Vol. 6, No. 12 December 1996

GSA TODAY

A Publication of the Geological Society of America

INSIDE

STRATA: Freeware for analyzing classic stratigraphic problems

Peter B. Flemings, *Department of Geosciences, Pennsylvania State University, University Park, PA 16802*
John P. Grotzinger, *Department of Earth and Planetary Sciences, Massachusetts Institute of Technology, Cambridge, MA 02139*

ABSTRACT

We use STRATA, a stratigraphic modeling package we have developed, to describe and illustrate several classic problems in both siliciclastic and carbonate stratigraphy that are still debated. Two simulations of clastic deposition show that, given constant subsidence rate, stratigraphic sequences can be generated by either eustatic sea-level change or variations in sediment supply, and that the resulting stratigraphic architectures are extremely similar. Two examples of carbonate deposition illuminate the development of meter-scale shallowing cycles, and a mechanism for generating "cycle bundling" that results from the interaction of sea-level change and the intrinsic dynamics of the carbonate system. Ultimately, stratigraphic models are most useful as a way of testing hypotheses of stratigraphic accumulation. We have found STRATA useful in research as well as geological education (it forms an integral component of stratigraphy classes at Penn State and MIT). We are releasing it as freeware over the Internet (http://hydro.geosc.psu.edu).

INTRODUCTION

Over the past two decades there has been a tremendous improvement in our ability to observe, describe, and interpret the stratigraphic record, made possible in large part by the advent of high-resolution seismic stratigraphic methods (e.g., Vail et al., 1977; Haq et al., 1987; Posamentier and Vail, 1988; Van Wagoner et al., 1990; Van Wagoner, 1995b; Christie-Blick, 1991; Christie-Blick and Driscoll, 1995). Forward modeling, which links sediment transport with basin subsidence, has played an important role in interpreting how complex depositional processes interact through time to produce the architectures observed in stratified sedimentary rocks (Read et al., 1986; Jervey, 1988; Jordan and Flemings, 1991; Lawrence et al., 1990). Developments in these fields have been extremely rapid. As a result, the literature is voluminous, and, particularly for those not intimately familiar with seismic and sequence stratigraphy, the terminology can be formidable (Van Wagoner, 1995a).

With the caveat that forward models are no better than their assumptions, either explicit or implied, stratigraphic modeling provides an objective basis for researchers to independently test hypotheses conceived in the field, or for teachers to illustrate complex sequence stratigraphic concepts with a minimum exposure to terminology. From a pedagogical perspective, an important advantage of forward models is that they can illustrate stratigraphic development through time, whereas the rock record provides only the final result, from which previous stages of evolution must be inferred.

It is now generally accepted that the three most important variables controlling stratigraphic geometry and the distribution

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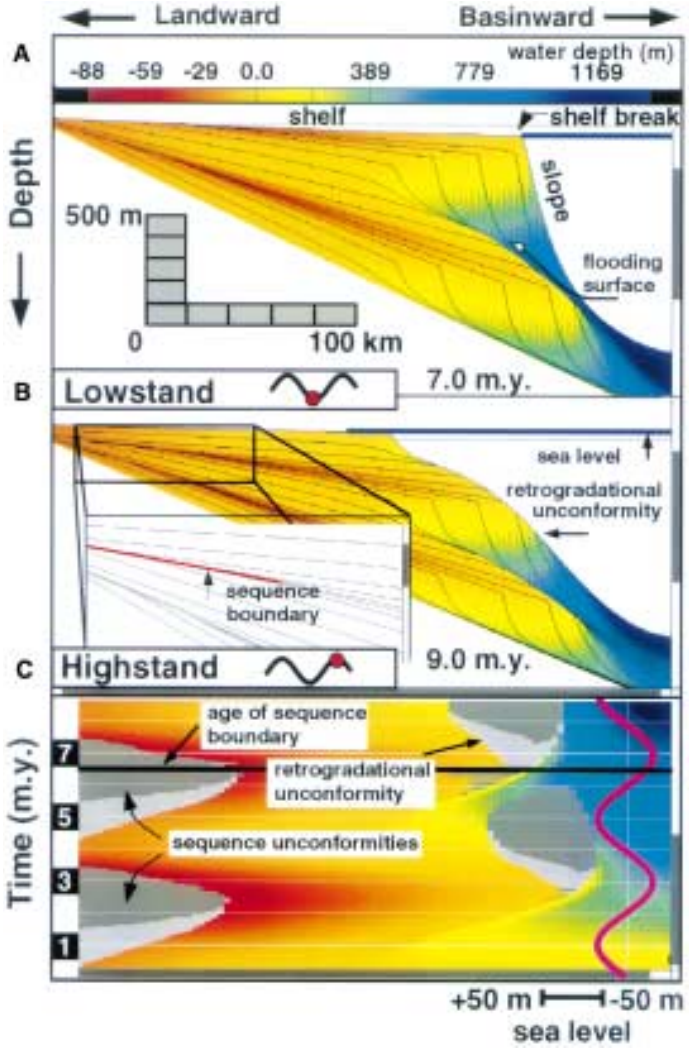

Figure 1. Generation of depositional sequences by eustatic sea-level change. A and B: Depth cross sections of evolving sedimentary basin at two time-steps (7 and 9 m.y.). Inset in B expands the sequence-boundary unconformity formed during falling sea level. Colors record water depth at which stratum accumulated (scale at top). Horizontal dashed line is a fixed reference datum (0 m absolute sea level); dark blue horizontal line marks sea-level position at the time of the display. Strata between successive black "time lines" were all deposited over the same 0.5 m.y. interval. C: Wheeler or chronostratigraphic diagram (vertical axis is time instead of depth). Gray areas represent lacunae, locations and times for which no deposition is recorded. Light gray records degradational vacuity (e.g., times and locations for which deposition occurred, but later the strata were eroded). Dark gray records hiatuses (e.g., times and locations for which there was no deposition). Eustatic sea-level history is shown on right-hand side. Parameters are listed in Table 1.

GSA TODAY *December*
Vol. 6, No. 12 *1996*

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of unconformities are tectonic subsidence, eustasy, and sediment flux (Christie-Blick and Driscoll, 1995). Simple as it seems, separation of these variables on the basis of field data alone, or using sophisticated inversion techniques (Kominz and Bond, 1990), can be troublesome (Kendall and Lerche, 1988). In contrast, forward numerical modeling provides the user with clear information about what the role and relative importance of the different variables can be. Despite their simplicity, forward models produce remarkably realistic results and generate many of the characteristics commonly observed in the stratigraphic record.

In this paper, we use STRATA to describe and illustrate several classic problems in both siliciclastic and carbonate stratigraphy that are still debated. We hope that these simple examples will serve as a foundation for other workers to use this stratigraphic model in their own efforts to understand the stratigraphic record.

SILICICLASTIC STRATIGRAPHY

Modeling Siliciclastic Deposition

STRATA assumes that sediment transport, or flux, is proportional to slope. When combined with the assumption of conservation of mass, the result is the diffusion equation

$$\frac{\partial h}{\partial t} = K \frac{\partial^2 h}{\partial x^2}, \qquad (1)$$

where h is elevation, t is time, K is the diffusivity constant, and x is horizontal position. Equation 1 states that deposition or erosion is proportional to the change in local topographic slope. Diffusive processes are those in which the time-rate of change of some property is proportional to spatial gradients in that property (e.g., heat conduction, Darcy flow, or chemical dispersion of solutes). The advantage of this approach is that a single equation can produce a broad range of stratal geometries that result from variations in initial and boundary conditions. The disadvantage of the diffusion-based approach is that it is a gross approximation of sediment transport behavior.

This approach has been applied in a wide variety of depositional settings. Begin et al. (1981) and Kenyon and Turcotte (1985) proposed that sediment transport could be described as a diffusive process in fluvial and deltaic environments, respectively. Jordan and Flemings (1991) linked these approaches to simulate stratigraphy in an evolving basin. Kaufman et al. (1991) proposed that the diffusion constant (K) declined as a function of water depth in marine settings. Paola et al. (1992) derived equation 1 for braided and meandering fluvial settings, and Rivaneaes (1992) used a multicomponent diffusion equation to describe the transport of individual grain sizes.

Siliciclastic Depositional Sequences

Shallowing-upward, siliciclastic depositional sequences, overlain by relatively deep water facies, are one of the most commonly observed signatures in the stratigraphic record. Over the past century, stratigraphers have come to understand that this basic attribute can be mapped in three dimensions and through time. For example, the depositional sequence often is interpreted to record progradation (basinward shift of facies) followed by retrogradation (landward shift of facies) driven by relative changes in sea level (Vail et al., 1977; Christie-Blick and Driscoll, 1995).

Two simulations of passive margin depositional sequences are illustrated. The first is caused by absolute (eustatic) sea-level change (Fig. 1). The second is driven by changes in sediment supply (Fig. 2). We assume for both simulations that the subsidence rate is zero at the left (landward) margin and increases linearly to the right (basinward). For the first example (Fig. 1),

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George Tunnell
Montecito, California
July 4, 1996

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sediment is supplied at a constant rate along the left-hand margin, no outflux is allowed to occur along the right margin, and sea level is varied sinusoidally with a 4 m.y. period and an amplitude of 50 m.

The model results are shown in the form of a lithostratigraphic cross section at two different times during the evolution of this basin (Fig. 1, A and B). At each point in the simulation, the depositional surface has a flat "shelf" on the landward (left) side which merges with a steeper "slope" on the basinward (right) side (Fig. 1A). This geometry is simulated by varying the diffusion constant (K) so that it decreases as a function of water depth; this approximates the more efficient sediment transport found in the fluvial and shallow-marine environment relative to that in the deeper marine environment. Shelf sediments are deposited at shallow depths (shaded yellow to red in Fig. 1). In contrast, slope sediments are deposited in deeper water (shaded in blue). The boundary between the shelf and slope is referred to as the shelf break (Fig. 1A).

Lowering and subsequently raising absolute sea level (Fig. 1, A and B) produces progradation (migration of the shelf break basinward [right]) (Fig. 1A) followed by retrogradation (migration of the shelf break landward [left]) (Fig. 1B). Maximum progradation is coincident with the eustatic sea-level lowstand (dark blue line in Fig. 1A is 50 m below dashed line, which is a fixed datum). Maximum retrogradation occurs slightly before the highstand in sea level (Fig. 1B).

The model generates two unconformities. The first unconformity is the sequence boundary and is formed during sea-level fall; this unconformity develops on the landward side of the basin (left). As the shelf break migrates basinward during progradation, the unconformity also propagates basinward. This unconformity exposes older strata to erosion and is marked by the intersection and truncation of the timelines at the topographic surface (Fig. 1A). This unconformity is then onlapped during the ensuing retrogradation (Fig. 1B, inset). The second unconformity is a marine unconformity formed during retrogradation. During sea-level rise, the relict shelf break is eroded (Fig. 1B) before it is ultimately overlain by downlapping strata during the ensuing progradational cycle. A chronostratigraphic plot known as a Wheeler diagram (Fig. 1C; Wheeler, 1964) is particularly useful for visualizing how unconformities develop in time. Both the progradational

STRATA *continued on p. 4*

TABLE 1. PARAMETERS FOR FIGURES 1, 2, 4, AND 5

Fig.	Width (km)	Subsidence rate (mm/yr)	Nonmarine diffusion constant (m^2/yr)	Marine diffusion constant (m^2/yr)	Sea-level 1st order amplitude (m)	Sea-level 1st order period (m.y.)	Sea-level 2nd order amplitude (m)	Sea-level 2nd order period (m.y.)	Sediment flux (m^2/yr)	Max. carbonate sed. rate (mm/yr)
1	300	0.200	50,000	200	50.00	4.00	0.000	-	20	-
2	300	0.200	50,000	200	0.00	-	-	-	Variable 0–40	-
4	150	0.027	10	10	2.00	0.724	1.750	0.120	0.00	0.30
5	600	0.029	1	1	1.00	0.100	-	-	0.00	0.50

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(sequence boundary) and the retrogradational unconformities are clearly illustrated.

The simulated stratigraphy (Fig. 1) captures much of what we observe in depositional sequences and provides insight as to how these stratigraphic architectures might evolve. Sequence boundaries are formed during sea-level fall as the landward unconformity steps basinward (Fig. 1, A and C). When the rate of sea-level fall decreases, the unconformity is covered by sedimentation (onlapped) progressively from right to left (Fig. 1, B and C). During this time, subsidence continues in the basinward zone (right), and the old shelf break is drowned and eroded. This retrogradational unconformity is analogous to a transgressive ravinement surface (e.g., Nummedal and Swift, 1987). Above this unconformity, a marine flooding surface is formed (marked by blue over orange in Fig. 1B). Between any two progradational unconformities (which form sequence boundaries) lies one depositional sequence. Figure 1C suggests that sequence boundary unconformities shrink basinward and ultimately converge with the overlying flooding surfaces as actually observed in outcrop (e.g., Van Wagoner, 1995b).

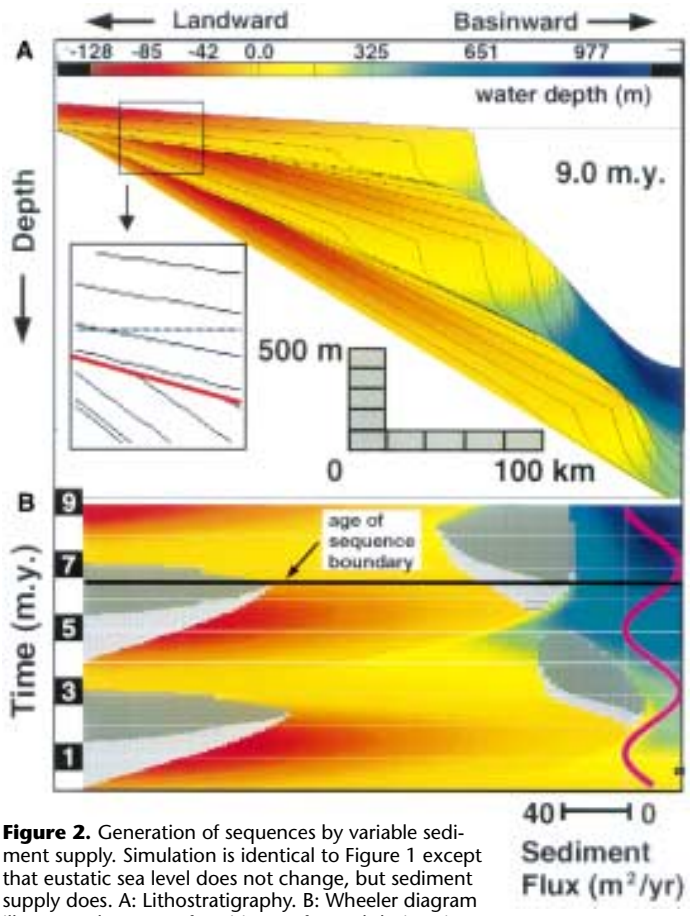

Figure 2. Generation of sequences by variable sediment supply. Simulation is identical to Figure 1 except that eustatic sea level does not change, but sediment supply does. A: Lithostratigraphy. B: Wheeler diagram illustrates that unconformities are formed during times of decreasing sediment supply. Note similarity of Figure 2 to Figure 1, even though the driving mechanism is different. Parameters are listed in Table 1.

Figure 3. The Milroy Member of the Middle Ordovician Loysburg Formation (person at lower right is about 2 m tall). Four of the six measured carbonate cycles are visible; the dashed lines delineate their tops. Darker rock is the subtidal facies; lighter rock is the intertidal facies. Cycle thicknesses are greater at the base and thinner in the middle. Located at intersection of Rt. 322 and Rt. 26, State College, Pennsylvania.

The temporal evolution of the sequence boundary unconformity portrayed here (Fig. 1C) has important implications for the interpretation of the timing of eustatic sea-level change. The approach espoused by Vail (1977) is to assume that onlap of the sequence boundary occurs slowly through time and that offlap, or formation of the sequence boundary, is instantaneous. In contrast, the results presented here suggest that erosion starts at the landward (left) side much earlier than at the basinward (right) side, as was originally predicted by Wheeler (1964). In accordance with the original prediction of Pitman (1978) and with the current Exxon approach to interpreting the timing of sea-level fall (Posamentier and Vail, 1988), the maximum rate of sea-level fall (the time of minimum creation of accommodation space) is roughly coincident with the onset of onlap of the sequence boundary (Fig. 1C) (see Christie-Blick and Driscoll [1995] for further discussion).

Flux-Driven Depositional Sequences

We contrast the eustatically driven depositional sequence (Fig. 1) with one driven by sediment supply (Fig. 2). Sediment supply is input from the left margin and changes sinusoidally with an amplitude of 20 m^2/yr and a period of 4 m.y. (Fig. 2B). Progradations and retrogradations correlate to increases and decreases in the rate of sediment supply. The progradational unconformity, or sequence boundary, is formed during times of decreasing sediment supply, while the retrogradational unconformity is formed during times of increasing sediment supply (Fig. 2B). In this case, the age of the sequence boundary (determined by the age of the first strata to onlap the unconformity) slightly postdates the maximum rate of decrease in sediment supply (Fig. 2B). This occurs in much the same manner as in the case of a sea-level–driven sequence (Fig. 1), for which the age of the unconformity immediately postdates the maximum rate of fall in sea level. The sediment-flux–driven simulation (Fig. 2) is extremely similar to the sea-level–driven example (Fig. 1).

This illustrates the complexity of the base-level concept. Variable sediment supply, coupled with constant subsidence, naturally results in stacked depositional sequences. Galloway (1989) emphasized that certain depositional sequences are driven by delta-lobe switching, rather than eustasy. STRATA (Fig. 2) clearly supports the plausibility of this alternative mechanism. Furthermore, unlike the prediction of Christie-Blick (1991), it appears to generate depositional sequences that are essentially indistinguishable from those generated by sea-level change. Jordan and Flemings (1991) showed that variable subsidence also can generate stratigraphic sequences, but we do not explore this here.

CARBONATE STRATIGRAPHY

Carbonate sedimentation differs fundamentally from clastic sedimentation, because most carbonate sediments are produced within, rather than external to, the sedimentary basin. Therefore, carbonate sediment generally does not undergo the extreme lateral sediment transport typical of siliciclastic sediment (Wilson, 1975). Studies of modern carbonate depositional environments show that carbonate production rates are extremely high in shal-

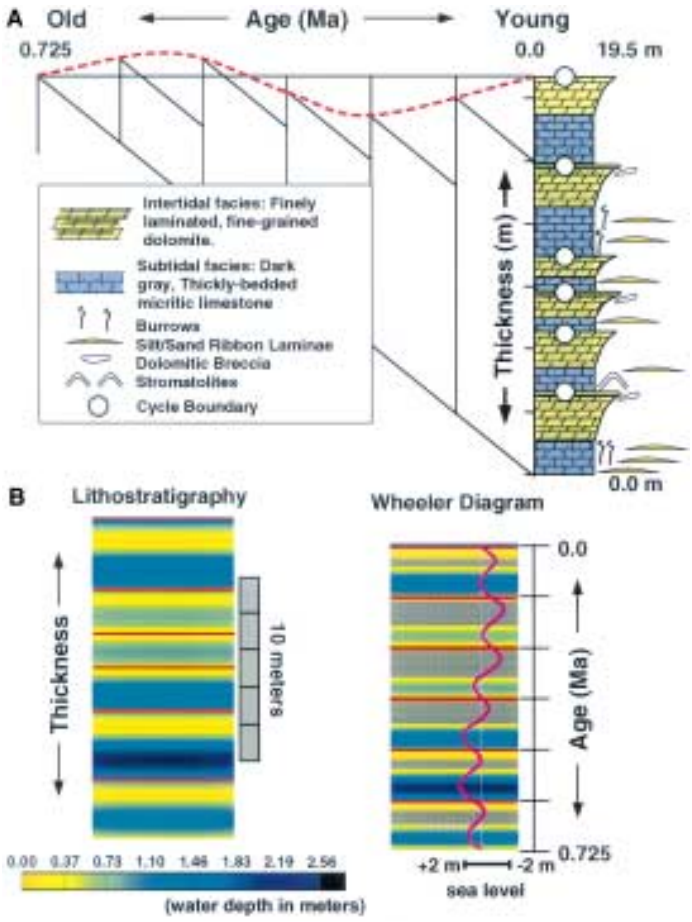

Figure 4. A: Fischer plot (left) and measured section of Milroy Member (right). B: Lithostratigraphy and Wheeler diagram simulated by STRATA. Red horizontal lines mark 0.12 m.y. intervals, which correspond to the cycle durations. Gray zones are disconformities. Parameters are illustrated in Table 1. The 0.725 m.y. duration of this section was calculated by dividing the thickness of these rocks (19.5 m) by the mean accumulation rate (during the Middle Ordovician) of these strata (0.027 mm/yr). Similarly, the 0.12 m.y. cycle duration is interpreted by dividing the total duration (0.725 m.y.) by the number of cycles (six).

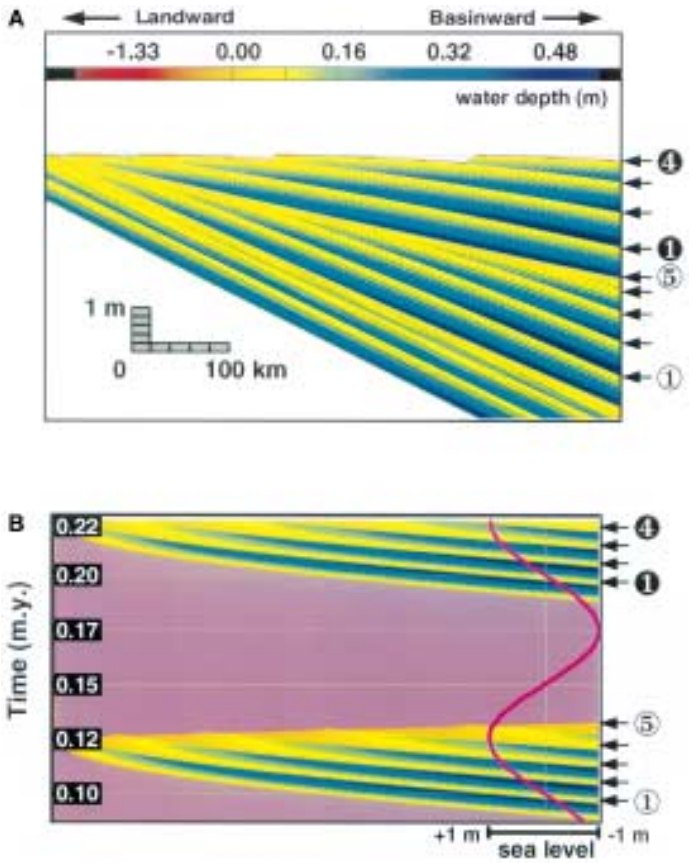

Figure 5. A: Cycle bundling as a result of "autocyclic" sedimentation dynamics. A 0.1 m.y. sea-level oscillation with a 1 m amplitude is imposed on a subsiding basin. Five cycles (circled numbers) are formed during the rising limb of the 0.1 m.y. sea-level change (fifth cycle has not yet formed for last 0.1 m.y. cycle). Deposition results in aggradation to sea level when it then stops for the 7000 yr lag time before it begins again; fortuitously, 5:1 cycle bundling is produced. B: In this Wheeler diagram, major unconformities tie to falling sea level. High-frequency cycles are diachronous, intersecting progressively younger time lines from right to left. Cycles are thickest at the base, during the maximum rate of rise of long-term sea level. Parameters used are illustrated in Table 1.

low water (1–1000 mm/yr) but decline rapidly within a few tens of meters of water depth (Schlager, 1981). STRATA approximates this behavior by assuming that carbonate production is an exponentially declining function of water depth.

Meter-Scale Shallowing-Upward Cycles

Meter-scale shallowing-upward cycles have been an essential component of carbonate platforms for at least the past 2 b.y. of Earth history. Their origin has been hotly debated (e.g., do these cycles record orbital forcing of global climate?); compare Goodwin and Anderson (1985), Algeo and Wilkinson (1988), and Koerschner and Read (1989). Modeling studies, beginning with those of Read et al. (1986), have helped quantify processes that occur on time scales shorter than the constraints offered by biostratigraphy and longer than human observation or radiocarbon dating can calibrate.

A simple example of how STRATA can be used to provide insight into understanding the origin of these shallowing-upward cycles is based on observations of the Middle Ordovician Milroy Member of the Loysburg Formation of central Pennsylvania (Figs. 3, 4A). Six successive shallowing-upward cycles progressively thicken and thin. Figure 4A illustrates a plot of differential cycle thickness through time (Fischer diagram) in which, through the assumption that cycle duration is constant, the progressive deviations in cycle thickness can be used to infer changes in accommodation space through time (Fischer, 1964; Read and Goldhammer, 1988; Sadler et al., 1993). One interpretation of Figure 4A is that sea level rose and then fell in a sinusoidal fashion over the 0.725 m.y. duration of these rocks. However, we note that the total number of cycles used in this analysis is well below the minimum required for the result to be rigorously valid (Sadler et al., 1993).

In a forward model of this outcrop (Fig. 4B), we impose a long-term eustatic sea-level change with an amplitude of 2.0 m and a period of 0.725 m.y. (see red curve on Wheeler diagram, Fig. 4B). On top of this we impose a high-frequency oscillation of 1.75 m and a period of 0.12 m.y. To simulate the biologic inertia associated with recolonization of the sea floor and "jump starting" the carbonate factory, we impose a lag-time of 5000 yr in carbonate production following complete shallowing to sea level (lag depth rather than lag time, or a combination of both, is possible with STRATA).

In an illustration of six modeled shallowing-upward cycles (Fig. 4B), the modeled and observed cycle thicknesses are similar; furthermore, both the observed and modeled cycles show that thicker cycles have a greater component of deeper water facies

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(dark blue) than thinner cycles. All of the modeled cycles shallow asymmetrically upward, as is observed in the outcrop. The Wheeler diagram (Fig. 4B) shows that the unconformities at the top of each shallowing-upward cycle are associated with the falling limb of the high-frequency sea-level change. In contrast, the base of each cycle is associated with the rising limb of each high-frequency sea-level change. During the times of long-term rise in sea level, which correspond to the thick cycles at the bottom and top of the section, the lacunae (disconformities) present between successive cycles are of a much smaller duration than those present during the falling limb of the sea-level cycle. During the long-term fall in sea level (the middle three cycles), the majority of time is recorded by a hiatus, because sea level is falling faster than subsidence and the shelf is exposed. Significantly, the Wheeler diagram shows that over half of the geologic time represented by the section is not recorded by rocks, similar to results previously obtained by Read et al. (1986), Grotzinger (1986), and Wilkinson and Drummond (1993) for other cyclic strata deposited under conditions of minimal long-term accommodation increase. STRATA suggests that these hiatuses may be preferentially partitioned within the rock record as a function of sea-level change (however, see below and Fig. 5 for an alternative explanation of hiatal origins). Finally, we note that even with the relatively slow sedimentation rate used, it is impossible to generate deepening-upward cycles without a lag time or a lag depth, because sea level is varying by only 1 m and sedimentation can always keep up with sea level.

Cycle Bundling

As a last example (Fig. 5), it is interesting to couple the long-term evolution of a carbonate shelf with high-frequency sea-level change. In this case, subsidence increases linearly from left to right. Two orders of high-frequency, shallowing-upward cycles are present, consisting of thicker cycles driven by sea-level change (0.1 m.y. period, 1.0 m amplitude) and thinner cycles that arise solely from the interaction between differential subsidence and sediment production. The latter mechanism for cycle generation is often referred to as "autocyclicity" (Ginsburg, 1971; Bosellini and Hardie, 1973; Wilkinson, 1982). The thicker cycles are defined by a systematic, upward decrease in the thickness of the thinner cycles that is related to the decreasing accommodation associated with the 0.1 m.y. sea-level oscillation. Cycle asymmetry in both sets results from the intrinsic lag time in carbonate production following complete shallowing to sea level. However, the "cycle bundling" does not result from nested sea-level oscillations, but rather reflects the lag in sedimentation, following shallowing to sea level. The shelf aggrades to sea level during the 0.1 m.y. cycle, but carbonate production shuts off, and the shelf subsides for 7000 yr every time it reaches sea level. This may occur numerous times as long as accommodation space is available. Here, through a fortuitous (but not unreasonable) combination of subsidence, lag time, and eustatic periods, this results in approximately 5:1 "bundling." This is interesting given that the observation of similar bundling in the rock record has been interpreted and modeled assuming multiple sea-level oscillations with frequencies (~0.1 and 0.02 m.y.) corresponding to the Milankovitch periods (Goldhammer et al., 1987; Goodwin and Anderson, 1985). Drummond and Wilkinson (1993) also investigated this behavior with a one-dimensional model.

In Figure 5A, the upward-shallowing cycles can be seen prograding in the direction of decreasing subsidence, away from the shelf margin and toward the inner part of the shelf (right to left). This pattern results not from any dependency on slope (there is no diffusive component) or other directional sediment transport terms, but because of the influence of lag time (lag depth produces similar geometry) operating in concert with differential subsidence. As the shelf is continuously flooded following the lowstand in the 0.1 m.y. sea-level period, the lag time progressively turns on and then off, allowing sedimentation and aggradation to occur. Accordingly, the time at which the sedimentation lag turns off is diachronous and so is the time at which shallowing to sea level takes place at any given point on the shelf. Both decrease in age up dip (to the left). The final result is that sedimentation at any point is aggradational, but the geometry of the cycle is progradational and the cyclic facies are markedly diachronous. A Wheeler diagram illustrates that the prominent unconformities correspond to the times of sea-level fall associated with the 0.1 m.y. oscillation (Fig. 5B). In contrast, the high-frequency cycles are unrelated to eustatic sea level and are diachronous, crossing time lines from right to left (Fig. 5B).

DISCUSSION

Examples from clastic and carbonate sedimentation illustrate how simple forward models can be used in conjunction with observation to provide insight into our interpretation of the stratigraphic record. The examples presented are not original, but have been chosen to illustrate STRATA's capabilities (and limitations) in addressing some of the classic (as well as more modern) problems in stratigraphy. The main goal of this paper is to demonstrate that simple physical descriptions of depositional processes, when integrated through time, can predict realistic stratigraphy. The modeling predicts the development of specific stratigraphic geometries and therefore provides independent tests of how rocks and unconformities are distributed in the stratigraphic record.

We emphasize that any model is only as good as its assumptions. This is particularly shown by the two clastic and carbonate examples. Depositional sequences in clastic rocks can be generated by variations in sediment supply, sea level, or subsidence. Cyclic carbonates can result from either extrinsic or intrinsic processes. Ultimately, perhaps, stratigraphic modeling is most useful in establishing the limits of our ability to reasonably distinguish driving variables based on existing data sets. Thus, modeling becomes a very useful tool in suggesting approaches to a new generation of field experiments required to test competing hypotheses.

Finally, we have found modeling to be a great asset to all students of stratigraphy. Although we have provided only a few simple examples, there are an infinite variety of questions a stratigrapher may ask. We hope that by releasing this software, we will allow students to pursue those questions independently. STRATA may be downloaded at http://hydro.geosc.psu.edu. Several additional stratigraphic examples are also presented therein.

ACKNOWLEDGMENTS

Many of the ideas presented in this paper have arisen from discussions, debates, and arguments in our stratigraphy classes at Penn State and MIT. In addition, we thank N. Christie-Blick, B. Demicco, B. Ginsburg, B. Goldhammer, L. Hardie, T. Jordan, C. Kerans, D. Osleger, M. Patzkowsky, R. Slingerland, F. Read, and B. Wilkinson for discussions and debates over the years. We thank C. Brett, M. Patzkowsky, T. Jordan, and D. Osleger for reviewing the manuscript. Jamie Morris wrote the graphical interface for STRATA and maintains the STRATA web site. A. Hoover measured the stratigraphic section in Figure 4. S. Nelson assisted in manuscript preparation. Funding for developing STRATA was provided by grants from Chevron (Flemings and Grotzinger), by a Shell Foundation Fellowship (Flemings) and by National Science Foundation grant EAR-9058119 (Grotzinger).

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Manuscript received August 26, 1996; revision received October 7, 1996; accepted October 9, 1996 ■

Each month, *GSA Today* features a short science article on current topics of general interest. For guidelines on submitting an article, contact *GSA Today* Science Editor S. M. Kay, Cornell University, (607) 255-4701, fax 607-254-4780, E-mail: kay@geology.cornell.edu.

1996 AEG Student Paper Competition

The Association of Exploration Geochemists will hold its eleventh biennial Student Paper Competition this year. Papers eligible for the competition must address an aspect of exploration geochemistry and represent research performed as a student. The student must be the principal author, and the paper must have been published in any refereed scientific journal within five years of the student's graduation with his/her last graduate-level degree (documentary proof of date of graduation required). A nomination may be made by anyone familiar with the work of the student. Nominations must be accompanied by three copies of the paper. The deadline for receipt of the nominations is December 31, 1996.

For information, contact Ian D. M. Robertson, c/o CSIRO Division of Exploration and Mining, Private Bag P.O., Wembley, WA 6014, Australia, phone 61-9-387-0748, fax 61-9-387-8642, i.robertson@per.dem.csiro.au.

Virtual Mentors Needed

The National Research Council's Career Planning Center for Beginning Scientists and Engineers (http://www2.nas.edu/cpc) provides information and guidance to students who are trying to get a job, planning their careers, or making educational choices. The center has been so successful that in the Advice Center area, there are more students who need mentors than there are mentors available. The Career Planning Center needs more scientists and engineers who are willing to be "virtual mentors" to undergraduate and graduate students and postdocs. All correspondence is by E-mail.

