. 452-457.
- Krogh, T. E., 1982, Improved accuracy of U-Pb zircon ages by creation of more concordant systems using an air-abrasion technique: *Geochimica et Cosmochimica Acta*, v. 145, p. 637-649.
- Kurten, B., 1959, Rates of evolution in fossil mammals: *Cold Spring Harbor Symposium on Quantitative Biology*, v. 24, p. 205-215.
- Landing, E., 1992, Lower Cambrian of southeastern Newfoundland: Epeirogeny and Lazarus faunas, lithofacies-biofacies linkages, and the myth of a global chronostratigraphy, in Lipps, J. H., and Signor, P. W., eds., *Origin and early evolution of the Metazoa*: New York, Plenum Press.
- Landing, E., Bowring, S. A., Fortey, R. A., and Davidek, K. L., 1997, U-Pb zircon date from Avalonian Cape Breton Island and geochronologic calibration of the Early Ordovician: *Canadian Journal of Earth Sciences*, v. 34, p. 724-730.
- Landing, E., Bowring, S. A., Davidek, K. L., Westrop, S. R., Geyer, G., and Heldmaier, W., 1998, Duration of the early Cambrian: U-Pb ages of volcanic ashes from Avalon and Gondwana: *Canadian Journal of Earth Sciences*, v. 35, p. 329-338.
- Li, C.-W., Chen, J.-Y., and Hua, T.-E., 1998, Precambrian sponges with cellular structure: *Science*, v. 279, p. 879-882.
- Ludwig, K. R., 1980, Calculations of uncertainties of U-Pb isotope data: *Earth and Planetary Science Letters*, v. 46, p. 212-220.
- Mundil, R., Brack, P., Meier, M., Rieber, H., and Oberli, F., 1996, High resolution U-Pb dating of Middle Triassic volcanics: Time-scale calibration and verification of tuning parameters for carbonate sedimentation: *Earth and Planetary Science Letters*, v. 141, p. 137-151.
- Myrow, P. M., and Hiscott, R. N., 1993, Depositional history and sequence stratigraphy of the Precambrian-Cambrian global stratotype section, Chapel Island Formation, southeast Newfoundland: *Palaeogeography, Palaeoclimatology, Palaeoecology*, v. 104, p. 13-35.
- Narbonne, G. M., and Knoll, A. H., 1994, Integrated chemostratigraphy and biostratigraphy of the Windermere Supergroup, northwestern Canada: Implications for Neoproterozoic correlations and the early evolution of animals: *Geological Society of America Bulletin*, v. 106, p. 1281-1292.
- Narbonne, G. M., Saylor, B. Z., and Grotzinger, J. P., 1997, The youngest Ediacaran fossils from southern Africa: *Journal of Paleontology*, v. 71, p. 953-967.
- Palmer, A. R., 1965, Biomere: A new kind of biostratigraphic unit: *Journal of Paleontology*, v. 39, p. 149-153.
- Palmer, A. R., 1979, Biomere boundaries re-examined: *Alcheringa*, v. 3, p. 33-41.
- Palmer, A. R., 1984, The biomere problem: Evolution of an idea: *Journal of Paleontology*, v. 58, p. 599-611.
- Parrish, R. R., and Krogh, T. E., 1987, Syntheses and purification of ^{205}Pb for U-Pb geochronology: *Chemical Geology*, v. 66, p. 103-110.
- Renne, P. R., Zhang, Z., Richards, M. A., Black, M. T., and Basu, A. R., 1995, Synchrony and causal relations between Permian-Triassic boundary crises and Siberian flood volcanism: *Science*, v. 269, p. 1413-1416.
- Retallack, G. J., 1995, Permian-Triassic life crisis on land: *Science*, v. 267, p. 77-80.
- Sadler, P. M., 1981, Sediment accumulation rates and the completeness of stratigraphic sections: *Journal of Geology*, v. 89, p. 569-584.
- Shergold, J. H., 1995, Timescales I. Cambrian: Australian Geological Survey Organization Record 1995/30.
- Simpson, G. G., 1944, *Tempo and mode in evolution*: New York, Columbia University Press, 237 p.
- Stitt, J. H., 1971, Repeating evolutionary patterns in Late Cambrian biomes: *Journal of Paleontology*, v. 45, p. 171-181.

Evolutionary Rates *continued from p. 7*

Stitt, J. H., 1975, Adaptive radiation, trilobite paleoecology and extinction. *Ptychaspid biomere, Late Cambrian of Oklahoma: Fossils and Strata*, no. 4, p. 381-390.

Thomas, R. C., 1995, Cambrian mass extinction ("biomere") boundaries: A summary of thirty years of research. *Northwest Geology*, v. 24, p. 67-75.

Tucker, R. D., and McKerrow, W. S., 1995, Early Paleozoic geochronology: A review in light of new U-Pb zircon ages from Newfoundland and Britain. *Canadian Journal of Earth Sciences*, v. 32, p. 368-379.

Tucker, R. D., Krogh, T. E., Ross, R. J., and Williams, S. H., 1990, Time-scale calibration by high-precision U-Pb zircon dating of interstratified volcanic ashes in the Ordovician and Lower Silurian stratotypes of Britain. *Earth and Planetary Science Letters*, v. 100, p. 51-58.

Tucker, R. D., Bradley, D. C., Ver Straeten, C. A., Harris, A. G., Ebert, J. R., and McCutcheon, S. R., 1998, New U-Pb zircon ages and the duration and division of Devonian time. *Earth and Planetary Science Letters*, v. 158, p. 175-186.

Westrop, S. R., and Ludvigsen, R., 1987, Biogeographic control of trilobite mass extinction at an Upper Cambrian "biomere" boundary. *Paleobiology*, v. 13, p. 84-99.

Wignall, P. B., Kozur, H., and Hallam, A., 1996, On the timing of paleoenvironmental changes at the Permo-Triassic (P/Tr) boundary using conodont biostratigraphy. *Historical Biology*, v. 12, p. 39-62.

Xiao, S., Zhang, Y., and Knoll, A. H., 1998, Three-dimensional preservation of algae and animal embryos in a Neoproterozoic phosphorite. *Nature*, v. 391, p. 553-558.

*Manuscript received June 17, 1998;
accepted July 22, 1998* ■

GSA Thanked for Book Donations

GSA Executive Director Donald M. Davidson, Jr., meets Colorado State University Dean of Libraries, Camila Alire, at the Flood Recognition Event in the Morgan Library at Colorado State University. The flood disaster that occurred in Fort Collins, Colorado, on July 28, 1997, extensively damaged the library. In October 1997, GSA donated to the Morgan Library approximately 220 books and about 20 years' worth of the journals *Geology* and the *GSA Bulletin*, valued at over \$11,000.



NOTICE OF COUNCIL MEETING

Meetings of the GSA Council are open to Fellows, Members, and Associates of the Society, who may attend as observers, except during executive sessions. Only councilors, officers, and section representatives may speak to agenda items, except by invitation of the chair. Because of space and seating limitations, notification of attendance must be received by the Executive Director prior to the meeting. The next meeting of the Council will be Tuesday afternoon, October 27, 1998, at the Annual Meeting in Toronto, Canada.



BORED with your "old" planet? Go ahead, try one of ours!

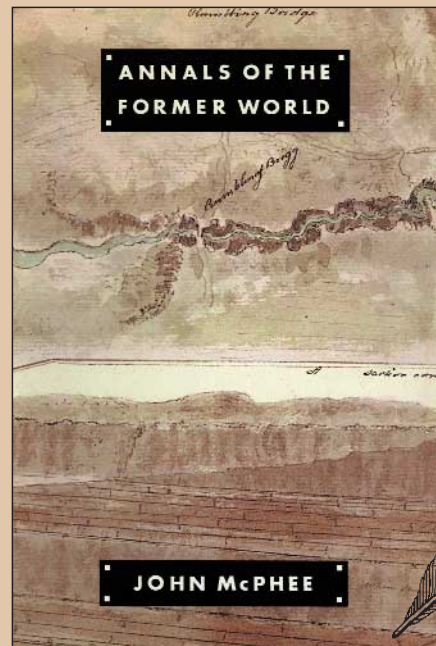
Join the Planetary Geology Division of GSA, and join us in one or more of our Toronto Meeting Activities, which include:

- The Pre-meeting Educational Program "Exploring the Solar System in the Classroom: A Hands-on Approach" (Saturday, all day)
- The Pardee Keynote Symposium "Pathfinder and Global Surveyor, New Views of Mars" (Thursday Morning)
- A variety of Theme Sessions including "Assembling a new understanding of Mars"; "Impact and Volcanism: Sudbury and Beyond!"; "Planetary Pot-Pourri"; and "Applied Geological Remote Sensing" (throughout the week)
- The Division Business meeting, including presentation of the G. K. Gilbert Award (Wednesday evening)

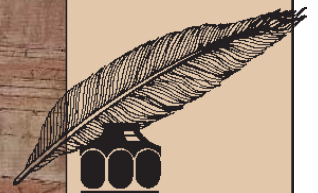
Remember to visit the Division's booth in the Exhibit Hall, where nifty posters, T-shirts, membership forms, and other goodies will be available.

Sign Here, Please

Who: Author John McPhee,
autographing his latest book
When: October 25 and 26
Where: 1998 GSA Annual Meeting in Toronto



Annals of the Former World will be on sale at the GSA Bookstore. Here's your chance to get a copy of this newly published book, featuring several of your GSA colleagues.





NATIONAL ACADEMY OF SCIENCES COLLOQUIUM "GEOLOGY, MINERALOGY AND HUMAN WELFARE"

NOVEMBER 8-9, 1998

The Arnold and Mabel Beckman Center, Irvine, California
Organized by Peter R. Buseck, Malcolm Ross, and Joseph V. Smith

Jillian F. Banfield, *University of Wisconsin, Madison*

"Biological impact on silicate mineral dissolution - application of the lichen model to understanding mineral weathering in soils."

Paul M. Bertsch, *University of Georgia/SREL*

"Advanced characterization of complex mineral assemblages and of contaminant-mineral interactions: Implications for contaminant transport and environmental remediation."

Gordon E. Brown, Jr., *Stanford University*

"Mineral surface chemistry in environmental science."

Peter R. Buseck, *Arizona State University*

"Airborne minerals and related aerosol particles: Effects on climate and the environment."

Rodney C. Ewing, *University of Michigan*

"Mineralogy: The design and selection of nuclear waste forms for actinides."

Robert B. Finkelman, *U.S. Geological Survey*

"The health impacts of domestic coal use in China."

Miriam Kastner, *Scripps Institution of Oceanography*

"Oceanic minerals and rocks, their origin, occurrence, and economic significance."

Keith A. Kvenvolden, *U.S. Geological Survey*

"Potential effects of gas hydrate on mankind."

Frederick A. Mumpton, *SUNY - College*

"Natural Zeolites."

Robert P. Nolan, *City University of New York*

"Asbestos minerals in the mining and occupational environment: Implications for fiber carcinogenesis."

D. Kirk Nordstrom, *U.S. Geological Survey*

"Negative pH, efflorescent mineralogy, extremely acidic mine waters, and the challenge of environmental restoration at the Iron Mountain superfund site, CA."

David R. Pevear, *Exxon Production Research Co.*

"The story of illite - How microscopic clay crystals constrain the thermal history of giant sedimentary basins and help us find oil."

F.D. Pooley, *Cardiff University*

"Characteristics of fibrous amphibole mineral dusts found in the human lung and their biological potential to cause disease."

Jeffrey E. Post, *Smithsonian Institution, National Museum of Natural History*

"Manganese oxides: Batteries and beyond."

Joseph M. Prospero, *University of Miami RSMAS*

"Transport of African mineral dust across North Atlantic: Impact on the environment of the eastern United States."

John D. Sherman, *UOP Research Center*

"Synthetic zeolites and other microporous oxide molecular sieves."

J.V. Smith, *University of Chicago*

"Geology, Mineralogy, and Human Welfare."

Garrison Sposito, *University of California, Berkeley*

"Surface geochemistry of the clay minerals."

Samuel J. Traina, *Stanford University*

"Geochemical controls on contaminant bioavailability in soils, sediments and aquatic environments."

Name _____
Affiliation _____ Position _____
Address _____ City _____ State _____ Zip _____
Phone _____ Fax _____ E-Mail Address _____

MAIL THIS FORM WITH PAYMENT TO:

Edward Patte
National Academy of Sciences, NAS-146
2101 Constitution Ave, NW
Washington, DC 20418
Fax (credit card only): 202-334-2153

For additional information,

Email: epatte@nas.edu

Web: <http://www2.nas.edu/abstract/20fa.html>

REGISTRATION FEE (non-refundable/can be transferred), including meals: <input type="checkbox"/> \$150 General Participant <input type="checkbox"/> \$50 Graduate Student	
PAYMENT: <input type="checkbox"/> Check or <input type="checkbox"/> Credit Card	
Circle One: VISA Amer. Express MasterCard	
Card #: _____	Expires: _____
Signature: _____	Date: _____

Bruce F. Molnia, *bmolnia@erols.com*

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

Climate Change Workshop Results Begin To Appear

The August 1997 Washington Report presented a description of the series of regional workshops, conducted on behalf of the administration, designed to be the first step in conducting regional assessments of the impact of changing climate. What started out as a handful of workshops has now grown to 20, encompassing all U.S. states and territories. The last of the workshops will be held in September.

Results of the Western Arctic/Bering Sea-Alaska Workshop has been released as "Implications of Global Change in Alaska and the Bering Sea Region—Mackenzie River to Lena River." The workshop was at the University of Alaska in Fairbanks in June 1997.

The Arctic, including Alaska, is one of the critical regions where climatic change is expected to be large and where the impacts (both positive and negative) on the environment and on socioeconomic activities could be pronounced. Consequently, the goals of the workshop were to educate the stakeholders (the individuals and groups who are directly affected) about the importance of the effects of climate change on issues of particular concern to them; to refine the coarse impact assessments already compiled from previous workshops; to define a research agenda to further improve the impact assessments; and to develop support, with the help of the stakeholders, for mitigation and adaptation options. The workshop was attended by a diverse group of more than 100 participants representing academia, government agencies, private industry, nongovernmental organizations, Native organizations, and the general public.

Prior to the workshop, the organizers commissioned six position papers on the likely impacts of climate change on the ocean system, coastal zone, land ecosystem, nonrenewable resources, infrastructure, and social and cultural values. These papers provided a starting point for detailed breakout session discussions and recommendations. A common thread of each paper was the climate warming observed over the land masses of the western Arctic during the past three decades, accompanied by decreases in snow cover and glacier area and volume, thawing of permafrost, and reductions in sea ice extent. Trans-boundary problems, such as

connections to Russia and Canada, were also considered in detail.

The workshop proceedings present the results of the deliberations of the six working groups on the role of climate change in Alaska and the Bering Sea Region as a series of positive (+) and negative (-) impacts on human activities. Not surprisingly, the majority of the impacts are negative. The following are the results as presented in the proceedings:

I. Socioeconomic impacts that have occurred over the past decade:

- Major increases in catches of Alaskan salmon in recent years resulted from the increase of El Niño conditions since the mid-1970s (+).
- The same conditions have unfavorably affected Pacific Northwest and Canadian salmon stocks due to increased smolt predation and adverse streamflow (-). Accelerated permafrost thawing has led to costly increases in road damage and road maintenance (up to \$ 3 million to replace 1 mile of road system) (-).
- Permafrost thawing has also caused major landscape changes, from forest to bogs, grasslands, and wetland ecosystems, affecting land use (-). Increased slope instability, landslides, and erosion have occurred in thawing permafrost terrain, threatening roads and bridges and causing local floods (-).
- But disappearance of permafrost also reduces construction problems; in some areas permafrost boundaries have moved north by 80 miles in the past century (+).
- The warmer climate has caused forest problems, such as increased fire frequency and insect outbreaks, that have reduced economic forest yields (-).
- A warmer climate has lengthened the growing season and growing degree days by 20% for agriculture and forestry, with the potential of producing higher yields (+).

- Boreal forests are expanding north at the rate of 60 miles for each 2° F temperature increase, thus increasing potential yields (+).
- With less sea ice in the Bering Sea, severe weather events such as storm surge frequency and severity have caused increased coastal erosion and inundation and threats to structures (-).
- Subsistence lifestyles have been adversely affected; for example, changes in sea ice conditions make hunting on the ice more dangerous (-).
- The availability of marine mammals for subsistence is lower, due to changes in oceanographic and sea ice conditions (-).
- A warmer climate has also thawed traditional ice cellars in several northern villages.
- Human health problems have increased, owing to new diseases moving north (-).
- The extended length of the summer season has been accompanied by an expansion of summer tourism (+).

II. Possible additional future consequences of climate change:

- Fisheries: Change in catches by location, volume, and species, and in markets (- and +).
- Seafood and Fish Industry (harvesters and processors):
 - Financial stresses caused by the need for relocation (-).
 - Local loss of fishing industry jobs due to relocation of support services (-).
 - Eventual worldwide financial losses as global fisheries decline (-), perhaps benefiting Alaskan fisheries (+).
- Oil and Gas:
 - Cost of maintaining structures (pipelines, etc.) in thawing permafrost terrain (-).
 - Improved construction after the thawing of permafrost (+).
 - Economic benefits resulting from extended surface mining (+).
 - Improved offshore exploration and production, owing to less sea ice (+).
 - Increased threats from higher sea levels and erosion to coastal installations (-).
- Agriculture, Forestry, and Wildlife:
 - Higher yields in agriculture and forestry due to longer growing season (+).
 - Increased incidence of forest fires and losses to timber industry (-).
 - Increased insect outbreaks and infestations, leading to economic losses (-).
 - Losses or changes in wildlife and reindeer herding as ecosystems change (+ and -).
 - Losses or changes in fish and marine mammals with decline in sea ice extent (-).
 - Effects on tourism: Longer season (+) but melting glaciers, smoke from forest fires (-).

- Flooding of coastal wetlands, affecting waterfowl and shorebird breeding (-).
- Government:
 - Reduction in local income means need for higher subsidies in villages to keep standards of living, as subsistence resources decline (-).
 - Greater investments needed to combat rising sea level, thawing of permafrost (-).
 - Possible need for greater investment in health services (new diseases) (-).
 - Reconstruction costs of government infrastructure (-).
 - Increased costs of forest fire control (-).
- Subsistence and Local Economy:
 - Increased village economy problems due to fewer subsistence resources (-).
 - Possible greater availability of other subsistence resources (e.g., salmon) in some areas (+).
 - Possible relocation of populations closer to new subsistence harvest sources (-).
 - Change in energy pattern use due to climate change (+).
 - Change in local transportation methods (+ and -).
- Construction and Transportation:
 - Higher cost of maintaining roads, bridges, etc. in thawing permafrost terrain (-).
 - Easier construction of buildings, roads, airports, etc. in permafrost-free terrain (+).
 - Greater availability of freshwater resources, potable water (+).
 - Improved shipping to villages and oil facilities, owing to less sea ice (+).
- Global Economy:
 - Impacts on the insurance industry and costs to the insured (-).
 - Changes in world markets and resource prices (-).
 - New, quicker, and therefore cheaper trans-Arctic shipping routes (+).
 - Relocation or protection of port and coastal facilities owing to sea-level rise (-).
- Nonmarket Concerns:
 - Changes in quality and duration of human life (+ and -).
 - Loss of cultural and historic assets, particularly in coastal areas (-).
 - Surprises and new risks due to nonlinear changes (+ and -).

Each workshop will be followed by additional assessment activities to pursue the questions and information needs identified by participants and to further develop and engage the network of interested and active individuals in the region. Information from each regional assessment will also be integrated into a national synthesis report, which will be released early next year. ■

Earth Science Week

The first Earth Science Week will be October 11–17, 1998. Earth Science Week, one of the American Geological Institute's 50th anniversary initiatives, offers the geoscience community new opportunities to demonstrate the importance of the earth sciences. AGI member societies and state geological surveys are planning Earth Science Week activities and events. "The goal for Earth Science Week," said AGI President Susan Landon, "is to have every geoscientist in the country do something in their community to promote the earth sciences."

Earth Science Week has enormous potential for increasing public awareness and understanding of the importance of the earth sciences in our lives. The celebration, which will be held annually during the second full week of October, will give geoscientists and organizations repeated opportunities:

- To give students new opportunities to discover the earth sciences
- To highlight the contributions that the earth sciences make to society
- To publicize the message that earth science is all around us
- To encourage stewardship of Earth, and
- To develop a mechanism for geoscientists to share their knowledge and

enthusiasm about Earth and how it works.

AGI's role in sponsoring an annual Earth Science Week is to provide a clearinghouse for ideas, activities, and special events and to provide support materials that make it easy for geoscientists to participate. Information about Earth Science Week is available from the American Geological Institute and on the World Wide Web at www.earthsciweek.org.

The following statement about Earth Science Week, by Oregon Senator Ron Wyden, was entered into the *Congressional Record* in July. (Current GSA Congressional Science Fellow David Verardo is serving on Wyden's staff.)

Mr. President, in the nineteenth century, Merriwether Lewis and William Clark explored the western reaches of our expanding country. As they explored my home region of the Pacific Northwest, Lewis and Clark cataloged the mineral and natural resources of the land. In particular, they spoke of a mighty river known to the local inhabitants as Nch'i Wana, the Great River. We know it today as the Columbia River and its importance as a reliable source of water and power to the people of the Pacific Northwest is undeniable.

When twentieth century American explorers embarked on a similar journey to explore the Moon, one of their earliest actions was to bend down to the surface and pick up a rock. That simple movement framed an ancient reflex that underscores the basic imperative to explore our surroundings. Today, I want to recognize the important role played by the earth sciences in expanding our economy, supporting our national goals, and increasing our knowledge of the larger world.

Modern geophysical research reveals that ours is a dynamic planet. On the Earth's surface, great tectonic plates shift continental positions with terrific force. On the ocean's surface, microscopic plants and animals help regulate global atmospheric gases and serve as the foundation of our planet's food web. In the deep ocean abyss, mysterious and wondrous animal communities thrive in endless darkness by deriving life-sustaining nutrients from active volcanic vents.

Earth science is a global science that speaks a global language and unites people by promoting sustainable development. The study of earth science provides the skills necessary for locating and utilizing natural resources, understanding natural processes that often conflict with human designs, and comprehending our natural heritage through the unusual perspective of geologic time. The unique panorama of geologic time allows us to observe the full range of natural processes on Earth and aids in developing a comprehensive view of the natural world beyond a perspective limited only to that of human influence. In my home state of Oregon, we celebrate the land and respect the power of nature. We have learned to protect our citizens and expand our economy by working with nature and prudently mitigating natural hazards. In consideration of the importance of the earth sciences in the daily lives of all Americans, I submit, for the Record, the resolution issued by the Association of American State Geologists.

The resolution follows:

Whereas the earth sciences are fundamental to society; and

Whereas the earth sciences are integral to finding, developing, and conserving mineral, energy, and water resources needed for society; and

Whereas the earth sciences promote public safety by preparing for and mitigating natural hazards such as floods, landslides, earthquakes, volcanic eruptions, sinkholes, and coastal erosion; and

Whereas the earth sciences are crucial to environmental and ecological issues ranging from climate change and water and air quality to waste disposal; and

Whereas geological factors of resources, hazards, and environment are vital to land management and land use decisions at local, state, regional, national, and international levels; and

Whereas the earth sciences contribute critical information that enhances our understanding of Nature,

Therefore, be it resolved that the second full week of October henceforth be designated as Earth Science Week. ■

Valerie Brown, Director of Development, GSA Foundation

Your Gift Dollars at Work

Tradition has it that September is “back-to-school” month, so let us observe the tradition by introducing a teacher: Parvinder S. Sethi, an assistant professor in the Department of Geology at Radford University in Virginia.

Prior to joining the Radford faculty, Sethi was with the Department of Earth Science at Northeastern Illinois University where, according to Professor Laura L. Sanders, he showed himself to be a brilliant teacher, an exceptional scholar, an extraordinary colleague, and a remarkable leader. Sethi’s academic career started as a Teaching Assistant at North Carolina State University where his faculty colleagues and undergraduate students named him the outstanding graduate student teacher for the 1992–1993 academic year. The success and accolades have accumulated over his six-year teaching career.

