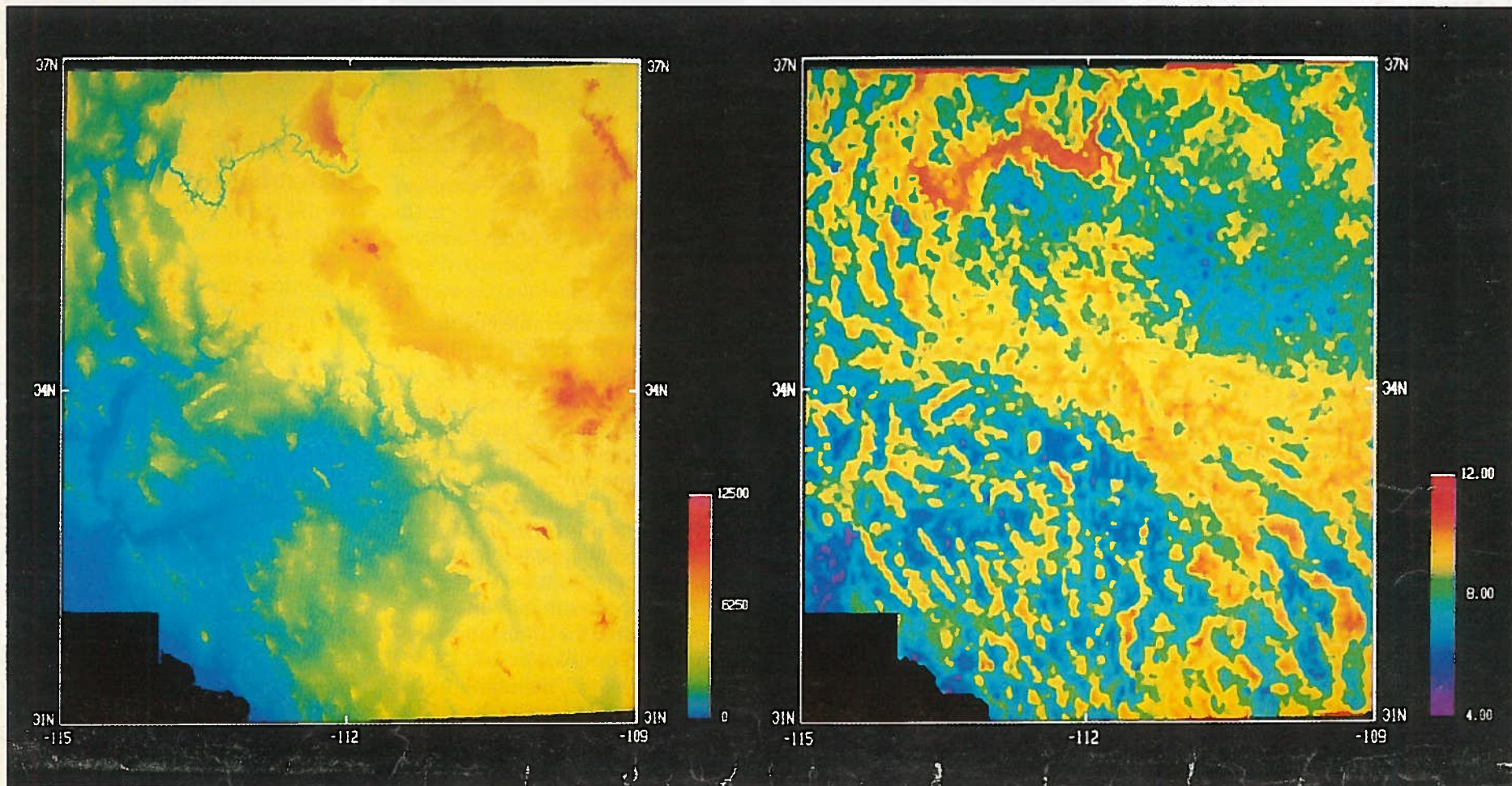


## INSIDE

- North-Central Section Meeting, p. 11
- Dallas Report, p. 14
- GSA Employment Service, p. 17



The photograph on the left is the color-coded elevation (in feet) of the state of Arizona. The photograph on the right is the color-coded roughness amplitudes (arbitrary units) of the state of Arizona.

## Fractals in geology: What are they and what are they good for?

Donald L. Turcotte  
Department of Geological Sciences  
Cornell University, Ithaca, NY 14853

### ABSTRACT

Objects that are scale invariant are fractals. Many geologic phenomena and processes are scale invariant and are therefore fractals. Rocky coastlines and river networks are examples. Statistical frequency-size distributions of economic ore deposits, earthquakes, and volcanoes are fractals. Fractals can be used in empirical correlations, but they are also associated with chaotic processes. There is considerable evidence that tectonics and erosion are examples of chaotic processes.

### What is a Fractal?

I am sure that you have heard of fractals; you may have seen fractally generated computer graphics and synthetic landscapes or may be aware that a rocky coastline is a fractal. But are fractals more than a scientific curiosity? I would like to convince you that at the very least, fractals help us to bridge the gap between geostatistics and physical and chemical modeling of geologic processes.

I am often asked the question, "What is a fractal?" A definition that is generally applicable is given by

$$N = \frac{C}{r^D} \text{ or } \frac{N_2}{N_1} = \left(\frac{r_1}{r_2}\right)^D, \quad (1)$$

where  $N$  is the number of objects associated with the size  $r$ ,  $C$  is a constant, and  $D$  is the fractal dimension. A power law (Prieto) geostatistical distribution is generally a fractal.

One of the best examples of a fractal is the classic Koch triadic island illustrated in Figure 1. At the largest scale  $r_1$ , the triangle has three sides,  $N_1 = 3$ . At the next smaller scale, three triangles with sides  $r_2 = r_1/3$  are added; there are now twelve sides,  $N_2 = 12$ . The construction can be continued indefinitely to smaller and smaller scales. The fractal dimension of this construction is easily obtained from equation 1 by taking its logarithm and writing it in the form

$$D = \frac{\ln(N_2/N_1)}{\ln(r_1/r_2)} = \frac{\ln 4}{\ln 3} = 1.262 \quad (2)$$

Two important points should be made:

1. The Koch triadic island is scale invariant. The sides are self-similar at any magnification. It is impossible to tell the scale from a photograph of the island. Scale invariance is a characteristic of many geologic features; it is well known to every geologist who has ever looked at a picture of a rock formation without a rock hammer or lens cap to show the scale and could not figure out the size.
2. The length of the perimeter of the island approaches infinity as the construction is extended to smaller and smaller scales. This is

the reason that the fractal dimension is greater than unity, the Euclidean dimension of a line. The length of the perimeter  $P$  is given by

$$P = Nr = Cr^{1-D}, \quad (3)$$

where  $N$  has been substituted from equation 1.

The length of the perimeter of the Koch triadic island is analogous to the length of a rocky coastline. It was in this context that Mandelbrot (1967) introduced the concept of fractals. The length of the coastline obtained using a measuring rod of a specified length is plotted against the length of the measuring rod. The results for the west coast of Great Britain,

Fractals continued on p. 3

ISSN 1052-5173

SECOND CLASS  
Postage Paid  
at Boulder, Colorado  
and at additional mailing offices

**Fractals in Geology:**  
**What are they and what are they good for?** page 1

Introductions . . . . . 2  
 Washington Report . . . . . 5  
 GSA Forum . . . . . 6  
 SAGE Remarks . . . . . 10  
 North-Central Section Meeting . . . . . 11  
 1990 Annual Meeting . . . . . 14  
 GSA Employment Service . . . . . 17  
 GSAF Update . . . . . 19  
 1991 GSA Officers and Councilors . . . 19  
 1991 GeoVentures . . . . . 20  
*Bulletin and Geology Contents* . . . . . 21  
 Book Reviews . . . . . 22  
 DNAG News . . . . . 22  
 On the Move . . . . . 23  
 In Memoriam . . . . . 23  
 GSA Meetings . . . . . 23  
 Meetings Calendar . . . . . 24  
 Classifieds . . . . . 27

**GSA TODAY** January 1991  
 Vol. 1, No. 1

**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. Second-class 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 © 1991, The Geological Society of America, Inc. Copyright is not claimed on content prepared by government employees within the scope of their employment. Limited permission is hereby given by GSA to photocopy any material appearing in *GSA Today* for the noncommercial purpose of scientific or educational advancement. GSA, a scholarly society, neither adopts nor supports positions of advocacy. We provide 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 1991 calendar year:  
**Society Members:** *GSA Today* is provided as part of membership dues. Contact Membership Services at (800) 472-1988 or (303) 447-2020 for membership information. **Nonmembers & Institutions:** \$30 for U.S./Canada/Mexico and \$40 elsewhere. Contact Subscription Services (same phones). **Single Copies** may be requested from Publication Sales. **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.

**STAFF**  
 Prepared from contributions from the GSA staff and membership.  
**Executive Director:** F. Michael Wahl, Ph.D.  
**Science Editor:** Eldridge M. Moores,  
 Department of Geology, University of California,  
 Davis, CA 95616  
**Forum Editor:** Bruce F. Molnia,  
 U.S. Geological Survey, MS 917, National Center,  
 Reston, VA 22092  
**Managing Editor:** Faith Rogers  
**Associate Editor:** Shaun Cisneros  
**Production & Marketing Manager:** James R. Clark  
**Advertising Coordinator:** Ann H. Crawford  
**Graphics Production:** Shaun Cisneros  
**Production Coordinators:** Joan E. Manly  
 Mona T. Gonzales

**ADVERTISING**  
 Classifieds and display: contact Ann Crawford  
 (303) 447-2020; fax 303-447-1133

Printed in the U.S.A.

Introductions



F. Michael Wahl  
 Executive Director

Welcome to the first issue of *GSA Today*—a new publication of the Geological Society of America. We hope you will find it both interesting and useful. Each issue will feature a lead science article and a Forum section, containing articles and letters on current issues and concerns. Some of these will be provocative and controversial, while others will state the Society's positions on matters of general concern. *GSA Today* will also contain features about people; honors and awards; opportunities for scholarships, fellowships and research funds; book reviews; a regular legislative update; and the meeting notices and announcements that previously appeared in *GSA News & Information*.

This new publication is the result of more than two years of deliberation by the GSA Council. They wanted a publication that would be more than a newsletter, one that would also be of scientific interest and contain articles and other information of concern to all members of our profession. *GSA Today* is the result of those considerations. We hope that you will not only read and enjoy it, but also find it helpful in keeping up with the concerns and activities of the GSA. Your comments, suggestions, and contributions for this new publication are always welcome. ■

**GSA Today Science Editor**  
**Eldridge M. Moores**  
 Department of Geology, University of California, Davis, CA 95616-8605  
 tel. (916) 752-0352  
 fax 916-752-0951

**GSA Today Forum Editor**  
**Bruce F. Molnia**  
 U.S. Geological Survey, MS 917, National Center, Reston, VA 22092  
 tel. (703) 648-4120  
 fax 703-648-4227



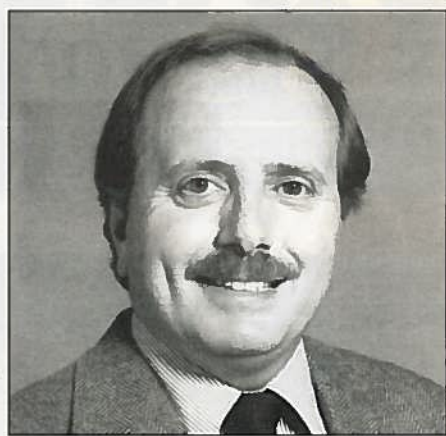
Eldridge M. Moores  
 Science Editor

It is with considerable enthusiasm that I assume the position of Science Editor of *GSA Today*. We hope to have a lead science article every month on new, fast-breaking items or current topics of general interest to the entire GSA membership. This article will be placed so that it begins on the front page and will ideally appear with a full-color photograph. We envision articles of approximately the length suitable for publication in *Geology*—16 double-spaced manuscript pages, including figures. Expedited peer review will keep submission-to-publication time down to 3 to 4 months. The articles will be included in a yearly archival issue, so that they can be considered formal scientific contributions.

In order to get the first few issues of *GSA Today* underway, I have invited submissions of science articles on subjects that should be of interest to all 17,000 GSA members. As time goes on, however, I look forward to receiving volunteered contributions. If you have a manuscript, or an idea for one, that you think might appeal to the entire GSA membership, please contact me at the address and numbers listed below.

We are also resuming the publication of book reviews. They were published in *Geology* until 1989, when the editors eliminated them because of lack of space. Letters to GSA headquarters have indicated that readers appreciate book reviews, so we will be publishing them in *GSA Today*, starting with this issue.

I look forward to working with Bruce Molnia, the Forum Editor, and the entire GSA membership to make *GSA Today* an exciting and valuable new publication. ■



Bruce F. Molnia  
 Forum Editor

This inaugural issue of *GSA Today* represents a major step forward from the monthly newsletter of the past. *GSA Today* offers several new features. I am pleased to be responsible for two of these, GSA Forum and Washington Report.

Forum is a monthly feature in which many sides of an issue or question of interest to the geological community will be explored. Each Forum presentation will consist of an introduction to the month's topic followed by two or more opposing views of the topic. Suggestions for future Forum topics are welcome. Readers are invited to respond to positions presented in Forum and to submit alternative views. Letters from readers will be published in the Forum Feedback section beginning in February. Upcoming Forum topics will be presented to *GSA Today* readers with sufficient lead time for all who wish to participate. February's Forum topic will address the question: Should the Arctic National Wildlife Refuge (ANWR) Be Open to Petroleum Activities? The March Forum topic will be Future Energy Needs and the Utilization of Fossil Fuels. Please send comments, suggestions for future Forum topics, and your feedback to this month's Forum to me at the address and numbers listed on this page.

Washington Report provides a monthly window on the activities of the Federal agencies, Congress and the legislative process, and international interactions that could affect the geoscience community. In future issues, Washington Report will present summaries of agency and interagency programs, track legislation, and present insights into Washington, D.C., geopolitics as they pertain to the geosciences. An annually recurring feature of Washington Report will be a summary of the Federal budget as it relates to agency geoscience programs.

Both Eldridge Moores and I invite your full participation in *GSA Today*. Please contact us with your ideas and your comments. With your involvement, *GSA Today* can provide rapid exchange of information among GSA members and a forum for members' views. ■



**Figure 1.** Three scales of the triadic Koch island, a classic fractal. At each smaller scale, triangles with sides one-third smaller are added to the center of each side of the larger scale. As the construction is carried to an infinitely smaller scale, the perimeter of the island has an infinite length, but its area is finite.

## Fractals continued from p. 1

originally considered by Mandelbrot (1967), are given in Figure 2. The value  $D = 1.25$  is typical for coastlines or topographic contours in a wide range of geologic provinces; it is also quite close to the value for the Koch triadic island. The length of a rocky coastline cannot be determined; the fractal dimension is a measure of its tortuosity.

The concept of fractals is easily introduced in an introductory physical geology course. When topographic maps are first considered the student can be asked to measure the total length along a specified contour using different spacings on a divider. The length of the contour (perimeter) is plotted against the divider length on log-log paper; from equation 3 the slope is  $1-D$  and the fractal dimension of the contour can be obtained.

## Self-similar Fractals

In many geological contexts the fractal distribution, equation 1, can be considered to be a statistical distribution. It is the only statistical distribution that is scale invariant; thus there is an underlying basis for its applicability to many geological problems. A few examples of self-similar fractals:

1. The Korcak relation for the number of islands with an area greater than a specified value is a fractal with  $D = 1.30$  (Mandelbrot, 1975).
2. Cargill et al. (1980, 1981) have suggested that the fractal (power law) relation can be applied to the relation between tonnage and grade in economic ore deposits (Turcotte, 1986a).
3. Ivanhoe (1976) has suggested that the fractal (power law) relation can be applied to the number-size statistics for oil fields. It should be noted that log-normal statistics are often applied, but log-normal statistics are not scale invariant.
4. Earthquakes have a fractal relation between size and frequency of occurrence. Gutenberg and Richter (1954) established an empirical relation for the number of earthquakes  $N$  occurring in a specified length of time with magnitudes greater than  $m$  of the form

$$\log N = -bm + a, \quad (4)$$

where  $a$  and  $b$  are constants. This relation is valid both globally and regionally, and the  $b$  value is usually near 0.9. Aki (1981) showed that equation 4 is a fractal relation equivalent to equation 1; when the magnitude  $m$  is converted to the

rupture area  $r^2$ , the result is the simple relation

$$D = 2b. \quad (5)$$

Thus,  $D \approx 1.8$  for seismicity. The regional fractal distribution of seismicity may be used to assess the seismic hazards (Turcotte, 1989). The frequency of small earthquakes can be extrapolated to determine the frequency of occurrence of large earthquakes.

5. McClelland et al. (1989) have published frequency-volume statistics for volcanic eruptions that correlate well with equation 1, taking  $D = 2.14$ .

6. Materials can be fragmented in a variety of ways: naturally, by impacts, by explosives. Under many circumstances a fractal distribution as defined by equation 1 results (Turcotte, 1986b). The classic example for broken coal in Britain obtained by Bennett (1936) is given in Figure 3; good agreement with equation 1 is obtained taking  $D = 2.50$ .

It should be noted that empirical applications of fractals such as that illustrated in Figure 3 have upper and lower limits. The upper limit is the size of the largest fragment and generally is of the order of the size of the region fragmented; the lower limit is generally of the order of the grain size.

A simple model illustrates how fragmentation can result in a fractal distribution. This model is illustrated in Figure 4; at each scale two diagonally opposed blocks are retained and no two blocks of equal size are in direct contact with each other. This is the comminution model for fragmentation proposed by Sammis et al. (1986). It is based on the hypothesis that the direct contact between two fragments of nearly equal size will result in the breakup of one of the fragments. It is unlikely that a small fragment will break a large fragment or that a large fragment will break a small fragment. For the cube of dimension  $h$  illustrated in Figure 4 we have  $N_1 = 2$  for  $r_1 = h/2$  and  $N_2 = 12$  for  $r_2 = h/4$ ; thus, from equation 1 we have  $D = \ln 6 / \ln 2 = 2.5850$ . Many fractal distributions of fragments have fractal dimensions near this value; one example was given in Figure 3; another is fault gouge (Sammis and Biegel, 1989).

The comminution model may also be applicable to tectonic fragmentation. It is probably a good approximation to assume that each fault has a characteristic earthquake. Thus the fractal frequency-magnitude statistics for earthquakes implies fractal number-size

statistics for faults. Because of lack of exposure, erosion, and other effects it is in general difficult to quantify directly the number-size statistics of faults. A systematic study of the statistics of exposed joints and fractures has been given by Barton and Hsieh (1989).

Basement rock near Yucca Mountain, Nevada, was cleared and the distribution of fractures mapped. Fractal dimensions near  $D = 1.7$  were obtained; this compares with  $D = 1.6$  for the surface exposure of the comminution model illustrated in Figure 4.

## Self-affine Fractals

The ruler method for determining the fractal dimension of a rocky coastline was discussed in the previous section. An equivalent method is to determine the number of square boxes  $N$  of size  $r$  required to cover the coastline. If the dependence of  $N$  on  $r$  satisfies equation 1 a self-similar fractal is defined. In many cases, however, it is appropriate to use rectangular rather than square boxes. A noisy time series is a specific example. If the number of rectangular boxes of various sizes required to cover the time series satisfies equation 1 a self-affine fractal is defined.

Topography is an example of both self-similar and self-affine fractals. As discussed above a topographic map is usually an example of a self-similar fractal. A cross-section of topography with elevation plotted against position along a linear track is not a self-similar fractal, however; it is usually a self-affine fractal.

Spectral methods are generally applied to self-affine fractals. Consider the Fourier sine series for the height of topography  $h(x)$  along a linear track of length  $L$ . The Fourier representation is

$$h(x) = \sum_{n=1}^{\infty} A_n \sin(2\pi n x/L), \quad (6)$$

where  $L$  is the length of the track and  $A_n$  is the amplitude associated with the wavelength

$$\lambda_n = \frac{L}{n}, \quad (7)$$

with  $n = 1, 2, \dots$ . The profile is a fractal if the amplitude coefficients  $A_n$  have a power law dependence on the wavelength  $\lambda_n$ , that is

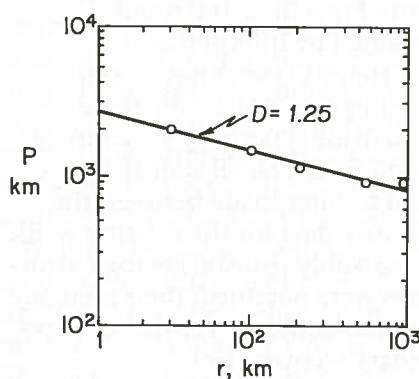
$$A_n = C \lambda_n^{\frac{5-2D}{2}}, \quad (8)$$

where  $C$  is again a constant. This relation is derived by counting the number of rectangular boxes of various sizes that are required to cover the profile (Voss, 1988).

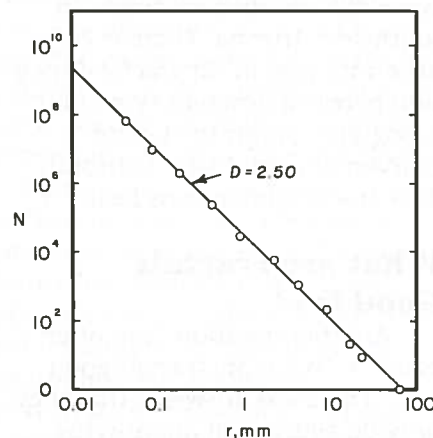
As a specific example of a self-affine fractal, consider the random walk illustrated in Figure 5. Take a step forward and flip a coin; if it is heads take a step to the right; if it is tails, take a step to the left; take another step forward and repeat the process; this is Brownian noise. The amplitude of the noise depends on the length of the step to the side compared to the length of the step forward. For Brownian noise  $D = 3/2$  and from equation 8  $A_n = C \lambda_n$ ; the amplitude is proportional to the wavelength. Brownian noise is a good statistical approximation to topography and bathymetry (Bell, 1975).

A global spectral expansion of topography and bathymetry has been carried out by Rapp (1989); his results are given in Figure 6. It is seen that equation 8 with  $D = 1.5$  and  $A_n = 10^{-4} \lambda_n$  is in good agreement with the data at all but the longest wavelengths. The fractal dimension of topography is

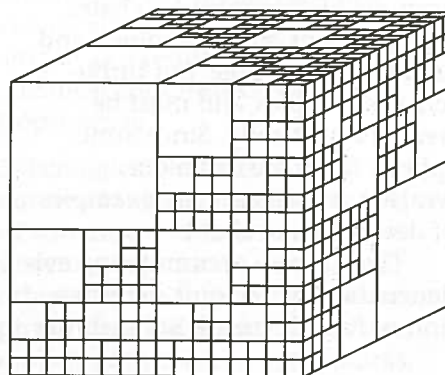
## Fractals continued on p. 4



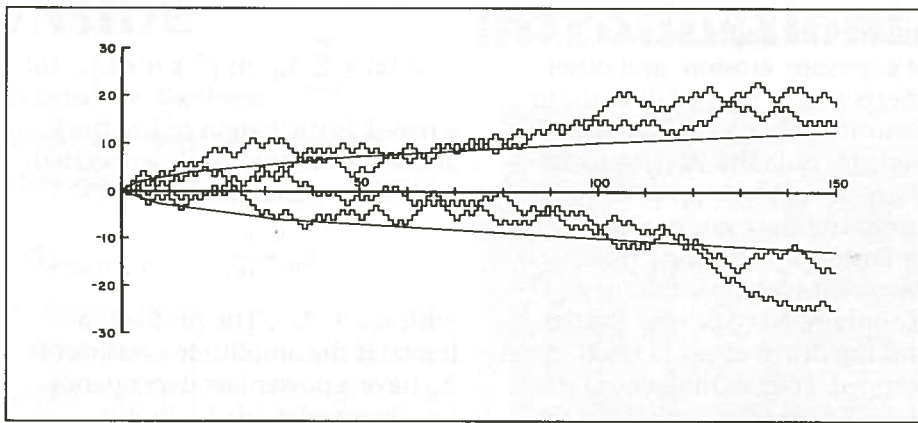
**Figure 2.** The open circles give the length  $P$  of the west coast of Great Britain as a function of the length of the measuring rod  $r$  (Mandelbrot, 1967). The solid line is equation 3 with the fractal dimension  $D = 1.25$ .



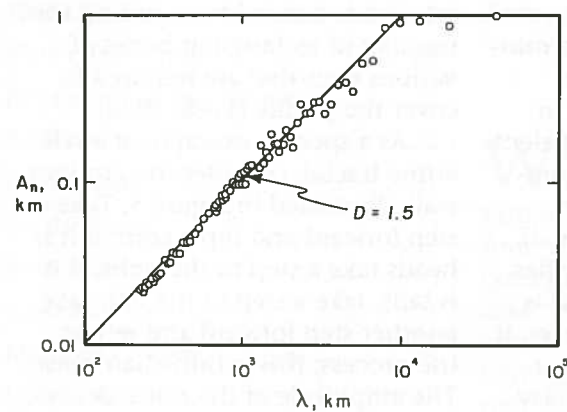
**Figure 3.** The number of pieces  $N$  of broken coal larger than a specified size  $r$  (Bennett, 1936) obtained by a sieve analysis. The line is equation 1 with the fractal dimension  $D = 2.50$ .



**Figure 4.** Fractal model for the comminution of a cube. Two large blocks are placed diagonally opposite each other at all scales. There are two blocks with  $r = h/2$  and twelve blocks with  $r = h/4$ ; thus,  $D = \ln 6 / \ln 2 = 2.58$ .



**Figure 5.** The zig-zag lines are four examples of a random walk (Brownian noise). The solid lines ( $y = \sqrt{x}$ ) represent the mean dispersion of the walk.



**Figure 6.** Dependence of amplitude coefficients  $A_n$  on the wavelengths  $\lambda_n$  for Earth's topography (Rapp, 1989).

### Fractals continued from p. 3

generally near  $D = 1.5$ , but the amplitude is quite variable, being a measure of the roughness of the topography. The front-page photographs give maps of color-coded topography and color-coded roughness of the state of Arizona (Huang and Turcotte, 1989). The fractal dimension and roughness amplitude were obtained for each  $4.5 \times 4.5$  km subregion in the state. The mean fractal dimension for linear tracks is  $D = 1.50 \pm 0.10$ . The roughness maps of Arizona clearly illustrate the erosional terrain associated with the Grand Canyon in northwest Arizona and the roughness contrasts between the basins (smooth) and ranges (rough) in southwest Arizona. There is very little variation in the fractal dimension between different types of topography; both the Grand Canyon and the Idaho batholith have fractal dimensions near 1.5.