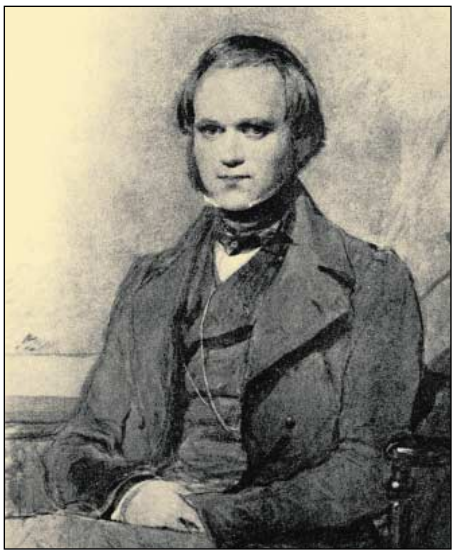
Mentors form a personal relationship with young scientists or engineers and have the opportunity to discuss many issues, including ethical and ideological, as well as practical skills such as how to write a good resume.

Mentors are especially needed in the disciplinary areas of engineering, physics (other than solid state), mathematics, computer science, ecology, and environment, as well as those who can provide general career guidance (especially women or couples in dual science and engineering careers). Mentors in all scientific and engineering areas are welcome, because new students are requesting mentors all the time. To find out more information or to sign up to be a mentor, access the mentor form directly at http://www2.nas.edu/cpcadv/mentor.html or send E-mail to ewojtasz@nas.edu (subject line: Mentor Volunteer).

Rock Stars

Darwin the Geologist

Léo F. Laporte, *Earth Sciences, University of California, Santa Cruz, CA 95064, laporte@cats.ucsc.edu*



Darwin in 1840 (age 31), painted by George Richmond. From de Beer (1964, p. 116).

On January 16, 1832, shortly before Charles Darwin's 23rd birthday, *H.M.S. Beagle,* with the young Darwin aboard, made its first stop at São Tiago in the Cape Verde islands off the west coast of Africa. Years later, Charles Darwin wrote:

> The geology of St. Iago is very striking yet simple: a stream of lava formerly flowed over the bed of the sea, formed of triturated recent shells and corals, which it baked into a hard white rock. Since then the whole island has been upheaved. But the line of white rock revealed to me a new and important fact, namely that there had been afterwards subsidence round the craters, which had since been in action, and had poured forth lava. It then first dawned on me that I might write a book on the geology of the countries visited, and this made me thrill with delight. That was a memorable hour to me.... (*Autobiography,* p. 81).

Today, few people are aware that Charles Darwin (1809–1882) was an accomplished geologist before becoming renowned as a biologist with *On the Origin of Species* in 1859. Despite his lack of formal training as a geologist, Darwin published major works on the structure and distribution of coral reefs (1842) and geological observations on volcanic islands (1844) and on South America (1846).

INFLUENCES

The irony of Darwin's success as a geologist was that he had little formal instruction in the subject. In his second year at the University of Edinburgh—before he dropped out—he attended the lectures of Robert Jameson, a champion of Werner's Neptunist theory, "but they were incredibly dull. The sole effect they produced on me was the determination never as long as I lived to read a book on Geology or in any way to study the science. Yet I feel sure that I was prepared for a philosophical treatment of the subject" (*Autobiography,* p. 52).

Disgusted by medicine in the days of surgery performed without the benefit of anesthesia, Darwin went on to Cambridge from Edinburgh to complete a degree that would prepare him for the Anglican clergy. At the same time Darwin continued his extracurricular pursuit of natural history and met various distinguished scholars, including John Stevens Henslow (botany), Adam Sedgwick (geology), and William Whewell (astronomy and philosophy). Darwin's enthusiastic interest in science impressed these men, for they became his mentors in various ways. Thus, despite his initial antipathy for geology, Darwin spent the better part of August 1831 on a geological tour of Wales with Adam Sedgwick, who was studying the rocks that he would later define as the Cambrian System.

> On this tour I had a striking instance of how easy it is to overlook phenomena, however conspicuous, before they have been observed by anyone. We spent many hours ... examining all the rocks with extreme care ... but neither of us saw a trace of the wonderful glacial phenomena all around us. (*Autobiography,* p. 70).

VOYAGE OF THE *BEAGLE*

At the end of August, Darwin returned home to discover that he had been recommended by his Cambridge professor and mentor, John Henslow, as the naturalist for the forthcoming *Beagle* voyage under Capt. Robert FitzRoy. Darwin was thought suitable for the position more because he was a well-bred gentleman who could socialize with the *Beagle's* captain than because of his skills as a trained naturalist. As a welcoming gift, FitzRoy gave Darwin the first volume of Charles Lyell's *Principles of Geology,* which had been published the year before. Closely reading this volume and the next two sent to him while on the voyage, Darwin became self-taught in geology. "I am proud to remember," he said, "that the first place, namely St. Iago, [where] I geologized, convinced me of the infinite superiority of Lyell's views over those advocated in any other work known to me" (*Autobiography,* p. 101).

Throughout the remainder of the voyage, Darwin "geologized" with excitement and enthusiasm. Writing home to his sisters, he remarked, "There is nothing like geology; the pleasure of the first day's partridge shooting ... cannot be compared to finding a fine group of fossil bones, which tell their story of former times with almost a living tongue ..." (*Correspondence,* v. 1, p. 379), or that he "literally could hardly sleep at nights for thinking over my [geology]." (*Correspondence,* v. 1, p. 445).

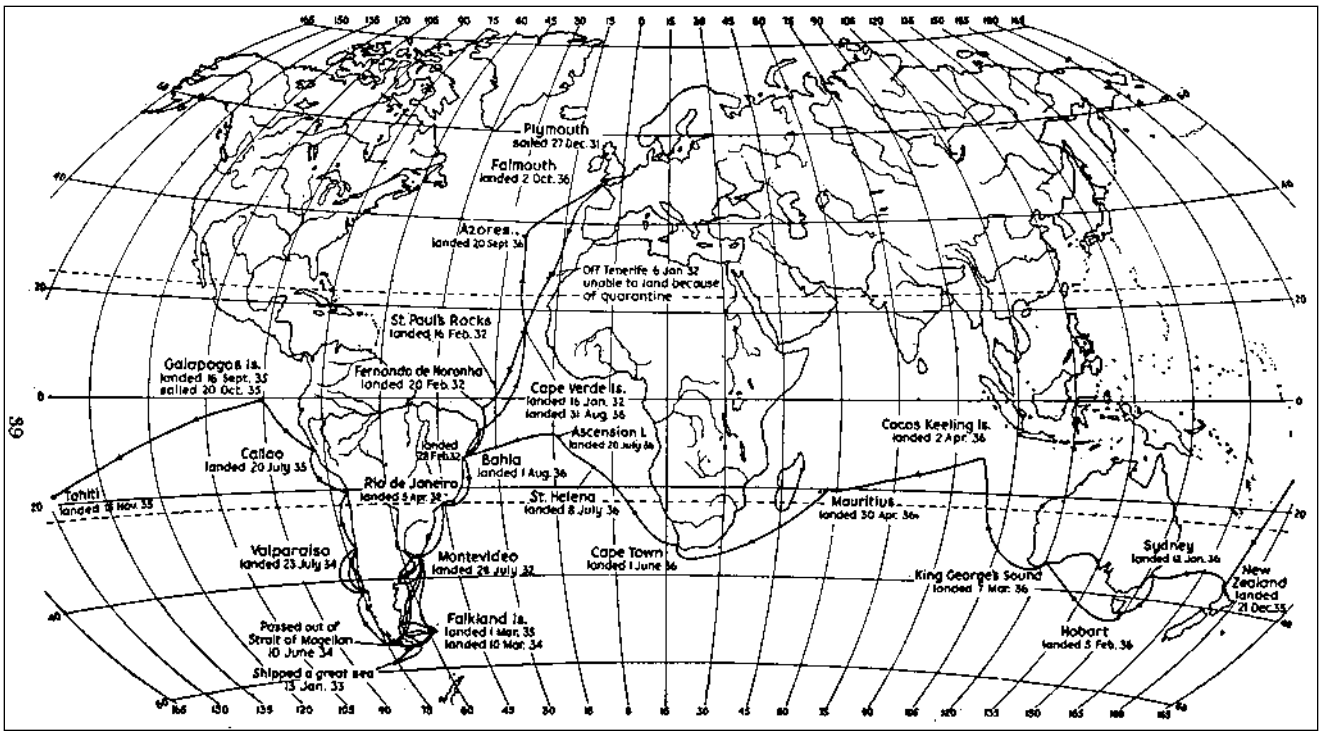
Darwin's diagram of the geological structure of the coast of St Iago, Cape Verde Islands. A, substratum of ancient volcanic rocks. B, bright white layer of limestone, originally deposited below the sea but now raised. C, recent basaltic lava. Near the extinct volcano shown, the limestone and overlying basaltic layers dip beneath the sea, evidence of local subsidence. From *Geological Observations on Volcanic Islands,* 1844.

From de Beer (1964, p. 58).

INTRODUCTION

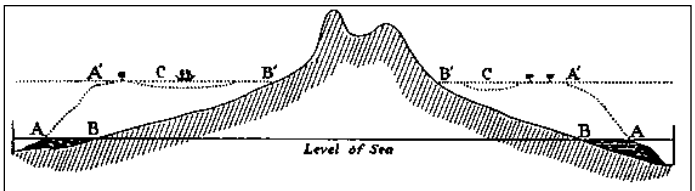
Bernard of Chartres, an 11th-12th century philosopher and teacher, said that we are like dwarfs on the shoulders of giants, so that we can see more than they and for a greater distance, not by any virtue of our own but because we are carried high and raised aloft by their stature.

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

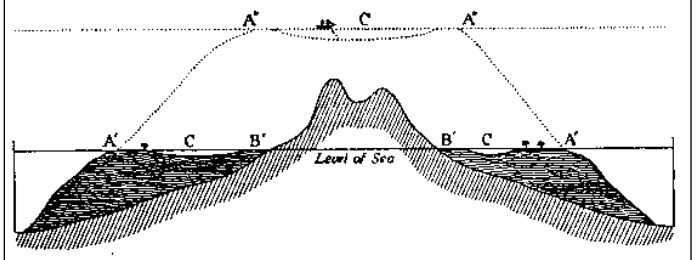


Voyage of the Beagle. From de Beer (1964, p. 39).

In Chile, on February 20, 1835, Darwin experienced a very strong earthquake and shortly afterward saw evidence of several feet of uplift in the region. Because one important aspect of Lyell's principles was the concept of a steady-state, nondirectional earth whereby uplift, subsidence, erosion, and deposition were all balanced, Darwin coupled in his mind this dramatic evidence of elevation with accompanying subsidence and deposition. Thus he hypothesized, before actually seeing them, that coral reefs of the Pacific developed on the margins of subsiding land masses, passing through the three stages of fringing reef, barrier reef, and atoll.



Darwin's diagram showing the formation of an atoll as a result of subsidence. The vertical section is taken through an island (shown shaded) bordered by a coral-reef (shown dark) the outer edges of which are at AA, while the shores of the island are at BB. If the land be imagined as sinking, the relative level of the sea will rise and the shores of the island will then be at B′B′. The coral-reef will have grown upwards, keeping pace with the relative rise in sea-level, and its outer edges will be at A′A′, bordering a narrow strip of dry reef bearing trees, separated from the shores of the island by a shallow circular lagoon-channel CC, on which a ship is shown. From *Structure and Distribution of Coral Reefs*, 1842.



The final stage in the formation of an atoll. The edges of the coral-reef at A′A′, the shores of the island at B′B′, and the lagoon-channel CC, are as in Fig. 9. If subsidence continues and the relative level of the sea rises still further, the island will be completely submerged and the coral-reef will grow upwards and form a circular ring of dry land at A″A″, enclosing a circular shallow lagoon at C on which a ship is shown. From *Structure and Distribution of Coral Reefs*, 1842.

From de Beer (1964, p. 68).

> No other work of mine was begun in so deductive a spirit as this; for the whole theory was thought out on the west coast of S. America before I had seen a true coral reef. I had therefore only to verify and extend my views by a careful examination of living reefs. But it should be observed that I had during the two previous years been incessantly attending to the effects on the shores of S. America of the intermittent elevation of the land, together with the denudation and deposition of sediment. This necessarily led me to reflect much on the effects of subsidence, and it was easy to replace in imagination the continued deposition of sediment by the upward growth of coral. To do this was to form my theory of the formation of barrier-reefs and atolls. (*Autobiography*, p. 98, 99).

When the *Beagle* visited the Cocos Islands in the Indian Ocean more than a year later, Darwin was able to test his hypothesis of reef formation "by examining the very interesting, yet simple structure and origin of these islands.... These low, insignificant coral-islets stand and are victorious ... thus do we see the soft and gelatinous body of a polyp ... conquering the great mechanical power of the waves..." (*Voyage*, p. 457, 459).

In his 1842 book on coral reefs, Darwin published a map of the southwest Pacific showing the distribution of fringing, barrier, and atoll reefs. Darwin noted that fringing reefs were concentrated along the coasts of continents that "are for the most part rising areas" whereas barrier and atoll reefs are found in the "central parts of the great oceans [that] are sinking areas" (*Voyage*, p. 478). (Knowing what we know about plate tectonics, we explain such subsidence by the cooling and accompanying increase in density of submarine volcanic rock as it moves away from active ridges or hot spots.)

Darwin *continued on p. 10*

Institute for Environmental Education

Interdisciplinary Scientific Opportunities at the Newly Consolidated U.S. Geological Survey and National Biological Service—Part 2

Daniel Sarewitz, *IEE Director, GSA*
Mary Barber, *Executive Director, Sustainable Biosphere Initiative, Ecological Society of America, 2010 Massachusetts Ave., NW, Washington, DC 20036*
John Huyler, Jr. *and* ***Paul DeMorgan,*** *The Keystone Center, P.O. Box 8606, Keystone, CO 80435*

BACKGROUND

On October 1, 1996, the National Biological Service (NBS) was merged into the U.S. Geological Survey (USGS), thereby becoming the new Biological Resources Division (BRD) of the USGS. The BRD has as its mission "to work with others to provide the scientific understanding and technologies needed to support the sound management and conservation of our Nation's biological resources." This mission is fully consistent with the USGS's broader mission of providing "the Nation with reliable, impartial information to describe and understand the Earth." Consolidation and fulfillment of these missions will require not only the administrative merger of the NBS and USGS, but also the development of a framework for scientific investigation and information management that promotes the application of integrated knowledge of biological, physical, and socioeconomic processes and forces.

To help foster this goal, the Geological Society of America, the Ecological Society of America, and the Keystone Center sponsored two workshops to identify new interdisciplinary opportunities relevant to the mission of the merged agencies. Here, we summarize the results and findings of the second workshop, held in Silverdale, Washington, in July 1996. (For a summary of the first workshop, see the October issue of GSA Today.) We address the general problem of how interdisciplinary opportunities can be fostered—a pervasive concern throughout the workshop—and then outline a series of specific interdisciplinary initiatives that emerged from the workshop deliberations. Participants included scientists and natural resource managers from a wide range of sectors, including academia, private companies, state and federal agencies that work with the USGS and NBS, and the USGS and NBS themselves. Our report presents the major ideas discussed during the workshop and is neither a consensus document nor a comprehensive workshop proceedings.

ENABLING INTERDISCIPLINARY SCIENCE

The administrative, professional, and intellectual culture of science encourages and reinforces disciplinary boundaries. Successful integration of the USGS and the NBS will require administrative action aimed at breaking down barriers to interdisciplinary science. Imposing such cultural change is not easy; assessment of other interdisciplinary projects, programs, and organizations would help the USGS to recognize and define characteristics of successful efforts and past failures. Workshop participants identified a range of organizational attributes that might encourage development of a truly interdisciplinary USGS:

1. Strong research investigation leadership, including explicit mandates for integrated, interdisciplinary planning and products.
2. Standardized and integrated data management protocols that allow for the compilation of multidisciplinary data sets and a comprehensive view of physical and biological attributes. (In many cases, an integrated information infrastructure is a necessary prerequisite for effective interdisciplinary activity.)
3. An organizational demand for studies that lead to generalizable principles, rather than simply local case histories and assessments.
4. An organizational demand for comprehensive, integrated historical baselines and trends to support environmental assessments and predictive modeling.
5. Effective lines of communication between researchers and information users, including clear articulation of uncertainties dictated by data sources and interpretive procedures.
6. Problem-oriented interdisciplinary research teams. More co-location of USGS and NBS facilities and scientists will be necessary.
7. Participation of engineers and social scientists. (Humans are major agents of geological and ecological change, and efforts to understand and respond to such

IEE *continued on p. 11*

Darwin *continued from p. 9*

GEOLOGICAL OBSERVATIONS

Although Darwin's theory of coral reefs is his best known geological contribution, he made others of equal interest. For example, he observed how rocks are altered by contact with hot lava; marked surface rupture and displacement from earthquakes; fossilization of extinct organisms; cleavage and foliation in metamorphic rocks and their relation to the formation of mountains; evidence for differing climates in the past based on fossils and glacial deposits; and dramatic changes in geography, particularly those related to fluctuations in sea level.

For Further Reading

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Ghiselin, M., 1969, The triumph of the Darwinian method: Los Angeles, University of California Press (see especially the chapter "Geology," p. 13–31).

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IEE *continued from p. 10*

change must consider the human element.)

PROPOSED INTERDISCIPLINARY INITIATIVES

The workshop identified and described eight interdisciplinary initiatives that would contribute to the achievement of the mission of the newly merged agency. These initiatives are grouped below into three broad, crosscutting themes. Order of presentation is not meant to imply relative priority of initiatives.

I. The Environmental Knowledge Base

Effective environmental decision making requires impartial, independent, state-of-the-science data and information on the current status and past history of the nation's energy, water, land, mineral, and biological resources.

A. Information Infrastructure

An integrated and standardized information infrastructure is an essential prerequisite for development of comprehensive environmental baseline information and for carrying out credible bioregional assessments. The USGS is now uniquely positioned to create this infrastructure. The viability of new interdisciplinary scientific opportunities will significantly depend on the existence of this infrastructure; indeed, the infrastructure may help create such opportunities.

An integrated information infrastructure will permit the effective use of existing data (from USGS, NBS, and regional, state, and other federal agencies, e.g., National Science Foundation–funded Long-Term Ecological Research network), thus preventing duplication of effort while creating a truly comprehensive assessment capability.

Implementation would be facilitated by cross-divisional teams charged with the development of database protocols, including collection, storage, retrieval, and delivery policies; coordination of information retrieval and use ("gatekeeper function"); and cultivation of linkages with appropriate external agencies. However, such protocols must be sufficiently flexible to accommodate methodological differences among scientists working on different projects and in different regions.

B. Baseline Data on Biological Communities, and the USGS-NBS Bioregional Assessment Capability

The absence of a complete baseline record, including Holocene, human-historical, and recent trend data, on the distribution and characteristics of biotic communities is a significant handicap to all efforts to effectively manage natural resources and restore degraded ecosystems. The USGS should develop a comprehensive information base on communities, for use by land managers, planners, and policy makers.

Developing the baseline record will require: (1) compiling past and recent data on distribution and abundance of species and communities and on physical conditions of the landscape (including land-use patterns, e.g., NBS Land Use History of North America project); (2) carrying out timely, efficient, scientifically credible bioregional assessments on vegetative cover; identification, distribution, and abundance of key plant and animal species; and surficial geology, topography, and surface water; (3) developing integrative, digitized baseline data maps.

Appropriate information infrastructure, combined with comprehensive baseline and trend data and bioregional assessments (including maps of present and past physical, biological, and cultural attributes), will allow the USGS to more effectively serve natural resource managers and policy makers through interdisciplinary evaluation, interpretation, and anticipation of the impacts of changing land-use practices and patterns on water quality and quantity and biological communities.

II. Responding to Biological Threats

A. Ecosystems and Health

The effects of emerging diseases, algal toxins, and natural and anthropogenic pollutants on the health of humans, wildlife, and vegetation are determined in part by the behavior of ecosystems. Disease agents are spread in the environment by physical processes in water and air, and also by organisms. Understanding the relation between ecosystem processes and health requires an interdisciplinary approach that would include monitoring and analysis of patterns of water flow and sedimentation, geochemical cycling, and invasion of disease organisms and their vectors, as well as social factors such as patterns of commerce, travel, urbanization, and agriculture.

Emerging problems of ecosystems and health are now being recognized in diverse environments and at various scales. Water quality may be adversely affected by proliferation of wildlife such as Canada geese. Unusual current regimes and eutrophication affect the timing and development of massive proliferation of toxic algae. On a larger scale, endocrine disrupters (e.g., PCBs and DDT byproducts) may represent a widespread and long-term threat to human and wildlife health, while climatic changes contribute to changes in the distribution and spread of disease-causing organisms, on land as well as in water.

Combining USGS capabilities in hydrology, geochemistry, and surface processes with NBS strengths in ecological science can lead to significant new insights into the natural history of disease. Integrative models should be developed that can more fully characterize the feedbacks that occur between environment and disease, and help anticipate and respond to new threats to the health of humans, wildlife, and vegetation.

B. Dynamics and Consequences of Species Invasions

Problematic species invasions resulting from human activities can have significant negative ecological and economic consequences. Acceleration of environmental change and ecosystem degradation at the local, regional, and global level may lead to increased invasion. Combining a long-term geological perspective on invasions through time (e.g., as facilitated by tectonic movements and climate and sea-level change) with short-term ecological studies on modern invasions will yield new insights into the dynamics and consequences of invasions that will enhance the response capabilities of land and resource managers.

Crucial questions include: (1) Which species are most apt to invade? (2) Which biological communities are most likely to contribute invaders? (3) Which communities are most vulnerable to invasion?

Studies of invasions in the geological past and in the record of human history, together with ongoing ecological studies, will allow characterization of long-term consequences of invasion, and modeling of the spread of invasions. Interdisciplinary knowledge will be necessary to develop effective strategies for controlling the introduction and spread of problematic invaders, reducing their harmful effects, and managing the human environment to reduce the threat of invasion. This initiative should be closely linked to studies of environment and disease, because species invasion dynamics reflect many of the same physical, biological, and social processes that link ecosystems to the health of humans, wildlife, and vegetation.

III. Maintaining Viable Ecosystems

A. Ecosystem Restoration

Remediation and restoration of damaged ecosystems may be necessary to sustain biological and economic productivity, and to maintain ecosystem services (such as flood control and water-quality preservation by wetlands) that are necessary for society's welfare. Effective remediation requires: (1) baseline data on the physical and biological condition of ecosystems, and comparison of ecosystems least

IEE *continued on p. 12*

IEE *continued from p. 11*

affected by human activities to those that have been modified to varying degrees; (2) integrated understanding of physical, chemical, and biological processes that control ecosystem function; (3) integrated understanding of natural and human-induced stresses on ecosystems; (4) knowledge of threshold indices for healthy systems (chemical and biological indicators); (5) knowledge of site conditions from surficial and engineering geology perspectives; (6) protocols for determining the consequences of alternative natural resource management practices (monitoring for adaptive management).

As a principal source of scientific information used by natural-resource managers dealing with ecosystem disruption, the USGS should develop a comprehensive approach to restoration that includes and integrates information on each of the above factors. This information should also be useable for decision makers seeking to design policies that can enhance the remediation process.

B. Recovery from Ecological Crises

Concern about "natural disasters" tends to focus on direct impacts to human systems, but earthquakes, volcanic eruptions, storms, floods, fires, and human-caused accidents profoundly affect species populations and even entire ecosystems, including the critical geochemical cycling on which life depends. Anticipating and successfully responding to future crises from this perspective require integration of geological, ecological, and historical knowledge about frequencies, magnitudes, spatial scales, and biological signatures of crises in the geological and human-historical past. Ultimately, such knowledge may lead to strategies for enhancing the ability of ecosystems to resist and recover from natural and human-caused crises, just as natural hazards programs now focus on societal preparation and recovery.

Ecological crises can be viewed as real-time natural experiments. Scientific response to the 1981 Mount St. Helens eruption represents a successful model of effective, interdisciplinary postcrisis assessment; the 1989 Loma Prieta earthquake was less successful because biological and ecological factors were largely neglected. USGS rapid response teams should include life scientists, to ensure a comprehensive assessment capability.

Interdisciplinary analysis of the historical record of ecological crises will augment study of modern crises. Analysis of past crises requires reconstruction of precrisis paleoecologic conditions. Similarly, effective and useful analysis of the ecological impacts of recent catastrophic events requires comprehensive baseline data as a basis for evaluating change.

Sub-Initiative on Fires: Millions of acres of the western United States burn annually. Restoration programs are aimed at preventing further land degradation and facilitating ecological recovery, but the effectiveness of these programs has not been adequately studied. Such analysis would include tests of the effects of various remedial treatments, systematic assessments of treatment results across a variety of landscape gradients, and retrospective study of a selection of past fires and subsequent recovery. This information would be applied to future restoration strategies.

C. Flood Plain Management

Natural resource and flood management practices on alluvial valley floors are often inadequate because research and application of knowledge has been fragmented among disciplines and agencies. The USGS can now develop a fully integrated study of the hydrology, biology, and engineering affecting the conditions of valley floors, as well as better analytical and planning tools for decision making about land use, habitat preservation, and water quality.

Comprehensive, interdisciplinary analysis of an appropriate flood plain could lead to the development of generalizable principles applicable to resource and hazard management. A large flood plain with diverse land-use patterns should be selected for analysis that would include: (1) field study and modeling of processes that affect hydrology (flood and dry-weather) and the transport of bioactive materials from upstream and local sources, and between the channel and the valley floor; (2) field study of the linkages in space and time between valley-floor characteristics (e.g., hydrogeomorphology, infrastructure) and the distribution of wetland, riparian, and other biological communities, with the objective of generating a modeling capability and identifying generalizable principles to explain relations among biological processes, geomorphic processes, human activities, and water quality; (3) development of tools that can be used by resource managers and policy makers to quantitatively assess how changing physical processes, cultural features, and land cover affect habitat distribution, flooding, and water quality. On the basis of this program, a protocol should be developed for rapid studies of other valley floors, including mechanisms for iterative improvement of general principles and resource management tools.

D. Biologic Processes and Soil Formation

Consideration of soil is often neglected in the study of land-based ecosystems. While the U.S. Department of Agriculture (USDA) conducts soil research on arable lands, there is insufficient understanding of soil formation, degradation, and erosion processes in nonagricultural terrain. In particular, the role of biological factors in weathering, erosion, transport, and depositional processes is not well known. The USGS, in cooperation with other relevant agencies (e.g., USDA, National Oceanic and Atmospheric Administration), is well positioned to develop the necessary knowledge. Understanding the interactions among geologic, hydrologic, meteorologic, and biologic processes in the creation and destruction of soils will be essential to successful management of ecosystems.

Key problems include: (1) biologic controls on rates and processes of soil formation in various landscape settings, including the role of soil microorganisms; (2) biologic controls on rates and processes of soil erosion in various landscape settings; (3) effects of acid precipitation on soil quality, rates of rock weathering, and rates of soil formation, and relation to integrity of forest communities; (4) impacts of human activities on soil genesis and degradation in nonagricultural areas, and maintenance of long-term soil fertility in impacted areas.

A few important environments could be selected for interdisciplinary pilot studies—for example midwestern loess, northeastern forest, and western peaty deltaic deposits. The long-term goal is to provide knowledge and tools for land and resource managers to maintain soil quality and ameliorate degraded soils.

Workshop Participants

Craig Allen, National Biologic Service
Mary Altalo, Scripps Institution of Oceanography
James Beach, National Science Foundation
Randy Brown, California Dept. of Water Resources
Michael W. Collopy, National Biological Service
Thomas Dunne, University of California, Santa Barbara
Milt Friend, National Biological Service
Leonard Gaydos, U.S. Geological Survey
Gordon Grant, U.S. Forest Service
Douglas Growitz, Bureau of Reclamation
Arthur Lachenbruch, U.S. Geological Survey
Charles Logue, Unified Sewerage Agency (Oregon)
Eugene Mancini, ARCO
Lindsay McClelland, National Park Service
Eldridge Moores, University of California, Davis
Gordon Orians, University of Washington
Jonathan Price, Nevada Geological Survey
Mark Schaefer, U.S. Dept. of Interior
Bruce Schmidt, Oregon Dept. of Fish and Wildlife
Marvin Shasby, U.S. Geological Survey
Peter Stine, National Biological Service
Mark Sylvester, U.S. Geological Survey
Geerat Vermeij, University of California, Davis
John Williams, National Marine Fisheries

This series of workshops was supported in part by contributions from the Exxon Corporation, the Campini Foundation, the Bullitt Foundation, the Minerals Management Service, and Michel T. Halbouty. ■

VIEWPOINT

Dev L. Advocate

Which Way Up?

Every once in a while, one of our brethren decides to right an old wrong or, more precisely, to invert an old ratio. The most recent example comes from Paris, the birthplace of SI, and concerns the helium isotopic ratio. For years and years, it has been conventional to discuss the $^{3}He/^{4}He$ ratio and sometimes to normalize it to the atmospheric value, Ra. Most basalts have ratios in the convenient range of 1 to 30 Ra, and there has been no problem. Our Paris colleagues have noted that most isotopic ratios have the stable isotope on the bottom and, for consistency, decided to start using the $^{4}He/^{3}He$ ratio, throwing the rare gas community into an uproar and making it impossible to follow 10-minute talks unless you are good at rapidly inverting large numbers in your head (and then normalizing to air). Here we have a clash among tradition, convention, culture, consistency, and convenience. Where is it written that the denominator must be the presumed invariant? And what do we do when both the numerator and the denominator can contain daughter products that are either radiogenic or cosmogenic? Is this a plot to make people focus on the numerator instead of the denominator and thereby push a theoretical agenda? If ^{3}He is in the denominator, no one will pay attention to it since it is the "invariant, stable, normalizing value." After all, how many people pay attention to ^{204}Pb or ^{86}Sr except as normalizers?

This is not the first time that diversion by inversion has been attempted. Seismologists have a quantity they call the seismic quality factor, or Q. For Earth's crust and mantle, it generally ranges from 10 to 1000; nice round numbers. The theory has been all worked out, and everyone was happy. One day, someone noticed that, in the theory, Q was always in the denominator; it was always on the bottom. The purists among them said hold on, Q is not fundamental; it is Q – 1 that is fundamental. They went on to define q as Q – 1 and started talking about numbers such as 0.025 and 0.0016, which did not improve the quality of life of those involved in dissipation. Thankfully, no new word was proposed, such as inequality, or seismic lack-of-quality, factor. All of this happened at about the same time as log-log graph paper started to disappear and there was an urgency to make all graphs into straight lines or fractoids.

One could equally make a case against the use of temperature. Temperature almost always occurs downstairs, particularly in plots of something vs. $1/T$. Outlaw temperature? What do we then call Kelvins? Do we follow the resistance troops who use mho for inverse ohm? Snivlek? And absolute zero becomes absolute infinity?

Some disciplines are more open-minded. Mineral physicists use both compressibility and incompressibility or bulk modulus, not worrying that the latter is theoretically suspect because it is upside down.

What is really unpardonable from a purist or theoretical point of view is the seismologists' insistence on the use of seismic velocity. Heavy-duty seismic computation involves inverse velocity, or slowness, and seismologists should henceforth quote to their geochemical friends, particularly in Paris, that the upper mantle slowness of 0.00012345 seconds per meter rules out pyrolite as an important component of the mantle, and also rules out inverse temperatures as high as 0.000666 snivlek.

We could continue this purifying of our science. Density should not be used, it has to be volume. Densities have gotten out of hand anyway, with kg/m^3 replacing g/cm^3 by SI fiat.

And of course, the origin of the Earth coordinate system is at $r = 0$ and only radius makes theoretical sense (geochemists think that the origin of Earth is at 4.5 Ga). By plotting volume and seismic slowness vs. radius, instead of the conventional density and velocity vs. depth, seismologists will have achieved a level of purity, and obscurity, only dreamed of by geochemists.

"A foolish consistency is the hobgoblin of little minds." —*Emerson*

Coal Division Offers Medlin Award

The Coal Geology Division of the Geological Society of America announces the availability of the Antoinette Lierman Medlin Scholarship in Coal Geology for the 1997–1998 academic year. The scholarships provide full-time students who are involved in research in coal geology (origin, occurrence, geologic characteristics, or economic implications of coal and associated rocks) with financial support for their project for one year.

Scholarship funding can be used for field or laboratory expenses, sample analyses, instrumentation, supplies, or other expenses essential to the successful completion of the research project. Approximately $1500 will be available for the 1997–1998 scholarship award. In addition, the recipient of the scholarship may be provided with a stipend of up to $500 to present results of the research at the 1998 GSA Annual Meeting. For the academic year 1997–1998, the Coal Geology Division is also offering a field study award of $500.

Proposals for the scholarship and the field study award will be evaluated by a panel of coal geoscientists. Applicants may apply for the scholarship award, the field study award, or both; however, only one award will be made to a successful applicant.

Interested students should submit five copies of the following: (1) a covering letter indicating which award(s) is (are) sought; (2) a concise statement of objectives and methods, and a statement of how the scholarship funds will be used to enhance the project. The proposal would be no more than five (5) double-spaced pages in length, including references; (3) a letter of recommendation from the student's immediate advisor which includes a statement of financial need and the amount and nature of other available funding for the research project.

Send the material to: **Peter D. Warwick**, Chairman, A. Lierman Medlin Scholarship Committee, U.S. Geological Survey, MS 956, National Center, Reston, VA 22092, (703) 648-6469, E-mail: pwarwick@usgs.gov.