For such unusual precocity, Sethi was the 1997 recipient of the Donald L. and Carolyn N. Biggs Award for Excellence in Earth Science Education. Don Biggs was dedicated throughout his distinguished career, not only to geoscience education but also to earth science teacher training. A longstanding member and Senior Fellow of GSA, his commitment to education and his loyalty to GSA coalesced in the editorship of the North-Central Section Field Guide as part of the Decade of North American Geology publications. At his death in 1990, it was fitting that his

widow, Carolyn, and dozens of his friends and professional colleagues honor Don’s accomplishments by creating a memorial fund to promote excellence in earth science education. Upon Carolyn’s death in 1992, significant additional contributions were made to the memorial fund, and Carolyn’s name was incorporated into the fund title.

Thus, the Biggs Award is prestigious both for perpetuating the memory of a geoscience educator whose eye was on the broadest possible outreach horizon, and for demanding of its recipients a comparable vision and versatility.

In today’s world, public and academic awareness of the earth sciences may no longer safely be viewed as optional. Consequently, teachers who inspire their students, who vitalize their fellow professors, who find and engage future earth science students, are essential treasures. Equally essential is the Biggs Award as a means of identifying and rewarding such young teachers.

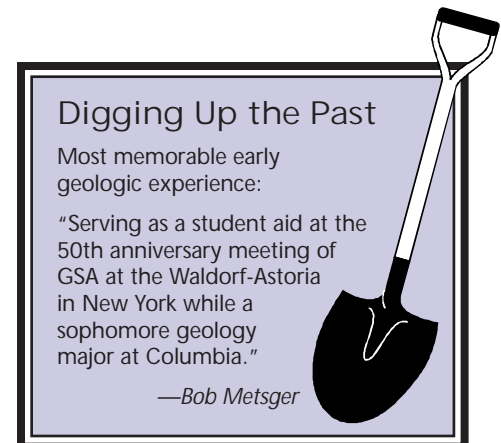
Since 1990, a steady renewal of gifts to the Biggs memorial fund has fostered growth in the value of the fund and in the recognition awards made from the fund. The generosity of many donors is enhancing GSA’s effectiveness in recognizing and investing in exceptional teaching talent and performance.

Which brings us back to Parvinder S. Sethi, who epitomizes the spirit of the

Biggs Award. His faculty colleagues and students unanimously attest to his ability and inventiveness. In Illinois and North Carolina alike, he established programs to visit and speak with high school students, encouraging their awareness of and interest in the earth sciences. He is an active and productive scientist who brings advanced science and technology to his students, whether they are enrolled in introductory Geology 101, or pursuing graduate degrees in geoscience.

Sethi is an earth science educator deserving of our appreciation and recognition. The Donald L. and Carolyn N. Biggs Award is a GSA asset deserving of our notice and support. Both illustrate the ways in which your gift dollars build bridges to people and opportunities.

So to all who have contributed to the Biggs Fund, many thanks for enabling GSA to reward such excellence in earth science education. ■



The Sustainability Challenge I: Energy for the 21st Century

A. R. (Pete) Palmer, Institute for Cambrian Studies

The earth science community holds several important keys to public understanding of the issue of sustainability. Humanity will face seriously negative consequences if the public, and our leaders, do not internalize the geoscience concepts that are fundamental to sustainability issues: that we live on “Spaceship Earth” and there is no place else to go; that we are parts of, not independent from, the global ecosystem; that the human context must be understood in the perspective of “deep time”; that some resources we take for granted, such as fossil fuels, are nonrenewable; and that other resources critical for sustainability, such as

arable soils, forests, and groundwater, although renewable, can suffer irreversible damage if sufficiently abused. Our profligacy in both procreation and consumption are about to catch up with us in a finite world! We might want to designate the 21st century as the Century of the Earth Sciences.

At this fall’s GSA meeting in Toronto, the Institute for Environmental Education (IEE) Annual Environmental Forum will focus on the topic of sustainable energy for the 21st century. This year’s forum is the first of a series planned by the Critical Issues Committee (CIC) and the IEE to focus on specific topics relating to sus-

tainability issues. The CIC is an ad hoc affiliate of GSA’s Committee on Geology and Public Policy.

We begin the series with the topic of energy because it encompasses many of our most immediate sustainability issues. In the 19th and 20th centuries, we became “addicted” globally to the material benefits procured directly and indirectly from oil, gas, and coal. Some voices point out that these are nonrenewable resources on human time scales and that demand during the next century will begin to exceed supply. Others say there is

Energy continued on p. 13

Donors to the Foundation, June 1998

GEOSTAR
Charles F. Bisbee
Robert F. Hudson

Institute for
Environmental
Education
M. Lee Allison
Ann Becker
Aaron Bobar
Thomas C. Davenport
E-an Zen♦

International
Division Award
Duke Engineering
Services*

John T. Dillon
Alaska Scholarship
Award
Charles F. Bisbee

John F. Mann, Jr.
Institute for
Applied Geosciences
Jerold F. Mann*

North-Central
Section Endowment
Richard C. Anderson ♦
Arndt Schimmelmann♦

Penrose Conferences
Y. W. Isachsen

Publications Fund
L. Barry Albright III
John Alroy
Anonymous*
Andres Aslan
Christopher M. Bailey*

Julian C. Baker
Gerald R. Baum
Keith B. Benn
Robert Bleiweiss
Timothy J. Bralower
Danielle L. Carpenter
Eric S. Cheney
Robert L. Christiansen*
Peter D. Clift
Jenny Collier
Maurice Colpron
Harrison O. Cookenboo
Kevin J. Cunningham
Gregory A. Davis
Howard W. Day
Cheryl A. Gansecki
Jeffrey K. Geslin
Jonathan M. G. Glen*
Arthur Grantz*
Vicki L. Hansen
Frederick E. Hutson
Glen A. Izett
Charlotte H. Jeffery
John S. Jell
Lawrence S. Jones
Harvey M. Kelsey III
Richard D. Law
Mian Liu
John A. Luczaj
Paul J. McCarthy
David Mohrig
James T. Neal
Timothy S. Paulsen
Michael E. Perkins
Josep Poblet
Michael Robert
Rampino
David M. Rubin*
Jeffrey P. Schaffer



GSA Foundation
3300 Penrose Place
P.O. Box 9140
Boulder, CO 80301
(303) 447-2020
drussell@geosociety.org

- Enclosed is my contribution in the amount of \$_____.
- Please add my name to the Century Plus Roster (gifts of \$150 or more).
- Please credit my gift to the _____ Fund.

PLEASE PRINT

Name _____

Address _____

City/State/ZIP _____

Phone _____

James Schmitt
Ronald C. Schott
Geoffrey O. Seltzer
John M. Sharp, Jr.
Zachary Sharp
John Shaw*
Marguerite A. Toscano
Claudio Vita-Finzi
Gregory E. Webb
Jack A. Wolfe
Michael O.
Woodburne*
Chen Zhu
Research Grants
Drew M. Clemens
Maria Luisa & William
A. Crawford*
Charles B. Sclar
Edward F. Stoddard♦

SAGE
Thomas C. Davenport
Joseph Edward
Gordon♦
Kenneth H. Noble
E-an Zen♦
Southeastern
Section Endowment
Charles Q. Brown♦
A. David Kendrick♦
Roy J. Shlemon
Applied Geology
Fund
Roy J. Shlemon♦
Unrestricted
Richard C. Anderson♦
Donald F. Beck

Charles F. Bisbee
Charles Q. Brown♦
Robert A. Cadigan
Ann Marie Cox
Fred W. Farwell
A. David Kendrick♦
Morris W. Leighton*
Chia-Yu Lu
Calvin F. Miller
Richard L. Nielsen*
Arndt Schimmelmann♦
Lee J. Suttner♦

* Century Plus Roster
(gifts of \$150 or more).
♦ Second Century Fund.

Energy continued from p. 12

no need to worry because technology will always supply a "fix" when it is needed. Meanwhile, it appears that the atmosphere is not handling very well the excess load of carbon generated by burning increasing quantities of fossil fuels. The build-up of CO₂ and its consequences have become an international concern.

The thrust of the Sunday afternoon symposium on October 25 is to explore the issue of "Energy for the 21st Century." A series of presentations is aimed at informing the media, teachers, and teachers of teachers, as well as professional geoscientists. We will start with a presentation by Tom Ahlbrandt, who is responsible for the USGS estimates of the volume of world oil. He will discuss the way such estimates are made and how robust they may be. Ahlbrandt will be fol-

lowed by Jack Edwards, former chief geologist of Shell Oil Company, and Colin Campbell, a member of Petroconsultants in Geneva. Both Edwards and Campbell have recently published articles, in the *AAPG Bulletin* and *Scientific American*, respectively, that predict a peak in world oil production before the year 2050. Campbell and Edwards each also note that both gas and coal will not lag far behind oil in terms of peak production. Consumption of fossil hydrocarbons, however, is showing no signs of decreasing. Thus, conflict between diminishing supplies and increased consumption lies ahead! Several major oil companies, including Shell and British Petroleum, as well as the International Energy Administration are taking these predictions seriously. Roy Levitch, who represents Shell's concerns in this area, will discuss Shell's plans for development of sustainable

energy. Walter Youngquist will examine the myths and realities of alternative energy sources. Our final speaker, Mike McCormack, a former U.S. Representative from Washington who was involved with energy issues in Congress, will review the political realities of shrinking fossil energy supplies. Discussion breaks are planned after each pair of speakers. These discussions will be moderated by Al Bartlett, emeritus professor of physics at the University of Colorado, who has lectured widely across the United States on issues of population growth and consumption. He will also briefly summarize the issues raised during the symposium.

At the GSA Annual Meeting in Toronto, come and join the discussion. Your grandchildren may appreciate your concern. ■



Dawson's interest in natural history began early. Cephalopods were readily available in his coastal village.

Rock Stars

INTRODUCTION

Bernard of Chartres, an 11th–12th century philosopher and teacher, said that we are like dwarfs on the shoulders of giants, so that we can see more than they and for a greater distance, not by any virtue of our own but because we are carried high and raised aloft by their stature.

All of us have our geological heroes, those giants on whose shoulders we stand. To encourage recognition of these luminaries and to provide inspiration for students and young professionals, the GSA History of Geology Division presents *Rock Stars*, brief profiles of our geological giants. If you have any comments on profiles, please contact Robert N. Ginsburg, University of Miami, RSMAS/MGG, 4600 Rickenbacker Causeway, Miami, FL 33149-1098, e-mail: rginsburg@rsmas.miami.edu.

—Robert N. Ginsburg, *History of Geology Division*

John William (Sir William) Dawson: Geologist and Educator

Susan Sheets-Pyenson, Department of Philosophy, Concordia University, Montreal, Quebec

INTRODUCTION

During the early 1970s, staff and patrons at the McGill University Archives were abuzz about a huge new bequest: the papers of John William Dawson. Dawson had been called from the tiny maritime village of Pictou, Nova Scotia, in 1855 to serve as McGill's principal. He presided over the university for nearly half a century.

Dawson was not only the major scientific player in 19th-century Canada, but he also commanded a leading position internationally. Dawson is one of those individuals whose diverse activities defy neat categorization. He was as much a paleontologist as a geologist, an administrator as well as an educator, and a popular writer on scientific and religious topics as well as the author of about 200 papers.

EARLY YEARS

John William Dawson, who always preferred to be addressed as "William," was born October 13, 1820, in the seaside town of Pictou, Nova Scotia. He was the elder of two sons of Scottish immigrants.

More History

The GSA History of Geology Division will sponsor Symposium 14, Hutton, Lyell, Logan—and their Influence in North America, at the 1998 GSA Annual Meeting in Toronto. The symposium is scheduled for Monday afternoon, October 26. Susan Sheets-Pyenson was scheduled to speak in that session.

For the first 30 years of his life, his parents were preoccupied with repaying debts incurred in maritime trade, a responsibility that they steadfastly discharged. Perhaps Dawson's intense earnestness and self-reliance were honed in this environment. Frugality was as important as piety in the Dawson household, giving William an inescapable and omnipresent seriousness of purpose.

Whatever young William lacked in material wealth during his formative years was overshadowed by his parents' deep affection and by the rich resources of Pictou. An academy in the town provided Dawson and other youths with a remarkable grounding in a range of subjects, especially in the natural sciences. Pictou Academy had been established in 1817 by the secessionist Presbyterian minister Thomas McCulloch as a school for training dissenting ministers and for teaching the liberal arts to youths of all religious persuasions. The academy housed an extensive collection of scientific apparatus, a small natural history museum, and a library with a remarkable assortment of treatises in natural philosophy and natural history.

Pictou was surrounded by sandstone and shale formations, which contained Carboniferous plant fossils. These provided fertile ground for Dawson's first scientific explorations, and allowed him to put together a respectable collection of geological and paleontological specimens. At age 16, Dawson delivered a paper on "The Structure and History of the Earth" to the Pictou Literary and Scientific Society.

HIGHER EDUCATION

In 1840, at the age of 20, Dawson matriculated at the University of Edinburgh in Scotland. Edinburgh was one of the few universities in the English-speaking world that offered a systematic natural history curriculum. There, Dawson learned geology, physical geography, and mineralogy from Robert Jameson; botany from John Hutton Balfour; and chemistry from William Gregory. Although Dawson remained fiercely proud of his birthplace and sensitive to any charges of hailing from the "backwoods," Nova Scotia must have seemed impoverished compared to the rich tapestry of life in Edinburgh.

Financial difficulties took him back to Pictou to help with the family bookselling business, but in 1841 he returned to Edinburgh to continue his studies and court his future wife, Margaret Ann Young Mercer, a distant cousin and daughter of a lace merchant. On the transatlantic voyage, Dawson met William Logan, who was about to become director of the Geological Survey of Canada. A few years later, Dawson guided Logan on a geological tour of the countryside, as he did Charles Lyell, showing both distinguished geologists the coalfields near Pictou, the cliffs of the Shubenacadie River, deposits at the Bay of Fundy, and the shores of the Minas Basin. Dawson maintained a cordial relationship with Logan, but he became the life-long protégé, confidant, and disciple of Lyell. Lyell assisted in publishing Dawson's work on the geology and paleontology of Nova Scotia, New Brunswick, and Prince Edward Island with the Geological Society of London.

STARTING A CAREER

Upon his return to Nova Scotia in 1847, after the completion of a second academic session at the University of Edinburgh, Dawson sought to enlarge the sphere of his interests beyond the bookselling business. He was hired by the General Mining Association of London to conduct a geological survey of Cape Breton, and he investigated coal and other mineral deposits for the provincial government and for small mining companies.

Dawson also turned his talents to educational matters. He lectured on natural history to the Pictou Academy, the Halifax Mechanics' Institute, and Dalhousie College. From 1850 to 1853, he traveled the length and breadth of Nova Scotia as its first superintendent of education. His devotion to the task was so complete that he is credited with single-handedly reforming the public-education system of the province. At the same time, he managed to continue his scientific investigations on the side, leading to some of his most important paleontological discoveries. These include unearthing a fragment of a skeleton of the earliest North American Carboniferous reptile or batracian (*Dendropteron acadianum*), the oldest land snail (*Pupa vetusta*), and the oldest millipede (*Xylobius sigillariae*), and to the first report of Devonian plants.

Dawson's investigations into the geology and mineral deposits of Nova Scotia provided data for his magnum opus, *Acadian Geology*, in 1855 (2nd ed., 1868; 3rd ed., 1880; 4th ed., 1891). This work, the most complete treatment of the geology of the maritime provinces, was but slightly modified by the findings of the Geological Survey years later. *Acadian Geology* made Dawson's reputation as a geologist of the first rank.

LATER GEOLOGIC STUDIES

Despite the extraordinary demands on Dawson's time from his administrative responsibilities, his unstinting field work, first in Nova Scotia and later in Quebec, increased the number of post-Pliocene fossils known in Canada from about 30 to more than 200. He often suggested to his scientific adversaries that they leave their armchairs and cabinets and observe specimens in situ. He helped to perfect the examination of thin fossil



Pictou, Nova Scotia, ca. 1845, as sketched by William Dawson.

slices using a microscope, a technique that allowed him to describe 125 new species of Paleozoic plants. His own collection of Canadian rocks and fossils formed the nucleus of the holdings of the Peter Redpath Museum, which in 1882 was donated to McGill in Dawson's honor.

Dawson's scientific reputation rests upon his work in paleobotany. He investigated Canadian formations stretching from the maritimes to the west (culminating in his *Geological History of Plants*, 1888), and he published several papers on the subject every year. Dawson has been called the grandfather of Paleozoic paleobotany in North America. His scientific legacy also includes pioneering work in Canadian geology, particularly for the eastern provinces and the St. Lawrence River valley.

CONTROVERSIES

Despite Dawson's claim to follow "a quiet middle course" in his scientific work, he loved to plunge into the heat of scientific controversy. He attracted both vehement critics and adoring acolytes for his outspoken denunciation of Darwinian evolution. He had discovered and named the puzzling *Eozoön canadense* in 1864, a fragment that appeared to be a foraminifer. For the rest of his life, he argued that the specimen proved the presence of animal life in the Laurentian rocks. Controversy continued for decades, despite mounting evidence of inorganic composition for this pseudofossil.

His contributions to paleozoology also invited debate, as they treated a vari-

ety of organisms, ranging from the lowest forms of life to prehistoric man (in *Fossil Men*, 1880). Finally, his work on Devonian plants, featured in his controversial Bakerian lecture to the Royal Society of London in 1870, never won universal respect by his contemporaries. Three-quarters of a century later, discovery of plant remains in the Rhynie Chest of Scotland supported his great discovery.

REWARDS

Dawson accumulated many scientific honors and awards. He became a fellow of the Geological Society of London in 1854, and of the Royal Society of London in 1862. He successfully lobbied for the formation of a national scientific organization, thereby leading to the creation of the Royal Society of Canada in 1882, for which he served as the first president. He brought both the American and British Association for the Advancement of Science to meet in Montreal. His firm guidance was felt in the affairs of the Geological Survey of Canada and in those of myriad scientific societies, especially the Natural History Society of Montreal. He presided over the American Association for the Advancement of Science meeting at Montreal in 1882 and over the British association's meeting in Birmingham, England, in 1886. He was knighted in 1884, becoming Sir William Dawson. In 1893, he became the fifth president of the Geological Society of America. His eldest son, George Mercer Dawson, became Canada's leading field geologist and director of the Geological Survey of Canada; he also served as 12th president of the Geological Society of America.

FOR FURTHER READING

Susan Sheets-Pyenson, *John William Dawson: Faith, Hope, and Science*, Montreal and Kingston, McGill-Queen's University Press, 1996. A "Note on Sources" discusses primary and secondary sources on Dawson. ■



Here in his late 30s, Dawson had already published *Acadian Geology*.

GSA Congressional Science Fellow Named for 1998–1999

Kai S. Anderson has been chosen as the 13th GSA Congressional Science Fellow. He will work as a special legislative assistant on the staff of a committee or member of the U.S. Congress from September 1998 through August 1999.

Anderson was born and raised in rural northeast Oregon. He graduated valedictorian of La Grande High School and was named Oregon Elks Student of the Year in 1989. He then enrolled at Stanford University to pursue his interests in geoscience and public policy. In 1991, he received a Barry M. Goldwater Science and Mathematics Scholarship to pursue undergraduate research concerning siliceous sinter deposits of Yellowstone National Park. He spent a term at Stanford's Washington, D.C., campus, where he researched energy and environmental policy issues while interning at Conservation International. In 1993, he graduated Phi Beta Kappa with a Bachelor of Science degree in geology. His Ph.D. research, also at Stanford, focuses on the facies architecture of turbidite systems.

Anderson said that he views the GSA Congressional Science Fellowship as a tremendous honor. He expects that the fellowship will provide an opportunity to contribute to, and learn from, integrating science into the public policy-making process. He said that he hopes the fellowship experience will help him become a geoscientist who can help dispel some of the mystery that surrounds the science-policy nexus.

The Fellowship

The GSA Congressional Science Fellowship provides an unparalleled opportunity for a geoscientist to apply scientific and technical expertise to a wide range of policy issues as a staff member in a congressional or committee office.

Funded by GSA and a grant from the U.S. Geological Survey, the fellowship demonstrates the value of science-government interaction and enhances involvement of the earth science community in the public policy arena. The program places highly qualified, accomplished scientists, engineers, and other professionals with the offices of individual members of Congress and committees for a one-year assignment. Fellows perform in much the same way as regular staff members; they have the opportunity to be involved in varied legislative, oversight, and investigative activities. They offer their special knowledge, skills, and competence for the opportunity to acquire experience and the chance to contribute to the formulation of public policy. In addition, the fellow

reports periodically to the GSA membership and to the U.S. Geological Survey on geoscience issues facing the U.S. Congress, and the positive roles available for all earth scientists in policy formulation.

To prepare for their assignments, fellows attend a two-week orientation conducted by the American Association for the Advancement of Science. Fellowship requirements include exceptional competence in some area of the earth sciences, cognizance of a broad range of issues outside the fellow's particular area, and a strong interest in working on a range of public policy programs. ■



New Congressional Science Fellow Kai Anderson.

1999–2000 CONGRESSIONAL SCIENCE FELLOWSHIP

The Geological Society of America is accepting applications for the 1999–2000 Congressional Science Fellowship. The Fellow selected will spend a year, or, optionally, 16 months in the office of an individual member of Congress, a congressional committee, or a congressional support agency for the purpose of contributing scientific and technical expertise to public policy issues and gaining firsthand experience with the legislative process. The American Association for the Advancement of Science conducts an orientation program to assist the Fellow seeking a congressional staff position in which he or she can work on major legislative issues.

CRITERIA

The program is open to highly qualified Ph.D. earth scientists. Candidates are expected to show exceptional competence in some area of the earth sciences, have a rather broad professional background, be cognizant of many matters outside their particular area, and have a strong interest and some experience in applying scientific knowledge toward the solution of societal problems.

AWARD

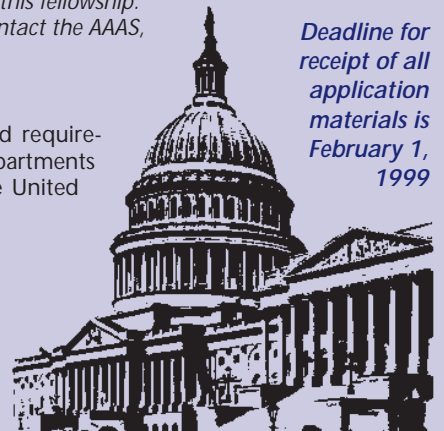
The 1999–2000 GSA Congressional Science Fellow will receive a one-year stipend of \$42,000, or \$56,000 for 16 months. The Fellow will also receive limited allowances for health insurance, relocation, and travel. The fellowship is funded by GSA and by a grant from the U.S. Geological Survey.

(The fellowship is available only to U.S. citizens, and employees of the USGS are ineligible to apply for this fellowship. For information about other programs, contact the AAAS, or the Geological Society of America.)

TO APPLY

Procedures for application and detailed requirements are available in the geology departments of most colleges and universities in the United States or upon request from:

Executive Director
Congressional Science Fellowship
Geological Society of America
P.O. Box 9140
Boulder, CO 80301



Deadline for receipt of all application materials is February 1, 1999

1998 GSA Annual Meeting



October 26–29, 1998 ■ Toronto, Ontario
Metro Toronto Convention Centre
Sheraton Centre Toronto — Headquarters Hotel

Registration and housing information
June issue of *GSA Today* or the GSA Web site: www.geosociety.org

Preregistration and Housing Deadline
September 18

FOR INFORMATION: Call (800) 472-1988, ext. 184; fax 303-447-0648; or
e-mail meetings@geosociety.org

*Register
Today!*

■ Air Travel

Get there for less! Conventions in America (CIA), GSA's official travel agency, has arranged special airline discounts for GSA attendees on United, American, and Canadian Air, or will provide the lowest available fare on any other airline.

YOU HAVE 3 WAYS TO MAKE YOUR RESERVATIONS

1. Call CIA, direct at 1-800-929-4242 (U.S. and Canada) and ask for **GSA Group # 633**. For reservations outside of the U.S. and Canada call (619) 453-3686.
2. Call the airlines direct and ask for the following codes:
American Airlines 1-800-433-1790, Starfile #9408UN
United Airlines 1-800-521-4041, Tour Code #522AN
Canadian Air 1-800-665-5554, Starfile #M02497
3. If you use your own travel agency:
Please refer to the ID numbers above when booking on official carriers in order to receive special discounts.

