Vol. 6, No. 7 July 1996

GSA TODAY

A Publication of the Geological Society of America

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The Biosphere and Me

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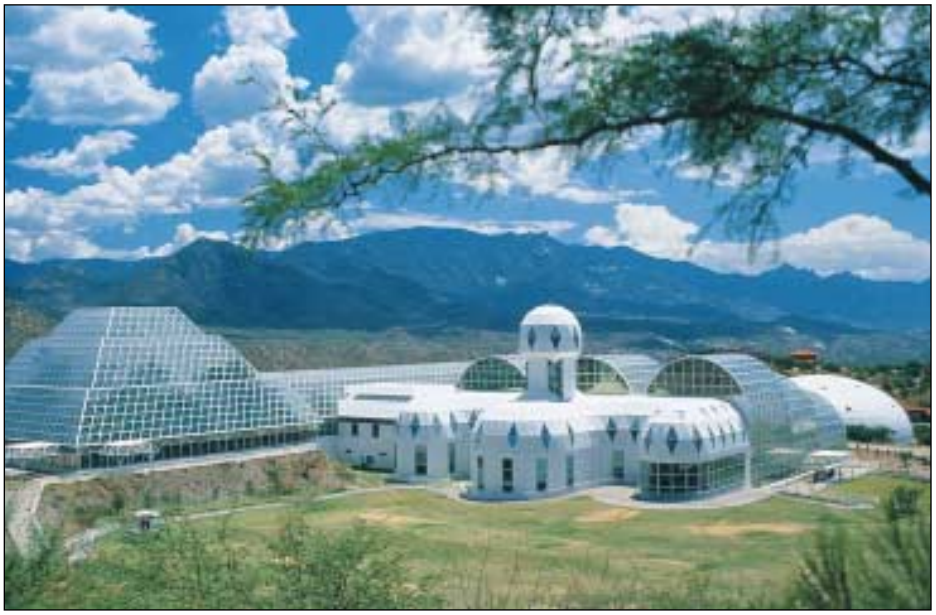
ABSTRACT

Biosphere 2 was originally constructed for the purpose of determining whether a materially closed ecological system could be maintained in equilibrium and sustain human beings for long time periods. But after a change in management, this initial goal was set aside, and it was decided to use this wonderful facility for research and education on various aspects of biogeochemistry, plant biology, and ecosystems studies. To this end, Columbia University was commissioned to manage the activities at this site, located just north of Tucson, Arizona.



Biosphere 2, near Oracle, Arizona. *Photo by Karen Silva. Copyright 1996 Biosphere 2 Center, Inc.*

SERENDIPITY

One visit to Biosphere 2 and I was hooked. Now, four years later, I'm locked in an alliance with Bruno Marino in an attempt to create a world-class research center on this site. People ask me, "Wally, how on earth did you ever get so involved in this thing?" I give a somewhat different answer each time I'm asked. The reason is that I am of many minds on this subject. No doubt part of my obsession stems from the sheer magnificence of the site in the Arizona desert and of the Biosphere itself, which fits comfortably with the surrounding beauty. On another level, I realize that the Biosphere is unique. Because the cost approached $150 million, no chance exists that this wonderfully engineered visionary garden will ever be duplicated. I considered it a tragedy that this incredible facility was being used to accomplish what I viewed to be a frivolous goal. Maintaining eight people in a matter-sealed environment for a period of two years was a clever stunt, but then what? Biosphere 2 also grabbed my geochemical antenna. Biosphere 1 (Earth) is a closed system, but this is a concept not so easily grasped. Could we use what goes on in the closed environment of Biosphere 2 to alert our fellow earthlings to the possible consequences of industrialization? Perhaps experiments could be conducted in Biosphere 2 which would help us to prepare for the impacts of the experiment mankind is conducting in Biosphere 1 through the addition of fossil fuel CO_2 to the atmosphere.

As is often the case for important events in one's life, the opportunity to influence the course of Biosphere 2's use came about through serendipity. Just eight months after the group of eight Biospherians was sealed up in this glass house, Jack Corliss, then a part-time consultant to the group that built and operated the Biosphere, asked me if I would be willing to discuss with John Allen, the group's leader, the possible causes for the ongoing drop in their O_2 reserve. Like almost everyone else on the planet, I had by this time read newspaper stories (largely critical) about this venture, but I was very short on details. I had just enough information that my curiosity would not allow me to turn down Jack's invitation. So, I crossed the

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GSA TODAY

July 1996

Vol. 6, No. 7

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

SUBSCRIPTIONS for 1996 calendar year: **Society Members:** *GSA Today* is provided as part of membership dues. Contact Membership Services at (800) 472-1988 or (303) 447-2020 for membership information. **Nonmembers & Institutions:** Free with paid subscription to both *GSA Bulletin* and *Geology,* otherwise $45 for U.S., Canada, and Mexico; $55 elsewhere. Contact Subscription Services. **Single copies** may be ordered from Publication Sales. **Claims:** For nonreceipt or for damaged copies, members contact Membership Services; all others contact Subscription Services. Claims are honored for one year; please allow sufficient delivery time for overseas copies.

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Printed with pure soy inks on recyclable paper in the U.S.A.

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Hudson to a Manhattan restaurant for a dinner with John Allen—and quite a dinner it turned out to be. Allen reminded me of an aging Indiana Jones. He flashed a somewhat crumpled graph showing the trend followed by the O_2 content of Biosphere 2's air over the period following closure. I say "flashed" because John clearly did not want any of the journalistic critics who might be lurking at the surrounding tables to get a glimpse of this evidence that all was not going well in his house of glass. My first thought (which ultimately proved to be correct) was the obvious one. I said, "John, I bet you put too much organic matter in Biosphere 2's soils." We argued the pros and cons of this idea at great length. We agreed on only two points. First, I would tell no one about the mysterious decrease of Biosphere 2's O_2, and second, I would visit the Biosphere after a meeting on soil radiocarbon which by chance was to be held in Tucson in a week's time.

It was with great anticipation that I drove across the desert to Biosphere 2 that May day in 1992. After a brief meeting with John Allen during which he regaled me with concepts put forth by his hero, the Russian geochemist Vernadsky, I was placed in the able hands of Biosphere 2's chief engineer, Bill Dempster. He toured me around (but, of course, not into) the fabulous Biosphere—its power plant, its cooling towers, and its "lungs." Then Bill and I sat down in his office to discuss the O_2 problem. It was Bill who unfolded the mystery by showing me that my theory based on excess respiration in Biosphere 2's soils could not be the whole story. The problem was that the CO_2 content of Biosphere 2 air had not risen anywhere near as far as would be expected from the disappearance of O_2. For each mole of O_2 consumed by the bacteria living in the soil, roughly one mole of CO_2 would have been produced. Had this CO_2 accumulated in the closed air space, the content should have risen to several percent. Yet, at that time, it was only about 0.1%. Here was the kind of puzzle designed to capture the attention of any alert geochemist. I went back to Lamont with visions of oxidation-reduction reactions dancing in my head.

SECOND THOUGHTS AND FINALLY SUCCESS

I sought out Jeff Severinghaus who had begun his graduate work at Lamont at the beginning of the spring term. Jeff was interested in the global carbon cycle and was particularly impressed by the approach being taken by Ralph Keeling, then a postdoctoral fellow at the National Center for Atmospheric Research. Ralph had succeeded in developing the capability to measure the rate of decline in Earth's O_2 resulting from the burning of fossil fuels. Jeff was on the lookout for a research problem related to this approach. So, I said, "Jeff, if you can't find one involving Biosphere 1, why not settle for Biosphere 2?" Jeff bit, and we immediately began what turned out to be a long series of investigations of possible solutions to the seeming enigma. As Biosphere 2 initially contained 1.2 million moles of O_2 (40 tons), we figured that it shouldn't be hard to track down the fate of the missing 10 or so tons. Could the Biospherians have removed the matching excess CO_2 into their sodium hydroxide scrubber? Could there be another sink for O_2—the oxidation of fixed nitrogen, of reduced sulfur, of divalent iron in the soils? Rust? Clearly, in order to answer these questions, one of us would have to spend some time at the Biosphere. Jeff offered. Dempster and Allen agreed. So, during the summer of 1992, Lamont's involvement in Biosphere 2 research began. Jeff, with considerable help from Bill Dempster, rather quickly eliminated the CO_2 scrubber and N and S oxidation from contention. Although the Biospherians had indeed run their NaOH stripper during winter months, the amount of CO_2 removed accounted for only one-fifth of that necessary to balance

its carbon budget. Any N and S oxidized would have appeared in the recirculating water supply as NO_3^- and $SO_4^=$. Analyses of the water showed that the amounts of these substances were far too small. The required 50 or so tons of rust were clearly nowhere to be seen. The acid soils of Biosphere 2 were hardly likely to host massive $CaCO_3$ accumulation. This left iron in the soils as the only remaining item on our list of suspects. Jeff, again with help from Bill Dempster, constructed a set of sealed soil chambers with the intent of measuring the ratio of O_2 consumption to CO_2 production. Although preliminary experiments with these chambers did indeed indicate that O_2 was going down faster than CO_2 went up, this result proved to be an artifact of CO_2 uptake by the soil moisture. Bafflement!

During this period, Jeff began to get cold feet about work at Biosphere 2. The press mercilessly hammered away at what they perceived to be evidence of cheating by the Biospherians. Did they import hamburgers or have secret nights on the town? Jeff and I both knew these suspicions were unfounded. One only had to look at the Biospherians to see that they were on the verge of starvation. One had only to speak with them to know that they took their mission very seriously. Further, Bill Dempster proved to be a superb colleague, intelligent, knowledgeable, dedicated, resourceful, and totally honest. But around us swirled the aura of public relations gimmicks and what we felt was a charade of great science as portrayed by John Allen and his top aides. John once told me, "Wally, we are out to uncover the great principles of ecology." I replied, "John, I'm not sure whether such principles exist. If they do, this is surely not the setting in which they will be discovered." When Jeff suggested that he cut his connection with the Biosphere for fear that he would inherit a reputation for Barnum and Bailey science, I tried to dissuade him by pointing out that geologists who worked in Cuba were not making a statement of admiration for Castro. As we took no money for consulting fees, research expenditures, or even airfares, I reminded him that we were clean!

Then, at last, the breakthrough came. Jeff's father, a high-altitude physiologist, pointed out something we had never considered; concrete takes up CO_2. Portland cement initially contains about 15% $Ca(OH)_2$, which upon exposure to carbon dioxide is converted to $CaCO_3$. CO_2 in–H_2O out. With the help of Taber McCallum, one of the eight resident Biospherians, Jeff obtained cores of concrete exposed on the inside of the Biosphere. He compared the thickness of the $CaCO_3$-saturated rind in these cores with that for cores he obtained from concrete on the outside of the structure. Those from the inside had a 2-cm-thick rind compared to only 0.2 cm for the outside. This was to be expected because the CO_2 content of the air inside the Biosphere averaged about eight times that outside. Although humidity dependent, the rate of CO_2 uptake by concrete should be roughly proportional to the CO_2 content of the air in contact with the concrete. Jeff multiplied the amount of $CaCO_3$ per unit area by the area of exposed concrete and, lo and behold, found that it accounted for the missing CO_2!

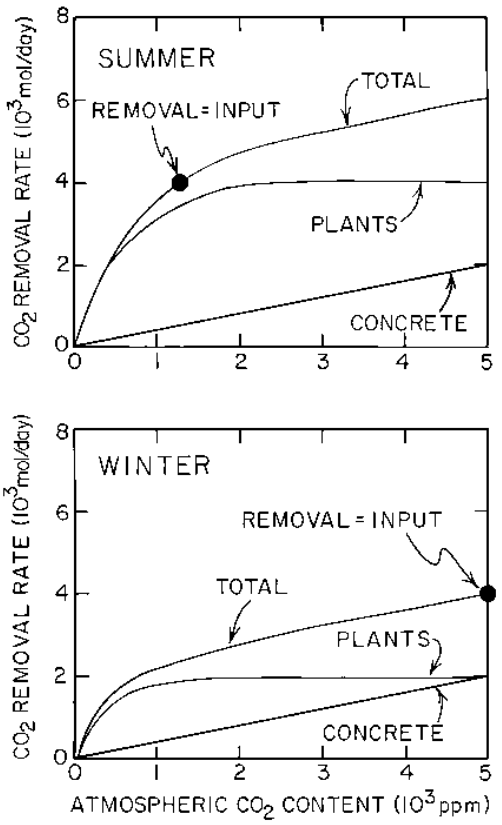

Figure 1. Hypothetical dependence of uptake of CO_2 by Biosphere 2 plants and concrete on the CO_2 content of its air. The former increases and then plateaus at CO_2 contents above 1500 ppm; the latter rises linearly with CO_2 content of the air. During summer months, when light is high, the plateau rate of uptake of CO_2 by plants is assumed to be twice that for winter months, when light is low. As the uptake of CO_2 by concrete is independent of light level, its trend with atmospheric CO_2 content should show no seasonality. Assuming that the rate of respiration is the same in summer and winter, (i.e., 4000 moles/day), the steady-state CO_2 content during winter months would have to be more than four times that in the summer in order for removal to match respiration input. In this hypothetical case, during summer months, 87% of the daily CO_2 goes to plant growth and 13% to the concrete carbonation. During the winter, the split is close to 50:50. If during winter months the Biospherians removed, through scrubbing, 600 moles of CO_2 per day, then the amount to be removed by the plants and concrete would have dropped to 3400 moles per day. This could be accomplished at a CO_2 content of 3500 ppm.