The proposal and letter of recommendation must arrive no later than **February 15, 1997.** Applicants will be notified of the Scholarship Committee's decision by April 1, 1997.

The scholarship was established as a memorial to Antoinette "Toni" Medlin who, for many years dedicated her efforts toward the advancement of coal geoscience and to the encouragement of students in coal geology. Monies for the scholarships are derived from the annual interest income from the scholarship fund.

Society of Economic Geologists Research Grants Available in 1997

Young economic geologists throughout the world may apply for grants available in 1997 through the Society of Economic Geologists Foundation and the Society of Economic Geologists. Grants will be made available this year under three separate programs. Grants from the Hugh E. Mckinstry Fund are awarded to graduate students and/or young professional economic geologists with field-oriented projects. The Hickok-Radford Fund awards grants for field projects in Alaska and British Columbia, but with consideration given to worthwhile proposals dealing with high latitudes and rugged terrain. A third new category of grant is the Student Research Grant, which provides funds for research in economic geology that presents new descriptive data on ore deposits, mining districts, or general ore types.

The 1997 awards, totaling $20,000, will range from $500 to $2000 each. Grant applications may be made by requesting forms from the Chairman, SEG Grants Program, 5808 South Rapp Street, Suite 209, Littleton, CO 80120, phone (303) 797-0332, fax 303-797-0417. Information is also available through the SEG Web Site, http://www.mines.utah.edu/wmgg/seg.htm. **Applications must be postmarked by March 1, 1997.** Awards will be announced on or about May 1, 1997.

Licensing Professional Geologists in Illinois

Illinois Public Act 89-0366, the Professional Geologist Licensing Act, went into effect on July 1, 1996. The Board of Licensing is in the process of formulating rules and regulations to recommend to the director of the Department of Professional Regulation (DPR). The grandfather period is scheduled by law to end on June 30, 1997, but it may possibly be extended by the legislature through a request from DPR.

All Geologists wishing a license in Illinois, especially those who would qualify under the grandfather provision, should request now to receive applications when they become available. Send requests to: Nikki M. Zollar, Director, Attention: Judy Vargas, Illinois Department of Professional Regulation, 320 West Washington Street, Third Floor, Springfield, IL 62786.

Not All Good Bills Go to Heaven

Peter F. Folger
1995–1996 GSA Congressional Science Fellow

The year in Congress ended with neither a bang nor a whimper, but rather a sense that the job is done, let's get on the campaign trail. Typical of other end-of-the-year sessions, Congress passed a flurry of legislation in September that included bills important to geoscientists, such as the Omnibus Appropriations bill, but failed to move other key measures for earth scientists, like the Geologic Mapping Reauthorization Act of 1996. Why some noncontroversial bills live while other measures die goes beyond the normal last-minute political posturing; it speaks to the heart of the political process. For many of these bills, time simply ran out.

I puzzle over what happened in this session's final days, and why some bills were "sent to heaven" (1600 Pennsylvania Avenue), while other bills of seemingly equal importance and bipartisan support jammed in the pipeline and never left Capitol Hill. Hill veterans show little sympathy when I indicate how perplexed I am about the life and death of different bills. Their view is colored, after all, by statistics: out of 5,329 measures introduced in the House of Representatives during this Congress, only 1,012, or 19%, passed. Similarly, in the Senate, 2,661 measures were introduced and 822, or 31%, were passed. Because identical bills must be passed in both houses before going to the President, only 234 bills became law during the 104th Congress, a mere 3% of all legislation introduced (this percentage will go up; many bills passed in the last weeks of Congress await the President's signature). For comparison, 5.5% of measures introduced in the 102nd Congress became law, and 5% of legislation in the 103rd Congress. These are coarse statistics only, and do not indicate which bills make sweeping policy changes, which were introduced simply to make political statements, or even which bills became parts of larger pieces of legislation. Nonetheless, the percentage of bills that become law has been remarkably similar over three congressional terms and two administrations, despite changes in the presidency from Republican to Democratic, and changes in congressional majority from Democratic to Republican.

Underlying these raw measures of legislative output are strategic motives and tactical maneuvers that move a bill toward "heaven," send it to oblivion, or simply allow it to remain in limbo until Congress adjourns. The threat of a filibuster in the Senate, a threat that does not exist in the House, allows individual Senators tremendous discretion over whether a bill makes it from the committee of jurisdiction to final passage on the Senate floor. Many bills of interest to geoscientists, for example, are referred to the Senate Energy and Natural Resources Committee, chaired by Senator Frank Murkowski (R—AK). The committee holds sway over controversial bills like the Nuclear Waste Policy Act of 1996 (S. 1271) and the Livestock Grazing Act of 1995 (S. 852), over bills with broad bipartisan support such as the Helium Privatization Act of 1996 (H.R. 3008), and over measures of a decidedly local focus, like a bill establishing the New Bedford Whaling National Historical Park (S. 608). Yet, for nearly two years various senators have placed "holds," or threats of a filibuster, on bills reported out of committee so that only a trickle of legislation reached the Senate floor. As of September 18, two weeks before Congress adjourned for the year, the Senate had passed only 13 out of 156 measures referred to the committee; of those, only six were signed into law.

The Art of Compromise

For over a year, Senator Bill Bradley (D—NJ) placed a hold on all bills reported from the Senate Energy and Natural Resources Committee because the Resources Committee in the House of Representatives, chaired by Rep. Don Young (R—AK) was holding up one of Senator Bradley's favorite bills: the Sterling Forest Protection Act (S. 223). S. 223 would outlaw development in a small forest on the border between New York and New Jersey. By delaying action on bills important to the other 19 senators on the committee, Senator Bradley was attempting to exert leverage on the Resources Committee in the House to act on his bill. Holding legislation hostage in the Senate is a time-honored technique used by majority and minority alike; although stretching that leverage to involve "the other body" is virtually unheard of. In response, members of the House Resources Committee offered to move Senator

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Good Bills *continued from p. 14*

Bradley's bill if he would drop opposition to the Utah Public Lands Management Act of 1995 (S. 884), a controversial bill that would place 1.8 million acres of southern Utah off-limits to development. The Utah Wilderness bill was opposed by members of the environmentalist community, who demanded that no less than 5.7 million acres be deemed wilderness. The resulting impasse stalled the Energy and Natural Resources Committee for months until the Senate failed to cut off debate on the Utah Wilderness bill in March, and the measure died.

Not to be outdone, both Democratic senators from Nevada, Harry Reid and Richard Bryan, placed holds on all Energy and Natural Resources Committee bills in an attempt to stall consideration of the Nuclear Waste Policy Act of 1996 (S. 1271), a bill establishing an interim storage facility for commercial nuclear waste on the Nevada Test Site near the proposed permanent repository at Yucca Mountain. Their delaying tactic worked until the Senate voted, 63-37, to pass S. 1271 on July 31, and sent the nuclear waste bill to the House. Now time grew short. Although Congress did not plan to adjourn until October 4, the August recess loomed, leaving precious little time to act on all the Energy Committee bills still pending. With Members chafing to leave Washington to campaign for reelection, and only the month of September left to complete a crushing legislative load that included annual spending bills necessary to keep the government running, Senators could exert even greater leverage to get what they wanted by placing "holds" on other bills. If a bill does not pass before Congress adjourns for the year, the game is over, at least until next year.

Democracy Without Voting

It is interesting to note that even though the Senate did not conduct a single roll-call vote on any Energy and Natural Resources Committee bill after July 31, dozens of committee bills ultimately passed the Senate to become law. How is that possible? Because the Senate conducts the bulk of its business by unanimous consent, which means that bills pass almost by default as long as not a single senator objects. But there is the rub. Bills that might ordinarily pass by unanimous consent on their merits alone, such as the reauthorization of the Geologic Mapping Act, are objected to so that the objector can extract a little leverage on another matter. And as Congress nears adjournment, the desire to strike a deal gains considerable urgency, as every senator knows. This year was no different, as Energy Committee bills were held up during debate and passage of the Omnibus Appropriations package, the Omnibus Parks bill, and several other weighty measures that demanded compromise and considerable backroom dealmaking before they were ready for a vote on the floor. After various deals were struck, small packages of bills began to emerge and were passed by unanimous consent as the Senate wrapped up its affairs at day's end.

Not all good bills go to heaven, and the 104th Congress was no different. Every Congress leaves town and abandons dozens of noncontroversial bills at the unanimous consent doorstep because nobody has the time or energy to make the deal releasing the various holds. Moreover, in the complex world of Congress, if one senator drops his filibuster threat, there remain 99 others ready to spring with a hold for their own reasons. At some point, the Senate leadership declares victory and puts an end to last-minute dealmaking. In the late afternoon of October 3, Senate Majority Leader Trent Lott (R—MS) summed up this sentiment by stating: "Mr. President, the staff is working desperately to wrap up a couple of final items [in reality, this meant dozens of bills]. [However], we feel that we need to go ahead and close [adjourn the 104th Congress] because as long as we stay here, there will be other opportunities to try to get something cleared." With over 95% of the legislation introduced in the 104th Congress still waiting to "get cleared," Senator Lott's comment was a bit of an understatement. Well, there is always next year. ■

Peter F. Folger, 1995–1996 GSA Congressional Science Fellow, served on the staff of Senator Pete V. Domenici (NM). The one-year fellowship is supported by GSA and by the U.S. Geological Survey, Department of the Interior, under Assistance Award No. 1434-95-G-2651. The views and conclusions contained in this report are those of the author and should not be interpreted as necessarily representing the official policies, either expressed or implied, of the U.S. Government.

GSAF UPDATE

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

From The Ground Up

I am privileged to address you for the first time in my position as the new Director of Development at the GSA Foundation. As of this writing, I've been on the job only a short time, but the rich history and achievements of the organization are already evident. Equally evident is the commitment of GSA and its members to advancing the interests of the profession. Recent issues of *GSA Today* have included thoughtful commentaries about the social and economic forces affecting earth science professionals, and each day I learn more about GSA's extensive outreach and educational activities to increase appreciation of the relevance of the earth sciences to our lives.

In the August *GSA Today,* Eldridge Moores quoted Will Durant:

> **Civilization exists by geological consent, subject to change without notice.**

That observation is as cogent a justification as may exist for GSA's program efforts. Whether improving opportunities for education and advancement within the profession or extending opportunities to the lay public and policy makers for learning and understanding what the geosciences mean to our common welfare, GSA's programs address issues that are vital to the profession's health and viability.

Thus, the support GSA receives from its members and its professional sector is a direct reflection of shared values and concerns. The rationale for contributions to GSA's programs is not merely that the programs need funding but—more important—that the programs meet a fundamental need in contributing to what humans know about their home planet.

So, to all the members who have given their support in 1996, *many thanks!* For those of you who have not yet made a donation, the end of the year is a good time to consider how you can help. The ideas have been presented to you before, frequently, and may look familiar, but they cannot be reiterated too often.

Despite persistent tinkering with the tax code, the U.S. Congress has reaffirmed its commitment to private philanthropy, and favorable rules are still in place for charitable gift tax deductions. Therefore, although it may be getting a bit late in the year to commence planning a complex gift you can still complete a straightforward gift of cash or marketable securities before the December 31 deadline for 1996 tax planning.

The suggestions below demonstrate the potential advantages of a year-end gift, which may be unrestricted or may be directed to a particular program. Note that the examples assume a donor who itemizes deductions and has a combined federal and state tax liability of 35%.

Gifts of cash by check. A cash gift makes an immediate impact and generates an immediate and meaningful tax deduction. For example, a gift of $500 will realize a deduction of $175, making the net cost of the gift only $325.

Gifts of marketable securities. A gift of *appreciated* securities has two benefits. The market value of the gift as of the date transferred to GSA is deductible in the same manner as a cash gift, and there is no capital gains tax on the appreciation as there would be if the stock were sold. For example, a gift of stock having a market value of $10,000 and a basis of $5,000 will realize a deduction of $3,500 (35% of the gift value) and save capital gains tax of $1,400 (28% of the $5,000 gain) for a total savings of $4,900 and a net gift cost of $5,100.

A gift based on *depreciated* securities also has two benefits. A donor who has realized taxable capital gains in 1996 and who owns a stock that has declined in value since acquisition can sell the depreciated stock and donate the proceeds of sale to GSA. The loss on the sale can be applied to reduce taxable gains, and the donation of sale proceeds will generate a charitable gift deduction. For example, stock with a market value of $5,000 and a cost basis of $10,000 can be sold to realize a loss of $5,000 to be subtracted from capital gains, and the gift of $5,000 sale proceeds to GSA will result in a charitable deduction of $1,750.

Some of the tinkering with the tax code may affect the calculation of actual charitable gift tax benefits for high-income taxpayers and taxpayers subject to the alternative minimum tax. Donors in these categories should contact their financial advisors before making decisions about the amount and timing of gifts.

Still on the subject of tinkering with the tax code, a flat tax is one of several versions of tax reform being proposed to eliminate most of the 9,400 pages of the current tax law. In its purest form, a flat tax would create a single, low tax rate. It would probably provide generous personal exemptions but would eliminate all deductions—including the charitable gift deduction. A strong coalition has formed to present the concept of a modified flat tax, preserving the deductions for home mortgage interest and charitable donations. But the possibility of change is yet another reason to give generously while we know what the rules and benefits are.

Above all, please accept my best wishes for a happy holiday season.

GEO-STAR
Supporting The Advancement of Research

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

☐ Enclosed is my contribution in the amount of $_____ for
☐ Foundation—Unrestricted ☐ GSA—Unrestricted
☐ The _____ program or fund.

☐ I would like to make a gift of appreciated stock to the Foundation. Please send me information.

☐ My pledge to the Second Century Fund is $_____ per year for ___ years.

PLEASE PRINT

Name _____

Address _____

City/State/ZIP _____

Phone _____

Calling All Cars!

GSA is the proud owner of a 1977 Oldsmobile Vista Cruiser which was bought used in 1987 and which now has 150,000 miles and a broken side window. (The window is relevant.) Owing to the age of the car, replacement parts are becoming difficult and extremely costly to obtain. (Estimated cost of a window: $500 to $800.) Aside from parts, the auto body and interior are beyond hope. The car makes roundtrips of about 10 miles from the GSA warehouse to the post office to the headquarters offices, so although daily use is not great, it's important.

The day is coming when replacing the vehicle will be urgent. (Applying Murphy's Law, the urgency will arise on a sub-zero day in January a block away from the post office.) Before that day comes, we call upon your good will and used cars.

Does any member have a vehicle, either a station wagon or mini-van, that has served you up to or a bit beyond its time, that is somewhat less than 20 years old, that you would consider donating or offering for sale (cheap!) to GSA? If so, please contact the Foundation office at (303) 447-2020. ■

Reminder! Make sure your donations are mailed to the Foundation office before the end of December in order to have a 1996 tax deduction.

Winners! We've got Winners!

During the GSA annual meeting in Denver, the Foundation held the Second Century Fund drawing for donors who had pledged $250 or more. The big winner was Chris Mathewson, who won the free GeoHostel. Other Second Century Fund winners were Arthur A. Bookstrom, Jeremy M. Boak, Reese E. Mallette, Donald W. Boyd, Robert A. Larson, Richard H. Mahard, Joseph Gordon, Clarence R. Allen, and Ardith K. Hansel.

All 1996 contributors to the Foundation's annual campaign were entered in a separate drawing for the prizes displayed at the booth in Denver. The winners were Ralph David, Patricia Seawald, Robert Hudson, Howard Day, William Brosge, and Peter K. Matthews.

Many thanks to those who have supported the Foundation this year!

Donors to the Foundation, September 1996

Cady Award
Jack A. Simon* *(in memory of Robert M. Kosanke)*

Dwornik Planetary Geoscience Award
John O. Annexstad
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John W. Hess, Jr.*
Catherine J. Hickson
Norris W. Jones
Konrad B. Krauskopf*
Phillip H. Manger
Kiguma J. Murata
James T. Neal
Noel M. Ravneberg*
Walter Schmidt
Daniel R. Shawe
Arthur E. Soregaroli*
Laureen C. Wagoner
F. Michael Wahl*
Edmund G. Wermund, Jr.

Unrestricted - Foundation
Arthur T. Fernald
Eric Allan Lauha*
Herbert E. Wright, Jr.

Unrestricted - GSA
Liang Chi Hsu
Eugen Seibold*
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LETTER

Eldridge Moores mentioned in his September statement in *GSA Today* that in his view, we live in a time of "the apparent end of the 'social contract' between society as a whole and science." It is my professional view that this social contract is in the process of *renegotiation*. Here is why.

The initial social contract between American society and science is rooted in the Morrill Act establishing the land grant research, education, and service (extension) funding system. This contract was driven by *economic security* considerations of those times, and it later included other scientific fields that were meeting, or asked to meet, national economic needs.

World War II broadened the contract to emphasize harnessing science to meet national concerns about *military security*, and because it was interpreted broadly, particularly in funding research, basic science was supported or was a byproduct of meeting national security goals. That contract continued through the Cold War, and most of our GSA colleagues functioned and made careers under this paradigm.

Ending the Cold War forced a review of national objectives in this social contract and is now leading to a *revision* focusing again on *economic security*, particularly in those areas where research will improve America's economic competitiveness in the global economic marketplace. Thus, along with increased accountability, scientific research funding will be directed towards proposals and projects that enhance America's economic competitiveness globally, foster economic security, provide a return on investment, and show measurable impacts. This revised contract represents a major paradigm shift and cultural change for the American scientific community and for GSA. In my professional view, geology, through its traditional leadership in the petroleum and mining industries, is ideally suited to move in the mainstream of the amended social contract emphasizing economic security.

So, what should GSA do? First, it could foster an evaluation of measurable economic impacts to which geology could contribute and lead during the next quarter century. Second, it should solicit manuscripts for its journals that address *both* basic science and economic impacts, and encourage authors with good basic science papers to address economic impacts via the editorial review process.

Third, GSA should publish a Geological Sciences Extension Series, ranging from one to four pages, of selected *Bulletin* or

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WASHINGTON REPORT

Bruce F. Molnia

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

"Science ScoreBoard" Analyzes House of Representatives Voting Pattern on Science and Technology Issues

In presenting these findings we want to emphasize that our Representatives have not heard enough from their constituents in the scientific community. Scientists must realize that their Representatives need their advice and counsel when voting on issues of importance to science. Therefore, to the extent that they have failed to inform their Representatives, the scientific community itself is just as responsible for these voting records as the Representative.

— Roland Schmitt, Chairman, Science Watch

Several weeks ago, Science Watch, Inc., an independent science watchdog group, released its Science ScoreBoard, a new index, which can be important both in tracking Congress and as a possible future leading indicator for forecasting the long-term scientific health of the nation. "We can now for the first time rank, evaluate and appreciate our Representatives in Congress based on their actual voting records, not on just four or five issues, but on their votes all throughout the 104th Congress," said Martin Apple, Science Watch's CEO. He continued, "Currently the USA leads the world in science and this keeps us internationally competitive. The federal investment in science research has paid off handsomely. Dozens of studies have now agreed that the rate of return on such federal investment in science research may be over 40 percent per year, year after year, making science a highly valuable and pivotal federal investment. Federal support of science is vital to the national future."

The report, touted as a "first of its kind," found that, on the basis of a review of the voting records of the 437 individuals who were members of the House of Representatives during the 1995-1996 104th Congress, on 30 selected key science bills and amendments, 91 members voted in favor of science research more than 75% of the time. The report also revealed that 64 members voted against science research more than 70% of the time. Of those 64 members, 63 are Republicans. The one Democratic exception is Rep. Andrew Jacobs (IN) who voted against 73% of the scientific research legislation considered in the survey. Rep. Jim Ramstad (R—MN) had the lowest rating of all members, supporting science on only 4% of the index votes.

Science Watch selected the 30 votes (19 in 1995 and 11 in 1996) it saw as impacting science and technology, from the nearly 1,200 full House roll call votes of the entire 104th Congress (i.e, until the August 1996 recess). The 30 were selected as indicators because they do one or more of the following: (1) favorably or unfavorably impact the quality review of science; (2) proscribe or prohibit specific types of science research; (3) eliminate or increase science needed for improved national decision-making; (4) promote or curtail science education; or (5) directly increase or decrease investment in science.

Because many important votes affecting science are held in committee and do not involve all members of Congress, no committee votes or actions were included in the Science Watch compilation. Because Science Watch chose to include only 30 votes, certain important science legislation, such as the Oceanographic Partnership Act (see October 1996 Washington Report) were not included in the analysis. Substitution of other legislation for some of the 30 used to evaluate congressional support of science and technology would likely change the outcome of the analysis. However, on its own merit, the results of the Science ScoreBoard are extremely significant.

The report shows that Democrats in the House (average rating of 72%) supported science on these indicator votes about twice as frequently as the Republicans (average rating of 35%). Democratic members with support of science ratings of 90% or higher were: Ken Bentson (TX—97%), Sheila Jackson-Lee (TX—97%), Eddie B. Johnson (TX—97%), Ronald Coleman (TX—96%), Martin Frost (TX—96%), John Murtha (PA—96%), Tom Bevill (AL—93%), Rick Boucher (VA—93%), George Brown (CA—93%), Kiki de la Garza (TX—93%), Steny Hoyer (MD—93%), Gene Green (TX—92%), Joe Moakley (MA—92%), Alan Mollohan (WV—92%), Robert Bud Cramer (AL—90%), John Bryant (TX—90%), Norman Dicks (WA—90%), Solomon Ortiz (TX—90%) and Ray Thornton (AR—90%).

Republican members with support of science ratings of 50% or higher were: James Hayes (LA—71%), Amo Houghton (NY—67%), Sherwood Boehlert (NY—60%), Nancy Johnson (CT—60%), Tom Davis (VA—57%), Constance Morella (MD—57%), Jim Greenwood (PA—55%), Jim Bunn (OR—53%), Paul Gilmore (OH—53%), James Walsh (NY—53%), William Clinger (PA—52%), Vernon Ehlers (MI—52%), Philip English (PA—52%), C. W. Bill Young (FL—52%), Michael Bilrakis (FL—50%), Herbert Bateman (VA—50%) Ken Calvert (CA—50%), Wayne Gilchrist (MD—50%), Steve Horn (CA—50%), Peter King (NY—50%), Steven LaTourette (OH—50%), and William Thomas (CA—50%).

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Geology papers that have an economic impact and *distribute* these to the public and policy domain (especially elected officials). The Kansas Geological Survey instituted such a series nearly 18 months ago, hired a science writer to manage and write the articles, and distributed these professionally produced documents statewide. Statewide response and support have been overwhelmingly positive in terms of support for that agency, including from elected officials. GSA's contribution of an Extension Series could lead to a similar impact and strengthen geology's role in the USA.

No doubt, other opportunities exist for GSA to show its economic impact, relevance, and accomplishments that help the USA's competitiveness in the global marketplace. Does GSA have the will to develop them?

George D. Klein
George D. Klein & Associates
Matawan, NJ, 07747-0944 ■

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As House Speaker Newt Gingrich traditionally only votes to break deadlocks, he is not included in the ScoreBoard.

Surprisingly, the ratings of both Republican and Democratic members of the House Science Committee were below their party averages. Republican committee members supported science legislation only 33.5% of the time (vs. party average rating of 35%) while Democratic committee members supported science legislation 69.2% of the time (vs. party average rating of 72%). Committee chairman Robert Walker (R—PA) had a rating of 40%, while ranking minority member George E. Brown, Jr. (D—CA) had a rating of 93%.

On a state basis, representatives from West Virginia, Montana, Hawaii, Massachusetts, Alabama, Texas, Rhode Island, Maryland, North Dakota, Virginia, and Vermont were found more likely to vote in favor of science, 60%–80% of the time, while representatives from New Hampshire, Nevada, Wyoming, Kansas, Idaho, Wisconsin, Nebraska, Iowa, Arizona, Indiana, and Oklahoma were least likely (only 25%–38% of the time).

The press release accompanying the Science ScoreBoard report stated that "while 4/5 of the public supports the federal investment in science, only 1/5 of the members of the House of Representatives consistently vote to support science and technology research...." The 4/5 finding is based on a Louis Harris Organization poll conducted in February 1996 in California, Florida, and Texas. In the poll, 3,000 adults were asked "Do you agree the federal government should support basic scientific research, even if it brings no immediate benefits?" Eighty-one percent agreed, 12% percent disagreed, and 7% percent responded that they "did not know." The poll findings are reported with a margin of error of 3.1%. The responses are similar to those reported from several other 1992–1995 state and national surveys.

Science Watch, Inc. is a group of nationally recognized science leaders concerned with helping educate the nation about the role and significance of science in the American future. Its members include: Roland Schmitt and James Duderstadt, both past chairmen of the National Science Board; Nobel laureates Ken Wilson, F. Sherwood Rowland, Herbert Simon, Gertrude Elion, and Leon Lederman; D. Allen Bromley, past science advisor to President Bush; Maxine Singer, president of the Carnegie Institution; Eric Bloch, past director of the National Science Foundation; and Martin Apple, the executive officer of the Council of Scientific Society Presidents. ■

BOOK REVIEWS

Geology of Wyoming. *Edited by A. W. Snoke, J. R. Steidtmann, and S. M. Roberts. Memoir 5, Geological Survey of Wyoming, Laramie, WY 82071-3006, 1993, two volumes plus map packet, $75 plus postage ($5 in Wyoming, $10 in rest of U.S., and $20 international, including Canada).*

These two volumes represent a benchmark and probable classic in the literature of the Middle Rocky Mountains. Produced jointly by authors mostly from the University of Wyoming and the Wyoming Geological Survey, this work represents a summary of where geologic research and understanding of the region stands as we approach the end of the 20th century. The dedication is to two of this century's greatest contributors to that understanding: Don Blackstone of the University of Wyoming and Dave Love of the USGS. Both began their streams of significant Wyoming publications in the 1930s, and both continue their geological activity in the region to the present day. There could have been no better choice for the dedication of such a volume.

For much too long there has been a void in literature on Wyoming geology. Innumerable articles deal with details of specific areas, commonly in guidebooks or other forms of gray literature. Where summary papers exist, the focus is largely on the approach of a subdiscipline to specific data and interpretation of the region. Overall syntheses exist but seem to be largely low-level books for a more general audience. Nowhere has there been a volume that one could turn to, knowing that it contained a good summary of whatever subdiscipline was of interest as well as a bibliography of the most pertinent data and publications on that subject. These volumes fill that void.

The 40-page editorial overview, by Snoke, with its 15-page bibliography, is a guide to the general literature as well as to more detailed summary sections that follow. This article is the finest and most readable summary of Wyoming geology at a highly professional level that I have seen to date, a "must read" item for any workers in the region who want information beyond their specialty or for any student starting a research project or field camp session. For details on individual topics, 26 articles by many authors are organized into sections on Precambrian, Paleozoic, Mesozoic, and Cenozoic history, and a final section on topical aspects such as ground water, oil and gas, coal, and radioactive materials. The 10-item map packet includes some new seismic and bathymetric data on Jackson Lake and the Teton fault by Smith et al.; eight balanced cross sections of the Wyoming thrust belt by Royse would be suitable for student exercises as well as regional understanding. A copy of the 1991 geologic highway map of the state at 1:1,000,000 scale links the driving geologist to the local bedrock.

This publication is the logical starting place for anyone, student or professional, who wants more detailed information on almost any aspect of Wyoming geology, be it the Yellowstone hotspot, the Heart Mountain detachment, stratigraphic nomenclature, tectonics, or the mysteries of the Precambrian. No field camp, no geology department nor its library, and no professional geologist or serious student of the region should be without it.

Donald U. Wise
Franklin and Marshall College
Lancaster, PA 17604-3003

Mechanics in the Earth and Environmental Sciences. *By Gerard V. Middleton and Peter R. Wilcock. Cambridge University Press, New York, 1994, $89.95 (hardback), $34.95 (paperback).*

A major trend, well underway, in earth science is the application of its techniques and results to solving the environmental problems besetting humankind. One sees examples of this in the newspapers every day. For instance, the proposed underground storage facility at Yucca Mountain, within the Nevada Test Site, must be certified capable of safely containing high-level radioactive waste for at least 10,000 years. To this end, numerous phenomena that might affect the integrity of this facility must be understood so well that they can be predicted into the geologic future with confidence.

Whatever the political fate of Yucca Mountain, it at least serves as a dramatic illustration of the need for improving our capability to analyze quantitatively the geologic and hydrologic processes that affect the topmost several kilometers of Earth's crust, because environmental problems of many types are not only encountered globally but, more alarmingly, are increasing in step with human population growth. Thus, this book by Middleton and Wilcock was written partly with a view to training workers to address these difficult problems, many of which, including Yucca Mountain, are so challenging as to force important new developments in the earth sciences.

As indicated by the title, this textbook, developed from courses taught by the authors, is intended to help students gain a working knowledge of applying the principles of mechanics (classical, continuum, and fluid) to understanding and modeling a broad variety of geologic pro-

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Book Reviews *continued from p. 19*

cesses. Although Middleton and Wilcock have written this book for an undergraduate science student with minimal technical background, they nonetheless present sufficient methodology to address at least simplified versions of problems that are currently vexing earth scientists in a broad range of subject areas.

This book may help to inject some new excitement into the earth sciences of the sort that is currently hard to find. Specifically, nearly all of our literature involves the application of old, well-established equations or procedures to new data sets or more elaborate numerical modeling. The trend into new, environmentally oriented problem areas is placing an unusually high premium on resourcefulness in developing novel approaches to problem solving, including new equations to represent geologic and hydrologic phenomena. In several ways this textbook caters to the needs of scientists keen to venture into new territory. First, the authors have provided some fine historical introductions to the various chapters (e.g., classical mechanics, stress, strain, fluid flow, pressure, buoyancy, consolidation, electricity, convection, and turbulence) to give the reader a good idea of how subject areas have developed to the current state of the art and who was involved. Second, the book is loaded with "back-of-the-envelope" calculations, which any scientist knows are perhaps the most exciting part of one's career, especially the simple calculations that yield novel insights. Third, this book includes a superb chapter, "Dimensional analysis and the theory of models," that presents some excellent techniques for developing new equations, modeling processes, and checking the correctness of theoretical analysis.

Not surprisingly, this textbook has a few weak points, none of which detracts seriously from it. Some of the detail provided for numerical techniques, including flow charts, seemed somewhat out of place and date. In several instances the authors have pushed analysis using simplified models too far to reach conclusions that are a little too unrealistic to provide useful insights. One example of this that disturbed me appears on p. 289 where, in problem 1, Middleton and Wilcock ask the reader to assume, for purposes of solving a state-of-stress problem, a boundary condition of zero horizontal strain! Finally, having been a seismologist for more than 30 years, I was surprised to read (p. 280) that the seismic wave speed is called "celerity."

These minor drawbacks notwithstanding, there are numerous good reasons to recommend this as a textbook for earth science courses or as a reference on one's bookshelf. Of these, perhaps the most important are the clarity of presentation, including a very intuitive approach

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1996 Annual Meeting Chorale Conductor Sings Praise

To the members of the GSA Mile High Chorale

Gregg M. Busch, Conductor

Thank you for the truly wonderful experience of conducting you at St. John's Cathedral. Although I was a little nervous after the first rehearsal, I was amazed at the high level of excellence you achieved in a very short time. You should all be very proud of the work you did to make the final performance a success. Each of you is a tribute to the choirs and chorales that you work with regularly.

Thanks also to those of you who attended the concert, for supporting your fellow geologists. Everyone should make sure to get a cassette tape of the performance. I have heard it myself and you will be absolutely delighted.

Finally, I urge all of you to continue this tradition at the next conference. You truly are a remarkable group, and yes, we DID make music!

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to describing the often complex subject matter, clear and effective figures, and instructive problems in each chapter, along with well-explained solutions. The many important numbers that crop up continuously in the earth sciences (e.g., the Rayleigh number) are explained and motivated quite effectively. Moreover, Middleton and Wilcock have demonstrated excellent scholarship by providing a lengthy and useful list of references for the reader seeking more details.

Art McGarr
U. S. Geological Survey
Menlo Park, CA 94025

Fractals in the Earth Sciences.

Edited by Christopher C. Barton and Paul R. La Pointe. Plenum Press, New York, 1995, $59.50.

Fractals became a popular element of the geological jargon about a decade ago. Since that time, studies making use of the concept of fractals have proliferated, albeit without the visibility of earlier days. The lower profile of recent fractals research in earth sciences stems not from a failure of the concept nor from a lack of interesting progress, but rather, I think, from the more systematic, more applied, and more topically specific character of ongoing work (e.g., see the early 1996 special issue of *Journal of Structural Geology* on fault populations).

Fractals in the Earth Sciences provides a good sampling of some directions taken by researchers using fractals as a tool. The book contains 13 papers that cover a range of topics, although about half of the papers focus primarily on different aspects of fractures, faults, and/or earthquakes. The first two papers are intended to provide an overview of the techniques used to analyze geologic data and of the variety of geologic phenomena that have been addressed. The following two papers concern the systematics of a few of the most commonly used techniques for quantifying the scaling of geologic phenomena. These are particularly welcomed contributions because so few studies have adequately scrutinized the methodologies; however, the techniques covered represent only a subset of those used even in this book. For the most part, the rest of the papers present topical studies of fracture surfaces, seafloor topography, fracture network geometry, fault breccia, fault lengths and displacements, earthquake dynamics, igneous rock textures, and gold-silver mineralization. An additional paper (the most interesting of the book, I think) defies the simple classification above, and addresses the transitions of geologic phenomena that follow different scaling patterns at different scale ranges.