### What are Fractals Good for?

Another question I am often asked is "What are fractals good for?" The short answer is that they provide a means of quantifying scale-invariant processes. Because geology is filled with scale-invariant processes, there are many applications, some of which have been described above. But the answer is broader than this. In parallel with the concept of fractals, the concept of chaos has evolved in the past decade. Chaos and fractals are intimately connected; solutions that exhibit chaotic behavior invariably satisfy fractal statistics (Devaney, 1988).

Fractals can be useful strictly on an empirical basis. Power-law (fractal) statistics have been applied to a variety of geological problems; examples include petroleum and ore reserves. If the

underlying physical and chemical processes are scale invariant, then the fractal distribution must be applicable.

Self-affine fractals are also applicable to a variety of problems on an empirical basis. Consider the problem of making a bathymetric chart when depths are known accurately along ship tracks. The bathymetry for a region can be expanded in a Fourier series in two directions. It is necessary to determine the amplitudes and phases for each harmonic. However, from the discussion given above, it is generally reasonable to assume that the amplitudes obey the fractal distribution given in equation 8. The data along the ship tracks are then used to specify the phases. The result is far more accurate than a brute-force fit or the results obtained by interpolation.

Hewett (1986) has used this technique to obtain the three-dimensional porosity structure of an oil field. Fractal statistics were used to interpolate between the porosity data for the existing wells. Remarkably realistic geologic structures were obtained; their accuracy was subsequently verified in a secondary recovery test.

Although empirical applications can be useful, fractals are often the result of chaotic processes. The definition of chaos is that two solutions with slightly different initial conditions diverge exponentially as they evolve. It is generally accepted that fluid turbulence is an example of deterministic chaos; the equations are well known and are relatively simple, but turbulence is complex and must be treated statistically. Since atmospheric flows are turbulent, weather and climate are examples of deterministic chaos.

There is also accumulating evidence that the tectonic deformation of Earth's crust is an example

of deterministic chaos. The strike-slip behavior of blocks pulled along a surface is a simple analog to earthquakes. Huang and Turcotte (1990) showed that an asymmetrical pair of sliding blocks exhibits classical chaotic behavior. Carlson and Langer (1989) showed that a large number of identical sliding blocks behave chaotically. Simple cellular automata models (Bak and Tang, 1989; Kadanoff et al., 1989) produce fractal statistics of failure resembling earthquakes and indicate that the crust may be in a state of "self-organized criticality."

Drainage patterns and topography are classic examples of fractals. Thus the equations governing erosion must be nonlinear. Linear equations such as the diffusion equation for erosion (Culling, 1960) cannot generate fractals. Newman and Turcotte (1990) have proposed a model for erosion resembling models for turbulence. This nonlinear model produces and maintains self-similar fractal topography.

If you have read this far you may be interested in learning more about fractals. The book by Mandelbrot (1982) is relatively easy reading and gives a very personalized view of fractal concepts, but it is not particularly useful in terms of applications. Probably the best overall treatment of fractals at an intermediate level is the book by Falconer (1990). The volume of *Pure and Applied Geophysics* edited by Mandelbrot and Scholz (1989) presents a variety of applications of fractals to problems in geology and geophysics; further applications will appear in a book edited by C. C. Barton and P. R. LaPointe.

### References Cited

- Aki, K., 1981, A probabilistic synthesis of precursor phenomena, in Simpson, D.W., and Richards, P.G., eds., *Earthquake prediction*: Washington, D.C., American Geophysical Union, p. 556-574.
- Bak, P., and Tang, C., 1989, Earthquakes as a self-organized critical phenomenon: *Journal of Geophysical Research*, v. 94, p. 15,635-15,637.
- Barton, C.C., and Hsieh, P.A., 1989, Physical and hydrologic-flow properties of fractures (28th International Geological Congress Field Trip Guidebook T385): Washington, D.C., American Geophysical Union, 36 p.
- Bell, T.H., 1975, Statistical features of sea-floor topography: *Deep-Sea Research*, v. 22, p. 883-892.
- Bennett, J.G., 1936, Broken coal: *London Journal of the Institute of Fuel*, v. 10, p. 22-39.
- Cargill, S.M., Root, D.H., and Bailey, E.H., 1980, Resource estimation from historical data: Mercury, a test case: *Journal of the International Association for Mathematical Geology*, v. 12, p. 489-522.
- Cargill, S.M., Root, D.H., and Bailey, E.H., 1981, Estimating usable resources from historical industry data: *Economic Geology*, v. 76, p. 1081-1095.
- Carlson, J.M., and Langer, J.S., 1989, Mechanical model of an earthquake fault, *Physical Reviews*, v. A40, p. 6470-6484.
- Culling, W.E.H., 1960, Analytical theory of erosion, *Journal of Geology*, v. 68, p. 336-344.
- Devaney, R.L., 1988, Fractal patterns arising in chaotic dynamical systems, in Peitgen, H. D., and Saupe, D., eds., *The science of fractal images*: New York, Springer-Verlag, p. 137-167.
- Falconer, K., 1990, *Fractal geometry*: Chichester, England, John Wiley, 288 p.
- Gutenberg, B. and Richter, C.F., 1954, *Seismicity of the Earth and associated phenomena* [second edition]: Princeton, New Jersey, Princeton University Press, 310 p.
- Hewett, T.A., 1986, Fractal distributions of reservoir heterogeneity and their influence on fluid transport: *Society of Petroleum Engineers Paper 15386*, 15 p.
- Huang, J., and Turcotte, D.L., 1989, Fractal mapping of digitized images: Applications to the topography of Arizona and comparisons with synthetic images: *Journal of Geophysical Research*, v. 94, p. 7491-7495.
- Huang, J., and Turcotte, D.L., 1990, Are earthquakes an example of deterministic chaos?: *Geophysical Research Letters*, v. 17, p. 223-226.
- Ivanhoe, L.F., 1976, Oil/gas potential in basin estimates: *Oil and Gas Journal*, v. 6, p. 154-155.
- Kadanoff, L.P., Nagel, S.R., Wu, L., and Zhou, S.M., 1989, Scaling and universality in avalanches: *Physical Review*, v. A39, p. 6524-6533.
- Mandelbrot, B.B., 1967, How long is the coast of Britain? *Statistical self-similarity and fractional dimension*: *Science*, v. 156, p. 636-638.
- Mandelbrot, B.B., 1975, Stochastic models for the earth's relief, the shape and the fractal dimension of the coastlines, and the number-area rule for islands: *National Academy of Science Proceedings*, v. 72, p. 3825-3828.
- Mandelbrot, B.B., 1982, *The fractal geometry of nature*: San Francisco, Freeman, p. 460.
- Mandelbrot, B.B., and Scholz, C.H., editors, 1989, *Fractals in geophysics: Pure and Applied Geophysics*, v. 131.
- McClelland, S.T., Summers, M., Nielson, E., and Stein, T.C., editors, 1989, *Global volcanism, 1975-1985*: Englewood Cliffs, New Jersey, Prentice-Hall, 655 p.
- Newman, W.I., and Turcotte, D.L., 1990, Cascade model for fluvial geomorphology: *Geophysical Journal International*, v. 100, p. 433-439.
- Rapp, R.H., 1989, The decay of the spectrum of the gravitational potential of the Earth: *Geophysical Journal International*, v. 99, p. 449-455.
- Sammis, C.G., and Biegel, R.L., 1989, Fractals, fault gouge, and friction: *Pure and Applied Geophysics*, v. 131, p. 255-271.
- Sammis, C.G., Osborne, R.H., Anderson, J.L., Banerdt, M., and White, P., 1986, Self-similar cataclasis in the formation of fault gouge: *Pure and Applied Geophysics*, v. 123, p. 53-78.
- Turcotte, D.L., 1986a, A fractal approach to the relationship between ore grade and tonnage: *Economic Geology*, v. 81, p. 1528-1532.
- Turcotte, D.L., 1986b, Fractals and fragmentation: *Journal of Geophysical Research*, v. 91, p. 1921-1926.
- Turcotte, D.L., 1989, A fractal approach to probabilistic seismic hazard assessment: *Tectonophysics*, v. 167, p. 171-177.
- Voss, R.F., 1988, *Fractals in nature: From characterization to simulation*, in Peitgen, H.O., and Saupe, D., editors, *The science of fractal images*: New York, Springer-Verlag, p. 21-70.

Bruce F. Molnia

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

## Our Changing Planet The Fiscal Year 1991 U.S. Global Change Research Program

*In the coming decades, global change may well represent the most significant societal, environmental, and economic challenge facing this nation and the world. The national goal of developing a predictive understanding of global change is, in its truest sense, science in the service of mankind.*

CEES Working Group on  
Global Change, 1990

Earth is a dynamic system, constantly undergoing change. As geologists, we are far more aware of the magnitude and variety of the changes that have occurred during the past 4.5 billion years than perhaps any other group. Recent events, such as the realization of the magnitude of ozone depletion over Antarctica, have made others cognizant of the dynamic Earth and have raised the question of how human activity affects the Earth system. Predictions by climate modelers stating that increased greenhouse gas emissions to the atmosphere will result in "catastrophic" global warming have generated further concern. In the past few years, this concern has spread beyond the scientific community to the general public who are now calling upon politicians and policy makers in Washington, D.C., to provide national direction.

In March 1987, recognizing the potential economic and social implications of responding to natural and human-induced changes in the Earth system, the Executive Office of the President's Office of Science and Technology Policy ordered its Federal Coordinating Council for Science, Engineering and Technology to establish the Committee on Earth Sciences (CES). Recently renamed the Committee on Earth and Environmental Sciences (CEES), this group includes representatives from the Departments of Agriculture, Commerce, Defense, Energy, Interior, State, and Transportation, the National Science Foundation (NSF), Environmental Protection Agency, National Aeronautics and Space Administration, Office of Science and Technology Policy, Office of Management and Budget, Council on Environmental Quality, and the Smithsonian Institution. CEES is chaired by Dallas Peck, Director of the U.S. Geological Survey. Initially, CES

was charged with reviewing Federal Government research in earth science and with improving the planning, coordination, and communication among those Federal agencies involved in Earth science research. One of the responsibilities of CEES is to increase the effectiveness and productivity of Federal research and development efforts toward understanding Earth as a global system. To reach this goal, in January 1989, CES issued a report, "Our Changing Planet: A U.S. Strategy for Global Change Research." This report accompanied the President's Fiscal Year 1990 Budget to the Congress. The report resulted in the formulation of the U.S. Global Change Research Program (USGCRP) and, later, in the establishment of a Working Group on Global Change, with Robert Corell, Assistant Director of Geosciences for NSF, as its chair. In July 1989, CES released "Our Changing Planet: The FY 1990 Research Plan," a description of the approach, the work plan, and the details of the FY 1990 budget of \$659.3 million for focused (vs. contributing) USGCRP programs. The FY 1990 budget represented a 44% increase over the FY 1989 level of funding for agency-focused global change programs. In "The FY 1990 Research Plan," the CES established the following goal and objectives for the USGCRP:

### Goal:

To establish the scientific basis for national and international policy making relating to natural and human-induced changes in the global Earth system.

### Objectives:

- (1) To establish an integrated, comprehensive long-term program of documenting the Earth system on a global scale.
- (2) To conduct a program of focused studies to improve our understanding of the physical, geological, chemical, biological, and social processes that influence Earth system processes and trends on global and regional scales.
- (3) To develop integrated conceptual and predictive Earth system models.

### FY 1991 USGCRP

Released in December 1990 "Our Changing Planet: The FY 1991 U.S. Global Change Research Plan," identified the FY 1991 USGCRP appropriated budget at a level of \$950.5 million, a 44% increase over the FY 1990 program.

As in previous years, the FY 1991 program has seven primary interdisciplinary science priorities, each with multiple subpriorities. As ranked by CEES, the priorities are:

1. Climate and Hydrologic Systems
2. Biogeochemical Dynamics
3. Ecological Systems and Dynamics
4. Earth System History
5. Human Interactions
6. Solid Earth Processes
7. Solar Influences.

Management of Data and Information was identified as an important common thread that runs through each of the science priorities; consequently, it was not included in the rankings.

The following section describes each of the science priorities of the FY 1991 USGCRP and presents policy-relevant questions raised by the CEES in the FY 1991 plan.

**1. Climate and Hydrologic Systems:** the role of clouds, ocean circulation and heat flux; land-atmosphere-ocean water and energy fluxes, coupled climate system and quantitative links, and ocean-atmosphere-cryosphere interactions. Key questions: (1) What is the role of clouds and water vapor in Earth's radiation and heat budgets? (2) How do the oceans interact with the atmosphere in the storage, transport, and uptake of heat? (3) How will climate change affect temperature, precipitation, and soil moisture patterns, the general distribution of water on the land surface, and how will those changes in turn influence the atmosphere? (4) How can the reliability of global- and regional-scale climate predictions be improved? (5) What is the role of the polar regions in global climate change?

**2. Biogeochemical Dynamics:** biosphere, atmosphere, ocean fluxes of trace species, atmosphere processing of trace species, surface and deep-water biogeochemistry, terrestrial biosphere nutrient and carbon cycling, and terrestrial inputs to marine ecosystems. Key questions: (1) How are the oceans and terrestrial biosphere affecting fluxes of carbon and the atmospheric concentration of carbon dioxide as sinks for fossil fuel carbon dioxide and how do they change with time? (2) What are the processes and the magnitude of the major sources and sinks responsible for the current increases in atmospheric nitrous oxide and methane? (3) Are the atmospheric lifetimes of key radiatively and chemically active gases being altered as a result of the changing chemical composition of the troposphere?

**3. Ecological Systems and Dynamics:** long-term measurements of structure and function of ecosystems; response to climate and other stresses; interactions between physical and biological processes; models of interactions, feedbacks,

and responses; and productivity and resource models. Key questions: (1) How will predicted changes in terrestrial and marine ecosystems alter radiation, heat, or water fluxes in the climate system? (2) How do ecological processes control the movement of nutrients and water within ecosystems, and how might these processes change over time? (3) What are the probable magnitudes, rates, and variations of human-induced change in ecological systems, and how can these changes be distinguished from natural fluctuations? (4) In which ecological systems and species are significant changes most likely to occur, and what attributes of importance to humans (e.g., harvestable resources, arable lands, and species diversity) will be at risk?

**4. Earth System History:** paleoclimate, paleoecology, atmospheric composition, ocean circulation and composition, ocean productivity, sea-level change, and paleohydrology. Key questions: (1) What are the natural ranges and rates of change in the climate and environmental systems? (2) How rapidly have ecosystems adapted to past abrupt transitions in climate? (3) Do past warm intervals in Earth history provide appropriate scenarios to test model predictions of future global warming? (4) How can reconstructions of past sea-level fluctuations improve the ability to predict future sea-level change? (5) Is there more than one stable mode of atmosphere-ocean circulation?

**5. Human Interactions:** data-base development and models linking population growth and distribution, energy demands, changes in land use, and industrial production. Key questions: (1) What is needed to develop the information required to verify models of interaction between human and natural systems and to assess the likelihood of changes in those processes? (2) How do population dynamics contribute to global environmental change? (3) How do institutions influence environmental processes and respond to changes in global environmental conditions? (4) How do technological and economic development contribute to global environmental change, and how will changing environmental conditions affect future technological and economic development? (5) How do human factors influence the use of land, water, energy resources, and other natural resources that affect global environmental change?

**6. Solid Earth Processes:** coastal erosion, volcanic processes, permafrost and marine hydrates, ocean and seafloor heat and energy fluxes, surficial processes, and crustal motions and sea level. Key questions: (1) How do different

**Washington** continued on p. 26

# GSA FORUM

Bruce F. Molnia

Forum is a monthly feature of *GSA Today* in which many sides of an issue or question of interest to the geological community will be explored. Each Forum presentation will consist of an informative, neutral introduction to the month's topic followed by two or more opposing views concerning the Forum topic. Selection of future Forum topics and participants is the responsibility of the Forum Editor. Suggestions for future Forum topics are welcome and should be sent to: Bruce F. Molnia, Forum Editor, U.S. Geological Survey, 917 National Center, Reston, VA 22092; (703) 648-4120; fax 703-648-4227.

## ISSUE:

### Antarctica—Mineral Resources vs. Environmental Protection

Should prospecting, exploration, and development of Antarctic mineral resources be permitted, or should Antarctica be recognized as an international park with a permanent prohibition on all mineral-related activities?

#### PERSPECTIVE 1:

##### Antarctica—An Introduction

Eileen McLellan, University of Maryland, College Park

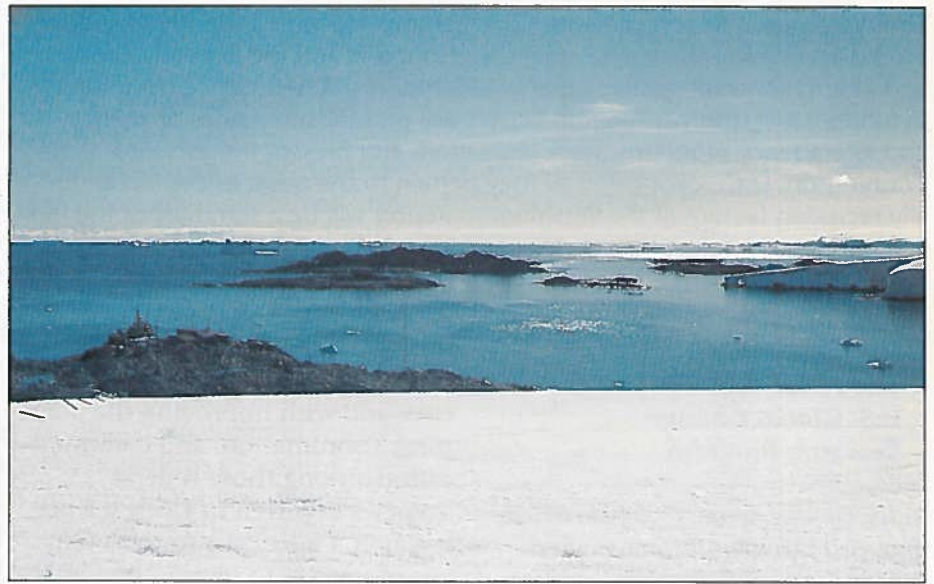
Traditionally, geologists have been concerned with helping society by locating the energy and mineral resources needed for economic growth. In the last two decades, however, the general public has become aware of both the finite nature of Earth resources and the environmental consequences of exploiting them. This gives rise to a conflict that can be seen, simply, as one of resource use vs. environmental protection. At this level, the choice is between two value systems, one dominated by economic concerns and the other dominated by ecological concerns. The issue of Antarctic mineral resources very clearly illustrates the interactions between geoscience, resource use, environmental protection, and politics. Since the International Geophysical Year in 1957–1958, Antarctica has been a "continent for science" with the emphasis on pure research. As a consequence of this research, the paleogeographic connections between Antarctica and the other continents of Gondwanaland have become clear, and the potential for mineral wealth in Antarctica can be assessed. These preliminary assessments of mineral potential vary considerably. Under current economic conditions, it is unlikely that any serious effort to extract oil, gas, or hard-rock minerals will be made for at least the next several decades. However, the prospect of future mineral extraction raises environmental concerns, and thus has led to considerable political controversy.

The politics of Antarctica are complicated by the fact that ownership is disputed. Claims have been based on originally expeditionary activities and continued scientific presence; such claims overlap in the area claimed by Britain, Chile, and Argentina. The United States and the USSR, although very active in Antarctic exploration and science, neither recognize existing claims nor make claims themselves, although they reserve the right to do so. Such dis-

puted ownership has the potential for serious conflict; in an effort to prevent this, the Antarctic Treaty System (ATS) has developed. This system has grown starting with the Antarctic Treaty of 1961 which was agreed upon by the countries then active in Antarctica. The treaty is "designed to preserve the continent as an international laboratory for scientific research and ensure that it be used only for peaceful purposes." It has since been modified to incorporate new acceding countries and includes additional recommendations and conventions, including agreements on the designation of sites of specific scientific interest, the conservation of living marine resources, and similar environmental issues.

The potential for discovery of mineral deposits (here taken to include oil and gas as well as hard-rock minerals) in Antarctica, coupled with anticipated world shortages in these resources in the next century, prompted the ATS members to begin development of a system to regulate mining. In the interim, voluntary restraint on minerals development was made conditional on progress toward a regulatory convention. Following many years of discussion and compromise, the ATS in 1988 produced an agreement, known as the Convention on the Regulation of Antarctic Mineral Resource Activities (CRAMRA), designed to provide a basis for the limited development of Antarctica's mineral potential. The United States was represented in these deliberations by the State Department, which actively supported the adoption of CRAMRA.

The language of CRAMRA is deliberately vague as a matter of political necessity, and this vagueness has led to concern in both the mining industry and environmental community. CRAMRA sets up a very complex process for prospecting, exploration, and development, each stage being under the jurisdiction of several committees, whose membership is politically mandated. The mining industry generally views this process as cumbersome, an unnecessary duplication of effort, and a deterrent to development in what are already economically unfavorable conditions. The environmental lobby, how-



View looking west toward Palmer Station, Anvers Island, Antarctica, the principal U.S. research station in West Antarctica. Ship at dock is the 2000-ton *Polar Duke*, of the U.S. Antarctic Research program. Picture taken on January 19, 1989, approximately one week before the 10,000 ton Argentine research vessel *Bahia Paraiso* attempted to take a short-cut through the rock-strewn passage to the right, went aground, and sank in broad daylight on a day not unlike this one, resulting in a major oil spill. Photo by E. M. Moores.

ever, regards CRAMRA as a mandate for development. Environmentalists are concerned that the environmental provisions of CRAMRA are inadequate, as shown by the use of such phrases as "significant adverse effects."

In addition to their specific concerns that CRAMRA as it stands will not provide adequate protection, environmentalists are more generally concerned about accidental ecological damage resulting from any mining. They therefore oppose any mineral extraction activity in Antarctica. Instead, they propose that Antarctica be declared a world park, effectively appending "wilderness status" to the existing Antarctic Treaty. Under this proposal, Antarctica would be open only for tourism, scientific research, and limited commercial fishing. This proposal has caused considerable concern among geoscientists who fear that under the provisions of a world park they would not have access to the continent and that they would be unable to conduct normal scientific activities.

In the closing days of the 101st Congress, the World Park idea received support from the passage of the Gore/Owens Resolution (S.J. Res. 206/H.J. Res. 418) and the Kerry/Conte Bill (S.2575/H.R. 3977). The former calls for environmental protection of Antarctica; the latter would make it unlawful for any U.S. national to engage in minerals activities in Antarctica. Thus, the U.S. Congress has adopted a position that negates CRAMRA. CRAMRA has also failed to win complete acceptance at the international level. Among the ATS parties, France, Australia, and New Zealand have stated that they will not ratify CRAMRA, citing environmental concerns. This opposition effectively means that CRAMRA will not come into effect. Partially in response to these problems, the ATS parties convened a special meeting in Chile in November 1990 to discuss comprehensive

measures for the protection of the Antarctic environment.

#### PERSPECTIVE 2:

##### Antarctic Geology and Mineral Potential

John Spletstoeser, Rockland, Maine

Antarctica consists of two geologically different provinces. East Antarctica is a typical Precambrian shield area of older igneous and metamorphic rocks overlain by younger, flat-lying stratified or sedimentary rocks. Granulite facies rocks in an Archean cratonic block in Enderby Land have been dated at about 3.9 Ga. West Antarctica is composed of generally younger rocks that are widely deformed and metamorphosed. The Transantarctic Mountains, a 3000-km-long linear chain of outcrops bordering the Pacific Ocean side of East Antarctica, is composed of a basement of metamorphosed sedimentary and igneous rocks of Middle Proterozoic to middle Paleozoic age that are unconformably overlain by rocks of the Beacon Supergroup and Ferrar Group. Beacon rocks contain evidence of Gondwana strata similar to that of the other southern continents, including tillites, coal beds with associated Permian Glossopteris forests, and land vertebrates of Early Triassic age. A fossil marsupial has been found in late Eocene rocks on Seymour Island near the northern end of the Antarctic Peninsula.

Mineral deposits in Antarctica are likely because all other continents have them, but in Antarctica no deposits of commercial value are known. This might be because of the ice that covers all but about 2% of the bedrock, or perhaps because no organized prospecting has been done. Coal is very widespread in the Transantarctic Mountains. Most of the coal has a high ash and low sulfur content and ranges in rank from medium volatile bituminous to anthracite. Hypothetical estimates of Permian

coal in the Transantarctic Mountains are 150 billion metric tons. Coal of equivalent age and similar lithology to those in the Transantarctic Mountains is also found in the Prince Charles Mountains on the Indian Ocean side of the continent. In the same general area, a banded iron-formation at Mount Ruker has a total Fe content average of 33.5%.

There are no known petroleum resources in Antarctica, although unexplored basins exist on the continent and offshore. Oil and gas fields, if they exist, would probably have to be of the supergiant variety (5 billion barrels) in order to be considered for exploitation, because of the major problems related to the deeper water over Antarctica's continental shelves, the presence of sea ice and icebergs, short working season, and hostile climate. Hydrocarbon production in coastal areas of continents once joined with Antarctica in Gondwana time is in Cretaceous and Tertiary reservoirs, implying that basins and hydrocarbons formed after the fragmentation of the continents. Opposing coasts of Antarctica might thus have similar reservoirs. Hydrocarbon production on the continent itself is not feasible because of the vast ice sheet which covers about 98% of the land mass.

Metallic sulfides and gold are known in small amounts in Tertiary Andean volcanic group rocks in the Antarctic Peninsula, but not in economic quantities. The concept of towing Antarctic icebergs to desert areas for freshwater supply has been proposed for many years, but no berg has yet been towed to determine whether it might be feasible. With favorable conditions of iceberg size and type, currents, and other factors, a towed iceberg might feasibly provide an economic source of fresh water for a desert area in the Southern Hemisphere.