CONVENTIONS IN AMERICA

7770 Regents Road, Suite 111, San Diego, CA 92122, 1-800-929-4242,
fax 619-453-7976, flycia@scitravel.com, www.scitravel.com
(Reference #633 when sending correspondence)

FUNDING OPPORTUNITIES IN THE HYDROLOGIC SCIENCES THROUGH THE NATIONAL SCIENCE FOUNDATION

Wednesday, October 28 from 3:00 to 5:00 p.m., Room 716B,
Metro Toronto Convention Centre.

Presiding: L. Douglas James, Program Director, National Science Foundation (NSF), Hydrologic Sciences

Have a great hypothesis? Need funding? Unsure about funding mechanisms? If so, you need to attend this session. The session will begin with opening remarks by James on current funding opportunities in the hydrologic sciences, followed by an open question-answer-discussion period. If you're nearing completion of your Ph.D., in a post doctorate position, struggling to achieve tenure, or just looking for new opportunities, then you need to take advantage of this chance to meet and question the program director of a major source of funding in the hydrologic sciences. Don't be shy, come to learn or come prepared with specific questions, comments, and/or concerns about current and future research funding in our field.

Late-Breaking Research Sessions

Exciting new data or breakthroughs over the summer?

*Present your work
at the GSA Annual Meeting this fall!*

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

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

Abstract Fee: For this meeting, a nonrefundable abstract fee of \$50 must accompany each Late-Breaking Research abstract submitted. Our Web-template form will ask for credit-card information. Our *secure server* system for transmission of your credit-card data will fully protect your confidential information.

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

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

Annual Meeting Cosponsors

UNIVERSITY OF TORONTO



The University of Toronto is currently celebrating 150 years of teaching and research in geology. The Department was founded in 1853 - Canada's first - but teaching programs predate that event by several years. The University has been ranked in several recent surveys as Canada's pre-eminent research-intensive institution of higher learning, and the

Department of Geology is recognized internationally for the breadth and strength of its faculty. Programs in geophysics and in geological engineering (the Lassonde Minerals Engineering Program) complement those in the Department of Geology.

MCMASTER UNIVERSITY



At McMaster University, our purpose is the discovery, communication, and preservation of knowledge. In our teaching, research, and scholarship, we are

committed to creativity, innovation, and excellence. We value integrity, quality, and teamwork in everything we do. We inspire critical thinking, personal growth, and a passion for learning. We serve the social, cultural, and economic needs of our community and our society.

CANACCORD CAPITAL



Founded in 1950, Canaccord Capital is one of Canada's largest independent investment firms, recognized as a leader in equity financing for resource, technology, and special situation companies, both North American and interna-

tionally based. With principal offices in Toronto, Vancouver, and Calgary, and affiliated partners in the United States, Britain, and Bermuda, Canaccord Capital offers a full range of professional investment services including corporate finance, research, institutional equities, international trading, and private client services.

CANADIAN INSTITUTE OF MINING, METALLURGY AND PETROLEUM (CIM)



The Canadian Institute of Mining, Metallurgy, and Petroleum (CIM) is the leading technical society of professionals in the Canadian minerals, metals, and energy industries. Founded in 1898, CIM has 12,000 members dedicated to the discovery, production, and economics of Canada's minerals, metals, materials, and energy

industries. Along with 60 coast-to-coast branches and sections, CIM's Societies, Divisions and Committees arrange conferences, meetings and courses, liaise with government departments, commission special volumes and reports, and publish technical papers. CIM website: www.cim.org

THE GEOLOGICAL ASSOCIATION OF CANADA



The Geological Association of Canada is Canada's most broadly based and multidisciplinary earth science society. Members include earth scientists from across Canada and around the world. The Association promotes earth science in Canada through conferences, publications, and educational programs.

THE GEOLOGICAL SURVEY OF CANADA



The Geological Survey of Canada (GSC) supplies the fundamental national geoscience knowledge base required to support effective mineral and hydrocarbon exploration and development across Canada; to provide the geological basis necessary to understand and address health, safety and environmental issues; and to advocate the interests of Canadian geoscience at the international level.

MINERALOGICAL ASSOCIATION OF CANADA



The Mineralogical Association of Canada was incorporated to promote and advance knowledge of mineralogy in its broadest sense. To this end, the Association publishes *The Canadian Mineralogist* and sponsors short courses devoted to specific aspects of mineralogy, petrology, geochemistry, mineral deposits, and crystallography. We invite you to visit our booth at GSA 1998.

ROYAL ONTARIO MUSEUM



Founded in 1914, the Royal Ontario Museum (ROM) has attained international recognition for its collections and the scope of its worldwide field activities.

The ROM is Canada's largest museum, having over 40 galleries featuring artistic, archaeological, and scientific objects from around the world. Our new exhibit, "Monsters from the Deep Past," featuring Burgess Shale and Ontario fossils, opens in time for your visit, October 21.

INTERNATIONAL GEOLOGICAL SURVEYS ATTEND 1998 GSA ANNUAL MEETING

The 1998 International Survey Program (ISP) Committee has invited national surveys worldwide to participate in the GSA Annual Meeting. Thirty delegates from 20 surveys will participate in various programs throughout the week.

International Survey Exhibits will focus on environmental developments in various countries. Sunday, 5:00 p.m. to 7:30 p.m.; Monday, Tuesday, and Wednesday, 9:00 a.m. to 5:30 p.m., MTCC Hall D, Booths 936 to 1144.

International Surveys Posters Symposium 30: Global Earth Science. Monday, 8:00 a.m. to 12:00 noon., MTCC Hall E. GSA extends a special welcome to delegates from the following international geological surveys and to all international registrants to the 1998 Annual Meeting in Toronto: Argentina, Australia, Austria, Bolivia, Brazil, Burkina Faso, Canada, Cote d'Ivoire, Ecuador, Finland, France, Ireland, Japan, Morocco, Norway, Peru, Slovak Republic, Ukraine.

GSA International Program Sponsors: Association of American State Geologists, Geological Survey of Canada, Geological Society of America, GSA International Division.

GSA International Program Donors: Amoco, Exxon, Geological Survey of Canada, Ocean Energy, University of Toronto

For more information please contact Blyth Robertson, co-chair of the International Program Committee, (613) 996-6575 or e-mail blrobert@nrcan.gc.ca

SPONSORS

Amoco Corporation
Brooks/Cole Publishing/
Wadsworth Publishing Company

Canadian Geological Foundation
Centre for Groundwater Studies
Duke Engineering and Services
EarthSoft
Exxon

Flinders University of
South Australia
Geological Survey of Canada
GSA Hydrogeology Division
Micromass, Inc.

Occidental Oil & Gas Corporation
Ocean Energy Inc.
Sinclair Knight Merz
University of Texas at Austin
University of Toronto

Overview of the 1998 GSA Annual Meeting Program

October 26–29, 1998 ■ Metro Toronto Convention Centre

Free ... **AND PRIOR TO PUBLICATION**
Create your own personal schedule for the meeting ...

GSA TECHNICAL SESSIONS ON THE WEB — SEPT. 1

The titles and authors database is now available on the Web. You can download sessions, events, exhibits, field trips, and courses together with a basic search and sorting software that will create your personal daily calendar. Web site: <http://www.geosociety.org/meetings/98>

There will be 176 technical sessions presented during the course of the meeting. Of these, symposia (invited papers) and theme sessions (volunteered papers submitted to a specific topic) are referred to by a number that precedes the title. All other sessions are referred to by disciplines, such as Geochemistry I, II. Sessions are oral unless poster is indicated.

Technical Session Program Calendar — 1998

Titles and Authors Database: <http://www.geosociety.org/meetings/98>

SUNDAY, OCTOBER 25

#	Time	Description/Sponsor	Location
1	8:00 a.m.	S08. Research Issues in Petroleum and Environmental Organic Geochemistry I—GS (Organic Geochemistry Division)	MTCC:801AB
2	1:30 p.m.	S05. The Voisey's Bay Ni-Cu-Co Deposit—SEG; 1998 Annual Meeting Committee	MTCC:718AB
3	1:30 p.m.	S08. Research Issues in Petroleum and Environmental Organic Geochemistry II—GS (Organic Geochemistry Division)	MTCC:801AB
4	1:30 p.m.	S15. IEE Annual Environmental Forum: The Sustainability Challenge: Energy for the 21st Century—IEE and GSA ad hoc Committee on Critical Issues	MTCC:715AB

MONDAY, OCTOBER 26, 1998

5	8:00 a.m.	Archaeological Geology I	MTCC:705
6	8:00 a.m.	Economic Geology I	MTCC:707
7	10:00 a.m.	Geochemical Society: Ingerson Lecture	MTCC:701A
8	8:00 a.m.	Hydrogeology I: Water Quality, Isotopes, Remediation	MTCC:703
9	10:00 a.m.	Igneous Petrology I	MTCC:709
10	8:00 a.m.	Micropaleontology (Posters)	MTCC:Hall E
11	8:00 a.m.	Paleontology (Posters)	MTCC:Hall E
12	8:00 a.m.	Paleontology/Paleobotany I: Paleobiological Dynamics from the Terrestrial Realm	MTCC:801AB
13	8:00 a.m.	Paleontology/Paleobotany II: Evolutionary Paleocology from Biofacies to Stable Isotopes	MTCC:715AB
38	8:00 a.m.	Regional-Scale Faulting <i>Misnumbered—but in correct order.</i>	MTCC:717AB
14	8:00 a.m.	Volcanology	MTCC:709
15	8:00 a.m.	K01. Tectonic Evolution of Precambrian North America I—A Synthesis of Recent Results—LITHOPROBE; GSA Structural Geology and Tectonics Division; GSA Geophysics Division; 1998 Annual Meeting Committee	MTCC:718AB
16	8:00 a.m.	S02. Controls on Sedimentation and Stratigraphy in Major Coal Producing Basins of North America—GSA Coal Geology Division	MTCC:712
17	8:00 a.m.	S07. Military Applications of Engineering Geology—GSA Engineering Geology Division	MTCC:716A
18	8:00 a.m.	S23. North American Ice Sheets during Marine Isotope Stages 3 to 1: Extent, Chronology, Data and Modelling—GSA Quaternary Geology and Geomorphology Division	MTCC:802AB
19	8:00 a.m.	S26. Paleocological and Geochemical Signature of Cretaceous Anoxic Events: A Memorial to William V. Sliter—CF and 1998 Annual Meeting Committee	MTCC:803AB
20	8:00 a.m.	S30. International Surveys (Posters)—International Subcommittee and 1998 Annual Meeting Committee	MTCC:Hall E

KEY TO ORGANIZATIONS SPONSORING SESSIONS

AGI American Geological Institute
 AGU American Geophysical Union
 CF Cushman Foundation
 CGU Canadian Geophysical Union
 GIS Geoscience Information Society
 GS Geochemical Society
 GAC Geological Association of Canada

GSC Geological Society of Canada
 IEE Institute for Environmental Education
 IAGC International Association of Geochemistry and Cosmochemistry
 IGCP International Geological Correlation Program
 IUGS International Union of Geological Sciences

MSA Mineralogical Society of America
 NAGT National Association of Geoscience Teachers
 NRC National Research Council
 NSF National Science Foundation
 PS Paleontological Society
 SEG Society of Economic Geologists

SEPM Society of Sedimentary Geology
 SGE Sigma Gamma Epsilon
 SLMS Society of Luminescence Microscopy and Spectroscopy
 SVP Society of Vertebrate Paleontology
 USDOE U.S. Department of Energy
 USGS U.S. Geological Survey

#	Time	Sponsor/Description	Location
21	8:00 a.m.	T02. Natural Sources of Mercury and Arsenic: Significance in Regional Cycles and Environmental Assessments—IEE	MTCC:716B
22	8:00 a.m.	T09. Luminescence in Geology: 10th Anniversary Meeting of Society of Luminescence Microscopy and Spectroscopy—SLMS	MTCC:701A
23	8:00 a.m.	T11. Breaking Down Barriers: Communicating Relevant Geoscience Issues to the Public I (Posters)—GSA Education, Outreach and Policy Programs and IEE	MTCC:Hall E
24	8:00 a.m.	T20. Controls on the Style, Distribution, and Intensity of Deformation Around Faults and Folds—GSA Structural Geology and Tectonics Division	MTCC:711
25	8:00 a.m.	T34. Terrestrial Records of Late-Glacial and Holocene Climate Change in the Americas	MTCC:701B
26	10:00 a.m.	T44. Groundwater Sustainability—GSA Hydrogeology Division and IEE	MTCC:714AB
27	8:00 a.m.	T45. Capture Zones in Fractured Rock—GSA Hydrogeology Division and GSA Engineering Geology Division	MTCC:714AB
28	1:30 p.m.	Climates, Oceans and Lakes of the Quaternary	MTCC:709
29	1:30 p.m.	Cordillera I: USA	MTCC:707
30	1:30 p.m.	Economic Geology II	MTCC:705
31	1:30 p.m.	Environmental and Engineering Geology	MTCC:703
32	1:30 p.m.	Geochemistry (Posters)	MTCC:Hall E
33	1:30 p.m.	Geochemistry, Aqueous (Posters)	MTCC:Hall E
34	1:30 p.m.	Geoscience Information Society (Posters)	MTCC:Hall E
35	1:30 p.m.	Igneous Petrology II	MTCC:711
36	1:30 p.m.	Paleontology/Paleobotany III: Paleobiological Patterns: Phylogenetics and Morphological Constraints	MTCC:701B
37	1:30 p.m.	Precambrian Geology (Posters)	MTCC:Hall E
38		<i>(See Monday a.m., p. 19)</i>	
39	1:30 p.m.	S09. Geochemical Indicators of Atmospheric Inputs into Terrestrial and Marine Environments—GS	MTCC:701A
40	1:30 p.m.	S14. Hutton, Lyell, Logan — and Their Influence in North America—GSA History of Geology Division	MTCC:716A
41	1:30 p.m.	S18. Deformation Mechanisms and Microstructures—GSA Structural Geology and Tectonics Division	MTCC:717AB
42	1:30 p.m.	S28. Multimodal Heterogeneity in Clastic Aquifers: Quantifying Permeability and Lithofacies Distributions—GSA Hydrogeology Division and SEPM	MTCC:714AB
43	1:30 p.m.	S29. Breaking Down Barriers: Communicating Relevant Geoscience Issues to the Public—GSA Education, Outreach and Policy Programs	MTCC:712
44	1:30 p.m.	T19. Geophysical Studies of the Crust and Lithosphere—GSA Geophysics Division; GSA Structural Geology and Tectonics Division	MTCC:803AB
45	1:30 p.m.	T24. Tectonic Evolution of Precambrian North America II (Posters)—LITHOPROBE; GSA Structural Geology and Tectonics Division; GSA Geophysics Division; 1998 Annual Meeting Committee	MTCC:Hall E
46	1:30 p.m.	T33. Continental Glaciations: Continuing Debates I	MTCC:802AB
47	1:30 p.m.	T34. Terrestrial Records of Late-Glacial and Holocene Climate Change in the Americas II	MTCC:716B
48	1:30 p.m.	T37. Paleontology Solves Geologic Problems—PS and SVP	MTCC:801AB
49	1:30 p.m.	T49. Hydrogeologic Controls on Ecosystems—GSA Hydrogeology Division and IEE	MTCC:715AB

TUESDAY, OCTOBER 27, 1998

50	8:00 a.m.	Archaeological Geology II	MTCC:709
51	8:00 a.m.	Central/Southern Appalachians	MTCC:701B
52	8:00 a.m.	Economic Geology III	MTCC:717AB
53	8:00 a.m.	Geochemistry, Aqueous I	MTCC:803AB
54	8:00 a.m.	Geoscience Education (Posters)	MTCC:Hall E
55	8:00 a.m.	Microstructures	MTCC:707
56	8:00 a.m.	Quaternary Geology and Geomorphology (Posters)	MTCC:Hall E
57	10:00 a.m.	SEG Distinguished Lecture	MTCC:717AB
58	8:00 a.m.	Stratigraphic Correlation, Models, Cycles, and Architecture	MTCC:705
59	8:00 a.m.	K03. Geology and Biology of Early Animal Evolution—PS	MTCC:718AB
60	8:00 a.m.	S16. Research Opportunities in the Earth Sciences: A Ten-Year Vision—NRC; NSF	MTCC:703
61	8:00 a.m.	S19. Accretionary Margins of North America—CF	MTCC:716B

#	Time	Sponsor/Description	Location
62	8:30 a.m.	S21. Experimental Petrology and Applications: A Tribute to 35 Years of Research in the Goldsmith-Newton Laboratory at the University of Chicago—MSA; GS	MTCC:716A
63	8:00 a.m.	T06. Geomicrobiology I	MTCC:801AB
64	8:00 a.m.	T11. Breaking Down Barriers: Communicating Relevant Geoscience Issues to the Public II—GSA Education, Outreach and Policy Programs and IEE	MTCC:712
65	8:00 a.m.	T24. Tectonic Evolution of Precambrian North America III—LITHOPROBE; GSA Structural Geology and Tectonics Division; GSA Geophysics Division; 1998 Annual Meeting Committee	MTCC:701A
66	8:00 a.m.	T31. The Power of Paleolimnology: State of the Art and Future Directions (Posters)	MTCC:Hall E
67	8:00 a.m.	T33. Continental Glaciations: Continuing Debates II	MTCC:802AB
68	8:00 a.m.	T35. Holocene Climate Change on the Great Plains—GSA Quaternary Geology and Geomorphology Division; Terrain Sciences Division, GSC; Global Change and Climate History Program, USGS	MTCC:711
69	8:00 a.m.	T41. Geological Evolution of Mexico: Its Relation to Conterminous North America	MTCC:715AB
70	8:00 a.m.	T46. Solute Transport in Aquitards: Field Studies—GSA Hydrogeology Division	MTCC:714AB
71	1:30 p.m.	Coal Geology (Posters)	MTCC:Hall E
72	1:30 p.m.	Cordillera II: Alaska/Canada and South America	MTCC:715AB
73	3:30 p.m.	Cretaceous and Tertiary Stratigraphy: Sequences, Volcanism, Paleomagnetism, and Impacts	MTCC:712
74	1:30 p.m.	Environmental and Engineering Geology (Posters)	MTCC:Hall E
75	1:30 p.m.	Geochemistry I	MTCC:717AB
76	1:30 p.m.	Geochemistry, Aqueous II	MTCC:714AB
77	5:00 p.m.	Geoscience Information	MTCC:716A
78	1:30 p.m.	Impact and Volcanism: Sudbury and Beyond!	MTCC:801AB
79	4:00 p.m.	MSA Presidential Address	MTCC:801AB
80	3:45 p.m.	Northern Appalachians and Caledonides	MTCC:711
81	1:30 p.m.	Patterns and Processes of Siliciclastic Basin Fill	MTCC:701B
82	1:30 p.m.	Sedimentary Carbonates: Models, Case Studies, and Processes	MTCC:701A
83	1:30 p.m.	Structural Geology: Veins	MTCC:711
84	1:30 p.m.	S04. Accreting the Continent's Collections of Earth Science Information—GIS	MTCC:716A
85	1:30 p.m.	S10. Developing Sustainability Curricula: A Challenge for Earth Sciences Educators—NAGT, IEE, and GSA ad hoc Committee on Critical Issues	MTCC:709
86	1:30 p.m.	S11. Student Research Symposium (Posters)—SGE	MTCC:Hall E
87	1:30 p.m.	S13. Conversations with the Earth: Philosophers and Geoscientists in Dialogue on the Role of the Earth Sciences in Society—IEE and International Association for Environmental Philosophy	MTCC:718AB
88	5:30 p.m.	S27. Understanding Ground Water in Arid and Semi-Arid Environments of North America and Australia—GSA Hydrogeology Division; The University of Texas at Austin; Flinders University of South Australia; Centre for Groundwater Studies; Duke Engineering and Services; Sinclair Knight Merz	MTCC:716B
89	1:30 p.m.	T06. Geomicrobiology II	MTCC:802AB
90	1:30 p.m.	T08. Continent Formation, Growth, and Recycling I	MTCC:803AB
91	1:30 p.m.	T15. Education About the Environment: What Works (Posters)—NAGT and IEE	MTCC:Hall E
92	1:30 p.m.	T17. Crustal Evolution and Historical Studies of American Geology—GSA History of Geology Division	MTCC:716B
93	1:30 p.m.	T22. What Are We Dating? Understanding the Crystallogenesis of U-Pb Geochronometers—GSA Structural Geology and Tectonics Division	MTCC:707
94	1:30 p.m.	T32. On the Nature and Origin of Stone Lines and Lithologic Discontinuities in Sediments and Soils—GSA Quaternary Geology and Geomorphology Division	MTCC:712
95	1:30 p.m.	T35. Holocene Climate Change on the Great Plains II—GSA Quaternary Geology and Geomorphology Division; Terrain Sciences Division, GSC; Global Change and Climate History Program, USGS	MTCC:703

KEY TO ORGANIZATIONS SPONSORING SESSIONS

AGI American Geological Institute	GSC Geological Society of Canada	MSA Mineralogical Society of America	SEPM Society of Sedimentary Geology
AGU American Geophysical Union	IEE Institute for Environmental Education	NAGT National Association of Geoscience Teachers	SGE Sigma Gamma Epsilon
CF Cushman Foundation	IAGC International Association of Geochemistry and Cosmochemistry	NRC National Research Council	SLMS Society of Luminescence Microscopy and Spectroscopy
CGU Canadian Geophysical Union	IGCP International Geological Correlation Program	NSF National Science Foundation	SVP Society of Vertebrate Paleontology
GIS Geoscience Information Society	IUGS International Union of Geological Sciences	PS Paleontological Society	USDOE U.S. Department of Energy
GS Geochemical Society		SEG Society of Economic Geologists	USGS U.S. Geological Survey
GAC Geological Association of Canada			

#	Time	Sponsor/Description	Location
WEDNESDAY, OCTOBER 28, 1998			
96	8:00 a.m.	Archaeological Geology (Posters)	MTCC:Hall E
97	8:00 a.m.	Climates and Oceans before the Quaternary	MTCC:703
98	8:00 a.m.	Geochemistry II	MTCC:705
99	8:00 a.m.	Hydrogeology II: Hydraulics, Fracture Flow, Karst	MTCC:716B
100	8:00 a.m.	Marine Geology (Posters)	MTCC:Hall E
101	8:00 a.m.	Metamorphic Petrology I	MTCC:717AB
102	8:00 a.m.	Paleontology/Paleobotany IV: Origin and Diversification of Early Life on Earth	MTCC:701A
103	8:00 a.m.	Structural Geology and Tectonics (Posters)	MTCC:Hall E
104	8:00 a.m.	K04. Deep Crustal Processes I—International Lithosphere Program; GSA Geophysics Division; GSA Structural Geology and Tectonics Division; Geological Association of Canada; Canadian Geophysical Union; International Association of Geomagnetism and Aeronomy; International Association of Seismology and Physics of the Earth's Interior; International Association of Volcanism and Chemistry of the Earth's Interior; American Geophysical Union	MTCC:718AB
105	8:00 a.m.	S06. The Lac de Gras Diamondiferous Kimberlite Field, Northwest Territories, Canada—SEG	MTCC:801AB
106	8:35 a.m.	S12. Geoscience Education: Predictions for the 21st Century—NAGT	MTCC:711
107	8:00 a.m.	S17. Fault Reactivations, Neotectonics, and Seismicity in the Great Lakes Region I—GAC; GSA Structural Geology and Tectonics Division	MTCC:803AB
108	8:00 a.m.	S25. Response to Holocene Climate Change on the Great Plains—GSA Quaternary Geology and Geomorphology Division; Terrain Sciences Division, GSC; Global Change and Climate History Program, USGS	MTCC:802AB
109	8:00 a.m.	T05. Landslides and Engineering Geology—GSA Engineering Geology Division; GSA Quaternary Geology and Geomorphology Division	MTCC:709
110	8:00 a.m.	T07. Sources, Transport, Fate and Toxicology of Trace Elements in the Environment—IAGC, <i>in memory of Helen L. Cannon</i>	MTCC:701B
111	10:00 a.m.	T10. Field Camp Pedagogies: Adjusting to Modern Equipment and the Modern Student	MTCC:712
112	8:00 a.m.	T29. Tonalites, Trondhjemites, and Granodiorites and Related Rocks: Ancient Examples and Modern Analogues	MTCC:714AB
113	8:00 a.m.	T30. Environments and Timing of the Last Interglaciation: Vegetation, Paleohydrology, and Climate—GSA Quaternary Geology and Geomorphology Division	MTCC:707
114	8:00 a.m.	T31. The Power of Paleolimnology: State of the Art and Future Directions	MTCC:716A
115	8:00 a.m.	T39. Paleontological Databases and Taxonomic Decisions—PS	MTCC:715AB
116	8:00 a.m.	T42. Onshore-Offshore Correlation of Cenozoic Strata, Western Margin of North Atlantic (Posters)	MTCC:Hall E
117	1:30 p.m.	Asian Tectonics	MTCC:703
118	1:30 p.m.	Epstein Colloquium I	MTCC:701B
119	1:30 p.m.	Geology Education	MTCC:709
120	1:30 p.m.	Hydrogeology (Posters)	MTCC:Hall E
121	1:30 p.m.	Metamorphic Petrology II	MTCC:712
122	3:30 p.m.	Mineralogy/Crystallography	MTCC:712
123	1:30 p.m.	Paleoceanography/Paleoclimatology (Posters)	MTCC:Hall E
124	1:30 p.m.	Paleontology/Paleobotany V: Phanerozoic Diversification, Dispersal, and Extinction Patterns	MTCC:701A
125	1:30 p.m.	Planetary (Posters)	MTCC:Hall E
126	1:30 p.m.	Precambrian Oil, Sedimentation, Zircon Chronology, and Mafic Magmatism	MTCC:711
127	1:30 p.m.	Quaternary Geology and Geomorphology I: Fluvial and Hillslope Geomorphology: Channel Erosion, Sediment Transport, and Paleoenvironmental Studies	MTCC:803AB
128	1:30 p.m.	S17. Fault Reactivations, Neotectonics, and Seismicity in the Great Lakes Region II—GAC; GSA Structural Geology and Tectonics Division	MTCC:716B
129	1:30 p.m.	S20. Role of Partial Melting During Evolution of Convergent Orogenic Belts—GSA Structural Geology and Tectonics Division	MTCC:714AB
130	1:30 p.m.	S24. Application of Cosmogenic Nuclides in Surficial Processes and Global Change Studies—GSA Sedimentary Geology Division; GSA Quaternary Geology and Geomorphology Division	MTCC:802AB
131	1:30 p.m.	T01. Gold Deposits Associated with Alkalic Rocks—SEG	MTCC:801AB
132	1:30 p.m.	T06. Geomicrobiology III	MTCC:707
133	1:30 p.m.	T12. Teaching Hydrogeology to Undergraduate and Graduate Students—GSA Hydrogeology Division; NAGT; GSA Education, Outreach, and Policy Programs	MTCC:716A