Barton and La Pointe have provided a volume that will interest many geoscientists with no experience in using fractals, although a couple of the papers probably are inaccessible to novices. The variety of topics offered, while not comprehensive, should at least attract a wide range of readers. Many of the topical papers are largely reviews and may well be the best places to start for those with new interests in the fractal aspects of the specific topics. In addition, discussions of the techniques

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CALL FOR NOMINATIONS REMINDERS

Penrose and Day Medals, and Honorary Fellowship

Nominations for 1997 Penrose and Day Medals and for Honorary Fellowship in the Society are due by **FEBRUARY 3, 1997.**

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 $15,000, was endowed by Dr. and Mrs. Fred A. Donath.

For the year 1997, only those candidates born on or after January 1, 1962, are eligible for consideration. In choosing candidates for the Young Scientist Award, scientific achievement and age will be the sole criteria. Nominations for the 1997 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 in addition to the person making the nomination.

Deadline for nominations for 1997 is **FEBRUARY 3, 1997.**

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).

Deadline for nominations for 1998 is **FEBRUARY 18, 1997.**

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, 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. Deadline for nominations for 1997 is **MARCH 3, 1997.**

John C. Frye Environmental Geology Award

In cooperation with the Association of American State Geologists (AASG), GSA makes an annual award for the best paper on environmental geology published either by GSA or by one of the state geological surveys. The award is a $1000 cash prize from the endowment income of the GSA Foundation's John C. Frye Memorial Fund. The 1997 award will be presented at the autumn AASG meeting to be held during the GSA Annual Meeting in Salt Lake City.

Nominations can be made by anyone, based on the following criteria: (1) paper must be selected from GSA or state geological survey publications, (2) paper must be selected from those published during the preceding three full calendar years, (3) nomination must include a paragraph stating the pertinence of the paper.

Nominated papers must establish an environmental problem or need, provide substantive information on the basic geology or geologic process pertinent to the problem, relate the geology to the problem or need, suggest solutions or provide appropriate land-use recommendations based on the geology, present the information in a manner that is understandable and directly usable by geologists, and address the environmental need or resolve the problem. It is preferred that the paper be directly applicable by informed laypersons (e.g., planners, engineers). Deadline for nominations for 1997 is **MARCH 31, 1997.**

National Awards

The deadline is **April 30, 1997,** for submitting nominations for these four awards: William T. Pecora Award, National Medal of Science, Vannevar Bush Award, Alan T. Waterman Award.

used in the papers are much more useful than the often perfunctory statements that remain in journal articles after editing.

The book probably will not be of great interest to researchers already working with fractals, except perhaps to get a broader picture of the uses of fractals in geosciences. Most of the material presented in the book has been published previously. In fact, in the rapidly evolving world of fractals, many of the articles are already dated. By my count less than 10% of the references were published during the 1990s. Nevertheless, I expect that this will be a book that I use.

Randall Marrett
University of Texas
Austin, TX 78712

Geology of Switzerland. *By Kenneth J. Hsü. Princeton University Press, Princeton, New Jersey, 1995, 250 p., $55.*

The subtitle for the German edition of Hsü's book is "A Textbook for Beginners and a Discourse with Experts," and the publishers would have done well to keep this subtitle with the English edition, as it neatly summarizes the widely disparate levels of the text. The book is a mixture of geological detective work, historical anecdote, personal reminiscence, and detailed discussion of obscure stratigraphic arguments. It would be much simpler for geology students to follow had Hsü started the book with the overview Chapter 12, Geological Evolution of Switzerland, and then gone into detail about historical ideas on particular outcrops, rather than the other way around. At least then the interested nonexpert would have a framework on which to hang all the minutiae of historical argument.

Throughout the first half of the book, Hsü uses the concept of tectonic facies as his basis for discussion of the classic subdivisions of the Alps, working from foreland to hinterland. Unfortunately, there is no clear exposition of the concept even in the chapter devoted to the tectonic facies concept, wherein historical anecdotes and autobiographical notes leave the reader no nearer to an understanding. One is left to surmise, without much confidence, that a tectonic facies must be a recognizable group of rocks that formed in a particular tectonic environment and that can be correlated from place to place.

The early chapters on the Jura Mountains, Swiss Midlands, and Swiss Alps are fluid and clear, but in the chapters on Helvetic unconformities, flysch versus wildflysch, and Pre-Alps, the book descends into the sticky mixture of place names, tectonic event names, formation names, and geologic time zones that have bogged down non-Alpine geologists for decades. The non-Swiss purchaser of this book should be aware that it is absolutely essential to have access to both the geology and tectonic maps of Switzerland; otherwise, much of the time he or she will have no idea where in Switzerland the particular feature under discussion is to be found. Even with the aid of the geologic maps, it is not always easy to follow the arguments presented. For example, on page 55, we find: "The so-called Einsiedeln Flysch, Blattengrat Flysch, and Ragaz Flysch are not flysch formations, but schuppen zones. The Globigerina Marl, Nummulitic Limestone, and Amden Marl of these zones are not flysch, but the Blattengrat Sandstone, or the turbidite sandstone and shale interbeds above the Globigerina Marl, in the Blattengrat and Einsiedeln schuppen zones [are] South Helvetic Flysch." No reference is made to maps or figures that would help the nonexpert unravel the complexities, or even sort out why they might be important.

In the central chapters on the Penninic core nappes, Bundnerschiefer, ophiolite melanges and Austroalpine Nappes, both the writing and geological exposition are clear. There are lucid discussions of how the Penninic ocean once was separated into two troughs by the Briancon-nais Swell and how this initial configuration was largely responsible for the present tectonic juxtapositions of the crystalline nappes. A strength of the book is that modern analogs of the presumed depositional and tectonic environments are suggested; some, such as the present eastern Mediterranean as an analog for Helvetic paleogeography, seem highly appropriate. However, in the same section other "actualistic" examples, such as the South China Sea and the Cascades, are also presented as analogs for the Eocene Helvetic and Ultrahelvetic realm, but with less convincing supporting arguments.

Geology of Switzerland is an entertaining book for the geological historian and raconteur. The style in several places is that of a detective story, as the reader is led through the development of ideas about a particular outcrop or structure. Reproductions of original field sketches from the late 1800s and early 1900s are a valuable addition. However, I longed for modern and informative maps and cross sections of the Alps in place of the numerous artistically pleasing but somewhat dated illustrations. The superb work of more modern authors is largely ignored throughout the book.

At the end of the book are two chapters that aim to link the tectonic facies concept to other geologic regions. Very brief summaries of the Caledonides, Appalachians, North American Cordillera, Andes, and China do give the novice an introduction to these areas, although there are more informative regional texts on the market. The final chapter consists of Hsü's miscellaneous philosophical thoughts about geology and geologists.

Overall, *Geology of Switzerland* gives the impression of an author with great knowledge genuinely seeking to inform and enlighten, and it provides an interesting and easily readable perspective on the Swiss Alps for geologists who already have a good knowledge of the area. This is not a book I can recommend to the nonspecialist or the average non-European student, however.

Carol Simpson
Boston University
Boston, MA 02215

The Great Dinosaur Extinction Controversy. *By Charles Officer and Jake Page. Helix Books, Addison-Wesley, New York, 224 p., $25.*

The main contention of this book is that the impact (or "Alvarez") theory of the Cretaceous-Tertiary mass extinction is (and always was) empirically bankrupt and that it has been maintained in the popular and scientific consciousness mostly by media bias and hype. Officer is one of the leading antagonists of the Alvarez theory, and such a book might have promised a genuine insider's look at the debate. This expectation is, in part, fulfilled. There is a brief but useful summary of the principal arguments against the impact scenario and in favor of the volcanic alternative, together with an incomplete but useful bibliography. This book is disappointing, however, chiefly because it adopts much of the tone and approach it criticizes.

The history of the impact theory is indeed one filled with acrimony and what Officer and Page call "media science." Its senior architect, physicist Luis Alvarez, did in fact dismiss most previous paleontological investigation, mostly on the grounds that physics is better and more rigorous science than paleontology. The media did make much of the evidence for the impact theory, and less about evidence to the contrary. A bandwagon effect was clearly operating, and some poor science was clearly done and published.

But to read Officer and Page, one would think that there never was any significant reason to take the impact theory seriously; that paleontologists already knew the answer to the K-T event in 1980, and that there was in fact no problem to solve; that the anti-impactors brought no biases or preconceived notions to their work, and that an Earth-based volcanic scenario is the only one possible; and that only a tiny minority of "legitimate scientists" today support the impact hypothesis.

It just isn't that simple. The truth is that in 1980 there was no consensus on either the structure of the extinction or its

causes. Climate and/or sea-level change was perhaps the most widely accepted, but the details were not clear. Volcanism and extraterrestrial impact had been seriously suggested; Walter Alvarez actually started investigating the problem in an attempt to test the supernova theory. The impact theory spurred an unprecedented burst of research on all mass extinctions and particularly the K-T. We now have a far greater (although still incomplete) understanding of what went extinct when, and of patterns of selectivity and recovery.

There is compelling evidence for both an extraterrestrial impact and an episode of extensive volcanism at around the K-T boundary. Some evidence for each is fairly strong, some is ambiguous, some is demonstrably false. Under such circumstances, the preconceptions of the two sides are of considerable importance. Officer and Page point out the motives of the impact camp without saying a word about what was, at least initially, an important preconception of the anti-impactors: gradualism and anti-catastrophism. They also resort to the same style of ignoring or sidestepping contrary findings that they criticize in their opponents. Among the paleontological work that supports a relatively sudden extinction, for example, the well-known work of Ward on ammonites and of Sheehan and colleagues on dinosaurs near the boundary were not cited. Evidence for impact is found to be ambigous because of "our lack of knowledge of what went on in K-T times," whereas volcanoes are "unquestionably responsible" for some K-T data and non-impact events are "known to have occurred."

Although there have been no real surveys of professional opinion on the Alvarez hypothesis since the mid-1980s, the idea has hardly "collapsed." Some paleontologists maintain that no impact occurred. By my judgment, however, most accept that one did and are wrestling with its possible effects; many believe it had little effect, but many maintain the opposite.

Perhaps most troubling is Officer and Page's insistence that the impact theory has violated the rules of science. They suggest that if a research program spends time "accomodating known facts" instead of generating "dramatic, unexpected, stunning new predictions," then it is "degenerative" instead of "progressive." This ignores the perfectly valid activity that follows announcement of all new theories: modification in light of additional information. New theories that link and coordinate preexisting observations are also legitimate.

We need to understand what happened at the end of the Cretaceous, and we do not yet. Few problems in historical geology have generated so much complex and contradictory evidence. It is a difficult problem. Voices of peer-review, caution, and even opposition are essential in science, especially in the early stages of development of a theory. We will continue to need authoritative yet balanced presentations of non-impact explanations as the search for the answer continues. The tone of this book does not contribute constructively to this search.

Warren D. Allmon
Paleontological Research Institution
Ithaca, NY 14850

The Global Environment; Water, Air and Geochemical Cycles. *Elizabeth K. Berner and Robert A. Berner. Prentice Hall, New York, 1996, 376 p. ISBN 0-13-301169-0.*

Elizabeth and Robert Berner have summarized their many years of teaching and research on global geochemical cycles in this new and very useful book. The new book is a substantially revised version of their previous work, *The Global Water Cycle* (1987). In the preface, the authors state that their intended audience is an intermediate one, that they are attempting to fill a gap between introductory texts on environmental science and more advanced works on aquatic chemistry.

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The Global Environment begins with a review of the major reservoirs and fluxes of water on Earth, and a brief description of the circulation patterns in the atmosphere and ocean. The treatment of circulation patterns and their driving forces is brief; a more satisfactory version will be found in most introductory oceanography texts. The second chapter, on air chemistry, provides an overview of the major constituents of the atmosphere and some discussion of the greenhouse effect, the ozone hole, and the problem of tropospheric ozone pollution. Again, this section is limited, and other books treat the subject more thoroughly at an undergraduate level. However, circulation patterns and atmospheric chemistry are not what this book is fundamentally about. Beginning in chapter 3, the book hits its stride, focusing on the major geochemical cycles. Chapters on precipitation, weathering, and rivers lay out the basic controls on the chemistry of these fluxes in a clear and useful fashion. In chapter 3, atmospheric deposition of anthropogenic constituents of the atmosphere is discussed in some detail using data from North America. As in all the chapters, relevant data are summarized in tables and figures that make for a clear exposition of the topic at hand. This visual representation of data makes it readily accessible to students but also a very handy summary for researchers, who might, for example, want a quick check on geographic trends in chloride content of rainwater. Chapter 4 summarizes much research into weathering focusing on macroscopic processes. The book does not develop the concepts of chemical equilibrium and kinetics in any formal way—the only weathering and precipitation equations it contains are balanced chemical reactions. Instead, the authors choose to describe the relevant chemistry in terms of the dominant processes, which may help students see the forest, rather than getting lost in reaction space. The Berners provide a significant service to the geological community by summarizing much of the available data on fluxes of river-borne material to the sea.

The final chapters on lakes, marginal marine environments, and the oceans focus on internal processes in those reservoirs, some of which are the sinks for the river- and atmosphere-borne inputs from land. The concepts of residence time and box models are introduced in the chapter on lakes, providing the only "math" found in the book. The chapter on marginal marine environments treats an area that is too often ignored in most reviews of marine chemistry, yet processes occurring there are essential for understanding the fate of river fluxes to the oceans. The review of chemical budgets for each of the major species dissolved in seawater is very useful. Estimates are made for the magnitudes of each of the significant removal processes for the major ions, information that is otherwise scattered about the geologic and oceanographic literature.

Students in a senior undergraduate class in biogeochemistry here at Cornell have responded positively to the book, as have members of a freshman seminar on environmental chemistry. The writing style is clear, and the illustrations are useful. However, as a textbook for an upper level undergraduate class, the book lacks some of the fundamental chemistry that is needed to quantify relevant chemical processes. These concepts can be provided in lecture, leaving the book to summarize a global data set and focus on the bigger picture. *The Global Environment* will also appeal to a wide professional audience, because it is a very useful summary of global geochemical cycles by workers who have made numerous significant contributions to this field. Many will find that the compact and clear compendium of data and key concepts will make this book an indispensable addition to their personal library. In short, I can recommend this book both as an undergraduate text and as a reference for graduate students and professionals who have some interest in geochemical cycling.

Louis A. Derry
Cornell University
Ithaca, NY 14853

Water on Mars. *By Michael H. Carr, Oxford University Press, New York, 1996, 229 p., $65.*

Published only months before the startling announcement by NASA of the discovery of possible evidence of ancient life on Mars, *Water on Mars* could not be timelier. Whether or not one accepts the hotly debated assertion that organic compounds, iron mineral associations and microstructures in meteorite ALH84001 are biological in origin, interest in the possibility of past or even present life on Mars has been overwhelmingly rekindled. As a requirement for life as we know it, knowledge of the distribution and history of water on Mars is crucial to developing an effective strategy for searching for life on the Red Planet.

Water on Mars summarizes our current knowledge of the subject, both theoretical and observational. No one is better qualified than Michael Carr to tell the story—as leader of the Viking Orbiter Imaging Team, Carr played a central role in acquiring many of the essential spacecraft observations that document the current and previous effects of water on the martian surface, and his *Surface of Mars* (Yale University Press, 1981) remains the most accessible reference on the Viking mission imaging results. *Water on Mars* is written at a more technical level but is aimed at both planetary scientists and interested geoscientists, assuming only a familiarity with basic geology and geomorphology. After a brief overview of martian geology for background and context, the text describes the present water cycle and the stability of H_2O under current climatic conditions as well as the evidence for and mechanisms of climate change, the initial water inventory and the evolution of the abundance and distribution of water throughout the planet's history. Perhaps the most valuable contribution of the text is a critical review of the literature interpreting diverse surface features as evidence for water on Mars: separate chapters discuss outflow channels, valley networks, and high-latitude debris aprons and other morphologic indicators of the movement or removal of ground ice. This section includes a lively discussion of Carr's sometimes unorthodox views on these subjects, and is well illustrated by a careful selection of pictures chosen from nearly 50,000 Viking Orbiter images to highlight fluvial, lacustrine, ground-water, and glacial or periglacial processes. A minor criticism is that the images are oriented randomly, requiring the reader to rotate and tilt the page until craters appear as depressions.

In light of recent developments, most readers (like me) will probably jump to Chapter 8, "Implications for Life" and Chapter 9, "Future Mars Exploration" to look for answers to the question of where to go from here. The story is as yet incomplete, but Carr's excellent summary of what is known about water on Mars and frank exposition of the gaps in our current knowledge will provide thought-provoking reading for those engaged in planning the next Mars missions and a useful addition to the libraries of students of planetary geology and exobiology.

Paul Geissler
University of Arizona
Tucson, AZ 85721

The Geology of Fluvial Deposits—Sedimentary Facies, Basin Analysis, and Petroleum Geology. *By A. D. Miall. Springer-Verlag, New York, 1996, 582 p., $69.*

There is a great need for brave individuals to synthesize the flood of literature in any field of science, and fluvial sedimentology is no exception. Andrew Miall must be given due credit for undertaking this daunting task. Miall's approach is as expected from someone who has been most closely involved with description and interpretation of fluvial sedimentary rocks, rather than with studying modern sedimentary processes. The central theme in this book is that fluvial deposits with distinctive characteristics (e.g., geometry,

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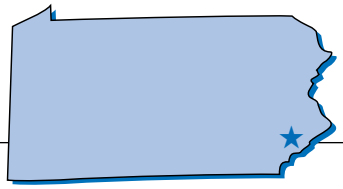
Final Announcement

NORTHEASTERN SECTION, GSA 32nd Annual Meeting

King of Prussia, Pennsylvania
March 17–19, 1997



Geologists from Bryn Mawr College, the Delaware Geological Survey, LaSalle University, Montgomery County Community College, Pennsylvania State University (Ogontz Campus), Temple University, the University of Delaware, Villanova University, West Chester University, Emrich & Associates, ERM Group, and the Pennsylvania Department of Environmental Protection will host the Northeastern Section of the Geological Society of America Annual Meeting at the Sheraton Valley Forge Hotel East and West in King of Prussia, Pennsylvania, located about 18 miles west-northwest of center city Philadelphia. The Eastern Section of SEPM, Northeastern Section of the Paleontological Society, Eastern and New England Sections of the National Association of Geoscience Teachers, and the Association for Women Geoscientists will meet with GSA's Northeastern Section. The meeting will be conducted from 8:00 a.m. Monday, March 17 to noon Wednesday, March 19. Short courses and K–12 workshops will be held on Sunday, March 16.

REGISTRATION

Preregistration discounts are given to members of GSA and the associated societies listed on the preregistration form. Please indicate your affiliation(s) to register using the member rates. Students and K–12 teachers must show a CURRENT ID in order to obtain these rates. Students or teachers not having a current ID when registering on site will have to pay the professional fee. Preregistration forms must be received at GSA no later than February 14, 1997. Please register only one professional or student per form and retain a copy for yourself.

By Mail: Northeastern Section GSA Annual Meeting, P.O. Box 9140, Boulder, CO 80301-9140.

By Fax: 303-447-0648 or 303-447-1133—credit card use only. Our fax line is open 24 hours. Do not send another copy in the mail.

If you preregister, you will not have to wait in long registration lines to pick up badges in the registration area, because they will be *mailed* within two weeks prior to the meeting. Save yourself time and money—preregister today. There is a savings in fees if you register before the preregistration deadline! Advance registration is required for many of the special activities because of participation limits. Use the preregistration form provided in this announcement.

All registration forms received at GSA by February 14 will be processed and badges mailed two weeks before the meeting. Registration will not be processed unless full payment is received. Unpaid purchase orders are NOT accepted as valid registration. Charge cards are accepted as indicated on the preregistration form. If using a charge card, please recheck the card number given. Errors will delay your registration. The confirmation sent to you

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texture, structure) occur at different superimposed scales, and that the time span over which these strata form generally increases with their physical scale. Thus, following a lengthy history of research in fluvial sedimentology, Miall works through successive chapters from small to large scales of fluvial deposits. This is a logical approach that works well. Miall has presented a profusion of information and opinions, and he has faced controversial issues head on. Notwithstanding the strengths of this book, I feel compelled to criticize parts of it, and to point out some important topics that were omitted.

I would like to see the historical background at the start of the book integrated more closely with the main body of the text, in order to give a historic perspective to modern viewpoints on specific topics. This would allow development of the central theme at the start of the book, and would perhaps result in giving less credibility to outdated and erroneous ideas.

The book is rife with poorly designed classifications (e.g., of lithofacies, bounding surfaces, architectural elements, fluvial styles, reservoirs, and more). I wrote a critique of some of these in 1993 (in *Sedimentology*), but it is clear that Miall does not agree with the views I expressed. Indeed, he appears to have pursued the classification and codification path with renewed vigor. If we are going to classify things, we must have: objectively defined, measurable parameters; logical, mutually exclusive classes, and; simple and clear terminology. We cannot have descriptive terminology that requires prior genetic interpretation. It is critical to separate depositional products (e.g., cross strata) from the morphological features (e.g., ripple, dune, or bar) with which they are interpreted to have been genetically associated. Does every sedimentary feature that we put into a pigeonhole have a unique interpretation? Do we really want to converse using a limited number of acronyms? It would be a shame if Miall's brand of classification methodology really does become as standard as he suggests it already has.

Those who feel faint at the sight of a mathematical equation will not be in danger of passing out while reading most of this book, as the treatment is almost entirely qualitative. This may, however, alarm those who think that fluvial deposition is essentially a physical phenomenon that requires the formalism of mathematics to describe and understand it. Some will find it strange that there is no mention of the sediment continuity equation and how it is used to understand the mechanics of erosion and deposition in river systems. Miall's flirtations with the mechanics of water flow, sediment transport, erosion, and deposition are possibly the weakest parts of the book.

Miall presents no fewer than 16 facies models for different types of river channel. It is not clear why there should be so many. Whatever the reason, they all lack critical three-dimensional details and are qualitative. Furthermore, the links between channel geometry, water flow, sediment transport, erosion, and deposition in these different kinds of channels are not explored in detail. Quantitative interpretation of ancient channel deposits receives short shrift, and perhaps the most sophisticated description and interpretation of ancient river deposits published to date (Willis, *Sedimentary Geology,* 1993) is barely mentioned. Miall also perpetuates myths about the nature and controls of channel geometry (e.g., discharge variability is a primary control of braiding, braiding is inhibited in vegetated areas, and braided rivers occupy most of the valleys in which they flow).

Overbank deposits now have the dubious distinction of having their own architectural element classification, warts and all. I suspect that readers might have wanted to know a little more about paleosols and specifically how isotopic studies of paleosols are yielding information

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by GSA will be your only receipt. You should receive it within two weeks after your registration is submitted.

Badges are needed for access to all activities, 8 a.m. Sunday through noon Wednesday.

Guest registration is required for those attending guest activities, technical sessions, or the exhibit hall. Guest registrants MUST be accompanied by a registered professional, a student, or a K–12 teacher. A guest is defined as a nongeologist spouse or friend of a professional, student, or K–12 teacher *registrant*.

All registrations received after February 14 will be considered *on-site* registrations and charged accordingly. Absolutely no preregistrations should be mailed or faxed after February 21. All forms received after February 21, regardless of when postmarked, will be held for on-site processing. Delegates who will attend only a short course or workshop must pay at least the one-day registration fee. Badges must be worn for all activities. Registration fees do not include provisions for insurance of participants against personal accidents, sickness, theft, or property damage. Participants and accompanying guests are advised to take out whatever insurance they consider necessary.

CANCELLATIONS, CHANGES, AND REFUNDS

All requests for additions, changes, and cancellations must be made in writing and received by February 21, 1997. NO REFUNDS OR CREDITS WILL BE MADE ON CANCELLATION NOTICES RECEIVED AFTER THIS DATE. Refunds will be mailed from GSA after the meeting. Refunds for fees paid by credit card will be credited according to the card number on the preregistration form. There will be NO refunds for on-site registration, *Abstracts with Programs,* and ticket sales.

On-Site Registration Schedule

Sheraton Valley Forge East Hotel
Sun., March 16, 3:00 p.m. to 8:00 p.m.
Mon., March 17, 7:00 a.m. to 4:30 p.m.
Tues., March 18, 7:00 a.m. to 4:30 p.m.
Wed., March 19, 7:00 a.m. to 11:00 a.m.

ACCESSIBILITY FOR REGISTRANTS WITH SPECIAL NEEDS

The GSA Northeastern Section is committed to making this meeting accessible to all people interested in attending. If you need any auxiliary aids or services (such as an interpreter or wheelchair accessibility) because of a disability, check the appropriate box on the registration form. If you have suggestions or need further information, contact W. A. Crawford, annual meeting general chair, at the Bryn Mawr College Department of Geology, wcrawfor@brynmawr.edu. Please let us know of your needs by February 14, 1997.

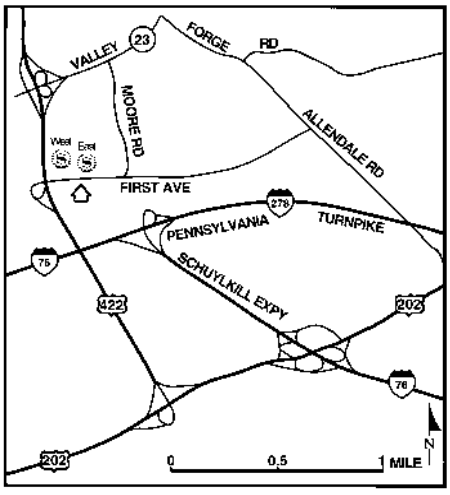
WEATHER

Daytime temperatures during mid-March range from the 30s to the 60s (°F); any combination of rain, snow, sleet, and sunshine is possible.

LOCATION

Meeting registration, technical sessions, poster sessions, and exhibits will be in the Sheraton Valley Forge Hotel East, a 14-story cylindrical tower located on First Street in King of Prussia, Pennsylvania. Most Northeastern Section attendees will be lodged in the East Hotel, and some in the West Hotel.

Those arriving from any direction on the Pennsylvania Turnpike should use the Valley Forge Exit (Interchange 24) and proceed south on I-76E (Schuylkill Expressway) to US-202S (Interchange 26B)



then to US-422W. Those arriving from I-76W or I-476N should proceed to US-202S then to US-422W (Pottstown, Valley Forge National Park).

Those arriving from US-202N should exit at US-422W (Pottstown, Valley Forge National Park). From US-422W, proceed 0.2 mile east on PA-23, Valley Forge Road. Turn right on Moore Road and proceed 0.6 mile to First Avenue. Turn right onto First Avenue. The hotel, 0.2 mile away, is on the right. Those arriving on US-422E should use the exit to First Avenue marked King of Prussia Industrial Park; the hotel, 0.2 mile away, is on the left.

Transportation is available from the Philadelphia International Airport to and from the Sheraton Valley Forge East Hotel; the current rate is $17. Taxi fare between the hotel and the AMTRAK 30th Street station in Philadelphia is about $40 for the 25-mile ride.

TECHNICAL PROGRAM

The technical program (oral and poster sessions) will begin Monday, March 17, and end at noon on Wednesday, March 19. Oral sessions will normally include 15 minutes for presentation and 5 minutes for questions and discussion. Two 35-mm carousel projectors, two screens, and one overhead projector will be provided for each oral session. Speakers are encouraged to bring their slides already loaded into carousel trays. A speaker-ready room (see program for room name) will be available for previewing slides. Additional carousel trays may be signed out from the speaker-ready room.

Poster sessions will allow at least three hours of display time; the authors must be present for two hours. Two 4-ft × 8-ft tackboards will be provided for each V-shaped booth. Access to electrical outlets and furniture for poster sessions must be requested well in advance.

General questions on format of sessions should be addressed to Technical Program Co-Chair Richard N. Benson, Delaware Geological Survey, University of Delaware, Newark DE 19716, (302) 831-8259, fax 302-831-3579, rnbenson@udel.edu. For general questions on equipment, contact Technical Services Chair Maria Luisa Crawford, Dept. of Geology, Bryn Mawr College, Bryn Mawr, PA 19010, (610) 526-5111, fax 610-526-5086, mcrawfor@brynmawr.edu.

In addition to general technical sessions organized by discipline, the following symposia, theme sessions, and special poster sessions are planned.

Symposia

1. **Finding the Adirondacks' Place in the Grenville.** James Alcock, College of Earth and Mineral Sciences, Penn State University, Ogontz Campus, 1600 Woodland Road, Abington, PA 19001,

REGISTRATION FEES

	Advance—by 2/14/97		On Site—After 2/14/97	
	Full Meeting	One Day	Full Meeting	One Day
Professional Member	$65	$40	$80	$50
Professional Nonmember	$80	$45	$95	$55
Student Member	$25	$20	$30	$25
Student Nonmember	$35	$30	$40	$35
K–12 Professional	$30	$15	$40	$20
Guest or Spouse	$15		$20	

(215) 881-7356, jea4@psuvm.psu.edu; Peter Muller, SUNY, College at Oneonta, (607) 436-3707, Mullerpd@oneonta.edu.

2. **Tectonic Connections Between the Northern and Southern Appalachians.** Alec Gates, Dept. of Geological Sciences, Rutgers University, Newark, NJ 07102, (201) 648-5034, gates@andromeda.rutgers.edu; David Valentino, Concord College, (304) 384-5238, valentid@math.concord.wvnet.edu.

3. **Flood Basalts and Margin Magmas of the Atlantic Rift.** Greg McHone, Graduate Liberal Studies Program, Wesleyan University, Middletown, CT 06459, (860) 685-3339, jmchone@wesleyan.edu; Dick Benson, Delaware Geological Survey, (302) 831-8259, rnbenson@udel.edu.

4. **Biogenic Influences on Sedimentation.** (Sponsored by SEPM). Kathy Browne, Dept. of Geological & Marine Sciences, Rider University, 2083 Lawrenceville Road, Lawrenceville, NJ 08648, (609) 895-5408, browne@enigma.rider.edu; Bob Demicco, SUNY at Binghamton, (607) 777-2604, demicco@bingsuns.cc.binghamton.edu.

5. **Freshwater Ecosystems of the Catskill Delta: Stratigraphic, Sedimentological, and Paleontological Approaches.** (Sponsored by SEPM). Neil Shubin, Dept. of Geology, University of Pennsylvania, Philadelphia, PA 19104, (215) 898-5724.

6. **Paleontology in Science Education. (Sponsored by Northeastern Section of Paleontological Society).** Jeff Over, Dept. of Geological Sciences, SUNY, College at Geneseo, 1 College Circle, Geneseo, NY 14454, (716) 245-5294 or 5291, over@uno.cc.geneseo.edu; Steve Good, SUNY, College at Cortland.

7. **Biotic Response to Global Change (Fossils as Clues to Global Change: Geochemical and Faunal Assemblage Indicators).** (Sponsored by Northeastern Section of Paleontological Society). Jeff Over, Dept. of Geological Sciences, SUNY, College at Geneseo, 1 College Circle, Geneseo, NY 14454, (716) 245-5294 or 5291, over@uno.cc.geneseo.edu.

8. **Cyclic Hierarchies: Fabric of the Stratigraphic Record or Figments of Stratigraphic Imagination?** Peter Goodwin and Edwin Anderson, Dept. of Geology, Temple University, Philadelphia, PA 19122, (215) 204-8229.

9. **The Influence of Sir Charles Lyell's Mid–19th Century Visits to North America.** Tom Pickett, 11236 Black Walnut Point, Indianapolis, IN 46236, (317) 823-2933, tpicket1@indyunix.iupui.edu; Don Hoskins, Bureau of Topographic and Geologic Survey, (717) 787-2169, hoskins.donald@A1.pader.gov.

10. **Superfund Successes.** Grover Emrich, Emrich & Associates, 1488 Hancock Lane, Wayne, PA 19087, (610) 296-5068, emrich@aol.com.

HOUSING FORM — Sheraton Valley Forge Hotel East

King of Prussia, Pennsylvania

Northeastern Section, Geological Society of America
Sunday, March 16–Wednesday, March 19, 1997

Arrival Date _____ Departure Date _____

Person Requesting Housing (type or print)

Last Name _____ First _____

Institution or Firm _____

Address or P.O. Box Number _____

City _____ State/Province _____ Zip Code _____

Phone: Work ( ) _____ Home ( ) _____

Place Reservation in Name of: _____

Name all other occupants:

Share with _____ Share with _____

Share with _____ Share with _____

Rates* per room *(includes 8% PA occupancy/state sales tax).*

TYPE OF ROOM Indicate choice:	PER DAY EAST	 WEST
☐ Single (1 person, 1 bed)	$ 86.40	$ 97.20
☐ Double (2 persons, 1 bed)	$ 86.40	$ 97.20
☐ Double (2 persons, 2 beds)	$ 86.40	$ 97.20
☐ Triple (3 persons, 2 dbl. beds)	$ 97.20	$108.00
☐ Quad (4 persons, 2 dbl. beds)	$108.00	$118.80
☐ Student rate** (1, 2, 3, or 4 persons, 2 beds)	$ 81.00	

Check-in time is after 3:00 p.m.; check-out time is 12:00 noon.
Preference (based on availability): ☐ Single bed ☐ Two double beds

SPECIAL NEEDS:
☐ Smoking room ☐ Nonsmoking room
☐ Special Room Requirements _____

*Enclose check or money order (for amount of one night's lodging) payable to Sheraton Valley Forge Hotel, or major credit card number and date of expiration. No cancellations will be accepted within 72 hours of arrival date.
Reservations must be received prior to February 15, 1997; otherwise reservations will be accepted on a space-available basis only and the group rate will not be guaranteed.

**Students must identify themselves as students upon booking their reservation and must present a student ID at check-in. A maximum of 40 rooms are available at this special rate.