IT COULD HAVE BEEN VENUS

Although this finding solved the original mystery, it served to whet my appetite to understand exactly how Biosphere 2's carbon cycle was regulated. On the basis of the magnitude of the soil-respiration–driven night-time rise of CO_2 content, it was clear that the CO_2 in Biosphere 2's atmosphere was being replaced on the time scale of just a few days. Yet, over periods of weeks, its CO_2 content oscillated about nearly the same daily mean, suggesting that some mechanism allowed Biosphere 2's CO_2 content to reach a steady state. In other words, a feedback loop must have been operative which tended to drive the CO_2 content of Biosphere 2's atmosphere toward that level at which the combined removal by plant growth and by concrete carbonation matched the input from respiration. As shown diagrammatically in Figure 1, the rates of both uptake processes are dependent upon CO_2 concentration. In the case of concrete carbonation, the rate presumably rises linearly with CO_2 content of the air. The rate of photosynthesis also rises with CO_2 content, but it asymptotically approaches an upper limit. The magnitude of this limit depends on the light level. As the environmental conditions in Biosphere 2 (temperature, rainfall, humidity) were held nearly the same around the year, light was the only seasonally variable factor. Indeed, during times of peak summer insolation, the amount of sunshine received in Arizona is slightly more than twice that received in winter months. While the curves shown in Figure 1 are based on my guesses, they are at least qualitatively correct. They clearly show why the CO_2 content of Biosphere 2's air underwent such strong seasonal cycles. Night-time CO_2 rise rates suggest that soil respiration was more or less the same in summer and winter. It averaged about 4000 moles/day. During summer months, higher photosynthesis rates permitted most, but not all, of this CO_2 to be removed through plant growth. By contrast, under winter conditions, we estimate that only about half the CO_2 generated by respiration could be removed by plant growth, and, hence, no plant-growth feedback control could exist. The rest of the CO_2 had to go into the concrete. For this to happen, a CO_2 content of roughly 5000 ppm was required. Because the Biospherians worried that the winter CO_2 content

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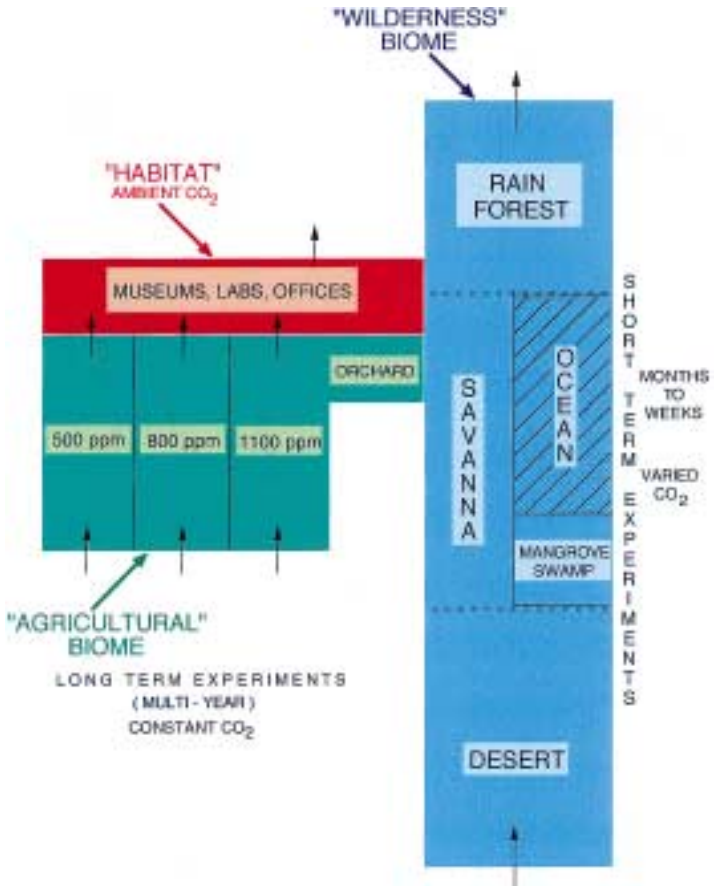

Figure 2. Diagram showing the compartmentalization planned for Biosphere 2. Colors indicate the threefold subdivision. Dashed lines show the positions of the roll-up curtains for temporary isolation of the rain forest and desert. The black arrows indicate the direction of the air flow associated with CO_2 control.

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of their air might skyrocket to unreasonable levels, they operated a scrubbing device capable of removing 500 moles of CO_2 per day. This dropped the net input from 4000 to 3500 moles per day and hence required removal by the concrete of 2000 to 1500 moles per day. Therefore, the winter CO_2 levels stabilized at about 3750 ppm instead of at 5000 ppm (see Fig. 1).

Unbeknownst to the builders of Biosphere 2, by incorporating immense amounts of concrete into their glass house, they prevented a Venus-like runaway CO_2 buildup. Without concrete, even with the scrubber running full tilt, during winter months, production of CO_2 by respiration would have exceeded removal by about 1500 moles per day. This excess would have accumulated in the air. Each winter day, the CO_2 content of Biosphere 2's atmosphere would have risen by about 250 ppm. Over the 90-day winter period, it would have climbed to a staggering 22,000 ppm.

Was no consideration given to this problem by Biosphere 2's designers? I think not. They were organic gardeners intent on maximizing the Biospherian's food supply. Consequently, they put too much organic matter into their soils (artificially created by mixing peat moss and bog mud with site excavation alluvial silt and clay). In the agricultural area, they made the additional mistake of extending the organic-rich material to a depth of nearly 1 m (in most of Biosphere 1's agricultural plots, the organic-rich A-horizon extends to about one fifth this depth). One has only to take another look at Figure 1 to realize that had its creators installed one-half the amount of organic matter, then even during the winter periods Biosphere 2 would have achieved steady state on the rising part of the curve of growth rate vs. atmospheric CO_2 content. The mean daily CO_2 content would have stabilized at perhaps 650 ppm during low-light periods and close to the outside ambient conditions during summer months.

Let us return to the situation with regard to O_2. For each mole of CO_2 generated by respiration, roughly 1 mole of O_2 is consumed. To the extent that this respiration CO_2 is consumed by plants, the lost O_2 is replenished. But if, instead, the CO_2 goes into the concrete, then replenishment doesn't occur. Hence, CO_2 uptake by Biosphere 2's concrete and O_2 decline went hand in hand. When initially closed, Biosphere 2 contained about 1.2 million moles of O_2. Averaged over the entire year, the excess of soil respiration over plant growth was about 1000 moles per day. Hence, during the course of one year about 0.4 million moles of O_2 (or one-third of the total) was lost. So great was this loss that eventually the management had to back off from their self-imposed ban against any transfer of matter into Biosphere 2 by bringing in tank trucks loaded with liquid O_2. By February 1993, 1.4 years after closure, the O_2 content had fallen from its initial 21% to about 14%. The Biospherians, living at 3800 feet elevation, were experiencing oxygen availability equivalent to that at an elevation of 17,500 feet! Again, it is easy to see from Figure 1 that if respiration had been 2000 rather than 4000 moles per day, a much smaller amount of CO_2 would have gone into the concrete (about 200 moles per day). In this case the O_2 content would have declined at the rate of only 10% per year, and the Biospherians would not have run short during their two-year stay.

One interesting observation was that just prior to replenishment of O_2, the eight Biospherians were dragging around, hardly capable of climbing stairs. When the first injection of O_2 was made into one of the two external lungs, the Biospherians waited behind a sealed hatch in the connecting tunnel. Their air contained 14% O_2. Upon completion of the first O_2 injection, the lung air contained 27% O_2. When the hatch was opened and the Biospherians stepped into the O_2-rich environment, their rejuvenation was instantaneous. They ran and jumped for joy and even did somersaults!

MEANWHILE, OUTSIDE

As my interest in the Biosphere rose, so also did my discontent regarding its management and direction. First, the advisory committee constituted by scientists of great prominence—Keith Runcorn, Jim Arnold, Tom Lovejoy—resigned in protest over the lack of information. Then, in a surprise move made without consultation with any of us, Jack Corliss was appointed director of research. Finally, a new crew of seven Biospherians was installed for a second mission whose objectives were no clearer than those surrounding the first. In my estimation, this very expensive facility was going nowhere. In frustration, I wrote a long letter to Ed Bass, the patron of the operation, bewailing this state of affairs and suggesting how the Biosphere might be put to better use. Much to my surprise and to that of many other Biosphere watchers, on April 1, 1994, Bass's financial advisors moved in and assumed management. As it turned out, this move had been in the offing well before my letter was written.

At the time of the takeover, John Allen and two of his faithful, Abigail Ailing and Mark Van Thillo, were in Japan. Ailing and Van Thillo flew back to Arizona and in the pre-dawn hours of April 3 came across the desert and broke the seal on one of Biosphere 2's hatches. Abigail went inside and ordered the resident Biospherians to leave. They refused, and

the Biosphere was resealed (but not until 15% of its air had been exchanged). This triggered arrests of Ailing and Van Thillo and generated lawsuits that have yet to be settled. Ailing claimed that she was trying to prevent something akin to the Challenger disaster. The new management said that had problems arisen, the Biospherians could simply have opened any of several hatches and walked out. Further, no one can point to any aspect of Biosphere 2's operation which might have placed it or its occupants in sudden jeopardy.

Upon the departure of the Allen group, the management of Biosphere 2 was placed in the hands of Bannon and Associates, a company specializing in the reorganization of troubled business enterprises. Their charge was twofold. First, stem the financial bleeding, and second, place the long-term operation of the Biosphere campus in the hands of a university or group of universities. Steve Bannon, the CEO of Bannon Associates, took personal charge of this exercise. He immediately took up residence on the Biosphere 2 campus and remained there for 21 months until these tasks were completed. On January 1, 1996, Columbia University assumed management of the Biosphere.

Steve Bannon turned to me, as the only external scientist actively involved at Biosphere 2 but not receiving funding from the Allen group, for advice regarding how a legitimate scientific program might be set up. My advice was to seek a hands-on scientist as director of research. "Any candidates in mind?" he asked. "Lots, but if you ask who might be good at it and also likely to accept the job, then I can think of only one, Bruno Marino at Harvard. He's a leader in the field of isotope biogeochemistry and is looking for this kind of job." A second piece of advice to Steve was that until a more permanent arrangement could be made, Biosphere 2 science should be planned jointly by scientists at Lamont and Biosphere 2. In this way, not only would the newly created research group on the Oracle campus be buttressed, but also the Lamont connection would provide the credibility necessary to entrain scientists from other places. With some reassurance from Columbia's Vice Provost, Michael Crow, the cooperative effort was launched. Bruno Marino accepted the job and arrived on site in September 1994.

The 1-meter-deep ocean with beach and coral reef. *Copyright A9 Biosphere 2.*

But the millennium had not arrived. Seven Biospherians still resided in the sealed glass house. The new management had never dealt with science or scientists. The mission-to-Mars mentality hung like a shroud over the whole enterprise. The outside world still rolled its eyes whenever Biosphere 2 was mentioned. Simply put, Bruno and I faced an uphill battle.

One problem was quickly resolved. When Bruno found that the N_2O content of the then three-year-old air in Biosphere 2 had risen to 79 ppm he said, "N_2O at this level is no laughing matter. It impedes vitamin B-12 synthesis in humans. Lack of vitamin B-12 can produce brain damage." So out they came, ending once and for all the use of Biosphere 2 as a human habitat.

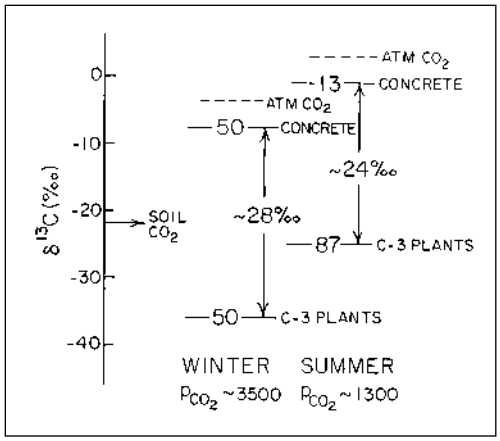

Figure 3. Cycle of carbon isotopes in sealed Biosphere 2. Since the CO_2 produced in Biosphere 2 resides in its atmosphere for only a few days before being removed by the plants or concrete, the ^{13}C budget must also be balanced on this time scale. As shown, the much greater importance of the concrete route during winter than during summer months gives rise to a large seasonal cycle in the $\delta^{13}C$ for the Biosphere's atmospheric CO_2 and hence also its plant matter.

TOWARD A NEW MISSION

This evacuation forced to the front the question of how exactly Biosphere 2 might be used as a science facility. Clearly, the fact that it was sealed offered the opportunity to do budgeting for carbon and water (and their isotopes). Also, the fact that it had been running at elevated CO_2 levels suggested that we might conduct experiments designed to explore the impacts of the ongoing buildup of anthropogenic CO_2 on the growth rate, water use, and product quality of plants. But this vision faced obvious problems. As the 500 or so species of plants in Biosphere 2 had been transplanted into a new regime of light, nutrients, temperature, and water, no true control or natural analogs existed. Further, all the biomes shared one air mass. Even the pH of the ocean tracked the ever-changing CO_2 content of Biosphere 2 air. Ranging up to 4000 ppm in the winter and down to 1000 ppm during the summer, the O_2 in Biosphere 2 also underwent 400 ppm diurnal cycles.

Realizing that the transformation of Biosphere 2 into a meaningful scientific apparatus raised complicated issues, Bruno and I decided to solicit white papers from

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prominent scientists knowledgeable about aspects of problems that might be explored at the Biosphere. The writers convened at the Biosphere in mid-December 1994. While I found this get-together inspiring, I was disappointed that we didn't come away with any crisp plan. Rather, somewhat by default it was agreed that we spend the following year trying to understand more about how the Biosphere operated and carefully documenting its biota and soils. It was not that we didn't receive good suggestions, but that those we did receive did not provide a clear route by which we could overcome the limitations imposed on us by the design of the Biosphere.

So we entered 1995 without a clear mission. Fortunately, a man with a mission soon emerged. I first became aware of Guanghui Lin at the working sessions of the December white-paper meeting. Bruno had hired Guanghui to work on problems in plant physiology. I didn't realize what a gem he was until during a phone conversation he pointed out that an idea I had for altering the night-time temperature in Biosphere 2 would interfere with his proposed experiment. I heard him through, but I went away a bit miffed. I soon realized, however, that Guanghui had indeed come up with a sound and interesting strategy for the use of Biosphere 2.