Perhaps the best prospect for economic deposits of any kind exists in the Dufek intrusion of the northern Pensacola Mountains, where a layered mafic igneous complex approaches South Africa's Bushveld Complex in size. It is mostly covered by ice, but the lower parts of the intrusion are expected to contain platinum-group and other potentially economic elements. Until an exploration program is conducted to confirm this, the Dufek intrusion remains only a potential prospect. Technology is available to exploit this and perhaps other prospects in Antarctica, depending on the commodity and location. The vulnerability of Antarctica to activities or accidents that might affect the environment was tested in January 1989 when the Argentine supply ship *Bahia Paraiso* grounded near Palmer Station in the Antarctic Peninsula, releasing thousands of gallons of diesel fuel and other

petroleum products into the surrounding sea.

No provisions were made in the 1961 Antarctic Treaty for prospecting or exploitation of mineral resources because at that time very little was known about economic potential. Whether Antarctica contains economic minerals is unknown, but agreements are needed to allow or restrict commercial development in the event that discoveries might be made.

### **PERSPECTIVE 3: The Mining Industry in Antarctica**

*Keith Knoblock, American Mining Congress, Washington, D.C.*

International debate over how to preserve the unique environment of Antarctica focuses on the question whether the entire continent should be declared off-limits to mineral resources development forever by creating a world park or whether it would be better protected if mining were subjected to rigorous controls. I discuss this issue from the viewpoint of a hard-rock miner. Almost nothing is known about the extent of mineral resources in Antarctica, and no mineral deposits of commercial value have been identified. The opportunities for mineral discoveries are far greater elsewhere in the world and are likely to remain so for the foreseeable future. At this time I know of no American mining company that has expressed any interest whatsoever in Antarctic mineral exploration and development.

Antarctica poses many obstacles to hard-rock mineral exploration and development. It is the coldest, windiest, highest, and most remote and inaccessible continent. Of the total land area, some 98% is covered by a very thick ice cap, which means geologic exploration would, for the most part, be confined to just 2% of the land area. Use of conventional prospecting methods would be very limited. Logistical problems of transportation and supply would be huge and virtually insurmountable. In Antarctica, extreme temperatures and great distances would impose substantial costs for material, transport, and energy. Production costs for a mining operation would be several times those in a traditional mining area such as North America. Only very large deposits or high-grade ores of high-value minerals could (perhaps) be developed into commercial operations. This pretty much limits the possibilities to precious metals and perhaps some of the so-called critical and strategic minerals. Any minerals likely to be found in Antarctica are now abundant elsewhere and will continue to be abundant in the foreseeable future in more accessible areas of the world.

As if the physical problems associated with exploration and development weren't enough,

CRAMRA is a significant obstacle to mineral exploration and development in Antarctica. It represents the most rigorous approach to environmental protection of any area in the world. In the broad sense, the framework established by CRAMRA is overly complicated and excessively unwieldy. There is so much uncertainty built into this regulatory scheme that I cannot visualize a mining company having any interest whatsoever in exploring Antarctica. What's more, the politics of Antarctica boggle the mind. The environmental organizations would have you believe that an environmental nightmare is not just a theoretical possibility but is right around the corner. They say that if CRAMRA takes effect, the bulldozers are poised right outside the gates ready to tear the continent apart. Australia and France are supporting a total ban on Antarctic development and would have the continent set aside as a world park, to be managed by the United Nations. In the U.S. Congress there is a host of bills, many of which place an outright ban on mineral activities in Antarctica. The members of Congress supporting this legislation say that coming shortages of minerals will encourage exploration for and exploitation of minerals in Antarctica. They feel that CRAMRA does not go far enough.

CRAMRA is a landmark document of international cooperation. It is not a prodevelopment instrument. The sheer complexity of its framework, the necessity for consensus of several states to permit minerals exploration to even be considered, provision for collective review before, during, and after activities are approved—all against a backdrop of stringent decision-making criteria—make the prospects of pursuing Antarctic development daunting in the extreme.

Proposals that would make Antarctica an international wilderness or world park are extremely short-sighted and could lead to the demise of the entire ATS. They are short-sighted because they assume that the world should remain ignorant of the mineral potential of Antarctica. Declaring 10% of Earth's land surface, an area roughly the size of the United States, as a wilderness reserve and off-limits to mineral exploration and development would be ill-advised. Development and environmental protection need not be in conflict, as many examples in the United States show. We in the mining industry support environmentally responsible mineral development and oppose environmentally irresponsible conduct. CRAMRA encourages the former and certainly discourages the latter. It is definitely preferable to the other alternatives.

CRAMRA has a significant advantage in that it minimizes the potential of minerals to be a source

of international conflict. In the absence of a convention, conflict would be direct and immediate. Even with CRAMRA, major uncertainties over jurisdictional matters will persist so long as Antarctica remains a no-man's land in terms of sovereignty.

The entire discussion is something like the religious issues discussed in the Middle Ages—entirely hypothetical and theoretical.

### **PERSPECTIVE 4: Antarctica as a Wilderness Park?— The Environmentalists' View** *Will Martin, Wilderness Society, Washington, D.C.*

Today, in practice although not in legal terms, Antarctica is a wilderness reserve where only science, tourism, and fishing are conducted. The Wilderness Society wants to write that status into the Antarctic Treaty—permanently. We want to make Antarctica an international park, where priority will be placed on ecosystem protection and scientific research. We believe we are supported by public opinion in the United States and throughout the world.

In the 1970s, some nations started thinking about the long-term prospects of exploiting Antarctica's minerals potential. But the Antarctic Treaty did not authorize mining, and this omission created an ambiguity that clouded the legal title to any minerals that could be extracted. To deal with the issue of mining, the Antarctic Treaty nations completed in 1988 the negotiation of a minerals convention (CRAMRA). CRAMRA is opposed by many groups including ours, and it has not been ratified.

Regardless of the intentions of the negotiators, there was one indisputable fact about CRAMRA: it gave developers the legal structure and foundation for the legal title they needed in order to risk substantial sums to explore and develop the minerals potential of Antarctica. In this sense, CRAMRA became a road map to development; in effect, it invited mining activity.

The most compelling argument given in support of CRAMRA by its defenders is that if nothing is in place to strictly regulate minerals activity, and if, say, a supergiant oil field is discovered, there would be the possibility of chaos and strife among the ATS nations over how to deal with the pressures to develop this field. Without CRAMRA, there is a legal "void," they say, and it is better to have a legal mechanism in place which can resolve those issues according to a previously agreed upon process.

**Forum continued on p. 8**

We point out that this argument has no analogy or precedent in ATS affairs. For example, the treaty contains a ban on the introduction of nuclear weapons or facilities into Antarctica, and there is no "backup" mechanism in place to regulate the situation if this ban is ever lifted. The same is true for other international bans, like the Basel Convention, which bans hazardous waste dumping in Antarctica. The call for a backup minerals convention is the bleating of a wolf in sheep's clothing. Our solution is simple: ban mining and provide that a unilateral breaking of that ban is a violation of international law.

A good test of our position is to check the pulse of the world public. Invariably, world reaction has regarded CRAMRA as dangerous to the environmental health of Antarctica:

- Only one environmental group in the world endorses CRAMRA.
- Australia, France, and New Zealand have spoken out against CRAMRA and have said they would not ratify it. They, like the environmental community, want the continent formally set aside as a nature reserve and land of science. The veto of CRAMRA by any one of these three nations kills it.
- An international forum, sponsored by the U.S. Senate and consisting of members of Congress and parliamentarians from 35 nations, resolved unanimously in May 1990 to favor world park status for the continent.
- Most important, the U.S. Congress very recently passed two pieces of legislation on the subject. The Gore/Owens resolution calls for Antarctica to be protected as a global ecological commons. The Kerry/Conte bill makes it unlawful for any U.S. citizen to engage in commercial minerals activity there. Both the Gore/Owens resolution and the Kerry/Conte bill call upon the State Department to negotiate an Antarctic Treaty supplement that would provide comprehensive environmental protection for the continent and would ban commercial minerals activity indefinitely. The Kerry/Conte bill also asks that the treaty supplement grant Antarctica protective status as a land of science dedicated to wilderness protection and scientific research.

In order for companies to justify the massive costs of mining in Antarctica, supergiant reserves must be discovered there. With the exploitation of supergiant reserves, there would be catastrophic damage to the Antarctic environment from facilities, towns, roads, airstrips, waste disposal facilities, pipelines, and spills. Not even the strictest regulations would prevent this damage. This is especially true of offshore oil drilling, which would be vulnerable to the harsh

environment of Antarctica. Mining and drilling supergiant reserves would be inconsistent with the traditional uses for Antarctica—science, tourism, preservation of wilderness, and fishing. The unique scenic, aesthetic, and wilderness values of Antarctica would be lost. Important scientific projects in Antarctica, including those exploring the hole in the ozone layer and investigating global climate change, would be compromised.

We contend that the mere presence of a regulatory mechanism like CRAMRA for handling minerals development will serve to enable an easy transition to minerals activity. Modern history has shown that environmental regulations have never prevented environmental damage; they have only mitigated it. A policy of mitigation for Antarctica is not enough and will not work. The only way to protect a fragile and vulnerable environment like Antarctica is to ban the dangerous activity altogether, just as other environmentally dangerous activities, like weapons testing or hazardous waste disposal, have been banned from the continent. The Wilderness Society and most other environmental groups believe that minerals activities should be banned from Antarctica permanently.

**PERSPECTIVE 5:**  
**CRAMRA: Its Impact on Science**  
*David Elliott, Byrd Polar Research Center, Ohio State University*

CRAMRA is a framework within which minerals prospecting, exploration, and development might occur, and it is neutral, neither promoting nor preventing such activities; as such, CRAMRA itself has no impact on science. The impacts on science stem from the consequences of establishing that framework. Assuming that CRAMRA will be presented to the U.S. Congress, the development of implementing legislation by Congress to accompany ratification of CRAMRA by the Senate may give rise to several issues. The most important derives from the possible roll of the federal government in the acquisition of baseline data in both the physical and biological sciences in order to meet perceived obligations under the convention. If the federal government has major obligations, it is a matter of great concern to the scientific community that the funding and logistic support for basic research, currently available through the Division of Polar Programs (DPP) at the National Science Foundation (NSF), not be diverted to support monitoring programs and similar activities.

A second major concern is the type of management structure that might be authorized or imposed by the implementing legislation. Possible models that have been proposed include: a new agency to meet all Antarctic needs, transferring the DPP to this agency; an existing agency being given the lead role for all Antarctic matters,

but leaving the DPP at NSF; and an existing agency being authorized to carry the new responsibilities under CRAMRA, as was the case when the National Oceanic and Atmospheric Administration became the designated agency for meeting the data and information obligations of the Convention on the Conservation of Antarctic Marine Living Resources. The scientific community is concerned that basic research remains independent of mission-oriented activities.

A third concern, unrelated to the two just mentioned, stems from the restrictions imposed by CRAMRA on drilling during prospecting (which is more loosely regulated than exploration and development). It is important that scientific drilling not be unduly restricted for fear that it might be prospecting under the guise of science. It should be pointed out that the ATS nations have recommended guidelines for scientific drilling in the treaty area and these guidelines include the same type of safety review as that carried out by the Ocean Drilling Program.

The November 1990 meeting in Chile on Comprehensive Measures for the Protection of the Antarctic Environment was concerned with CRAMRA, even if only in the corridors rather than in open meetings. Protection of the environment may lead to unexpected impediments to the conduct of basic research. Earth science research can be particularly susceptible to environmental concerns because of the perception that it could lead to discoveries and consequent pressures to exploit. However, earth science research in Antarctica can make substantial contributions to understanding global physical systems, including climate change, and such research is likely to include proposals for drilling programs. To restrict such research would be counterproductive. The unpredictability that is inherent in all research must not be allowed to jeopardize legitimate scientific endeavor.

Another concern is that even with a moratorium or ban on resource-related activities, prospecting would be conducted under the guise of basic research and hence make earth science

research suspect. Bringing data into the public domain in a timely manner, say two years, is the key to defusing those concerns and separating scientific activities from those with commercial intent. Apart from the general issue of freedom of scientific research in Antarctica, a continent that in the view of many is set aside for science, the increasing concerns about the environment have led to proposals that might have a heavy impact.

The outcome of the Chile meeting was in one sense a moving target. At least three constituencies—resources, scientific research, environmental concerns—are involved in some manner, and all of them are linked. Earth scientists in general encompass the complete spectrum, from the resource group to the environmental group, but the Antarctic earth scientists, as a whole, lie closer to the environmental group. Having spent time conducting research in Antarctica, they have a much greater awareness of the continent than most participants in the debate about resources, and most have well-informed concerns about the environment. Nevertheless, the philosophical underpinnings of the scientific and environmental groups are not identical, though the two have much in common. The scientific community must be concerned with whether decisions stemming from "comprehensive measures" are driven by the philosophy of scientific inquiry. For instance, if an overarching international review committee is established, what will the philosophical base be? What will its membership be? What powers will it have? Will it review national programs on principle, or will it review individual scientific projects, and on what basis will the reviews be done? What sort of delays would such a review impose on the process of grant application through to fieldwork? (It is already 16–20 months from the proposal submission deadline to the start of fieldwork.) Answers to these and other questions will determine whether Antarctica does become, as intended by the Antarctic Treaty system, a "land of science." ■

GSA members' reactions to Forum topics are encouraged. Members are invited to respond to positions presented in Forum and to submit alternative views. Letters from the membership will be published in the Forum Feedback section beginning in February. Responses up to 500 words (double-spaced) should be sent to the Forum editor. Upcoming Forum topics will be presented to *GSA Today* readers with sufficient lead time for all who wish to participate. February's Forum topic is Future Energy Needs and the Utilization of Fossil Fuel. The March Forum will ask the question: Should the Arctic National Wildlife Refuge (ANWR) Be Open to Petroleum Activities?

Future Forum topics may include:

- What should GSA do to enhance the role of minorities and women in the geosciences?
- Are the geological sciences properly represented in the U.S. Global Change Research Program?
- Should all professional geologists be licensed?
- Are there alternatives to Yucca Mountain?
- Should GSA assume a more visible advocacy role?
- What is the role of GSA in precollege and informal science education?



## Call for Nominations

### Officers and Councilors

The GSA Committee on Nominations requests your help in compiling a list of GSA members qualified for service as officers and councilors of the Society. The committee requests that each nomination be accompanied by basic data and a description of the qualifications of the individual for the position recommended (vice-president, treasurer, councilor).

Nominations for 1992 officers and councilors must be received at GSA headquarters no later than **FEBRUARY 15, 1991**. Please send nominations and backup material to the Administrative Department, Geological Society of America, P.O. Box 9140, Boulder, CO 80301.

### Penrose and Day Medals Honorary Fellowship

Nominations for GSA's Penrose and Day Medals, and for Honorary Fellowship in the Society are due at headquarters by **FEBRUARY 1, 1991**.

For procedures and additional information, please refer to the October 1990 issue of *GSA News & Information*, or call headquarters at (303) 447-2020.

Send your nominations and required backup and supporting materials to the Administrative Department, Geological Society of America, P.O. Box 9140, Boulder, CO 80301.

### Young Scientist Award (Donath Medal)

The Young Scientist Award was established in 1988 to be awarded to a young scientist (35 or younger during the year in which the award is to be presented) for outstanding achievement in contributing to geologic knowledge through original research that marks a major advance in the earth sciences. The award, consisting of a gold medal called the Donath Medal and a cash prize of \$10,000, was endowed by Dr. and Mrs. Fred A. Donath.

For the year 1991, only those candidates born on or after January 1, 1956, are eligible for consideration. In choosing candidates for the Young Scientist Award, scientific achievement and age will be the sole criteria. Nominations for the 1991 award must include

- biographical information,
- a summary of the candidate's scientific contributions to geology (200 words or less),
- a selected bibliography (no more than 10 titles),
- supporting letters from five scientists.

Nominations for the 1991 Young Scientist Award must be received at GSA headquarters by **FEBRUARY 1, 1991**. For procedures and additional information, please refer to the October 1990 issue of *GSA News & Information*, or call headquarters at (303) 447-2020.

Recipients to date: 1989 . . . . . *Mark Cloos*  
1990 . . . . . *Leigh H. Royden*

### Distinguished Service Award

The GSA Distinguished Service Award was established by Council in 1988 to recognize individuals for their exceptional service to the Society. GSA Members, Fellows, Student Associates, or, in exceptional circumstances, GSA employees may be nominated for consideration. Any GSA member or employee may make a nomination for the award. Awardees will be selected by the Executive Committee, and all selections must be ratified by the Council. Awards may be made annually, or less frequently, at the discretion of Council. This award will be presented during the Annual Meeting of the Society. Nominations and any supporting information may be addressed to Executive Director, Geological Society of America, P.O. Box 9140, Boulder, CO 80301.

Deadline for nominations for 1991 is **MARCH 1, 1991**.

Recipients to date: 1988 . . . . . *Campbell Craddock*  
*Robert D. Hatcher, Jr.*  
*Eldridge M. Moores*  
*William A. Thomas*  
1990 . . . . . *William B. Heroy, Jr.*

## Announcing 1991 Penrose Conference

A Penrose Conference, "Development and Evolution of Foreland Basins," will be held October 6-11, 1991, in the southern Pyrenean foreland basin at Can Boix, Oliana, Spain. The conveners of this conference are: Douglas Burbank, Department of Geological Sciences, University of Southern California, University Park, Los Angeles, CA 90089, U.S.A.; James Meyers, Department of Geology, Winona State University, Winona, MN 55987, U.S.A.; Cai Puigdefabregas, Servei Geologic de Catalunya, Carrer de la Diputacio, 92, 5e. 08105 Barcelona, Spain; Lee Suttner, Department of Geological Sciences, Indiana University, Bloomington, IN 47405, U.S.A.

Since the 1985 International Association of Sedimentologists conference on foreland basins in Fribourg, research by tectono-stratigraphers, sedimentologists, structural geologists, and geophysicists has stimulated a lively debate on the development and evolution of foreland basins. Documentation of deep lithospheric structure is beginning to provide important data regarding the response of the lithosphere to different states of stress. Extra-basinal tectonic controls, including global reorganization of plate patterns, large-scale changes in stress fields, variations in subduction polarity, terrane accretion, and the history of thrust faulting adjacent to the basin, are being recognized as important controls on crustal flexure and the evolution of basin-fill sequences. Intrabasinal tectonic controls, including reactivation of ancestral structural elements and differential crustal subsidence, have also been documented as important factors in controlling the structural, geomorphic, and stratigraphic evolution of foreland basins. Principles of sequence stratigraphy have become powerful tools for defining a framework of event stratigraphy and for comparing the effects of tectonism and eustasy in foreland-basin fill.

Recent research has led to the development of models designed to relate tectonic loading to crustal subsidence and to explain the sedimentary response in various parts of foreland basins to deformation and denudation in adjacent orogenic belts. A major goal of the conference is to synthesize geologic data from diverse foreland basins and to assess the predictions of different models of foreland-basin subsidence and evolution of basin fill. Especially important will be a consideration of new approaches to the study of foreland basins, criteria used to delineate basin history, and ways in which we can calculate or quantify rates of processes that influence basin evolution.

The conference will begin with a Sunday evening introduction to the problems and key questions to be discussed during the following

four-and-one-half days. The first half of the conference will deal with thrust-belt, lithospheric, and plate-tectonic controls upon basin formation and subsidence history. The second half of the conference will deal with evolution of basin fill, emphasizing large-scale controls such as eustatic, climatic, and plate-tectonic effects; regional controls such as basin-margin and intrabasinal tectonism; and geomorphic controls in source areas and within the basin. Discussion of topics will take place in two-hour sessions, each of which will be introduced by two talks designed to provoke thought and controversy. Working groups will be formed as necessary to deal with significant questions. Posters contributed by participants will be on display throughout the conference and will also form the basis for discussion.

Two field trips are integral to the conference. The first trip will be a 10-km hike through Eocene thrust sheets and syntectonic conglomerates, which tower above the conference site. Here we will examine the sequence, timing, and rates of thrusting based upon crosscutting stratigraphic and structural relations between four proximal conglomeratic units. The second trip, to the nearby Pedraforca region, will include structural evolution of a major thrust front, development of progressive unconformities, and syntectonic controls on deposition of coarse-grained siliciclastic sediments. Participants traveling to the conference site from the airport in Barcelona on Sunday morning, October 6, will have the opportunity to make several stops to see rocks of the Montserrat fan delta. An optional postconference trip to the Boixols thrust, the Roda, St. Esteban, and Campaune fan deltas, and the Sierras Marginales thrust system will provide participants with an additional opportunity to examine and debate evidence related to the conference theme on the outcrop. Extra charges for this trip will be approximately US \$125.

Participation in the conference will be limited to 60 persons. Prospective participants should apply by submitting a 250-word abstract describing their contributions by *April 1, 1990*, to Jim Meyers, Department of Geology, Winona State University, Winona, MN 55987, U.S.A. The registration fee for the conference will be approximately US \$550 and includes transportation between the Barcelona airport and Oliana, food, lodging (double occupancy), and all costs associated with the two conference field trips. Applicants will be informed regarding procedures for payment of deposits for formal registration. The official language of the conference is English. ■

## SAGE REMARKS

Science Awareness through Geoscience Education

Allison R. (Pete) Palmer

### SAGE Activities

Along with the new name and format for news about GSA activities, the powers that be have decided on a new heading for this column, SAGE Remarks. The SAGE Program is now a going concern. Our thanks to many of you who were at Dallas and visited the SAGE booth. You not only helped to publicize our efforts with SAGE buttons but you contributed over \$850 to the SAGE Program Fund in the GSA Foundation.

We also interviewed candidates for the permanent Director of the SAGE Program and will be able to announce who that person will be in the next column. Meanwhile, cards from registrants in the Partners for Excellence project are arriving in each day's mail. We will be building a database in the next month or so and feeding the names of these registrants into the

SAGE network so that information about Partnering, materials for Partners, etc. can efficiently move through the system. Additional brochures about Partners for Excellence can be obtained in any quantity by writing to me at GSA.

Until we get full-time leadership for the SAGE Program, we will be focusing on development of the SAGE network through the GSA Section Education Committees, and building a quality set of materials for Partnering activities.

### Resource Information

The AAAS has recently come out with a publication that may be of value to some of the SAGE audience. This is *Sourcebook for Science, Mathematics & Technology Education, 1990-1991* and includes "all the programs, people, projects, publications, and organizations ... that seek to improve the quality

of teaching and learning in science, mathematics, and technology teaching" known to AAAS. Whether you want to know whom to contact within the NSF directorates; or who is the educational contact person for a myriad of organizations, from federal agencies to museums; or where to get leads about resources for education, the information seems to be in this well-indexed and organized 200-page paperback book. I suspect that it will be a useful companion to the *AGI Directory of Geoscience Departments*. The book is AAAS Publication 90-34S and can be ordered from AAAS Books, P.O. Box 753, Waldorf, MD 20604, for \$12.95 (\$10.35 for AAAS members). ■

## GSA Gets NSF Grant

The Geological Society of America has received a grant from the National Science Foundation to increase the funds available to graduate students for thesis and dissertation research through the Research Grants Program of the Society. The additional funding will enable GSA to increase the dollar level of grants and make it possible to fund several more applicants than could be supported in previous years. A large number of very good proposals aimed at truly worthwhile research projects have gone unfunded each year simply because the dollars requested exceeded the funds available.

The National Science Foundation grant will increase the total amount of money available to \$300,000. In 1990, GSA awarded 244 grants totaling \$190,900. The NSF grant is a continuing one that has been approved on scientific/technical merit for approximately three years. Renewal is contingent on the availability of funds and the scientific progress of the project.

The primary role of the Research Grant Program is to provide partial support of master's and doctoral thesis research for graduate students at universities in the United States, Canada, Mexico, and Central America. Requests for grants are judged, in general, on how the proposed investigations will contribute to the purpose for which the Society was organized, namely, promotion of the science of geology.

Members and nonmembers of the Society are eligible. Grants are awarded only to individuals. GSA strongly encourages women and minorities to participate fully in this grants program.

Applications are evaluated on the basis of the scientific merits of the program, the capability of the investigator, and reasonableness of the budget. Applications for grants to be awarded in April 1991 must be submitted on the 1991 forms and post-marked by *February 15, 1991*. Application forms and additional information may be obtained from June R. Forstrom, Research Grants Administrator, Geological Society of America, P.O. Box 9140, Boulder, CO 80301. ■

## The Geological Society of America

# Congressional Science Fellowship 1991-1992



**T**he Geological Society of America invites applications for the 1991-1992 Congressional Science Fellowship. The Fellow selected will spend a year (September 1991-August 1992) in the office of an individual member of Congress or a congressional committee advising on a wide range of scientific issues as they pertain to public questions. Guided by the American Association for the Advancement of Science, the Fellow selects a congressional staff position in which he or she can work on major legislative issues.

### Criteria

The program is aimed at highly qualified earth scientists in early or mid-career. Candidates should have exceptional competence in some area of the earth sciences, cognizance of a broad range of matters outside the Fellow's particular area, and a strong interest in working on a range of public policy problems.

### Award

The GSA Congressional Science Fellowship carries with it a \$35,000 stipend, and limited health insurance, relocation, and travel allowances. The fellowship is funded by GSA and the U.S. Geological Survey which supports 47% of the program with a \$21,000 grant. (Employees of the USGS are ineligible to apply for this fellowship.)

### 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  
Geological Society of America  
P.O. Box 9140  
Boulder, Colorado 80301



**Deadline for receipt of all application materials is February 15, 1991**

**YOUR ADS COULD  
BE SEEN BY  
20,000 READERS  
1-800-472-1988**

GSA Journal Advertising

## Final Announcement

# NORTH-CENTRAL SECTION, GSA 25th Annual Meeting

Toledo, Ohio  
April 18-19, 1991

The North-Central Section of the Geological Society of America will meet at the University of Toledo SeaGate Centre. The meeting will be hosted by the Department of Geology at the University of Toledo. Several associated societies will be meeting in conjunction with the North-Central Section of the GSA, including the North-Central Section of the Paleontological Society, Great Lakes Section of SEPM, and East-Central Section of the National Association of Geology Teachers.

### TRAVEL ARRANGEMENTS

Toledo is on Interstate 80-90 (the Ohio Turnpike) and Interstate 75. The University of Toledo SeaGate Centre is located approximately 5 miles from the university main campus in downtown Toledo. Convention hotels are located at the intersection of Secor Road and Interstate 475, and adjacent to SeaGate Centre (see map).

Toledo Express Airport is served by Delta and US Air. Air link service connects with O'Hare Airport (United Express, American Eagle) in Chicago, with Detroit Metro Airport (Northwest Mesaba Express), and with Hopkins International Airport (Continental, British Express) in Cleveland. Amtrak provides daily east-west service.