Telephone reservations accepted: (610) 337-2000, fax 610-337-2564

Type of card _____ Card number _____

Exp. date _____ Signature _____

SEND THIS FORM AND REMITTANCE OR CREDIT CARD INFORMATION TO:
Sheraton Valley Forge Hotel East,1160 First Avenue, King of Prussia, PA 19406-1355

11. **Well-Head Protection.** Jerry Kauffman, Water Resources Agency for New Castle County, 2701 Capitol Trail, Newark, DE 19711, (302) 731-7670.

Theme Sessions

1. **Frontiers of Mineralogy.** Darby Dyar, Dept. of Geology and Astronomy, West Chester University, 750 S. Church Street, West Chester, PA 19383, (610) 436-2727, ddyar@wcupa.edu.

2. **Economic Mineral Deposits of Northeastern North America.** Bill Kelly, New York State Geological Survey, 3140 CEC, Albany, NY 12230, (518) 474-7559, wkelly@museum.nysed.gov; Bob Altamura, University of Pittsburgh, Johnstown.

3. **Current Research in Sand Resources of the Inner Continental Shelf.** (Sponsored by SEPM and U.S. Department of Interior Minerals Manage-

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ment Service). Jane Uptegrove, New Jersey Geological Survey, CN 427, Trenton, NJ 08625, (609) 292-2576, janeu@njgs.dep.state.nj.us; Bob Conkwright, Maryland Geological Survey, (410) 554-5500, tbird@mgs.dnr.md.gov.
4. **Nearshore Processes and the Development of the Coastal Stratigraphic Record.** Sue Halsey, Division of Science and Research, Dept. of Environmental Protection & Energy, State of New Jersey, Trenton, NJ 08625, (609) 292-0950, shalsey@dep.state.nj.us; Nicholas Coch, Queens College (CUNY), (718) 997-3326; Dan Belknap, University of Maine at Orono (207) 581-2159, belknap@maine.maine.edu.
5. **Geological Applications of GIS.** Mary Jo Hall, Dept. of Geological & Marine Sciences, Rider University, Lawrenceville, NJ 08648, (609) 895-5416, hall@enigma.rider.edu; Randy Kerhin, Maryland Geological Survey, rkerhin@mgs.dnr.md.gov.
6. **Geologic Hazards.** Grover Emrich, Emrich & Associates, 1488 Hancock Lane, Wayne, PA 19087, (610) 296-5068, emrich@aol.com.

Special Poster Sessions
1. **Undergraduate Research.** (Sponsored by the Geology Division, Council on Undergraduate Research). Students must be listed as the authors and have been the major preparer of the poster. Topics may vary over a broad spectrum (e.g., see GSA abstract form), but must be the result of the student's own participation in undergraduate research programs. Lawrence L. Malinconico, Dept. of Geology, Lafayette College, Easton, PA 18042, (610) 250-5193, malincol@lafayette. edu.
2. **Superfund Remediation.** Ed Sullivan, ERM, Inc., 855 Springdale Dr., Exton, PA 19341, (610) 524-3848, Edward_Sullivan@erm.com.
3. **Philadelphia Navy Base Cleanup.** Ben Greeley, Pennsylvania Dept. of Environmental Protection, Bureau of Water Supply & Community Health, 555 North Lane, Suite 6010, Conshohocken, PA 19428, (610) 832-6055, greeley.benjamin@a1.pader.gov.
4. **Redevelopment of Past Industrial Sites: Pennsylvania Act II.** Jim La Regina, 678 North Vine St., Hazleton, PA 18201, (717) 454-3626; Ron Fender, ERM, Inc., (610) 524-3516, Ronald_Fender@erm.com.
5. **Acid Mine Drainage and Coal Mine Reclamation.** Jim La Regina, 678 North Vine St., Hazleton, PA 18201, (717) 454-3626.
6. **Surface Water Hydrology: 1996 Northeastern Pennsylvania Floods.** Eric Conrad, Pennsylvania Dept. of Environmental Protection, P.O. Box 2063, Harrisburg, PA 17105-2063.

STUDENT AWARDS AND TRAVEL ASSISTANCE

Awards will be given for the best oral paper and best poster session presented by students. Although the faculty mentor may appear as the junior author, a major part of the paper or poster session must represent work by the single student author. NOTE: *Only those papers designated as student author on the abstract form will be considered for this award.*

The GSA Northeastern Section will award travel grants to students who give papers (oral or poster) of which he or she is the presenter and author or coauthor at the meeting. In addition, the Northeastern Section will award student research grants to undergraduate students in 1997. Applications for travel assistance and guidelines for student research grants may be obtained from Kenneth N. Weaver, Secretary-Treasurer, Northeastern Section, GSA, c/o Maryland Geological Survey, 2300 St. Paul Street, Baltimore, MD 21821-5210, (410) 554-5532, fax 410-554-5502.

K–12 TEACHER WORKSHOPS

1. **Standards-based Earth Science Teaching.** David L. Smith, Dept. of Geology and Environmental Science, Institute for Advancement of Mathematics and Science Teaching, La Salle University, Philadelphia, PA 19141, (215) 951-1298, dsmith@lasalle.edu.

Cost: Free. Limit: 30. Preregistration required. Sunday, March 16, 9 a.m.–4 p.m., Sheraton Valley Forge Hotel East.

This workshop will explore the implications of the new National Science Education Standards for the teaching of earth science. Participants will work with colleagues from similar grade levels to explore the following areas: teaching approaches that foster inquiry and community; earth science content for elementary, middle, or high school; and assessment of inquiry-based science. The workshop will include several short demonstration lessons. Free or low-cost take-home material and software will be available.
2. **Facets of Regional Geology.** Barbara Grandstaff, New Jersey State Museum; Marta Kolman, Central Bucks County School District; Hermann Pfefferkorn, University of Pennsylvania; Nancy Polan, Central Bucks County School System; Joseph Schmuckler, and Gene Ulmer, (215) 204-7171, ulmer@vm.temple.edu. Cost: $50; includes mid-morning and mid-afternoon refreshments and lunch. Limit: 35. Preregistration required. Sunday, March 16, 10 a.m.–4 p.m., Bryn Mawr College. Topics: Paleobotany and the Origin of Coal; What New Jersey Taught the World About Dinosaurs; Local Five County Geology and Its Role in Environmental Problems (Pennsylvania and New Jersey); and Societally Important Aspects of the Geology of the State of Pennsylvania. Each of these topics will be presented and discussed with an aim to provide materials suitable for preparing teachers' lesson plans. Audience participation is expected. Many handouts, geologic maps and brochures, a scientifically curated kit of take-along samples of ten of the area's most common rocks and their derived soils, six 35 mm color slides, with description, about coal and paleobotany and five 35 mm slides, with description, about New Jersey dinosaurs, and New Jersey fossil shark teeth and clams and casts will be included.

The Bryn Mawr College geology department has a display of the famous George Vaux, Jr., mineral collection.

SHORT COURSES:

1. **Aminostratigraphy.** John F. Wehmiller, Dept. of Geology, University of Delaware, Newark, DE 19716-2544, (302) 831-2926, jwehm@udel.edu; Penny Hall, University of Delaware, Newark.

Cost: $20. Limit: 15. Preregistration required by *February 1, 1997*. Sunday, March 16, 9:30 a.m. to 4:30 p.m. The drive from the Sheraton Valley Forge Hotel to Newark takes about one hour. Attendees will be expected to arrange their own transportation, although with enough advance request, some transportation may be made available.

This course covers the applications of amino acid racemization geochemistry to the geochronology and stratigraphy of Quaternary deposits. Lecture and laboratory demonstrations will include sample preparation and actual instrumental analyses. Discussions will include geochemical issues, comparisons of racemization methods with other dating methods, and potential applications.
2. **Geoscience Courseware Workshop.** Declan De Paor, Dept. of Earth and Planetary Science, Harvard University, 20 Oxford St., Cambridge, MA 02138, (617) 495-8926, depaor@eps.harvard.edu, or Earth'nware Inc., 148 Cadish Avenue, Hull, MA 02045, (617) 925-0264, earthnmail@aol.com.

Cost: $20; includes morning and afternoon refreshments and lunch. Limit: 30. Preregistration required. Sunday, March 16, Park Science Center, Bryn Mawr College. Bryn Mawr College is within one-half hour driving time from the Sheraton Valley Forge Hotel. Some free transportation may be available upon advance request.

This hands-on course addresses the needs of educators who wish to use the latest technology in their courses, but are limited by tight budgets or by lack of technical know-how. Both Macintosh and IBM PC-compatible computers will be used. This workshop is aimed at advanced high

Northeastern *continued on p. 30*

PREREGISTRATION FORM GSA Northeastern Section

Preregistration Deadline: February 14, 1997. **King of Prussia, Pennsylvania • March 17–19, 1997**

Please print clearly • THIS AREA IS FOR YOUR BADGE

Name as it should appear on your badge (last name first)

Employer/University Affiliation

City State or Country

Mailing Address (use two lines if necessary)

City State

ZIP Code Country (if other than USA)

Circle member affiliation (to qualify for registration member discount):

(A) GSA (B) AWG (C) NAGT (D) PS (E) SEPM

GUEST INFORMATION • Please print clearly • This area is for badge

Name as it should appear on your guest's badge

City State or Country

Please indicate if you or your guest will need services to accommodate a disability: ☐ Yes

( ) _____ - _____
Business Phone

( ) _____ - _____
fax

( ) _____ - _____
Home Phone

Preregistration Deadline: February 14
Cancellation Deadline: February 21

MAIL TO:
GSA NORTHEASTERN SECTION MEETING,
P.O. BOX 9140, BOULDER, CO 80301

Remit in U.S. funds payable to:
1997 GSA Northeastern Section Meeting
(All preregistrations must be prepaid.
Purchase Orders not accepted.)

Payment by (check one):
☐ Check ☐ American Express ☐ VISA ☐ MasterCard

Card Number

Signature Expires

FOR OFFICE USE

A _____ V _____ M _____
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REGISTRATION FEES

	Full Meeting	One Day	Amount
Professional Member	(01) $65 ☐	(02) ☐ $40	$ _____
Professional Nonmember	(03) $80 ☐	(04) $45 ☐	$ _____
Student Member	(05) $25 ☐	(06) $20 ☐	$ _____
Student Nonmember	(07) $35 ☐	(08) $30 ☐	$ _____
K–12 Professional	(42) $30 ☐	(43) $15 ☐	$ _____
Guest or Spouse	(09) $15 ☐	N/A	$ _____

SPECIAL EVENTS

Lily Langtree Dinner Theatre ..... March 18 (20) $28.50 $ _____

TICKETED GROUP FUNCTIONS

1. Paleontological Society Luncheon (60)..... March 17 $20 $ _____
2. NAGT Luncheon (61)..... March 17 $20 $ _____
3. GSA Northeastern Section Annual Banquet..... March 17

Professional $30	Student $15
☐ Prime Rib (62)	☐ Prime Rib (65)
☐ Chicken (63)	☐ Chicken (66)
☐ Vegetarian (64)	☐ Vegetarian (67)

$ _____

4. AWG Breakfast ..... March 18
   Professional (68) $15
   Student (69) $10 _____

CONTINUING EDUCATION

1. Aminostratigraphy (150) ..... March 16 $20 $ _____
2. Geoscience Courseware Workshop (151) PC
   (152) MAC .... March 16 $20 $ _____
3. NAGT Workshop, Teaching Geoscience (153)..... March 16 FREE FREE

K–12 PROGRAMS

1. Standards-based Earth Science Teaching (302).... March 16 FREE FREE
2. Facets of Regional Geology (303)..... March 16 $50 $ _____

TOTAL FEES $ _____

Northeastern *continued from p. 28*

school to introductory level university faculty. Subjects: Hardware—how to set up an instructional facility on a shoestring budget; off-the-shelf software—effective use of commercial graphics, spreadsheets, hypertext, and the instrument control programs in traditional lab courses; custom courseware—where to find it and how to incorporate it; do-it-yourself courseware—how to create it even if you do not know the difference between three bytes and a trilobite.

Facilities will include 10 MACS and four PCs. When registering, please indicate your preference of Windows or MAC operating systems.

3. **NAGT Workshop on Innovative and Effective Techniques for Teaching Geoscience.** Sponsored by the National Association of Geoscience Teachers and funded partially by the National Science Foundation. R. Heather Macdonald, Dept. of Geology, College of William and Mary, Williamsburg, VA 23185, (757) 221-2443, rhmacd@facstaff.wm.edu; Jeffrey Niemitz, Dickinson College; and Barbara Tewksbury, Hamilton College.

Cost: Free. Limit: 35. Preregistration required. Sunday, March 16, 8 a.m.–5 p.m., Sheraton Valley Forge Hotel. Lunch will be provided.

This workshop is designed to give participants specific strategies for more effective teaching, emphasizing innovative techniques for more actively engaging students in classroom, lab, and field. It is intended for faculty and graduate students who are interested in teaching careers.

EXHIBITS

Companies or organizations wishing to display or sell publications, scientific equipment, or other products, services, or public relations materials may rent a display area for the duration of the meeting. The exhibits will be between the poster sessions and the main corridor. The 8' × 8' booths framed with 8-foot-high rear and 3-foot-high side drapes are available at $350 for commercial exhibitors, $250 for publishers, $200 for educational, governmental, and nonprofit organizations or institutions. A table, two chairs, and a company sign will be provided for each booth. A limited number of unsecured table-top exhibit spaces at reduced rates will be available in the corridor adjoining the registration area. The exhibits will be open from 8:00 a.m. to 6:00 p.m. on Monday and Tuesday, March 17 and 18, and from 8:00 a.m. to noon on Wednesday March 19. Application deadline for exhibit space is *February 24, 1996*. For information and an exhibitors brochure, contact Gil Wiswall, Dept. of Geology and Astronomy, West Chester University, West Chester, PA 19383, (610) 436-2570, fax 610-436-3036, gwiswall@wcupa.edu. Space will be allocated on a first-come, first-served basis.

SPECIAL AND GUEST ACTIVITIES

The Sheraton Valley Forge Hotel is convenient to attractions in Philadelphia and its suburbs, including numerous museums (the Philadelphia Museum of Art, the Academy of Natural Sciences, the Franklin Institute), gardens and historic estates (Longwood Gardens, Winterthur), cultural events, and of course, the historic sites around Independence Mall and Valley Forge. Brochures and knowledgeable staff will be available to assist meeting participants and guests with their plans.

Another special activity is an evening of dinner theater in the elegant Lily Langtry Theater, in the Sheraton Valley Forge East Hotel. Tickets at a special discount rate of $28.50 are available for the performance on Tuesday evening, March 18. Dinner begins at 6:00 p.m., followed by the live musical revue, "Hollywood Boulevard," a high-energy tribute to motion pictures. Advance registration is required to obtain the discount rate.

ACCOMMODATIONS

A large block of rooms has been reserved for meeting participants at the Sheraton Valley Forge Convention Complex, which consists of the Sheraton Valley Forge Hotel East and the Sheraton Valley Forge Hotel West; the hotels are connected by an indoor passageway. The Sheraton has provided reasonable room rates. The rooms in the smaller West hotel have more amenities than those in the larger East hotel, hence the higher rate. The number of upscale rooms available is limited. Parking in the 2000-car lot around the hotel complex is free. For conference planning purposes and to ensure the guaranteed room rates, it is imperative that you reserve your room(s) before *February 15, 1997*. If you make telephone reservations, it is important that you state you are attending the Northeastern Section GSA meeting. *Mail the housing form directly to the hotel.*

SPECIAL EVENTS

GSA Northeastern Section Management Board Meeting. Sunday, March 16, 4:30 to 6:30 p.m. in the Strafford Room, Sheraton Valley Forge Hotel East.
Welcoming Reception. Sunday, March 16, 6:30 to 10:00 p.m. Sheraton Valley Forge Hotel East, Grand Ballroom North and South. Liquid refreshments and hor d'oeuvres will be served. A cash bar will be available for mixed drinks.
Northeast Section of the Paleontological Society Luncheon. Monday, March 17, 12 noon to 1:30 p.m., Sheraton Valley Forge Hotel East; see program for room. Cost: $20; preregistration required.
Eastern Section of NAGT Luncheon and Business Meeting. Monday, March 17, 12 noon to 1:30 p.m., Sheraton Valley Forge Hotel East; see program for room. Cost: $20; preregistration required.
Annual GSA Northeastern Section Reception and Banquet. Monday, March 17, 6:30 to 9:00 p.m., Sheraton Valley Forge Hotel East, Grand Ballroom, North and South. Cost: $30 for professionals; $15 for students; preregistration required. A cash bar will be available. The banquet will conclude with a short business session.
Association for Women Geoscientists Breakfast. Tuesday, March 18, 6:45 to 8:30 a.m., Sheraton Valley Forge Hotel East; see program for room. Cost: $15 for professionals; $10 for students; preregistration required.
Dinner—Live Musical Revue. Tuesday, March 18, 6:00 p.m. to ?, Sheraton Valley Forge Hotel East, Lily Langtree Theater. See the Special and Guest Activities Section for a description. Cost: $28.50; preregistration required to obtain the discount rate.
SEPM Eastern Section Business Meeting and Reception. Tuesday, March 18, 4:30 to 6:30 p.m., Grand Ballroom North, Sheraton East. President-Elect Richard F. Moiola, Mobil Oil, Dallas, Texas, will

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GSA Northeastern Section Offers Undergrad Student Research Grants

The GSA Northeastern Section's student research grants for 1997 are competitive and are available to undergraduate students.

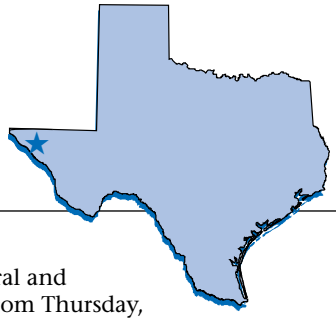
To be considered for a research grant, the student must be enrolled at an institution within the GSA Northeastern Section and must be a Student Associate of GSA. Applications must be postmarked no later than *February 14, 1997*.

Grants will be awarded following the Northeastern Section Meeting in Valley Forge, Pennsylvania. For further information or a copy of the research grant application form, contact: Kenneth N. Weaver, Secretary NEGSA, Maryland Geological Survey, 2300 St. Paul St., Baltimore, MD 21218. Phone is (410) 554-5532, fax 410-554-5502, E-mail: kweaver438@aol.com.

Final Announcement

SOUTH-CENTRAL and ROCKY MOUNTAIN SECTIONS, GSA

El Paso, Texas • March 20–21, 1997

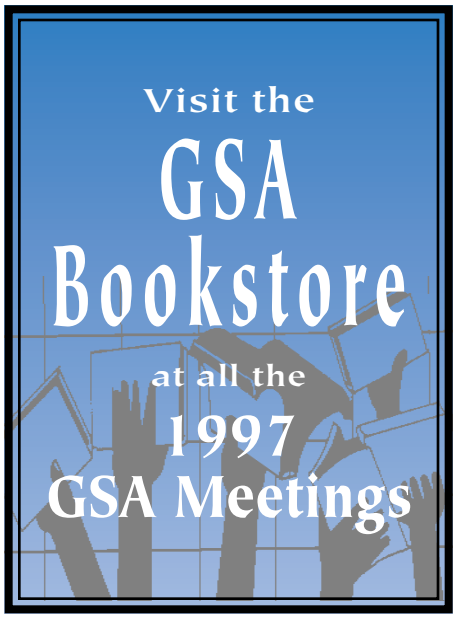


The Departments of Geological Sciences of the University of Texas at El Paso (UTEP) and New Mexico State University (NMSU) invite you to the annual meeting of the South-Central and Rocky Mountain sections of the Geological Society of America. The meeting will be held from Thursday, March 20, through Friday, March 21, on the University of Texas at El Paso campus during spring break. **All events, including registration, will be held in the Student Union.** All field trips are scheduled for the weekend after the meeting.

LOCATION

El Paso, Texas, in the corner of Texas, New Mexico, and Mexico, is easily reached along U.S. interstates 10 and 25 and has inexpensive air connections via America West, American, Continental, Frontier, Southwest, and Aeromexico.

The name El Paso is a shortened version of El Paso del Rio del Norte, the name given to the river valley by conquistador Don Juan de Onate more than four centuries ago. Through this pass, today marked as a historic monument, Spanish explorers found their way into what is now the United States, claiming it for the Spanish Crown. Visitors enjoy this city—its historic mission trail, beautiful mountain vistas and desert sunsets, Mexican cuisine, and colorful history. It offers the lure of the Old West and three distinct cultures in two nations.



Mentor Program

Graduate students and undergraduate seniors: The Roy J. Shlemon Mentors Program in Applied Geology is coming to all of your 1997 section meetings. This program can help you learn about professional opportunities in the applied geosciences, as explained by leading private-sector practitioners in fields such as Quaternary geology, geomorphology, environmental geology, engineering geology, and hydrogeology. For more information, contact your section committee chair, section secretary, or GSA's Institute for Environmental Education.

SYMPOSIA

1. **Pander Society Conodont Symposium.** James Barrick, Texas Tech University.
2. **Precambrian Geology of the Western United States.** Karl Karlstrom, University of New Mexico, Calvin Barnes, Texas Tech University; Kate Miller, UTEP.
3. **Mesozoic Redbeds of Mexico.** Claudio Bartolini, UTEP; Jaime Rueda Gaxiola, Universidad Nacional Autonóma de México; Mario Aranda, PEMEX; Wolfgang Stinnesback, Universidad Autonóma de Nuevo Leon.
4. **Rio Grande Rift: Its Geology and Geophysics.** G. Randy Keller, Libby Anthony, and Wendi Williams, UTEP.
5. **Environmental Geology and Hydrogeology of Intermontane Basins.** Greg Ohlmacher and John Walton, UTEP; Mike Whitworth, New Mexico Tech.
6. **Mesozoic Geologic History of the Southern United States and Mexico.**

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deliver an address, title to be announced. Refreshments will be served. The meeting is open to all SEPM members.

Special Needs. If you have special dietary needs, contact LeeAnn Srogi, Dept. of Geology and Astronomy, West Chester University, West Chester, PA 19383, (610) 436-2721, esrogi@wcupa.edu.

NEWS ROOM

The Northeastern Section News Room staff will coordinate and assemble information on topics for release to the news media. Please let them know of material that is newsworthy for the science or general and local press. Members of the press may receive complimentary meeting registration with appropriate press credentials by contacting Kelvin Ramsey, Delaware Geological Survey, University of Delaware, Delaware Geological Survey Building, Newark, DE 19716-7501, (302) 831-3586, fax 302-831-3579. The news room will be open Sunday, March 16 through noon Wednesday, March 19. See the program for the room.

CHILD CARE

For information and arrangement for child care, available Sunday, March 16 through noon Wednesday, March 19, contact Mary Louise Hill, Department of Geology, Temple University, Philadelphia, PA 19122, (215) 204-8226, mlhill@astro.ocis.temple.edu. Deadline: February 14, 1997. ■

South-Central–Rocky Mountain
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Tim Lawton, Kate Giles, and Nancy McMillan, NMSU.

7. **Recent Advances in the Economic Geology of Mexico and Adjacent Areas.** Ken Clark, UTEP.

8. **Using Multimedia in the Classroom.** Vicki Harder, UTEP.

9. **Geology and Public Policy: The Political Education of a Scientist.** Joe Yelderman, Baylor University.

10. **New Refinements of the Geochronology of Events in the Western U.S. and Mexico.** Bill McIntosh and Matt Heitzler, New Mexico Tech.

11. **Undergraduate Student Research.** Betsy Julian, UTEP; Diane Smith, Trinity University. (Sponsored by the Geology Division of the Council on Undergraduate Research.)

12. **Nuclear Waste Disposal in the Southwest.** Norbert Rempe, WIPP Westinghouse; David LaMone, UTEP.

13. **Cenozoic Paleontology of the American West.** Art Harris, UTEP; David LaMone, UTEP.

FIELD TRIPS

All trips will be after the meeting. Trip fees include all transportation during the trip and a guidebook. Other included items are noted by B—breakfast, L—lunch, D—dinner, ON—overnight lodging. Please contact the trip leaders for additional information.

1. **Lower Mississippian Waulsortian Mounds, Sacramento Mountains, New Mexico.** Friday, March 21, through Sunday, March 23. Kent Kirkby, Dept. of Geology and Geophysics, University of Minnesota, 310 Pillsbury Dr., SE, Minneapolis, MN 55455-0219, (612) 624-1392, fax 612-625-3819, kirkby@gold.tc.umn.edu; Kate Giles, New Mexico State University, (505) 646-2033, fax 505-646-1056, kgiles@nmsu.edu; Steve Dorobek, Texas A&M University, (409) 845-0635, fax 409-845-6162, dorobek@tamu.edu. Cost: $175 (2 ON, 2 L, 1 D). Leaves El Paso on Friday evening, March 21 and returns late afternoon on Sunday, March 23.

This trip will reexamine hypotheses of the origin and depositional setting of Waulsortian Mounds and associated facies in southern New Mexico. It includes stops at the classic Muleshoe Mound and updip tabular mounds in the Sacramento Mountains.

2. **Quaternary Landscape Evolution and Geoarchaeology of the El Paso-Las Cruces Region.** Saturday, March 22, and Sunday, March 23. H. Curtis Monger, Dept. Agronomy and Horticulture, Box 3Q, New Mexico State University, Las Cruces, NM 88003, (505) 646-1910, fax 505-646-6041, cmonger@nmsu.edu. Cost: $195 (2 ON, 2 B, 2 L, 1 D). Starts and ends each day at UTEP.

This trip will focus on Quaternary geology and soil isotopes as a means to (1) date neotectonic events, (2) understand ecologic and geomorphic thresholds, and (3) develop predictive models for archaeological surveys. Stops will be the Franklin Mountain fault, Fort Bliss Reservation, the Desert Project, and the NSF Jornada Long Term Ecological Research Site.

3. **Beginning of the Age of Dinosaurs.** Friday, March 21 through Sunday, March 23. Adrian Hunt, Mesalands Dinosaur Museum, Mesa Technical College, 911 South Tenth St., Tucumcari, NM 88401, (505) 461-4413, fax 505-461-1901, mesalands@aol.com; Spencer G. Lucas, New Mexico Museum of Natural History, (505) 841-2873, fax 505-841-2866, lucas@darwin.nmmnh-abq.mus.nm.us. Cost: $170 (2 ON, 2 B, 2 L, 2 D). Leaves El Paso on Saturday morning and ends in Tucumcari, New Mexico, on Sunday evening. Buses will be available on Monday, March 24, to transport participants to the Albuquerque International Airport.

This trip will examine outcrops of various parts of the Upper Triassic Chinle Group in eastern New Mexico. These strata probably contain the most complete sequence of Late Triassic vertebrate faunas known. The fauna, dominated by tetrapods, including a variety of crurotarsans (e.g., phytosaurs), has a significant dinosaurian component.

4. **Facies Architecture and Stratigraphic Evolution of the Great American Bank: The Lower Ordovician El Paso Group, Franklin Mountains, El Paso, Texas.** Robert K. Goldhammer, Bureau of Economic Geology, University of Texas at Austin, University Station, Box X, Austin, TX 78713-7508, (512) 475-9571, fax 512-471-0140, goldhammer@begv.beg.utexas.edu. Cost: $70 (1 ON, 1 L). Leaves from and returns to El Paso on Saturday, March 22, after an informal 1-hour geologic overview on Friday evening.

This trip provides the opportunity to examine in detail superb exposures of Lower Ordovician, shallow-marine platform carbonates that accumulated during the passive-margin evolution of the lower Paleozoic of the southwestern United States. Participants will observe and interpret facies with the goal of developing sequence stratigraphic models for the El Paso Group, with control provided by measured section from nearby areas.

5. **Geochronology and Geochemistry of the Potrillo Volcanic Field, New Mexico.** Elizabeth Anthony, Dept. Geological Sciences, University of Texas at El Paso, El Paso, TX 79968, (915) 747-5483, fax 915-747-5073, anthony@geo.utep.edu. Cost: $70 (1 ON [camping], 1 B, 2 L, 1 D). Leaves El Paso on Saturday morning, March 22, and returns to El Paso in time for late Sunday (March 23) flight connections.

This trip will focus on surface exposure dating, $^{40}Ar/^{39}Ar$ chronology, paleomagnetism, major and trace element variations, and isotopic character of mafic lavas and xenoliths in this rift-related volcanic field. We will visit several maars, including Kilbourne Hole.

6. **Stratal Architecture of Forestepping and Backstepping Shallow Marine Sequences: The Upper Cretaceous Gallup and Hosta Sandstones, San Juan Basin, New Mexico.** Dag Nummedal, Unocal Corporation, 14141 Southwest Freeway, Sugar Land, TX 77478, (713) 287-5212, fax 713-287-5403, o1094dxn@endeavor1.unocal.com; Robyn Wright Dunbar, Rice University, (713) 285-5169, fax 713-285-5214, rwd@ruf.rice.edu. Cost: $215 (one way airfare El Paso–Albuquerque, 2 ON, 2 B, 2 L, 2 D). Participants will fly from El Paso to Albuquerque on Friday evening, March 21, and continue to Gallup, New Mexico, by van. Ends at the Albuquerque airport on Sunday, March 23, by 5:00 p.m.

This trip will examine Upper Cretaceous sandstones in the San Juan Basin near Gallup, New Mexico. Participants will examine the sequence stratigraphic architecture of forestepping sequences in the Gallup Sandstone and backstepping sequences in the Hosta Sandstone.

SHORT COURSE AND FIELD TRIP

A short course, "Industrial Minerals and Their Markets," on Saturday, March 22, will be followed by a field trip on Sunday, March 23 to the Cementos de Chihuahua near Ciudad Juarez. Contact Peter Harben (harbenp@magnum.wpe.com) or Kenneth Clark (clark@geo.utep.edu) if you wish to be put on the mailing list for information and registration for this course.

ABSTRACTS

Attendees are encouraged to order *Abstracts with Programs* for the meeting either with their annual dues or with their preregistration. There will be only a limited number of copies available for purchase on site.

PROJECTION EQUIPMENT

There will be two projectors for each oral session. Please bring your own loaded carousel trays. Overhead projectors will be available upon request. Specifics of the poster session will be published in the *Program*.

South-Central–Rocky Mountain
continued on p. 34

PREREGISTRATION FORM

GSA South-Central and Rocky Mountain Sections
Preregistration Deadline: February 7

El Paso, Texas
March 20–21, 1997

Please print clearly • THIS AREA IS FOR YOUR BADGE

Name as it should appear on your badge (last name first)

Employer/University Affiliation

City State or Country

Mailing Address (use two lines if necessary)

City State

ZIP Code Country (if other than USA)

GUEST INFORMATION • Please print clearly • This area is for badge

Name as it should appear on your guest's badge

City State or Country

Please indicate if you or your guest will need services to accommodate a disability: ☐ Yes

(_____) _____-_____
Business Phone

(_____) _____-_____
fax

(_____) _____-_____
Home Phone

Cancellation Deadline: March 1

MAIL OR FAX THIS REGISTRATION FORM TO:
Conference Services, Professional and Continuing Education
University of Texas at El Paso
500 West University, El Paso, TX 79968-0602
(915) 747-5142 • fax 915-747-5538

REMIT IN U.S. FUNDS PAYABLE TO:
The University of Texas at El Paso
(All preregistrations must be prepaid. Purchase Orders not accepted.)

Payment by (check one): ☐ check ☐ Discover ☐ VISA ☐ MasterCard

_____
card number expires

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signature

PREREGISTRATION

GSA Member	$50	☐	$ _____
Nonmember	$60	☐	$ _____
GSA Member Student	$25	☐	$ _____
Nonmember Student	$30	☐	$ _____
K–12 Teacher	$15	☐	$ _____
Guest	$15	☐	$ _____
Abstracts with Programs	$22.50	☐	$ _____

SPECIAL EVENTS

Mexican Dinner	$15 (on-site $20)	☐	$ _____
Pander and Paleontological Societies Luncheon	$10 (on-site $15)	☐	$ _____

DORMITORY HOUSING

$15 single per night	$ _____
$12 double per night	$ _____

Person with whom you intend to room:

_____

FIELD TRIPS

1. Lower Mississippian Waulsortian Mounds March 21–March 23	$175	_____$
2. Quaternary Landscape Evolution March 22–March 23	$195	_____$
3. Beginning of the Age of the Dinosaurs March 21–March 23	$170	_____$
4. Facies Architecture and Stratigraphic Evolution March 22	$ 70	_____$
5. Geochronology and Geochemistry, Potrillo Volcanic Field March 22–March 23	$ 70	_____$
6. Stratal Architecture, Shallow Marine Sequences, March 22–March 23	$215	_____$

TOTAL FEES $ _____

South-Central–Rocky Mountain
continued from p. 32

EXHIBITS

Exhibit facilities for business, educational, and governmental institutions will be available in the Student Union Building. On-site registration, oral and poster sessions, the welcoming party, and the Thursday evening dinner will be held in this building. Space rental of $125 will include one complimentary registration. Exhibitors are encouraged to set up Wednesday afternoon for registration and the welcoming party. For information concerning exhibits, contact Nancy Wacker, Professional and Continuing Education, Assistant Director for Conferences and Special Events, University of Texas at El Paso, 500 West University, El Paso, TX 79968-0602, (915) 747-5142, fax 915-747-5538, nwacker@mail.utep.edu.

SPECIAL EVENTS

Welcoming Party, beginning at 7 p.m. on Wednesday, March 19. On-site registration will be available, and those who have preregistered may pick up their name badges, tickets for the dinner, and *Abstracts with Programs*.

West Texas Mexican Dinner, on Thursday, March 20. Tickets must be purchased in advance.

Pander Society and Paleontological Society Luncheon, Friday, March 21. Cost is $10.