Guanghui's original idea eventually became known as the spring experiment. It began in late February 1995 and continued through May 1995. The idea was to use analyzers manufactured by LiCor to measure the rates of CO_2 uptake and H_2O loss from leaves of selected species of C3 and C4 plants from each of Biosphere 2's biomes. By creative use of the lungs and a blow-through fan system, the research team was able to drop the CO_2 content of Biosphere 2's air in progressive steps from its February closed-system value of 1800 ppm to 400 ppm. During each week-long step, Guanghui and his team carefully measured CO_2 fixation and H_2O transpiration rates for leaves of his selected plants. He also archived leaf tissue and sugar samples for subsequent stable isotope analyses. Guanghui had launched us on what we hope will prove to be a very successful line of research. As outlined below, a second and more extensive winter experiment was subsequently completed.

Finding a creative use for Biosphere 2's ocean proved to be a more demanding task. Constructed as the analog of an east-facing Caribbean reef, this Olympic-swimming-pool–sized water body has some serious drawbacks. Despite the deployment of an algae scrubber through which its water is processed once each 3.2 days, the water clarity remains marginal. Interception by the overlying glass and space frame and the afternoon shadowing by the cliff along its western shore results in woefully low light levels, down to 15% of the incoming radiation. The pumps that recirculate the water through the algae scrubber efficiently grind up those plankton that manage to sprout. Nitrate, ammonia, and phosphate are not measurable in the water column. While this near absence of nutrients is normal for coral lagoons, it prevents us from assessing the nutrient status of a benthic community. Air injectors push 1000 CFM of air through its waters, creating such a high gas-exchange rate that its CO_2 content (and hence pH and $CO_3^{=}$) slavishly follows that for the overlying atmosphere. While many of the corals remain alive, they must by any measure be in a poor state of health. Rather, the red algae, *Amphiroa*, thrives with such rapid growth rates that divers must periodically harvest it in order to prevent a complete takeover.

Clearly our first task was to revamp this monster. The air-injection system has been replaced with a water-recirculation system. The algae scrubber will be turned off, and we hope that its cleansing action will be replaced by that of a healthy planktonic ecosystem. New corals will be transplanted into small areas where the light will be artificially enhanced. Thanks to the efforts of Lamont's Taro Takahashi and Chris Langdon, we have the capability to precisely monitor pCO_2 and pO_2 in the ocean. We also have access to Taro's lab for the measurement of ΣCO_2 (to ±1 µmol/kg) as well as to isotope dilution techniques for high-precision measurement of water-column Ca, Mg, Sr, and U. Taro, Chris, and their troops have already shown that diurnal changes in O_2, ΣCO_2, and alkalinity can be precisely determined.

At a planning meeting held at Lamont in the summer of 1995, it was decided that our goal would be studies of coral growth and chemistry as a function of $CO_3^{=}$ ion content. Through chemical additions in the absence of the air-injection system, we could decouple the ocean's pCO_2 from that in the air and thereby maintain the $CO_3^{=}$ concentration at any desired level. By mounting "tracer" corals on base plates, we can deploy benthic chambers to compare their carbon fixation and $CaCO_3$ deposition to that for the entire Biosphere ocean (as tracked by water-chemistry changes). We can also study how the Sr to Ca, U to Ca, ^{13}C to ^{12}C, ^{11}B to ^{10}B, etc. ratios change with the ocean's acidity and other environmental variables.

Before we proceed with any such program, however, we must assess the state of health of the resident corals. Fortunately, everything grown in Biosphere 2 carries a very strong carbon isotope signature. Upon closure of Biosphere 2, the $\delta^{13}C$ of its air was offset to a new value, which averaged 5‰ more negative than that for outside air. With the passage of seasons, it has swung back and forth through an annual cycle of about 5‰. Briefly, the cause of the offset and annual cycle (Fig. 2) has to do with the split of CO_2 removal between photosynthesis on one hand and concrete uptake on the other. The former, dominated by C3 plants, exhibits a 20‰ or so preference for isotopically light CO_2. The latter exhibits the 4‰ difference between the diffusion rates of $^{12}CO_2$ and $^{13}CO_2$. Hence, during summer when photosynthesis dominates, the $^{13}C/^{12}C$ ratio of the photosynthate is close to that in respiration CO_2 (i.e., – 22‰). During winter, when CO_2 removal by the two processes is closer to equal, the $\delta^{13}C$ for C3 plant matter is more negative. Because with the air-injection system operating the isotopic exchange time between ocean carbon and atmosphere carbon was on the order of two weeks, any $CaCO_3$ precipitated in the ocean must bear the ^{13}C signature of the overlying atmospheric CO_2.

Despite these strides toward harnessing both the terrestrial and ocean systems for research, the basic problem remained. Did these short-term experiments offer any insight into the consequences of the ongoing buildup of CO_2 in Earth's atmosphere? While sequenced changes in the CO_2 content of Biosphere 2 air provided a way to at least partially compensate for the absence of a true control, such experiments provide only information on how a given species responds to short-term changes in CO_2 content of the air in which it grows. Many plant physiologists and most ecologists would consider such experiments to yield a misleading guide to the long-term impacts of fossil fuel–induced rise in our atmosphere's CO_2 content. Realizing this, we decided early on that we must also find a way to conduct long-term experiments. I initially thought in terms of building a separate set of identical greenhouses on the Biosphere 2 site. Each would operate at a different CO_2 content. It didn't take long to realize that this was impractical, for it would blow the budget. During the December 1994 white paper meeting, Bruce Kimball of the U.S. Department of Agriculture suggested that the agricultural biome lent itself to separation into three separate sections that could be operated at different CO_2 levels. Although this was a very appealing idea, it was clear that Ed Bass, Biosphere 2's patron, did not look with favor on dividing up his glass house into many independent compartments; so our thinking was stalled for several months.

About the time our spring experiment was completed, rumors began to spread that Columbia's Mike Crow and Biosphere's Steve Bannon had been working behind the scenes to create an arrangement under which Columbia would assume management of the Biosphere campus. By July 1995, it became clear that

such an arrangement was likely to come about. It was also clear that under the auspices of this arrangement Columbia would be allowed to make reversible structural changes to the Biosphere, so we decided to use Kimball's idea. In fact, an even more sweeping plan was put into place. The Biosphere would be divided into three quite separate parts. The wilderness (including the ocean) would be completely isolated from the agricultural area. The former would be used for time-sequenced experiments, and the latter, following the Kimball plan, would be used for long-term experiments at three different CO_2 levels. Finally, the habitat section of the Biosphere would be isolated from both the agricultural biome and the wilderness sections. It would be converted in part to a museum and in part to research space and run at ambient conditions. These "reversible" renovations are now in progress. A big question remains, however: What plants shall we grow in the tripartite agricultural area?

BIOSPHERE 2 AS A SCIENTIFIC LABORATORY

As I was writing this article (February 1996), a plan for use of the Biosphere as a research facility had begun to crystallize. The agricultural section would be used for long-term experiments carried out at controlled CO_2 levels. Each of its three newly isolated compartments would be ventilated during hours of darkness with outside air, and during daytime, they would be ventilated with enriched CO_2 air maintained in the Biosphere's south lung (stocked with CO_2-generating peat), so as to maintain the desired average CO_2 level and to minimize the diurnal swings. The wilderness area would be run in a time-sequenced fashion, varying both air temperature and CO_2 content. Through chemical additions, the ocean would be programmed through its own sequence of CO_2 (and hence also $CO_3^{=}$ concentrations).

So far, surprisingly enough, I've mentioned the word isotope only in a couple of paragraphs. As both Bruno and I are isotope geochemists, this might appear a bit odd. But be assured that, indeed, isotopic measurements will play a big role in the research program at Biosphere 2. In Bruno's research lab reside two isotope ratio machines, giving him the capability to measure the isotope ratios of carbon, nitrogen, oxygen, and hydrogen. As already mentioned, the carbon isotope ratio in Biosphere 2 air changes with season. It also undergoes a large diurnal cycle (~6‰). Five hundred or so plants draw their carbon from this isotopically variable supply, each one fractionating in accord with its own rules. The original $^{13}C/^{12}C$ ratio in the carbon of Biosphere 2 soils (~ – 22‰) sets the mean. Concrete and C4 plants fractionate by only a few per mil, while C3 plants produce a much larger separation which depends on CO_2 content of the air and probably a host of other environmental parameters whose values we can set. Clearly, Biosphere 2 is an ideal place to try to learn the rules governing these fractionations. We plan to exploit this potential.

The isotopes of water are also of interest. Currently, water is recycled within the Biosphere. In order to simplify isotopic bookkeeping, we have plans to convert the Biosphere to a one-pass system where all the rain and mist are supplied from a single reservoir of well water (desalted by reverse osmosis). We collect, sample, and then discharge to the outside the condensate created by the humidity control system (and by periodic condensation on the glass walls). We also collect, sample, and then discharge to the outside the water that drains through the soils. The difference between the isotopic composition of these two sinks will provide an index of the importance of evaporation from the soil surface (fractionating) and transpiration through the plants (nonfractionating). Of course, we can also explore the factors influencing the isotopic composition of the hydrogen and oxygen bound into organic matter.

Bruno plans to explore the cycles of N_2O and other trace gases. Because no UV light penetrates the glass ceiling, no photodissociation occurs in its atmosphere. Hence, the environment in Biosphere 2 offers insights into the production and destruction mechanisms in soil for these gases and, in the case of N_2O, also a means to explore what influences the isotopic composition of both the N and O in this gas.

The list of interesting isotopic studies is long. How much respiration CO_2 leaving the soil comes from the original soil organic ($\delta^{13}C = -22‰$) and how much from the C3 vegetation grown on that particular plot? What controls the $\delta^{18}O$ in Biosphere 2's CO_2?

Our small research group at the Biosphere can't possibly exploit this vast array of possibilities. Rather, we are reaching out to scientists at other institutions to join in our effort. So far, we have courted plant physiologist Joe Berry, Carnegie Institution; coral specialist Marlin Atkinson, University of Hawaii; and agriculturist Bruce Kimball, U.S. Department of Agriculture. We hope that still others will seek us out. Only if we can build cooperative efforts involving high-profile people at leading institutions (and also their students and postdocs) is there a chance that we can reach our goal of establishing the Biosphere 2 campus as a world-recognized center for biotic research.

Running parallel with our research program will be efforts to create a first-class educational program. It will range from on-site courses for students and teachers to a first-rate visitors center portraying issues related to our planet's future, and to an educational outreach program taking full advantage of the rapidly burgeoning global computer network.

Finally, a few words about our patron, Ed Bass. I find him to be a remarkable man, totally dedicated to the preservation of our planet's wildlife. During a period when competition for government support is more intense than at any time since World War II, Ed has taken it upon himself to bankroll the launch of this effort. I personally feel an enormous sense of obligation to make good on my promise to him to do everything possible to make a success of this remarkable opportunity.

Manuscript received March 19, 1996; revision received April 13, 1996; accepted May 1, 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

Rock Stars

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 any of the other profiles, please contact Robert N. Ginsburg, University of Miami, RSMAS/MGG, 4600 Rickenbacker Causeway, Miami, FL 33149-1098, E-mail: rginsburg@rsmas.miami.edu.

—Robert N. Ginsburg, Past Chair, History of Geology Division

Mather in his Harvard office in the 1950s. This photo was used in the valedictory volume of book reviews that Mather wrote for *American Scientist*.

A Scientist Concerned About Society: Kirtley F. Mather (1888–1978)

Kennard B. Bork, Denison University

INTRODUCTION

It was a hot week in July of 1925 when the famous trial of John T. Scopes took place in Dayton, Tennessee. At issue was whether the theory of evolution should be taught in public schools. William Jennings Bryan and the prosecution said no, defenders of Scopes said yes. One of the expert witnesses working for Clarence Darrow's defense team was the chairman of the Department of Geology at Harvard University. Still relatively young, at 37, Kirtley Fletcher Mather was just beginning his long career in the spotlight of the national media.

In the 1930s he fought against teachers' oaths, argued for supporting the anti-Fascist forces struggling against Franco in the Spanish Civil War, coauthored a classic book on adult education, and pioneered the use of educational radio and motion pictures. During the McCarthy era of the early 1950s, Mather became known as one of the country's most outspoken scientists, counseling that witch hunts and thought control were themselves un-American.

Mather in the field (1912) during his research association with W. W. Atwood, in the San Juan Mountains of Colorado. Field work in the high Rockies before World War I often involved long days on horseback.

The scientific community responded by electing him president of the American Association for the Advancement of Science and four-term president of the American Academy of Arts and Sciences.

Despite his fame, or notoriety, as a politically and socially active scientist, Mather at heart was a geologist with wide-ranging interests in the history and workings of Earth. His doctoral dissertation concerned invertebrate paleontology; his summer work during and immediately after graduate school involved the glacial geology and geomorphology of the high Rockies; and his early years as a professor included leaves devoted to petroleum exploration in the mountains and jungles of Bolivia. Throughout his career, Mather retained active interests in many phases of geology, even though his energies were concentrated on teaching and communicating with the public about science, religion, and politics.

It was in his role as a teacher and communicator that many people came to appreciate Mather's eloquent style of speaking, his dry wit combined with warm humor, and his deep belief in the mutual powers of the scientific endeavor and religious faith. For three decades (1924–1954) he taught generations of Harvard students, many of whom went on to become well-known geologists. He also lectured to audiences, ranging from college students to retired senior citizens, about the messages to be gained from the Scopes trial, contemporary science, and the Judeo-Christian world view.

What motivates such productive people? How do they get started in their life's work? Are there lessons we can take from the lives of individuals such as Kirtley Mather, well known in their time, but no longer part of popular culture?