#### From Toledo Express Airport:

Airport Limo Service to Westgate or SeaGate Centre: \$13/person, check at Budget Leasing desk in airport.

Taxi: \$21 to Westgate hotels, \$26 to SeaGate Centre, flat rate up to four persons.

#### From Detroit Metro Airport:

Metro Express: 13 trips daily to Sheraton Westgate and downtown Toledo (about 5 blocks from SeaGate Centre), \$12 each way, \$20 round trip. For additional information call 1-800-543-9457.

#### From Toledo Amtrak Station:

Taxi: \$3-4 to SeaGate Centre, \$11-12 to Westgate hotels.

#### From Westgate hotels to SeaGate Centre:

Free shuttle service will be provided during the meeting.

A drive from the Westgate hotels to SeaGate Centre will take about 10 minutes under non-rush hour conditions. Turn right on Monroe St. from Secor Rd. (one block north of I-475); turn left on Jefferson Ave. at the Toledo Museum of Art; and follow Jefferson to SeaGate Centre. Surface parking lots, located south and west of SeaGate Centre, cost \$1.25 per day whereas parking garages are \$3.50 to \$4.50 per day. (See the downtown map for parking locations.)

### REGISTRATION

Registration is required for all who participate in any event at the

meeting, including technical sessions, symposia, exhibits, planned social events, and field trips.

**Preregistration.** Advance registration is encouraged to aid the local committee in making final plans for the meeting. A preregistration discount is available to those who register using the Registration Form on page 13 by **March 31, 1991**. Advance registration is required for those who plan to attend a field trip. Return the completed Registration Form with check or money order (payable to the University of Toledo in U.S. currency), or pay by credit card. Mail to: Division of Continuing Education Seminars, Driscoll Center, University of Toledo, Toledo, OH 43606-3393.

Registration must be post-marked by March 31, 1991, to qualify for discount. Refunds for canceled registration will be made until March 31, 1991. After that date no refunds will be made for field trips or other events unless the events are canceled or the field trips are oversubscribed.

**On-Site Registration.** Registration will be from 6 to 9 p.m. on Wednesday, April 17, at the welcoming reception in the Sheraton Westgate Hotel. Thereafter, registration will take place at the UT SeaGate Centre from 7 a.m. to 5 p.m. on April 18 and from 7 to 9:30 a.m. on April 19. Preregistrants may pick up their folders and tickets at the registration desk. A limited number of tickets for special events will be available for those who did not preregister.

### WELCOMING RECEPTION

A welcoming reception for all registrants will be held in the Sheraton Westgate Hotel from 7 to 9 p.m. on Wednesday, April 17.

### STUDENT ARRANGEMENTS

**Student Travel.** The North-Central Section will provide GSA student members with travel awards up to \$200 on a first-come, first-served basis. The students must be enrolled in an academic geology department in the North-Central Section, and travel must be fully documented by receipts presented to meeting chairman Lon C. Ruedisili by May 1991, two weeks following the meeting. Applications for the travel awards must

be submitted by **March 30, 1991**. Application forms for student travel awards have been sent to all academic geology departments within the North-Central Section as listed in the AGI Directory. Additional application forms may be obtained from: Lon C. Ruedisili, Department of Geology, University of Toledo, Toledo, OH 43606.

**Student Paper Awards.** The North-Central Section will present up to four \$100 awards and certificates for the best student oral or poster papers. The Student Awards Committee will select the winners. To be eligible for any student award, the paper must be written and presented by students only. The paper may have a single author or multiple student authors. To be considered for a student award, *all papers submitted must be clearly labeled by attaching a note to the abstract form*. Student papers will be marked in the program. Thus, papers to be considered for a student award cannot be submitted after the December 12, 1990, abstract deadline. Also, the SEPM Great Lakes Section will award \$50, a certificate, and an SEPM publication to the best student paper in the fields of stratigraphy, sedimentation, and paleontology.

### TECHNICAL PROGRAM

Technical sessions are scheduled as oral and poster presentations on Thursday and Friday, April 18 and 19. The 25th Annual Meeting of the North-Central Section of the Geological Society of America will be the first regional GSA meeting to present a symposium on consultants' and industries' innovative approaches to solving environmental problems. In response to GSA's SAGE Program (Science Awareness through Geoscience Education), there will be a special session on how state geological surveys and natural history museums can assist geoscience education for K-12, community college, and college and university educators.

### SYMPOSIA

Symposia include invited as well as volunteered papers. Authors are encouraged to contact the individual symposia organizers for information.

1. **The Geology of Radon.** James A. Harrell, Department of Geology, University of Toledo, Toledo, OH 43606, (419) 537-2009; Michael C. Hansen, Geological Survey, Ohio Department of Natural Resources, Columbus, OH 43224, (614) 265-6580.

Indoor radon is perhaps the most dangerous environmental health hazard facing Americans today. This radioactive gas is the only major pollutant that has an entirely natural, geologic origin. Although geologists are not essential in the effort to establish the areal distribution of indoor radon levels, their contributions are essential to understanding the underlying cause of the radon

problem. The geologic controls on radon generation and migration are complex and still not well understood. This symposium will present papers on the geologic aspects of the radon problem.

2. **Quaternary Paleoecology of the Lower Great Lakes.** Barry Miller, Department of Geology, Kent State University, Kent, OH 44242, (216) 672-2505.

Geographically the theme area is interpreted to include Lakes Ontario and Erie and the southern parts of Lakes Michigan and Huron and their drainage basins. Climatic environmental changes inferred from biologic, sedimentologic, and geochemical data for this region during the Quaternary are the subject of this symposium.

3. **Tectonics of the Northern Cincinnati Arch Area.** Stuart L. Dean, Department of Geology, University of Toledo, Toledo, OH 43606, (419) 537-4570; Byron R. Kulander, Department of Geological Sciences, Wright State University, Dayton, OH 45435, (513) 873-3444.

This symposium focuses on the evolution of the northern Cincinnati Arch area and adjacent basins. It will consider aspects of local structural geology, regional tectonics, local and regional geophysics (including earthquake seismology, heat flow studies, etc.), and stratigraphy and sedimentology. Papers pertinent to the origin and tectonic evolution of the region will be presented.

4. **State Geological Surveys and Natural History Museums—A Resource for the Earth Science Teacher** (*East-Central Section, National Association of Geology Teachers and Education Committee, GSA North-Central Section*). Mark J. Camp, Department of Geology, University of Toledo, Toledo, OH 43606, (419) 537-2398; Charles E. Mason, Department of Physical Sciences, Morehead State University, Morehead, KY 40351, (606) 783-2914; Marian Smith, Department of Geology, Western Michigan University, Kalamazoo, MI 49008, (616) 387-5485.

State geological surveys and natural history museums within the North-Central Section vary in their emphasis on geologic education. This forum will focus on the ways these organizations can benefit science educators. Low-cost publications, field trips, workshops, and teaching kits are some of the offerings.

5. **Late Quaternary Time Classification in the Great Lakes Region.** Paul F. Karrow, Department of Earth Sciences, University of Waterloo, Waterloo, Ontario N2L 3G1, Canada, (519) 885-1211 (ext. 3731); Thomas V. Lowell, Department of Geology, University of Cincinnati,

*North-Central continued on p. 12*

Cincinnati, OH 45221, (513) 556-3732.

The time classifications currently used in the Great Lakes area are those of Frye and Willman (1960) and Dreimanis and Karrow (1972). Over the years there have been various criticisms of these schemes as to their compliance with the 1961 Code of Stratigraphic Nomenclature, the one then current. A revised Code appeared in 1983 and much new work suggests it is time to reconsider and revise the time classification in this classic area. The 1969 and 1972 classifications are compatible and complementary in many ways, and a small group of workers have been discussing devising a single scheme for the Great Lakes area. We feel it is time for review and an attempt at a new framework.

- 6. **Consultants' Innovative Applications in Geophysical/Hydrogeological/Engineering Geological Techniques in Environmental Investigations.** Lon C. Ruedisili, Department of Geology, University of Toledo, Toledo, OH 43606, (419) 537-2634; Kevin Woka, Geraghty-Miller Consultants, 50 West Big Beaver Rd., Suite 145, Troy, MI 48084, (313) 524-9030.

This new symposium topic will involve consultants and industrial experts who will present case histories concerning updated or new instruments, procedures, and developments utilized in environmental problem solving. This symposium will be of great interest to students (many of whom will be employed by these consulting companies and industries) and faculty (many of whom are on review panels and technical advisory committees).

- 7. **Silurian Systems of Cratonic North America (Great Lakes Section SEPM).** Bruce H. Wilkinson, Department of Geological Sciences, University of Michigan, Ann Arbor, MI 48109-1063, (313) 763-4391.

This session is intended to serve as a forum wherein studies of all aspects relating to the paleontology, paleoecology, stratigraphy, sedimentology, and/or diagenesis of North American Silurian reef, platform, and evaporite sequences can be related and integrated in order to gain a better understanding of these fascinating marine systems. Papers will be presented on the multifaceted nature of the many investigations that have been completed in recent years.

- 8. **The Biological Underpinning of Global Diversity Trends (North Central-Section, Paleontological Society).** Arnold Miller, Department of Geology, University of Cincinnati, Cincinnati, OH 45221-0013, (513) 475-3732.

Utilizing a variety of analytical techniques, paleobiologists have come to appreciate the underlying complexity of temporal trends in global diversity, including radiation and mass extinction, within and among higher taxa. The presentations in this symposium will highlight several approaches currently being used to explore the significance of global diversity trends, including numerical modeling and statistical evaluation of diversity patterns, analysis of local paleoecological transitions associated with global trends, assessment of potential morphologic and genetic bases for diversity transitions, and consideration of potential taphonomic overprints on apparent diversity pathways.

- 9. **Scientific Drilling and Geophysical Investigation in the Mid-Centimeter.** Jeffrey Daniels, Department of Geological Sciences, Ohio State University, Columbus, OH 43210, (614) 292-4295.

This symposium will discuss deep boreholes, past and proposed, and how information collected by such projects improves our understanding of the history, resources, and geologic hazards of the mid-continent.

- 10. **Utilization of High-Sulfur Coals of the Eastern United States.** William A. Kneller, Department of Geology, University of Toledo, Toledo, OH 43606, (419) 537-2228.

This symposium focuses on new, innovative uses of high-sulfur coal which could offset the effect of the pending Clean Air Act Amendments of 1990 (HR 30-30, Section 501—Acid Deposition Control) on the deterioration of, not the depletion of, this valuable resource of the eastern United States.

**EQUIPMENT AND FACILITIES**

All slides used in oral presentations must be 2" x 2" and fit a standard 35 mm carousel projector. Only one projector, screen, and pointer will be available in each meeting room. Please bring your own loaded carousel trays, identified with your name, session, and speaker number to the appropriate session projectionist 15 minutes before the session begins.

Poster sessions will be housed in an area adjacent to the exhibits and coffee bar, and will be available for viewing for one-half day. Poster booths will consist of three 4' x 4' display panels set on tables; tacks and masking tape will be provided.

A Speaker Ready Room equipped with projectors and screens will be available for review and practice. Carousel trays will not be available.

**CAMERAS, SOUND-EQUIPMENT, AND SMOKING POLICY**

Annual meeting policy prohibits the use of cameras or sound-recording equipment at technical sessions. A no-smoking policy has been adopted by the Program Committee and will be followed in all meeting rooms for technical sessions.

**FIELD TRIPS**

**Registration. Field trip registrants must register for the meeting.** Registration procedures, deadlines, and forms are provided in this announcement. Registration at the meeting for the postmeeting field trips may be possible if trip logistics and space permit. If trips are underenrolled, participants will be notified no later than ten days before the start of the meeting, and all registration fees will be refunded. There will be no refunds if participant fails to show on time for a field trip for other than documented serious illness or extreme family emergency. Sponsoring agencies assume no liability whatsoever for failure of participants to show for trips, for missed connections, or for injury, losses, or damages during or resulting from participation in the field trips. Further information will be sent to field trip participants. Postmeeting field trip coordinator is V. Max Brown, (419) 537-4571.

**Postmeeting (April 20, 1991)**

- 1. **The Kelleys Island Glacial Grooves, Subglacial Erosion Features on Marblehead Peninsula, Carbonate Petrology, and Associated Paleontology.** R. Scott Snow, Department of Geology, Ball State University, Muncie, IN 47301; Thomas V. Lowell, Department of Geology, University of Cincinnati, Cincinnati, OH 45221; Robin Frank Rupp, 911 Carleton Court, Bloomington, IN 47401. Limit: 33. Cost: \$25, including guidebook, lunch, and transportation. This trip will begin in the parking lot of the Sheraton Westgate at I-475 and Secor Road at 8 a.m. Saturday and will return about 6 p.m.

On this trip we will examine the giant glacial groove site on Kelleys Island and subglacial erosion features on nearby Marblehead Peninsula. Field evidence for the relative roles of ice, debris, and meltwater will be studied. Qualitative description of the erosional features will be supplemented by quantitative results from fractal analysis of groove profiles. The sedimentology and paleontology of the Middle Devonian Columbus Limestone, the material eroded to form the grooves, will be examined. The glacial abrasion has provided large, relatively smooth surfaces for the viewing of the fossils in cross section. Finally, we will view bedrock erosion caused by modern shoreline processes.

- 2. **Joint Patterns and Geomorphological Features of Northern Ohio.** Stuart L. Dean, Department of Geology, University of Toledo, Toledo, OH 43606; Byron R. Kulander, Department of Geological Sciences, Wright State University, Dayton, OH 45435; Jane L. Forsyth, Department of Geology, Bowling Green State University, Bowling Green, OH 43403; Ronald M. Tipton, France Stone Co., Sylvania, OH 43560. Limit: 20. Cost: \$12, including guidebook and transportation. This trip will begin in the parking lot of the Sheraton Westgate at I-475 and Secor Road at 8 a.m. Saturday and will return about 5 p.m. Lunch will be at participants' expense at local fast-food restaurants.

On this trip we will focus on bedrock joints in Middle and Upper Devonian carbonate and shale lithologies from Toledo through Bellevue to Castalia, Ohio. Joint patterns and related features will be examined in quarry and stream-bed exposures in the context of joint origin and propagation dynamics. Geomorphological features related to glaciation, Pleistocene lake levels, and differential solution of Devonian carbonates will also be examined along the field trip route.

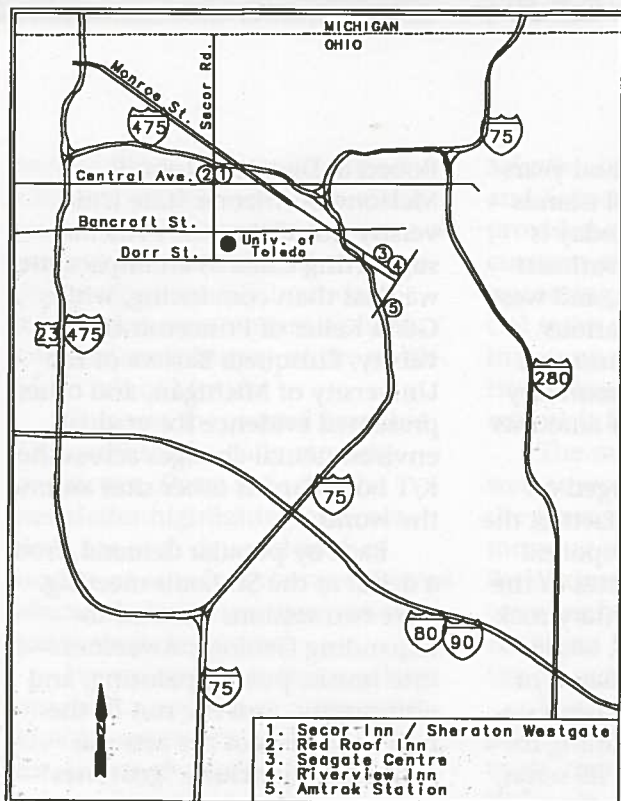
- 3. **Middle Devonian Silica Shale of Northwest Ohio.** Mark J. Camp and Craig B. Hatfield, Department of Geology, University of Toledo, Toledo, OH 43606. Limit: 50. Cost: \$20, including guidebook and transportation. This trip will begin in the parking lot of the Secor Inn at I-475 and Secor Road, at 8 a.m. Saturday and will return about 12:15 p.m.

Middle Devonian marine strata will be examined in the Medusa South Quarry of the France Stone Company at the famous Silica locality of northwestern Ohio. The formations exposed are the Dundee Limestone, Silica Formation, and Ten Mile Creek Dolomite. Lithologies and profuse fossil content of the Silica Formation suggest an open marine depositional setting contiguous with seas in Ontario and New York. Biostratigraphy indicates correlation of the Silica Formation with part of the Hamilton Group of New York, Pennsylvania, and West Virginia, with the Plum Brook Shale of north-central Ohio, with the Bell Shale of Michigan, and with the Hungry Hollow Formation of southwestern Ontario.

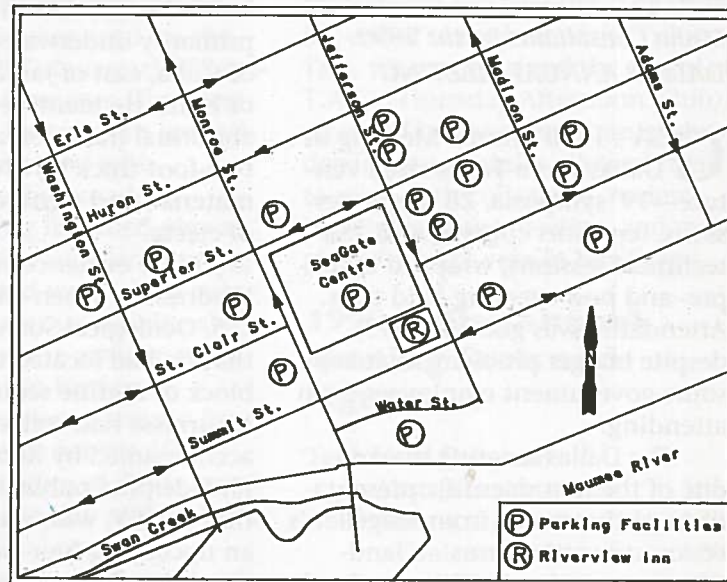
- 4. **Slumps, Slides, Mud Diapirs, and Associated Fracturing in Mississippian Delta Deposits, Berea Sandstone, Cleveland, Ohio.** Neal A. Wells, Alan H. Coogan, and Judy J. Majoras, Department of Geology, Kent State University, Kent, OH 44242.

Limit: 25. Cost: \$8, including guidebook and transportation: This trip will begin outside the toll booth at Exit 8, I-80, at Elyria, Ohio, at 9 a.m. Saturday and will return about 5 p.m. Lunch will be at participants' expense at local fast-food restaurants.

We will first briefly examine a well-exposed mud diapir and deformation related to soft-sediment overthrusting at the type section of the Mississippian Berea Sandstone at Berea Falls. For the remainder of the day, we will examine soft-sediment deformation and large-scale synsedimentary to postdepositional mass movements in very complicated exposures of delta-front facies in Elyria. The trip will stress the history of associated fracturing and the variable plastic to brittle behavior seen in the sediments. This outcrop information will be tied to subsurface details obtained farther to the south.



## MAPS Toledo, Ohio



### EXHIBITS

Space will be available for educational, research, and commercial exhibits. Exhibits will be located on the second floor in the Knowles Room of the UT SeaGate Centre next to the area used for poster sessions and coffee breaks. A single 8' x 10' booth used for the duration of the meeting will cost commercial exhibitors \$100. Geological surveys and museums will pay \$50 if selling publications and \$25 if exhibiting and distributing free information and items. Geology departments will be charged \$25. GSA and other publishers' publications will be available for purchase. A special information booth on employment in the geosciences will offer pamphlets from companies and governmental agencies. For additional information, contact James A. Harrell, Department of Geology, University of Toledo, Toledo, OH 43606, (419) 537-2009.

### SPECIAL EVENTS

**GSA North-Central Section Management Board Breakfast** and business meeting will be held on Thursday, April 18, at 7:00 a.m. in the Dowd Room (Room 310) in the UT SeaGate Centre.

**GSA Campus Representatives Complimentary Breakfast** will be held at 7:00 a.m. on Friday, April 19, in the Dowd Room (Room 310) in the UT SeaGate Centre. Please indicate on the preregistration form if you plan to attend.

**SEPM Luncheon** will be held in the Dowd Room (Room 310) in the UT SeaGate Centre at 12:00 noon on Thursday, April 18. Please indicate on the preregistration form if you plan to attend.

**National Association of Geology Teachers and GSA North-Central Section Education Committee Luncheon** will be held in the

**North-Central** continued on p. 16

## REGISTRATION FORM

GSA North-Central Section, 25th Annual Meeting  
April 18-19, 1991, Toledo, Ohio

### IMPORTANT

1. Full payment must accompany registration.
2. Register one person per form.
3. Your canceled check will be your receipt. See Housing Form.
4. Preregistration deadline for meeting and field trips is March 31, 1991.
5. Registrants are responsible for making their housing arrangements. See Housing Form.

PLEASE PRINT OR TYPE (Copy this form for your records)

Name (Last, First, Middle) \_\_\_\_\_

Nickname for badge \_\_\_\_\_

Spouse/Guest name (if accompanying) \_\_\_\_\_

Professional affiliation/business \_\_\_\_\_

Address \_\_\_\_\_ City \_\_\_\_\_ State \_\_\_\_\_ ZIP \_\_\_\_\_

Day Phone ( ) \_\_\_\_\_

GSA Member  Yes  No GSA Member # \_\_\_\_\_ GSA Student Associate  Yes  No GSA Student Associate # \_\_\_\_\_

Consideration for Student Paper Award  Yes  No

### PREREGISTRATION (postmarked before March 31, 1991)

GSA Member .....	\$40.00
Other Professional .....	\$45.00
GSA Student Associate .....	\$10.00
Other Student .....	\$15.00
Spouse/Guest .....	\$10.00

### REGISTRATION

GSA Member .....	\$45.00
Other Professional .....	\$50.00
GSA Student Associate .....	\$15.00
Other Student .....	\$20.00
Spouse/Guest .....	\$15.00
Teachers (K-12) .....	\$ 5.00

### FIELD TRIPS (meeting registration required)

Postmeeting	
1. Kelleys Island, Ohio: Subglacial/Shoreline Erosion Features .....	\$25.00
2. Joint Patterns and Geomorphological Features of Northern Ohio .....	\$12.00
3. Middle Devonian Silica Shale of Northwest Ohio .....	\$20.00
4. Slumps, Slides, Mud Diapirs in Miss. Delta Deposits, Berea SS., Cleveland, Ohio .....	\$ 8.00

### SPECIAL EVENTS

Annual Banquet (6:30 p.m., April 18) .....	\$15.00
Combined Paleontological Society and SEPM Luncheon (Noon, April 18) .....	\$ 7.75
NAGT/NC-GSA Education Committee Luncheon (Noon, April 19) .....	\$ 7.75
GSA Campus Representatives Breakfast (7 a.m., April 19) Please check if you will attend .....	NC

### SPOUSE/GUEST EVENTS

Toledo Museum of Art/Libbey Glass Factory Outlet Tour (10 a.m.-3:30 p.m., April 18) .....	\$ 3.00
Manufacturers Marketplace Shopping Tour (9:30 a.m.-3:30 p.m., April 19) .....	\$ 5.00

**ABSTRACTS WITH PROGRAMS** (reserved, on-site pick up) .....

**TOTAL FEES** .....

Check enclosed payable to University of Toledo

I wish to pay by  VISA  MasterCard Card No. \_\_\_\_\_ Exp. date \_\_\_\_\_

Card Holder's Signature \_\_\_\_\_

Mail to: Division of Continuing Education Seminars, Driscoll Center, University of Toledo, Toledo, OH 43606-3393; (419) 537-2033

# Big D—Delightful!

by Sandra Rush and  
Diana Somerville

Media Consultants for the 1990  
DALLAS ANNUAL MEETING

**G**SA's 1990 Annual Meeting in Dallas was a Texas-sized venture—19 symposia, 28 theme sessions, ten short courses, and 153 technical sessions, wrapped by 21 pre- and post-meeting field trips. Attendance was good at 4513, despite budget problems that kept some government employees from attending.

The Dallas meeting marked one of the first scientific presentations of the results from Magellan's encounter with Venus—a landscape revealed to be "like the Earth without the water damage," as James W. Head of Brown University noted. He represented the Magellan Radar Investigation Group at a special Tuesday noon session focusing on Venus which followed a morning symposium on the geology of the planet. The geologic features of the surface of Venus stand out with a pristine clarity, which may help increase understanding of processes closer to home. But the Venusian surface also features regions with almost graph-paper-like checkering that may reflect a primal process overlooked or washed away by terrestrial conditions, researchers speculated. As the images of Venus continue coming in, planetary geologists will be revising their understanding of Earth's sister planet.

Marcus E. Milling and Steve Schamel, convenors of the Geology and Public Policy Forum, chose a timely topic, "Future Energy Needs and the Utilization of Fossil Fuel," given the current instabilities in the Middle East, and one of considerable interest in energy-conscious Texas. A Sunday session, also sponsored by the Geology and Public Policy Committee, addressed Antarctic mineral resources policy. Another venture of the Public Policy Committee was the special Wednesday noon session, which gave interested members the chance to meet with Daniel R. Sarewitz, GSA's 1990 Congressional Science Fellow. Sarewitz spent a year working in the office of Congressman George E. Brown, Jr., where he worked on earthquake hazard mitigation, science education, international scientific cooperation, and federal support for research and development.

The continuing debate on what exactly happened at the K/T boundary heated up, garnering a great deal of interest among attendees and the news media, beginning on Monday. Florentin Maurrasse of Florida International University presented evidence for

an impact crater 65 million years ago over a series of small islands located in an area that today is primarily underwater, southeast of Cuba, east of Jamaica, and west of Haiti. He identified various abnormal fractures, an unusual, two-foot-thick layer of boundary material, and significant amounts of ejecta.