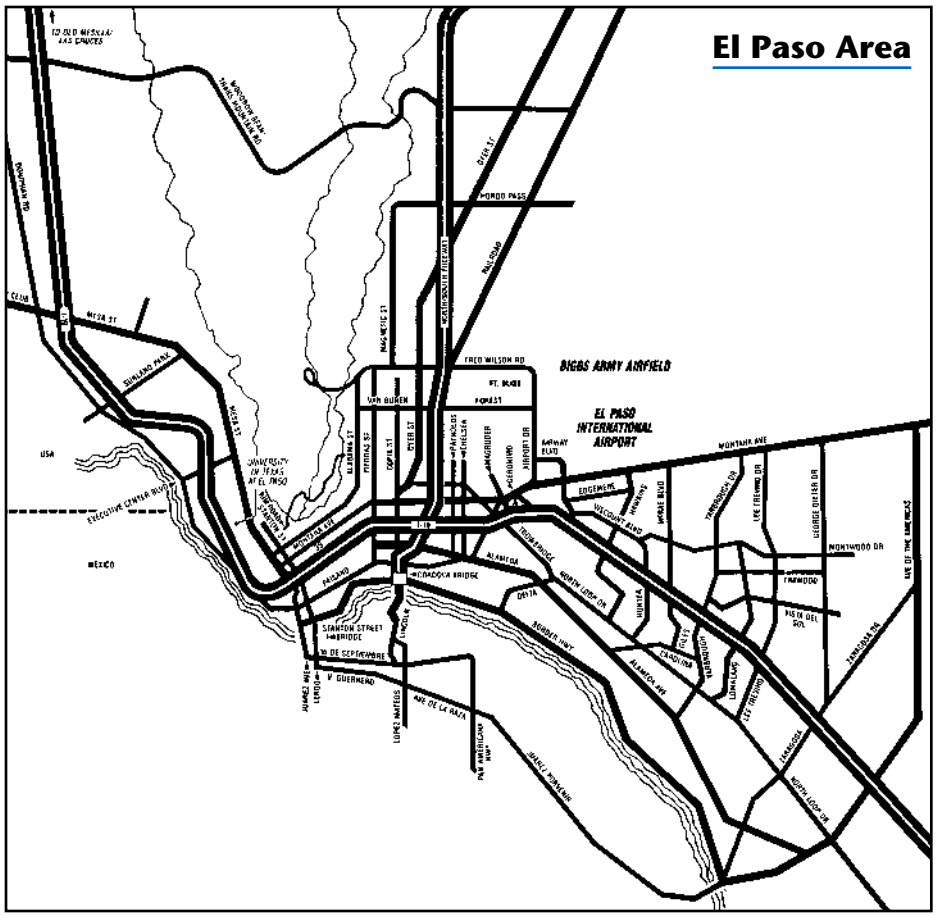
STUDENT PAPERS AND TRAVEL GRANTS

Awards will be presented for the best student paper in both oral and poster formats. Awards will be based on the quality of research and effectiveness of presentation. Limited funds for travel expenses are also available. To be considered for both a travel stipend and the best paper awards, student should attach a note to their submitted abstract. William Cornell, UTEP, will administer these student awards. Checks for travel grants will be given to student after his/her presentation.

PREREGISTRATION

Preregistration Deadline:
February 7, 1997.

Preregistration by mail will be handled by Professional and Continuing Education at UTEP. Please take advantage of the lower registration fees and register by February 7. All field trip participants must register for the meeting. Preregistration costs are listed on the accompanying form. On-site registration costs are as follows: GSA members—$60, Nonmembers—$70, GSA member students—$30, Nonmember students—$35, K–12 teachers—$15.



CANCELLATION POLICY

Cancellations must be received in writing by Nancy Wacker at UTEP on or before March 1, 1997. There will be a $20 cancellation fee. After March 1, there will be no refunds for cancellations. Substitutions may be made at any time at no extra cost.

HOTEL ACCOMMODATIONS AND HOUSING

The historic Camino Real Paso del Norte Hotel, a historic landmark in a 400-year-old city, was built in the golden age of expansion and progress that the railroads brought to the American Southwest. A centerpiece of the hotel is a Tiffany glass dome in the meeting area on the ground floor. The hotel is a short walk from the U.S.-Mexico border and is close to the border trolley, which allows one to shop and eat in Juarez. Staying in this grand hotel is a reason in itself to visit El Paso. A block of rooms at the special rate of $75 single and $80 double is available for the meeting. Cutoff date for this rate is February 7, 1997. Reservation requests received after that date will be accepted on a space-available basis and at the prevailing published rate. Please make your hotel reservations and cancellations directly with the hotel and indicate you are part of the GSA meeting in order to qualify for the special rate. The first night's deposit and credit card information must accompany your reservation. Mail, fax, or phone your information to Camino Real Paso del Norte, 101 South El Paso St., El Paso, TX 79901, (915) 534-3000, (800) 769-4300, fax 915-534-3024. The hotel offers complimentary shuttle service to and from El Paso International Airport, and it is a 10 minute drive from the UTEP campus along a route that also has frequent buses.

We have also reserved dormitory rooms on the UTEP campus, for $15 single and $12 double, including use of sheets and towels. To reserve a double room, you must have arranged for a roommate. The dormitory rooms are intended for students and international scientists.

OTHER INFORMATION

It is our goal that this program be accessible to all persons. If you have a special dietary or physical need, please state them on the registration form or contact Nancy Wacker at the address given in the Exhibits section.

Budget Rent-a-Car has a special rate for UTEP conference attendees. Call toll free 1-800-377-0605 and tell the reservations clerk you are attending a University of Texas at El Paso conference, rate code ACE.

Nos vemos pronto! ! ■

New GSA Members

The following 683 Members were elected by Council action during the period from April 1996 through October 1996.

Geoffrey A. Abers
Mark J. Abolins
Jared D. Abraham
Thierry Adatte
Soumava Adhya
Richard O. Aguirre
Ivano W. Aiello
Jeff C. Aitken
Solaiman A. Alaabed
John V. Alcott
Scott A. Alderfer
Betsy L. Allen
Charles E. Allen
Heather Almquist-Jacobson
Jeffrey M. Amato
Jan P. Amend
Alejandro E. Amigo
Douglas R. Anderson
Robert C. Anderson
Roger S. Anderson
Samantha D. Andrews
Chilyere N. Anglin
Irene Antonenko
John G. Arnason
Emmanuelle Arnaud
John Aspden
Joanna Athanassopoulos
Danielle M. Ayan
Francisco J. Azpiroz
Hwanjo Baek
Elizabeth D. Baker
Martin G. Balinsky
Clinton I. Barineau
Oliver S. Barnouin-Jha
Manuel A. Barrantes
Eldad Barzilay
Pattie C. Baucom
Randy M. Bechtel
Deborah L. Beck
E. Glynn Beck
Laurence R. Becker
William S. Bedsole
William A. Begley
Elise B. Bekele
Andrey Bekker
Linda C. Bell
Shawn D. Beltman
Paul J. Bembia
David A. Benson
Julia K. Berger
Riona M. Bernatsky
Bruce G. Bernel
Janet L. Bertog
Maryk R. Besonen
Mairi M. Best
Tavia L. Bicklein
Katharina Billups
Ilya N. Bindeman
Keith L. Binker
Michael Bizimis
Jodi K. Blakely
Wayne V. Bloechl II
Anna L. Bloom
Paul E. Blubaugh
Danny J. Bobrow
Brian K. Bohm
Bethany A. Bolles
Craig Boomgaard
Rick Bostian
Lawrence C. Boucher
Lisa D. Boucher
Judith Ann Boughner
Karen L. Boven
John R. Bowman
Brendan R. Bream
Anna B. Breuninger
Thomas M. Brocher
Christopher A. Brochu
Brendan M. Brodie
Craig W. Brougher
Mark L. Brusseau
Brenda J. Buck
John M. Bukowski
David A. Burch
Minnie Burford
Jerry L. Burgess
James R. Burke
Scott G. Bushmire
Anya Z. Butt
Doane E. Cafferty
John E. Callahan
Marta L. Calvache
M. David Campbell
John G. Cargill IV
Mark W. Carter
Robert R. Casavant
Craig S. Casey
Anthony W. Catalano
Ginny A. Catania
Craig R. Cavicchia
Jennifer L. Celeste
Arthur V. Chadwick
Robert W. Chalmers
Robert E. Chambers
Marshall Chapman
Rebecca L. Charlton
Jacques L. Chasse
Lynne M. Chastain
Sergio Chavez-Perez
Yang Chen
M. Sean Chenoweth
Dae-Kyo Cheong
Gian Piero Cherchi
Jennifer K. Chesterfield
Jonathan K. Child
Kyungsik Choi
Yonghoon Choi
Constance M. Christensen
Alan J. Clague
Timothy L. Clarey
B. Christopher Clark
Tonya D. Clayton
Edward B. Coalson
David W. Cobrain
Michael J. Cogan
Andrew J. Coleman
Annette R. Colgan
Geoffrey C. Collins
Debra C. Colodner
John C. Combs
Stephen J. Cook
Skye W. Cooley
Michael T. Coon
E. J. Cowan
Stephen F. Cox
Janet Wert Crampton
Chapman L. Creighton
Anna M. Cruse
Diane Curewitz
Janet H. Curran
Jana L. DaSilva
Thomas C. Davenport
Gregg R. Davidson
Michael R. Davis
Stacey B. Davis
Steven R. Dawes
Scott A. Dawson
Marc A. O. De Batist
Carol M. Dehler
Nicole A. Delude
Xinhua Deng
Can Denizman
Catherine M. Dentan
Nathaniel W. Diedrich
Julie J. Dieu
Jennifer A. Distlehorst
Eloise H. Doherty
Jose R. Dominguez
James A. Donohue
Paul J. Donovan
Neal A. Doran
Patrick E. Drouin
Shannon M. Dunn
Alexander D. Durst
Todd A. Ehlers
Ann L. Elledge
John P. Encarnacion
Annette S. Engel
Staci L. Ensminger
John R. Evans
Catherine E. Everett
William D. Everham
Linda S. Falk
Peter D. Falk
Raymond P. Fallon
Liyan Fang
Robert A. Farrar
Sheri L. Favors
John S. Fedorowich
Thomas R. Fenn
Eric J. Fermann
Jonathan R. Ferris
Jeffrey L. Field
Tiffani A. Fielder
Susan J. Fielek
Bernardino R. Figueiredo
Kim L. Finkbeiner
Frederick A. Flint
Peter F. Folger
Sheryl A. Fontaine
Grace L. Ford
John A. Fortescue
John R. Foster
David Francis
Mark R. Frank
Tracy D. Frank
Charles D. Frederick
Kurt C. Friehauf
Todd G. Fritch
Marsha J. Fronterhouse
Andrew C. Fulton
Silvia Fumagalli
Antonio Funedda
Tracy T. Furutani
Stan J. Galicki
Priya M. Ganguli
Basri Muhammad Ganie
Glenn W. Garneau
Carolyn E. Garrison
Douglas E. Gay
Allen Gellis
Brenda Kirkland George
Christopher C. Gerbi
Judit German-Heins
Francis F. Gervais
Ayati Ghosh
Laurie A. Giannotti
Heather-Marie Gibson
Jerlyn R. Gilmore
Julie L. Gloss
Melinda A. Goelz
Craig N. Goodwin
David H. Goodwin
Caroline L. Gordon
Steven J. Gordon
Howard L. Grahn
Todd J. Greene
C. J. Greig
Mary E. Grez
Daniel R. Griffiths
William S. Grimes
David A. Grimley
Alicia Y. Groeger
Eric B. Grosfils
Matthew S. Grove
Jose Dioscoro Guardiario
Javier Guerrero
Alfred C. Guiseppe
Dennis L. Gustafroh
Jeffrey R. Hale
Mitchell H. Hall
Zachary S. Hall
Diedre A. Hamil
Michael A. Hamilton
John M. Hanchar
Diane J. Hanley
Bruce V. Hanson
Sarah L. Hanson
William E. Hanson
Kazuhiko Harada
Jorunn Hardatdottir
Amy Hardberger
Jodi N. Harney
Joel T. Harper
Bradley N. Harrington
Donald E. Harrison
Garret L. Hart
Mary T. Hartman
Sarah O. Hartman
Nina T. Harun
Forrest Edwin Harvey
Kirk R. Haselton
Brian K. Hastings
Garrett B. Hazelton
Randall F. Hedegaard
Elizabeth A. Heise
M. Jim Hendry
Thomas D. Henze
Reginald L. M. Hermanns
Ricardo Hernandez
Donna M. Herring
James C. Hester
John D. Hickman
Katrina M. Higgins
Joseph C. Hill
Rebecca B. Hinnefeld
Richard M. Hipwell
Brian G. Hoal
J. Janine Hoaster
James F. Hogan
Melody R. Holm
Amy M. Holmes
Ann E. Holmes
Sara C. Hotchkiss
Christopher H. House
Konrad A. Hughen
John Alfred Hunt III
Kimberly S. Hunter
Amber G. Huntoon
Michele L. Huppert
Jennifer M. Husek
Quentin S. Huss
Marcella M. Hutchinson
William H. Hutchinson
Kristin T. Huysken
Greg D. Icenhour
Arild J. Ingebrigtsen
Jennifer L. Jacob
John S. Jacob
David H. James
Gary E. Jaroslow
Michael D. Jarvis
Mary A. Jay
Jeff Jeter
Gary G. Johannson
Beth L. Johnson
Marcus K. Johnston
Bradley L. Jolliff
Caron S. Jones
Mark E. Jones
Michael P. Joy
Maurice E. Kaasa, Jr.
Wayne A. Karem
Margaret F. Kasim
Eric J. Kaupanger
Glenn B. Kays
Kevin M. Keenan
Martin Keller
Katie KellerLynn
Peter J. Kelly
Chris R. Kelson
Richard D. Kendrick
Craig Kennedy
Syed M. Khalil
David C. King
Hobart M. King
Robert E. King
Neil R. Kinnane
Gerald Kirkpatrick
Hans F. Kishel
Jeffrey S. Klein
Debora M. Kligmann
Ralph E. Klinger
Deborah A. Kliza
Jay H. Knight
Ruthann Knudson
N'Guessan R. Koffi
Kurt O. Konhauser
Kenji Konishi
Sarah K. Konrad
Dorte Kortum
Michael S. Kovach
Michael S. Kovacs
Ian R. Kraemer
Scott F. Kreitz
Gregory W. Kruse
David D. Kuehn
Anish Kumar
Elizabeth Lacey
Tor B. Lacy
Nicholas B. Larabel
Michael De Freest Larner
Neal L. Larson
Eric A. Lauha
Rebecca R. Laws
Lawrence A. Lawver
Rene F. Leclerc
Andrew W. Lee
Christopher B. Lee
Katherine F. Lee
Melinda A. Legg
Varner L. Leggitt
Robert S. Leighty
Maggy F. Lengke
Rebecca S. Lesher
Amy Leventer
Harold L. Levin
Michael T. Lewchuk
Claudia J. Lewis
Juan H. Lias
Julie C. Libarkin
Chul Lim
Angela R. Linse
Oscar Loayza
William E. Long
Diane P. Loy
Jun Lu
James J. Luepke
David J. Lundquist II
Juliano M. Macedo
William S. Mah
C. Paul Majors
Peter E. Malin
David M. Manaker
Rocco Mancinelli
Christine S. Manhart
Renee S. Manton
Benjamin S. Mark
Paul J. Markwick
Charles M. Maroni
Maria F. Marquez Zavalia
Kimberly A. Marsella
Monte Marshall
Laura E. Marston
A. Thomas Martel
Barbara M. Martiny
Gyorgy L. Marton
Rebecca L. Masters
Louis L. Matich
Veit J. Matt
Debra J. Matthews
John L. Mayers
George R. McAllister
Lisa A. McBee
Barry C. McBride
Francis J. McCarthy III
Thomas M. McCollom
Jeffrey A. McCormack
Bryan B. McDonald
Graeme D. McDonald
Thomas A. McElroy
Barbara A. McGavern
Larry D. McKay
Margaret E. McMillan
Christopher A. McRoberts
Sarah D. McVay
Christina P. Medlyn
Patrick A. Meere
Andrew J. Meigs
Luis G. Menendez
Kirsten M. Menking
Clifford D. Mertink
Scott C. Mest
Elizabeth V. Meyers
Jayson B. Meyers
Susan W. S. Millar
Bernard M. Millen
Kristin M. Miller
Timothy D. Miller
Amy L. Mills
Sarah T. Mills
Sharon L. Minchak
Richard G. Monk
Stephen M. Monk
Danielle Montague-Judd
William W. Montgomery
Gordon M. Moore
Jean E. Moran
Jean M. Moran
Stephanie L. Moret
Timothy T. Morley
Rebecca S. Morris
Juliet E. Morrow
John L. Muntean
Hilary Muray
Denise R. Muriceak
MaryLynn Musgrove
Todd A. Myse
Robert S. Nail
Mylavarapu V. Narayana
William D. Nashem
Jessica L. Nelson
Lars G. Nelson
Nicole T. Nelson
Pete L. Nester
Yunxiang Ni
Linda P. Nicks
Ronald M. Nielsen
Hiroshi Nishi
Suzanne E. Norrell
Wendy E. Nystrom
Rachel O'Brien
Matthew D. O'Connor
Yuet-Ling O'Connor
Michael K. O'Keeffe
Osaguona M. Ogbebor
Ann E. Olesen
James A. Olson
Jill A. Oppenheim
Gary L. Oppliger
Richard L. Orndorff
Richard B. Owen
Mutlu Ozdogan
Stephen L. Palmes
Young-Rok Park
Andrew P. Patrick
Earnest D. Paylor II
Adina Paytan
Tom Pedersen
Jason M. Pelton
Alejo D. Perez
Eric W. Peterson
John C. Petroff
Sarah E. Pfeiffer
Sam E. Phifer
Thomas Pichler
Mariusz Pierzchala
Michelle A. Pike
Gabriel L. Plank
Thomas K. Pletsch
Robert K. Podgorney
John H. Poehler
Colin D. Poellot
Buford B. Pollett
Michael R. Ponte
Michael C. Pope
Michael J. Portwood
Larry J. Powell
Rachel A. Pressley
John P. Pretola
Louis J. Pribyl

Joanne Rachel Price
Rene M. Price
Maria G. Prokopenko
Edward A. Prudic
Robert P. Pryde
Abdul Qudus
Saleem R. Qureshi
Andrew G. Raby
Hope A. Radin
Michael A. Raines
Robert S. Ralls
Joan M. Ramage
David W. Ramsey
Michael S. Ramsey
Eric J. Rapport
Sara L. Rathburn
Adam S. Read
Robert S. Regis
Kevin D. Reid
Tom Reid
Minghua Ren
Luca L. Rigo de Righi
Michael N. Ritter
Sergio A. Rivera
Jennifer S. Rivers
Angela L. Roach
Carter W. Roberts
Clint E. Roberts
Sheila M. Roberts
Delores M. Robinson
Karyn L. Rogers
Michael F. Rosenmeier
David A. Rothstein
James J. Roush
Scott D. Rutherford
Terri C. Ryland
Seth J. Sadofsky
Arito Sakaguchi
Vickey P. Sare
Leslie Sautter
Daniele Savelli
Mohammad Sayeeduzzaman
Robert B. Scarborough
Mary Jo Schabel
Randall J. Schaetzl
Thomas P. Schar
Joseph P. Schleeper
Esther K. Schmaedicke
Karen S. Schooler
Catherine L. Schuur
Ronald G. Scott
Elizabeth J. Screaton
D. Erich Seamon
Suanna C. Selby
Animikh Sen
Gregory M. Sena
Rajesh Sharma
Devin T. Shay
Amy Sheldon
Jian Shen
Yunqing Shen
Clark E. Sherman
Robert H. Silliman
Mary C. Simmons
Keith Sircombe
Michelle M. Sirota
Catherine P. Skinner
Sonya Y. Skoog
Brian T. Smith
David S. Smith
James E. Smith
Timothy M. Smith
N. Christian Smoot
Amy J. Snyder
David L. Snyder
Glen T. Snyder
Mark D. Sonnenfeld
Gordon Southam
Honore D. Southern
Solomon M. Sparks
George D. Spence
Dan Spinogatti
Theodore R. Steinke
Lora R. Stevens
Stephen Stokes
Jeffrey C. Strasser
Luther M. Strayer IV
Randall K. Streufert
Laura E. Strickland
Nikki Strong
Miguel R. Suarenz
James H. Sullivan
Christopher Sumner
Dawn Y. Sumner
Ben E. Surpless
Michael P. Sykes
Aaron S. Taylor
Cliff D. Taylor
Steve B. Taylor
Thomas A. Taylor
W. Lansing Taylor
Akihiro Tazawa
Paul D. Theriault
Amy Thibodeau
Douglas M. Thompson
Stephen C. Thompson
Bradley W.C. Thurber
John Peter Thurmond
Stephen F. Tillinghast
J. Michael Timmons
Keith J. Tinkler
Chad G. Tomforde
Daniel R. Tormey
David A. Townsend
David Tretbar
Paul J. Troiano
Bruce R. Tufts
Caroline B. Tuit
Maria E. Uhle
Ana L. Unruh
Robert B. Valentine
Pieter A. Van Der Beek
Stephen J. Van der Hoven
Frederick J. Vanden Bergh
John J. Vander Veer
Michel M. Vannier
Emmanuel M. Vassilakis
Laura M. Vaugeois
Ginger L. Vaughn
Francisco J. Vega
Charles A. Ver Straeten
Kirk R. Vincent
Jennifer C. Voncannon
Vladimir N. Vyssotski
Amy M. Waddell
Bruce Wahle
Miles E. Waite
Luke J. Walker
Charles K. Waltman
Heather A. Waterman
Michael Webb
Janine Weber-Band
Catherine M. Weitz
Raelyn E. Welch
Beverly C. Wemple
Douglas D. Werkema, Jr.
Cynthia A. Werner
Paul Wessel
Rick Wessels
Katherine M. White
James Whitehead
Karen E. Whittlesey
Anne W. Wibiralske
George J. Wiegman
Dean G. Wilder
Christopher P. Williams
Dana E. Williams
Erika L. Williams
Steven J. Williams
David R. Williamson
Susan M. Wilson
William J. Winegard
Harry C. Wise
Russell R. Wolff
Christina R. Wood
Dana C. Wood
Keith L. Woodburne
Jonathan F. Woodworth
Alfred Wu
James R. Wysor
Hirofumi Yamamoto
Haitao Yang
Emi Yano
Tesfaye Yemane
Jiun-Yee Yen
Kristal G. Yipon
J. Douglas Yule
Edward P. Zaengle
C. William Zanner
David J. Zbieszkowski, Jr.
Yong Zhang
Jodi M. Zuckerman ■

New GSA Student Associates

The following 312 Student Associates became affiliated with the Society during the period from April 1996 through October 1996.

Stephen C. Adams
Mario Aigner-Torres
Stephen T. Allard
Carrie E. Allberg
Angela K. Ashurst
Christopher D. Augustine
Angela M. Ayers
Christina L. Baack
Joey J. Barker
Brian Barone
Joseph D. Barr III
Lisa A. Battiato
Dayo O. Bayewu
Andrew R. Bechtold
Nadia F. Bellezza
Peter A. Bennett
Kimberly M. Berends
Amy E. Berger
Brian C. Bird
David F. Boutt
Howard B. Brenner
Andrew L. Brownstone
Melissa A. Buciak
Reuben G. Bullard, Jr.
Andrew S. Byers
Jeffrey M. Byrnes
Bradford G. Campbell
Ken F. Casamento
Robert P. Cave, Jr.
James Chapman
Kathryn L. Chapman
Annaick Chauvet
James C. Christiansen
P. J. Clayburg
Jill D. Clemenich
John W. Coates
Charles A. Coffindaffer
Joseph A. Cook III
Katherine H. Cooper
Paul A. Corts
Jonathan W. Cox
Lance W. Crabtree
Jenny L. Crook
Kathleen M. Cummins
Jason W. Curry
Todd A. Dallegge
Carina L. Dalton
Jeffrey S. Danielian
Greg S. Danziger
David J. Dariano
Megan G. Dascoli
Christopher D. Dawkins
Sherland R. Decker, Jr.
Thomas D. Dehli
Christopher G. Del Monico
Goran Denkovski
Todd A. Diehl
Jacob L. Dimond
Amanda B. Downing
Brian L. Duffany
James A. Dutcher
Donna N. Eaves
Eric E. Eddlemon
John G. Eldridge
Erin J. Fallis
Matthew S. Fantle
Andrew H. Feldman
Lisa R. Ferber
Luis A. Fernandez
James A. Ferrara
Richard J. Fink
Amy L. Fonville
Christine L. Ford
Deryk J. Forster
Bryan Franke
Christian L. Frederick
Mark B. Garcia
David A. Garrett
Lisa M. Gatto
Brandy G. Gilmore
Robert W. Gimpel
Lorraine E. Givens
Fernando Gonzalez
Kyle S. Graff
Sally D. Gramstad
Dibby A. Green
Rebecca L. Greenwood
Jay W. Grider
Joy D. Griffin
Susan E. Grover
Jenny M. Hall
Matthew S. Hall
Zane E. Hamiel
Andreas Hansen
Belal D. Hansrod
Michael A. Harder
Bradley J. Harris
James L. Hatchett
Michelle S. Hays
Ted J. Heath
Jordan E. Hegedus
Tara L. Heinrich
Dawn M. Hendricks
Eric W. Hewson
Julia M. Hirzel
Mary K. V. Hodges
Richard M. Hodgson
Jennifer L. Holland
John L. Howell, Jr.
Jason M. Hughes
Hallie P. Humphrey
Katherine M. J. Hurlburt
Julia Ann Hyatt
James A. Inman
Matthew C. Irvine
Erik W. James
Eleanore B. Jewel
Thomas C. Johannesmeyer
James R. Johnston
Sheila A. Keasler
Terry L. Keasler
Amanda K. Kelly
James R. Kight
Hyun Jin Kim
Judith A. King
Jodi L. Klemme
Claudia S. Kobisz
Jeffrey A. Koch
Kyle D. Kolodziejski
Lori Krikorian
Jade-Star Lackey
Sherrie C. Landon
Richard S. Law
Susan J. Leigh
Wes M. Leon
Catherine B. Lewis
Michael R. Lewis
Cayce A. Lillesve
Darren R. Locke
Jennifer M. Lohr
Daniel A. Long
Alison A. Lowrey
John K. Lucey
Ernest J. Luikart
Lynne MacDonald
Bruce A. Madill
Carrie A. Maher
Timothy F. Maher
Lauren M. Maigret
Jacques A. Marcillac
David W. Markell
Brian S. Marlow
Scott D. Marsic
Ron Mart
Jeffrey M. Marts
Joseph A. Maule
Nilah Ann Mazza
Jennifer H. McCord-Thompson
Daniel H. McCrumb
James T. McDermott
Therese D. McGee
Emmet H. McGuire
Robert J. McKenna III
Kevin R. McRae
Aaron D. Melody
Jeffrey W. Menken
Matthew J. Mertens
Robert P. Meyer
Marlo Mikolas
Keith A. Milam
Zachary D. Miller
Wendy A. Mitteager
Jeff G. Moats
Ronald R. Moore
Wendy L. Morgan
Nicholas D. Morgia
Suzette A. Morman
Bonnie A. Morris
Joshua B. Morris
Timothy A. Morse
Cyndi J. Mosch
Lona D. Mullinax
Claudio Ernesto Munoz
Christine A. Munson
Jerel G. Nelson
Timothy D. Nelson
James Osborne
Mia L. Palmieri
Thomas E. Parana
Steven W. Parrett
Jason D. Pearlman
Sandi Pesak
James W. Peters
Jeffrey N. Peters
Stephanie J. Phippen
Michael J. Pickering
Katherine R. Pickett
Mary A. Podzemny
Joseph J. Pompei
Michael L. Putt
Lindsey A. Quackenbush
Rachel E. Ramirez
Luis R. Ramos
Wayne E. Randolph
Heidi M. Rantala
Chad R. Relhm
Elisabeth D. Rennow
Meredith K. Rhodes
Russell V. Richmond
Peter C. Riddle
Bruce E. Rider
John P. Riley
Joshua H. Ring
Peter G. Rinkleff
Edgar R. Rivera
Jack V. Rogers II
Jimi R. Rogers
Brian R. Roosa
Lisa M. Rosi
Susan M. Rosin
Jill E. Rozycki
Michael L. Sawyer
Jennifer D. Schmidt
Katherine M. Schmitz
Tara L. Schrader
Kathryn G. Sharp
Frederic L. Shean, Jr.
Wayne B. Shoemaker
Sandra L. Simchick
Regina J. Slape-Law
Carter L. Smith
Donald N. Smith
Jennifer L. Smith
Ute D. Smith
William T. Smith
James H. Sneeringer
Gad Soffer
Connie J. Sorell
Erika L. Stapleton
Matthew B. Stead
John M. Stein
Nat P. Stephens
Michael K. Stevens
Vanessa L. Svihla
Casey N. Swan
Jonathan E. Tichenor
Kristin L. Tobin
Tracy L. Tobin
N. Georgis Tompkins
Robert P. Trail
Gregory S. Trapp
Michael J. Turco
Aleta Van Riper Turner
Jon L. Turner
Tanya S. Unger
Rose A. Van Hook
Allison W. Vaughn
Karen M. Viskupic
Sarah R. Vlachos
Sharin L. Wadleigh
Dale A. Walker
Heather C. Walker
Kathleen A. Walsh
Andrew P. Way
Alan R. Weaver
Sarah J. Weaver
James Wells
Margery E. Willett
Christopher D. Williamson
David B. Williamson
Michael R. Willinger
Alan M. B. Willis
Mae E. Willkom
Tyler D. Woods
Christopher C. Yarnell
Grant Y. Yip
Bernard H. Yost
Chris K. Zeliznak
Nicholas D. Zerr
Ryan D. Zick
Michele H. Zimmer ■

GSA SECTION MEETINGS

1997

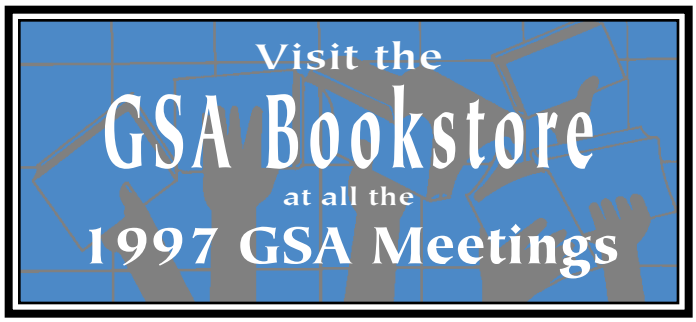
NORTHEASTERN SECTION, March 17–19, Sheraton Valley Forge Hotel, King of Prussia, Pennsylvania. Information: William A. Crawford, Department of Geology, Bryn Mawr College, Bryn Mawr, PA 19010-2899, (610) 526-5112, fax 610-526-5086, wcrawfor@brynmawr.edu. *Preregistration Deadline: February 14, 1997.*

SOUTH-CENTRAL and ROCKY MOUNTAIN SECTIONS, March 20–21, University of Texas, El Paso, Texas. Information: Elizabeth Y. Anthony, Department of Geological Sciences, University of Texas, El Paso, TX 79968-0555, (915) 747-5483, anthony@geo.utep.edu. *Preregistration Deadline: February 7, 1997.*

SOUTHEASTERN SECTION, March 27–28, Auburn University, Auburn, Alabama. Information: Mark G. Steltenpohl, Department of Geology, Auburn University, Auburn, AL 36849-5305, (334) 844-4893, steltmg@mail.auburn.edu. *Preregistration Deadline: February 21, 1997.*

NORTH-CENTRAL SECTION, May 1–2, The Concourse Hotel, Madison, Wisconsin. Submit completed abstracts to: Bruce Brown, Wisconsin Geological & Natural History Survey, 3817 Mineral Point Rd., Madison, WI 53705, (608) 263-3201, babrown1@facstaff.wisc.edu. *Abstract Deadline: January 9, 1997.*

CORDILLERAN SECTION, May 21–23, Kona Surf Resort and Convention Center, Kailua-Kona, Hawaii. Submit completed abstracts to: Fred MacKenzie, Department of Oceanography, University of Hawaii–SOEST, 1000 Pope Road, Honolulu, HI 96822, (808) 956-6344, fredm@soest.hawaii.edu. *Abstract Deadline: January 24, 1997.*



New GSA Fellows

The following 31 Members were advanced to Fellowship in October 1996.

John M. Armentrout
Roger P. Ashley
G. Arthur Barber
Kenneth Belitz
Philip C. Bennett
Bruce A. Bouley
Thure E. Cerling
Dennis P. Cox
Peter G. DeCelles
Henry J. B. Dick
Ronald J. Goble
Karen Grove
Steven E. Ingebritsen
Craig M. Jarchow
Thomas C. Johnson
Brian G. Katz
Steven J. Lambert
David K. Larue
J. Gregory McHone
Daniel P. Murray
Noriyuki Nasu
Norman J. Page
Fred M. Phillips
David D. Pollard
Dennis W. Powers
Margaret N. Rees
Bridget R. Scanlon
James G. Schmitt
J. Leslie Smith
Uri S. ten Brink
Chester T. Wrucke

GSA ANNUAL MEETINGS

1996

Denver meeting registered a high of 6501 attendees!!
See photos and story in the January issue or visit the home page for details (http://www.geosociety.org).

FOUND at Colorado Convention Center: White envelope. Call to identify the contents and we'll return it. Kathy Lynch (303) 447-2020, x114. klynch@geosociety.org.