A BIT OF BIOGRAPHY

One key to Mather's drive was a burning curiosity and a deep interest in communicating, both fostered by his parents. Although not college educated, Kirtley's mother and railroad employee father supported his quest for learning. When he did a grade-school project on insects, they made him a capture net; in an era before Parent-Teacher Association groups, they visited school to discuss his progress with teachers; and they scrimped and saved to make college education a reality for their children. They also asked each child to take a few moments at dinnertime to report on all that happened during their day. Thus, even before going to college, Mather had an appreciation of the value of knowledge and communicating about that knowledge.

A second important facet of Mather's intellectual evolution was his more formal education, exemplified by three pivotal teachers. Students may sometimes wonder about the motives of demanding teachers, and teachers occasionally may question their own mission, when students seem less than receptive. The chemistry of good teaching, however, is explosive in its liberating power. Mather profited from such intellectual catalysts in the persons of Jane Perry Cook in the Chicago public schools, Frank Carney at Denison University, and Thomas C. Chamberlin in the rigorous graduate-school environment of the University of Chicago. Jane Cook introduced a city boy to the joys and mysteries of geological field work. Frank Carney served as a model of the dedicated teacher of undergraduates—full of information to impart but especially concerned with his students' finding their own knowledge, both of their discipline and of themselves. And T. C. Chamberlin, known to many for his concept of "multiple working hypotheses," helped Mather understand the merits of research and communicating about deep ideas.

For many field-oriented geologists, the greatest rewards come from the numerous joys and occasional rigors of doing hands-on field work. Mather tackled two very challenging areas, the San Juan Mountains of Colorado and the largely unexplored terrain of Bolivia. While in his twenties, he worked with Wallace W. Atwood to decipher the glacial history and geomorphology of the Rockies (see Atwood and Mather, 1932). As a first-year graduate student, Mather was already thinking of a career in teaching, and he realized the great value of seeing geology in the field. In the summer of 1910 he wrote to a friend, "I can see how my summer's work here will make me a whole lot better teacher of geology."

The adventures in Bolivia centered on the quest for oil. From the high Andes to the steaming jungles of Brazil, Mather and Kenneth Heald traveled by mule and canoe and on foot in their successful efforts to recognize sources of petroleum that had a surface expression as oil seeps (see Mather, 1922; Heald and Mather, 1922). A crack shot, Mather often supplied meat for the field team. His one dangerous encounter with wildlife did not involve jaguars or poisonous snakes, but a tiny insect. When an insect bite on his leg became infected, the local medico suggested amputation. Realizing how dangerous that could be in the jungle, Mather and his Yurucare Indian guide voted no, depending on hot compresses to finally relieve the swelling.

The Bolivian work generated an unanticipated response—a search committee from Harvard University was sufficiently impressed by Mather's presentation at the 1923 meeting of the Geological Society of America that he was invited to join the Harvard faculty. No doubt it also helped to have a good word from Wallace Atwood, his professor at Chicago, who had moved to Harvard prior to becoming president of Clark University. Mather thus filled the position in physiography once held by William Morris Davis and then Atwood.

Teaching and administrative duties took him away from active research, but he enjoyed engaging students in discussion about current geological topics and about important issues in politics, religion, and life in general. Undergraduates appreciated the style and substance of Mather's teaching. One student noted that "because of the sympathy and vision with which you presented the course, geology and intellectual curiosity became one." Mather also demonstrated his strong belief in the merit of offering women equal treatment in education and in all facets of life. Radcliffe students recognized that commitment and were vocal in their appreciation of his efforts. An alumna commented that he really seemed to listen to her questions, rather than appearing, as some faculty members did, to be "trying to think of footnotes for their next research paper." Combining his interest in teaching with his administrative flair, Mather headed the Harvard Summer School from 1934 through 1942.

Recognizing that only a small number of people could attend Ivy League schools, Mather moved beyond Harvard to make contact with a wider audience. During the Depression of the 1930s he became a leader of the adult education movement (see Hewitt and Mather, 1937). He stressed that democracy depended upon a well-informed public. Part of his motivation was political, deriving from his strong belief in furthering causes for the general good, and part of it seems to have stemmed from a religious upbringing akin to the Social Gospel movement, which argued that educating the public about social responsibility and Judeo-Christian virtues would pay dividends for society at large. In 1934 he lectured students from Hitler's Germany about the evils of Nazism and anti-Semitism, reflecting his belief that dictators and demagogues profit from thought control, intolerance, and information manipulation.

Those exact concerns fueled his fights against


Dr. Mather Will Refuse To Take Teachers' Oath

In 1936 Mather led the dissidents who argued against signing the loyalty oath proposed by the Massachusetts legislature. Mather was happy to pledge allegiance to the federal government when he was inducted into the U.S. Army, but he rebelled against state fealty oaths for faculty members at private universities.

Mather

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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.

Working with Congress

"All too often we hear scientists and engineers bemoaning the lack of scientific and technical understanding in Congress. If we, as scientists and engineers, expect Congress to understand us, it is essential that we make more of an effort to understand and work with them.... To ignore Congress or to remain aloof is to forego the chance to influence policy and to abdicate one's responsibility to the science and engineering communities—and to the nation."

William G. Wells, Jr.—AAAS

The American Association for the Advancement of Science (AAAS) recently released the second edition of "Working with Congress—A Practical Guide for Scientists and Engineers," prepared by William G. Wells, Jr., head of the AAAS Office of Public Sector Programs, for the AAAS and the Carnegie Commission on Science, Technology, and Government. In its foreword, written by AAAS staffers Bonnie Cassidy and Albert Teich, "Working with Congress" is described as presenting "the constitutional basis of Congress, its culture and traditions, its power structure and organization, and its principal activities." They characterize "Working with Congress"as containing clear, concise advice on how to communicate with lawmakers and their staffs with respect to science and technology issues and as being a practical manual to assist scientists and engineers in "Working with Congress," be it through personal visits, telephone, fax, E-mail, regular mail, or participation in hearings. One of the most significant messages that "Working with Congress" presents is that although Congress's agenda is characterized by numerous science and technology issues, very few members of Congress or members of their staff have training, experience, or background in science and technology. Therefore, if Congress is going to make knowledgeable decisions about such issues, then the science and technology communities must develop a beneficial interaction with Congress and provide them the necessary information for educated decision making.

"Working with Congress" makes a strong plea to members of the science and technology communities to become proactive and involved in interacting with Congress. Considering that during the present Congress, the Bureau of Mines has been eliminated and the U.S. Geological Survey was almost eliminated, this message is especially pertinent to members of the Geological Society of America community.

Earth science and geology are disciplines that are apparently absent from the education and experience background of

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McCarthyism in the 1950s. Anyone who differed with Senator Joseph McCarthy (R—Wisconsin) was branded a Communist, and many scientists and artists feared for their jobs and reputations. A few brave voices spoke out, attempting to highlight the inherent problems of politicians wielding excessive power. Thus, education meant more to Mather than memorizing facts; it represented the key to operating optimally in a complex society.

In order for the public to appreciate science, history, and philosophy, difficult topics often need to be "popularized." Mather's commitment to sharing ideas led him to write some 1500 book reviews on topics ranging from geology to religion. Committed to the value of history as an enlightening agent, he edited two important Source Books on the history of geology (see Mather and Mason, 1939; Mather, 1967). Kirtley Mather just loved to talk about ideas, and even his casual conversations included questions about the best books you had recently read or exciting events in current affairs. In his 70s, Mather traveled across the country as a Phi Beta Kappa and Danforth visiting lecturer. At 87, he revised his well-received book, *The Earth Beneath Us*, incorporating the exciting new concept of plate tectonics.

LEGACY

The life of someone like Kirtley Mather illustrates that education can be liberating, and its power should be available to everyone in a democracy. True education transcends performance on tests; it represents the empowering potential of a lifelong interaction with ideas. We also see that the impact of gifted teachers can extend for generations. Mather integrated what he learned from his teachers and experiences, then passed along factual information, a thirst for learning, and a message of political sensitivity to a radiating network of students and audiences.

Observing Mather's battles along the interfaces of politics and science, it is evident that scientists need to raise their voices on matters of importance to society. Whether at the Scopes trial or during the McCarthy era, Mather followed his own advice that informed dialog is mandatory if light is to be shed in dark corners. He felt strongly that an informed and educated public is the best defense against the dual evils of misunderstood science and technology or the negative intrusion of self-serving politicians.

FURTHER READING

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Congress *continued from p. 10*

members of the present Congress. A summary of the expertise of the present Congress is as follows: 225 lawyers, 186 businessmen, 114 public servants, 75 educators, 11 physicians, 6 engineers, 1 Ph.D. chemist, and 1 Ph.D. physicist. No member describes himself or herself as an earth scientist.

Why should scientists and engineers, especially earth scientists, become more involved with assisting the Congress? According to Wells, the alternative would be to leave science and technology policy-making in the hands of groups dominated by other interests. He states, "Congress will make decisions on support for science and engineering research and on other science and technology policy issues whether scientists and engineers choose to become involved or not." Former member of Congress John Brademas is quoted as saying "Congress is more and more becoming a place of independent contractors, each Member intent on constructing his record in a manner most pleasing to the eye of his constituents or special interests but without regard to his responsibility to serve the national well-being." As the words "earth sciences" can as easily be substituted for the word "national," we in the earth science community need to wake up and pay attention.

Generally speaking, as a community we have failed to develop an effective interaction with Congress. Improved communication could provide substantial benefit to the earth science research community and to the quality of national policymaking. Cassidy and Teich state that "members of Congress, especially the newer members, resent what they perceive as an assumption that research funding is an 'entitlement.' Members of the science and technology community must begin to take responsibility for explaining the significance of their work and demonstrate the return on the federal investment in research."

"Working with Congress" presents 17 Cardinal Rules for Working with Congress. In essence, the 17 rules are the scientific method for working with Congress. The rules are designed to provide a scientist with a mechanism to work effectively with Congress and to stay in touch in an informed and beneficial manner. They are: (1) Convey that you understand something about Congress; (2) demonstrate your grasp of the Congressional decision-making system; (3) don't seek support of science as an entitlement; (4) don't convey negative attitudes about politics and politicians; (5) perform good intelligence gathering in advance; (6) always use a systematic checklist; (7) do your homework on the issue or problem; (8) timing is vital; (9) understand Congressional limitations; (10) make it easy for those in Congress to help you; (11) keep the "bottom line" in mind; (12) use time—yours and theirs—effectively; (13) remember that members and staff are mostly generalists; (14) don't patronize either members or staff; (15) don't underestimate the role of staff in Congress; (16) consider and offer appropriate follow-up; and (17) remember that the great majority of members and staff are intelligent, hard-working, and dedicated to public service.

"Working with Congress" is divided into six chapters, a glossary, eight appendices, a map of Capitol Hill, and an index. The glossary contains 73 useful terms. The appendices present names, addresses, and telephone numbers of House and Senate committees, subcommittees, and other offices; suggested readings; sources of information about Congress, including Internet access; descriptions on how to obtain Congressional documents; information about the Library of Congress; contact information for Washington, D.C., offices of professional societies and similar organizations (note: the only earth science organizations listed are the American Geological Institute and the American Geophysical Union); details about the Congressional year; and information about the legislative buzzer, bell, and signal system. Copies of "Working with Congress" can be obtained from AAAS, 1200 New York Avenue, NW, Washington, DC 20005. The price is $15.95. ■

Correction

In May *GSA Today* Forum Perspective 4: Ground-water Modeling: The Digital Back of the Envelope, by Stuart Rojstaczer, the sentence in the center of the right-hand column, 14 lines from the beginning of the only complete paragraph in that column, should be:

However, while our models generally have a sound theoretical basis, the data requirements for accurate application of these models to the real world are beyond any current and likely future data-collection capability.

About People

Named this year by Secretary of the Interior Bruce Babbitt to the National Cooperative Geologic Mapping Program Advisory Committee are GSA Member **Earl H. Bennett,** Idaho Geological Survey; Fellow **Thomas M. Berg,** Ohio Geological Survey; Fellow **Donald C. Haney,** Kentucky Geological Survey; Fellow **Robert D. Hatcher, Jr.,** University of Tennessee; Fellow **P. Patrick Leahy,** U.S. Geological Survey; Fellow **Charles J. Mankin,** Oklahoma Geological Survey; Fellow **Elizabeth L. Miller,** Stanford University; Member **John S. Pallister,** U.S. Geological Survey; and Fellow **Stephen J. Reynolds,** Arizona State University.

Fellow **Philip Abelson,** Washington, D.C., has received the National Science Foundation's 1996 Vannevar Bush award for outstanding contribution toward the welfare of the nation and humankind through public service activities in science and technology.

Fellow **Phyllis M. Garman,** Kansas City, Kansas, has been elected chair of the Association of Ground Water Scientists and Engineers.

Fellow **John R. Giardino** has been appointed associate director of graduate studies at Texas A&M University.

Fellow **Bruce Martin,** Leonardtown, Maryland, has been awarded Life Membership by the American Society of Civil Engineers. In conjunction with the Maryland State Highway Administration, Martin developed the state's sediment control program, the first of its type and scope in the United States.

The Texas Tech University Health Sciences Center has named an endowed professorship after Fellow **Grover Murray,** president emeritus and professor of geosciences. Murray also was awarded the Society for Sedimentary Geology's Twenhofel Medal this year.

Member **Ken Verosub** has won the University of California, Davis, 1996 Prize for Undergraduate Teaching and Scholarly Achievement.

Robert L. Fuchs

Stout Bequest Expands Mackin Fund

Martin Stout, who died in September 1994 after a long illness, was a very active GSA member, serving as Secretary of the Cordilleran Section for 12 years and as a member of the Committee on Membership for four years; ultimately, he chaired both groups. Stout's will named the GSA Foundation, more specifically the Foundation's J. Hoover Mackin Fund, as one of the beneficiaries of the estate. The estate was recently settled, and the principal of the Mackin Fund has been increased to more than $36,000 through this $14,400 bequest.