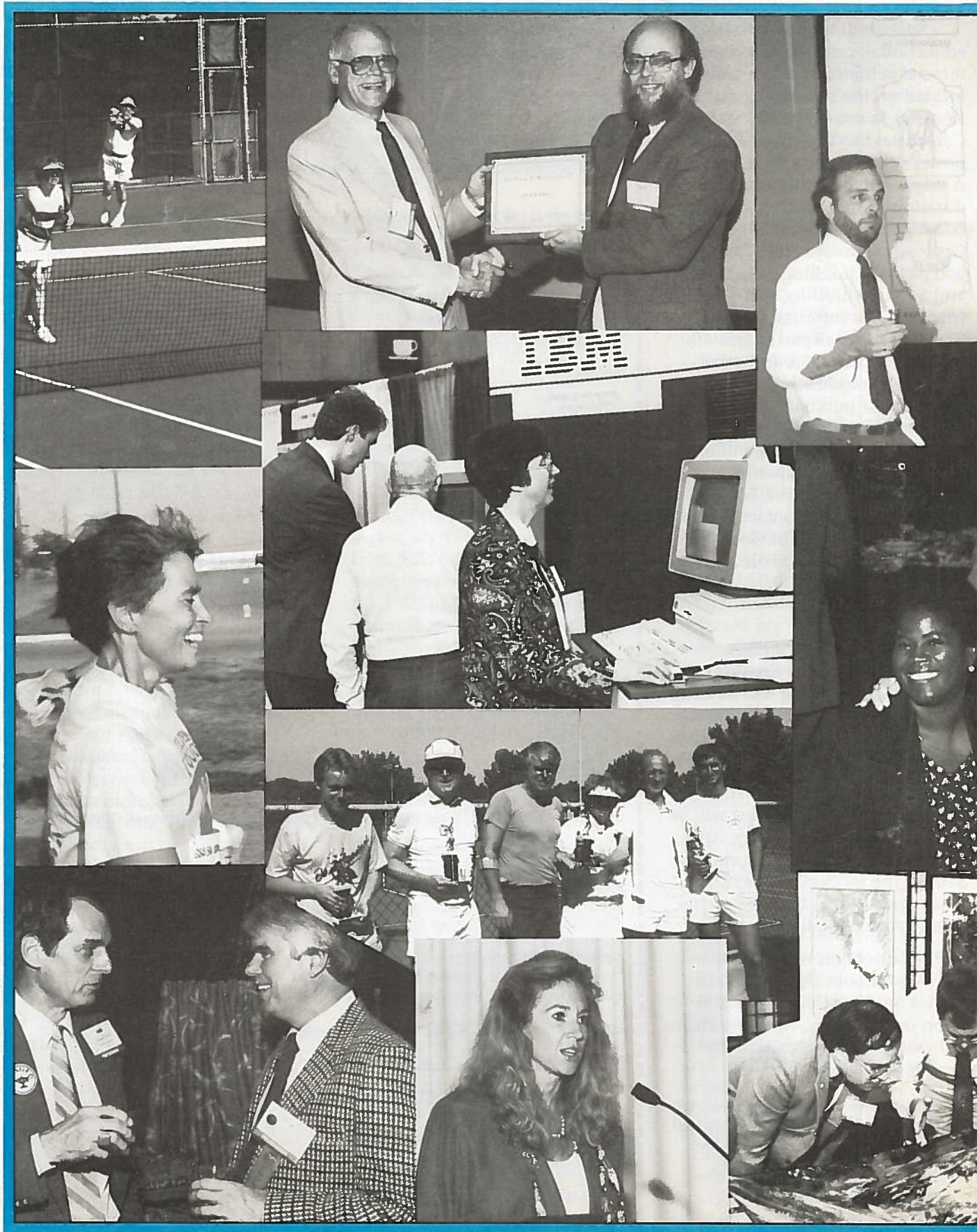
More evidence emerged on Wednesday when Glen Izett of the U.S. Geological Survey reported that he had located tektites in the block of marine sedimentary rock Maurrasse had collected, while accompanied by Robin Bates, of Philadelphia public television station WHYY, who was filming for an upcoming four-part PBS series, "Dinosaur." At the same time,

Robert S. Dietz and John F. McHone of Arizona State University noted that the evidence supporting Cuba as an impact site was less than convincing, while Gerta Keller of Princeton University, Enriqueta Barrera of the University of Michigan, and others presented evidence for gradual environmental changes across the K/T boundary at other sites around the world.

Back by popular demand, from a debut at the St. Louis meeting, were two sessions devoted to Expanding Geologic Awareness—into music, poetry, painting, and philosophy. And the run-of-the-mill definition of the arts was expanded to include "geotunes"—cartoons with a geology theme—in

a humorous talk entitled "What's Up, Roc?"

Geoscience education was a major interest at the meeting, as evidenced by the proliferation of bright green buttons proclaiming "SAGE"—not a personal proclamation but a show of support for Science Awareness through Geoscience Education. This new GSA initiative will include many diverse programs implemented through the GSA Committees on Education, Geology and Public Policy, and Women and Minorities in Geosciences, developed in response to members' interest in science education and society's need to enhance scientific awareness at all levels. SAGE activities include Partners for Excellence, a project to



bring together K-12 teachers and GSA members, the Awards for Excellence for outstanding earth science teachers, the film-video series, and the Congressional Fellowship Project.

A series of lively posters explored ways to use writing assignments in geology teaching, and a session sponsored by NAGT examined ways of enhancing geologic education. Winner of the informal prize for best title in this session was Scott Burns, Portland State University, who exhorted his fellow teachers "Don't Treat Soils Like Dirt."

The 1990 Dallas Local Committee sponsored a unique geologic overview session on Wednesday morning, which was well attended. The session featured

presentations on general subjects allowing attendees to learn about areas outside their primary focus of interest. Topics included stratigraphy, evaporites, K/T boundary, subduction zone metamorphism, and Cenozoic history of the north-west Gulf of Mexico.

This was the second year that GSA published a daily meeting newsletter, *Down to Earth*. The newsletter highlighted presentations for each day and advised readers of schedule changes. Several educators plan to use these newsletters in their classrooms.

Press coverage at this meeting involved a number of magazines—look for articles from the Dallas meeting in the coming months in *Science*, *Scientific American*, *New*

*Scientist*, *Leading Edge*, *Environment*, and *Science News*. This meeting also provided an opportunity for discussions and background for the upcoming (1992) four-part PBS special series on dinosaurs. The meeting scene was dotted with journalists taping interviews with scientists for radio broadcast.

The meeting included play as well as work. On Sunday morning the tennis crowd went off to enjoy morning matches under blue skies. By Wednesday, the athletic types were ready to run for fun at Bachman Lake—once around for the 5K race, twice for the 10K.

The centerpiece of Texas hospitality was Wednesday night's Wild West BBQ at the Longhorn Ballroom, featuring first-rate food,

country western music—and random shootouts on the dance floor throughout the evening. The meeting ended to the beat of the Trilobite Trio, who entertained the crowd at T.A.C. (Thursday Afternoon Club), attended by those registrants whose departure schedules allowed them to relax with colleagues, review highlights of the meeting, and make plans for next year in San Diego.

## 1990 Dallas Annual Meeting Facts and Figures

### Technical Program

Abstracts submitted	1952
Abstracts presented	1822
Oral: volunteered symposia	1200
Poster: volunteered	196
	426

### Registration

Professional	2671
Student	1067
Guest	221
Exhibitor	554
Total	4513

### Short Courses

Participants	9
	333

### Field Trips

Participants	21
	440

### Half Day Field Trips

Participants	2
	84

### Exhibits

Number of booths	239
Number of exhibitors	163

### Employment Service

Applicants	262
Employers	34
Positions available	58
Interviews	588

### Race Winners

**5K**  
1st Female: *Constance Hayden-Scott*

1st Male: *Mike Sandidge*

1st Male 40 & Older: *Terry Engelder*

1st Male 50 & Older: *Art Sylvester*

**10K**  
1st Female: *Carol Bruton*  
1st Male: *Donald Rodbell*

1st Male 40 & Older: *Graham Ryder*

1st Male 50 & Older: *Jim Kennett*

### Tennis Winners

1st Place: *Ian Johnston*  
2nd Place: *Jan Amend*  
3rd Place: (3-way tie)  
*Tanna Anderson*  
*Lucian Platt*  
*James Tull* ■



## REQUEST FOR ROOM RESERVATIONS

Geological Society of America, North-Central Section  
April 18-19, 1991, Toledo, Ohio

Riverview Inn*	Red Roof Inn	Secor Inn**	Sheraton Westgate
141-N. Summit	3300 Executive Pkwy.	3560 Secor Rd.	3536 Secor Rd.
Toledo, OH 43606	Toledo, OH 43606	Toledo, OH 43606	Toledo, OH 43606
(419) 243-8860	(419) 536-0118	(419) 531-1666	(419) 535-7070

### RATES

	Riverview Inn*	Red Roof Inn	Secor Inn**	Sheraton Westgate
Single (1 person, 1 bed)	\$42	\$35	\$41	\$49
Double (2, 3, or 4 persons, 2 double beds)	\$42	\$46	\$41	\$49

Deadline for receiving reservations	April 3, 1991	April 7, 1991	March 17, 1991	March 17, 1991
Parking	In/Out \$6 (garage)	Free (outdoor)	Free (outdoor)	Free (garage)
Cancel on day of arrival before	12:00 noon	6:00 p.m.	6:00 p.m.	6:00 p.m.

\*Less expensive parking is available within one or two blocks (see map).

\*\*Includes complimentary "extensive" continental breakfast.

Note: Rooms are guaranteed until 6:00 p.m. at all four hotels. Rates do not include sales tax (12% at present).

## HOUSING FORM

Geological Society of America, North-Central Section  
April 18-19, 1991, Toledo, Ohio

PLEASE COMPLETE ONLY ONE FORM FOR EACH ROOM REQUESTED.

Name \_\_\_\_\_

Address \_\_\_\_\_

City \_\_\_\_\_ State \_\_\_\_\_ ZIP \_\_\_\_\_

Phone ( ) \_\_\_\_\_ Day ( ) \_\_\_\_\_ Evening \_\_\_\_\_

Arrival Date \_\_\_\_\_ Time \_\_\_\_\_ Departure Date \_\_\_\_\_ Time \_\_\_\_\_

Type of room requested  Single  Double (2 double beds)  Smoking  Non-Smoking

Name(s) of additional person(s) sharing room \_\_\_\_\_

### TO GUARANTEE ACCOMMODATIONS FOR A LATER ARRIVAL

Reservations are held until 6:00 p.m. unless guaranteed by payment of one night's lodging. To guarantee one night's payment fill in the form below.

VISA  MasterCard Credit Card Number \_\_\_\_\_ Expiration Date \_\_\_\_\_

Name (Print) \_\_\_\_\_ Signature \_\_\_\_\_

DETACH AND SEND TO THE HOTEL OF YOUR CHOICE (Mail directly to the Hotel, not GSA)

### North-Central continued from p. 13

Dowd Room (Room 310), in the UT SeaGate Centre at 12:00 noon on Friday, April 19. Please indicate on the preregistration form if you plan to attend.

### ANNUAL BANQUET

The North-Central Section Annual Banquet is scheduled in the UT SeaGate Centre on Thursday, April 18, at 6:30 p.m. A "kegger" will be available to all banquet registrants before the banquet. A short business meeting for the section will be held in conjunction with the banquet. Our banquet speaker is Robert Bates, emeritus professor of geology, Ohio State University, familiar to all of us as the witty, clever, and informative author of "The Geologic Column" in *Geotimes*. Bob's talk is titled "Geoliterary Scenarios." Don't miss

this opportunity to hear this renowned scholar.

### GUEST AND SPOUSE ACTIVITIES

A special tour to the world-famous Toledo Museum of Art to see Impressionist paintings, Tiffany, Lalique, Labino, and Libbey glass collections, ancient Egyptian art, medieval ivories, precious metals, stained glass, and woven tapestries will be conducted from 10:00 a.m. to 2:00 p.m., Thursday, April 18. This will be followed by a stop (2:30-3:30 p.m.) to shop at the Libbey Glass Factory Outlet Store. Tumblers, stemware and glass accessory pieces, storage canisters, gift sets, and souvenirs are available. Please sign up on the registration form.

A special tour to the Manufacturers Marketplace, Monroe, Michigan, to shop at brand-name outlet stores such as Cape Isle

Knitters, Jordache, Van Heusen, Gitano, and Hervé Benard will be conducted from 9:30 a.m. to 3:30 p.m. You will enjoy visiting more than 70 outlet stores, plus a food court, and other restaurants. Please sign up on the registration form.

### HOUSING

Rooms have been reserved for the GSA North-Central Section Meeting at the Red Roof Inn, Secor Inn, and Sheraton Westgate near the intersection of I-475 and Secor Road (about 10 minutes from the convention site), and at Riverview Inn, adjacent to SeaGate Centre (see map). Information for hotel reservations is given above. Be sure to specify you are attending the GSA meeting in order to qualify for the reduced rates. Reservations are on a first-come, first-served basis.

### MEALS

Companion Volumes  
from DNAG

## Surface Water Hydrology

edited by

M. G. Wolman and H. C. Riggs, 1990

Provides reviews of all major facets of hydrology. Topics covered include: influences of the atmosphere and of land and vegetation on stream flow; temporal and spatial variability of stream flow, with separate chapters on floods and on low flow and hydrologic drought; snow and ice, the frozen components of the hydrosphere; the hydrology of lakes and wetlands; hydrogeochemistry of rivers and lakes; the aquatic biota; sediment movement and storage; the riverscape for selected North American rivers; and the influence of Man on hydrologic systems. Accompanying color plates show histograms of river water chemistry, runoff and flow regimes, and the distribution of precipitation minus evaporation for North America.

GNA-O1, 382 p., 3 pocket plates, indexed, ISBN 0-8137-5210-8, hardbound, \$60.00

## Hydrogeology

edited by

W. Back, P. R. Seaber, and  
J. S. Rosenshein, 1988

Discusses hydrogeology from the geological perspective. After describing the major features of 28 hydrogeologic regions of North America, the volume devotes eight chapters to discussion of the comparative hydrogeology of kinds of different bedrock regimes and surficial deposits; seven chapters to geologic processes including karstification, diagenesis, tectonics, ore deposits, and hydrocarbon migration intimately involved with ground water; and two concluding chapters to a look at future scientific and societal problems related to ground water.

GNA-O2, 534 p., 3 pocket plates, indexed, ISBN 0-8137-5206-X, hardbound, \$49.50

GSA PUBLICATION SALES  
P.O. BOX 9140 • BOULDER, CO 80301  
303-447-2020 • 1-800-472-1988  
fax 303-447-1133

In addition to hotel dining, there are numerous restaurants and fast-food outlets located near the hotels. Toledo is well known for many ethnic restaurants. For example, Tony Packo's, a Hungarian restaurant, was made famous by often being mentioned by Corporal Klinger (Toledo native Jamie Farr) in the TV show *M\*A\*S\*H\**.

### ADDITIONAL INFORMATION

For more information on program content, call Lon C. Ruedisili, (419) 537-2634; for registration information, call James A. Harrell, (419) 537-2009 or UT Department of Geology; fax 419-537-4421. ■



# GSA Employment Service

## Looking for a New Employee?

When was the last time you hired a new employee? Did you waste time and effort in your search for a qualified geoscientist? Let the GSA computerized search file make your job easier.

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

You will receive a printout that includes the applicants' names, addresses, phone numbers, areas of specialty, type of employment desired, degrees held, years of professional experience, and current employment status. Résumés for each applicant are sent with each printout at no additional charge.

In 1991, the cost of a printout of one or two specialty codes is \$150. (For example, in a recent job search for an analyst of inorganic materials, the employer requested the specialty codes of geochemistry and petrology.) Each additional specialty is \$50. A printout of the applicant listing in all specialties is available for \$350. (Specialty codes printed in boldface type are considered major headings. If you request a listing of one of the subspecialties, applicants coded under the major category will be included but not those coded under the other related subspecialties.) If you have any questions about your personalized computerized search, GSA Membership Services will assist you.

The GSA Employment Service is available year long. However, GSA also conducts the Employment Interview Service each fall in conjunction with the Society's Annual Meeting (this year in San Diego, California, October 21-24). You may rent interview space in half-day increments from GSA. Our staff will schedule all interviews with applicants for you, the recruiter. In addition, GSA offers a message service, complete listing of applicants, copies of résumés at no additional charge, and a posting of all job openings.

## Looking for a New Job?

Are you looking for a new position in the field of geology? The GSA Employment Service offers an economical way to find one. Potential employers use the service to find the qualified individuals they need.

You may register any time throughout the year. Your name will be provided to all participating employers who seek individuals with your qualifications. If possible, take advantage of GSA's Employment Interview Service, which is conducted each fall in

conjunction with the Society's Annual Meeting. The service brings potential employers and employees together for face-to-face interviews. Mark your calendar for October 21-24 for the 1991 GSA Annual Meeting in San Diego, California.

To register, complete the application form on the following page, prepare a one- to two-page résumé, and mail it with your payment to the address given below. One-year listing for GSA Members and

Student Associates in good standing: \$30, nonmembers: \$60.

**NOTE TO APPLICANTS:** If you plan to interview at the GSA Annual Meeting, GSA must receive your material no later than *August 15, 1991*. If we receive your materials by August 15, your record will be included in the information employers receive prior to the meeting. Submit your forms early to receive maximum exposure!

Don't forget to indicate on your application form that you would like to interview in October. Good luck with your job search!

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



## The Geological Society of America

3300 Penrose Place • P.O. Box 9140 • Boulder, Colorado 80301

### EMPLOYER'S REQUEST FOR EARTH SCIENCE APPLICANTS

(Please type or print legibly)

NAME \_\_\_\_\_ DATE \_\_\_\_\_

ORGANIZATION \_\_\_\_\_

MAILING ADDRESS \_\_\_\_\_

CITY \_\_\_\_\_ STATE \_\_\_\_\_ ZIP CODE \_\_\_\_\_ TELEPHONE ( ) \_\_\_\_\_  
area code Number

MEMBERS OF GSA ONLY: Check here if you do not wish to have this number included in the Membership Directory

**SPECIALTY CODES** (see list below)

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

1. \_\_\_\_\_ 2. \_\_\_\_\_ 3. \_\_\_\_\_ 4. \_\_\_\_\_ 5. \_\_\_\_\_ 6. \_\_\_\_\_

**POSITION DATA:** What position(s) do you expect to fill? \_\_\_\_\_

In what area(s)? \_\_\_\_\_

Degree requirements \_\_\_\_\_ Number of positions available \_\_\_\_\_

**SPECIALTY CODES** Select those that best describe your ability. Use codes in bold face only when other breakdowns are inadequate.

<b>100 Economic Geology</b>	223 low temperature	<b>350 Mathematical Geology</b>	454 paleobotany	<b>620 Remote Sensing</b>
101 coal geology	224 stable isotopes	351 computer science	455 paleoecology	621 photogeology
102 geothermal, etc.	225 geochronology	352 statistical geology	<b>500 Petroleum Geology</b>	622 photogrammetry
103 metallic deposits	<b>250 Geomorphology</b>	<b>400 Mineralogy</b>	501 exploration	<b>630 Science Editing</b>
104 nonmetallic deposits	<b>300 Geophysics</b>	401 crystallography	502 subsurface strat.	<b>650 Sedimentology</b>
105 mining geology	301 seismic	402 clay mineralogy	<b>520 Petrology</b>	651 sed. processes
<b>120 Engineering Geology</b>	302 gravity/magnetics	<b>410 Museum (curator)</b>	521 igneous	652 sed. environments
<b>150 Environmental Geology</b>	303 seismicity	<b>420 Oceanography</b>	522 metamorphic	<b>720 Stratigraphy</b>
<b>160 Public Education &amp; Communication</b>	304 paleomagnetism	421 marine geology	523 sedimentary (clastic)	<b>750 Structural Geology</b>
<b>200 General Geology</b>	<b>320 Hydrogeology</b>	422 coastal geology	524 sedimentary (carb.)	751 tectonics
<b>220 Geochemistry</b>	321 hydrochemistry	<b>450 Paleontology</b>	525 experimental	752 tectonophysics
221 organic	322 ground water	451 invertebrate	<b>550 Planetology</b>	753 rock mechanics
222 high temperature	323 surface water	452 vertebrate	<b>575 Quaternary Geology</b>	<b>800 Volcanology</b>
	<b>330 Library</b>	453 micropaleontology	<b>600 Regional Geology</b>	

**Applicants seeking employment in:**

Academic  Government  Industry  Other \_\_\_\_\_

**Minimum degree required:**

None  B.A. or B.S.  M.A. or M.S.  Ph.D.

**Minimum professional experience:**

None  1-5 years  6-plus years

**Employment in:**  U.S. only  U.S. with foreign assignments  Either

**Foreign Languages:**  French  German  Russian  Other \_\_\_\_\_  Not required

**Experience desired (years):**

	None	1-5	6-plus
Administrative	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Exploration/Production	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Field	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Research	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Teaching	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

I am interested in interviewing applicants through the GSA Employment Service at the 19\_\_\_\_\_ Annual Meeting

in \_\_\_\_\_

- I agree to use this service for valid recruiting purposes.
- I agree that no placement charges will be assessed to any applicant participating in the GSA Employment Matching Service.

See attached sheet for current fee schedule

Total fee enclosed .....\$ \_\_\_\_\_

or invoice requested .....\$ \_\_\_\_\_

Signature (required) \_\_\_\_\_

Date \_\_\_\_\_

5/90



## GSF UPDATE

Robert L. Fuchs

### IGC Funds to GSA Foundation

The 28th International Geological Congress, held in Washington, D.C., July 9-19, 1989, has concluded its activities and the operating organization was liquidated late in 1990. In addition to providing a very extensive and informative technical program, the Congress was also a financial success. As a result, \$30,000 in gifts were divided among three scientific organizations, \$10,000 each to the American Association of Petroleum Geologists Foundation, the International Union of Geological Sciences, and the Geological Society of America Foundation. The gift to the GSA Foundation has been placed in the Foundation's Unrestricted Fund.

In addition to these outright gifts, the Bureau of the 28th IGC has transferred the balance of the surplus generated by the Congress, in excess of \$300,000, to a new fund at the GSA Foundation, the IGC Fund. This will be a permanent Foundation fund until an International Geological Congress is again convened in the United

States, perhaps in 20-25 years. During the intervening years, income from the IGC Fund will be used to provide grants to young geoscientists, including students, who are residents of the United States. These grants will allow the awardees to participate in future International Geological Congresses, generally convened every four years, by defraying the cost of travel to and attendance at these meetings. Part of the income generated by the Fund will be used for ongoing expenses that will be incurred by the president and secretary general of the 28th Congress with respect to their future obligations to succeeding Congresses. Finally, at least 10% of the annual net income will be reinvested in the principal of the fund.

At the time of the next convening of an International Geological Congress in the United States, the organizing committee will have the right to receive distribution of at least one-half of the principal of the IGC Fund, to be used as seed money for that Congress.

GSA is responsible for the administration of the IGC Fund

and will direct the disbursements that are to be made by the Foundation from the fund. With respect to the grants to young (under age 40) geoscientists, GSA will appoint a committee to conduct a competition for selection of grant recipients prior to each Congress.

During the formal presentation in Dallas to the GSA Council by 28th IGC President Charles L. Drake and Secretary General Bruce Hanshaw, Drake related a few of the financial trials and tribulations that were encountered along the way. "Three weeks before opening we were facing a significant deficit," he said. "On-site registrations were way over prediction and saved the day."

GSA President Doris Curtis expressed particular pleasure with this gift, stating, "The establishment of this fund is a very fitting conclusion to the highly successful 28th International Geological Congress. The IGC Fund comes into being at an appropriate time in the Society's history as there is increased communication internationally among geoscientists with respect to global change and

worldwide scientific studies." Foundation Chairman F. Beach Leighton also expressed thanks on behalf of the Foundation's Board of Trustees, "The GSA Foundation was established for the purpose of administering funds such as this that will finance and facilitate geologic study."

### Foundation Trustees Elect 1991 Officers

At the Board of Trustees meeting in Dallas during the GSA 1990 Annual Meeting, the Trustees elected the following officers for the forthcoming year: Chairman—F. Beach Leighton; Vice Chairman—William B. Heroy, Jr.; President—Robert L. Fuchs; Vice-President—F. Michael Wahl; and, Secretary-Treasurer—Donna L. Russell. Incoming Chairman F. Beach Leighton expressed his thanks to outgoing Chairman Philip E. LaMoreaux for his leadership of the Foundation during the previous two years. Phil LaMoreaux was also the recipient of AGI's Ian Campbell Award at the Dallas meeting.

GSF Update continued on p. 26

## GSA Officers and Councilors for 1991



Doris M. Curtis, *President*  
Curtis & Echols  
Geological Consultants  
Bellaire, Texas



E-an Zen, *Vice-President*  
University of Maryland  
College Park, Maryland



Raymond A. Price, *Past President*  
Queen's University  
Kingston, Ontario



Robert L. Fuchs, *Treasurer*  
First Fairfield Investment Co.  
Denver, Colorado

### Councilors (1989-1991)

James F. Hays  
National Science Foundation  
Washington, D.C.

Eldridge M. Moores  
University of California  
Davis, California

David A. Stephenson  
GeoWest, Inc.  
Scottsdale, Arizona

James F. Tull  
Florida State University  
Tallahassee, Florida

### Councilors (1990-1992)

Arden L. Albee  
California Institute of Technology  
Pasadena, California

William L. Fisher  
University of Texas  
Austin, Texas

Marie E. Morisawa  
State University of New York  
Binghamton, New York

Elaine R. Padovani  
U.S. Geological Survey  
Reston, Virginia

### Councilors (1991-1993)

Victor R. Baker  
University of Arizona  
Tucson, Arizona

Gordon P. Eaton  
Lamont-Doherty  
Geological Observatory  
Palisades, New York

John M. Sharp, Jr.  
University of Texas  
Austin, Texas

John F. Sutter  
U.S. Geological Survey  
Reston, Virginia

# GeoVentures 1991

## Registration Starts January 2, 1991

By Sue Beggs  
Meetings Manager

Where will you be spending your free time next year? Some of GSA's members and friends will be enjoying trips to New Zealand, Great Britain, Grand Canyon, and Colorado as part of GSA's 1991 GeoVenture program. GeoVentures offer an array of trips and classroom experiences. They are especially designed for geologists who would like to experience an interesting travel destination in the company of other geologists who share similar educational interests.

GeoVentures are a special benefit created for members, but are open to guests and friends also. GeoVentures is the overall name for adult educational and adventure experiences of two kinds: GeoTrips or GeoHostels. Both are known for expert scientific leadership. Fees for both are low to moderate (relative to the length, time of year, and destination) and include lodging and meals as designated.