#	Time	Sponsor/Description	Location
134	1:30 p.m.	T31. The Power of Paleolimnology: State of the Art and Future Directions II	MTCC:715AB
135	1:30 p.m.	T38. The End-Permian Mass Extinction: Paleozoic Nemesis	MTCC:718AB
136	1:30 p.m.	T53. Origin and Transport of Non-Hydrocarbon Gases in Sedimentary Basins	MTCC:717AB

THURSDAY, OCTOBER 29, 1998

137	8:00 a.m.	Carbonates: Paleoenvironmental Records	MTCC:705
138	8:00 a.m.	Epstein Colloquium II	MTCC:801AB
139	8:00 a.m.	Experimental Petrology	MTCC:707
140	8:00 a.m.	Geophysics: GPR, GPS, Earthquakes, Paleomagnetism, and Tectonics (Posters)	MTCC:Hall E
141	8:00 a.m.	Hydrogeology III: Karst, Nitrates, Tracers, Aquitards	MTCC:715AB
142	8:00 a.m.	Mesoscopic Studies of Joints and Faults	MTCC:716A
143	8:00 a.m.	Paleontology/Paleobotany VI: Evolutionary Paleobiology from Micro- to Macroevolution	MTCC:714AB
144	8:00 a.m.	Quaternary Geology and Geomorphology II: Tectonic Geomorphology and Soil Geomorphology/Weathering	MTCC:716B
145	8:00 a.m.	Sedimentary Geology: Stratigraphy, Carbonate and Clastic Deposition, and Diagenesis (Posters)	MTCC:Hall E
146	8:00 a.m.	K02. Pathfinder and Global Surveyor: New Views of Mars—GSA Planetary Geology Division	MTCC:718AB
147	8:00 a.m.	S03. Environmental Quality vs. Economic Development: The Role of Coal in Developing Nations—GSA International Division; GSA Coal Division; USGS; GSC; IEE	MTCC:703
148	8:00 a.m.	S22. Locating Old Mantle Plumes—GSA Geophysics Division; Geophysics Division, GAC; GSA International Division	MTCC:701A
149	10:00 a.m.	T08. Continental Formation, Growth, and Recycling II	MTCC:803AB
150	8:00 a.m.	T13. Creating Learning Environments with the Internet and Multimedia I—NAGT and AGI	MTCC:711
151	8:00 a.m.	T14. Teaching Through Inquiry in the Geosciences I—NAGT and GSA Geoscience Education Division	MTCC:712
152	8:00 a.m.	T23. Deep Crustal Processes I (Posters)—International Lithosphere Program; GSA Geophysics Division; GSA Structural Geology and Tectonics Division; GAC; CGU; International Association of Geomagnetism and Aeronomy; International Association of Seismology and Physics of the Earth's Interior; AGU	MTCC:Hall E
153	8:00 a.m.	T25. NAFTA: North American Floating Terrane Accretion—IGCP 376	MTCC:709
154	8:00 a.m.	T26. Role of Partial Melting During Evolution of Convergent Orogenic Belts (Posters)	MTCC:Hall E
155	8:00 a.m.	T27. Applied Geological Remote Sensing—IUGS	MTCC:803AB
156	8:00 a.m.	T36. Surficial Processes and Landscape Dynamics Within Arid and Desert Environments—U.S. Army Research Office; Desert Research Institute	MTCC:701B
157	8:00 a.m.	T48. Radionuclide Transport Experiments at Underground Research Laboratories—USDOE/Yucca Mountain Project	MTCC:802AB
158	8:00 a.m.	T50. From Continental Shelf to Abyssal Plain—Links Between Sediment Transport and Morphology	MTCC:717AB
159	1:30 p.m.	Coal Geology	MTCC:712
160	1:30 p.m.	Economic Geology (Posters)	MTCC:Hall E
161	1:30 p.m.	Experimental Petrology (Posters)	MTCC:Hall E
162	1:30 p.m.	Geochemistry, Aqueous: Paleo and Processes	MTCC:715AB
163	1:30 p.m.	Igneous Petrology (Posters)	MTCC:Hall E
164	1:30 p.m.	Metamorphic Petrology (Posters)	MTCC:Hall E
165	1:30 p.m.	Mineralogy/Crystallography (Posters)	MTCC:Hall E
166	1:30 p.m.	Paleontology/Paleobotany VII: Preservation Anomalies and Refinements to the Record: Taphonomy to Trace Fossils	MTCC:701A
167	1:30 p.m.	Quaternary Geology and Geomorphology III: Quaternary Glacial Events and Paleoclimate	MTCC:705
168	1:30 p.m.	Volcanology (Posters)	MTCC:Hall E
169	1:30 p.m.	T13. Creating Learning Environments with the Internet and Multimedia II—NAGT and AGI	MTCC:707
170	1:30 p.m.	T14. Teaching Through Inquiry in the Geosciences II—NAGT and GSA Geoscience Education Division	MTCC:711

KEY TO ORGANIZATIONS SPONSORING SESSIONS

AGI American Geological Institute	GSC Geological Society of Canada	MSA Mineralogical Society of America	SEPM Society of Sedimentary Geology
AGU American Geophysical Union	IEE Institute for Environmental Education	NAGT National Association of Geoscience Teachers	SGE Sigma Gamma Epsilon
CF Cushman Foundation	IAGC International Association of Geochemistry and Cosmochemistry	NRC National Research Council	SLMS Society of Luminescence Microscopy and Spectroscopy
CGU Canadian Geophysical Union	IGCP International Geological Correlation Program	NSF National Science Foundation	SVP Society of Vertebrate Paleontology
GIS Geoscience Information Society	IUGS International Union of Geological Sciences	PS Paleontological Society	USDOE U.S. Department of Energy
GS Geochemical Society		SEG Society of Economic Geologists	USGS U.S. Geological Survey
GAC Geological Association of Canada			

#	Time	Sponsor/Description	Location
171	1:30 p.m.	T23. Deep Crustal Processes II—International Lithosphere Program; GSA Geophysics Division; GSA Structural Geology and Tectonics Division; GAC; CGU; International Association of Geomagnetism and Aeronomy; International Association of Seismology and Physics of the Earth's Interior; AGU	MTCC:801AB
172	1:30 p.m.	T28. Archean Cratons: Evolution and Assembly	MTCC:803AB
173	1:30 p.m.	T40. Sequence Stratigraphic Controls on Organic Facies	MTCC:716A
174	1:30 p.m.	T43. Interpreting Fossil Earthquakes from the Stratigraphic Record	MTCC:716B
175	1:30 p.m.	T47. Groundwater Flow and Solute Transport into the Great Lakes—GSA Hydrogeology Division	MTCC:701B
176	1:30 p.m.	T54. Assembling a New Understanding of Mars—GSA Planetary Geology Division	MTCC:718AB

GSA-SPONSORED SHORT COURSES

Registration information and course descriptions were published in the June issue of *GSA Today*. For additional information, contact Edna Collis, GSA headquarters, ecollis@geosociety.org, or see GSA's Web site, www.geosociety.org. Fees are given in U.S. dollars

PREREGISTRATION DEADLINE: SEPTEMBER 18

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

Saturday, October 24 and Sunday, October 25, 8:00 a.m. to 5:00 p.m. Metro Toronto Convention Centre. Cosponsored by *GSA Structural Geology and Tectonics Division*. **FACULTY:** David V. Wiltschko, John W. Morse, and Will Lamb, Dept. of Geology and Geophysics, Texas A&M University, College Station, and Zachary D. Sharp, Dept. of Earth and Planetary Sciences, University of New Mexico. **Limit:** 40. Fee: \$290, students \$270; includes course manual and lunch both days. CEUs: 1.6.

2. ■ DEFORMATION MECHANISMS AND MICROSTRUCTURES

Saturday, October 24, 8:00 a.m. to 5:00 p.m., and Sunday, October 25, 8:00 a.m. to 12:00 noon. University of Toronto. Cosponsored by *GSA Structural Geology and Tectonics Division*. **FACULTY:** Jan Tullis, Dept. of Geological Sciences, Brown University; Christian Teyssier, Dept. of Geology, University of Minnesota; Holger Stunitz, Geology and Paleontology Institute of Basel University, Switzerland. **Limit:** 30. Fee: \$250, students \$230; includes course manual, slide set, and lunch on Saturday. CEUs: 1.6.

3. ■ PHASE I ENVIRONMENTAL SITE ASSESSMENTS

Saturday, October 24 and Sunday, October 25, 8:00 a.m. to 5:00 p.m. Metro Toronto Convention Centre. Cosponsored by *GSA Engineering Geology Division*. **FACULTY:** Raymond C. Kimbrough, Tom Joiner & Associates, Inc., Tuscaloosa, Alabama. **Limit:** 30. Fee: \$245, students \$225; includes course manual and lunch both days. CEUs: 1.6. *Optional exam fee: \$90. Optional NREP Study Guide is available for \$50.*

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

Saturday, October 24 and Sunday, October 25, 8:00 a.m. to 5:00 p.m. Metro Toronto Convention Centre. **FACULTY:** Bruce S. Hart, New Mexico Bureau of Mines and Mineral Resources, Socorro. **Limit:** 40. Fee: \$240, students \$220; includes course manual and lunch both days. CEUs: 1.6.

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

Sunday, October 25, 8:00 a.m. to 5:00 p.m. University of Toronto. Cosponsored by *GSA Archaeological Geology Division*. **FACULTY:** Patrick J. Julig, Dept. of Sociology and Anthropology, Laurentian University, Sudbury, Ontario; Darrel G. E. Long, Dept. of Earth Sciences, Laurentian University, Sudbury, Ontario; R. G. V. Hancock, SLOWPOKE reactor facility, Dept. of Chemical Engineering and Applied Chemistry, University of Toronto. **Limit:** 30. Fee: \$220, students \$200; includes course manual and lunch. CEUs: 0.8.

6. ■ APPLICATIONS OF ENVIRONMENTAL ISOTOPES IN GROUNDWATER STUDIES

Sunday, October 25, 8:00 a.m. to 5:00 p.m. Metro Toronto Convention Centre. Cosponsored by *GSA Hydrogeology Division*. **FACULTY:** Ramon Aravena, Dept. of Earth Sciences, University of Waterloo, Ontario; Ian D. Clark, Dept. of Geology, University of Ottawa. **Limit:** 50. Fee: \$190, students \$170; includes course manual and lunch. CEUs: 0.8.

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

Sunday, October 25, 8:00 a.m. to 5:00 p.m. Metro Toronto Convention Centre. **FACULTY:** John H. Kramer, Condor Earth Technologies, Inc., Sonoma, California; Todd T. Fitzgibbon, U.S. Geological Survey, Menlo Park, California. **Limit:** 35. Fee: \$240, students \$220; includes course manual and lunch. CEUs: 0.8.

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

Sunday, October 25, 8:00 a.m. to 5:00 p.m. University of Toronto. **FACULTY:** Parvinder S. Sethi, Dept. of Geology, Radford University, Radford, Virginia. **Limit:** 25. Fee: \$230, students \$210; includes course manual and lunch. CEUs: 0.8.

9. ■ DETECTING ENVIRONMENTAL EFFECTS USING BENTHIC FORAMINIFERA AND THECAMOEBIANS

Sunday, October 25, 8:00 a.m. to 5:00 p.m. Metro Toronto Convention Centre. Cosponsored by *Cushman Foundation*. **FACULTY:** David B. Scott, and Eduard G. Reinhardt, Dept. of Earth Sciences, Dalhousie University, Halifax, Nova Scotia; Francine M. G. McCarthy, Dept. of Earth Sciences, Brock University, St. Catharines, Ontario; R. Timothy Patterson, Dept. of Earth Sciences, Carleton University, Ottawa, Ontario. **Limit:** 30. Fee: \$230, students \$210; includes course manual and lunch. CEUs: 0.8.

10. ■ GEOTECHNICAL AND ENVIRONMENTAL APPLICATIONS OF TIME DOMAIN REFLECTOMETRY

Sunday, October 25, 8:00 a.m. to 5:00 p.m. Metro Toronto Convention Centre. Cosponsored by *GSA Engineering Geology Division*. **FACULTY:** Kevin M. O'Connor, President, GeoTDR, Inc., Apple Valley, Minnesota; Charles H. Dowding, Dept. of Civil Engineering, Northwestern University. **Limit:** 50. Fee: \$190, students \$170; includes course manual and lunch. CEUs: 0.8.

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

Sunday, October 25, 8:00 a.m. to 5:00 p.m. Metro Toronto Convention Centre. Cosponsored by *GSA Hydrogeology Division*. **FACULTY:** Donald I. Siegel, Dept. of Earth Sciences, Syracuse University. **Limit:** 50. Fee: \$170, students \$150; includes course manual and lunch. CEUs: 0.8.



Inaugurating GSA's New Annual Meeting Program Structure

Sharon Mosher, Annual Program Committee Chair

You are invited to participate in the 1999 Denver Annual GSA meeting where the new programming initiatives will be inaugurated (see *GSA Today*, October, 1997, p. 19-20 or GSA's Web site: www.geosociety.org). As GSA enters the next millennium, we ask your help in increasing the vitality and quality of the Annual Meeting through these programming changes. The 1999 Annual Meeting program structure offers new opportunities for effective and dynamic programming, and increases programming flexibility by allowing a mixture of invited and volunteered papers and different session formats. Because the changes to program and procedures are major, we ask that you carefully read the descriptions of the various programming options and procedures before submitting a proposal.

Starting in 1999, the program will consist of Pardee Keynote Symposia, Topical Sessions, Oral and Poster General Sessions, and Hot Topic Sessions at lunch. The current all-invited symposia and all-volunteered theme sessions have been merged to form Topical Sessions that allow a mixture of invited and volunteered abstracts. General sessions with all-volunteered papers remain the same. Lunch time forums on Hot Topics will be continued with more discussion and audience participation. A brief description of Pardee Keynote Symposia and Topical Sessions and instructions for submitting proposals follow. More specific guidelines are available from the GSA Meetings Department, cgriswol@geosociety.org, or on the Web, www.geosociety.org/meetings/99.

PARDEE KEYNOTE SYMPOSIA

These sessions are *special events* that are of broad interest to the geoscience community. Topics appropriate for these scientific *Keynote Symposia* are those on the leading edge in a scientific discipline or area of public policy, which address broad fundamental problems, are interdisciplinary, or focus on global problems. The primary criterion for selection is excellence. Selection is on a competitive basis with *only four to eight* half-day, non-concurrent sessions being offered (one per half day; minimum of one per day). All speakers will be invited. We are striving for a good mix of Pardee Keynote Symposia for each annual meeting that will be of interest to the GSA and Associated Society membership. Funding up to \$2000 per Pardee Keynote Symposia is available to help the conveners bring in the very best speakers. Session scheduling commitment will be made to conveners by April 30, 1999.

These sessions are made possible by the generous support of the Joseph T. Pardee Bequest Fund.

Proposals. Proposals must justify why the session should have a "Keynote" stature, have a well-formed plan, discuss the format of the session, and include a tentative list of appropriate, effective speakers. Individuals, GSA Divisions, and Associated Societies may submit proposals.

Deadline. January 6, 1999, midnight MST; firm deadline. *Sorry! NO proposals will be accepted after that date. Web submission is required!*

Review. After January 6, these proposals will be reviewed by a seven-member panel of Joint Technical Program Committee (JTPC) representatives who broadly cover the major geoscience disciplines. Affiliations with a Division, Associated Society, or other group will not be a factor considered during the review process. Proposals

Denver Program *continued on p. 26*

GRADUATE SCHOOL INFORMATION FORUM

METRO TORONTO CONVENTION CENTRE, HALL D, MONDAY, OCTOBER 26 THROUGH WEDNESDAY, OCTOBER 28, 9:00 A.M. TO 5:30 P.M.

Shortcut your search for the right graduate school by coming to the GSA Annual Meeting in Toronto. Meet with representatives from universities across the nation without spending travel time and money to go to each school for interviews. The schools participating (at press time) are listed below.

Individual appointments are not necessary, although students are welcome to contact the schools in advance to schedule a meeting time. If you would like to receive a complete list of schools, with the contact person and telephone number, contact Tammy White, GSA Meetings Department, E-mail: twhite@geosociety.org.

<i>Institution</i>	Mon	Tues	Wed	<i>Institution</i>	Mon	Tues	Wed
Ball State University		■		University of Greenwich		■	
Central Washington University	■	■		University of Illinois at Chicago		■	
Cornell University	■	■		University of Massachusetts		■	
East Carolina University	■	■		University of Minnesota		■	
Florida State University		■		University of New Brunswick	■	■	■
Laurentian University	■	■		University of New Hampshire		■	
McMaster University			■	University of North Carolina—Chapel Hill	■	■	
New Mexico Tech		■		University of North Carolina at Wilmington	■		
Rice University	■	■		University of South Carolina	■	■	
Saint Louis University	■			University of Tennessee	■		
South Dakota School of Mines and Tech	■			University of Texas at Dallas	■	■	■
Southern Illinois University at Carbondale	■			University of Toronto	■	■	
University of Alabama		■		University of Utah		■	
University of Alaska Fairbanks	■	■		Virginia Tech	■	■	
University of California, Riverside	■	■		Washington State University	■		
University of Chicago	■	■	■	Western Michigan University		■	
University of Delaware		■					

STUDENTS —

THIS BREAKFAST'S FOR YOU!

... AND IT'S FREE

What's the occasion? It's the annual GSA President's Student Reception to welcome and honor students. There will be a ticket in your preregistration envelope that will invite you to enjoy the buffet breakfast on Monday, October 26, from 7:30 to 8:30 a.m. For students registering on site, tickets will be available at the registration area.

GSA President Vic Baker and other GSA officers will be on hand to visit with you informally and to listen to your expectations of GSA. Exxon is the sponsor for this taste-full event, which will be held in Hall D of the Metro Toronto Convention Centre.

Denver Program *continued from p. 25*

not chosen as Pardee Keynote Symposia will automatically be considered for Topical Sessions unless the convener indicates otherwise.

Scheduling. Conveners may indicate preferred times for the proposed symposia; however, only one per half day with a minimum of one per day, *including Thursday*, will be allowed. In scheduling the Pardee Keynote Symposia, we will consider what is best for the entire program and which order will provide the most effective meeting. We will consider preferences based on other programmatic issues. In submitting a Pardee Keynote proposal, the convener (and any affiliated group) agrees that any half day, Monday through Thursday, is acceptable. *If a specific time slot is desired, please submit a proposal for a Topical Session instead.*

TOPICAL SESSIONS

These sessions are topically focused with a mix of invited and volunteered papers. The sessions are designed to promote the exchange of timely or state-of-the-art information with respect to a central topic, and to allow scheduling of interdisciplinary talks that bear on a specific topic. Organizers (advocates) may invite specific papers to ensure a successful and excellent session. A maximum of four invited speakers is automatically allowed, but an advocate may request more invitations with a justification for the larger

number. Volunteered abstracts will be automatically solicited in *GSA Today* for all approved Topical Sessions. Any individual or group may propose and organize one or more Topical Sessions.

Proposals. Proposals must include (1) brief description of the session for publication (limited to 50 words); (2) rationale for the session, the number of proposed invited speakers (names of prospective invited speakers may be included), and a justification for the number of invited speakers if more than four are proposed; (3) program format or relationship to other potential sessions (see below). Three scientific discipline categories should be selected; the JTPC representatives for these categories will serve as reviewers of the proposal if more than four invited speakers are proposed. The first category selected by the advocate will determine which JTPC representative is responsible for the session and which category should be checked on the abstract form. Sponsorship by an organization is not necessary.

Deadline. January 6, 1999, midnight MST; firm deadline. *Sorry! NO proposals will be accepted after that date. Web submission is required.*

Review. These proposals will be reviewed by the Technical Program Chairs (TPC). Proposals with more than four invited speakers will be reviewed by two JTPC representatives; the 1999 Technical Program Chair and the Annual Program Committee will make the final decision.

It is essential that proposals be submitted by January 6, 1999.

Organization. After acceptance, the advocates will formally invite speakers who will ensure a dynamic session, and are encouraged to solicit additional volunteered contributions. In addition, the "Call for Papers" in *GSA Today* and other GSA mailings will request volunteered abstracts for both the Topical and General Sessions. Final scheduling of abstracts is the responsibility of the advocate and appropriate JTPC representative.

Please note: Because of the review process, proposals for Pardee Keynote Symposia and Topical Sessions must be made using the 1999 submittal form! *Electronic submission is necessary.* The form will be available on the Web by November 1, 1998, at www.geosociety.org/meetings/98. Questions? Contact us by phone, (303) 447-2020, ext. 133, or e-mail, meeetings@geosociety.org.

SESSION FORMAT

Flexible and creative programming is encouraged for both the Pardee Keynote Symposia and Topical Sessions. A Topical Poster and/or Oral Session related to a Keynote Symposium or a combination of a Topical Oral followed by Poster Session is encouraged. Such combinations should be outlined in the proposals. In general, each session should have a different primary advocate or convener.

Organizers are encouraged to have one or more of the invited speakers present an overview of the topic at the beginning of the session that would be of interest and understandable to fellow scientists who are not in the specialty field but nevertheless are interested in the topic. This type of overview presentation will be so designated in the program and should be given by well-regarded, effective speakers.

Different or new formats are allowed, but they must be stated in the proposal along with the technical support needs. Formats that promote discussion are encouraged. See specific guidelines for more information.

We strongly encourage you to participate in the 1999 Denver GSA Annual Meeting! The new program structure is more flexible and designed to encourage excellence in programming. Special Topical Session organizers now have the ability to ensure a successful, excellent program, and everyone may contribute papers to sessions with invited speakers. The new Pardee Keynote Symposia expand the opportunity for high-profile sessions on significant scientific developments that impact our science. Help us make the GSA Annual Meeting an increasingly dynamic and stimulating meeting that appeals to a wide audience. For more information, contact the GSA Meetings Department, cgriswol@geosociety.org or www.geosociety.org/meetings/99. ■

CALL FOR NOMINATIONS

New Direction for Technical Program and Hot Topics Chairs

The Technical Program Chair for GSA Annual Meetings as of 2002, and Hot Topics Chair as of 1999, will no longer be tied to the meeting site location. This change will give more people the opportunity to organize the Annual Meeting Technical Program or the Hot Topic lunchtime forums.