The J. Hoover Mackin Fund was named for a truly outstanding geomorphologist who stimulated and guided students at two major universities over his lifetime. Mackin was born and raised in upstate New York, and the death of his father when Mackin was six necessitated an early life of hard work. He studied geology at New York University and completed his graduate work at Columbia. He was on the teaching staff of the University of Washington for 28 years, 16 of those as a professor. The second stage of Mackin's career was on the faculty at the University of Texas, but his life ended prematurely, due to fatal heart disease, after only seven years there.

J. Hoover Mackin's specialization was geomorphology, and he is well known for his work in the east, the northern Rocky Mountains, and the Pacific Northwest. Perhaps he is even better known among his students as an outstanding teacher. A letter in the Foundation files from one of his former students, the president of an independent oil and gas company in Fort Worth, Texas, described him as "one of the finest teachers I ever had." In 1971, three years after Mackin's death, the GSA Quaternary Geology and Geomorphology Division established the J. Hoover Mackin Award for outstanding student research in the field of geomorphology. Recipients are selected annually by the division. Two to three graduate students are chosen, and award sizes have ranged from $500 to $1000.

Why did Martin Stout select the Mackin Fund as a legatee during the course of his estate planning? Certainly one reason was the respect that he held for his graduate school professor. After a youth spent in the Los Angeles area and an undergraduate degree in geology from Occidental College, Stout enrolled as a graduate student and teaching assistant at the University of Washington. This was a fortuitous choice, for those years of study and instructing in Seattle fostered his subsequent dual interests in teaching and applied geomorphology. Clearly, Mackin was a superb guide and mentor, and Stout responded favorably to his style, which involved students directly in problem solving.

Teaching and consulting were the mainstays of Martin Stout's career. He joined the staff of the Department of Geological Sciences at California State University in Los Angeles in 1960. Ten years later he became a full professor, continuing to teach until 1994 and also serving a three-year term as chair of the department. Throughout this period he was active as a consultant on geologic and engineering problems. All told, he worked as a consultant on more than 800 projects during 34 years of professional activity, and along the way he published 50 papers, articles, and books on such topics as landslides, regional geomorphology, and radiocarbon dating. Students weren't neglected during those years. There were accolades galore from those fortunate enough to study under Stout. One student summed it up concisely: "I want to be a teacher just like you."

The Stout bequest to the Mackin Fund significantly enhances the Quaternary Geology and Geomorphology Division's ability to provide student support and recognize excellent scientific work. The bequest also stands as a tribute to a noted teacher and scientist, from one who attained the same heights.

Employees Support Second Century Fund

More than three fourths of the GSA headquarters staff of 60 full- and part-time employees have made pledges or contributions to the Second Century Fund. Some of the staff members are using a convenient payroll deduction plan for this purpose. The total of all gifts from employees to the Second Century Fund is now $36,500.

The employee campaign was chaired by Membership Services Manager Terry Moreland. He organized a coffee break to mark the conclusion of the campaign; department heads provided the culinary items, and their staffs provided the appetites. In reporting the financial results, Terry noted that the high level of participation demonstrated strong support for the programs of the Society (and the managers' culinary artistry).

News of the Second Century Fund Membership Campaign

The North-Central Section, at its meeting in early May, became a pacesetter in the Second Century Fund (SCF) membership campaign. By action of its management board, the section contributed $2000 from its treasury to the section's endowment at the Foundation.

In order to enhance student support activities by GSA sections, 20% of unrestricted contributions during the SCF membership campaign are placed in section endowments, the income from which will be available for these activities. The guidelines governing these endowment funds have been approved by all six sections and the Foundation's Board of Trustees. Specifically, these guidelines state that the income will be used for various student programs such as "meeting travel grants, research, field camps, undergraduate programs, awards, and similar activities that benefit the education and field training of earth science students." Campaign success engenders a further attribute—after a section's goal is reached the portion of funds going to the endowment increases to 50%.

Here is a direct benefit accruing to members and future members from the Second Century Fund. The SCF membership campaign is important to the education of geology students. If you haven't made your gift or pledge yet, take a few minutes to get this done now. Call or E-mail the Foundation if you need a pledge card or an information brochure. ■

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ENVIRONMENT MATTERS

Institute for Environmental Education

Environmental Impacts of Urbanization and Mining — An International Project On Global Change

W. R. Osterkamp, *U.S. Geological Survey, Tucson, AZ 85745*
R. A. Morton, *Texas Bureau of Economic Geology, Austin, TX 78713*

In recent decades, anthropogenic effects on global systems have emerged as a major concern among government planners, earth scientists, environmental managers, and ordinary citizens. In the past 10,000 years, land-surface changes often have been dominated by human activities, particularly agriculture. In addition to deforestation, land degradation, and soil erosion associated with agricultural development, major transformations of landscapes and of fluvial and coastal systems continue to occur in areas of human settlement and mineral extraction. The environmental imprint of urbanization and related activities of mining, quarrying, and infrastructure development represent a principal factor promoting change in the nature and processes of Earth's surface.

One important deficiency in our understanding of global change is inadequate data about the impacts of mineral extraction and urbanization on the transport of rock and soil particles and solutes adsorbed on them. Such knowledge will be increasingly important for planners concerned with industrial expansion in support of urbanization, who must ensure that population centers are relatively safe from flooding, excessive erosion, and mass movements, while preserving wildlife habitat in fluvial and coastal ecosystems affected by urban expansion.

Among various national and international projects that address earth-surface problems caused by population growth are the studies of ESPROMUD (earth-surface processes, materials use, and urban development: understanding the human contribution to global geomorphological change). ESPROMUD is part of the Global Changes cluster within the scientific program of SCOPE (Scientific Committee on Problems of the Environment), an activity of the International Council of Scientific Unions, and is conducted by a volunteer staff of 12 scientists and various support personnel representing eight countries. The activities of SCOPE and ESPROMUD are carried out in cooperation with the International Union of Geological Sciences.

The ESPROMUD project is designed to evaluate the effects of urbanization and extractive industries on earth-surface processes. An objective of ESPROMUD is to compile and evaluate available information regarding these effects and thus to identify gaps in the understanding of the impacts. ESPROMUD activities are also intended to define key problems and processes of urban expansion and minerals extraction, to identify the regions of the world where the perceived problems are most likely to be severe, and to highlight key management issues that need to be addressed. One objective, therefore, will be to establish the spatial extents and volumes of land-form voids and depositional forms created by human actions in representative drainage basins. The major contributors to these earth-surface transformations, which are now comparable in volume and rate with landforms created naturally over longer time spans, are the extractive activities of quarrying, mining, mineral working and processing, and the construction activities related to urban- and transportation-infrastructure development. To define the nature and to assess the effects of those changes, we will use an approach based on (1) a general conceptual model, (2) "activities models" for mining and urbanization, and (3) "systems models" for fluvial and coastal environments.

General aims of the ESPROMUD project, therefore, are to quantify and describe the magnitudes of these direct and indirect people-driven changes, to evaluate the influence of the changes on geomorphic and hydrologic processes, to assess the consequences of the impacts on people, other biota, and their environments, and to suggest urban and extractive practices consistent with a stable society.

Credible estimates of urban expansion and extraction activities at the global scale seem feasible only if considerable time is spent collecting the necessary information. The ESPROMUD project, therefore, is concentrating efforts on the compilation of pertinent data from several drainage basins selected on the basis of urban and mineral-extraction activities. Two case studies selected are the Rio Grande de Loiza Basin in Puerto Rico, which provides much of the water supply for the city of San Juan and is strongly affected by mining, and the Besaya and Nervion River basins in northern Spain.

ESPROMUD is now soliciting suggestions for other candidate basins in which urbanization and mining have had a significant impact on fluvial and coastal systems. If you know of a basin that might be suitable for an ESPROMUD case study, please contact one of us.

Basins proposed for inclusion in the study should have a rich data base describing the climate, hydrology, landforms, land use (particularly mining history), and population trends within the watershed; ideally, the trunk stream of the basin should discharge water and sediment to an ocean or estuary. Among the pertinent topics that should be included in a case study are: (1) Physical diversity of the region or watershed as expressed by its geologic setting, the prevalent processes of natural erosion, the variation of the intensity of denudation across the region or basin, and the factors that control the susceptibility of weathering products to transport; (2) nature of the fluvial system,

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Ecogeology on the Web

Stuart P. Hughes, a geologist formerly with the U.S. Forest Service and Bureau of Land Management, has started an "ecogeology" home page on the Internet that "provides descriptions of two systems for integrating geology into ecosystem studies: a matrix that relates geologic features such as rock types and structures to other components of ecosystems such as trees and wildlife; and a geologic terrane-based geomorphic hierarchy for applying matrix information to specific land units. Also included is a database with examples of specific relationships between geologic features and other components of ecosystems."

The home page address is http://ourworld.compuserve.com/homepages/shughes_2

Geology, writes Hughes, is crucial to ecosystem studies because it deals with "the abiotic framework to the biotic body of ecosystems." He adds, somewhat optimistically, that "there is opportunity for employment in ecosystem studies but geologists must be aggressive in offering their services to land managers and other earth scientists."

LETTERS TO THE EDITOR

Better Presentations at Meetings by KISSing

The scientific brilliance of our talks and posters at national and sectional meetings is unconformably overlain by their increasingly poor stylistic quality. The two main causes are lack of an "abstract" in the introduction and brazen technological sophistication (computer-drafted slides) or lack of it (overhead transparencies).

The two most important guidelines for such presentations are KISSing (U.S. military for "Keep it simple, Stupid") and legibility. KISSing is an acquired skill. KISSing and the production of legible slides require significant preparation time (planning).

Organization. The most important KISS factor in a talk is an abstract in the introduction. Landes (1951) stressed that printed articles require an informative abstract, not an expanded table of contents. An abstract (or "take-home message") is more important in talks because most of those in the audience either have limited prior knowledge of the topic or have sensory overload from other talks. Additionally, too many talks expire without a conclusion. To KISS well, "Tell 'em what you are going to tell 'em; tell 'em; and then tell 'em you told 'em."

Illustrations. Reams of highly technical advice have been written about illustrations, but Gallagher (1965) said it all with his 12:1 rule: whatever the longest dimension of your drafted illustration in inches (no matter if it is with colored pens on butcher's paper or on the screen of a computer), step back that number of feet to preview your slide. If you can read it from that distance, so can an audience. Although the lantern slides of Gallagher's day are obsolete (and you probably can "go metric"), his advice still applies to 35 mm slides and overhead projections. A useful variation of Gallagher's technique is to look at a slide without any magnifying device (except your glasses). A more sophisticated mathematical formula: visibility $\cong 1/D^2$; to confirm this, view your illustrations from the last row in the hall!!??!! An obvious cure would be to require all speakers (especially those using overhead projectors in the front of the hall) to lecture from the back of the hall!

Slides copied without modification from illustrations in printed articles and most view-graphs used on overhead projectors violate the 12:1 rule and KISSing. View-graphs for overhead projection can be improved somewhat by simply enlarging them on a photocopy machine so that the image fills the horizontal dimension of the screen. Even so, overheads commonly are illegible for more than several people sitting around the same table (in which case, each person could be provided with a photocopy instead).

Overheads have the additional disadvantage of being distracting, especially if part of the talk uses 35 mm slides and then switches to overheads. In addition, the rustling of the overhead illustrations and the interleaved papers is annoying.

Colored pencils and pens can be superb technologies. A slide does not have to be beautiful or computer-drafted. Instead it has to be legible. To be legible, violate neither KISS nor Gallagher. If a complex picture is required (as is commonly the case in the earth sciences), give multiple KISSes by showing a series of slides (e.g., various portions of a map that would otherwise violate 12:1, or successive overlays in successive slides); that is, each slide is a KISS.

For the largest possible image on a screen (and to avoid the distraction of refocusing), design all art work for every slide or overhead to be elongate horizontally by 3:2, which is the approximate ratio of a slide. Likewise, fill the computer screen horizontally with your illustration, not with titles (that you should present orally) and not with fancy borders that only diminish the size of the illustration.

Even if you are a computer wizard, do consult your friendly visual arts expert; do solicit suggestions. When the time comes to photograph the artwork (to make slides), be there to be sure that the correct path of the artwork is photographed, the exposure best illustrates your point, and the largest possible image is photographed (to beat 12:1). Do not read a slide that is mainly text. The audience can read silently faster than you can aloud; thus, your voice causes interference. Some in the audience might even be insulted that you consider them illiterate.

In illustrations consisting mostly of text, avoid using entirely upper-case (capitalized) letters. People read faster (recognize a word more easily) by the variation in lower-case lettering. A note of caution: lower-case lettering more commonly violates 12:1. "I know that this slide is too dark and hard to see" is inexcusable. Any processing laboratory can produce the correct exposure from a dark slide.

Poster Session. Do have an abstract. Poster sessions are really slow-motion slide shows (using the artwork and captions instead). Avoid more than a few lines of text in any one caption or item; that is, have more visuals than text. Poster sessions permit some (but not total) avoidance of KISSing and Gallagher. For text and captions use lettering that can be read from a meter away. For excellent advice on poster sessions, heed Connor (1991).

Remember, there is no profit in making good work look bad—not even with a computer or overhead projectors. Slides are the appropriate technology; overheads are not. The drafting and photographing

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Impacts *continued from p. 14*

including climate, the characteristics of water and sediment discharges, and the principal fluvial-geomorphic and hydrologic processes; (3) major environmental concerns within the basin, such as flood potential, mass movements, and other natural hazards; (4) nature of mining activities in the basin, including materials mined or quarried, types of mines or quarries, and characteristics of the landscape at the mine site; (5) impact of mining on earth-surface processes, including quantities and fluxes of ores and waste products, local impacts of mining activities, the cumulative effects (physical and chemical) of mining on landforms and the hydrologic system, erosion and stability of tailings or other waste products, and effects of mining on downstream and coastal population centers and ecosystems; (6) nature of urban growth in the watershed; the locations of urban areas relative to affected landforms, geomorphic change caused by urban growth, and recent trends in urban growth; (7) impacts, at various areal scales, of urbanization on earth-surface processes; (8) quantification of changes in river systems, including direct impacts of discharge, channel morphology, and imposed alterations such as dredging and dam construction and their indirect impacts on sediment discharge and erosion processes; (9) nature of coastal processes and transformations, such as the types of coasts and coastal features, and the coastal processes and sediment fluxes that are altered; and (10) quantification of changes to coasts, especially the magnitudes and rates of change of coastal processes, and impacts on coastal systems

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Letters *continued from p. 15*

of adequate slides require that time be spent in planning and preparation (which is why overheads usually are disasters). The required amount of time depends on the skill of the presenter. Most of us need to dedicate as much time in preparation as the length of the talk (in minutes) times the desired number of people in the audience. Talks should have an abstract and slides should be legible. KISS Gallagher or Connor; and follow the directions that GSA distributes to speakers.