### GT912 **Great Britain's Classic Geologic Sites** Co-sponsored by NAGT and GSA 21 Days: June 15–July 6, 1991

#### Scientific Leadership

The trip will be coordinated by Dorothy (Dottie) L. Stout, Cypress College, California. Expert geologists from England and Wales will be sharing in the scientific leadership. Donald McIntyre, Professor Emeritus, Pomona College, and bagpipe player extraordinaire, will lead the Scotland portion of the trip. Participants will also enjoy the interpretive insights provided by persons familiar with other environmental, cultural, and social aspects of Great Britain.

#### Focus

The purpose of the trip is to visit the classic sites in England and Scotland that have molded understanding of Earth's geology. The potential participant is a geologist who would enjoy visiting these classic sites under the guidance of geological experts. GeoTrips are not standard field trips, however. Fascinating non-geological activities are woven into the itinerary, and guests are welcome.

#### Itinerary

During its 21 days, the trip will visit nearly all the classic geological sites in Great Britain, beginning with the Geological Museum of London and the grand old Geological Society of London. During the London evenings, as in the evenings in most of the cities and towns, there will be theater or other local cultural options. England, Wales, and Scotland lie ahead as the trip explores the type sections for the various geologic periods. The itinerary includes visits to the following geologically and historically colorful places: the Sedgwick Museum, Chalk Cliffs, Lyme Regis, Sidmouth, Cornwall, Stonehenge, Bath, Stratford, Isle of Arran, Glasgow, parallel roads of Glenroy, Whin Sill, Hadrian's Wall, Edinburgh, and Siccar Point. It's back to London on the evening of the 20th day, for return home the next day.

#### Limits

The trip is limited to 30 participants plus leaders. The minimum age is 18 years old. GeoTrippers should be in good health, and although the trip is not strenuous, there will be some hiking and persons must be able to carry their own luggage.

#### Trip Cost

The estimated cost will be between \$3090 and \$3390 U.S. for the 21 days. This is a reasonable fare considering the trip is going at the best time of year and is based on an exchange rate that is currently unfavorable to the U.S. dollar. The fee includes double occupancy, lodging, most morning and evening meals, ground transportation, entry fees, transfer costs, and taxes.

#### Airfare

Since the trip fee does not include airfare, we will be providing a special travel package on a certified International Air Transport Association carrier. The air travel arrangements will be made only through the official travel agent designated for this trip. Everyone's participation is assumed in the fare. An extra fee of \$160 will be due from those not using the specially arranged fare, for example, those using frequent flier miles.

#### Registration

Registration is open to everyone, but GSA and NAGT members will be given preference during the advance period up to January 30, 1991. Interest in GeoTrips has been very high, so if you are thinking about this trip, let us know soon.

#### Deposit and Payment

Cost: \$3090 (based on 25 person minimum)  
Special \$2990 for NAGT and GSA members

#### Register Before January 30 and Save \$100 More

GSA and NAGT Members . . . . . \$2890  
Guests and Nonmembers . . . . . \$2990

\$250 deposit is due with your reservation and is completely refundable until February 28.

### GT913 **Grand Canyon Adventure**

An Educational Adventure:  
Rafting, Hiking, and Camping

Nine Days, Eight Nights on the River—  
Lee's Ferry to Pearce Ferry  
250 Miles of River Ride  
Sunday, July 14– Monday, July 22

Scientific Leaders:  
George H. Billingsley,  
U.S. Geological Survey, Flagstaff  
William K. Hamblin,  
Brigham Young University

Guests welcome with a GSA member

#### General Program

July 13 . . . . . Travel day from home to Las Vegas  
July 14 . . . . . Depart Las Vegas for arrival at Lee's Ferry put-in by 10:00 a.m.  
July 15–July 22 . . . . . River days  
July 22 . . . . . Arrive Pearce Ferry (Lake Mead) for bus back to Las Vegas  
July 23 . . . . . Travel day from Las Vegas to home

#### Deposit and Payment

Cost: \$1440  
\$100 less for GSA members  
Limit: 35 persons

#### Register Before February 10 and save \$50!

GSA Members . . . . . \$1290  
Guests and Nonmembers . . . . . \$1390

Included in the fee: Tents, sleeping bags and pads, meals, dry bags, waterproof river guidebook, geologic reading materials, comfortable transportation to and from Las Vegas and the Grand Canyon, and, of course, the companionship of expert and engaging scientific leaders.

When you are ready to decide, \$150 per person will hold your place. The deposit is completely refundable up to April 9.

Science and vacation in one glorious river ride for the spirited and adventurous!

### GH91 **Colorado GeoHostel Program**

Colorado School of Mines,  
Golden, Colorado

Five Days:  
Sunday, June 23–Thursday, June 27

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

Colorado School of Mines is set in the foothills of the Colorado Rockies and is conveniently located between Denver and Boulder. June will be a wonderful time to visit Colorado and the spectacular high country of the Rockies.

#### General Program

June 22 . . . . . Welcoming Get-together  
June 23– June 26 . . . . . Morning Classes  
June 27 . . . . . Full Day Field Excursion and Farewell Party

GH91A Evolution of Geologic Landscapes in the Colorado Rockies, 8:00–9:30 a.m.  
GH91B Environmental and Engineering Issues in Colorado, 9:30–11:00 a.m.

These two geology classes will be offered each morning and include local field trips. They are meant for geologists who are not experts in this area. A person may take one or both classes.

GH92B Old Mining Towns of the Rockies, 9:30–11:00 a.m.

Also offered, primarily for the non-geologist, is a fascinating class on Colorado's mining towns. This class will include at least one full-day trip to visit several mining towns. Persons registering in this class will not be able to take either of the geology classes.

#### Deposit and Payment

Cost: \$350  
\$25 less for GSA members  
Limit: Minimum age is 21  
No other limits

Fee includes classroom programs and materials, field excursions, lodging (double occupancy), breakfast, welcoming and farewell events. Not included is transportation to and from Colorado, transportation during non-class hours, meals or other expenses not specifically included.

\$50 deposit is due with your reservation. It will be applied to the total due and is refundable up to April 1.

**See Registration Form on opposite page or call GSA's GeoVentures Coordinator at (303) 447-2020 ⇒**

GT911

## STANDBYS WANTED FOR THE 1991 NEW ZEALAND TRIP

March 3-23, 1991

Although the New Zealand trip is now full, we still need people interested in filling any cancellations.

Standbys will be notified as soon as there is an opening. Flexibility is necessary since a cancellation could come up at any time.

If interested, please call 1-800-472-1988 and ask for the GeoTrip Coordinator.



## GeoVentures Registration Form

REGISTRATION OPENS JANUARY 2, 1991

Registration will be accepted *after* January 2. Please keep in mind that the GeoVentures fill quickly and it is best to make a decision early.

Name \_\_\_\_\_

Institution/Employer \_\_\_\_\_

Mailing Address \_\_\_\_\_

City \_\_\_\_\_ State \_\_\_\_\_ Country \_\_\_\_\_ ZIP \_\_\_\_\_

Business Phone ( ) \_\_\_\_\_

Home Phone ( ) \_\_\_\_\_

Guest Name \_\_\_\_\_

GSA Member # \_\_\_\_\_ or NAGT Member # \_\_\_\_\_

	Deposit Per Person	No. of Persons	Total Paid Deposit
GT912 — Great Britain's Classic Geologic Sites	\$250	_____	_____
GT913 — Grand Canyon Adventure	\$150	_____	_____
GH91 — Colorado GeoHostel Program	\$ 50	_____	_____

Please check the GeoHostel programs you would like to take:

GH91A (8:00 a.m.) Evolution of the Rockies

GH91B (9:30 a.m.) Environmental Issues

GH92B (9:30 a.m.) Mining Towns

TOTAL DEPOSIT \_\_\_\_\_

I've enclosed no deposit, but I'm interested. Please send more information.

VISA  MasterCard  Diners Club/Carte Blanche

American Express

Credit Card # \_\_\_\_\_ Exp. Date \_\_\_\_\_

Signature \_\_\_\_\_

Mail Registration Form and check or credit card information to:  
1991 GSA GeoVentures, GSA Meetings Department,  
P.O. Box 9140, Boulder, CO 80301

Non-U.S.-based registrants are encouraged  
to use GSA's fax number: 303-447-1133

Call today for more information: (303) 447-2020 or 1-800-472-1988

## GSA BULLETIN and GEOLOGY contents

**Are you missing out?** If you're not a *Bulletin* or *Geology* subscriber, you may miss the articles listed below. But it's not too late; you can still subscribe and receive all 1991 issues, even if you've already paid your 1991 dues. Just call Membership Services today at 1-800-472-1988.



The Geological Society of America

**BULLETIN**

Volume 103, Number 1, January 1991

### CONTENTS

- 1-21 Origin and morphology of limestone caves  
*Arthur N. Palmer*
- 22-36 An example of an accretionary forearc basin from northern Central Anatolia and its implications for the history of subduction of Neo-Tethys in Turkey  
*A. Kocyiğit*
- 37-47 High-Mg, low-Al bulk composition of the Talkeetna island arc, Alaska: Implications for primary magmas and the nature of arc crust  
*Susan M. DeBari and Norman H. Sleep*
- 48-55 Stratigraphic effects of change from internal to external drainage in an extending basin, southeastern Nevada  
*W. H. DiGiuseppi and J. M. Bartley*
- 56-72 Igneous petrogenesis of magnesian metavolcanic rocks from the central Klamath Mountains, northern California  
*W. G. Ernst, B. R. Hacker, M. D. Barton, and Gautam Sen*
- 73-81 Old courses of the New River: Its late Cenozoic migration and bedrock control inferred from high-level stream gravels, southwestern Virginia  
*Mervin J. Bartholomew and Hugh H. Mills*
- 82-97 Precise chronology of the last interglacial period: <sup>234</sup>U-<sup>230</sup>Th data from fossil coral reefs in the Bahamas  
*J. H. Chen, H. A. Curran, B. White, and G. J. Wasserburg*
- 98-111 Transition from back-arc to foreland basin development in the southernmost Andes: Stratigraphic record from the Ultima Esperanza District, Chile  
*Terry J. Wilson*
- 112-124 High-resolution strontium-isotope stratigraphy and biostratigraphy of the Miocene Monterey Formation, central California  
*Donald J. DePaolo and Kenneth L. Finger*
- 125-135 New U/Pb zircon age constraints on the timing of deformation in north-central Newfoundland and implications for early Paleozoic Appalachian orogenesis  
*Colleen G. Elliott, Greg R. Dunning, and Paul F. Williams*
- 136-143 Structure of the Kelley Mountain culmination, central Alabama, and implications for the evolution of the southeastern southern Appalachian foreland thrust belt  
*S. Gregg Erickson*
- 144-154 The neotectonic setting of Puerto Rico  
*D. G. Masson and K. M. Scanlon*
- 155-156 Bulletin Information

## GEOLOGY

VOLUME 19

NO. 1

P. 1-96

JANUARY 1991

- 3 Mineral magnetic record of the Chinese loess and paleosols  
*Barbara A. Maher, Roy Thompson*
- 7 Cambrian-Ordovician paleogeography of Baltica  
*Trond H. Torsvik, Paul D. Ryan, Allan Trench, David A. T. Harper*
- 11 Arc-transform magmatism in the Wrangell volcanic belt  
*Thomas Skulski, Don Francis, John Ludden*
- 15 Intertidal stromatolites in a fringing Holocene reef complex, Bahamas  
*R. Pamela Reid, Kathleen M. Browne*
- 19 Lithospheric uplift in eastern Gondwana: Evidence for a long-lived mantle plume system?  
*Ray Kent*
- 24 Variations in the strontium isotopic composition of seawater during the Neogene  
*David A. Hodell, Paul A. Mueller, Jose R. Garrido*
- 28 Postcollision extension in arc-continent collision zones, eastern Indonesia  
*T. R. Charlton*
- 32 Philippine fault: A key for Philippine kinematics  
*E. Barrier, P. Huchon, M. Aurelio*
- 36 Genesis of sediment-hosted disseminated-gold deposits by fluid mixing and sulfidation: Chemical-reaction-path modeling of ore-depositional processes documented in the Jerritt Canyon district, Nevada  
*A. H. Hofstra, J. S. Leventhal, H. R. Northrop, G. P. Landis, R. O. Rye, D. J. Birak, A. R. Dahl*
- 41 Bermuda and Appalachian-Labrador rises: Common non-hotspot processes?  
*Peter R. Vogt*
- 45 Opposite thrust systems in northern Victoria Land, Antarctica: Imprints of Gondwana's Paleozoic accretion  
*Thomas Flöttmann, Georg Kleinschmidt*
- 48 Yardea Dacite—Large-volume, high-temperature felsic volcanism from the Middle Proterozoic of South Australia  
*Robert A. Creaser, Allan J.R. White*
- 52 Cathodoluminescence of magnesite: Examples from the Eastern Alps  
*Christoph Spötl*
- 56 Unusually large subsidence and sea-level events during middle Paleozoic time: New evidence supporting mantle convection models for supercontinent assembly  
*Michelle A. Kominz, Gerard C. Bond*
- 61 Geological controls on seismic sequence resolution  
*Craig S. Fulthorpe*
- 66 Antler orogeny: A Mediterranean-type orogeny  
*B. C. Burchfiel, L. H. Royden*
- 70 Generation of plagiogranite by amphibolite anatexis in oceanic shear zones  
*Patricia A. Flagler, John G. Spray*
- 74 Backstacking apatite fission-track "stratigraphy": A method for resolving the erosional and isostatic rebound components of tectonic uplift histories  
*Roderick W. Brown*
- 78 Role of subduction erosion in the generation of Andean magmas  
*Charles R. Stern*
- 82 Temperature and pressure of mylonitization in a Tertiary extensional shear zone, Ruby Mountains-East Humboldt Range, Nevada: Tectonic implications  
*Hugh A. Hurlow, Arthur W. Snoke, Kip V. Hodges*
- 87 Basin development and syntectonic sedimentation associated with kinematically coupled strike-slip and detachment faulting, southern Nevada  
*Ernest M. Duebendorfer, E. Timothy Wallin*

### Forum

- 91 Glacial-eustatic sea-level curve for early Late Pennsylvanian sequence in north-central Texas and biostratigraphic correlation with curve for midcontinent North America  
*Comment: Paul M. van Veen, Bjorn T. Simonsen*  
*Reply: Darwin R. Boardman II, Philip H. Heckel*
- 94 Two high levels of continental waters in the southern Tunisian chotts at about 90 and 150 ka  
*Comment: C. Vita-Finzi, G. W. Richards*  
*Reply: C. Causse, R. Coque, J. Ch. Fontes, F. Gasse, E. Gilbert, H. Ben Ouezdou, K. Zouari*

## BOOK REVIEWS

**An Introduction to Applied Geostatistics.** Edward H. Issaks and R. Mohan Srivastava. Oxford University Press, New York, 1989, 361 p., \$35.

Geostatistics, in a nutshell, is a stochastic spatial interpolation method. The method consists of two steps: first, construction of a sample variogram and fitting it to a theoretical variogram, and second, kriging. The variogram is a measure of spatial continuity (most earth-science data are spatially continuous), which is the unique feature of geostatistics, not found in all other interpolation methods. The second step, kriging, is essentially a linear regression with a twist. The twist comes from the incorporation of spatial correlation structure deciphered in the variograms.

Geostatistics is a branch of spatial statistics that was "invented" by George Matheron and popularized by his students—now in their third generation. When Matheron's paper "Principles of Geostatistics" was published in *Economic Geology* (v. 58, 1963), the impact was not immediately felt because it was incomprehensible to most "economic geologists." It took nearly 15 years of incubation to be discovered, but the technique has since been widely and successfully applied to diverse disciplines, such as mining engineering (ore reserve estimation); hydrology (hydraulic conductivity and aquifer transmissivity); hazardous waste management and environmental sciences (pollutant transport and toxic element concentration); geophysics

(seismics and well logs); and petroleum geology and engineering (porosity and permeability distributions and hydrocarbon volume estimation).

This book is written by two third-generation geostatisticians (both were students of Prof. Journal of Stanford University). Although there is a growing number of geostatistics books on the market, this one has a new and different approach. One remarkable feature of this book, when compared to other geostatistics books, is that it is very nonmathematical (and therefore suited to geologists?). All the statistics you need to follow the discussion in this book are summarized in three chapters (2, 3, and 9). Unlike other textbooks, the writing in this book is informal, yet pedagogic, with lots of diversions and intuitive, qualitative looks at abstract mathematical and statistical computations.

Of course, there are always shortcomings in any textbook. I mention just two of them. First, it is my opinion that the book should be simply called "Introductory Geostatistics," not "An Introduction to Applied Geostatistics," because there are no examples of applications to any field, other than mention of various fields in which geostatistical techniques have been used. Readers would like to see real-world examples of application of geostatistics incorporated in the book, as exercises, problems, or examples. This would give a more intimate feeling of technique as an added incentive to apply geostatistics to one's domain of interest. The second criticism is that

some chapters should be combined or deleted: Chapter 5 (The Exhaustive Data Set) and Chapter 6 (The Sample Data Set) should have been combined; Chapters 8, 10, and 11 should also have been combined. Chapters 18 and 20 might have been deleted and the space filled with topics more relevant to geostatistics. For instance, indicator kriging, which is of great interest to geologists, should be better explained and discussed.

In short, I strongly recommend this book as an indispensable introductory (and self-study) book for the novice. [Postscript: I had decided to adopt this book as a text for my course in geostatistics (fall semester, 1990), before I was asked to review it.]

J. H. Fang  
Department of Geology  
University of Alabama  
Tuscaloosa, AL 35487

**The Politics of Earthquake Prediction.** Richard Stuart Olson with Bruno Podesta and Joanne M. Nigg. Princeton University Press, Princeton, N.J., 1989, 187 p., \$19.95.

On June 28, 1981, a great earthquake of Richter magnitude 8.4 or so did not occur off the coast of Peru. This non-event was big news in the U.S. and in Peru, however, because it occurred in the face of a prediction made in 1976 by Brian Brady of the U.S. Bureau of Mines and William Spence of the U.S. Geological Survey. The prediction, an outgrowth of a series

of articles on earthquake prediction by Brady in the journal *Pure and Applied Geophysics*, received little attention at first, but slowly and inexorably it became an international *cause célèbre*, as the date neared and as various organizations from both countries became embroiled in trying to resolve the question of whether it would or wouldn't occur. Using an unusually large amount of written documentation of the debate, Olson weaves an engrossing account of the fate of the prediction from start to finish. The chapter headings give the flavor of the book: Introduction: Politics and science; A prediction contained, 1976-1979; The stakes increase, 1979; Bureaucratic politics takes over, 1980; Late 1980: The prediction goes public—in the U.S.; Brady's 1981 "trial": The first day; Hardball: The second day of the trial; The controversy continues: "Doomsday" approaches—and passes; Reflections. Olson is a political scientist, and his narrative reflects that fact. He tries to fit the controversy into a Kuhnian framework, an attempt not entirely convincing. Nevertheless, the book makes fascinating reading. Anyone interested in the public policy consequences of our geo-endavors should buy it, read it, and ponder its message.

E. M. Moores  
Department of Geology  
University of California  
Davis, CA 95616

## DNAG NEWS

Allison R. (Pete) Palmer

### Good News First

As of this writing, blueprints for the Caribbean volume (GNA-H) have been received and checked, and the next thing we'll see is the printed volume—arriving just about the time you read this. George Kiersch has just finished proofing the entire set of galley proofs for *Heritage of Engineering Geology* (CSV-3), and final paging is in progress. This volume will complete the set of Centennial Special Volumes. All chapters for *Economic Geology of Mexico* (GNA-P3) have been through copy editing, and the last few are being typeset. These two books will probably appear in March. Transect H-1, across northern Mexico at the latitude of the

southern tip of Baja California, will have been published by the time you read this. Two-thirds of the chapters for *The Geology of Alaska* (GNA G-1) are now in hand.

GNA volumes *The Geology of North America: An Overview* and *Hydrogeology* are now in their second printing, and supplies of the Cordilleran and Rocky Mountain Centennial Field Guides are getting low.

### How Close and Yet How Far

Only 17 chapters are needed to complete the writing of the entire set of volumes of *The Geology of North America* being produced by GSA (477 of the expected 494

chapters have been written). Fifteen of those that are written are still being revised and have not yet been received in final form. These 32 missing chapters involve only 27 senior authors, and are delaying the completion of six volumes. Only 14 chapters (14 authors) are needed to complete the writing of the two other remaining DNAG volumes.

The lagging authors for all eight volumes are being contacted frequently, and except for the special volume to accompany the transects (six individuals), all should have their chapters in production by the end of the year. There are perhaps 200 individuals, who are involved in the 145 com-

pleted chapters for these eight volumes, who would be delighted to see their colleagues complete their assignments.

### Another Acknowledgment of Contributors

The 60 authors who contributed to Volume GNA-P3, now in the wrap-up stage, are listed below. This brings the total number of DNAG contributors to 1629. With eight Canadian volumes and eight GSA volumes still to come, it looks as if we will easily break the 2000 mark for authors in this monster project. ■

R. Alexandri R.  
F. Arellano G.  
C. Ariciaga M.  
G. Berrocal L.  
J. Bravo N.  
F. Castañeda A.  
F. Castillo N.  
H. M. Clark

J. De la Campa G.  
F. J. Diaz T.  
J. M. Espinoza  
R. Esquivel  
E. Flores G.  
J. Flores M.  
P. Fraga M.  
C. Fries

C. García H.  
E. García M.  
G. García G.  
R. Guiza, Jr.  
L. C. A. Gutiérrez N.  
I. Hernández C.  
G. H. Huitrón R.  
N. Leija V.

G. K. Lowther  
D. Maldonado E.  
E. Mapes  
A. Martínez V.  
H. Mendoza E.  
H. Monje H.  
E. Navarro  
B. Noguez A.

J. Ojeda R.  
P. Olivares R.  
A. Osorio H.  
H. A. Palacios M.  
O. Palma P.  
J. Pantoja A.  
J. de J. Parga P.  
A. Pelayo

J. Perezysera y  
Zapata  
F. Querol S.  
J. L. Quijano L.  
G. Ramírez S.  
J. C. Ramírez L.  
A. Razo M.  
P. Reyes V.

V. S. Rocha  
J. Rodríguez S.  
C. Romero G.  
F. Romero R.  
S. A. Rosas  
G. P. Salas  
C. Sánchez H.  
B. Solano R.

A. Toscano F.  
S. Venegas S.  
F. Verdugo D.  
D. E. White  
I. F. Wilson

## GSA ANNUAL MEETINGS

### ■ 1991

**GSA Annual Meeting, San Diego, California  
October 21-24**

General Chair:

R. Gordon Gastil, Dept. of Geological Sciences,  
San Diego State University, San Diego, CA 92182



### ■ 1992

**GSA Annual Meeting, Cincinnati, Ohio  
October 26-29**

Call for field trip proposals:

Send proposals to Thomas M. Berg, State Geologist and Chief, Division of Geological Survey, Ohio Dept. of Natural Resources, Fountain Square, Columbus, OH 43224; (614) 265-6605

### ■ FUTURE

San Diego	October 21-24	1991
Cincinnati	October 26-29	1992
Boston	October 25-28	1993
Seattle	October 24-27	1994
New Orleans	November 6-9	1995

For general information on technical program participation (1991 or beyond) contact: Sue Beggs, Meetings Manager, GSA headquarters.

## GSA SECTION MEETINGS

### ■ 1991

#### Northeastern-Southeastern

**Omni Inner Harbor Hotel, Baltimore, Maryland, March 14-16**

Emery Cleaves, Maryland Geological Survey, 2300 St. Paul Street,  
Baltimore, MD 21218; (301) 554-5504

or Juergen Reinhardt, U.S. Geological Survey, 926 National Center,  
Reston, VA 22092; (703) 648-6789

#### Cordilleran

**Cathedral Hill Hotel, San Francisco, California, March 25-27**

Raymond Sullivan, Dept. of Geosciences, San Francisco State University,  
San Francisco, CA 94132; (415) 338-7730

#### North-Central

**University of Toledo, Toledo, Ohio, April 18-19**

Lon Ruedisili or Mark Camp, Dept. of Geology, University of Toledo,  
Toledo, OH 43606; (419) 537-2009

#### Rocky Mountain-South-Central

**University of New Mexico, Albuquerque, New Mexico, April 22-24**

G. Randy Keller, Dept. of Geological Sciences, University of Texas at  
El Paso, El Paso, TX 79968-0555; (915) 747-5501

or John Geissman or Wolfgang Elston, Dept. of Geology, University of  
New Mexico, Albuquerque, NM 87131; (505) 277-4204

### ■ 1992 (all dates and locations subject to change)

Cordilleran	May 11-13	Eugene, Oregon
Rocky Mountain	unknown	Ogden, Utah
North-Central	April 16-17	Iowa City, Iowa
South-Central	February 24-25	Houston, Texas
Northeastern	March 26-28	Harrisburg, Pennsylvania
Southeastern	March 18-20	Winston-Salem, North Carolina

### ■ 1993 (all dates and locations subject to change)

Cordilleran	unknown	unknown
Rocky Mountain	unknown	unknown
North-Central	April 15-16	Rolla, Missouri
South-Central	March 15-16	Fort Worth, Texas
Northeastern	unknown	Burlington, Vermont
Southeastern	unknown	Tallahassee, Florida

### FOUNDATION TO FUND MATCHING STUDENT-TRAVEL GRANTS

The GSA Foundation will award matching grants up to a total of \$3000 each to the six GSA Sections. The money, when combined with equal funds from the Sections, will be used to assist students traveling to the 1991 Section Meetings and the GSA Annual Meeting in San Diego.

Travel grants will be awarded and administered by the Sections, whose officers should be contacted for further information.

## 1990 GSA SHORT COURSE NOTES FOR SALE

A limited supply of short course notes is available from courses presented at the Dallas Annual Meeting. The notes available are:

- Computer Modeling of Cyclic Carbonate Sequences — \$10
- Creating Geological Applications with Macintosh HyperCard — \$9
- Practical Tracing of Groundwater with Emphasis on Karst Terranes, Volumes I and II — \$10

To purchase a copy, please call  
GSA, Meetings Department  
1-800-472-1988

### On the Move

GSA Fellow and 1985 Penrose Medalist **James Freeman**, University of California, San Diego, received the 1990 Balzan Prize, for his contributions to solid earth geophysics, from The International Balzan Foundation, Milan, Italy.