The Technical Program chair(s) (TPC), has the final responsibility for the entire technical program, including the review and acceptance of keynote and topical-session proposals (January–February), and the scheduling of all the sessions for the Annual Meeting (July–August) in coordination with the Joint Technical Program Committee representatives. This position also includes a three-year commitment of active participation on the Annual Program Committee that meets twice a year (usually March and August). The chair is reimbursed for all GSA-related travel expenses, including full expenses to attend the annual meeting during the prior and current year of office.

The Technical Program chair must have a broad perspective on the geological sciences and be efficient, organized, fair-minded, flexible, and committed to organizing a dynamic meeting. Some experience with technical program scheduling would be helpful, especially membership on the GSA Joint Technical Program Committee (JTPC) within the past 5 years, but it is not required. The chair must be able to work regularly and interactively on the Web and the Internet and must be a GSA member.

The Hot Topics chair is to organize four spirited lunch time debates during the Annual Meeting and is to be sure that their titles reflect their controversial and lively nature. Responsibilities include securing debate organizers who will identify topics and speakers.

If you know of someone who would be an effective Technical Program or Hot Topics chair, or are interested yourself, please contact the GSA Meetings Department for a nomination form (303) 447-2020, ext. 186, snace@geosociety.org. *Nominations are due January 31, 1999.*

SOUTH-CENTRAL SECTION, GSA 33rd Annual Meeting

Lubbock, Texas
March 15–16, 1999

The Department of Geosciences of Texas Tech University in conjunction with the Departments of Economics and Geography, Civil Engineering, and Plant and Soil Science will host the 1999 annual meeting of the South-Central section of the Geological Society of America. The meeting will be held from Sunday evening, March 14, through Tuesday, March 16, at the Holiday Inn Civic Center in Lubbock, Texas. Both premeeting and postmeeting field trips are scheduled.

LOCATION

Lubbock is on the Southern High Plains, the largest plateau in North America. It is the hub of a diverse agricultural industry, and therefore is the focus of research relating to environment, water supply and quality, climate effects, and waste disposal. It lies at the intersection of Interstate 27 and U.S. highways 62, 82, and 84. Inexpensive air connections can be made via Southwest, American, Continental, and Delta.

Lubbock is also the location of the world-class Lubbock Lake Site, a Texas State Park and museum that preserves a 12,000-year record of habitation, the longest continuous record known in North America. Other locations of interest to visitors include the Museum of Texas Tech and the Ranching Heritage Center. Lubbock is also home to three award-winning wineries that are open for touring and wine tasting.

CALL FOR PAPERS

Papers are invited for presentation in oral sessions, symposia, and poster sessions. Oral presentations will be 15 to 20 minutes in length. Poster sessions will be set up for four hours, and authors will be available for two hours. Volunteered abstracts not included in symposia will be scheduled for regular technical sessions. Anyone wishing to organize a symposium should contact James Barrick at Dept. of Geosciences, Texas Tech University, Lubbock, TX 79409-1053, (806) 742-3107, fax 806-742-0100, ghjeb@ttu.edu.

ABSTRACTS

Abstract Deadline:
December 15, 1998.

Abstracts for all sessions must be submitted camera-ready on official 1999 GSA abstract forms. These forms are available from the Abstracts Coordinator, GSA, P.O. Box 9140, Boulder, CO 80301, (303) 447-2020, ext.161, or ncarlson@geosociety.org.

Send an original and five copies of the abstract (for both volunteered and

invited papers) to James Barrick, Dept. of Geosciences, Texas Tech University, Lubbock, TX 79409-1053.

Indicate on the abstract your preference for a poster or oral session and the symposium (if any) appropriate to your research. GSA rules prohibit individuals from presenting more than one volunteered abstract, although they can be co-authors on additional volunteered abstracts. Abstracts submitted for symposia are not affected by this limitation.

Attendees are encouraged to order an abstract booklet either with their annual dues or by contacting GSA Publication Sales (1-800-472-1988 or www.geosociety.org). There will be a limited number of abstract booklets available for purchase on site.

SYMPOSIA

1. Paleontology and Stratigraphy of Cretaceous and Tertiary Strata in West Texas and Northern Mexico. (*Sponsored by South-Central Section, Paleontological Society.*) Thomas M. Lehman, Dept. of Geosciences, Texas Tech University, Lubbock, TX 79409-1053, (806) 742-3148, fax 806-742-0100, tlehman@ttu.edu; Francisco J. Vega, Instituto de Geología, Ciudad Universitaria, 04510 Mexico, phone 52-5-622-4320, fax 52-5-622-4289, vegver@servidor.unam.mx.
2. Proterozoic and Early Paleozoic Magmatism and Tectonics in Southern Laurentia. Melanie Barnes, Dept. of Geosciences, Texas Tech University, Lubbock, TX 79409-1053, (806) 742-3204, fax 806-742-0100, l9mel@ttu.edu; Elizabeth Y. Anthony, Dept. of Geological Sciences, University of Texas–El Paso, (915) 747-5483, fax 915-747-5073, anthony@geo.utep.edu.
3. Eolian Processes and Geomorphology. Jeffrey Lee, Dept. of Economics and Geography, Texas Tech University, Lubbock, TX 79409-1014, (806) 742-3838, fax 806-742-1137, j.lee@ttu.edu.
4. Environmental Applications of Geology in the Southern High Plains. Ken Rainwater, Dept. of Civil Engineering, Texas Tech University, Lub-

bock, TX 79409-1023, (806) 742-3490, fax 806-742-3449, kenrainwater@ttu.edu.
5. Calcium Carbonate–Enriched (Caliche) Horizons in the Soils of the Southwest. Susan Casby-Horton, Natural Resources Conservation Service, 4609 W. Loop 289, Lubbock, TX 79414, (806) 791-0592, fax 806-791-0565, shorton@tx.nrcs.usda.gov; B. L. Allen, Dept. of Plant and Soil Sciences, Texas Tech University.

6. Applications in Geophysics. Harold Gurrola, Dept. of Geosciences, Texas Tech University, Lubbock, TX 79409-1053, (806) 742-3299, fax 806-742-0100, v4har@ttu.edu.

7. Environmental Applications of Stable Isotopes. Haraldur Karlsson, Dept. of Geosciences, Texas Tech University, Lubbock, TX 79409-1053, (806) 742-3130, fax 806-742-0100, hrkar@ttu.edu.

UNDERGRADUATE RESEARCH POSTER SESSION

This session, sponsored by the Geology Division of the Council on Undergraduate Research, will showcase senior theses and other undergraduate research projects. Topics may vary over a wide spectrum (e.g., see GSA abstract form), but the lead author and major preparer of the poster must be a student. For further information, contact Diane Smith, Dept. of Geosciences, Trinity University, (210) 736-7656, fax 210-736-8264, dsmith@trinity.edu.

STUDENT WORKSHOP

Basic Well Log Analysis. This one-day course for students will cover the standard open-hole well logging tools, including what they measure and how geologists use the measurements. The logs that will be covered include resistivity logs, the spontaneous potential log, nuclear logs, and acoustic logs. In the discussion of each of the log types, example problems will be presented so that the course participant will gain an understanding of how each of the logs is used. The course will end with a complete logging problem in which the participant will be able to determine lithology, porosity, and water saturation from a suite of logs, and then use this information to determine the potential of the well being analyzed. Enrollment will be limited to 30 students, and a nominal registration fee will be required. Register via the registration form to be published in the December 1998 issue of *GSA Today*. For further information, contact George Asquith, Dept. of Geosciences, Texas Tech University, Lubbock, TX 79409-1053, (806) 742-3154, fax 806-742-0100, gicga@ttu.edu.

South-Central *continued on p. 28*

NORTHEASTERN SECTION, GSA 34th Annual Meeting

Providence, Rhode Island
March 22–24, 1999

The hosts for the 1999 meeting of the Geological Society of America Northeastern Section are geologists from the University of Rhode Island, Rhode Island Geological Survey, Wellesley College, Boston College, Lincoln Environmental, Inc., and Applied Science Associates, Inc.

Meeting in conjunction with the GSA Northeastern Section will be the Eastern Section of SEPM, the Northeastern Section of the Paleontological Society, the Eastern and New England Sections of the National Association of Geoscience Teachers, the Association for Women Geoscientists, and the Council on Undergraduate Research Geology Division. The meeting will be held at the Westin Hotel, Providence, Rhode Island.

CALL FOR PAPERS

Papers are solicited from students and professionals to be included in: general oral and poster sessions; theme sessions, which are composed of volunteered papers focusing on specific topics; and symposia, which consist mostly of invited papers. Volunteer presentations that are consistent with one of the symposia are also solicited. If you wish to present a paper at a symposium, contact the convener of the symposium.

ABSTRACTS

Abstracts must be submitted camera-ready on the official 1999 GSA section meeting abstract form in accordance with instructions on that form, which is available from: Abstracts Coordinator, Geological Society of America, P.O. Box 9140,

Boulder, CO 80301, (303) 447-2020, ext. 161, ncarlson@geosociety.org.

Send one original plus five copies of all abstracts to be considered to: Anne I. Veeger, Technical Program Co-chairperson, Dept. of Geology, University of Rhode Island, 8 Ranger Rd., Suite 2, Kingston, RI 02881, (401) 874-2187, veeger@uriacc.uri.edu. An individual may present only one volunteered paper; however, a person may also be co-author on papers presented by others. Individuals invited for symposia may present additional papers.

Abstracts due: **December 8, 1998**

SYMPOSIA

Prospective authors should contact the conveners directly. For general information, contact Technical Program Co-

chair David E. Fastovsky, 315 Green Hall, Dept. of Geology, University of Rhode Island, Kingston, RI 02881, (401) 874-2185, defastov@uriacc.uri.edu.

1. History of the Connecticut River Valley Since Deglaciation. (*Sponsored by Eastern Section SEPM.*) Gail Ashley, Rutgers University, Wright Geological Laboratory, 610 Taylor Rd., Piscataway, NJ 08854, (732) 445-2221, gmashtley@rci.rutgers.edu; Janet Radway Stone, U.S. Geological Survey, East Hartford, Connecticut, (860) 291-6748, jrstone@usgs.gov.

2. Saving the Beach: Successes and Problems. (*Sponsored by Eastern Section SEPM.*) Jon Boothroyd, Dept. of Geology, University of Rhode Island, Kingston, RI 02881, (401) 874-2191, boothroyd@uriacc.uri.edu; William Cleary, University of North Carolina—Wilmington, (910) 256-3721, ext. 251, clearyw@uncwil.edu.

3. Integrating Science in the Decision-Making Process: Managing Estuarine Habitats in Narragansett Bay. Laura Ernst, Rhode Island Coastal Resources Management Council, Stedman Government Center, Tower Hill Rd., Wakefield, RI 02879, (401) 222-2476, ricrnc@riconnect.com; Thomas Ardito, Narragansett Bay Project, (401) 222-3961, ext. 7237.

4. Sediment Input and Dispersal in Shallow-Water Environments. Neal Driscoll, Woods Hole Oceanographic Institution, Woods Hole, MA 02543, (508) 457-2000 ext. 2619, ndriscoll@whoi.edu; Dave Twichell, USGS, Woods Hole.

5. Hydrogeologic Issues Behind "A Civil Action"—Woburn, Massachusetts. (*Sponsored by the Hydrogeology Division.*) Chuck Myette, EMCON Inc.,

South-Central *continued from p. 27*

FIELD TRIPS

The field trip coordinator is C. C. (Tex) Reeves, Dept. of Geosciences, Texas Tech University, Lubbock, TX 79409-1053, (806) 742-3115, fax 806-742-0100.

1. Stratigraphy of the Caprock Escarpment. Thomas Lehman, Department of Geosciences, Texas Tech University, Lubbock, (806) 742-3148, fax 806-742-0100, tlehman@ttu.edu.
2. Quaternary Stratigraphy of the Southern High Plains. Vance Holliday, Dept. of Geography, University of Wisconsin, Madison, WI 53706, (608) 262-6300, holliday@geography.wisc.edu.
3. Nuclear Waste Storage at the WIPP Site, New Mexico. C. C. Reeves, Dept. of Geosciences, Texas Tech University, Lubbock, (806) 742-3115, fax 806-742-0100; Judy Reeves, Compliance Services Group, (806) 748-0040.
4. Geology of Palo Duro Canyon. Gerald Schultz, West Texas A&M Univer-

sity, Canyon, TX 79016, (806) 651-2580, fax 806-651-2928, gschultz@faculty.WTAMU.edu.

5. Triassic Vertebrates of West Texas. Sankar Chatterjee, Dept. of Geosciences, Texas Tech University, Lubbock, (806) 742-3108, fax (806) 742-0100, g5san@ttu.edu.

PROJECTION EQUIPMENT

Please bring your own loaded carousel trays. There will be two projectors for each oral session; overhead projectors will be available. Specifics of the poster session will be published in the final announcement.

EXHIBITS

Exhibit facilities for business, educational, and governmental institutions will be available in the Holiday Inn Civic Center. Space rental is \$125, which will include one complimentary registration. Exhibitors are encouraged to set up Sunday afternoon for registration and the

welcoming party. For more information, please contact Susan Tomlinson, Dept. of Geosciences, Texas Tech University, Lubbock, TX 79409-1053, (806) 742-3200, fax 806-742-0100, gislt@ttu.edu.

BUSINESS MEETINGS AND SOCIAL EVENTS

The Welcoming Party, in the exhibit hall, will begin at 7 p.m. on Sunday, March 14. On-site registration will be available, and those who have preregistered may pick up their name badges and tickets for the banquet and purchase abstract booklets.

The Meeting Banquet, in the Holiday Inn atrium at 7 p.m. on Monday, March 15, will be followed by a special lecture presentation. Banquet tickets should be purchased in advance; only a limited number of tickets will be available during on-site registration.

A luncheon meeting of Departmental Heads and Chairs will be held at noon on Monday, March 15. For further

3 Riverside Dr, Andover, MA 01810, (978) 682-1980, cmyette@emconinc.com; E. Scott Bair, Ohio State University, Columbus, (614) 292-6197, bair.1@osu.edu. 6. Extensional Basins in the Northeast Appalachians: Stratigraphy, Sedimentology, Tectonics, and Resource Potential. (*Sponsored by Eastern Section SEPM.*) Margaret D. Thompson, Dept. of Geology, Wellesley College, Wellesley, MA 02181, (781) 283-3029, mthompson@wellesley.edu; Sandra M. Barr, Acadia University, sandra.barr@acadiau.ca; Charles E. Mitchell, SUNY at Buffalo, cem@acsu.buffalo.edu; Robert D. Jacobi, SUNY at Buffalo, rdjacobi@acsu.buffalo.edu. 7. Events and Dynamics in the Acadian Orogeny: Foreland Basin and Mountain Belt Perspectives. Chuck Ver Straeten, Dept. of Geology, Gustavus Adolphus College, St. Peter, MN 56082, (507) 933-7307, cverstra@gac.edu. 8. Comparison of the Relative Importance of Magma Mixing and Fractionation in New England and Cordilleran Settings. John B. Reid, Jr., School of Natural Sciences, Hampshire College, Amherst, MA 01005, (413) 582-5568 jbrns@hamp.hampshire.edu; Daniel P. Murray, University of Rhode Island, (401) 874-2197, dpmurray@uriacc.uri.edu. 9. What's Hot and What's Not: Changing Directions in Geologic Inquiry in New England. Daniel P. Murray, Dept. of Geology, University of Rhode Island, Kingston, RI 02881, (401) 874-2197, dpmurray@uriacc.uri.edu;

John B. Reid Jr., Hampshire College, (413) 582-5568, jbrns@hamp.hampshire.edu. 10. Science Standards: Comparison of Versions, Adoption Mechanisms, and Resources for Successful Implementation. James I. Sammons, Jamestown Middle School, Jamestown, RI 02835, (401) 423-7015, jamessas@ids.net; Peter Leddy, Norton (Massachusetts) High School, (508) 285-0160, volcano@ici.net.

THEMES

Theme sessions are similar to symposia in that they focus on specific topics, but each is an open forum where the papers are volunteered. Prospective authors should contact the conveners directly. For general information about theme sessions, contact David E. Fastovsky (see Symposia).

1. El Niño 1997-1998—Impact on Mid-Atlantic to New England Coastal Zones. Joseph P. Klinger, Rhode Island Coastal Resources Management Council, Stedman Government Center, Tower Hill Road, Wakefield, RI 02879, (401) 222-2476, ricrnc@ricconnect.com; Duncan Fitzgerald, Boston University, (617) 353-2532, dunc@crsa.bu.edu.
2. Late Holocene Salt Marsh Dynamics. Jeffrey P. Donnelly, Dept. of Geological Sciences, Brown University, Box 1846, Providence, RI 02912, (401) 863-2810, Jeffrey_Donnelly@brown.edu; Thompson Webb III, Brown University, (401) 863-3128, Thompson_Webb_III@brown.edu.
3. Late Quaternary Deglaciation and Sea-Level Rise in Southern New England and Adjacent New York and

New Jersey. Ralph Lewis, State Geological and Natural History Survey of Connecticut, Dept. of Environmental Protection, Natural Resources Center, 79 Elm St. Store Level, Hartford, CT 06106, (860) 424-3540, ralph.lewis@po.state.ct.us.

4. Age of the Earth, Evolution, and Empiricism in Science. Samuel A. Bowring, Dept. of Earth, Atmospheric, and Planetary Sciences, 77 Massachusetts Institute of Technology, Massachusetts Ave., Bldg. 54, Room 1124, Cambridge, MA 02139, (617) 253-1520, sbowring@mit.edu; David E. Fastovsky, University of Rhode Island, (401) 874-2185, defastov@uriacc.uri.edu.

5. Devonian Sedimentology, Stratigraphy, and Paleontology of Eastern North America. John Bridge, Dept. of Geological Sciences and Environmental Studies, SUNY at Binghamton, Binghamton, NY, 13902, (607) 777-2831, jbridge1@mail.arco.com.

6. Environmental Isotope Geochemistry: Applications in the Geosciences. Anne I. Veeger, Dept. of Geology, University of Rhode Island, Kingston RI 02881, (401) 874-2187, veeger@uriacc.uri.edu.

7. Use of Geologic Models in Hydrogeologic Investigations. Leslie A. DeSimone, U.S. Geological Survey, Water Resources Division, 28 Lord Rd., Suite 280, Marlborough, MA 01752, (508) 490-5023, ldesimon@usgs.gov.

8. Hydrogeology in the Regulatory Arena: Addressing Uncertainty in Practice. (*Sponsored by the Hydrogeology*

Northeastern *continued on p. 30*

information, contact Calvin Barnes, Dept. of Geosciences, Texas Tech University, Lubbock, TX 79409-1053, (806) 742-3106, fax 806-742-0100, gical@ttu.edu.

STUDENT PAPER AWARDS AND TRAVEL ASSISTANCE GRANTS

Awards will be presented for the Best Oral Student Paper and Best Student Poster at the South-Central GSA meeting. Awards will be based on quality of research and effectiveness of presentation. To be eligible, the abstract must list only student authors and must be identified clearly as a student paper.

The South-Central Section of GSA will award travel grants to GSA student members who give papers (oral or poster) of which she or he is the presenter and author or co-author at the meeting. To be eligible for travel assistance grants, students must be currently enrolled in an academic department in the South-Central Section and certify their student membership in GSA. Applications for travel assis-

tance may be obtained from James E. Barrick, Dept. of Geosciences, Texas Tech University, Lubbock, TX 79409-1053, (806) 742-3107, fax 806-742-0100, ghjeb@ttu.edu. Applications must be received by December 18, 1998.

REGISTRATION

Preregistration deadline: February 5, 1999. The registration form will appear in the December 1998 issue of *GSA Today*. Please take advantage of the lower registration fees and register by February 5. All field trip participants must register for the meeting.

Members pay less! Join GSA now or at the meeting. Contact Membership Services for further information.

HOUSING

A block of rooms is reserved at the Holiday Inn Lubbock Civic Center, 801 Avenue Q, Lubbock, TX 79401, (806) 763-1200, fax 806-763-2656. This hotel is located in the Civic Center district and is

within walking distance or a short drive of several restaurants and clubs. The hotel offers shuttle service to and from Lubbock International Airport. The Texas Tech campus is a 5-minute drive from the hotel. Campus can also be reached via the city bus service.

OTHER INFORMATION

It is our goal that this program be accessible to all persons. If you have special dietary or physical needs, please state them on the registration form.

More detailed information will appear in the December 1998 *GSA Today*. If you have questions about the meeting, contact the general chairperson, Calvin Barnes, Dept. of Geosciences, Texas Tech University, Lubbock, TX 79409-1053, (806) 742-3106, fax 806-742-0100, gical@ttu.edu. ■

Division.) Donald I. Siegel, Dept. of Earth Sciences, 204 Heroy Laboratory, Syracuse University, Syracuse, NY 13244, (315) 443-3607, disiegel@mailbox.syr.edu.

9. Economic Mineral Deposits in Northeastern North America.

Robert J. Altamura, Dept. of Geosciences, Penn State University, University Park, PA 16802, (814) 234-5011, boba@geosc.psu.edu; William M. Kelly, New York State Geological Survey, (518) 474-7559,

wkelly@museum.nysed.gov.

10. Geoarchaeology in the Northeast. Barbara Calogero, 148 Lawler Rd., West Hartford, CT 06117, (860) 233-3417, logero5307@aol.com; Duncan Ritchie, Public Archaeology Laboratory, Pawtucket, Rhode Island, (401) 728-8780.

11. Actualism in Paleontology: Using Physiology of Modern Organisms as Analogies for Paleontological Interpretation. (*Sponsored by the Paleontological Society*.) Paul Strother, Weston Observatory, Boston College, 381 Concord Rd., Weston, MA 02193, strother@bc.edu; Cynthia Fisher, West Chester (Pennsylvania) University, (610) 436-2203, cfisher@wcupa.edu.

12. Teaching with Fossils. (*Sponsored by the Paleontological Society*.) (POSTER ONLY.) Paul Strother, Weston Observatory, Boston College, 381 Concord Rd., Weston, MA 02193, strother@bc.edu; Steven Good, West Chester (Pennsylvania) University, (610) 436-2203, sgood@wcupa.edu.

13. Use of Multimedia and Internet for Enhancing Undergraduate Geology Education—Examples, Experiences, Evaluating Effectiveness.

(ORAL AND POSTER PRESENTATIONS.)

Gary A. Robbins, Dept. of Geology and Geophysics, 354 Mansfield Rd., University of Connecticut, Storrs, CT 06040, (860) 486-1392, robbins@uconnvm.uconn.edu.

14. Science Standards Tailgate Party: An Open Forum for the Display and Trade of Standards-Based Lessons, Web Addresses, Geologic Materials, Contacts, Ideas, and Other Geoscience Resources. (POSTER ONLY.)

Rachel Burks, Dept. of Physics, Towson State University, Towson, MD 21204, (410) 830-3005, rburks@towson.edu.

15. Progress in Geologic Mapping: Seabed, Shoreline and Upland.

(POSTER ONLY.) Christopher Galagan, Applied Science Associates, Inc., 70 Dean Knauss Dr., Narragansett, RI 02882-1443, (401) 789-6224, ext. 30, chris@appsci.com.

16. Undergraduate Research.

(*Sponsored by the Council on Undergraduate Research Geology Division*.) (POSTER ONLY.) Larry Malinconico, Dept. of Geology, Lafayette College, Easton, PA 18042, (610) 250-5193, malincol@lafayette.edu.

SHORT COURSES

Water Waves and Coastal Processes. Cy Galvin, P.O. Box 623, Springfield, VA 22150, (703) 569-9187, galvincoastal@juno.com.

Practical Hydrogeology: How to Make Do with Scant "Real World" Data. Donald I. Siegel, Dept. of Earth Science, 307 Heroy Geology Laboratory, Syracuse University, Syracuse, NY 13244-1070, (315) 443-3607, disiegel@mailbox.syr.edu.

WORKSHOP

Roy Shlemon Mentor Program in Applied Geology. Sunday, March 21. For graduate and advanced undergraduate students, a workshop on professional opportunities and challenges in the applied geosciences.

STUDENT AWARDS AND TRAVEL ASSISTANCE

The GSA Northeastern Section will give awards for the best oral paper and best poster session presented by students. A faculty mentor may be a junior author, but a major part of the paper or poster session must represent work by the student author. Designate papers submitted for this award at the bottom of the abstract form.