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Geology and UVA

In the April 1996 *GSA Today* (v. 6, no. 4, p. 11), Dr. Bruce Nelson of the Department of Environmental Sciences, University of Virginia, defended the evolution of his department from Geological to Environmental as a response to P. Geoffrey Feiss's warning to all geologists that our University training grounds, especially in Virginia, are disappearing. I merely wish to congratulate Dr. Nelson on so eloquently proving Dr. Feiss's thesis. This proof is contained within the lines "When one faculty member retired, we dropped courses in paleontology and stratigraphy. These no longer seemed essential to our central purpose."

Dr. Nelson has just eliminated two of the three primary tools used in sequence stratigraphy with 3-D seismic, in oil and gas exploration. Effectively, the fundamental tools of geology since the origin of our profession, paleontology and stratigraphy are at the core of managing risk and in creating new frontiers in petroleum exploration and development.

The reason for geology as a profession has always been for resource evaluation and management. Without a strong fundamental knowledge of paleontology and stratigraphy, no student can come out of this department calling himself a Geologist. A department which no longer teaches a student how to tear a rock apart and tell its life history does not qualify as a Geology department. Dr. Feiss is correct that such a department no longer exists at UVA.

Michael N. Fein
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Reviewers' Duties

A recent number of the *Bulletin* (v. 108, no. 1. p. 40–77) presents a truly excellent summation of the continuing work of P. R. Olsen and colleagues on the Triassic-Jurassic fill of the Newark Basin—I congratulate them on a job well done! Unfortunately, this fine paper represents yet another example of inadequate attention to detail in the peer-review stage of manuscript preparation—an inadequacy that is becoming increasingly apparent throughout the categories of the Society's publications.

One case in point involves the application of formal nomenclature. Olsen and colleagues (p. 49) state "... in [their] nomenclatural system, member boundaries are not necessarily contiguous with formational boundaries. " One could argue about word choice here but their figures make it clear that certain "members" straddle the contacts between formations. The "North American Stratigraphic Code" (1983) and the "International Stratigraphic Guide" (1994) agree explicitly that "a member is always part of a formation," meaning that a member cannot comprise parts of two vertically successive lithostratigraphic units. The history of the evolution of nomenclature applied to the Newark stratigraphy suggests that many of the units emerged and were named in "gray" publications; GSA has now placed its official stamp of approval on this Topsy-like structure.

Issues such as this are seen by many readers as legalistic trivia unworthy of serious attention; for others who may be involved in any of a variety of geotechnical pursuits dependent on the precise definition of stratal units for resource exploitation, waste management, hazard mitigation, etc., codification is a matter of deep concern. My own view is that "Codes" and "Guides" should either be observed by authors and enforced by reviewers or the geologic community should cease to expend time and money on supporting nomenclatural bodies and the volumes of paper they produce.

The paper by Olsen and colleagues raises another question that has not been addressed by reviewers: to what degree is it appropriate to approach the classification (and nomenclature) of rock units from a position founded on the genetic assumption of rhythmic cyclicity defined by the Milankovitch hierarchy? I would judge that the burden of disproof rests on those who say that climatic cyclicity, probably related to orbital forcing factors, is not represented but it would add grace and strength to the authors' opinions if these were presented as conclusions rather than as introductory statements. Further, if the reader is led to accept as fact the 413 ka periodicity of the defining McLaughlin cycle, rates of sedimentation can be approximated; spectral analysis would add much to reinforcement of the acceptability of Milankovitch controls.

It is manifestly unfair to pick on one paper to illustrate the problems of the peer-review system and for this I apologize. Still, maintaining the high level of the Society's publications is the single most important responsibility placed on GSA's leadership. Should we relax in the face of inevitable decline? Or should we petition Council to initiate review-enhancing steps—such as publishing names of reviewers of each contribution printed?

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Letters *continued on p. 17*

PEPTALK

Barbara L. Mieras, Partners for Education Program Manager

Experts and Electronic Partners

Hello, Partners! Requests for assistance from PEP are increasing rapidly in two areas: (1) people want advice on specific topics in both geoscience (e.g., plate tectonics or dinosaurs) and K–12 education (e.g., grade-appropriate activities or effective presentation techniques); (2) we need both educators and scientists who want to assist Partners, other adults, or students by E-mail.

If you would like us to share your name in response to requests for expertise in specific areas, please call us at 1-800-824-7243 and/or, if you would like to join the E-mail team, please contact us at bmieras@geosociety.org. In either case, leave us your name, the areas of your expertise (please be as specific as possible), and where you prefer to have others contact you.

As always, PEP will not assign you to specific requests but will make you and the requesters aware of each other so you can decide the direction and level of your involvement. Thank you!

GSA Employment Service

Looking for a New Job?

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

You may register any time throughout the year. Your name will be provided to all participating employers who seek individuals with your qualifications. If possible, take advantage of GSA's Employment Interview Service, which is conducted each fall in conjunction with the Society's Annual Meeting. The service brings potential employers and employees together for face-to-face interviews. Mark your calendar for the 1996 GSA Annual Meeting in Denver, Colorado.

To register, complete the application form on this page, prepare a one- to two-page résumé, and mail it with your payment to GSA headquarters. One-year listing for GSA Members and Student Associates in good standing: $30, nonmembers: $60.

NOTE TO APPLICANTS: If you plan to interview at the GSA Annual Meeting, GSA must receive your materials no later than September 1, 1996. If we receive your materials by September 1, your record will be included in the information employers receive prior to the meeting. Submit the form on page 18 early to receive maximum exposure! Don't forget to indicate on your application form that you would like to interview in October. Good luck with your job search!

For additional information or submission of forms, please contact T. Michael Moreland, Manager, Membership Services, Geological Society of America, P.O. Box 9140, Boulder, CO 80301, (303) 447-2020, or E-mail: member@geosociety.org.

Looking for a New Employee?

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

How does it work? Complete the Employer's Request for Earth Science Applicants form on page 19. Remember to specify educational and professional experience requirements as well as the specialty area or areas of expertise your applicant should have. The GSA computer will take it from there.

You will receive a printout that includes the applicants' names, addresses, phone numbers, areas of specialty, type of employment desired, degrees held, years of professional experience, and current employment status. Résumés for each applicant are sent with each printout at no additional charge. For 1996, the cost of a printout of one or two specialty codes is $150. (For example, in a recent job search for an analyst of inorganic materials, the employer requested the specialty codes of geochemistry and petrology.) Each additional specialty is $50. A printout of the applicant listing in all specialties is available for $350. (Specialty codes printed in boldface type are considered major headings. If you request a listing of one of the subspecialties, applicants coded under the major category will be included but not those coded under the other related subspecialties.) If you have any questions about your personalized computer search, GSA Membership Services will assist you.

The GSA Employment Service is available year round. However, GSA also conducts the Employment Interview Service each fall in conjunction with the Society's Annual Meeting (this year in Denver, Colorado, October 28–31). You may rent interview space in half-day increments from GSA. Our staff will schedule all interviews with applicants for you, the recruiter. In addition, GSA offers a message service, complete listing of applicants, copies of résumés at no additional charge, and a posting of all job openings. ■

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USGS RIF

In *GSA Today,* Volume 6, No. 4, April 1996, I was appalled to read the Letter to the Editor, whose authors are not GSA members, but practicing attorneys. It is obvious to me that someone who was RIF'ed either wrote the article or contributed very substantially to it.

It is exceedingly difficult for me to understand why the GSA permitted the publication of such a one-sided, critical letter. I am concerned that GSA may have opened the door for any non-member to use the publication as a public opinion forum for a grievance of any nature.

It's public knowledge a lawsuit has been filed against the USGS by one or more former employees who were RIF'ed and to permit attorneys to denounce the USGS in an official GSA publication is bizarre as well as ludicrous. After all, a very large number of GSA's membership is composed of USGS scientists. It is possible that the article/letter may be utilized by the plaintiffs in their attack on the USGS and referred to as sanctioned by the GSA.

The attorneys failed to recognize that the financial conditions of the USGS's Geologic Division cannot and should not be tied in any way to the Contract with America. The Geologic Division had for the last half dozen years been in a state of severe financial stress with RIF finally invoked as a last resort in the Winter and Spring of 1995. It is my understanding that the FY 1996 budget had very little, if anything, to do with the need to implement the RIF.

The suggestion that an organization with the long history of integrity and excellence of the USGS is incapable of reorganizing itself illustrates a total lack of understanding of management principles by the authors. There is no way the USGS, or any other organization, large or small, would place its future into the hands of outsiders with little or no knowledge of the fundamental basis, credibility or functions of the entity.

Anyone who has worked with the Geologic Division staff for years, as I have, knows that their management model is one of rotational geologists-managers. The long-term career of these individuals is that of scientists which is fully consistent with what happened.

I have to take great exception with the statement... "no good for science came from this RIF and the prospects of survival of the Division and the Survey had been dealt a severe blow...." Lawyers are hardly the experts to judge the health of science.

The reputation of the Geologic Division is not in question as it will continue on the road of scientific excellence with the talents and expertise of the large number of its geologists who remain and the utilization of their innovative analyses and creativity will maintain the Division in good stead.

I firmly believe GSA erred very seriously in lending its name to an attack on the USGS, the largest geological scientific organization in the world and one that has strongly supported GSA since its inception.

Michel T. Halbouty
Houston, TX 77086 ■

Note to GSA Today *readers: As stated in the masthead (p. 2), opinions presented in this publication do not reflect official positions of the Society.*

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104 nonmetallic deposits
105 mining geology
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150 Environmental Geology
160 Public Education & Communication
200 General Geology
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652 sed. environments
720 Stratigraphy
750 Structural Geology
751 tectonics
752 tectonophysics
753 rock mechanics
800 Volcanology

Résumé must be attached, ***limited to two pages,*** typewritten on one side only, to be acceptable for reproduction to employers. Include your name, address, and phone number; concise details of work experience; and majors/minors on degrees.

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105 mining geology
120 Engineering Geology
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200 General Geology
220 Geochemistry
221 organic
222 high temperature
223 low temperature
224 stable isotopes
225 geochronology
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400 Mineralogy
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402 clay mineralogy
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622 photogrammetry
630 Science Editing
650 Sedimentology
651 sed. processes
652 sed. environments
720 Stratigraphy
750 Structural Geology
751 tectonics
752 tectonophysics
753 rock mechanics
800 Volcanology

Applicants seeking employment in:
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***Minimum* degree required:**
☐ None ☐ B.A. or B.S. ☐ M.A. or M.S. ☐ Ph.D.

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Field	☐	☐	☐
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BOOK REVIEWS

Radiogenic Isotope Geology.
Alan P. Dickin, Cambridge University Press, Cambridge, UK, 1995, 452 p., $89.95.

Since the publication of the second edition of Gunter Faure's *Principles of Isotope Geology* in 1986, developments of new techniques and applications in radiogenic isotope geology have continued apace, most notably in the use of thermal ionization mass spectrometry in U-series age determinations and in applications of the Re-Os decay pair. Readers can now catch up on these developments through Alan Dickin's new textbook in radiogenic isotope geology, which provides a well-written introduction to state-of-the-art techniques, as well as a nice overview of more entrenched methods. Overall, the book reads like a third edition of Faure's book. The organization is similar (general techniques, followed by chapters on Rb-Sr, Sm-Nd, U-Pb, Re-Os, K-Ar and Ar-Ar, U series, cosmogenic nuclides, and fission-track dating). The contents of the two books even look similar; many of the diagrams illustrating basic methodology are virtually identical in both. Dickin's effort, however, is more current in its discussion of U-series and Re-Os systematics, and contains chapters on rare-gas geochemistry and extinct nuclides that are missing from Faure's book. Dickin also provides a clear discussion of the implications that radiogenic isotope systematics have for the origin of oceanic volcanic rocks and for mantle topology.

On the downside, readers with an abiding interest in the origin and evolution of the continental lithosphere, the origin of magmas in continental regions, or the applications of radiogenic isotopic data in economic or environmental geology are apt to be disappointed with this new text. And it should be pointed out that Faure's book, but not Dickin's, covers both radiogenic and stable isotope systematics, and so those interested in an integrated overview of isotope geology will still be better served by Faure's more comprehensive, if somewhat dated, text. Despite these shortcomings, however, Dickin's new book provides the most current and thorough introduction to many aspects of radiogenic isotope geology now available in the marketplace and is certainly worth a close look.

Lang Farmer
University of Colorado
Boulder, CO 80309

Monitoring Active Volcanoes.
Edited by B. McGuire, C. R. J. Kilburn, and J. Murray. UCL Press Limited, London, 421 p., 1995, $99.

Those of us who have a continuing desire to work on erupting and potentially active volcanoes, or who wish to teach monitoring techniques to students, will want to purchase *Monitoring Active Volcanoes*. Of its 15 chapters, 12 provide specific information on current methods, equipment, and data interpretation. Each chapter is written by established veterans of volcano monitoring. Nearly all contributions are from European volcanologists. The style of presentation differs considerably from traditional books on volcanology that stress volcanic land forms, tectonic environments, eruption products, physical-chemical characteristics of magmas, and famous eruptions.