1997

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

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

Technical Program Chairs:
John Bartley, Erich Petersen, *University of Utah*

Theme Session Proposal Deadline is January 2, 1997.
See the November *GSA Today* for the theme invitation *or* the World Wide Web for invitation and proposal form: ***http://www.geosociety.org.*** Proposals are sent directly to John Bartley.

Field Trip Chairs: ***Bart Kowallis,*** *Brigham Young University*
Paul Link, *Idaho State University*
No more field trips will be accepted.

1998

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

General Chairs: ***Jeffrey J. Fawcett,*** *University of Toronto*
Emlyn Koster, *Ontario Science Centre*

Technical Program Chairs:
Denis M. Shaw, *McMaster University*
Andrew Miall, *University of Toronto*

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

Pierre Robin
University of Toronto
Dept. of Geology
22 Russell Street
Toronto, ON M5S 3B1, Canada
(416) 978-3022
Fax 416-978-3938

Henry Halls
Erindale College
Mississauga, ON L5L 1C6, Canada
(905) 828-5363
Fax 905-828-3717
hhalls@credit.erin.utoronto.ca

FUTURE MEETINGS

1999 — Denver, Colorado . . . . . October 25–28
2000 — Reno, Nevada . . . . . November 13–16
2001 — Boston, Massachusetts . . . . . November 5–8

December *BULLETIN* and *GEOLOGY* Contents

The Geological Society of America
BULLETIN
Volume 108, Number 12, December 1996

CONTENTS

Book Reviews *continued from p. 25*

about paleovegetation and paleoclimate. Toward the end of the book, I noted the important point that Miall made about there being few reliable lithofacies indicators of paleoclimates, and the warning about trying to link Milankovitch climatic cycles with pre-Pleistocene fluvial sedimentary cycles.

So how can knowledge of the nature and origin of fluvial deposits contribute to the exploration, production, and management of economic resources such as oil, gas, water, and placer minerals? It seems, from the catalogue of oil and gas reservoirs with particular geometries and tectonic settings in chapters 14 and 15 of Miall's book, that all we can do is classify reservoirs in very broad terms. The reality is, of course, that detailed quantitative description and interpretation of fluvial deposits are critical to prediction of their subsurface characteristics, and to effective exploitation and management of the economic resources they contain.

Finally, regarding presentation, there is quite a lot of repetition and cross-referencing between chapters, suggesting that the organization could be improved. I noted some awkward sentence constructions and some typographical errors. The quality of the figures is variable, at least partly because most of them are lifted directly from other publications. Figure 2.20 (upper) is upside down. These minor problems with presentation should have been dealt with by the editor.

John Bridge
Binghamton University
Binghamton, NY 13902-6000 ■

GEOLOGY
VOLUME 24
NO. 12
P. 1053–1200
DECEMBER 1996

Environmental & Engineering Geoscience Contents

Volume II, Number 3, Fall 1996

CALENDAR

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

1997 Penrose Conferences

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

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

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

1997 Meetings

March

March 22–24, **Triassic Basin Initiative,** (TRIBI): Initial workshop and field trip, Durham, North Carolina. Information: Tyler Clark, Dept. of Geology, Duke University, P.O. Box 90227, Durham, NC 27708-0227, (919) 684-5847, fax 919-684-5833, E-mail: tclark@geo.duke.edu.

June

June 2–6, **14th International Conference on Basement Tectonics,** Blacksburg, Virginia. Information: A. K. Sinha, Dept. of Geological Sciences, Virginia Polytechnic Institute and State University, Blacksburg, VA 24061-0420, (540) 231-5580, fax 540-231-3386, E-mail: searches@vtvm1.cc.vt.edu or sentelle@vt.edu, http://www.geol.vt.edu/profs/aks/basement.html.

June 9–13, **Changing Water Regimes in Drylands,** Lake Tahoe, California. Information: Nicholas Lancaster, Desert Research Institute, P.O. Box 60220, Reno, NV 89506, E-mail: nick@maxey.dri.edu, Web: http://www.dri.edu.

September

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

September 22–27, **6th International Conference on Fluvial Sedimentology,** Cape Town, South Africa. Information: Conference Organiser, 6 ICFS, Postgraduate Conference Div., UCT Medical School, Observatory 7925, South Africa, phone 27-21-406-6911 or 406-6348, fax 27-21-448-6263, deborah@medicine.uct.ac.za.

About People

GSA Honorary Fellow **Gabriel Dengo,** Center for Geological Studies of Central America, Guatemala City, Guatemala, is the 1996 recipient of the Hollis D. Hedberg Award from the Institute for the Study of Earth and Man, Southern Methodist University, Dallas.

Fellow **Gerald M. Friedman,** Brooklyn College and City University of New York, has in 1996 been elected an honorary fellow of the Geological Society of London, was given the Russian Academy of Natural Sciences Kapitsa Gold Medal of Honor, and received the American Association of Petroleum Geologists Distinguished Educator Award; next spring he will be awarded the Twenhofel Medal by the Society of Sedimentary Geology.

Position Announcements *(from Employers using GSA's Employment Service at the 1996 GSA Annual Meeting)*

SURFACE PROCESSES
BOSTON COLLEGE

The Department of Geology and Geophysics at Boston College seeks a dynamic candidate for a tenure-track faculty position (rank open) in the area of Surface Processes, beginning September 1997. Individuals may have research interests in any of the sub-specialties in this broad field, but those with backgrounds in geomorphology, surface hydrology, wetland dynamics, sedimentation or coastal dynamics are particularly encouraged to apply. A Ph.D. is required and post-doctoral experience desirable. The individual will be expected to teach undergraduate and graduate courses in our geology and environmental programs and to carry out an aggressive research program in his or her specialty. The Department, which also runs the nearby Weston Geophysical Observatory, is well equipped (including flume and GIS laboratories) and is housed in modern, recently renovated facilities on a suburban campus 8 miles west of Boston. Rank of appointment will be commensurate with experience.

A curriculum vitae, statement of research interests, list of references and copies of selected publications should be sent to Christopher Hepburn, Chairman, Dept. Geology and Geophysics, Boston College, Chestnut Hill, MA 02167 by January 10, 1997. For further information, contact the above at 617-552-3641 or 3642 or via E-mail, hepburn@bcvms.bc.edu. Boston College is an affirmative action/equal opportunity employer. Qualified women and minorities are encouraged to apply.

DEPARTMENT OF GEOLOGY,
UNIVERSITY OF ILLINOIS AT URBANA-CHAMPAIGN
ASSISTANT PROFESSOR OF
SEDIMENTARY GEOLOGY (TENURE-TRACK)

The Department of Geology at the University of Illinois invites applications for a full-time (9-month academic year) tenure-track faculty position in sedimentary geology. We are seeking an outstanding scientist and enthusiastic teacher for an appointment at the rank of assistant professor that will begin in August 1997. A Ph.D. is required; salary is negotiable. The successful candidate will establish an innovative, externally funded research program, preferably relating to tectonics and/or global change, and will pursue excellence in teaching and student-research supervision in all aspects of our educational program.

The University of Illinois at Urbana-Champaign is a major research university with 37,000 students in residence. Currently, the Department of Geology has 14 full-time faculty (see our homepage at http://www.geology.uiuc.edu/) and offers M.S. and Ph.D. degrees in geology and geophysics. Opportunities exist for collaboration with current staff in structural geology, hydrogeology, geochemistry, geophysics, clay mineralogy, and paleontology, both at the department and at the Illinois State Geological Survey.

To apply, please send a curriculum vita, a list of publications, a brief letter describing research and teaching interests and plans, and the names of three references to: Dr. Stephen Marshak, Search Committee Chair, Department of Geology, University of Illinois, 1301 W. Green St., Urbana, IL 61801. In order to ensure full consideration, applications must be received by December 10, 1996. For further information, contact Dr. Marshak by E-mail at smarshak@uiuc.edu, by telephone at 217-333-7705, or by Fax at 244-4996. The University of Illinois is an Equal Opportunity/Affirmative Action employer.

DEPARTMENT OF GEOLOGY/UNIVERSITY
OF PUGET SOUND/TACOMA, WASHINGTON

Two Sabbatical replacement teaching positions are anticipated to become available for the 1997-1998 academic year, and possibly for the Fall of the 1998-1999 year, in
GEOMORPHOLOGY/QUATERNARY GEOLOGY (Position #1) and in MINERALOGY/PETROLOGY (Position #2). Depending upon leave schedules yet to be finalized, each position may last anywhere from 1 semester to 3 semesters in length. Position #1 will teach a one-semester senior-level geology major course in geomorphology and Quaternary geology; Position #2 will teach either a one-semester sophomore-level majors course in mineralogy, a one-semester sophomore-level majors course in igneous and metamorphic petrology, or both. Both positions will also participate in teaching introductory Physical Geology classes for non-majors, as well as in the interdisciplinary team-taught Science in Context program.

Appointments will be at the Assistant Professor level; a Ph.D., a minimum of 1 year of college-level teaching, and a commitment to excellence in undergraduate teaching and liberal arts education are required. When the nature of these positions has been finalized, individuals on our mailing list will receive official vacancy announcements and application procedures. The University of Puget Sound is a private, liberal arts college with 2800 undergraduates.

WESTERN WASHINGTON UNIVERSITY
TENURE-TRACK POSITIONS
GEOPHYSICS AND GEOLOGY/SCIENCE ED.

For details see http://www.wwu.edu/~cas/dept.pages/geology.html or contact Jim Talbot at talbot@cc.wwu.edu

SEDIMENTOLOGIST
ASSISTANT PROFESSOR
SMITH COLLEGE

The Department of Geology at Smith College invites applications for a full-time, tenure-track position in sedimentology at the rank of Assistant Professor. The successful candidate will be expected to teach an intermediate-level course in sedimentology as well as geology courses at the introductory and advanced levels. This initial appointment is for a three-year term and begins in September, 1997. A Ph.D. is required.

Applicants should forward a letter of application before November 15, 1996. Include a concise statement of current and long-term teaching, research, and career goals, transcripts, a current curriculum vitae, and names of three references.

All materials should be addressed to Geology Search, c/o Dr. John B. Brady, Chair, Department of Geology, Smith College, Northampton, MA 01063. Smith College is an Equal Opportunity/Affirmative Action Institution. Minorities and women are encouraged to apply.

HYDROGEOLOGIST,
SAN FRANCISCO STATE UNIVERSITY

The Department of Geosciences invites applications for a tenure-track faculty position at the assistant professor level in hydrogeology, beginning in August 1997. The position requires a Ph.D. in geology and a strong commitment to excellence in teaching and research. Some background in teaching and in industry is preferred. The successful candidate will be expected to teach at all academic levels and will be primarily responsible for teaching undergraduate and graduate courses in hydrogeology, groundwater contamination, and environmental geology. Responsibilities will include maintaining an active research program that involves graduate and undergraduate students. We seek someone who will work with local environmental firms and agencies and assist in building our new graduate program in Applied Geosciences and an interdisciplinary undergraduate environmental studies program.

The Department of Geosciences includes geology, meteorology, and oceanography and consists of 13 faculty members from these fields. The department offers BS and BA degrees in geology and, beginning Fall 1996, a MS degree in Applied Geosciences.

To apply, send curriculum vitae including a statement of teaching and research interests, and names and addresses of three references to: John Monteverdi, Dept. of Geosciences, San Francisco State University, San Francisco, CA 94132. Applications should be received before January 15, 1997. San Francisco State University is an Equal Opportunity/Affirmative Action employer.

WESLEYAN UNIVERSITY
LIMNOLOGIST

The Department of Earth & Environmental Sciences at Wesleyan University invites applications for a tenure-track position in the field of limnology, to commence with the 1997-98 academic year at the Assistant Professor rank. The successful applicant will be responsible for teaching the following types of courses on a regular basis: an introductory course for non-science majors, a major-level course in limnology, an upper-level course in their specialty; and occasionally alternate with other faculty in the teaching of one of the following: environmental geochemistry, oceanography, or paleoecology. Candidates should have good quantitative skills and should be prepared to incorporate these in their teaching. All requirements for the Ph.D. should be completed by the time of appointment. Women and minority candidates are encouraged to apply for this position. Wesleyan University is an affirmative action employer. Letters of application should be accompanied by a statement of research and teaching interests, a recent vitae, and the names and addresses of at least three referees; these should be sent by January 1, 1997, to: Gregory S. Horne, Chair, Department of Earth & Environmental Sciences, Wesleyan University, Middletown, CT 06459

AMHERST COLLEGE
ENVIRONMENTAL GEOSCIENTIST

The Department of Geology is seeking applications for a one-year faculty position at the level of Assistant Professor beginning in the fall semester, 1997. Possible fields of expertise include one or more of the following: aqueous geochemistry, biogeochemistry, paleoclimatology, hydrogeology, surficial or glacial geomorphology, and/or paleoecology. Although a Ph.D. is desirable, those nearing completion of that degree are encouraged to apply.

Candidates should have a strong interest in undergraduate teaching as well as research interests that can incorporate undergraduate students. Teaching responsibilities will consist of: one introductory-level course and one intermediate-level course that stress environmental and surficial processes. In addition the candidate is expected to teach one upper-level course in his/her specialty. Amherst College has opportunities to teach in interdisciplinary programs.

Submit a résumé, three letters of recommendation, and a brief statement of your research interests to: Prof. Edward S. Belt, Department of Geology, Amherst College, Amherst, MA 01002-5000, tel: (413)542-2712. Review of applications will begin on 15 January 1997, but applications will be accepted until a pool of qualified candidates is identified. Amherst College is an equal opportunity/affirmative action employer. Women and minorities are particularly encouraged to apply.

CALIFORNIA STATE UNIVERSITY AT BAKERSFIELD
AQUEOUS GEOCHEMIST

Subject to approval of funding, the Department of Physics and Geology at CSU Bakersfield anticipates a tenure-tract position in aqueous geochemistry/hydrology to be filled at the assistant professor level. A Ph.D. in geology or a related geoscience is required. Experience and interest in teaching is mandatory. Responsibilities include teaching graduate and undergraduate courses in geochemistry, aqueous geochemistry, contaminant transport, and related topics of the successful candidate's choosing. Successful candidate will also be expected to teach some general education geology and/or physical science courses and to develop a research program in their specialty involving undergraduate and master's level graduate students.

Hydrogeology and soft rock geology are deparrtment specialities.Housed within the Geology Department are aqueous chemistry and hydrology labs including field hydrology equipment, a mini/micro-computer lab with MINTEQ and MODFLOW software, an automated XRD, and SEM-EDX, research petrography lab, and field geophysics equipment. The department has access to GC-MS, AA, and NMR instruments in the Chemistry Department and the campus has GIS access. The San Joaquin Valley is an area of intensive agricultural activity and petroleum development. Thus, local research opportunities are readily available and connections are easily made with local industry and government agencies.

The starting date is September 1, 1997. Review of applications will begin after December 1, 1996. Candidates should submit a letter of application, a current curriculum vita, and names of at least three references to: Dr. Robert Horton, Chair, Department of Physics and Geology, California State University, 9001 Stockdale Highway, Bakersfield, CA 93311-1099.

FUTURE . . . GeoVentures are a special benefit created for members, but are open also to guests and friends. 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 of time and destination) and include lodging and meals as designated. The venues, however, are quite different.

Choose from two types of GSA GeoVentures

	GeoHostels	GeoTrips
Length	6 days	1 to 3 weeks
Cost	Under $700	$1000 and up
Site	College campuses or resort towns, North America	Worldwide
Time of Year	Summer	Anytime
Traveling	Limited to local areas	Daily change of site
Physical Requirements	None	May be physically demanding
Education	Daily educational programs and field excursions	Daily outdoor field instruction

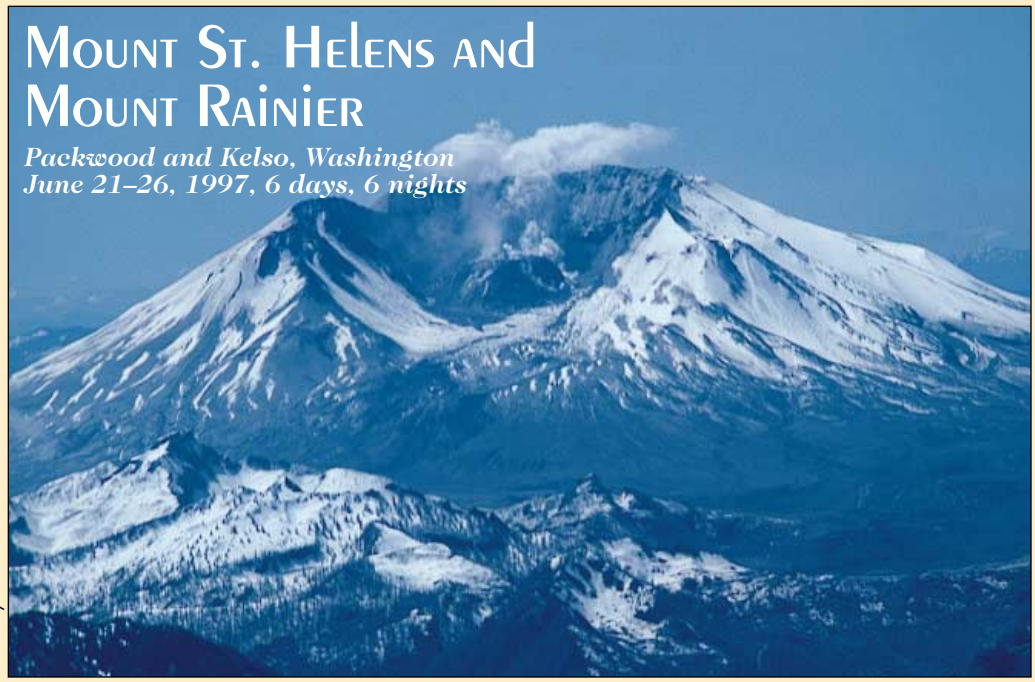


Photo by Richard Waitt.

GeoHostel

Scientific Leaders

Richard Waitt, U.S. Geological Survey, Cascades Volcano Observatory, Vancouver, Washington

Patrick Pringle, Washington Department of Natural Resources, Olympia, Washington

Both leaders have many years of geological field experience, summarized in numerous scientific publications about Mount St. Helens and Mount Rainier, as well as extensive experience at other Cascade and Alaskan volcanoes.

Description

This GeoHostel will focus on field trips to Mount St. Helens, especially to explore processes and effects of the cataclysmic eruption of May 18, 1980. Among them are: decapitation of former summit; world's largest historic landslide; tsunami wave as high as 800 feet on Spirit Lake; gigantic pyroclastic surge (so-called "lateral blast") that in four minutes mowed down 235 square miles of mature forest; great muddy floods (lahars). The ever-changing processes of revegetation, reforestation, and re-entry of fauna to the devastated area are part of the scientifically unique experience, one of the reasons Congress set aside the heart of the affected area as Mount St. Helens National Volcanic Monument. Two days will be devoted to the east and southeast sides of Mount St. Helens, and two days to the south and west sides, including two stunning new visitor facilities in the heart of the devastated area, and one day will be at spectacular Mount Rainier (northeast, east, and south flanks) in Mount Rainier National Park. While at Mount St. Helens, we will hike through a remaining stand of old-growth coniferous trees, many as tall as 230 feet. Each day involves a hike through a unique landscape; none of the hikes is longer than about three miles nor with an altitude change of more than about 900 feet. Because snow will still be visible on the higher mountain peaks, June will be stunning for photography.

Lodging, Meals, and Ground Transportation

The group will stay on Saturday, Sunday, and Monday at the Inn of Packwood, Packwood, Washington, and on Tuesday, Wednesday, and Thursday nights at the Red Lion Inn in Kelso, Washington. All lodging is based on double occupancy. GSA will do its best to find roommates for single travelers. Meals will include plenty of hors d'oeuvres at the Welcoming Reception and Orientation on Saturday evening, daily breakfasts, sack lunches, and a hearty farewell dinner on Thursday evening. Field trip transportation will be provided in air-conditioned, 15-passenger vans.

Fee and Payment

$650 for GSA Members *$700 for Nonmembers*

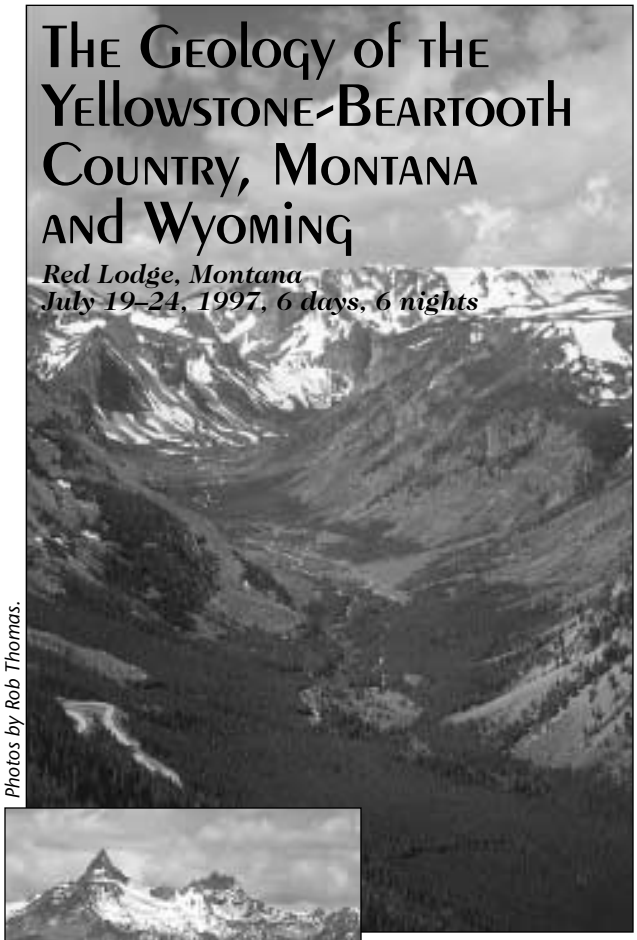
$100 deposit is due with your reservation and is refundable through April 28, less $20 processing fee. Total balance is due: April 28.

Included: Classroom programs and materials; field trip transportation; lodging for six nights (double occupancy); meals outlined above; welcoming and farewell events.

Not included: Transportation to and from Portland, Oregon; transportation during hours outside class and field trips; and other expenses not specifically included.

The Geology of the Yellowstone-Beartooth Country, Montana and Wyoming

Red Lodge, Montana
July 19–24, 1997, 6 days, 6 nights



Photos by Rob Thomas.

GeoHostel

Scientific Leaders
Rob Thomas *and* ***Sheila Roberts,*** *Western Montana College, Dillon, Montana*

Rob Thomas is currently an associate and chair of the Department of Environmental Sciences at Western Montana College. Rob developed an interest in the geology of the Yellowstone-Beartooth country while working on Cambrian mass extinctions for his dissertation at the University of Washington. Since then, his research has focused on the dynamics of carbonate platform development and destruction, the origin and timing of extensional tectonism in southwestern Montana, interdisciplinary geosciences program development, and geoscience teacher-education reform.

Sheila Roberts is an assistant professor of geology in the Department of Environmental Sciences at Western Montana College. Having lived much of her life in Montana and Wyoming, she has a deep passion for educating people about the geology of her home area. Sheila did her doctoral work at the University of Calgary.

Description

The geology of the Yellowstone-Beartooth country is some of the most spectacular in North America, from Archean metamorphic rocks to Quaternary glacial deposits. The GeoHostel will include field trips to look at Archean through Quaternary geology of the Beartooth plateau via the famous Beartooth Highway, layered mafic intrusions at the Stillwater Mine, Absaroka volcanics in the upper Clarks Fork drainage, the Heart Mountain detachment and Phanerozoic stratigraphy of the Sunlight Basin and Dead Indian Hill region, and volcanics of the northeastern edge of the Yellowstone plateau. The trips are full days. Enjoy the spectacular scenery of the Yellowstone-Beartooth country.

Lodging, Meals, and Ground Transportation

The group will be lodged at the Best Western Lu Pine Inn in double occupancy motel-type rooms. GSA will do its best to help find a suitable roommate for single travelers. Meals will include plenty of hors d'oeuvres at the Welcoming Reception and Orientation on Saturday evening, daily breakfasts and sack lunches, dinner on Monday evening at the Grizzly Bar, and a hearty farewell dinner on Thursday evening. Field trip transportation will be provided in air-conditioned, 15-passenger vans.

Fee and Payment

$690 for GSA Members *$740 for Nonmembers*
$100 deposit is due with your reservation and is refundable through May 28, less $20 processing fee. Total balance is due: May 28.

Included: Classroom programs and materials; field trip transportation; lodging for 6 nights; double occupancy, meals outlined above; welcoming and farewell events.

Not included: Transportation to and from Red Lodge, Montana; transportation during hours outside class and field trips; and other expenses not specifically included.

Registration Form

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

Name

Institution/Employer

Mailing Address

City/State/Country/ZIP

Phone (business/home)

Guest Name

GSA Member #

	Deposit Per Person	No. of Persons	Total Paid Deposit
GT971—Italy	$250	____	$_____
GT972—Canyonlands	$200	____	$_____
GH971—Mount St. Helens	$100	____	$_____
GH972—Yellowstone	$100	____	$_____
GH973—Sky Islands	$100	____	$_____
	TOTAL DEPOSIT		$_____

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

☐ VISA ☐ MasterCard ☐ American Express

Credit Card # Exp. Date

Signature

PLEASE MAIL OR FAX REGISTRATION FORM AND CHECK OR CREDIT CARD INFORMATION TO:
1997 GSA GeoVentures, GSA Meetings Department,
P.O. Box 9140, Boulder, CO 80301.
Registrants are encouraged to use the GSA Meetings Department fax number: 303-447-0648

MAKE CHECKS PAYABLE TO: GSA 1997 GeoVentures

CALL TODAY FOR MORE INFORMATION: 1-800-472-1988, x134, or (303) 447-2020, E-mail: ecollis@geosociety.org • fax 303-447-0648.
Check for updates: http://www.geosociety.org

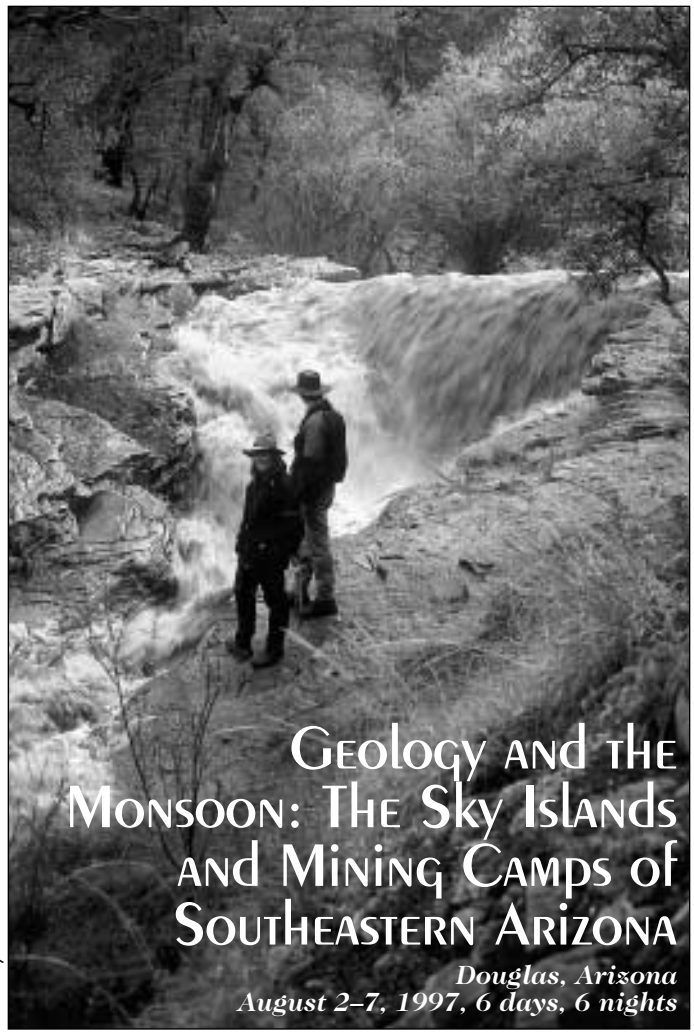


Photo by Tim Lawton.

GeoHostel

Scientific Leaders
Tim Lawton *and* ***Nancy McMillan,***
New Mexico State University, Las Cruces, New Mexico

Tim Lawton is an associate professor at New Mexico State. His research interests are tectonics and sedimentation, including the Jurassic-Cretaceous and Laramide history of the southwestern United States and northern Mexico. Tim was the assistant director and director (1987–1991) of the University of Arizona field camp in Cochise County, Arizona.

Nancy McMillan is also an associate professor at New Mexico State. Her research specialties include Tertiary volcanic rocks of the Rio Grande rift; Jurassic-Cretaceous volcanic rocks of the Bisbee basin, southeastern Arizona; Laramide volcanic rocks of southwestern New Mexico; mantle xenoliths of Kilbourne Hole, south-central New Mexico; and the petrologic evolution of the mantle, southwestern United States.

Description

Above the grasslands of southeastern Arizona, isolated ranges, the "sky islands," rise to heights of 8,000–9,000 feet. The geology and natural history of these mountains have stronger affinities with the Sierra Madre of Mexico than with the Rocky Mountain cordillera, making the region unique in the United States. The monsoons of late July and August bring cooling—and sometimes drenching—afternoon rains and an array of Sierra Madre wildflowers to the higher elevations. The geology of the Chiricahua, Mule, and Huachuca mountains records Paleozoic marine deposition, Jurassic-Cretaceous crustal extension and basin formation, latest Cretaceous mountain building and basin inversion of the Laramide orogeny, and catastrophic volcanism in the Tertiary. Within and among these ranges are the mining camps—Tombstone, Bisbee, and Gleeson, among others—that generated the early wealth of Arizona and sowed the seeds of conflict recorded by U.S. Army forts Huachuca and Bowie.

This GeoHostel, which includes a program of ambitious hikes, will explore this geology and the natural and human history of the area by means of a series of field trips and half-day hikes to several ranges and mining centers. Located within 50 miles of the Mexican border, the area is a world-renowned mecca for birdwatchers. Daily field trips will allow plenty of time for birding. Participants will see Ocotillo and cacti of the Chihuahuan Desert, oak woodland and Arizona sycamore—Arizona cypress riparian habitat, and Douglas fir and Apache pine of the high mountains. The towns of Bisbee, Benson, and Tombstone offer a variety of tourist attractions, including a train ride out of Benson, gift shops, and restaurants. Visits to nearby ghost towns, mining camps (including the Penrose Mine), old military forts, and the Butterfield Trail will offer glimpses of the spirit and allure of this last holdout of the old Southwest.

Lodging, Meals, and Ground Transportation

The group will be lodged at Cochise College in dormitory style, single occupancy (doubles for couples) type rooms. Meals will include plenty of hors d'oeuvres at the Welcoming Reception and Orientation on Saturday evening, daily breakfasts and sack lunches, and a hearty farewell dinner on Thursday evening. Field trip transportation will be provided in air-conditioned, 15-passenger vans.

Fee and Payment

$540 for GSA Members *$590 for Nonmembers*
$100 deposit is due with your reservation and is refundable through June 28, less $20 processing fee. Total balance is due: June 28.

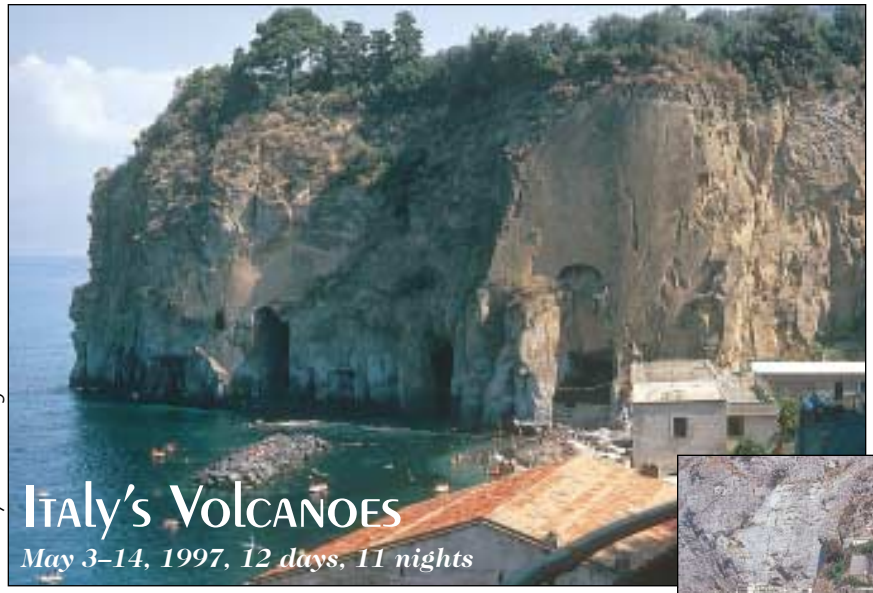
Included: Classroom programs and materials; field trip transportation; lodging for six nights; single occupancy (double for couples), meals outlined above; welcoming and farewell events.

Not included: Transportation to and from Douglas, Arizona; transportation during hours outside class and field trips; and other expenses not specifically included.

Register Today!

Space will go quickly, so get in touch with us if you are interested. Detailed information on itineraries, registration fees, and travel arrangements will be sent on request. No obligation. Questions welcomed.

For details on the 1997 GeoVentures, contact Edna Collis, GSA Meetings Department
1-800-472-1988, ext. 134 ❁ 303-447-2020 ❁ fax 303-447-0648
E-mail: ecollis@geosociety.org ❁ http://www.geosociety.org



Photos by Haraldur Sigurdsson.