The Northeastern Section will award travel grants to students who present papers (oral or poster) of which she or he is author or co-author and the presenter at the meeting. The section will also award student research grants to undergraduates in 1999. Applications for travel assistance and guidelines for student research proposals are available from Kenneth N. Weaver, Secretary-Treasurer, Northeastern Section, GSA, c/o Maryland Geological Survey, 2300 St. Paul St., Baltimore, MD 21821-5210, (410) 554-5532, fax 410-554-5502.

EXHIBITS

Booth and table exhibit space will be available in a large convention hall at the Westin Hotel in the same room as the poster sessions. Reduced rates are available for educational or not-for-profit groups. For further information and space reservation, contact Chris Galagan, Exhibits Coordinator, Applied Science Associates, 70 Dean Knauss Dr., Narragansett, RI 02882, (401) 789-6224, chris@appsci.com.

SPECIAL EVENTS

The Welcoming Reception, Sunday evening, March 21.

Map Blast '99, the Sequel, Monday evening, March 22, a special, informal session for display and discussion of newly published, unpublished, or in-progress geologic maps of any sort. Maps should have a title and a stand-alone explanation. This is not a poster session; abstracts are not required, and none will be published. Authors must be present.

Contact Jon Boothroyd, Dept. of Geology, University of Rhode Island, Kingston, RI, 02881, (401) 874-2191, fax 401-874-2190, boothryd@uriacc.uri.edu.

Breakfasts, Luncheon Meetings, Receptions, and Business Meetings. SEPM Eastern Section; Association for Women Geoscientists; GSA Northeastern Section Education Committee and National Association of Geoscience Teachers, Eastern and New England Sections; Paleontological Society, Northeastern Section; and GSA Northeastern Section Management Board.

The GSA Northeastern Section banquet, Tuesday, March 23.

ACCOMMODATIONS

A large block of rooms has been reserved for meeting participants at the Westin Hotel (1-800-WESTIN-1) or (401) 598-8000, site of the meeting. To ensure guaranteed room rates, be sure to state your GSA connection when making reservations. Attendees should make their reservations before *February 16, 1999*.

CHILD CARE

Child-care arrangements will be coordinated by Lesley Fastovsky, Dept. of Geology, University of Rhode Island, Kingston, RI 02881, (401) 295-1173, fax 401-874-2190, defastov@uriacc.uri.edu.

REGISTRATION

Registration will be handled by GSA headquarters. To obtain low registration fees and to assist planning by the local committee, please preregister, using the registration form in the December 1998 issue of *GSA Today*.

Members pay less! Join GSA now or at the meeting. Contact Membership Services for further information.

Preregistration deadline: **February 19, 1999.**

DETAILED INFORMATION

The GSA Northeastern Section is committed to making every event at the 1999 meeting accessible to all people interested in attending. Indicate special requirements, such as an interpreter or wheelchair accessibility, on the meeting registration form, or contact O. Don Hermes (address below).

Complete information on registration, accommodations, and activities will appear in the December 1998 issue of *GSA Today*, and as part of the *Abstracts with Programs* for 1999 mailed in March 1999. For additional information or suggestions, contact the general chairs, O. Don Hermes, (401) 874-2192, dhermes@uriacc.uri.edu, or Jon C. Boothroyd, (401) 874-2191, boothryd@uriacc.uri.edu, Dept. of Geology, University of Rhode Island, Kingston, RI 02881, fax 401-874-2190. ■

SOUTHEASTERN SECTION, GSA 48th Annual Meeting

Athens, Georgia • March 25–26, 1999

The 1999 meeting of the Southeastern Section of the Geological Society of America in Athens, Georgia, will be hosted by the University of Georgia Department of Geology. Find us at: <http://www.gly.uga.edu>.

CALL FOR PAPERS

Papers are invited for presentation in oral technical sessions and poster sessions. Although papers dealing with all aspects of the southeastern or Appalachian regions of the United States are especially encouraged, papers dealing with other regions are also welcome. Abstracts not accepted for symposia (invited) or theme (volunteered) sessions will be considered for regular technical sessions.

REGISTRATION

Preregistration deadline:

February 19, 1999

Please preregister to qualify for lower registration fees and to assist the local committee in planning. On-site registration, at a higher fee, will also be available. Students and precollege teachers can register at a reduced rate during the preregistration period. Preregistration by mail will be handled by GSA headquarters. Preregistration forms will be in the December 1998 issue of *GSA Today*.

Members pay less! Join GSA now or at the meeting. Contact Membership Services for further information.

ABSTRACTS

Abstract deadline: **December 14, 1998**

Abstracts for all sessions must be submitted camera-ready on official 1999 GSA abstract forms, available from the Abstracts Coordinator, Geological Society of America, P.O. Box 9140, Boulder, CO 80301, (303) 447-2020, ext. 161, ncarlson@geosociety.org. An original and five copies of all abstracts (volunteered and invited) should be sent to Mike Roden, Dept. of Geology, University of Georgia, Athens, GA 30602, (706) 542-2416, mroden@gly.uga.edu. We encourage participants in symposia and theme sessions to send an extra copy to the convener of the session. Abstracts will be reviewed for information content, format, and originality. GSA rules prohibit individuals from presenting more than one volunteered abstract. Abstracts submitted for symposia are not affected by this limitation.

FIELD TRIPS

Contact the field trip leaders listed below for details about specific field trips. For general questions concerning field trips, contact Erv Garrison, (706) 542-1097,

egarriso@uga.cc.uga.edu, or Sue Goldstein, (706) 542-2397, sgoldst@gly.uga.edu, both at Dept. of Geology, University of Georgia, Athens, GA 30602.

FIELD TRIPS (TENTATIVE)

1. Coastal Plain Paleocene-Eocene Stratigraphy and Paleontology of Southeastern and South-Central Georgia. (*Sponsored by the Southeastern Section of SEPM.*) John R. Anderson, Georgia Perimeter (formerly Dekalb) College, Dunwoody Campus, 2101 Womack Rd., Dunwoody, GA 30038, (770) 551-3121, janderso@gpc.peachnet.edu.
2. Dahlongega Gold Belt as Exemplified by the Findley Mine, Dahlongega, Georgia. Jerry German, Georgia Dept. of Transportation, Office of Materials and Research, 15 Kennedy Dr., Forest Park, GA 30297, (404) 363-7500.
3. Geology and Geomorphology of Stone Mountain, Georgia. (*Sponsored by NAGT.*) James A. Whitney, Dept. of Geology, University of Georgia, Athens, GA 30602, (707) 542-2027, jwhitney@arches.uga.edu; John Dennison, University of North Carolina; Pamela Gore, Georgia Perimeter College, pgore@gpc.peachnet.edu.
4. Geotraverse across the Western Part of the Southern Appalachian Acadian Metamorphic Core—Eastern Blue Ridge to Western Inner Piedmont, Northeast Georgia and South Carolina. Robert D. Hatcher, Jr., Dept. of Geological Sciences, University of Tennessee, Knoxville, TN 37996-1410, (615) 974-2238, bobmap@utk.edu.
5. Graves Mountain Georgia: Mineralogy, Economic Geology, and Environmental Problems. Dave Wenner, Doug Crowe, and Paul Schroeder, Dept. of Geology, University of Georgia, Athens, GA 30602, (706) 542-2652, dwenner@arches.uga.edu; Todd Rasmussen, University of Georgia, (706) 542-4300, trasmuss@smokey.forestry.uga.edu
6. Elberton Granites: Geology and Processing. Sam Swanson and R. D. Dallmeyer, Dept. of Geology, University of Georgia, Athens, GA 30602, (706) 542-2415, sswanson@arches.uga.edu; dallmeyr@arches.uga.edu.
7. Ordovician of Northwest Georgia. (*Sponsored by the Paleontological Society.*) Anthony J. Martin, Emory University, Geosciences Program, Atlanta, GA 30322

(404) 727-6476, paleoman@learnlink.emory.edu; Andrew Rindsberg, Geological Survey of Alabama, arindsberg@ogb.gsa.tuscaloosa.al.us.

8. Crystalline Rock Hydrology, Lawrenceville, Georgia. Melinda Chapman, U.S. Geological Survey, 3030 Amweiler Rd., Doraville, GA 30360, (770) 903-9170, mjchap@usga.gov.

9. Coastal Geology and Paleontology: Sapelo Island. (*Sponsored by the Paleontological Society.*) Susan T. Goldstein, Dept. of Geology, University of Georgia, Athens, GA 30603, (706) 542-2397, sgoldst@gly.uga.edu.

SYMPOSIA

Contact the conveners for further information on the symposia listed below. If you have suggestions for additional symposia, contact Sally Walker, Dept. of Geology, University of Georgia, Athens, GA 30602, (706) 542-2396, swalker@gly.uga.edu.

1. Relevance of Environmental Ethics to the Geosciences: The Case of Coastal and Marine Environments. Dorinda G. Dallmeyer, Dean Rusk Center, University of Georgia, Athens, GA 30602, (706) 542-5141, dorindad@arches.uga.edu.
2. Precambrian Rocks in the Southern Appalachians: Nature, Age, Distribution, and Tectonic Significance. Calvin F. Miller, Dept. of Geology, Vanderbilt University, Nashville, TN 37235, (615) 322-2232, millercf@ctrvax.vanderbilt.edu; Paul Fullagar, University of North Carolina, (919) 966-4516, pdfullag@pop.unc.edu.
3. Ultramafic Rocks and Eclogites in the Southern Appalachian Orogen: Petrology and Tectonic Significance. Loren A. Raymond, Dept. of Geology, Appalachian State University, Boone, NC 28608, (704) 262-3049, RaymondLA@Conrad.appstat.edu; Rich Warner, Clemson University, (864) 656-5023, rich.warner@ces.clemson.edu.
4. Tectonic History and Deformation Processes in the Southern Appalachians. Robert D. Hatcher, Dept. of Geological Sciences, University of Tennessee, Knoxville, TN 37996-1410, (615) 974-2238, bobmap@utk.edu; Jim Wright, Rice University, (713) 285-5130, jwright@owlnet.rice.edu; Sandra Wyld, University of Georgia, (706) 542-9908, swyld@gly.uga.edu.
5. New Developments in Carolina Terrane Geology: Igneous, Metamorphic, and Tectonic. Mark Colberg, Dept. of Geology, University of Georgia, Athens, GA 30602, (706) 542-2394, fax 706-542-2425, mrc@gly.uga.edu; Alberto Patino-Douce, Dept. of Geology, University of Georgia, Athens, GA 30602, (706) 542-2394, klingon@3rdrock.gly.uga.edu.
6. Environmental Research and Remediation at the Savannah River DOE Site. Christopher Romanek, SREL, Drawer E, Aiken, SC 29802, (803) 725-5883, romanek@srel.edu.

Southeastern continued on p. 32

7. Memorial Symposium in Honor of Robert Frye. Stephen Henderson, Dept. of Geology, Emory University—Oxford College, Oxford, GA 30267, (770) 784-8345, shender@emory.edu; Anthony J. Martin, Emory University, (404) 727-6476, paleoman@learnlink.emory.edu.
8. Cenozoic Patterns in Paleontology. Debra Krumm, Harbor Branch Oceanographic Museum, 5600 U.S. Route 1, Ft. Pierce, FL 34946, (561) 465-2400, ext. 428, krumm@hobi.edu.
9. Geologic Maps and Digital Geologic Maps. (POSTER ONLY.) Mike Higgins, Applied Mapping Systems, Inc., 162 Spring Drive, Roswell, GA 30075-4849, (770) 641-1268, fax 770-631-5088, appliedmapping@mindspring.com or mhiggins@mindspring.com; Mark Steltenpohl, Auburn University, (334) 844-4893, steltmg@mail.auburn.edu.
10. John Dennison Retirement Celebration Symposium. Richard Diecchio, Dept. of Geography & Earth Systems Science, Mail Stop IE2, George Mason University, Fairfax, VA 22030-4444, (703) 993-1218, rdiechi@gmu.edu; Lisa Pratt, Indiana University, (812) 855-5581, prattl@indiana.edu.

THEME SESSIONS

If you are interested in convening an additional theme session, contact Sally Walker, Dept. of Geology, University of Georgia, Athens, GA 30602, (706) 542-2396, swalker@gly.uga.edu.

1. Geomorphic and Other Terrestrial Records of Quaternary Climate Change in the Southeast. David Leigh, Dept. of Geography, University of Georgia, Athens, GA 30602, (706) 542-2346, dleigh@arches.uga.edu; Andrew Ivester, Dept. of Geography, University of Georgia, Athens, GA 30602, (706) 542-2856, ivester@athens.net.
2. Biogeochemical Interactions and Processes. Johnson R. Haas, Dept. of Geography and Earth Sciences, University of North Carolina, Charlotte, NC 28223, (704) 547-4252, jrhaas@email.uncc.edu.
3. Recent Advances in Crystalline Rock Hydrology. Melinda Chapman, U.S. Geological Survey, 6481-B Peachtree Industrial Blvd., Doraville, GA 30360, (770) 903-9131, mjchap@usgs.gov.
4. From Microbes to Flowers: The Geologic Record of Photosynthesis. Julie Bartley, Geology Department, State University of West Georgia, Carrollton, GA 30118, (770) 830-2315, jbartley@westga.edu.
5. Paleozoic Puzzles: Problems in Biostratigraphy and Stratigraphy. Jack Hall, Dept. of Earth Sciences, University of North Carolina, Wilmington, NC 28403-3490, (910) 962-3488, hallj@uncwil.edu; Carl Stock, University of Alabama, Tuscaloosa, (205) 348-1883, cstock@wgs.geol.ua.edu.
6. Tectonic History and Deformation Processes in the Southern Appala-

- chians. Robert D. Hatcher, Dept. of Geological Sciences, University of Tennessee, Knoxville, TN 37996-1410, (615) 974-2238, bobmap@utk.edu; Jim Wright, Dept. of Geology and Geophysics, Rice University, Houston, TX 77005, (713) 285-5130, jwright@owl.net.rice.edu; Sandra Wyld, University of Georgia, (706) 542-9908, swyld@gly.uga.edu.
7. Geology, Mineralogy, Genesis, and Industrial Use of Kaolin Deposits from the Southeastern United States. Jessica Elzea, Thiele Kaolin Company, P.O. Box 1056, Sandersville, GA 31082, (912) 552-3951, jessica.elzea@thielekaolin.com.
8. Undergraduate Research. (POSTER ONLY.) (*Sponsored by the Council for Undergraduate Research.*) Joel B. Thompson, Marine Sciences, Eckerd College, 4200 54th Ave. S., St Petersburg, FL 33711, (813) 864-8991, thompsjb@eckerd.edu.
9. Advances in Archaeological Geology. Kent Schneider, USDA—Forest Service, 1720 Peachtree Rd. NW, Atlanta, GA 30367, (404) 347-7250, schneider_kent/r8@fs.fed.us.
10. Standard-Based K-12 Geoscience Education in the Southeast. (*Sponsored by NAGT and GSA-ED.*) Don Byerly, Dept. of Geological Sciences, University of Tennessee, Knoxville, TN 37996-1410, (423) 974-6007, dbyerly@utk.edu.
11. Approaching Questions of Origins in Earth Science Education—Creative Solutions to Evolving Controversies. (*Sponsored by NAGT, Paleontological Society, and GSA Geoscience Education Division.*) Jon Bryan, Earth Sciences, Okaloosa-Walton Community College, 100 College Blvd., Niceville, FL 32578-1294, (850) 729-5246, bryanj@owcc.net; Michael Gibson, University of Tennessee at Martin, (901) 587-7435, mgibson@utm.edu.
12. Environmental Geochemistry and Health. June Mirecki, Dept. of Geology, 58 Corning St., College of Charleston, Charleston, SC 29424, (843) 953-8278, mireckij@cofc.edu; Mike Higgins, Roswell, Georgia.
13. Coastal Plain Geology of the Southeastern United States. (*Sponsored by the Southeastern Section of SEPM.*) John T. Hayes, Dept. of Geography and the Earth System Sciences, George Mason University, Fairfax, VA 22030-4444, jthaynes@umd5.umd.edu.

POSTER SESSIONS

Four half-day poster sessions are planned for the meeting. Please indicate your preference for a poster session on the GSA abstract form.

STUDENT RESEARCH PROGRAMS

The Council for Undergraduate Research will sponsor a student poster session (theme session 8 above) to showcase senior theses and other undergraduate research projects. First authors must be undergraduate students and responsible for the bulk of the research, preparation of posters, and presentation of results. For more information, contact Joel B. Thomp-

son, Marine Sciences, Eckerd College, 4200 54th Ave. S., St. Petersburg, FL 33711, (813) 864-8991, thompsjb@eckerd.edu.

K-16 TEACHERS

Two half-day theme sessions (10 and 11) are planned for K-12 and college-level introductory geoscience teachers. Session 10 will focus on standards in earth science education and include a keynote speaker followed by a panel discussion in addition to volunteered papers and posters. See session 10 above for contact information. Session 11 will explore approaches to teaching the evolution of life in earth science education. Contact Michael Gibson, Dept. of Geology, Geography, and Physics, University of Tennessee, Martin, TN 38238-5039, (901) 587-7435, mgibson@utm.edu.

EXHIBITS

Exhibit facilities for business, educational, and governmental institutions will be in the Classic Center, adjacent to the technical sessions. Booth space is limited, so plan to reserve early. Exhibits will be open all day Thursday and Friday morning. For space reservation or further information contact Barbara Ruff or Vicki Mullis, Dept. of Geology, University of Georgia, Athens, GA 30602, (706) 542-2652, bruff@gly.uga.edu or vickim@gly.uga.edu.

STUDENT TRAVEL GRANTS

Limited funds for travel expenses of students presenting papers at the meeting are available from the GSA Southeastern Section. Students must be members of GSA to apply. For information, contact Harold Stowell, Dept. of Geology, University of Alabama, Tuscaloosa, AL 35487-0338, (205) 348-5098, hstowell@wgs.geol.ua.edu.

All information and necessary forms are on the World Wide Web at <http://www.geol.ua.edu/segas/segas/html>.

Travel grant requests must be post-marked no later than *March 1, 1999*.

ACCOMMODATIONS

Blocks of rooms have been reserved for attendees at Holiday Inn, (706) 549-4433 (\$84 per night for a standard room, \$99 for a deluxe room) and Holiday Inn Express, (706) 546-8122 (\$74 per night for 1-2 guests; \$79 per night for 3-4 guests). Rates do not include 7% sales tax.

WELCOME PARTY AND GUEST ACTIVITIES

The welcome party Wednesday evening will be in the Classic Center. All party attendees must be registered; on-site registration will be available in the Classic Center prior to the party.

Several guest activities are planned during the meeting. An Athens city bus tour will be held Thursday morning, March 25, and lunch and a visit to the State Botanical Garden in the afternoon. A bus tour of historic Madison, Georgia, will be available on Friday, March 26. ■

GSA Awards Research Grants

Leah Carter, GSA Grants Administrator

The GSA Committee on Research Grants met in Boulder, Colorado, on April 17–18, 1998, and awarded \$309,315 to 187 graduate student applicants, and \$20,000 for the Gladys W. Cole and W. Storrs Cole Awards to two postdoctoral applicants. Committee members for 1998 are James N. Connelly (Chair), Duncan M. FitzGerald, Paul M. Myrow, Thomas L. Patton, Allen F. Glazner, Brian G. Katz, Jim E. O'Connor, and Thomas O. Wright (National Science Foundation conferee).

COLE AWARDS FOR POSTDOCTORAL RESEARCH

Steven L. Forman, University of Illinois—Chicago, was awarded the Gladys W. Cole Memorial Research Award for 1998 to support his project, "Holocene Eolian Activity on the Eastern Snake River Plain, Idaho." This award is restricted to support research for the investigation of the geomorphology of semi-arid and arid terrains in the United States and Mexico.

The W. Storrs Cole Memorial Research Award, which is restricted to support research in invertebrate micropaleontology, was presented this year to Susan T. Goldstein, University of Georgia, for her project "Phylogeny and Reproductive Pattern in the Foraminiferida."

Eligibility for both Cole awards is restricted to GSA Members and Fellows between 30 and 65 years of age.

STUDENT AWARDS

This year, proposals were received from 443 students of which 187 (37%) were awarded grants. Of these recipients, 93 are master's candidates, and 94 are doctoral candidates. Proposal requests totaled \$833,886 for an average of \$1,882. The average award was \$1,654.

Fourteen alternate candidates were selected by the committee in the event that some of the grantees return all or part of their grant funds because they have changed their research project or have received funds from another source.

The committee's budget included \$130,000 from the Penrose Endowment and the Pardee Memorial, \$100,000 from the National Science Foundation, \$6,000 from the Second Century Fund (donations by Unocal and the Lipman Research Fund), \$8,050 from the Harold T. Stearns Award Fund, the Geophysics Division, the Sedimentary Geology Division, and the Structural Geology and Tectonics Division; and \$4,902 funds returned too late in 1997 and early 1998 to be re-awarded. The budget also included \$65,682 from the GSA Foundation, which included \$24,739 from the Research Fund (including \$2,000 from Mobil Oil), \$24,728 from GEOSTAR and unrestricted funds, and \$10,215 from various restricted special funds and the Engineering Geology and Hydrogeology Divisions.

The recipients of student research grants awarded by GSA divisions and sections will be announced in the October issue of *GSA Today*.

OUTSTANDING MENTION

The Committee on Research Grants specially recognized 25 of the proposals as being of exceptionally high merit in conception and presentation:

Rebecca K. R. Ambers, University of Oregon, "Reservoir-Bottom Sediments: A Record of Land Use in a Watershed."

Dyke Andreasen, University of California, Santa Cruz, "Pliocene Changes in the Thermohaline Circulation in Relation to Heat Input into the South Atlantic Ocean."

Daniel M. Deocampo, Rutgers University, "Lake-Margin Springs in the East African Rift: High-Resolution Closed-Basin Records of Holocene Paleoclimate."

Julie E. Friddell, University of South Carolina, Columbia, "Holocene Climate Variability and the History of ENSO."

Amy M. Gaffney, University of Washington, "Petrology and Geochemistry of Xenoliths in Mauna Loa Tholeiite: Implications for Hawaiian Magmatism."

Forest James Gahn, University of Cincinnati, "Evolutionary Paleocology, Taphonomy and Systematics of Early Mississippian (Kinderhookian) Crinoids from the Wasonville Formation of Southeast Iowa."

Philip M. Gottshall, University of Cincinnati, "Comparative Geographic and Environmental Dynamics of Gastropods and Bivalves During the Ordovician Radiation."

Todd Halihan, University of Texas, Austin, "The Physical Origins and Properties of Fracture Skins in Quartzite."

Angela M. Hessler, Stanford University, "Chemical Weathering under Archean Conditions: Thermodynamic, Geochemical, and Mineralogical Analysis of the 3.2 Ga Moodies Group, South Africa."

Aaron W. Johnson, University of Missouri, Columbia, "Basinal Fluid Flow and Dolomitization in an Extensional Tectonic Setting in the Irish Midlands."

Jonathan L. Jones, Ball State University, "Direct Relationships between Metamorphic Phase Transitions and Earthquake Faulting from Detailed Structural Observations of Fault and Fracture Systems in Western Norway."

Paul Kapp, University of California, Los Angeles, "Detachment Faulting and Blueschist Exhumation, Central Tibet."

Daniel John Koning, University of New Mexico, Albuquerque, "Application of Cosmogenic ^{10}Be Dating to Paleoseismic Studies of the Alamogordo Fault, Southern New Mexico."

Andrew C. Kurtz, Cornell University, "Quantifying Mineral Aerosols as a Source Term in the Marine Silica Budget."

Suzanne Florence Leclair, Binghamton University, "Preservation of Cross-Strata due to Migration of Subaqueous Dunes: Flume Width and Flow Depth Effects on Dune and Cross-Set Characteristics."

Jeffrey David Manuszak, Purdue University, "Development of a Sedimentologic and Structural Model for Collisional Basins: A Case Study of the Nutzotin Basin, Alaska."

Heather A. Moffat, University of Rochester, "Comparative Taphonomy of Meter-Scale Cycles: Ordovician and Jurassic Examples."

Salma Monani, University of Wisconsin, Madison, "Oxygen Isotopes from Tertiary Granites, Scotland: Evidence of Crust/Mantle Interaction during the Opening of the Atlantic."

Patricio I. Moreno, University of Maine, "High-Resolution Pollen and Charcoal Records from Lago Condorito (41° 30'S), Southern Chile."