Monitoring Active Volcanoes concentrates on the basics of acquiring useful data before, during, and after eruptive activity, with a strong focus on geophysical techniques. Data acquisition systems, seismic monitoring, ground deformation, microgravity, geomagnetic and geoelectric methods, and satellite-based monitoring compose the core of the book. By comparison, only one chapter each describes remote sensing of plume compositions, study of volatile components, and forecasting of lava flow hazards. Most chapters discuss choices of equipment for given techniques, logistics and strategies for each monitoring problem, and data reduction for at least one case study. No information is provided on the study of pyroclastic rocks or on interrogation of phreatic and phreatomagmatic ash clouds that are produced during so many eruptive events. The geologic and geochronologic studies that are necessary to establish baseline data on potential hazards from past eruptive performance are not discussed. In spite of these omissions, the book provides much valuable information.

Most readers will find the chapter on forecasting of volcanic events to be very informative. Several case studies of eruptions that have occurred since the mid-1970s (some catastrophic) are discussed, and the chapter is summarized with a concise section on lessons learned. Mistakes and lack of knowledge have resulted in the deaths of nearly 30,000 people since 1975, but several workable monitoring strategies have been devised in spite of the tragedies. Some unfortunate pitfalls, as well as successes, of forecasting are described.

Finally, an appendix at the end lists sensible safety measures for those who dare to work close to active volcanoes. This addition was partially spurred by the unexpected explosion at Galeras Volcano, Colombia (January 14, 1993), during which very few of the volcanologists present were wearing complete safety equipment. Six scientists died, including the microgravity expert Geoff Brown, to whom this book is dedicated. Appropriate precautions and safe attitudes can prevent injuries and save lives. *Monitoring Active Volcanoes* is a very worthwhile book for any student or professional who works in volcanology.

Fraser Goff and Cindy Werner
Los Alamos National Laboratory
Los Alamos, NM 87545 ■

In Memoriam

Charles B. Belt, Jr.
Des Peres, Missouri
May 7, 1996

Henry W. Coulter
Hanover, New Hampshire
February 12, 1996

Robert M. Kosanke
Lakewood, Colorado
April 17, 1996

Kenneth E. Lohman
Fairfax, Virginia
February 25, 1996

Robert G. Reeves
Odessa, Texas
December 28, 1995

Tully M. Robison
Boca Raton, Florida
April 2, 1996

Howard E. Simpson
Golden, Colorado
May 14, 1996

Stanley G. Volbrecht
Lodi, California

William E. Wallace, Jr.
Slidell, Louisiana

Memorial Preprints

The following memorial preprints are now available, free of charge, by writing to GSA, P.O. Box 9140, Boulder, CO 80301.

Wallace C. Fallaw
David S. Snipes

Adam Richard Wasem
Paul Fuenning

Thomas Brennan Nolan
Luna B. Leopold and Arthur A. Baker

Louis Crawford Raymond
Geraldine Raymond Custer

Vladimir Joseph Okulitch
Walter W. Nassichuk

William Lee Stokes
M. Dane Picard

Fred M. Bullard
Ernest L. Lundelius, Jr., William Fisher, and Clark Wilson

1997 Officer and Councilor Nominees

Council announces the following officer and councilor candidates. Biographical information on all candidates will be mailed with the ballot to all voting members in August.

PRESIDENT (1997)
George A. Thompson, Stanford, California

VICE-PRESIDENT (1997)
Victor R. Baker, Tucson, Arizona

TREASURER (1997)
David E. Dunn, Richardson, Texas

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Christopher R. Barnes, Victoria, British Columbia, Canada
Leslie J. Smith, Vancouver, British Columbia, Canada

COUNCILOR (1997–1999), POSITION 2
Burrell Clark Burchfiel, Cambridge, Massachusettts
Jan A. Tullis, Providence, Rhode Island

COUNCILOR (1997–1999), POSITION 3
John P. Grotzinger, Cambridge, Massachusettts
Gail Mahood, Stanford, California

COUNCILOR (1997–1999), POSITION 4
William L. Graf, Tempe, Arizona
Dorothy Stout, Cypress, California

July *BULLETIN* and *GEOLOGY* Contents

GEOLOGICAL SOCIETY OF AMERICA
BULLETIN
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Journal Indexes To Be Printed

In response to requests from subscribers to *GSA Bulletin* and *Geology*, author and subject indexes for the two journals will be produced as printed items for 1995 and subsequent years. The searchable GSA Retrospective Electronic Index will continue to be available on the World Wide Web (www.geosociety.org).

The indexes for 1995 will be printed as stand-alone inserts and will be included with one of the fall 1996 issues of the respective journals. If you subscribe to the *Bulletin* and/or *Geology* for 1996, you will automatically receive a copy of the 1995 index(es). A limited number of extras will be available to 1995 subscribers who did not renew for 1996; those subscribers may request a copy by E-mail to bgetman@geosociety.org, by phone to GSA Publication Sales at (303) 447-2020, or by letter to GSA INDEX, P.O. Box 9140, Boulder, CO 80301-9140.

In December 1996, GSA will resume printing the current year's index in the December issue of each journal.

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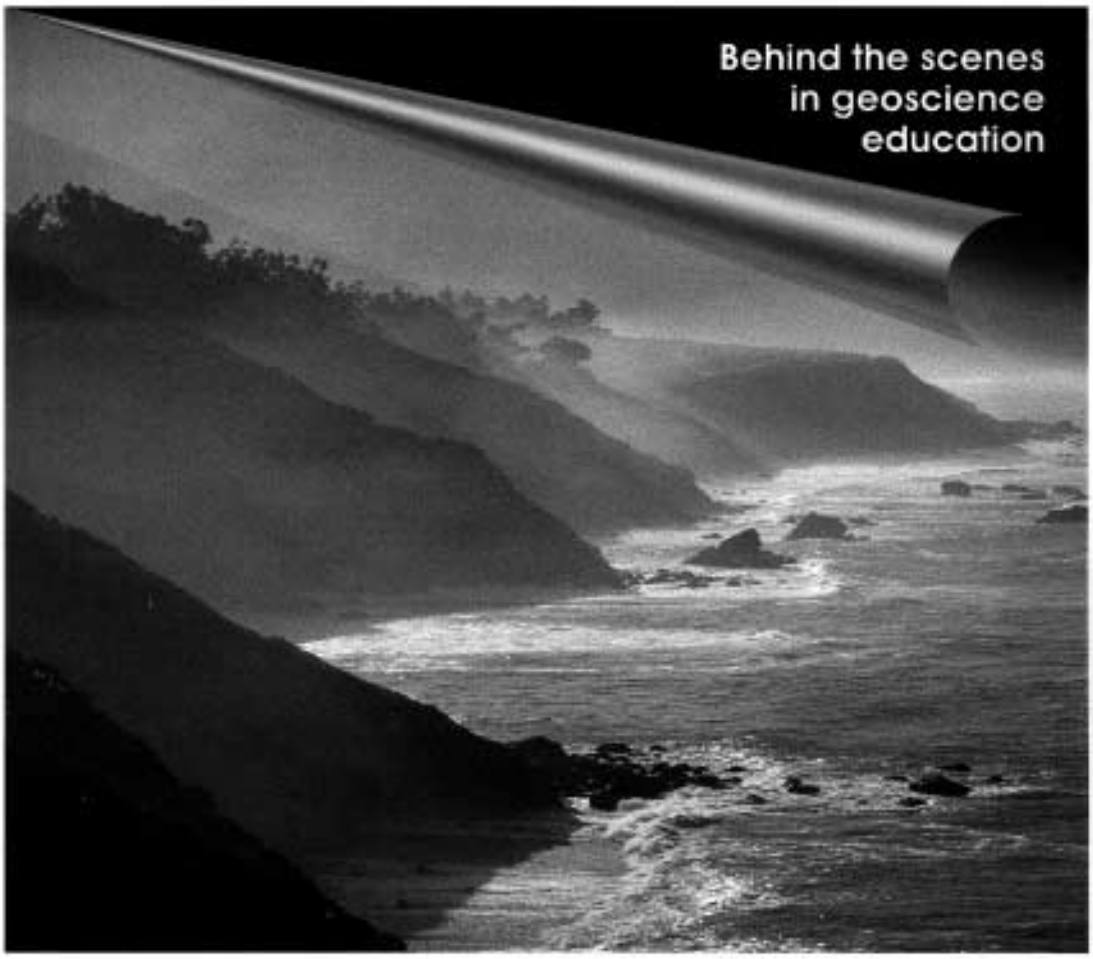

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_____ New _____ Renewal

The membership year runs from January through December, and members receive 5 issues of JGE per year. Subscriptions received after July 1 will begin receiving the Journal in January of the following year. Back issues are available for $8 each ($10 foreign).

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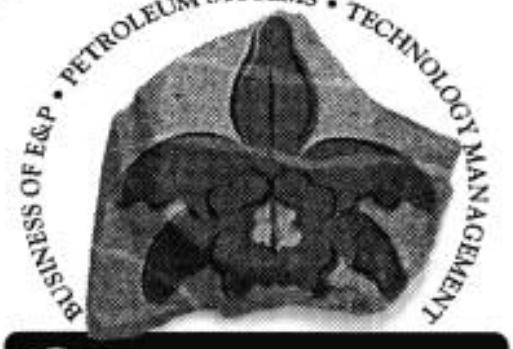

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For registration or exhibitor information, please contact the AAPG convention department:
phone (918) 560-2679, fax (918) 560-2684, e-mail dkeim@aapg.org

Registration information now on the World Wide Web — http://www.geobyte.com

GSA Names 1996 Medal and Award Recipients

Society awards for 1996 will be presented to the following individuals at the Denver Annual Meeting.

Penrose Medal
John R. L. Allen
Postgraduate Research Institute for Sedimentology, The University of Reading, P.O. Box 227, Whiteknights
Reading RG6 2AB, United Kingdom

Day Medal
Robert A. Berner
Department of Geology, Yale University, New Haven, CT 06520

Donath Medal (Young Scientist Award)
Paul R. Bierman
Department of Geology, University of Vermont, Burlington, VT 05405

New Honorary Fellows
Alfonso Bosellini
Instituto di Geologia, Università Ferrara Corso Ercole d'Est 32, 44100 Ferrara, Italy

Bruno d'Argenio
Dipartimento de Scienze della Terra, Università Federico II, Largo San Marcellino 10, 80138 Naples, Italy

Paul Tapponnier
Laboratoire de Tectonique et Mécanique de la Lithosphère, Institut de Physique du Globe de Paris, 4 Place Jussieu, 75252 Paris Cedex 05, France

GSA Distinguished Service Award
David Fountain
Department of Geology and Geophysics University of Wyoming, P.O. Box 3006 University Station, Laramie, WY 82071-3006

Royann (Gardner) Cygan
8125 E. Geddes Avenue, Englewood, CO 80112-1817

Louis C. Pakiser, Jr.
111 Emerson Street, Apt. 1142, Park Place Denver, CO 80218

Anthony Reso
Peak Production Company, P.O. Box 130785, Houston, TX 77219-0785

Rip Rapp Archaeological Geology Award
Larry D. Agenbroad
Department of Geology, Northern Arizona University, P.O. Box 4099, Flagstaff, AZ 86011-4099

Gilbert H. Cady Award (Coal Geology Division)
Frank E. Kottlowski
New Mexico Bureau of Mines, New Mexico Institute of Mining and Technology Campus Station, Socorro, NM 87801-4796

E.B. Burwell, Jr., Award (Engineering Geology Division)
Gerard Shuirman
1426 Eastwind Circle, Westlake Village, CA 91361

James E. Slosson
Slosson and Associates, 15500 Erwin Street, Suite 1123, Van Nuys, CA 91411

George P. Woollard Award (Geophysics Division)
Nikolas I. Christensen
Department of Earth and Atmospheric Sciences, 1397 CIVL Building, Purdue University, West Lafayette, IN 47907-1397

History of Geology Award
Gordon L. Herries Davies
Ballinaclough House, Ballinaclough Nenagh, County Tipperary, Ireland

O. E. Meinzer Award (Hydrogeology Division)
John L. Wilson
Department of Earth and Environmental Science, New Mexico Institute of Mining and Technology, Campus Station, 801 Leroy, Socorro, NM 87801

G. K. Gilbert Award (Planetary Geology Division)
Robert P. Sharp
Division of Geological and Planetary Science, 170-25, California Institute of Technology, Pasadena, CA 91125

Kirk Bryan Award (Quaternary Geology and Geomorphology Division)
Roger T. Saucier
4325 Winchester Road, Vicksburg, MS 39180-8969

Structural Geology and Tectonics Division Career Contribution Award
Winthrop D. Means
Department of Geological Sciences, SUNY at Albany, 1400 Washington Avenue, Albany, NY 12222 ■

Impacts *continued from p. 15*

from engineered structures and extraction activities.

The main output of the project will be a global assessment of (1) the amount of soil, rock, and waste moved and created by towns and cities, (2) the volume of rock extracted for human use, including sand and gravel, limestone, coal, and minerals, (3) the volume of oil, gas, and water extracted to meet social needs, and (4) the changes that the movements of these resources cause to river and coastal systems. The assessment will be published as a book in the SCOPE series. The book will show how transfer of materials links mining areas to cities, rivers, and coastlines, and how these environments respond to human activities in different geologic settings. It will also include an assessment of present policies and practices concerning urban development and mineral extraction, as well as guidelines and recommendations for improving these policies.