GSA Fellow **James Lee Wilson**, Rice University, received SEPM's highest award, the Twenhofel Medal. Honorary Membership in SEPM was awarded to Fellow **Raymond L. Siever**, Harvard University. Fellow **Daniel J. Stanley**, U.S. National Museum of Natural History, Washington, D.C., was awarded the Francis P. Shepard Medal. GSA Fellow **William A. Cobban**, U.S. Geological Survey, Denver, Colorado, received the Raymond C. Moore Medal. Fellow **Allan P. Bennison**, Tulsa, Oklahoma, was awarded SEPM's Distinguished Service Award. Fellow **Roderick W. Tillman**, Tulsa, Oklahoma, has been elected president, and Fellow **Gail M. Ashley**, Rutgers University, was named president-elect. GSA Member **Michael E. Field**, U.S. Geological Survey, Menlo Park, California, was appointed secretary-treasurer, and Member **Lisa M. Pratt**, Indiana University, was appointed to the SEPM Council for Research Activities. ■

### In Memoriam

Charles F. Bassett  
Springfield, Missouri

Paul N. Bond  
Wayne, Pennsylvania  
October 5, 1990

William T. Coulbourn  
Honolulu, Hawaii  
June 13, 1990

Arthur M. Piper  
Pacific Grove, California  
December 31, 1989

Louis Unfer, Jr.  
Cape Girardeau, Missouri  
August 27, 1990

### GSA's Publication Catalog

It's

# FREE!

BOOKS • MAPS  
SPECIAL PRODUCTS

Clearance sale continues  
on many items  
(limited to stock on hand)

**REQUEST YOUR  
COPY TODAY**

GSA Marketing  
1-800-472-1988

P.O. Box 9140  
Boulder, CO 80301  
(303) 447-2020

We'll help you...

## DO YOUR SHARE FOR THE ENVIRONMENT

GSA's new, reusable  
canvas shopping bag—  
FREE with purchases  
of at least two items  
totaling \$55 or more.  
Available for sale at  
\$3.50 each, net.

For details call  
GSA Publication Sales  
1-800-472-1988 or  
(303) 447-2020

Available late January

# MEETINGS

■ Indicates new or changed information.

## 1991

### February

**American Geophysical Union 1991 Front Range Meeting: Our Changing Environment**, February 11-12, 1991, Boulder, Colorado. Information: Rush Services, 5106 Forsyth Place, Boulder, CO 80303; (303) 443-8489; fax 303-449-4394.

**Seventh Annual V.E. McKelvey Forum on Mineral and Energy Resources**, February 11-14, 1991, Reno, Nevada. Information: Buhler and Abraham, Inc., 8700 First Avenue, Silver Spring, MD 20910; (301) 588-4177.

■ **American Association for the Advancement of Science Annual Meeting**, February 14-19, 1991, Washington, D.C. Information: AAAS Meetings Office, 1333 H Street, N.W., Washington, DC 20005; (202) 326-6448.

■ **Mineral Resources and the Changing International Economy of the 90's**, February 14-19, 1991, Washington, D.C. Information: Carroll Ann Hodges, U.S. Geological Survey, MS 984, 345 Middlefield Rd., Menlo Park, CA 94025; (415) 329-5357.

**United Nations Development Programme 5th International Conference on Heavy Crude and Tar Sands**, February 17-22, 1991, Caracas, Venezuela. Information: Sigfrid Steinhilf S., 5th UNITAR/UNDP Conference, 801 U.N. Plaza, 5th Floor, New York, NY 10017; (212) 370-1122; fax 212-986-5779.

**10th Annual Symposium on Caribbean Geology: Tectonics and Mineral Deposits of the Caribbean**, February 20-24, 1991, Mayagüez, Puerto Rico. Information: J. H. Schellekens, Dept. of Geology, University of Puerto Rico, P.O. Box 5000, Mayagüez, Puerto Rico 00709-5000; (809) 265-3845.

**Society for Mining, Metallurgy, and Exploration Annual Meeting**, February 25-28, 1991, Denver, Colorado. Information: Meetings Department, Society for Mining, Metallurgy, and Exploration, P.O. Box 625002, Littleton, CO 80162; (303) 973-9550; fax 303-979-3461.

■ **TER-QUA Symposia on Early Man, Eolian Activity, and Climate Change on the Great Plains**, February 28-March 2, 1991, Lawrence, Kansas. Information: Wakefield Dort Jr., Dept. of Geology, University of Kansas, Lawrence, KS 66045; (913) 864-4974.

### March

**AAPG/SEPM/SEG/SPWLA Pacific Sections 66th Annual Meeting**, March 5-10, 1991, Bakersfield, California. Information: Robert Horton, 1991 Annual Pacific Sections Convention, 4909 Stockdale Highway, Suite 251, Bakersfield, CA 93309.

**Second International Conference on Recent Advances in Geotechnical Earthquake Engineering and Soil Dynamics (including special session on the Loma Prieta [California] Earthquake of October 17, 1989)**, March 11-15, 1991, St. Louis, Missouri. Information: Shamsher Prakash, Dept. of Civil Engineering, 308 Butler Carlton Hall, University of Missouri, Rolla, MO 65401-0249; (314) 341-4489; fax 314-341-4729.

**GSA Northeastern and South-eastern Sections**, March 14-16, 1991, Baltimore, Maryland. Information: Emery Cleaves, Maryland Geological Survey, 2300 St. Paul Street, Baltimore, MD 21218; (301) 554-5504; Juergen Reinhardt, U.S. Geological Survey, 926 National Center, Reston, VA 22092, (703) 648-6789.

**Appalachian Karst Symposium**, March 23-26, 1991, Radford, Virginia. Information: Ernst H. Kastning, Department of Geology, Radford University, Radford, VA 24142; (703) 831-5336 or 5652; fax 703-831-5970.

**Sixth Biennial Meeting of the European Union of Geosciences**, March 24-28, 1991, Strasbourg, France. Information: Organizing Committee of E.U.G. VI, University of Trieste, Institute of Mineralogy, Piazzale Europa, 1-34100 Trieste, Italy.

**GSA Cordilleran Section**, March 25-27, 1991, San Francisco, California. Information: Raymond Sullivan, Dept. of Geosciences, San Francisco State University, San Francisco, CA 94132; (415) 338-7730.

**Fifth SIAM Conference on Parallel Processing for Scientific Computing**, March 25-27, 1991, Houston, Texas. Information: SIAM Conference Coordinator, Dept. CC0990, 3600 University City Science Center, Philadelphia, PA 19104-2688; (215) 382-9800; fax 215-386-7999; E-mail [siamconfs@wharton.upenn.edu](mailto:siamconfs@wharton.upenn.edu).

**Petroleum-Reservoir Geology in the Southern Midcontinent**, March 26-27, 1991, Norman, Oklahoma. Information: Kenneth S. Johnson or Jock A. Campbell, Oklahoma Geological Survey, University of Oklahoma, 100 E. Boyd, Rm. N-131, Norman, OK 73019; (405) 325-3031.

### April

**Engineering Geology and Geotechnical Engineering, 27th Symposium**, April 9-13, 1991, Logan, Utah. Information: James McCalpin, Dept. of Geology, Utah State University, Logan, UT 84322-4505; (801) 750-1220.

**Permian Basin Section—SEPM Annual Field Seminar: Sequence Stratigraphy, Facies, and Reservoir Geometries of the San Andres/Grayburg/Queen Formations, Guadalupe Mountains, New Mexico and Texas**, April 11-13, 1991, Permian Basin, Texas. Information: Sally Meador-Roberts, PBS-SEPM 1991 Annual Field Seminar, P.O. Box 1595, Midland, TX 79702; (915) 684-7122.

**Association of American Geographers Annual Meeting**, April 13-17, 1991, Miami, Florida. Information: AAG, 1710 16th Street NW, Washington, DC 20009-3198; (202) 234-1450.

**International Conference on Environmental Pollution**, April 15-19, 1991, Lisbon, Portugal. Information: ICEP Conference Office, ICTR Secretariat, 11-12 Pall Mall, London SW1Y 5LU, England; phone 01-930-6825; telex 925312 REICO G; fax 01-976-1587.

**GSA North-Central Section**, April 18-19, 1991, Toledo, Ohio. Information: Lon Ruedisili or Mark Camp, Dept. of Geology, University of Toledo, Toledo, OH 43606.

**International Symposium on Geophysical Hazards in Developing Countries and Their Environmental Impacts**, April 21-27, 1991, Cairo, Egypt. Information: T. S. Murty, Hazards-91, c/o Institute of Ocean Sciences, P.O. Box 6000, Sidney, B.C. V8L 4B2, Canada; (604) 356-6311; telex 04-9728T; fax 604-356-6390; Mohammed I. El-Sabh, Hazards-91, Dept. Océanographie, Université du Québec, 300, Allée des Ursulines, Rimouski, Québec G5L 3A1, Canada; (418) 724-1707; telex 051-31623; fax 418-723-7234.

**GSA Rocky Mountain and South-Central Sections**, April 22-24, 1991, Albuquerque, New Mexico. Information: G. Randy Keller, Dept. of Geological Sciences, University of Texas, El Paso, TX 79968-0555, (915) 747-5501; John Geissman or Wolfgang Elston, Dept. of Geology, University of Albuquerque, Albuquerque, NM 87131; (505) 277-4204.

**European Geophysical Society XVI General Assembly**, April 22-26, 1991, Wiesbaden, Federal Republic of Germany. Information: EGS Office, Postfach 49, 3411 Katlenburg-Lindau, Germany; phone 49-5556-1440; fax 49-5556-4709; telex 965564 zil d.

**Association of Exploration Geochemists 15th International Geochemical Exploration Symposium**, April 29-May 1, 1991, Reno, Nevada. Information: Harold Bonham, 15th IGES, P.O. Box 9126, Reno, NV, 89507; (702) 784-6691; fax 702-784-1709.

**Eighth Thematic Conference on Remote Sensing for Exploration Geology**, April 29-May 2, 1991, Denver, Colorado. Information: Robert H. Rogers, ERIM Thematic Conferences, P.O. Box 8618, Ann Arbor, MI 48107-8618; (313) 994-1200.

### May

**Society for the Preservation of Natural History Collections, 6th Annual Meeting**, May 6-11, 1991, Ottawa, Ontario. Information: G. R. Fitzgerald, Canadian Museum of Nature, Earth Sciences (Paleobiology), P.O. Box 3443, Station D, Ottawa, Ontario K1P 6P4, Canada.

**14th Annual Spring Systematics Symposium: Origin of Anatomically Modern Humans**, May 11, 1991, Chicago, Illinois. Information: Sophia L. Brown, Symposium Coordinator, Department of Geology, Field Museum of Natural History, Roosevelt Road and Lake Shore Drive, Chicago, IL 60605-2496; (312) 922-9410, x298.

**Third International Seminar on Coastal Parks and Protected Areas**, May 11-June 5, 1991, Florida and Costa Rica. Information: John R. Clark, University of Miami-RSMAS, 4600 Rickenbacker Causeway, Miami, Florida 33149-1098; (305) 361-4620; telex 317454; fax 305-361-9306; Easylink mailbox 62845425.

**International Symposium on Land Subsidence**, May 12-18, 1991, Houston, Texas. Information: Ivan Johnson, A. Ivan Johnson, Inc., 7474 Upham Ct., Arvada, CO 80003; (303) 425-5610.

■ **Fifth National Outdoor Action Conference on Aquifer Restoration, Ground-Water Monitoring, and Geophysical Methods**, May 13-16, 1991, Las Vegas, Nevada. Information: Fifth National Outdoor Action Conf., National Water Well Association,

P.O. Box 182039, Dept. #017, Columbus, OH 43218; (614) 761-1711.

**Brazil Gold '91**, May 13-17, 1991, Belo Horizonte, Brazil. Information: Organizing Committee, Av. Afonso Pena, 3880-3/5 andares, 30130 Belo Horizonte MG, Brazil, or Charles Thorman, U.S. Geological Survey, Box 25046, MS 905, Denver Federal Center, Denver, CO 80225; (303) 236-5601; fax 303-236-5603.

**14th International Radiocarbon Conference**, May 20-24, 1991, Tucson, Arizona. Information: Austin Long, Dept. of Geosciences, University of Arizona, Tucson, AZ 85721; (602) 621-8888; fax 602-621-2672; telex 650-3839821.

**Geological Association of Canada—Mineralogical Association of Canada Annual Meeting held jointly with the Society of Economic Geologists**, May 27-29, 1991, Toronto, Ontario. Information: J. J. Fawcett, Dept. of Geology, Earth Sciences Center, University of Toronto, 22 Russell St., Toronto, Ontario M5S 3B1, Canada; (416) 978-3027; fax 416-978-3938.

### July

**Second International Conference on Industrial and Applied Mathematics (ICIAM 91)**, July 8-12, 1991, Washington, D.C. Information: SIAM Conference Coordinator, Dept. CC0990, 3600 University City Science Center, Philadelphia, PA 19104-2688; (215) 382-9800; fax 215-386-7999; E-mail [siamconfs@wharton.upenn.edu](mailto:siamconfs@wharton.upenn.edu).

**11th International Symposium on Ostracoda**, July 8-13, 1991, Warrnambool, Victoria, Australia. Information: Peter J. Jones, Bureau of Mineral Resources, P.O. Box 378, Canberra A.C.T. 2601, Australia; phone (06) 249 9737; fax 06-257 6465.

**Sixth International Symposium on the Ordovician System**, July 15-19, 1991, Sydney, Australia. Information: Earth Resources Foundation, Edgeworth David Building, University of Sydney, Sydney, N.S.W., Australia, 2006; phone (02) 692 2038 (Int. 61+2); fax 02-692 0184 (Int. 61+2).

### August

**150th Anniversary Conference on the Permian System**, August 1991, Perm, USSR. Information: A.E.M. Nairn, Perm Conference, Earth Sciences & Resources Institute, University of South Carolina, Columbia, SC 29208; (803) 777-6484; fax 803-777-6437; telex 9102501347 USC ESRI UQ.

**Sedimentary and Paleolimnological Records of Saline Lakes**, August 13-16, 1991, Saskatoon, Saskatchewan. Information: Robin W. Renaut, Dept. of Geological Sciences, University of Saskatchewan, Saskatoon, Saskatchewan S7N 0W0, Canada; fax 306-966-8593; W. M. Last, Dept. of Geological Sciences, University of Manitoba, Winnipeg, Manitoba R3T 2N2, Canada; fax 204-261-7581.

**SEPM Midyear Meeting—Continental Margins, Tectonics, Eustacy and Climate Change**, August 15-18, 1991, Portland, Oregon. Information: Sam Boggs, Jr., Dept. of Geology, University of Oregon, Eugene, OR 97403; (503) 686-4573.

**1st International Meeting of Young Geologists**, August 22-28, 1991, Budapest, Hungary. Information:



Anna Balog, Dept. of Geology, Technical University of Budapest, H-1521 Budapest, Hungary; phone (36-1) 16-67-370; fax 36-1-16-66-808; telex 225931.

**Third U.S. Conference on Lifeline Earthquake Engineering**, August 22-23, 1991, Los Angeles, California. Information: American Society of Civil Engineers, Specialty Conference Dept., 345 E. 47th St., New York, NY 10017; (212) 705-7139.

**September International Symposium on Computer Applications in Geoscience**, September 2-6, 1991, Beijing, China. Information: Zhang Bojun, 31 Xue Yuan Rd., Beijing 100083, China; phone 2012233, ext. 312; fax 2024674; telex 222484 GBCC CN.

**Geometry of Naturally Deformed Rocks (John Ramsay Meeting)**, September 9-11, 1991, Zürich, Switzerland. Information: E. Pour, Geologisches Institut, ETH-Zentrum, CH-8092, Zürich, Switzerland; phone 256 36 80; fax 252-70-08. (Abstracts deadline: June 1, 1991.)

**International Symposium on Fossil Cnidaria Including Archaeocyatha and Porifera**, September 9-14, 1991, Münster, Federal Republic of Germany. Information: Fossil VI. Cnidaria, Pferdegasse 3, D-4400 Münster, Federal Republic of Germany.

**Gold and Platinum in Central Africa**, September 11-13, 1991, Bujumbura, Burundi. Information: W. Pohl, Institute of Geosciences, Technical University, P.O. Box 3329, D-33 Braunschweig, Germany.

**Second International Conference on the Abatement of Acidic Drainage**, September 16-18, 1991, Montreal, Québec. Information: Pamela Friedrich, Centre des Recherches Minérales, 1665, boulevard Hamel, Édifice 2, 1er étage, Québec, Québec G1N 3Y7, Canada.

**2nd International Symposium on Environmental Geochemistry**, September 16-19, 1991, Uppsala, Sweden. Information: Mats Olsson, Dept. of Forest Soils, Swedish University of Agricultural Sciences, Box 7001, S-750 07 Uppsala, Sweden; phone 46-18-672212; fax 46-18-300831. (Abstracts deadline: March 28, 1991.)

**Second Hutton Symposium on Granites and Related Rocks**, September 23-28, 1991, Canberra, Australia. Information: ACTS, GPO Box 2200, Canberra City, ACT 2601, Australia.

**International Mine Water Association Fourth Congress**, September 25-30, 1991, Ljubljana, Yugoslavia. Information: Miron Veselic, S.P. Geoloski Zavod Ljubljana, Dimiceva 14, 61000 Ljubljana, Yugoslavia; fax 38 61 371 557.

**1991 American Association of Petroleum Geologists International Conference and Exhibition**, September 29-October 2, 1991, London, England. Information: 1991 AAPG International Conference, P.O. Box 979, Tulsa, OK 74101-0979.

**October Fifth International Congress on Pacific Neogene Stratigraphy and IGCP 246**, October 6-10, 1991, Shizuoka, Japan. Information: V-CPNS-IGCP246 Organizing Committee,

Geoscience Institute, Faculty of Science, Shizuoka University, Shizuoka 422, Japan; fax 81-542-37-9895.

**International Symposium on Debris Flow and Flood Disaster Protection**, October 14-20, 1991, Emeishan City, Sichuan Province, China. Information: Tong Yuling, International Research and Training Centre on Erosion and Sedimentation (IRTCS), P.O. Box 366, Beijing, China 100044; phone 8413372; telex 22786 ITCES CN; fax 8412539.

**American Institute of Professional Geologists Annual Meeting**, October 16-19, 1991, Gatlinburg, Tennessee. Information: Lawrence I. Benson, ERC/EDGE, P.O. Box 22879, Knoxville, TN 37933-0879; (615) 966-9761; fax 615-966-4155.

**New York State Geological Association 63rd Annual Field Conference**, October 18-20, 1991, Oneonta, New York. Information: James R. Ebert, Department of Earth Sciences, State University of New York, Oneonta, NY 13820-4015; (607) 431-3065; fax 607-431-2107.

**International Symposium on Geological Hazards and Prevention**, October 20-25, 1991, Beijing, People's Republic of China. Information: Chu Zhanchang, Secretariat, Organizing Committee, International Symposium on Geological Hazards and Prevention,

64, Funei St., Beijing, People's Republic of China; phone 658561-410.

**Geological Society of America Annual Meeting**, October 21-24, 1991, San Diego, California. Information: GSA, Meetings Dept., P.O. Box 9140, Boulder, CO 80301; (303) 447-2020; fax 303-447-1133.

**Brazilian Geophysical Society Second International Congress**, October 28-November 1, 1991, Salvador City, Bahia, Brazil. Information: Brazilian Geophysical Society—SBGf, Alberto Brum Novaes, Universidade Federal da Bahia/UFBA-PPPG, Rua Caetano Moura 123, Federação 40.210, Salvador BA, Brasil; phone 55-071-2370408. (Abstracts deadline: May 31, 1991.)

**November 5th International Circum-Pacific Terrane Conference**, November 11-28, 1991, Santiago, Chile. Information: D. G. Howell, U.S. Geological Survey, MS 902, 345 Middlefield Rd., Menlo Park, CA 94025; (415) 329-5430.

**December Mining Indonesia '91**, December 4-7, 1991, Jakarta, Indonesia. Information: Eileen M. Lavine, Information Services, Inc., 4733 Bethesda Ave., #735, Bethesda, MD 20814; (301) 656-2942; fax 301-656-3179.

## 1991 Penrose Conferences

**February Flow and Associated Transport in Basins: Driving Forces, Coupling and Geologic Controls**, February 25-March 1, 1991, Napa Valley, California. Information: Stuart Rojstaczer, Dept. of Geology/Old Chemistry Bldg., Duke University, Durham, NC 27706, (919) 648-5847; Patrick A. Domenico, Dept. of Geology, Texas A&M University, College Station, TX 77843; (409) 845-2451 (dept.), (409) 845-0636 (dir.).

**October Development and Evolution of Foreland Basins**, October 6-11, 1991, Oliana, Spain. Information: James H. Meyers, Dept. of Geology, Winona State University, Winona, MN 55987; (507) 457-5266 (dir.), (507) 457-5000 (dept.), fax 507-457-5586; Douglas W. Burbank, Dept. of Geological Sciences, University of Southern California, Los Angeles, CA 90089-0740; Lee J. Suttner, Dept. of Geology, Indiana University, Bloomington, IN 47405; Cai Puigdefabregas, Dept. de Política Territorial, Servei Geologic de Catalunya, Diputació, 92, Se, 08015 Barcelona, Spain.

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

## The Geological Society of America

# Research Grants Program 1991



The Geological Society of America will continue its annual Research Grants Program in 1991. Eligibility is not restricted to GSA members. New application forms for the current year and detailed requirements are available each fall in the geology departments of colleges and universities offering graduate degrees in earth sciences. Forms are mailed annually to GSA Campus Representatives and department secretaries and chairmen in the United States and Canada. They are also available upon request from the Research Grants Administrator, Geological Society of America, P.O. Box 9140, Boulder, Colorado 80301. *Please use only the 1991 application and appraisal forms.*

The primary role of the Research Grants Program is to provide partial support for research of graduate students who are candidates for the M.S. or Ph.D. degree at universities in the United States, Canada, Mexico, and Central America. GSA strongly encourages women, minorities, and persons with disabilities to participate fully in this grants program.

The Geological Society of America awarded \$190,900 in grants in 1990. The grants went to 244 students doing research for advanced degrees. The average amount awarded was \$787. The largest grant was \$1,520, but there is no predetermined maximum amount.

Confidential evaluations from two faculty members are required from candidates for the M.S. or Ph.D. degree and must accompany applications submitted. PLEASE USE THE "APPRAISAL OF APPLICANT" FORMS, WHICH ACCOMPANY THE 1991 APPLICATION FORMS.

The Committee on Research Grants will meet in March to evaluate applications and award grants. In April, all applicants for grants will be informed of the committee's actions by the Executive Director of the Geological Society of America.

**ALL APPLICATIONS MUST BE SUBMITTED ON THE 1991 FORMS AND POSTMARKED BY FEBRUARY 15, 1991**

coastal regions respond geologically and ecologically to rising sea level, and how can the contributions from changes in climate (e.g., glacier melting and ocean warming) be differentiated from those due to tectonic processes? (2) What are the effects of volcanic emissions on regional and global climate? (3) How do permafrost regions of the Northern Hemisphere respond to climate warming? (4) How and at what rate do cli-

matically sensitive transition regions respond to climate change and human activities? (5) What are the causes and consequences of crustal deformation processes (e.g., uplift and earthquakes)?

7. Solar Influences: ultraviolet monitoring, atmosphere and solar energy coupling, irradiance, climate and solar record, and proxy measurements and long-term database development. Key questions: (1) What aspects of solar variability are influencing the stratospheric

ozone level? (2) What impacts do other solar inputs, e.g., particles, have on the upper atmosphere and how are they coupled to the other atmospheric regions? (3) How does the sun's output vary, and what is the impact on terrestrial climate? (4) How do upper atmosphere changes induced by solar variability affect the impact of greenhouse gases?

Data Management includes the means and mechanisms to describe, gather, transmit, validate, process, archive, and disseminate

data. Key questions: (1) How can full use be made of existing global change data? (2) How can data sets be built to facilitate early research results from the program?

A future column will address how successful the USGCRP has been in answering the policy-relevant questions posed by the CEES, describe where the money has gone and is going, and discuss the political aspects of global change. ■

GSAF Update continued from p.19

The Lucky Winners

At the conclusion of the Dallas meeting, a drawing was held at the Foundation's exhibit booth. The following are the lucky winners of mineral specimens, books, and videos: Jack A. Simon, Robert R. Shrock, Steven D. Mitchell, Charles H. Summerson, James O. Brown, Edward McFarlan, Jr., Donn S. Gorsline, Melvin C. Schroeder, and Jack C. Rosenau.