Georgios P. Tsoflias, University of Texas, Austin, "Use of Ground Penetrating Radar for the Characterization of Fracture and Rock Matrix Hydraulic Properties in Geologic Formations."

Eugene Richard Wahl, University of Minnesota, St. Paul, "Holocene Paleocology and Testing of Climate Model Simulations in Southern California."

Michael Wara, University of California, Santa Cruz, "Boron Isotopes in Foraminiferal Calcite: Testing a Paleo-pH Proxy."

Mark Webster, University of California, Riverside, "Evolutionary Trends in Morphological Variability in Late Cambrian Trilobites across the Pteroccephaliid Biomere Boundary: Resolving Controls on Major Evolutionary Faunal Turnovers."

Jonathan Guy Wynn, University of Oregon, "Neogene Paleosols of the Turkana Basin, Northern Kenya."

Research Grants *continued on p. 34*

Susan Logan Brown Zenker, University of North Carolina, Chapel Hill, "Neodymium Isotopes in Late Cretaceous and Cenozoic Fish Teeth."

STUDENT RECIPIENTS OF SPECIAL AWARDS IN 1998

Gretchen L. Blechschmidt Research Award. This award supports research for women interested in achieving a Ph.D. in the geological sciences and a career in academic research. This year's recipient is Heather A. Moffat, University of Rochester, for her project "Comparative Taphonomy of Meter-Scale Cycles: Ordovician and Jurassic Examples."

John T. Dillon Alaska Research Award. John T. Dillon was noted for his radiometric dating work in the Brooks Range, the results of which have had a major impact on the geologic understanding of this mountain range. The recipient of this award is Jeffrey David Manuszak, Purdue University, for "Development of a Sedimentologic and Structural Model for Collisional Basins: A Case Study of the Nutzotin Basin, Alaska."

Robert K. Fahnstock Award. This award honors the memory of Ken Fahnstock, who was a member of the Committee on Research Grants. It is awarded to the applicant with the best proposal in sediment transport or related aspects of fluvial geomorphology. The 1998 recipient is Suzanne Florence Leclair,inghamton University, for "Preservation of Cross-Strata due to Migration of Subaqueous Dunes: Flume Width and Flow Depth Effects on Dune and Cross-Set Characteristics."

Lipman Research Award. The Lipman Research Fund is supported by gifts from the Howard and Jean Lipman Foundation to promote and support student research grants in volcanology and petrology. Peter W. Lipman, president of the Lipman Foundation, was the recipient of a GSA research grant in 1965. The 1998 Lipman Award recipient is Jennifer M. Wenner, Boston University, for "The Role of High-Silica Granites in the Sierra Nevada

Batholith as End Members in a Mixing Process that Generates Average Continental Crust."

Bruce L. "Biff" Reed Scholarship Award. The Bruce L. "Biff" Reed Scholarship Award was established in Reed's memory to provide grants to graduate students pursuing studies in the tectonic and magmatic evolution of Alaska, primarily, and also can fund other geologic work in Alaska. This year's recipient is Matthew A. Pachell, Utah State University, for "Glacial Tectonism of Pleistocene Sediments, Flat Cape, Southwestern Alaska."

Alexander Sisson Research Award. Family members of Alexander Sisson established a fund in his memory to promote and support research for students pursuing studies in Alaska and the Caribbean. The recipient of the award this year is Rachel Susan Hannah, Michigan State University, for "Ash Flow Tuffs of El Valle Central, Costa Rica."

Harold T. Stearns Fellowship Award. Stearns established the Harold T. Stearns Fellowship Award in 1973 for student research on aspects of the geology of the Pacific Islands and the circum-pacific region. The 1998 recipients are: Julie E. Friddell, University of South Carolina, Columbia, for "Holocene Climate Variability and the History of ENSO," and Amy M. Gaffney, University of Washington, for "Petrology and Geochemistry of Xenoliths in Mauna Loa Tholeiite: Implications for Hawaiian Magmatism."

Industrial Donations and Awards. Industrial donations this year amounted to \$7,000 (\$2,000 from Mobil Oil Corporation and \$5,000 from Unocal Corporation). The 1998 recipients are: Elisa T. Bergslien, University of Buffalo, for "Experimental Investigation of Two-Phase Flow in Rough-Walled Fractures"; Amy E. Clifton, Rutgers University, for "Temporal Evolution and Scaling Relationships of Fracture Populations in Oblique Rift Zones"; Todd Halihan, University of Texas, Austin, "The Physical Origins and Properties of Fracture Skins in Quartzite"; Michael Hseih, University of Oklahoma, "Characterization/Evaluation of High Molecular Weight Hydrocarbons (>C₄₀) in Crude Oils from Various Depositional Environments Worldwide"; M. Bruce Rohrbaugh, Jr., University of Tennessee, "Characterization of Joint Patterns using Circular Scanlines." ■

OTHER SUCCESSFUL APPLICANTS Other applicants recommended for funding are the following:

Helge Alseben	Nicole M. DeNovio	Vladimir Ispolatov	David Mitchell	Joshua B. Smith
Robert Andress	Stephen Quinn Dornbos	Glenn S. Jaecks	Jessica D. Moore	Jeannine M. St. Clair
Chris Andronicos	Andrea L. Dutton	Thomas C.	German Mora	James St. John
Christopher David Augustine	Timothy Karl Ehrlich	Johannesmeyer	Jeffrey S. Munroe	Stephanie B. Stack
Yarrow L. Axford	Jennifer M. Elick	Brennan T. Jordan	Remo Nardini	Joshua Sternberg
Victoria A. Baeder	Julie Anne Esdale	Thomas J. Kalakay	Guadalupe Velazquez	Margaret Streepey
Claire L. Beaney	Peter John Evans	Dale A. Kerner	Oliman	Matthew L. Stutz
Andrey Bekker	Brian Exton	Eric Killenbeck	Colin Ozanne	Aviva Joy Sussman
Tara Lynn Benda	Laura Faulkenberry	Matthew E. Kirby	Mutlu Ozdogan	David W. Szymanski
Deborah Bergfield	Tammy C. Fawcett	Dirk Kirste	Michael B. Parsons	Neil John Tabor
Adam Edward Bielecki	Hilary Fletcher	Andre Klein	Sandra Passchier	David Leland Taylor
Gerald O. Black IV	David A. Fowle	John M. Kollmeier	William H. Peck	Stephen Thompson
Sarah L. Brown	Duane G. Froese	Thomas R. Kulp	Lesley A. Perg	Douglas K. Tinkham
Matthew E. Brueseke	Robert R. Gaines	Julie V. LaBranche	Heather Lynne Petcovic	Vaughn Charles Turekian
Andrew M. Bush	Stanley J. Galicki	Melissa Lafreniere	Michael S. Petronis	Matthew M. Uliana
Ilya Val Buynevich	Juan Carlos Garcia y Barragan	Christopher K. Lajewski	Molly Marie Pohl	Chad Underwood
Lucia Capra	Adrian E. Goettemoeller	Michael T. Landrum	Matthew Jude Pranter	G. Hampton Uzzelle IV
Robert P. Casavant	D. A. Grau	Ovidiu R. Lazar	Jessica L. Pursley	Rosario Vasquez-Scheerhorn
Andrea D. Cicero	Jessica Graybill	Cosmos Lettich	Steven L. Quane	John A. Vines
Casey D. Clapsaddle	Sean Andre Guidry	David William Leverington	Jason A. Rech	David Welch
Arlene D. Collins	Diana P. Hallman	Charles R. Lindsay	Tammy M. Rittenour	Amy Thomson Welty
John Comstock	K. Jill Hammond	Aimee Lyn MacEachern	Delores M. Robinson	Joshua Craig Whipple
Badescu Adrian Constantin	Wayne G. Henderson	Thomas Edward Macrini	Michelle A. Roth	Brian Willhite
Luke Copland	Casey Storm Hermoyian	Kevin Mahan	Jason Charles Ruf	Scott J. Wilkins
Robert D. Crangle, Jr.	James P. Hogan	Jeffrey Mariga	Jennifer Claire Russel	Nathan D. Williams
Betsy Lynn Cunningham	Jason Andrew Hooten	Jason Mayfield	Seth J. Sadofsky	Shawn Patrick Willsey
Kristina A. Curry	Richard G. Hoy	Brannon Wade	Hilary Sanders	Grace Sherwood Winer
Brian J. Darby	Trent D. Hubbard	McDonald	Juan C. Bermudez Santana	Paul Adam Wisniewski
Kathleen A. DeGraaff	Brian Butler Hunt	Cathleen E. McGinnis	Andrew T. Scott	Elizabeth Marie Witton
Carol Merritt Dehler	Emily P. Hunt	Angela A. McLain	Kurt A. Shoemaker	Virginia Wong
John DeLaChapelle	Sonja Ingram	Sunil Mehta	Mark Skidmore	Brian R. Zurbuchen
	Alexander Iriondo	Brian Menounos	Garret L. Slaughenhoup	



The Geological Society of America
BULLETIN
Volume 110, Number 9, September 1998

- 1105-1122 Three-dimensional stratigraphic evolution of the Miocene Baltimore Canyon region: Implications for eustatic interpretations and the systems tract model
Chris J. Poulsen, Peter B. Flemings, Ruth A. J. Robinson, and John M. Metzger
- 1123-1148 Paleoseismology of an active reverse fault in a forearc setting: The Poukawa fault zone, Hikurangi forearc, New Zealand
Harvey M. Kelsey, Alan G. Hull, Susan M. Cashman, Kelvin R. Berryman, Patricia H. Cashman, James H. Trexler, Jr., and John G. Begg
- 1149-1162 Analysis of a regional middle Paleozoic unconformity along the distal southeastern Laurentian margin, southernmost Appalachians: Implications for tectonic evolution
James F. Tull
- 1163-1173 Lithological and hydrological influences on ground-water composition in a heterogeneous carbonate-clay aquifer system
Shelley J. Kauffman, Janet S. Herman, and Blair F. Jones
- 1174-1192 Sediment accumulation on top of the Andean orogenic wedge: Oligocene to late Miocene basins of the Eastern Cordillera, southern Bolivia
Brian K. Horton
- 1193-1207 Tectonic controls on magmatism in The Geysers-Clear Lake region: Evidence from new geophysical models
William D. Stanley, Harley M. Benz, Mark A. Walters, Antonio Villaseñor, and Brian D. Rodriguez
- 1208-1226 Late Cenozoic extension of the Alpine collisional orogen, northeastern Greece: Origin of the north Aegean basin
David A. Dinter
- 1227-1230 Guidelines for Authors of Papers Submitted to the Geological Society of America Bulletin. Part I

Clinton Nominates Groat To Head USGS

GSA Fellow and Councilor Charles G. Groat has been nominated by President Clinton to head the U.S. Geological Survey.

Groat, 58, has been active for more than 25 years in geological studies, energy and minerals resource management, groundwater occurrence and protection, geomorphic processes and landform evolution in desert areas, and coastal studies.

Currently, Groat is Associate Vice President for Research and Sponsored Projects at the University of Texas, El Paso. Previously, he has served as Director of the Center for Environmental Resource Management at the university (1995-1998), Executive Director at the Center for Coastal, Energy, and Environmental Resources at Louisiana State University (1991-1995), Executive Director of the American Geological Institute (1990-1992), and Director and State Geologist for the Louisiana Geological Survey (1978-1990).

Groat received an A.B. in geology from the University of Rochester in 1962, his M.S. from the University of Massachusetts in 1967, and his Ph.D. in 1970 from the University of Texas at Austin.

Groat's nomination goes to the Senate Energy and Natural Resources Committee for a hearing and vote, and then to the Senate for confirmation.

- 771 Analog modeling of progradational delta systems
K. R. McClay, T. Dooley, G. Lewis
- 775 Possible crystalline gastroliths of large marine Vertebrata from Oligocene pelitic sediments of the Northern Apennines, Italy
Enrico Pandolfi, Paola Vannucchi, Simonetta Monechi
- 779 Duplex arrays and thickening of accretionary prisms: An example from Boso Peninsula, Japan
Tetsuro Hirono, Yujiro Ogawa
- 783 24-norcholestanes as age-sensitive molecular fossils
A. G. Holba, E. W. Tegelaar, B. J. Huizinga, J. M. Moldowan, M. S. Singletary, M. A. McCaffrey, L. I. P. Dzou
- 787 Thermal-metamorphic signature of an impact event in the Vredefort dome, South Africa
Roger L. Gibson, W. Uwe Reimold, Gary Stevens
- 791 Strain partitioning along the Himalayan arc and the Nanga Parbat antiform
Leonardo Seeber, Arnaud Pêcher
- 795 Subduction obstruction and the crack-up of the Pacific plate
Christopher Small, Dallas Abbott
- 799 Advective heat transport by low-temperature discharge in the Oregon Cascades
Michael Manga
- 803 Long-runout rockfalls
W. Brian Dade, Herbert E. Huppert
- 807 History of hydrocarbon charge on the Atlantic margin: Evidence from fluid-inclusion studies, West of Shetland
J. Parnell, P. Carey, W. Duncan
- 811 Consolidation patterns during initiation and evolution of a plate-boundary decollement zone: Northern Barbados accretionary prism
J. Casey Moore, Adam Klaus, Nathan L. Bangs, Barbara Bekins, Christian J. Bucker, Warner Brückmann, Stephanie N. Erickson, Olav Hansen, Thomas Horton, Peter Ireland, Candace Olson Major, Gregory F. Moore, Sheila Peacock, Saneatsu Saito, Elizabeth J. Sreaton, John W. Shimeld, Philip Henry Stauffer, Tuncay Taymaz, Phillip A. Teas, Tomochika Tokunaga
- 815 Heterogeneity of the middle crust: Implications for strength of continental lithosphere
Karl E. Karlstrom, Michael L. Williams
- 819 Polycyclic motion history of some Gulf Coast growth faults from high-resolution displacement analysis
Joe Cartwright, Renaud Bouroulicc, David James, Howard Johnson
- 823 Low-latitude sea-surface temperatures for the mid-Cretaceous and the evolution of planktic foraminifera
Richard D. Norris, Paul A. Wilson
- 827 Role of plate kinematics and plate-slip-vector partitioning in continental magmatic arcs: Evidence from the Cordillera Blanca, Peru
Brendan A. McNulty, Daniel L. Farber, Glen S. Wallace, Robert Lopez, Oscar Palacios
- 831 DNA-labeled clay: A sensitive new method for tracing particle transport
Barbara J. Mahler, Matthew Winkler, Philip Bennett, David M. Hillis
- 835 Wisconsinan refugia and the glacial history of eastern Baffin Island, Arctic Canada: Coupled evidence from cosmogenic isotopes and lake sediments
Eric J. Steig, Alexander P. Wolfe, Gifford H. Miller
- 839 Tectonic delamination and subcrustal imbrication of the Precambrian lithosphere in northwestern Canada mapped by LITHOPROBE
F. A. Cook, A. J. van der Velden, K. W. Hall, B. J. Roberts
- 843 Carbonate precipitation into alkaline silica-rich environments
Juan Manuel Garcia-Ruiz
- 847 Mid-crustal detachment and ramp faulting in the Markham Valley, Papua New Guinea
C. Stevens, R. McCaffrey, E. A. Silver, Z. Sombo, P. English, J. van der Kevie
- 851 Bacterial methane oxidation in sea-floor gas hydrate: Significance to life in extreme environments
Roger Sassen, Ian R. MacDonald, Norman L. Guinasso, Jr., Samantha Joye, Adolfo G. Requejo, Stephen T. Sweet, Javier Alcalá-Herrera, Debra A. DeFreitas, David R. Schink
- 855 Shear zones, fault networks, and Archean gold
Julian R. Vearncombe
- Forum
- 859 Pb isotopes of granitoids suggest Devonian accretion of Yangtze (South China) craton to North China craton
Comment: Weidong Sun, Shuguang Li
Reply: Hong-Fei Zhang, Shan Gao, Ben-Ren Zhang, Ting-Chuan Luo, Wen-Li Ling
- 861 Vertical and lateral collapses on Tenerife (Canary Islands) and other volcanic ocean islands
Comment: E. Ancochea, J. M. Cantagrel, J. M. Fuster, M. J. Huertas, N. O. Arnaud
Reply: Joan Martí, Marcel Hürlimann, Giray Ablay, A. Gudmundsson
- 863 Late-stage sinking of plutons
Comment: Scott R. Paterson
Reply: Allen F. Glazner, David M. Miller

1999 Denver, Colorado



GSA Annual Meeting and Exposition

October 25–28
Colorado Convention Center

GENERAL CO-CHAIRS

Mary J. Kraus

(303) 492-7251, fax 303-492-2606,
kraus@spot.colorado.edu

David Budd

(303) 492-3988, fax 303-492-2606,
budd@spot.colorado.edu

Both at Dept. of Geosciences,

Campus Box 250, University of Colorado,
Boulder, CO 80309-0250

TECHNICAL PROGRAM CHAIRS

Craig Jones

(303) 492-6994, fax 303-492-2606,
cjones@mantle.colorado.edu

G. Lang Farmer

(303) 492-6534, fax 303-492-2606,
farmer@terra.colorado.edu

Both at Dept. of Geosciences,

Campus Box 399, University of Colorado,
Boulder, CO 80309-0399

Due date for
Pardee Keynote Symposia
and
topical Session proposal s:
January 6, 1999

Electronic Proposal Form Available
November 1, 1998.

FUTURE GSA MEETINGS

- 2000 Reno, Nevada**
November 13–16
- 2001 Boston, Massachusetts**
November 5–8
- 2002 Denver, Colorado**
October 28–31
- 2003 Seattle, Washington**
November 2–5

Crossing Divides

CALL FOR FIELD TRIP PROPOSALS

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

Alan Lester

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

Bruce Trudgill

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

CALL FOR SHORT COURSE PROPOSALS

Due December 1, 1998

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

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

For proposal guidelines or information, contact:

Edna Collis, Continuing Education Coordinator, GSA headquarters,
1-800-472-1988, ext. 134, ecollis@geosociety.org

GSA SECTION MEETINGS — 1999

SOUTH-CENTRAL SECTION

March 15–16, 1999, Lubbock, Texas.
Submit completed abstracts to
James Barrick, Dept. of Geosciences,
Texas Tech, Lubbock, TX 79409-1053,
(806) 742-3107, ghjeb@ttu.edu.
Abstract deadline: December 15, 1998.

NORTHEASTERN SECTION

March 22–24, 1999, Providence,
Rhode Island. Submit completed
abstracts to Anne I. Veeger, Dept. of
Geology, University of Rhode Island,
Green Hall, Kingston, RI 02881, (401)
874-2187, veeger@uriacc.uri.edu.
Abstract deadline: December 8, 1998.

SOUTHEASTERN SECTION

March 25–26, 1999, Athens, Georgia.
Submit completed abstracts to Michael F.
Roden, Dept. of Geology, University
of Georgia, Athens, GA 30602-2501,
(706) 542-2416, mroden@uga.cc.uga.
edu. *Abstract deadline: December 14,
1998.*

ROCKY MOUNTAIN SECTION

April 8–10, 1999, Pocatello, Idaho.
Submit completed abstracts to Paul Link,
Dept. of Geology, Idaho State University,
785 South 8th Ave., Pocatello, ID 83209-
8072, (208) 236-3846, linkpaul@isu.edu.
Abstract deadline: December 29, 1998.

NORTH-CENTRAL SECTION

April 22–23, 1999, Champaign-Urbana,
Illinois. Submit completed abstracts to
C. Pius Weibel, Illinois State Geological
Survey, 615 Peabody Dr., Champaign, IL
61820, (217) 333-5108, weibel@isgs.
uiuc.edu. *Abstract deadline: January 11,
1999.*

CORDILLERAN SECTION

June 2–4, 1999, Berkeley, California.
Submit completed abstracts to George
Brimhall, Dept. of Geology & Geophys-
ics, University of California, Berkeley, CA
94720-4767, (510) 642-5868, brimhall@
socrates.berkeley.edu. *Abstract deadline:
February 19, 1999.*

CLASSIFIED ADVERTISING

Published on the 1st of the month of issue. Ads (or cancellations) must reach the GSA Advertising office one month prior. Contact Advertising Department (303) 447-2020, 1-800-472-1988, fax 303-447-1133, or E-mail: acrawfor@geosociety.org. Please include complete address, phone number, and E-mail address with all correspondence.

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

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

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

Positions Open

POSTDOCTORAL POSITION

IN SILICON STABLE ISOTOPE BIOGEOCHEMISTRY UNIVERSITY OF CALIFORNIA SANTA BARBARA

We seek someone to help us understand why Si dissolved in the oceans is enriched in Si-30 relative to the Si in igneous and metamorphic rocks; a question that is fundamental to progress in quantifying the biogeochemical cycle of Si. The position entails analysis of isotopic fractionations occurring during the processes (weathering, clay and phylolith formation, etc.) that transform Si in rocks into dissolved Si that washes into the ocean. The work involves application of a technical breakthrough in measuring isotopes in dissolved and particulate Si (Anal. Chem. 68, 3746-3750, 1996). We seek an individual with background in geochemistry, soils or clay mineralogy, preferably with experience with stable isotopes, and an interdisciplinary interest. Send resume, including the names of 3 references, to Oliver Chadwick, Geography Dept., University of California, Santa Barbara, CA 93106. E-mail queries about the position can be sent to Chadwick (oac@geog.ucsb.edu) or to the other 2 principals on the project, Mic DeNiro (deniro@magic.geol.ucsb.edu) or Mark Brzezinski (brzezinski@lifesci.ucsb.edu). Position open until filled. Preliminary interviews will be conducted with qualified individuals at the Geological Society of America Meeting in Toronto in October, 1998 or by phone for those not attending GSA. Initial appointment is for 1 year, with additional year (funding in place) contingent on satisfactory progress. An EO/AA employer.

POMONA COLLEGE SEDIMENTOLOGIST / GEOMORPHOLOGIST

The Department of Geology at Pomona College invites applications for a tenure-track position in sedimentology and geomorphology. Responsibilities include teaching undergraduate courses in physical geology, historical geology, geomorphology and sedimentology. Opportunities to teach additional subjects such as paleontology and/or geochemistry may occur on a less regular basis.

The successful candidate must have a commitment to undergraduate teaching (the foremost condition of employment), and to conducting an active research program with field and laboratory components which allows undergraduate participation. Our geology program has strong computing, field and analytical facilities, and collegial participation in the operation and development of the department is expected.

Applicants should send a current resume, a statement of teaching philosophy, a statement of research plans, reprints and three letters of recommendation by November 16, 1998 to: Dr. Linda A. Reinen, Search Coordinator,

Department of Geology, Pomona College, Claremont, CA 91711. Address questions of Ireneen@pomona.edu.

Pomona College, the founding member of The Claremont Colleges, is among the nation's most selective undergraduate institutions with an ethnically diverse student body. Pomona College is an affirmative action, equal opportunity employer and especially invites applications from women and minorities.

SOUTHERN ILLINOIS UNIVERSITY, CARBONDALE

The Department of Geology invites applications for a tenure-track position in paleobiology at the assistant professor level, starting August 16, 1999. Applicants must hold a Ph.D. or show that they will complete all degree requirements by August 16, 1999. If the successful candidate has not completed all requirements for the Ph.D. degree by August 16, 1999, he/she will be appointed for one year as instructor at a reduced salary. The successful candidate must have demonstrated teaching ability and the existence of, or potential for developing, an externally funded research program of high quality. Areas of research emphasis may include but are not limited to paleobiology, biostratigraphy, and global change. Teaching duties will include invertebrate paleontology and paleoecology, introductory undergraduate geology courses, and upper level and graduate courses in the emphasis area. Applicants should submit a curriculum vitae, a statement of teaching and research interests, and the names and addresses of at least three referees to: Dr. James R. Staub, Search Committee Chair, Department of Geology, Mail Code 4324, Southern Illinois University, Carbondale, IL 62901-4324; fax 618-453-7393; e-mail: jstaub@geo.siu.edu. Applications will be accepted until December 7, 1998, or until the position is filled. Information about the Department and its programs can be found at: <http://www.science.siu.edu/geology/index.html>. Southern Illinois University is an Equal-Opportunity, Affirmative-Action Employer.