Italy's Volcanoes

May 3–14, 1997, 12 days, 11 nights

GeoTrip

Scientific Leaders

Haraldur Sigurdsson, *Graduate School of Oceanography, University of Rhode Island*

Mauro Rosi, *Department of Geology, University of Pisa, Pisa, Italy*

Haraldur Sigurdsson is a leading volcanologist with an international reputation for his research on many aspects of volcanism and other studies of Earth. His studies include research on volcanoes in Italy, Iceland, Mexico, Colombia, the United States, Indonesia, Cameroon, Greece, Japan, the West Indies, and the Galapagos Islands. He has also investigated volcanoes on the ocean floor of the North and South Atlantic oceans and the eastern Pacific, Mediterranean, and Indian oceans.

Mauro Rosi is well-known for his Ph.D. dissertation on volcanism of the continuously erupting island of Stromboli. He has researched the eruptions of Vesuvius, the volcanic deposits in the Campi Flegrei caldera, and other active Italian volcanoes. He has also worked extensively in South America.

Description

This unique trip has been requested dozens of times. At last it's here, with extraordinary leaders! It begins with air travel to Rome, connecting to Naples, and a tour of Vesuvius volcano. The trip continues with visits to the archaeological sites of Pompeii and Herculaneum, destroyed by the famous A.D. 79 eruption. The group takes a ferry to the island volcano of Stromboli, which has been continuously active for more than 2,500 years. Additional ferry trips go to the adjacent volcanic islands of Lipari and Vulcano. The group continues to Sicily and ascends Mount Etna, Europe's largest active volcano.

Schedule

May	2	Air travel to Italy
May	3	Arrival in Naples and overnight on Sorrento coast, southwest of Vesuvius
May	4	Pompeii and Vesuvius
May	5	Vesuvius Volcano Observatory and crater rim
May	6	Herculaneum, Naples Archaeological Museum and overnight boat trip to Stromboli
May	7	Hike to the summit crater of Stromboli
May	8	Scenic areas and geology of the island of Stromboli
May	9	Volcanic island of Lipari
May	10	Vulcano Island and Il Faraglione fumaroles and mudbaths
May	11	Sicily to flank of Etna
May	12	Ascent of Etna
May	13	Return from Etna to Catania
May	14	Air travel to home

Physical Requirements

No special physical requirements, although we will ask that everyone provide verification of health care coverage.

Included: The trip fee includes all lodging, meals, ground transportation (including ferries), and fees. Accommodations are based on double occupancy in "Superior Tourist" class hotels, and one night aboard a ferry on May 6. Every day includes full breakfasts, box lunches, and full dinners. Meals are included for the arrival night on May 3 and continue through the departure breakfast on May 14. Transport is by deluxe air-conditioned motorcoach for eight days (Naples, Lipari, and Sicily); none is required in Vulcano and Stromboli. Ferry transportation is included for island travel. Also included are field guides and maps, wine with dinner, gratuities, taxes, and all fees. Just pack your bags!

Not Included: Airfare, airport departure taxes, travel insurance, lodging in Newark, personal expenses such as soda pop and alcoholic beverages, laundry, excess baggage fees, transfers for passengers arriving and departing independently, and other expenses not specifically included.

Air Travel

Group reservations on Alitalia Airlines are offered at $876 plus tax between Newark and Naples-Catania-Newark. An add-on fare using Continental airlines from selected United States gateways to Newark to connect with Alitalia is available. Of course, air miles on other airlines can be used. We strongly encourage you to talk with TR Consultants about your air reservations at 1-800-923-7422.

TR Consultants and Volcano Tours, Inc.

All arrangements for the ground parts of this trip have been made by TR Consultants, Inc. and its partner company, Volcano Tours—both in Providence, Rhode Island. They will answer specific questions about the tour.

Fee, Payment, and Cancellation

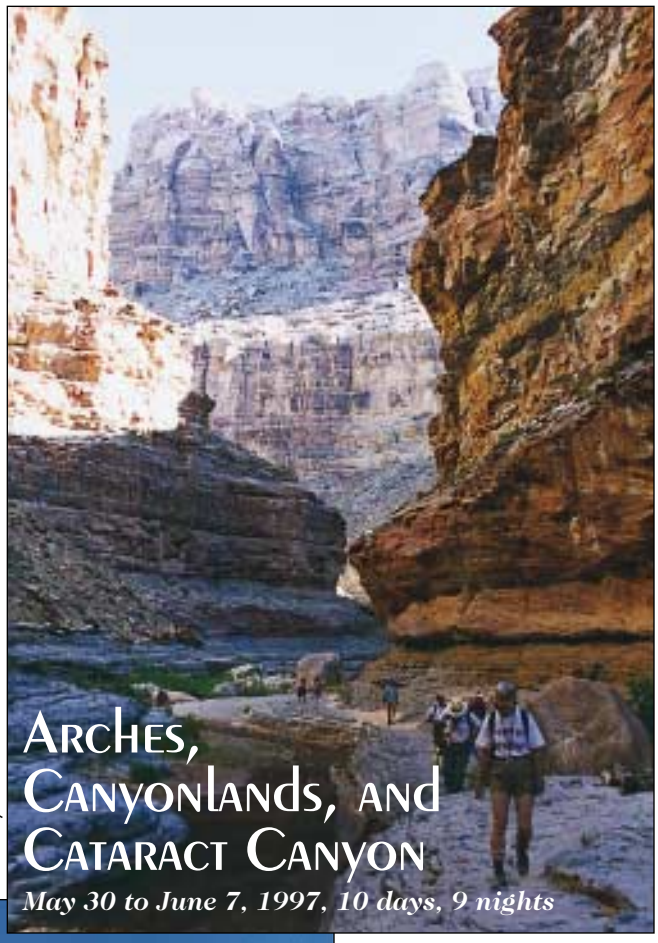
GSA Member Fee: $2375 *GSA Nonmember Fee: $2475*

The single supplement is $350, based on availability of rooms—many of the places we are visiting have very limited lodging. We will do our best to provide single travelers with a suitable roommate.

GSA IS HANDLING TRIP RESERVATIONS; call 1-800-472-1988 or (303) 447-2020, ext. 134. A deposit of $250 is due with your reservation. The deposit is refundable (less a $50 processing fee) through Feburary 28. The total balance is due February 28. (Because of the limited access to some of the sites, we have to make payments to the Italian providers 60 days in advance of departure.) The fee is nonrefundable after February 28. Information on reasonable travel insurance will be sent to you.

Additional reservations may be made after February 28 if space is available, and the total fee will be due at the time of the reservation.

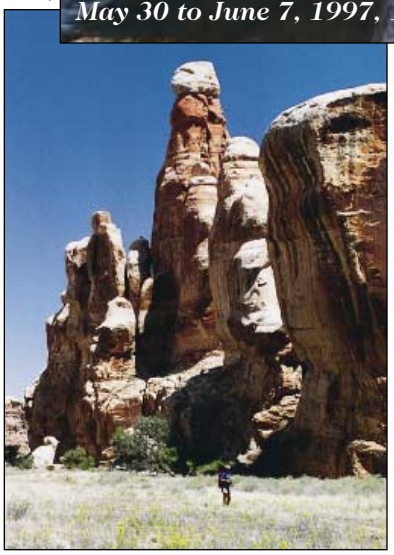
See registration form (page 43) or call 1-800-447-2020, x134.



Photos by Ken Kolm.

Arches, Canyonlands, and Cataract Canyon

May 30 to June 7, 1997, 10 days, 9 nights



GeoTrip

Scientific Leader
Jack Campbell,
Department of Geology,
Ft. Lewis College,
Durango, Colorado

Jack Campbell has to his credit 30 years of research and publications on the Paleozoic geology of the Southern Rocky Mountains and the Colorado Plateau. Jack has conducted short courses on the geology of the San Juan Mountains and the Colorado Plateau for many organizations. He has also led field trips and/or lectured on field trips for GSA, the Rocky Mountain Geological Society, the Colorado Scientific Society, Four Corners Geological Society, New Mexico Geological Society, and the Utah Geological Survey. You'll find him a personable, experienced, and engaging leader.

Description

This trip is an exceptional educational opportunity for the physically active person. The itinerary includes geologic features found nowhere else. More than 1,500 natural stone arches stand in Arches National Park, which has the world's highest concentration of these remarkable features. Nearby is Canyonlands, Utah's largest national park, a unique area of sandstone pillars and mazes of incredible beauty that have been formed into three districts by the Colorado and Green rivers. We will be hiking the rim area of the Canyonlands as well as traveling down the Colorado River by raft. We will go through Cataract Canyon, a major whitewater experience.

Moab is within driving distance of Natural Bridges, Capitol Reef, Bryce Canyon, the recently established Grand Staircase–Escalante National Monument, Zion Canyon, Grand Canyon, and the Lake Powell Recreation Area.

Schedule

May 30	Travel day to Moab. Orientation and dinner at 7:30 p.m.
May 31	Van to Fisher Towers and Professor Valley
June 1	Van and hike through Arches National Monument
June 2	Moderate hike from rim at Upheaval Dome to the Green River. Meet motorized J-rig rafts. Easy raft trip to camp site at Spanish Bottom.
June 3	Moderate steep hike up from Spanish Bottom in Canyonlands Maze District.
June 4	Raft downriver to beach campsite at base of Surprise Valley.
June 5	Raft heavy whitewater through Cataract Canyon to beach camp at mouth of Dark Canyon.
June 6	Rigorous hike from river to rim up through the water seeps, pools, and broad ledges of incredibly beautiful Dark Canyon. Picked up by van and taken to Hite Marina for sunset overflight of Canyonlands. Return to Moab for final celebration meal.
June 7	Return home or continue journey.

Lodging, Meals, and Transportation

Travel will be by vans, motorized rafts (J-rigs) or on foot. During the days on the rim, transportation will be by van. Lodging in Moab will be in a comfortable motel. Camping near the river for several nights will be in tents and sleeping bags provided by the rafting outfitter. Meals are provided except for the arrival night and the departure morning.

Physical Requirements

Especially because of the heat in southwestern Utah at this time of year (~90–100 °F), individuals must be in excellent health. The trip includes several substantial hikes for which each person will carry a day pack with camera, water, and snacks. The longest hike will be 5 miles with a 2000-ft. elevation gain. Although taken at a reasonable pace with many points to rest and to explore the geology, these hikes should be undertaken only by persons who are in good health and physically active. Verification of health care coverage will be required. No rafting experience is necessary; however, Cataract Canyon offers some of the biggest and most challenging whitewater in the United States.

Fee and Payment

GSA Member: $1445 *Nonmember: $1545*

A $200 deposit, due with your reservation, is refundable through March 28, less $50 processing fee. Total balance due: March 28. Minimum age: 21.

Included: All meals except breakfast on the departure day; comfortable four-wheel van transportation; double-occupancy lodging in Moab; tents, sleeping bags, and pads when camping; geological reading materials and guidebook; overflight of Canyonlands; and of course, the companionship of expert scientific leaders.

Not included: Gratuities for raft guides. Airfare from Grand Junction, Colorado, or transfer to Moab. We will arrange for an optional group pick-up and return.

CLASSIFIED ADVERTISING

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

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

Positions Open

See p. 40 for position announcemnts from the Employment Service at the GSA 1996 Annual Meeting in Denver.

IDAHO STATE UNIVERSITY

We seek a field-based earth scientist to fill a tenure-track position, beginning academic year 1997- 1998 at a rank commensurate with qualifications, in one of the following fields: (1) Applied Geophysics, or (2) Sedimentary Geology/Paleontology. A Ph.D. or A.B.D. is necessary. Teaching duties include 3 undergraduate/graduate classes per semester or equivalent work plus participation in our Geology Field Camp. Supervision of M.S. students and pursuit of a funded research program is required, while expertise in the geology of the North American Cordillera is desirable. The successful candidate will have broad geologic interests, be comfortable in a small department where cooperation and shared teaching and research are standard, and assist the department's expansion into quantitative methods and GIS applications. Send resume, transcripts, statement of academic philosophy and interests, and names of 3 referees to Search Committee, Department of Geology, Idaho State University, Pocatello, ID 83209-8072. Position is contingent on funding, and applications will be reviewd beginning February 15, 1997. ISU is an EO/AA Employer.

SAINT LOUIS UNIVERSITY

The Department of Earth and Atmospheric Sciences has two tenure-track positions at the Assistant Professor level for Fall 1997. We are revitalizing our undergraduate Geoscience curriculum and we seek energetic individuals who will help to implement a new program in Environmental Science. After these appointments, our department will have eight faculty in Geosciences and six in Atmospheric Sciences.

We particularly encourage innovative researchers and we intend that one position should be within the general area of surficial processes, including (but not limited to) geochemistry, geomorphology, hydrology, paleoclimate studies, sedimentology and soil studies. Criteria for the second position are less specific, but applicants should complement our current expertise in geochemistry, global geophysics, paleontology, petrology, seismology and structural geology. In addition, we have a strong atmospheric science section with which active collaboration would be possible. Candidates must possess a Ph.D. and are expected to sustain active research programs in their field of expertise. Breadth of teaching will be seen as a definite asset for both positions.

Applicants should submit a statement of teaching and research interests, CV and the names, addresses (including E-mail) and telephone numbers of four referees to: The Chairman, Department of Earth and Atmospheric Sciences, St. Louis University, 3507 Laclede Avenue, St. Louis, Missouri 63103. For further details contact: 314-977-3131, search@eas.slu.edu or http://www.eas.slu.edu/. Applications will be received until December 31, 1996, or until the position is filled.

Saint Louis University is an equal opportunity/affirmative action employer. Women, minorities, veterans, and people with disabilities are encouraged to apply.

STATE UNIVERSITY COLLEGE AT CORTLAND

The Geology Department at the State University at Cortland invites applications for two anticipated, tenure-track positions at the assistant professor level to begin September 1997.

Individuals are sought who have a commitment to quality undergraduate teaching in the fields of invertebrate paleontology/stratigraphy, and hydrogeology/low temperature geochemistry. Teaching responsibilities include courses related to the areas of specialization and introductory geology courses for majors and students enrolled in the general education program. One or both appointments shall provide support for the secondary science eucation curriculum that is administered by the School of Arts and Sciences. Willingness to participate in the interdisciplinary geology-biology course designed for the elementary education curriculum is desirable.

Successful candidates are expected to conduct a sustained program of research and scholarly activity that involve undergraduate students, and to participate in the summer field geology program offered at the College's Brauer Geology Field Station near Albany, NY.

A Ph.D. in the geological sciences at the time of appointment is required.

To apply send a curriculum vitae, copies of transcripts, statements on teaching and research interests, and the names, addresses, and phone numbers of three (3) referees to: Paleontology/Stratigraphy or Hydrogeology/Geochemistry Search Committee, Geology Department, 147 Bowers Hall, SUNY Cortland, Cortland, NY 13045. Completed applications should be received by January 1, 1997, but will be considered until the positions are filled. For additional information, please contact: Dr. James E. Bugh at (607) 753-2921. SUNY Cortland is an AA/EEO employer and does not discriminate in employment or the provision of services on the basis of disability. Women and minorities are encouraged to apply.

BRYN MAWR COLLEGE

The Department of Geology seeks a 1997-1998 leave replacement in environmental goelogy and sedimentology to teach two courses per semester and to participate in a concentration in Envrionmental Science with anthropology and biology. Courses include environmental geology or earth systems science, selected undergraduate offerings in sedimentology, oceanography, geophysics, or geohydrology, possibly a graduate course in some aspect of sedimentary geology, and the directing of undergraduate research projects. The candidate must have a Ph.D.

Bryn Mawr College is a selective liberal arts college located west of Philadelphia. The department is well-equipped for teaching, research and computer. http://www.brynmawr.edu/Adm/academic/geology.html

Applications, including three references and complete vita, should be sent to Wm. A. Crawford, Chairman, Department of Geology, Bryn Mawr College, 101 N. Merion Avenue, Bryn Mawr, PA 19010. Bryn Mawr College is an Equal Opportunity Affirmative Action Employer. The College particularly wishes to encourage applications from individuals interested in joining a multicultural and international academic community. Minority candidates and women are especially encouraged to apply. Deadline for applications: January 20, 1997.

PETROLEUM SYSTEM MODELING RESEARCH ASSISTANT

The Department of Geology at the University of Alabama seeks applicants for a graduate research assistantship at the Ph.D. level in petroleum system modeling. Previous experience in subsurface 3-D geologic modeling is preferred. The Department is housed in a state-of-the-art research complex equipped with the required analytical and computer capabilities to perform innovative basin analysis studies. Twelve-month stipend is $15,000 and tuition is paid by the University.

A letter of interest should be sent to the Graduate Research Committee, Box 870338, Department of Geology, University of Alabama, Tuscaloosa, Alabama 35487 by January 15, 1997. The University of Alabama is an equal opportunity/affirmative action employer.

SEDIMENTARY GEOLOGY
GEOLOGY DEPARTMENT
CENTRAL MICHIGAN UNIVERSITY

The Department of Geology invites applications for an entry-level tenure-track position beginning in mid-August 1997 dependent upon funding. Position specifications: Ph.D. required; effective communication skills required; teaching experience required; graduate course work in sedimentary geology required; teaching experience in sedimentary geology preferred; preferred research areas are carbonate sedimentology/stratigraphy or basin analysis or glacial stratigraphy; willingness to develop collaborative research programs with departmental colleagues preferred; willingness to involve undergraduates in research program required, experience in directing undergraduate research preferred. The applicant will be expected to teach introductory courses as well as upper level courses in her/his discipline. Interested persons should send a resume and arrange to have three letters of reference sent to Dr. Stephen D. Stahl, Chairman, Geology Department, Central Michigan University, Mt. Pleasant, MI 48859. All applications and supporting materials must be received by January 15, 1997. CMU (AA/EO institution) encourages diversity, and resolves to provide equal opportunity regardless of race, sex, disability, sexual orientation, or other irrelevant criteria.

LONG ISLAND UNIVERSITY
DEPARTMENT OF
EARTH AND ENVIRONMENTAL SCIENCE

The Department of Earth and Environmental Science invites applications for a visiting professor position for the 1997-1998 academic year. The successful candidate will teach courses from among Introductory Earth Science, Physical Geology, Historical Geology, Mineralogy, Igneous and Metamorphic Petrology, and Environmental Geology. Candidates with specialization in the areas of environmental geochemistry, mineralogy/petrology are preferred. A Ph.D. is required at the time of employment.

Applications should include a vita and statement of teaching interests. Applicants should arrange to have three letters of reference sent. Review of applications will begin February 17, 1997 and will continue until the position is filled. Applications should be sent to Chair: Search Committee, Department of Earth and Enviornmental Science, Long Island University, C.W. Post Campus, Brookville, Long Island, NY 11548. Long Island University is an affirmative-action/equal opportunity employer.

CALIFORNIA STATE UNIVERSITY, LOS ANGELES
TWO TENURE-TRACK FACULTY POSITIONS,
DEPARTMENT OF GEOLOGICAL SCIENCES
STARTING DATE: OCTOBER, 1997

ENGINEERING GEOLOGIST / GEOPHYSICISTS. Ph.D. required with training in engineering geology. Postdoctoral experience preferred. Preference will be given to candidates with interests in engineering geology and applied geophysics and to those who have an interest in maintaining the close ties between our large graduate student body and the professional engineering geology community in southern California. A candidate should have a broad background in geology and strong interests in field geology and its application to engineering geology and geophysics and will be expected to establish a vigorous research program involving undergraduate and MS students. Duties will include supervision of MS theses and qualified instruction of undergraduate and graduate courses in the subject areas of structural geology, geologic mapping, summer field geology, neotectonics, tectonic problems, geophysics, and engineering geology. Instruction in general educations courses will also be required.

HYDROGEOLOGIST. Ph.D. required with training in hydrogeology. Postdoctoral experience preferred. The successful candidate must have interests in the applied aspects of hydrogeology, groundwater hydraulics, computer modeling of groundwater flow, and contaminant waste transport and/or chemistry. Candidate must have an interest in maintaining the close ties between our large graduate student body and the professional hydrogeology community in southern California. Candidate must have a broad background in geology and will be expected to establish a vigorous research program involving undergraduate and MS. students. Duties will include supervision of MS. theses and instruction of senior and graduate level hydrogeology courses. Instruction of general education courses, such as physical and enviornmental geology, is also required.

The successful candidate must have an interest in working in a multi-ethnic, multi-cultural environment.

The Department has a faculty of 6 and plans to hire 2 more in hydrogeology & engineering geology/geophysics. Programs lead to BA, BS, and MS degrees. Approximately 60 students are enrolled in the MS program which has emphasized applied aspects of engineering and hydrogeology since its inception in 1972. Facilities include modern computer work stations for students and faculty, instrumentation for geochemical analysis, and a newly remodeled geochemistry laboratory.

California State University at Los Angeles, a comprehensive urban university and one of 22 campuses that comprise the California State University system, offers programs in more than 50 academic and professional fields. The campus is at the eastern edge of Los Angeles, adjacent to the western San Gabriel Valley, and has more than 18,000 full and part-time students reflecting the rich ethnic diversity of the area. the University has an active affirmative action program and encourages minorities, women, and disabled persons to apply.

Applicants should submit curriculum vitae, statement of research plans, college transcripts, and three letters of recommendation. Complete dossier, including letters of recommendation is due no later than January 3, 1997. Review of applicants begins immediately. Send to: Dr. Gary Novak, Search Committee, Department of Geological Sciences, Calfornia State University at Los Angeles, Los Angeles, CA 90032-8203, E-mail gnovak@flash.calstatela.edu

SURFACE PROCESSES—BOSTON COLLEGE

The Department of Geology and Geophysics at Boston College seeks a dynamic candidate for a tenure-track faculty position (rank open) in the area of Surface Processes, beginning Sept. 1997. Individuals may have research interests in any of the sub-specialties in this broad field, but those with backgrounds in geomorphology, surface hydrology, wetland dynamics, sedimentation or coastal dynamics are particularly encouraged to apply. A Ph.D. is required and post-doctoral experience desirable. The individual will be expected to teach undergraduate and graduate courses in our geology and environmental programs and to carry out an aggressive research program in his or her specialty. The Department, which also runs the nearby Weston Geophysical Observatory, is well equipped (including flume and GIS laboratories) and is housed in modern, recently renovated facilities on a suburban campus 8 miles west of Boston. Rank of appointment will be commensurate with experience.

A curriculum vitae, statement of research interests, list of references and copies of selected publications should be sent to Christopher Hepburn, Chairman, Dept. of Geology and Geophysics, Boston College, Chestnut Hill, MA 02167 by Jan. 10, 1997. For further information, contact the above at 617-552-3541 or 3642 or via E-mail hepburn@bcvms.bc.edu

Boston College is an affirmative action/equal opportunity employer. Qualified women and minorities are encouraged to apply.

Z&S CONSULTANTS, INC.
GEOLOGICAL STAFF VACANCIES IN HOUSTON, TEXAS

The Z&S Group, through it's unique combination of geoscientific expertise and computer engineering skills, is the market leader in the provision of well log processing software and associated geological and petrophysical services. With strategically located offices in London, Aberdeen, Houston, Perth, Stavanger, and Copenhagen, the groups expertise is readily available throughout the world.

The Z&S Group are industry leaders in the development of innovative interpretation approaches for the evaluation of borehole image and dipmeter data. Our particular strengths are the application of traditional structural skills, core-based sedimentological analysis and interpretation of borehole image data.

Due to our rapidly growing geological consulting activities in the USA and internationally, we have vacancies for sedimentologists and structural geologists. All posts will be based in Houston, but applicants must be willing to travel and work abroad.

Sedimentologists. We seek people who are educated to post-graduate level with applied skills in clastic sedimentology, with particular strengths in: deep marine fan and slope, clastic shallow marine and mixed fluvial/aeolian depositional systems.

Structural Geologists. Individuals, educated to post-graduate level with experience in the analysis of outcrop or core-scale structural features, including fractured carbonates and fault systems in clastic rocks. Experience of multi-scale investigations (petrographical to seismic scale) and fault population studies would be advantageous.

For these posts we expect individuals who are self-motivated able to multi-task in a team environment and to produce quality work to strict deadlines. A working knowledge of UNIX and some programming experience would be a distinct asset, but is not essential. Training will be provided in all aspects of borehole image interpretation and workstation practice. Salaries will be commensurate with experience.

To apply, please wirte with resume to Dr. Robert Trythall, Z&S Consultants, Inc. 440 Benmar, Suite 2300, Houston, TX 77060.

Visit our web site on http://www.zands.com

MINERALOGIST/GEOCHEMIST/ STRUCTURAL GEOLOGIST

The Department of Earth Sciences at the State University of New York at Oswego invites applications for a tenure-track position at the assistant professor level beginning Fall of 1997. This appointment is contingent on administrative approval. The successful candidate is expected to teach general education courses in introductory Geology as well as Mineralogy, Petrology, Structural Geology and Geochemistry. We are especially interested in candidates who are able to contribute to Environmental Sciences. In addition to teaching, the successful candidate will be expected to continue scholarly development, research and to supervise undergraduate research projects.

Our department has a strong commitment to undergraduate liberal arts education. Within the department we have two computer laboratories for student use in research and course work. computational facilities include networked Macintoshes and PCs. The department houses equipment for water sediment sampling and analysis, as well as for preparation of thin sections. Visit our web site for more information about our department at www.oswego.edu/Acad_Dept/a_and_s/earth.sci/geo_geochem /geol/

We offer a B.A. and a B.S. in Geology and a B.S. in Geochemistry in cooperation with the Department of Chemistry. Our department also offers a B.A. and B.S. in Meteorology. We have four geologists, three meteorologists, and two astronomers, and one technician at the present time.

The candidate must hold a Ph.D. and have at least one year full-time teaching experience. Send letter of application, resume, official transcripts and three letters of reference to: Dr. David J. Thomas; Chair, Deparment of Earth Sciences; SUNY Oswego; Oswego, New York 13126. Review of applications will begin January 15, 1997; however they will continue to be accepted until the position is filled. SUNY Oswego is an Affirmative Action Employer.

ENVIRONMENTAL GEOLOGY
SIMON FRASER UNIVERSITY
EARTH SCIENCES PROGRAM

The Earth Sciences Program is seeking to fill a tenure-track position at the Assistant Professor level in Environmental Geology. The ideal candidate is a geoscientist with an established research program in some aspect of environmental geology or geotechnics. The successful candidate must have a commitment to both undergraduate and graduate education as well as to developing a funded research program, and be willing to play a central role in the development of the environmental geology component of the Program. For detailed information about this position refer to the Program's home page: www.sfu.ca/earth-sciences.

The Ph.D. is required at the time of appointment and the successful candidate will be eligible, preferably, for professional registration (PGeo, PEng) in BC. The appointment will commence in September 1997.

In accordance with Canadian Immigration this advertisement is directed to Canadian citizens and Permanent Residents. Simon Fraser University is committed to the principle of equity in employment and offers equal employment opportunities to qualified applicants.

Applicants should send a curriculum vitae, a letter describing current and near-term research interests, and copies of appropriate reprints. Please provide an E-mail address, fax number and the names of at least three referees by January 31, 1997 to: Dr. Michael C. Roberts, Director, Earth Sciences Program, Simon Fraser University, Burnby, BC, Canada V5A 1S6. Phone (604) 291-4657; fax 604-291-4198; mroberts@sfu.ca.

MARINE STRATIGRAPHY/SEDIMENTOLOGY

The Department of Earth Sciences, University of Southern California, continuing a search for a tenure-track faculty member at the assistant professor level in marine stratigraphy/sedimentology to begin September 1997. We seek an accomplished individual with primary research interests in marine sedimentary rocks, linking global paleoenvironmental ecological change through study of the stratigraphic record. A strong land-based field research orientation is desirable, as well as the ability to integrate one or more analytical approaches. The successful candidate will be expected to foster interaction with ongoing programs in paleobiology, marine geology, paleoceanography, marine geochemistry, paleomagnetism and geomorphology. Major USC facilities include XRD and XRF systems, stable and radioisotope labs, a computer/GIS facility and the Center for Electron Microscopy and Microanalysis. Teaching responsibilities will include undergraduate offerings in stratigraphy and sedimentology as well as graduate offerings in the area of specialty.

Applications including curriculum vitae, a statement of teaching and research interests, and the names of three references should be sent directly to: Professor Charles Sammis, Chair, Dept. of Earth Sciences, University of Southern California, Los Angeles, CA 90089-0740. Applications from women and individuals from under-represented groups are strongly encouraged; USC is an AA/EOE.

HYDROGEOLOGY AND TECTONICS

The Department of Geology, University of Florida, is accepting applications for two tenure-track assistant professors for August 1997 or January 1998 in the broad fields of hydrogeology and tectonics. Preference will be given to quantitative, process-oriented scientists who will develop strong and innovative research programs, and exhibit a strong commitment to teaching. We are particularly interested in scientists whose research involves fundamental earth processes and the rates at which these processes occur, e.g.; physical and chemical analysis of hydrodynamic systems, including wetlands; basin analysis and evolution; numerical geodynamics; and thermochronology. The Department will relocate and research space will double in 1998 as a result of an NSF/ARI grant. More information can be found at: http://www.clas.ufl.edu/CLAS/Departments/Geology/

Qualified candidates should send a letter of interests, including a statement of research and teaching goals, a curriculum vitae, and the names and addresses of three references by Feburary 1, 1997 to: Dr. Michael Perfit, Dept. of Geology, P.O. Box 117340, University of Florida, Gainesville, FL 32611-7340; (352) 392-2231 (perfit@geology.ufl.edu). The University of Florida is an equal opportunity-affirmative action employer; qualified women and minorities are especially encouraged to apply.

Services & Supplies

FOR SALE: CUBAN GEOLOGY BOOK. The IGCP proj.-364 contribution "Cuban Ophiolites and Volcanic Arcs" (254 pp., Miami, 1996) is now available ($20 + $3.50 S&H). It has three chapters: General geology and geophysics, Geology of the ophiolites, Geology of the volcanic arcs. To order a copy send a check or money order payable to Wanda Iturralde, 1300 W. 47 Place, 216A, Hialeah, FL 33012.

Opportunities for Students

California Institute of Technology. Postdoctoral Fellowships in Geological and Planetary Sciences. The California Institute of Technology announces two fellowships in earth and planetary sciences: The O.K. Earl Postdoctoral Fellowship, and the Texaco Postdoctoral Fellowship. These awards are from funds endowed by Orrin K. Earl, Jr. and by the Texaco Philanthropic Foundation. Each fellowship carries an annual stipend of $34.000 and offers a research expense fund of $1,000 per year and one-way travel to Pasadena. The duration of each apppointment will normally be for two years, contingent upon good progress in the first year, and beginning with the 1997-98 academic year. Fellows are eligible to participate in Caltech's health and dental program.

These fellowships have been established to support the research of scientists typically within two years after receipt of the Ph.D. The intent of the program is to identify and support innovative and creative work in the earth and planetary sciences, with particular emphasis on interdisciplinary work. Applicants with training in physics, chemistry, biology or computer sciences are urged to apply. The Caltech faculty is currently active in geobiology, geochemistry, geology, geophysics, petrology, seismology, and atmospheric and planetary sciences. It is expected that each fellowship holder will be hosted by a division professor (designated by the division chairman) who will contribute to the fellowship support both financially and by providing intellectual guidance.

Application forms may be obtained by writing to Prof. E. M. Stolper, Chair, Division of Geological and Planetary Sciences, Mail Code 170-25, California Institute of Technology, Pasadena, California 91125 (email:stover@gps.caltech.edu)

Completed applications with references should arrive at Caltech by Monday, January 27, 1997.

Fellowship candidates will automatically be considered for other available postdoctoral positions at Caltech in their fields of interest.

Caltech is an Affirmative Action/Equal Opportunity Employer. Women, minorities, veterans and disabled persons are encouraged to apply.

Graduate Research Opportunities in Active Tectonics. Financial support is available at Southern Illinois University at Carbondale for highly qualified students interested in working at the boundary between geomorphology and structural geology/tectonics. Research will be field oriented, in the California Channel Islands. Interested students or advisors should contact Dr. Nicholas Pinter at (618) 453-7375 or npinter@geo.siu.edu. Other research possibilities exist at SIUC in surface processes, environmental geology, and other fields. Application materials may be obtained by writing to the Graduate Program Coordinator, Dept. of Geology, Southern Illinois University, Carbondale, IL 62901-4324. The final deadline for graduate application to the SIUC Geology program is Jan. 15, 1997.

Smithsonian Offers Research Fellowships

Fellowships

The Smithsonian Institution research fellowships for 1997 include the fields history of science and technology, biological sciences, and earth sciences.

Smithsonian Fellowships are awarded to support independent research in residence at the Smithsonian in association with the research staff and using the Institution's resources. Under this program, senior, predoctoral, and postdoctoral fellowships of three to twelve months and graduate student fellowships of ten weeks are awarded. Proposals for research in the following areas may be made.

History of science and technology: industrial archaeology, natural history, physical sciences.

Anthropology: archaeology, cultural anthropology, physical anthropology.

Biological sciences: ecology, environmental studies, evolutionary biology, marine biology, natural history, paleobiology, systematics.

Earth sciences: meteoritics, mineralogy, paleobiology, petrology, planetary geology, sedimentology, and volcanology.

Deadline: January 15, 1997.

For more information and application forms, write to Smithsonian Institution, Office of Fellowships and Grants, 955 L'Enfant Plaza, Suite 7000, Washington, DC 20560, siofg@sivm.si.edu. Indicate the area in which you propose to conduct research and give the dates of degrees received or expected.