Donors to the Foundation October 1990

- Century Challenge**  
Paul Ray Butler  
James R. Clark  
H. Allen Curran  
Bruce R. Doe  
Leon R. Follmer  
Walter D. Gardner  
Rhea L. Graham  
Ralph C. Heath  
Carol T. Hildreth  
Elizabeth A. Holt  
Richard L. Mauger  
James C. Ratte  
Holly J. Stein  
Linda S. Trapasso  
Steven I. Weiss
- DNAG**  
Robert O. Karisian  
Pennzoil Exploration & Production Company\*  
Paul Dean Proctor  
Stephen J. Urbanik
- GEOSTAR Funds**
- Allan V. Cox Scholarship Award**  
Philip H. Close, III  
Maureen P. Leshendok  
Ernest H. Muller  
J. Michael O'Neill  
Victor Vacquier  
Clyde Wahrhaftig\*  
Mary Lou Zoback
- Antoinette Lierman Medlin Scholarship Award**  
Bruce R. Doe  
Juergen Reinhardt
- Archaeological Geology Division**  
William R. Farrand  
Arthur Mirsky \*
- Engineering Geology Division Award**  
Lisle T. Jory  
William R. Judd  
George A. Kiersch
- GEOSTAR**  
John Eliot Allen\*  
Frederick W. Bachhuber\*
- Albert W. Bally\*  
James R. Bauder  
J. Robert Berg\*  
Bruce J. Bilodeau\*  
Kenneth G. Brill, Jr.  
Lawrence R. Cann  
Mark Cloos\*  
H. Basil S. Cooke  
William S. Cordua\*  
Jerry B. Dahm  
Steven N. Daviss\*  
James F. Davis  
Charles S. Denny \*  
Paul L. Drummond  
Steven Esling  
Gilbert H. Espenshade\*  
Orwell Milton Hackett\*  
Mark L. Holmes\*  
Richard A. Hoppin\*  
Walter D. Gardner  
Norma Del Giudice  
Richard P. Goldthwait\*  
A. David Kendrick  
Charles W. Klasse  
James C. Knox  
Robert C. Lafferty\*  
William N. Laval\*  
Ronald J. Lipp  
Mark J. Logsdon  
Frank R. Luther  
Edwin T. McKnight\*  
Duncan A. McNaughton\*  
Malcolm M. Mouat  
William R. Muehlberger\*  
Floyd R. Nave  
William L. Newman  
Alan L. O'Neill\*  
F. H. Pough\*  
Richard H. Ragle  
William A. Ranson  
Leslie Dean Reed  
Marie Siegrist  
Paul K. Sims\*  
Charles H. Summerson\*  
Edward J. Tarback\*  
Roger D. K. Thomas  
Edwin W. Tooker  
Volker C. Vahrenkamp  
John W. Webb\*  
Malcolm P. Weiss\*  
Edmund G. Wermund, Jr.\*  
Virgil D. Winkler\*  
Jean Lower Younker \*  
Peter B. Yuan\*
- Gladys Cole Memorial Award**  
Arthur L. Bloom
- History of Geology Award**  
Robert H. Dott, Jr.  
Arthur Mirsky \*
- Hydrogeology Division Award**  
Jean M. Bahr  
Alfred Clebsch, Jr.  
Claire B. Davidson  
George H. Davis  
Andy Horn  
Nevin D. Hoy  
John E. Nay  
Darryll T. Pederson  
Lyle V. A. Sendlein  
Joe C. Yelderman, Jr.
- Institute for Environmental Education**  
Nancy S. Alexander  
Thomas L. Annaratone\*  
John L. Fauth  
Harry C. Mussman, II
- John C. Frye Environmental Award**  
George T. Cardwell  
George Hallbert  
Frank E. Kottlowski \*  
Sheila M. Roberts  
Atheil G. Unklesbay
- John T. Dillon Alaska Research Award**  
Joseph L. Coronas  
John C. Crowell  
John Thomas Dutro, Jr.  
Elizabeth L. Miller\*  
Douglas C. Pasley, Jr.  
Sarah M. Roeske  
Richard Hugh Sibson  
George R. Tilton\*  
Florence M. Weber
- Memorial Fund**  
Kirk Badgley  
(memory of William J. McMannis)
- Jo Laird\* (memory of Donald L. Biggs)  
Robert D. Lyon\* (memory of Gretchen Louise Blechschmidt)  
Kurt Wilkie (memory of Donald L. Biggs)
- Minority Fund**  
Michele L. Aldrich  
James N. Brune  
Chris I. Chalokwu  
John F. Childs  
Raymond M. Coveney, Jr.  
Jeffrey K. Miller  
Walter C. Pusey, III  
Melvin C. Schroeder  
Richard E. Uthe  
Clyde Wahrhaftig\*  
Howard G. Wilshire\*
- Research Fund**  
Mamoru Adachi  
Roger L. Ames  
Elwood Atherton  
David B. Bannan\*  
Philip C. Bennett  
Mary Lou Bevier  
Marion Eugene Bickford, Jr.  
Ernest W. Blythe, Jr.  
Michael Boran\*  
Robin Brett  
James A. Brown, Jr.\*  
Thomas J. Carrington  
James Channing-Cole\*  
Richard L. Chase  
John F. Childs  
Drew Clemens  
Mark Cloos\*  
Robert F. Dill  
Michael C. Dix  
Glennville Draper  
Steven P. Esling  
W. G. Ernst  
Russell C. Everts  
Charles V. Fulmer  
Robert N. Ginsburg  
Billy P. Glass  
Harry D. Goode\*  
Vivien M. Gornitz  
Edward S. Grew  
Richard H. Groshong, Jr. \*  
Janet Griswold Hammond\*  
William Henry Hays
- Keith A. Howard  
Joseph M. Hull  
Roscoe G. Jackson, II \*  
Tina Jeffers  
D. E. Karig  
William N. Laval\*  
David A. Link  
Stephen F. Lintner  
Christina Lochman-Balk\*  
Christer J. Loftenius  
Heinz A. Lowenstam  
Eric M. Luttrell  
Marathon Oil Company\*  
Larry G. Mastin  
George E. McGill  
Calvin F. Miller  
David M. Miller  
Ernest H. Muller  
William E. Nellist  
Stephen Norwick  
Douglas C. Pasley, Jr.  
Walter C. Pusey, III  
Phyllis M. Radack  
Robert Raymond, Jr.\*  
Mary E. Savina  
Charles B. Sclar  
William E. Scott  
Jane Selverstone  
Michel P. Semet  
Robert P. Sharp  
Marie Siegrist  
Daniel P. Spangler  
Robert Harry Stewart  
Dale Malcolm Stickney\*  
David B. Stone  
Alan M. Stueber  
Edmondo Sugar\*  
Harold H. Sullwold  
Robert J. Weimer  
Ray E. Wells\*  
Don Winston  
Paul A. Witherspoon, Jr.  
Zengliang Xu  
Peter B. Yuan\*
- Judith L. Hannah  
James A. Hartman  
James Fred Haus  
Richard W. Hazlett  
Milton T. Heald  
John J. Hickey  
Melvin J. Hill \*  
Richard K. Hose  
Benjamin F. Howell, Jr.  
Yngvar Isachsen\*  
Kathleen M. Johnson  
James R. Jones  
Donald G. Jordan  
Kenneth F. Keller\*  
William E. Kelly  
Lois S. Kent  
Carl H. Kiesewetter  
John Edward Kilkenny  
Arthur S. Knox  
Paul R. Kopsick  
E. Dean B. Laudeman  
Charles R. Lewis\*  
Henry M. Lieberman  
Karl E. Limper  
Jay Glenn Marks  
Milton R. Marks  
John W. Mason\*  
Vincent Matthews  
Richard L. Mauger  
John C. Maxwell\*  
Edward McFarlan, Jr.  
Richard C. Mielenz\*  
Daniel J. Milton  
Akiho Miyashiro  
Charles B. Moke  
Watson H. Monroe\*  
George E. Moore, Jr.  
Virginia S. Neuschel  
Sherman K. Neuschel  
Donald R. Nichols  
Charles J. Orth  
Elizabeth F. Overstreet  
William C. Overstreet  
Lincoln R. Page\*  
Douglas C. Pasley, Jr.  
Elmer D. Patterson  
Ralph B. Peck\*  
Harriet E. Powell  
Christopher C. Puchner\*  
Richard C. Quittmeyer  
John A. Reinemund  
Coleman R. Robison  
Jack C. Rosenau  
Nathaniel McLean Sage, Jr.  
Edward T. Schenk  
Erwin Schiebner  
Charles E. Sears  
Paul R. Shaffer  
Glenn L. Shepherd\*  
Eli A. Silver  
Clay T. Smith\*  
Myron T. Sturgeon  
Donald A. Swanson  
Rowland W. Tabor  
George C. Taylor, Jr.  
Bennie W. Troxel  
Laurence G. Trudell  
Joseph E. Upson, II  
George P. W. Walker  
Robert F. Walters  
Lawrence A. Warner  
Warren B. Weeks  
Ray E. Wells\*  
W. Arthur White\*  
Jesse W. Whitlow  
John W. Williams  
James E. Wilson\*  
Leonard Alton Wood

advertisement

POSITION OPEN

Geophysicist or Geologist

The U.S. Geological Survey, Office of Earthquakes, Volcanoes, and Engineering, Branch of Geologic Risk Assessment, is soliciting applications from geophysicists or geologists with a strong record of demonstrated ability or outstanding potential for basic and applied research in seismotectonics, especially as it relates to intraplate regions and structure and neotectonics of the lithosphere, particularly the crust. The position also involves participation in the management of new USGS initiatives in the New Madrid region under the National Earthquake Hazards Reduction Program (NEHRP). The position will be based at the Center for Earthquake Research and Information (CERI), Memphis State University, in Memphis, Tennessee.

Research opportunities include independent and collaborative seismotectonic studies that may include analyses of earthquake data from the local and regional networks of seismographs in the central US for the determination of seismotectonic structure and earthquake source characteristics or investigations of the structure and neotectonic processes of the lithosphere, especially the crust, in the central US. Significant interaction with the scientists and projects of CERI and other groups studying the central US is expected. The successful candidate is expected to have demonstrated an ability to integrate complementary geologic, geomechanic, and geophysical data in the interpretation of the seismotectonic structure and processes of intraplate regions.


The salary level for federal employment depends upon education, experience, and accomplishments. Applications will be reviewed by a search committee. Interested persons should submit a detailed resume of education, experience, and publications; a summary of research interests; and a completed Application for Federal Employment (Standard Form 171, available from the address below or any US Government Office of Personnel Management) by January 31, 1991, to:

Kaye Shedlock  
USGS - MS 966, Box 25046  
Denver Federal Center  
Denver, CO 80225

The US Geological Survey is an Equal Opportunity Employer. US citizenship is required.

**Women in Science**  
Helen L. Cannon  
Marta Corbin  
Chester L. Dodson  
Jessica E. Donovan\*  
Charlotte K. Johnson  
Marcia E. Kinadle  
Christina Lochman-Balk\*  
Daniel B. Sass  
Ruth D. Terzaghi

\* Second Century Club—gifts of \$100 or more



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

Enclosed please find my contribution in the amount of \$ \_\_\_\_\_ to:

GEOSTAR Unrestricted  
 SAGE  
 DNAG

PLEASE PRINT

Name \_\_\_\_\_

Address \_\_\_\_\_

City/State/ZIP \_\_\_\_\_

Phone \_\_\_\_\_

## CLASSIFIED ADVERTISING

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

Classification	Per line for each add'l month (same ad)	
	1st month	Per Line for each add'l month (same ad)
Situations Wanted	\$1.75	\$1.40
Positions Open	\$4.50	\$3.80
Consultants	\$4.50	\$3.80
Services & Supplies	\$4.50	\$3.80
Opportunities for Students	\$0.00	\$1.35
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.

### Situations Wanted

**TEACHING POSITION:** sabbatical replacement for a quarter/semester. Ph.D. Intro, Physical Geology, Structure, Mineralogy/Ig.-Met. Petrology. Academic year 1990-91. Reply GSA Code #1050. X1/91

### Positions Open

**STRATIGRAPHER/BASIN ANALYST**  
Department of Geology, Florida State University, invites applications for an anticipated tenure-track assistant-professor position to begin August 1991. Applicants should have a Ph.D. with demonstrated research potential in the area of stratigraphy. Specializations may include (but are not restricted to) general stratigraphy, basin analysis, isotope stratigraphy, seismic stratigraphy, or magnetostratigraphy. The successful candidate will be expected to conduct an active research program, supervise graduate theses and dissertations, and share the department's strong commitment to both graduate and undergraduate education. Teaching duties will include development of courses in areas of speciality, and instruction at graduate and undergraduate levels (including an undergraduate stratigraphy course). Opportunities exist for interaction with existing research programs in marine geology, sedimentology, hydrology, biostratigraphy and structure/tectonics. Salary will be competitive. Applicants should submit a curriculum vitae, a statement of research interests, and the names of three references to Dr. James Tull, Department of Geology, Florida State University, Tallahassee, Florida, 32306 (Bitnet: geology@fsu; MCI Mail: 361-5445; TELEX: 6503615445). Phone: (904) 644-5860. The closing date is February 15, 1991. Florida State University is an equal-opportunity/affirmative-action employer. X1/91

**COLBY COLLEGE**  
The Department of Geology at Colby College seeks to fill a tenure-track position in Groundwater Hydrology and Environmental Geology at the assistant professor level, beginning September 1, 1991. Qualified women candidates will also be considered for appointment as Claire Boothe Luce Assistant Professor of Geology. Courses to be taught will include groundwater hydrology, environmental geology, structural geology, a course in the candidate's subdiscipline, and alternating duties in the introductory physical geology course. Average teaching load 4-5 courses per year, including appropriate laboratories and the January term. Applicants should have completed all Ph.D. requirements and expect to have degree in hand by September 1, 1991. Please submit letter of application, resume, undergraduate and graduate transcripts, and names of three references by January 15, 1991 to: Associate Professor Robert E. Nelson, Chair, Department of Geology, Colby College, Waterville, ME 04901-4799. Colby is an AA/EO Employer and encourages applications from women and minorities. X1/91

**NORTH DAKOTA STATE GEOLOGIST**  
**\$45,000-\$60,000**  
Directs activities of ND Geological Survey. Oversees geologic, paleontological research. Disseminates information relating to ND geology, oil and gas, minerals and ground water resources. Regulates certain mineral related activities. Responsible for management of staff, budget, research projects, rules and regulations. Develops long range plans and goals. Liaison to federal government on geologic issues.

Requires high degree of communication skills (orally and written), completion of a minimum of a masters degree in geology with a doctoral degree preferred, and a minimum of ten years related experience.

Send resume: Karlene Fine, Industrial Commission, State Capitol, Bismarck, ND 58505. Application deadline: Jan. 15, 1991. More details 701-224-3722 EOE/AA.

**RADIOACTIVE WASTE DIVISION DIRECTOR**  
**Agency of Natural Resources**  
**Waterbury, Vermont**  
Permanent, full-time position to manage, plan, organize and direct administration of a low-level waste program.

Masters degree in engineering, geology, geohydrology, physics or chemistry. Five years professional level in a waste management field including two years supervisory experience.

Send standard State application form and resume to State Department of Personnel, 110 State Street,

Montpelier, Vermont 05602, (802) 828-3483. Application forms are available at this address. Inquiries may be directed to the program supervisor at (802) 244-5164. State of Vermont. Equal Opportunity Employer.

**HYDROGEOLOGIST**  
**UNIVERSITY OF TENNESSEE, KNOXVILLE**  
The Department of Geological Sciences seeks applications for the Jones Hydrogeology Professorship in hydrogeology, a tenure-track teaching/research position to be filled at the assistant professor level beginning August, 1991. The area of specialization in hydrogeology is open, but a Ph.D. in hydrogeology or in a closely related field is required. The appointee is expected to teach graduate and undergraduate courses, develop a strong research program and interact with Geology faculty and scientists at nearby Oak Ridge National Laboratory.

Applicants should submit, by January 15, 1991 a complete resume, graduate transcripts, a statement of research and teaching plans, and the names and addresses of at least three references to Professor Kula C. Misra, Hydrogeologist Search Committee Chair, Department of Geological Sciences, University of Tennessee, Knoxville, TN 37996-1410. UTK is an EEO/AA/Title IX/ Section 504 employer. X1/91

### Opportunities for Students

**Graduate Research Assistantships** in Geophysics, Geohydrology, Petroleum Research, The University of Kansas. Opportunities for graduate study at M.S. or Ph.D. level while assisting and conducting research with faculty-equivalent staff at the Kansas Geological Survey. Assistantships available at one-half time during academic year and full-time during summers. For further information and/or application, please write: Dr. Don Steeples, Kansas Geological Survey, 1930 Constant Avenue, Campus West, The University of Kansas, Lawrence, KS 66047, (913) 864-3965. An Equal Opportunity/ Affirmative Action Employer. X1/91

## Mt. Eden Books & Bindery

Specializing in out-of-print and rare books in the **GEOLOGICAL SCIENCES**. Including USGS publications, general geology, mining, paleontology, geophysics, hydrology, mineralogy, etc.

### FREE SEARCH SERVICE

For FREE catalog contact us at  
P.O. Box 421  
Mt. Eden, CA 94557  
(415) 782-7723

## NEW ADDRESS?

If you're planning on changing your address, simply clip out the mailing label on the cover, give us your new address, and mail both to:  
GSA Membership Services,  
P.O. Box 9140, Boulder, CO 80301.  
Or you may call with your change of address information at  
(303) 447-2020 or 1-800-472-1988.

Many geologists have discovered

# Notebook II Plus

A textual data and bibliographic reference management system

Shouldn't you?

If you have ever spent an hour (or two) searching through your office for your lecture notes from last term, or misplaced a note with a key reference for your manuscript, or been distracted from your research by publishing style requirements for bibliographic citations — Notebook II Plus can be very useful.

Notebook II Plus combines a powerful textual data management program with a superior bibliographic citation system. Together, they can help prevent your research from becoming re-search.

- **Organize, file, and cross reference** research and lecture notes, lab notes, field notes, chronologies, discussion or exam questions, news clippings, address files, bibliographic references, and any other type of textual material.
- **Search, sort, index, and print** textual material in just about any form you like. Output can be sent directly to a printer, or to a diskfile you can edit with your word processor.
- **Generate bibliographies and reference lists** automatically in any of over 700 citation styles for academic journal and press editors, including GSA, ACS, ASM, CBE, Chicago B, and many styles required by Earth Science & Geological publishers.

The program lets you tag your notes and other textual data with an unlimited number of keywords. You can use Notebook II's built in text editor to take all the notes you want, or read in files from your word processor. You can use keywords (or any phrase you choose) to select all your notes on similar topics. Notebook manages up to 50 fields and 20 pages of text per record.

The New York Times says "... the amount of time, error, and frustration Notebook II can save for those needing to annotate their writing is simply amazing." And another critic says, "Once you find out what this program can do, it's my guess that you'll want a copy... fast."

We think you'll agree. At \$363, Notebook II Plus is a real find.

**OBERON RESOURCES**

147 East Oakland Avenue Columbus, Ohio 43201  
1 • 800 • 594 • 9062

## PLANETARY GEOSCIENTIST

Jet Propulsion Laboratory, in Southern California, currently has opportunities for Research Scientists in the fields of planetary geology and planetary geophysics.

The opportunities involve studies of the geologic and geophysical processes of the terrestrial planets, particularly Moon and Mars. The selected candidate should be capable of applying modern quantitative techniques and approaches to planetary problems and have a Ph.D in geologic/geophysical sciences, plus have experience in planetary science.

Both established researchers and new researchers are encouraged to apply and will be considered. To apply, please send a statement of research interest, resume and the name of at least 3 references who are familiar with the candidate's research and potential to Dr. Jeffrey Plescia, Department T-98, Jet Propulsion Laboratory, Earth and Space Systems Division, MS 183-335, Pasadena, CA 91109. For further information contact Dr. Plescia at (818) 354-6936. Equal Opportunity Employer.

**JPL**  
Jet Propulsion Laboratory  
California Institute of Technology

“VG Instruments' commitment to the earth science community provides a comprehensive range of instruments dedicated to all aspects of geological research.”

### The VG IsoLab

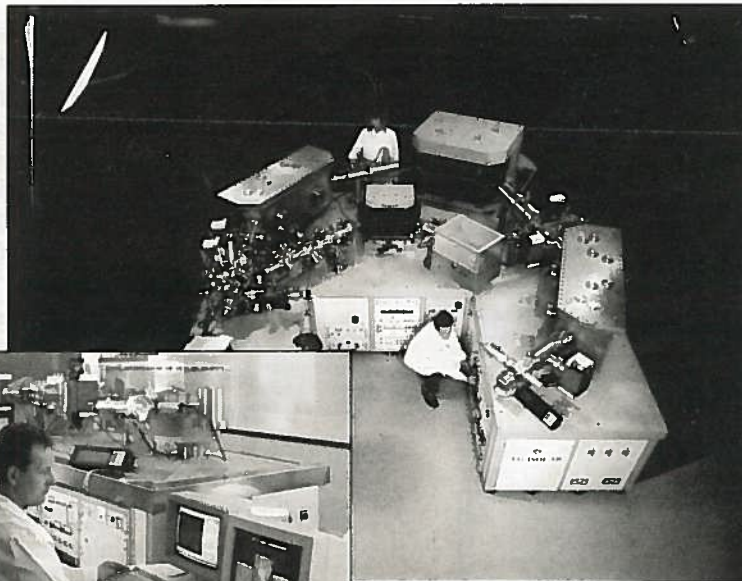
The VG IsoLab takes the geologist into a new realm of sensitivity. The instrument provides the ultimate isotope ratio precision obtainable using an ion microprobe, through the use of a unique multiple collection system. The exciting new technique of Hot SIMS gives vastly improved sensitivity. The IsoLab gives unrivalled abundance sensitivity with all ion sources.

### Noble Gas Mass Spectrometry

The VG Model 5400, a noble gas mass spectrometer, provides the ultimate in performance.

### Thermal Ionization Mass Spectrometry

The VG Sector 54 provides the flexibility and performance for all geological research. The electrostatic filter (ESF) for the VG Sector 54 provides very high abundance sensitivity for critical applications.



VG IsoLab 120

### Stable Isotope Mass Spectrometry

A new concept in stable MS, the OPTIMA, takes the technique to new levels of performance, flexibility and ease of use. A wide range of accessories including GC-Combustion - MS are available for the OPTIMA.



**VG INSTRUMENTS**

VG Instruments Inc.  
32 Commerce Center  
Cherry Hill Drive, Danvers  
Massachusetts 01923  
Telephone: (508) 777 8034  
Telex: 6819094

**FISONS**  
instruments

## Recently released titles from GSA

from the  
**GSA Bookshelf**  
available from  
GSA  
Publication Sales  
1-800-472-1988

GSA PUBLICATION SALES  
P.O. BOX 9140, BOULDER, CO 80301

Geophysical Framework of the Continental United States, edited by L. C. Pakiser and W. D. Mooney, MWR172, \$92.50

The Nature and Origin of Cordilleran Magmatism, edited by J. L. Anderson, MWR174, \$65.00

Style and Mechanics of Liquefaction-Related Deformation, Lower Absaroka Volcanic Supergroup (Eocene), Wyoming, by Paul L. Decker, SPE240, \$32.50

Establishment of a Geologic Framework for Paleo-anthropology, edited by L. F. Laporte, SPE242, \$22.50

Dawn of the Age of Mammals in the Northern Part of the Rocky Mountain Interior, edited by T. M. Bown and K. D. Rose, SPE243, \$45.00

Volcanism and Fossil Biotas, edited by M. Lockley and A. Rice, SPE244, \$27.50

Geology of the Composite Avalon Terrane of Southern New England, edited by Anthony D. Socci, James W. Skehan, and Geoffrey W. Smith, SPE245, \$45.00

Ore-Bearing Granite Systems; Petrogenesis and Mineralizing Processes, edited by H. J. Stein and J. L. Hannah, SPE246, \$65.00

Recent Advances in Coal Geochemistry, edited by L. Lynn Chyi and C. L. Chou, SPE248, \$22.50

The Cretaceous/Tertiary Boundary Interval, Raton Basin, Colorado and New Mexico, and its Content of Shock-Metamorphosed Minerals; Evidence Relevant to the K/T Boundary Impact-Extinction Theory, by Glen A. Izett, SPE249, \$30.00

Late Quaternary History of the Lake Michigan Basin, edited by A. F. Schneider and G. S. Fraser, 1990 SPE251, \$32.50

Ground Water Geomorphology; The Role of Sub-surface Water in Earth-Surface Processes and Land-forms, edited by C. G. Higgins and D. R. Coates, SPE252, (in press 1/91)

GSA Centennial Articles, Reprinted from Vol. 100 of GSA Bulletin, edited by R. D. Hatcher, Jr., and W. A. Thomas, SPE253, \$24.50

The Appalachian-Ouachita Orogen in the United States, edited by Robert D. Hatcher, Jr., William A. Thomas, and George W. Viele, GNA-F2, \$75.00

The Caribbean Region, edited by G. Dengo and J. E. Case, GNA-H, \$80.00

The Arctic Ocean Region, edited by Arthur Grantz, L. Johnson, and J. F. Sweeney, GNA-L, \$85.00

Surface Water Hydrology, edited by M. G. Wolman and H. C. Riggs, GNA-O1, \$60.00

Archaeological Geology of North America, edited by N. P. Lasca and J. Donahue, CSV004, \$62.50

### TITLES NOW OUT-OF-PRINT (12/90)

Stratigraphy and Depositional History of the Star Peak Group (Triassic), Northwestern Nevada (SPE178); Selected Studies of Archean Gneisses and Lower Proterozoic Rocks, Southern Canadian Shield (SPE182); Geological Implications of Impacts of Large Asteroids and Comets on the Earth (SPE190); Studies in New England Geology (MWR146).

DNAG CENTENNIAL SPECIAL VOLUMES

## ARCHAEOLOGICAL GEOLOGY OF NORTH AMERICA

edited by N.P. Lasca and J. Donahue, 1990

This volume covers the geological aspects of archaeology from both regional and topical perspectives in an attempt to reflect the diverse and heterogeneous nature of archaeological geology. Of the 28 chapters, some are site-specific archaeological investigations that typify a variety of other sites: for example, the Commins site, Canada; the Calico site, California; and the Teotihuacan site, Mexico. Others summarize the archaeological geology of regions such as Alaska, western Canada, glacial Lake Agassiz basin, the central and southern Great Plains, or the North American continental shelf. Others focus more generally on topics such as the old copper industry of the continent, point-bar geoarchaeology of the Savannah River valley, and molluscs and coastal archaeology. Finally, a section on techniques includes chapters on geophysics, isotope geochemistry, pedology, and stratigraphic nomenclature as each applies to archaeology.

CSV004, 543 p., indexed, hardbound, ISBN 0-8137-5304-X, \$62.50

GSA Publication Sales • P.O. Box 9140, Boulder, CO 80301  
1-800-472-1988 • (303) 447-2020

MEMOIRS

## THE NATURE & ORIGIN OF CORDILLERAN MAGMATISM

edited by J. Lawford Anderson, 1990

The North American Cordillera records the tectonic, metamorphic, and magmatic history of a continental margin active since the middle Paleozoic. Many fine volumes deal with regional tectonics, metamorphism, core complexes, and paleogeography, but until now no comparable set of papers has dealt with the remarkable compositional span of igneous activity that characterizes the orogen. These papers are from individuals doing research in specific areas of the orogen, and emphasize magma genesis (including the role of multiple source control and changes of magmatic trends caused by fractional crystallization), assimilative fractional crystallization, and mixing. Here is an abundance of new data and exciting interpretations of the Mesozoic and Tertiary igneous suites of the Cordillera from Baja California to Alaska, including work in the Peninsular Ranges batholith, Transverse Ranges, Mojave Desert and Lake Mead regions, Sierra Nevada batholith, Salinian magmatic arc, Great Basin, Klamath Mountains, Idaho batholith, Colville igneous complex, and Coast batholith.

MWR174, 440 p., indexed, hardbound, ISBN 0-8137-1174-6, \$65.00

GSA Publication Sales • P.O. Box 9140 • Boulder, CO 80301 • 1-800-472-1988