FACULTY POSITION IN GEOLOGICAL SCIENCES SCRIPPS INSTITUTION OF OCEANOGRAPHY UNIVERSITY OF CALIFORNIA, SAN DIEGO

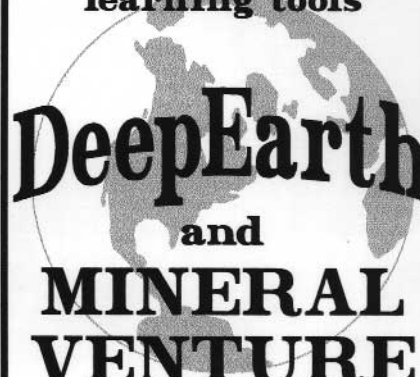
Applications are invited for a faculty position in the geological sciences. We are seeking a candidate who will study sediments or sedimentary units with an interest in their record of environmental change, or the processes that produced them. Investigations could be conducted from a (geo)physical, chemical or (paleo)biological perspective. We hope to fill this position at the Assistant (tenure track) level, but will consider appointment at a higher level in exceptional circumstances; exact rank and salary will be commensurate with qualifications and experience in accordance with University of California academic policy and pay scales. Applicants must show evidence of excellence and independence in research as demonstrated by their publication record. A strong extramurally funded research program is expected. The position will involve teaching, supervision and support of graduate students. The appointee will also have the opportunity to play a role in the undergraduate Earth Sciences degree program. Applicants must hold a doctoral degree at the time of appointment. Applications should include a detailed resume with a description of research interests and teaching plans, a publication list and the names and addresses of at least three referees. Send applications by October 1, 1998, to Chair, Geological Sciences Search, SIO Graduate Department, University of California, San Diego, 9500 Gilman Drive, La Jolla, CA 92093-0208. UCSD is an Equal Opportunity/Affirmative Action Employer.

CARLETON COLLEGE

The Geology Department at Carleton College invites applications for a tenure-track position (Ph.D. required) at the assistant professor level. We seek an individual with strengths in volcanology, geochemistry (low-temperature and environmental), and/or geochronology, and extensive field experience. The ideal applicant will have demonstrated outstanding skills and interests in teaching with an emphasis on field and laboratory-oriented, hands-on learning. In addition, we seek someone who will be actively engaged in a strong research program that can include undergraduate students in an integral way. All Carleton geology majors complete a senior integrative exercise; we expect our new colleague to help students design and carry out these projects. Carleton is engaged in efforts to attract, retain, and nurture underrepresented groups in the sciences; we seek candidates with particular interest and strength in this area.

The successful candidate is expected to teach four courses and associated labs each year, including intro-

The most innovative
teaching and
learning tools



DeepEarth
and
MINERAL
VENTURE

A complete field
experience through
computer simulation

Eighteen Software

P. O. Box 1059
Ashland, Or 97520
Tel/Fax (541) 488 5246
18soft@jefnet.org

ductory courses, core courses for majors, advanced courses, and interdisciplinary courses. We are especially interested in someone who can occasionally teach mineralogy or petrology, two of our core courses. Carleton's geology department averages between 20 and 30 majors in each graduating class; it is a vibrant place that emphasizes cooperation, discussion, field work, inquiry-based learning, creativity, and intellectual depth in a supportive atmosphere. Carleton's geology department has a strong, successful tradition of teaching geology as one of the liberal arts and we are looking for someone to help carry on that tradition.

The position begins in late August 1999. Interested individuals should submit a letter discussing their qualifications, a statement of teaching and research interests (the latter addressing how undergraduate students will be incorporated) plus a curriculum vitae with the names and addresses of at least three references (we will request letters from applicants passing the initial selection) to David M. Bice, Chair, Department of Geology, Carleton College, One North College Street, Northfield, MN 55057. The closing date for applications is October 15, 1998. Carleton College is an equal opportunity/affirmative action employer. Women and minorities are encouraged to apply.

CRUSTAL SEISMOLOGIST

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

This position is part of a focused initiative in the area of Geodynamics that includes the potential in the future for up to three additional faculty hires in rheology, crustal geodynamics, and observational crustal deformation. The successful candidate will join a geodynamics group with research activities in seismology, lithospheric geodynamics, surface processes, active tectonics, and structural geology. Opportunities exist to participate in our Applied Geosciences program and/or the college-wide Center for

Natural Hazards Research in the EMS Environment Institute. Applicants should demonstrate the potential for developing a funded research program and high-quality teaching. A Ph.D. is required at the time of appointment. We expect to fill this position at the Assistant Professor level, but appointment at an Associate Professor level is possible in exceptional cases. The search process begins immediately and will continue until suitable candidates are identified.

Applications should include a complete resume, examples of published work, a statement outlining teaching and research interests, and the names and addresses of at least four (4) individuals who could provide references.

Send application materials to: Geosciences Search Chairman, The Pennsylvania State University, Department of Geosciences, 503G Deike Building, University Park, PA 16802. AA/EOE.

STRUCTURAL GEOLOGY — PETROLEUM GEOLOGY WEST VIRGINIA UNIVERSITY

The Department of Geology & Geography invites applications for a tenure-track faculty position in structural geology. The appointment will be at the level of beginning assistant professor, effective January or August 1999, and the Ph.D. degree is required at the time of appointment.

We are seeking an individual who is adept in both quantitative and field approaches to geological research and teaching. This individual will be expected to collaborate with others in the department and to establish linkages with the petroleum industry. The successful candidate will have demonstrated research capabilities in structural geology and petroleum geology, and he or she should be able to effectively teach undergraduate and graduate courses in these two fields and supervise M.S. and Ph.D. students. The candidate should be able to teach a large section of introductory geology and to participate in the team-teaching of our capstone field camp. In addition, the successful candidate must attract external research funding. Additional information is available online at <http://www.geo.wvu.edu>.

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

ENVIRONMENTAL CONSULTANT CANADIAN NATIONAL

In order to ensure compliance with CN's Real Estate sales/leasing objectives and to minimize financial and legal risks to the corporation, you will be responsible for initiating, guiding, prioritizing, and managing to completion environmental site assessments and cleanup. You will ensure that assessments are conducted in accordance with internal, corporate and industry applicable standards, policies, and processes. You will also be called upon to provide clear and effective guidance and advice regarding environmental matters to Management as well as to recommend improvements or develop strategies for quality and cost improvement. Finally, you will oversee consultants responsible for conducting site assessments in order to ensure high quality and cost-effectiveness of services provided.

You have successfully completed an undergraduate degree in Environmental or related sciences, and have a minimum of ten years related experience. You possess in-depth site assessment knowledge and have been exposed to hydrogeology projects. You possess a proven track record of accomplishments, sound judgment, superior writing and oral communication skills. You have demonstrated excellent skills in consulting, strategic thinking, project management, and teamwork. You have the ability to analyze complex data, recommend course of action, implement optimal solutions and monitor results.

Please forward your resume and a cover page indicating your interest no later than August 4, 1998, to the Human Resources Department, Canadian National, 935 de La Gauchetiere Street West, 8th Floor, Montreal, Quebec, H3B 2M9. Fax 514-399-8335. Internet: joanis@cn.ca. We are looking for a consultant that would work on-site. The office is located in Toronto, Ontario, Canada.

We thank all applicants for their interest in this position, however, only those selected for an interview will be contacted.

ILLINOIS STATE WATER SURVEY

The Illinois State Water Survey is seeking a highly motivated Ground-Water Hydrologist to lead a very successful and productive groundwater program covering research, data collection, and public service. The successful candidate must have an earned Doctorate in Civil Engineering, or Hydrogeology, or other related field, and at least 5 years of relevant work experience. The successful applicant will have demonstrated management and leadership skills to manage a group of groundwater professionals and experience in using groundwater models and conducting ground-water resources assessment. Knowledge of the physical and chemical processes in groundwater is necessary. An ability to conduct deterministic and stochastic analyses and to use geostatistics for groundwater applications is highly desirable, as well as a working knowledge of aquifer conditions within the Midwest. A successful record in proposal preparation, report writing, and refereed publications is required as is good written and verbal communication skills. The candidate must also show demonstrated skills in working with other disciplines and a track record of being a team player. The successful candidate will be expected to: (a) manage and supervise groundwater professionals, (b) identify research needs and participate in research in the general area of groundwater hydrology such as regional parameter estimations, well field design, capture zone analysis, ground-water/surface water interactions, and ground-water quality, (c) show that he/she has used various ground-water models and have experience in conducting ground-water resources assessment, (d) initiate projects based on emerging issues, funding opportunities and personal interests, (e) develop working relationships with researchers and professionals from related disciplines, and (f) disseminate research results through reports, peer-reviewed papers, and technical and public presentations. Availability: January 1999. Salary: negotiable. Benefits include: vacation and sick leave, State Universities Retirement System, and University of Illinois Health Benefits. Deadline: October 30, 1998. Send resume to: Human Resources, Illinois State Water Survey, 2204 Griffith Drive, Champaign, IL 61820. The University of Illinois is an AA/EEO/ADA employer. Position No. 98.15.

ASSISTANT PROFESSOR IN PALEONTOLOGY

The Department of Geology at the University of Iowa invites applications for a full-time tenure-track Assistant Professorship with a specialty in micropaleontology or invertebrate paleontology. The appointment will begin in August 1999. We seek an outstanding researcher and teacher whose approach is both quantitative and specimen-based, and who will work with other faculty to improve our strong graduate program in paleontology and sedimentary geology. In addition to developing an active, externally funded program of research, the successful candidate will be expected to teach three courses per academic year. These will include: (1) an upper-level undergraduate/graduate course in biostratigraphy, micropaleontology or invertebrate paleontology, (2) team-participation in Evolution and History of Life, a general education course, and (3) a graduate seminar in paleontology. He/she will also be expected to contribute both to our Paleontology Repository as well as to new departmental initiatives in the environmental sciences and climate change. Applicants should have a Ph.D. or be in the final stages of completing the degree. Women and minorities are especially encouraged to apply. Applicants should send a complete resume (including a bibliography and statement of teaching and research interests) and have at least three letters of recommendation sent to: Dr. Holmes Semken, Search Committee Chair, Department of Geology, University of Iowa, Iowa City, IA 52242-1379, phone: (319) 335-1818; fax: 319-335-1821. The closing date for applications is December 1, 1998, and screening of candidates will begin immediately thereafter and continue until the position is filled. The University of Iowa is an Affirmative Action/Equal Opportunity Employer.

SEDIMENTOLOGIST

UNIVERSITY OF ILLINOIS, CHICAGO

The Department of Earth and Environmental Sciences, University of Illinois at Chicago, seeks a process-oriented sedimentologist for an Assistant Professor, tenure-track appointment, starting Fall, 1999. We are interested in candidates who will develop a strong research program. The appointee is expected to teach at the undergraduate and graduate levels. A Ph.D. is required. Applicants should send a resume, statements outlining research and teaching interests, and names of at least four references to: Steven L. Forman, Sedimentology Search Chair, Univer-

sity of Illinois at Chicago, Department of Earth and Environmental Sciences, 845 W. Taylor Street, M/C 185, Chicago, IL 60607-7059. For more information about the Department see our web page: www.uic.edu/depts/geos/. For fullest consideration, submit by October 15, 1998 or until the position is filled. UIC is an affirmative action/equal opportunity employer.

MINERALOGY/PETROLOGY DENISON UNIVERSITY

The Department of Geology and Geography invites applications for a tenure-track appointment at the Assistant Professor level, to begin in the Fall semester of 1999; a Ph.D. is required. Primary teaching responsibilities include mineralogy, petrology, and introductory physical geology. Other subjects which would complement our program include economic geology and geochemistry. Our department stresses a balance of classroom, field, and laboratory experiences for our majors, and we seek a colleague who will contribute to and collaborate with us on all these components of undergraduate geoscience education. Denison is a selective liberal arts college strongly committed to and supportive of excellence in teaching and active faculty research which involves undergraduate students.

Candidates should submit a letter of application, including a discussion of their approach to teaching and research in a liberal arts setting, along with a vitae, academic transcripts and the names, addresses, e-mail and phone numbers of three or four references — to Tod A. Frolking, Chair, Department of Geology and Geography, Denison University, Granville, OH 43023; (740) 587-6217; frolking@denison.edu. Application materials must arrive by December 1, 1998 for full consideration, interviews will be held on campus in late January. Early applications are strongly encouraged as we hope to meet with candidates at the GSA meeting in Toronto. Denison is an affirmative action/equal opportunity employer.

QUATERNARY GEOLOGIST

The Department of Geological Sciences at California State University, Fullerton, invites applications for a tenure-track position starting August 1999. Applicants should have the following credentials and capabilities: (1) A Ph.D. in geology; (2) An interest in achieving excellence in teaching; (3) Expertise in: surficial processes, Quaternary stratigraphy and sedimentation, paleoclimatology, and/or tectonic geomorphology; we are most interested in a person expert in non-glacial Quaternary geology; and (4) Strong quantitative and computer skills with a field-based research emphasis.

Teaching responsibilities will include physical geology, field geology, and courses in the applicant's area of expertise. The ability to teach remote sensing/GIS, oceanography, or meteorology is a plus. Before applying, see the full text of this announcement at <http://geology.fullerton.edu/geology/>.

To apply, please send the following: (1) A detailed curriculum vitae; (2) A letter telling us about yourself and detailing how you meet the qualifications outlined above; (3) A statement about teaching that includes a discussion of relevant course work and/or experience in preparation for teaching, a list of courses you would feel comfortable teaching, and a statement of your teaching philosophy; (4) A statement of your future research plans and goals; and (5) The names, addresses, phone numbers, and e-mail addresses of at least three references familiar with your teaching and research potential.

Send application to: Dr. Brady Rhodes, Chair, Search Committee, Dept. of Geological Sci., CSUF, P.O. Box 6850, Fullerton, CA 92834-6850. Applications will be accepted until November 15, 1998. We will interview applicants at the GSA Meeting in Toronto, October 26-29, 1998.

CSU, Fullerton is an Affirmative Action/Equal Opportunity Employer. All personnel policies conform to the requirements of Executive Order 11246, the Americans with Disabilities Act (ADA) of 1990, Title IX of the Higher Education Amendments of 1972 and other federal regulations regarding nondiscrimination.

GEOMORPHOLOGIST — DARTMOUTH COLLEGE

The Department of Earth Sciences at Dartmouth College invites applications for an entry level, tenure-track position at the rank of assistant professor in geomorphology. Fields of particular interest include, but are not limited to, landscape/climate interaction, tectonic geomorphology, and geologic hazards. The successful candidate will be expected to demonstrate excellence in both teaching and research, develop a vigorous externally funded research program, and advise student research at the BA, MS, and Ph.D. levels. A strong field component of research is essential.

CALENDAR

1998 Penrose Conferences

September

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

1999 Penrose Conferences

January

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

March

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

June

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

August

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

November

November 21–27, Volcanic Rifted Margins, Sana'a, Yemen. Information: Martin Menzies, Dept. of Geology, Royal Holloway, University of London, Egham Hill, Egham, Surrey TW 20 OEX, United Kingdom, 44-1784-443105, fax 44-1784-471780, menzies@gl.rhnc.ac.uk.

1998 Meetings

October

October 19–22, 14th Annual Conference on Contaminated Soils, Amherst, Massachusetts. Information: Denise Leonard, (413) 545-1239, dleonard@schoolph.umass.edu.

October 25–28, Lessons from Frontier Regions, St. John's, Newfoundland, Canada. Information: Lessons from Frontier Regions Planning Office, (709) 739-3517, fax 709-739-3537, frontiers@nf.sympatico.ca, www.frontier-regions.nfld.net.

November

November 10–15, 2nd International Conference on the Geology of Cuba, the Gulf of Mexico and Northwestern Caribbean, Pinar del Rio, Cuba. Information: Jorge Corbiella-Regura, University of Pinar del Rio, Marti 270, Pinar del Rio 20100, Cuba, fax 53-82-5479 or 53-82-5813, jcobiella@upr.edu.cu.

November 30–December 3, South Island Plate Boundary Symposium, Christchurch, New Zealand, <http://www.gsnz.org.nz>. (Abstract deadline: September 25, 1998.)

December

December 8–9, Geosynthetic Institute Annual Conference: Lessons Learned from Geosynthetic Incidents, Philadelphia, Pennsylvania. Information: Marilyn Ashley, Geosynthetic Institute, 475 Kedron Ave., Folsom, PA 19022-8440, (610) 522-8440, fax 610-522-8441.

1999 Meetings

January

January 19–21, Applications of Remote Sensing and GIS for Disaster Management, Washington, D.C. Information: Greg Shaw, George Washington University VA Campus, 20101 Academic Way, Suite 220B, Ashburn, VA 20147-2604, (703) 729-8271, fax 703-729-8272, glshaw@gwu.edu, <http://www.gwu.edu/~cms/gis/>.

February

February 7–10, International Society of Explosives Engineers 25th Annual Conference on Explosives and Blasting Technique, Nashville, Tennessee. Information: Lynn Mangol, 29100 Aurora Rd., Cleveland, OH 44139, (440) 349-4004, fax 440-349-3788, <http://www.isee.org>.

April

April 22–24, 2nd International Symposium on Petroleum Geology, Zagreb, Croatia. Information: Zdenko Kristafor, Faculty of Mining, Geology, and Petroleum Engineering, Pierottijeva 6, 10000 Zagreb, Croatia, phone 385-1-4605-201, fax 385-1-4836-074.

August

August 12–14, American Society of Civil Engineers 5th U.S. Conference on Lifeline Earthquake Engineering, Seattle, Washington. Information: Andrea Dargush, Multidisciplinary Center for Earthquake Engineering Research (MCEER), University of Buffalo, Red Jacket Quadrangle, Buffalo, NY 14261, (716) 645-3391, fax 716-645-3399, dargush@acsu.buffalo.edu, <http://www.mceer.buffalo.edu>.

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

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

Send curriculum vitae, list of publications, description of teaching and research interests and objectives, and the names, address (including street address), e-mail address and fax/phone numbers of at least three references to: Search Committee, Department of Earth Sciences, Dartmouth College, 6105 Fairchild, Hanover, NH 03755. E-mail: earth_sciences@dartmouth.edu; web pages: <http://www.dartmouth.edu/~earthsci>.

Applications will be accepted until October 15, 1998. The appointment will be effective July 1, 1999.

Dartmouth College is an equal opportunity/affirmative action employer. Women and minorities are encouraged to apply.

LOW-TEMPERATURE GEOCHEMISTRY HARVARD UNIVERSITY

DEPARTMENT OF EARTH & PLANETARY SCIENCES
The Department of Earth and Planetary Sciences at Harvard University seeks to fill a faculty position in the general area of low-temperature geochemistry. The appointment will be made at the assistant or untenured associated professor level. Candidates from all fields of low-temperature geochemistry are encouraged to apply: areas of interest include, but are not limited to, biogeochemistry, geochronology (particularly of surficial and sedimentary processes), continental weathering and continent-ocean exchanges, and applications of cosmogenic isotopes to surficial processes. The successful candidate will be expected to develop a strong research program and to teach at the undergraduate and graduate levels. Applicants should send a statement of research and teaching interests, curriculum vitae, and the names of three referees

to: Geochemistry Search Committee, Department of Earth and Planetary Sciences, Harvard University, 20 Oxford Street, Cambridge, MA 02138. Applications should be received by September 15, 1998. Harvard University is an Affirmative Action / Equal Opportunity Employer. We particularly encourage applications from women and minorities. For more information about the department, you may visit our web site at: www.eps.harvard.edu.

ASSISTANT PROFESSOR OF STRUCTURAL GEOLOGY / ACTIVE TECTONICS

Responsibilities will include advising M.S. and undergraduate research, academic-year teaching of the sophomore-level core introductory field geology course, structural geology and other courses of the candidate's choosing. To approach structural problems using both field and analytical methods and to bridge current departmental interests in crustal studies/petrology and surface processes. Ph.D. required, specific expertise could include: quantitative analysis, geophysics and geochronology. Individual dedicated to integrating high quality research and teaching at the undergraduate and Master's levels. Apply by December 15, 1998 with CV and names of 3 references to: Chair, Search Committee, Department of Geology, University of Vermont, Burlington, VT 05405.

HYDROGEOLOGIST

The Maryland Geological Survey, an agency of the Maryland Department of Natural Resources, invites applications for a full-time, benefited position in its Hydrogeology and Hydrology Program. The purpose of the position is to support hydrogeologic studies in coastal plain settings.

Responsibilities will include water-level monitoring, water-quality sampling, aquifer characterization, ground-water flow and solute-transport modeling, and report preparation.

The position requires a Master's degree in Hydrogeology or a related field with significant graduate-level courses in hydrogeology, computer applications, and aqueous chemistry. Experience in ground-water modeling using MODFLOW, MODPATH, and SUTRA is desired. Depending on qualifications, the starting salary range is \$26,282 to \$30,257 with promotional opportunities.

Send resume, transcripts, and references to: Personnel Office (Code .002), Maryland Geological Survey, 2300 St. Paul Street, Baltimore, Maryland 21218. Maryland Geological Survey is an EEO/AA employer.

Opportunities for Students

Traveling Fellowship: Interdisciplinary Research Training Group (RTG) in ecology, geology, archeology, geography, and soils. Limited funding available for graduate students to come to Minnesota for up to 3 months to enhance training in "Paleorecords of Global Change." Application must arrive by October 7, 1998 for travel during 1999. Students applying for this award should contact the U-M faculty with whom they wish to work well in advance of the application date. For application, contact Sue Julson, RTG, University of Minnesota, Ecology, Evolution and Behavior, 1987 Upper Buford Circle, St. Paul, MN 55108. Phone (612) 624-4238; fax 612-624-6777; e-mail: julso001@tc.umn.edu; web: <http://lrc.geo.umn.edu/RTG/>. An Equal Opportunity Educator and Employer.



Preregistration Due

September 18

See June
GSA Today or
Web site for:

- Technical Program
- Short Courses
- Field Trips
- Exhibits
- Registration
- Housing and Travel

FOR INFORMATION:

GSA Meetings Department, P.O. Box 9140, Boulder, CO 80301, • (303) 447-2020, (800) 472-1988, meetings@geosociety.org, http://www.geosociety.org/meetings/98

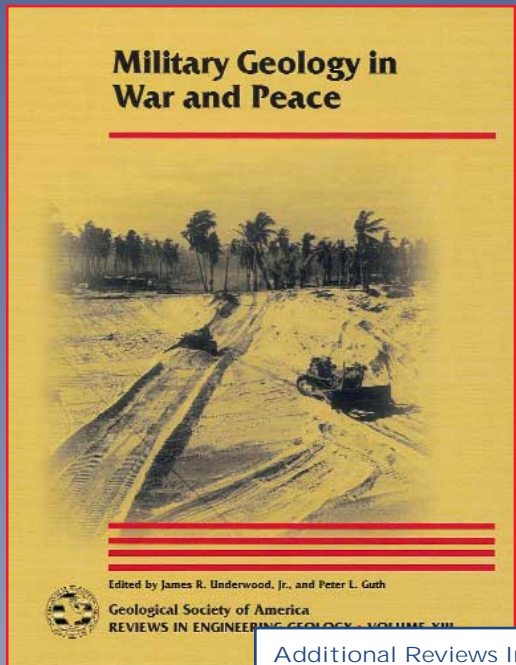
1998 ANNUAL MEETING AND EXPOSITION  October 26-29, 1998

New!

Military Geology in War and Peace

edited by James R. Underwood, Jr., Peter L. Guth, 1998

In warfare, military geologists pursue five main categories of work: tactical and strategic terrain analysis, fortifications and tunneling, resource acquisition, defense installations, and field construction and logistics. In peace, they train for wartime operations and may be involved in peace-keeping and nation-building exercises. The classic dilemma for military geology has been whether support can best be provided by civilian technical-matter experts or by uniformed soldiers who routinely work with the combat units. In addition to the introductory paper this volume includes 24 papers, covering selected aspects of the history of military geology from the early 19th century through the recent Persian Gulf war, military education and operations, terrain analysis, engineering geology in the military, use of military geology in diplomacy and peace keeping, and the future of military geology.



Additional Reviews In Engineering Geology Volumes

- Clay and Shale Slope Instability (REG10, \$60 list)
- Storm-Induced Geologic Hazards ... (REG11, \$60 list)
- A Paradox of Power:Voices of Warning (REG12, \$64 list)

REG013, 256 p., ISBN 0-8137-4113-0, \$76.00, Member price \$60.80

ORDER NOW contact GSA directly.

TOLL-FREE **800-472-1988** FAX **303-447-1133**

WEB **www.geosociety.org**

GSA Publication Sales, P.O. Box 9140, Boulder, CO 80301

Volumes are 8-1/2" x 11", hardbound. Prices include shipping and handling.

The Geological Society of America

01-98-9-T