We will convene a one-day theme session titled "Global Impacts of Mining and Urbanization on Fluvial and Coastal Systems" as part of the 1996 GSA Annual Meeting in Denver, Colorado. The session, cosponsored by the GSA Institute for Environmental Education and SCOPE, reflects growing concerns that steadily increasing human habitation may be adversely and irreversibly altering global land, water, and air resources. Several papers will be presented by members of the ESPROMUD project, but we encourage other presentations that address the impacts of urbanization and mineral extraction on fluvial and coastal environments. ■

Call for Applications — International Secretariat

GSA seeks a Member or Fellow interested in serving a three-year term in a new GSA endeavor: an International Secretariat. Demonstrated international activities are essential to this volunteer position. The International Secretary will be appointed by Council for a three-year term to:

- Facilitate development of symposia and theme sessions at GSA Annual Meetings and Section meetings (where appropriate) involving geologists from other countries;
- Enhance the international character of GSA by encouraging international membership, encouraging submission of quality articles from other countries to GSA journals, and assisting in providing editorial assistance with English (in cooperation with International Division members) where necessary;
- Utilize *GSA Today* and GSA's Internet site as a medium to publicize international activities, meetings, conferences, programs, and events of the International Division and other GSA entities;
- Facilitate the establishment and development of a worldwide network of collaborative research between U.S. and overseas scientists and institutions;
- Facilitate the establishment of a clearinghouse for sponsors to donate publications, including GSA publications, to needy universities in developing countries;
- Facilitate international collaboration between industry and academia, including symposia planning and corporate sponsorship for foreign attendees at GSA meetings;
- Facilitate contacts between GSA and foreign geological societies, as well as other affiliated societies (e.g., AAPG) with international activities;
- Assist in development of a special GSA membership and dues structure for scientists from developing countries;
- Explore the development of international GSA sections.

GSA headquarters will serve as a resource for operations. Interested individuals should send a vita and other pertinent materials by *August 1, 1996*, to:

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

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GSA's presence on the World Wide Web is growing. New, useful material is being added regularly. Visit us soon. Our Web address is: **http://www.geosociety.org**. That will take you to our home page, and from there you can link to many informational resources. Here are some highlights.

View the **Meetings** page for complete information on the 1996 GSA Annual Meeting in Denver. Use the live links to expand on the information that appeared in the June issue of *GSA Today*.

Go to our **Membership** section to learn about the GSA Employment Service. You'll also find out how to become a GSA Campus Representative, or how to get Member or Student **forms to join GSA.** You'll also find information here on how to nominate a GSA member to **Fellowship** standing.

In the **Education** section, read about GSA's educational programs, including **PEP** (Partners for Education), and Project Earth S.E.E.D. What is IEE? Find out in the **Institute for Environmental Education** section.

See our **Administration** section for information on GSA Medals and Awards, and other general information about GSA.

In our **Publications** section, read the tables of contents and **abstracts of journal articles** each month for *GSA Bulletin* and *Geology.* You'll also find **information for authors** on preparation of articles for submission to GSA publications. Specific guidelines for submissions to *Geology* are a recent addition. There are 12 months of complete issues of *GSA Today,* in living color, that you can read or download. In our **Web Catalog of GSA Publications,** search all GSA's nonperiodical titles in print, read descriptions and tables of contents (for books), or copy from the catalog. You can now submit abstracts electronically for the 1996 GSA Annual Meeting in Denver, via our **Web Abstracts system. (The deadline is July 9.)** (See April *GSA Today*.)

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**.

Penrose Conferences

October 1996

October 8–14, **Exhumation Processes: Normal Faulting, Ductile Flow, and Erosion,** Island of Crete. Information: Uwe Ring, Institut für Geowissenschaften, Universität Mainz, Becherweg 21, D-55099 Mainz, Germany, 49-6131-392164, fax 49-6131-394769, E-mail: ring@mzdmza.zdv.uni-mainz.de.

April 1997

April 24–30, **Paleocene/Eocene Boundary Events in Time and Space,** Albuquerque, New Mexico. Information: William A. Berggren, Department of Geology and Geophysics, Woods Hole Oceanographic Institution, Woods Hole, MA 02543, (508) 289-2593; fax: 508-457-2187, E-mail: wberggren@whoi.edu.

1996 Meetings

September

September 6–9, **47th Highway Geology Symposium,** Cody, Wyoming. Information: G. Michael Hager, Wyoming Dept. of Transportation, Geology Program, P.O. Box 1708, Cheyenne, WY 82003, (307) 777-4475, fax 307-777-3994.

September 9–12, **MINExpo International '96,** Las Vegas, Nevada. Information: National Mining Association, 1130 17th St., NW, Washington, DC 20036.

September 20–October 2, **American Association of Radon Scientists and Technologists,** Haines City, Florida. Information: Teedra Hudson, (309) 728-2363, fax 309-728-2364 or (312) 996-2613, fax 312-413-1857, E-mail: nishna@aol.com.

October

October 8–11, **Large and Unique Deposits of Rare and Precious Metals** International Symposium, St. Petersburg, Russia. Information: Y. B. Marin, St. Petersburg State Mining Institute, 21—th Line, 2, V.O., St. Petersburg 199026, Russia, phone 7-812-2188247, fax 7-812-2132613, E-mail: marin@mineral.spb.su.

October 11–12, **Geological Association of New Jersey 13th Annual Meeting.** Information: Jim Brown, G.A.N.J. at J.M.Z. Geology, 43 Emory Ave., Flemington, NJ 08822, (908) 738-0505, fax 908-788-0388.

November

November 11–15, **Comparative Evolution of PeriTethyan Rift Basins,** Cairo, Egypt. Information: William Cavazza, Dept. Earth and Geoenvironmental Sciences, University of Bologna, Bologna, Italy, fax 39-51-243-336, E-mail: cavazza@geomin.unibo.it.

1997 Meetings

January

January 13–17, **Tailings and Mine Waste '97,** Fort Collins, Colorado. Information: Linda Hinshaw, Dept. of Civil Engineering, Colorado State University, Fort Collins, CO 80523, (970) 491-6081, fax 970-491-3584 or 7727.

February

February 2–7, **American Meteorological Society 77th Annual Meeting,** Long Beach, California. Information: Evelyn Mazur, American Meteorological Society, 45 Beacon St., Boston, MA 02108-3693, (617) 227-2426, ext. 204.

March

March 5–9, **American Society for Environmental History Biennial Meeting,** Baltimore, Maryland. Information: Jeffrey Stine, National Museum of American History, MRC 629, Smithsonian Institution, Washington, DC 20560, fax 202-357-4256.

March 17–19, **Fourth International Conference on Remote Sensing for Marine and Coastal Environments,** Orlando, Florida. Information: Wendy Raeder, ERIM, (313) 994-1200, ext. 3453, fax 313-994-5123, E-mail: raeder@erim.org, Web: http://www.erim.org/CONF/conf/html.

March 25–26, **Marine Clastics in the Southern Midcontinent,** Norman or Oklahoma City, Oklahoma. Information: Kenneth S. Johnson, Oklahoma Geological Survey, 100 East Boyd, Rm. N-131, Norman, OK 73019, (405) 325-3031, fax 405-325-7069.

Calendar *continued on p. 31*

1996

Denver, Colorado
October 28–31
Colorado Convention Center

Call for Papers: **April and June *GSA Today***
Abstract Deadline: **July 9**
Preregistration Deadline: **September 20**
Technical Program Schedule:
September *GSA Today* and the Web

Registration and housing materials appear in June **GSA Today. *REGISTER TODAY!***

GSA Continuing Education Courses—Register now!

Registration information and full course descriptions were published in the June issue of *GSA Today*. To register contact Edna Collis, Continuing Education Coordinator, GSA headquarters, (303) 447-2020 ext. 134; E-mail: ecollis@geosociety.org.

1. Geomorphic Expression of Active Tectonics. Saturday, October 26 and Sunday, October 27. University of New Mexico, Albuquerque. Cosponsored by *Structural Geology* & *Tectonics Division and Quaternary Geology and Geomorphology Division.*
Faculty: Frank J. Pazzaglia, University of New Mexico; Nicholas Pinter, Yale University. **Limit:** 40. Fee: $325, students $305; includes course manual, lunch both days, and van transportation from Albuquerque to Denver. CEUs: 1.6.

2. How To Do Anything with Mohr Circles (Except Fry an Egg): A Short Course About Tensors for Structural Geologists. Saturday, October 26 and Sunday, October 27. Colorado Convention Center. Cosponsored by *Structural Geology and Tectonics Division.*
Faculty: Winthrop D. Means, State University of New York at Albany. **Limit:** 30. Fee: $195, students $175, includes two course manuals and lunch on Saturday. CEUs: 1.2.

3. New Numerical Techniques for Sedimentary Data: Fractals and Nonlinear Dynamics. Saturday, October 26 and Sunday, October 27. Colorado School of Mines, Golden. Cosponsored by *Sedimentary Geology Division and Society for Sedimentary Geology (SEPM).*
Faculty: Gerard V. Middleton, McMaster University, Ontario; Roy E. Plotnick, University of Illinois; David M. Rubin, U.S. Geological Survey, Menlo Park. **Limit:** 40. Fee: $320, students $300; includes course manual and lunch both days. CEUs: 1.6.

4. Applications of Environmental Isotopes to Solving Hydrologic and Geochemical Problems. Sunday, October 27. Colorado Convention Center. Cosponsored by *Hydrogeology Division.*
Faculty: Carol Kendall, U.S. Geological Survey, Menlo Park; Robert J. Drimmie, University of Waterloo, Ontario. **Limit:** 50. Fee: $205, students $155; includes course manual, lunch, and casual postcourse reception. CEUs: 0.8.

5. Applications of GPS in the Earth Sciences. Sunday, October 27. University NAVSTAR Consortium, (UNAVCO), Boulder. Cosponsored by *Structural Geology and Tectonics Division.*
Faculty: Charles Meertens, University NAVSTAR Consortium, University Corporation for Atmospheric Research, Boulder; Roland Burgmann, University of California, Davis. **Limit:** 40. Fee: $185, students $165; includes course manual and lunch. CEUs 0.8.

6. Effective Teaching of Hydrogeology: How To Make Do with Scant *Real World* Data. Sunday, October 27. Colorado Convention Center. Cosponsored by *Hydrogeology Division* and *National Association of Geoscience Teachers.*
Faculty: Donald I. Siegel, Syracuse University. **Limit:** 100. Fee $175, students $125; includes course manual and lunch. CEUs: 0.8.

7. Recognition, Investigation, and Mitigation of Landslides. Sunday, October 27. Colorado Convention Center. Cosponsored by *Engineering Geology Division.*
Faculty: Jerome V. DeGraff, U.S. Forest Service, Clovis, California; Michael W. Hart, Consultant, San Diego; William R. Cotton, William Cotton & Associates, Inc., Los Gatos, California. **Limit:** 50. Fee $170, students $150; includes course manual, slide set, and lunch. CEUs: 0.8.

8. Vadose Zone Hydrology: Introduction and Applications to Water and Solute Transport. Sunday, October 27. Colorado Convention Center. Cosponsored by *Hydrogeology Division.*
Faculty: Scott W. Tyler, Desert Research Institute and University of Nevada, Reno; Bridget Scanlon, Texas Bureau of Economic Geology, Austin. **Limit:** 30. Fee: $310, students $255; includes course manual and lunch. CEUs: 0.8.

New Course!

Geophysical Map Interpretation on the PC

Thursday, October 24 through Saturday, October 26; Jefferson County Schools Training Center, Golden, Colorado. Sponsored by *Society of Economic Geologists.*

Tien Grauch and others from the U.S. Geological Survey have volunteered to teach their course *Geophysical Map Interpretation for the PC* again at the GSA Annual Meeting in Denver. They taught this course to a maximum capacity crowd at the SEG Meeting in Denver in 1993 and received excellent reviews.

Introductory lectures will address the principles of mapping with gravity, airborne EM, magnetic, remote sensing, and radiometric data for mineral exploration problems on district scale, followed by hands-on exercises on the PC in interpretation of gridded geophysical data in terms of geologic structures and lithologies related to mineral deposits. Data from the Getchell gold trend area, Nevada, will be used for illustrative examples and exercises. Topics will include (1) physical-property parameters available from geophysics and their relations to geology, (2) characteristics and limitations of geophysical data, (3) display methods used for areal geophysical data, (4) techniques of data enhancement, and (5) methods of integration and correlation among various data types. The workshop will focus on use of PC-based software developed at the USGS for analyzing gridded geophysical data.

Participants should have a basic knowledge of geological and geophysical exploration techniques and a working knowledge of MS-DOS and IBM-compatible computers (PCs). Software, instruction materials, Getchell data, and the use of a PC for each participant will be supplied. Participants may bring their own data sets, provided they are in standard USGS grid format (format can be supplied upon request).

Limit: 20. Cost: $250. For information and registration: V. J. S. (Tien) Grauch or Jeffrey D. Phillips, U.S. Geological Survey, MS 964, Federal Center, Denver, CO 80225, (303) 236-1393 or (303) 236-1206, E-mail: tien@musette.cr.usgs.gov or jeff@musette.cr.usgs.gov.

GSA Section Meetings — 1997

1997

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

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

Technical Program Chair: ***John Bartley,*** *University of Utah*

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

Paul Link, *Department of Geology, Idaho State University, Pocatello, ID 83209-8072, (208) 236-3365, fax 208-236-4414, E-mail: linkpaul@isu.edu,*

Bart Kowallis, *Department of Geology, Brigham Young University, Provo, UT 84602-4646, (801) 378-3918, fax 801-378-2265, E-mail: bjk@geology.byu.edu*

Field trip guides will be published jointly by Brigham Young University Geology Studies and the Utah Geological Survey. Review drafts of field guides will be due March 15, 1997.

CALL FOR

1997 Continuing Education Course Proposals

Proposals Due by December 1

The GSA Committee on Continuing Education invites those interested in proposing a GSA-sponsored or cosponsored course or workshop to contact GSA headquarters for proposal guidelines. Continuing Education courses may be conducted in conjunction with all GSA annual or section meetings. We are particularly interested in receiving proposals for the 1997 Salt Lake City Annual Meeting or the 1998 Toronto Annual Meeting.

Proposals must be received by December 1, 1996. Selection of courses for 1997 will be made by February 1, 1997. For those planning ahead, we will also consider courses for 1998 at that time.

For proposal guidelines or information, contact:

Edna Collis, Continuing Education Coordinator,

GSA headquarters 1-800-472-1988, ext. 134.

E-mail: ecollis@geosociety.org

Call for Papers

NORTHEASTERN SECTION

March 17–19, 1997
Sheraton Valley Forge Hotel,
King of Prussia, Pennsylvania

Abstract Deadline:
November 12, 1996

Submit completed abstracts to:
Allan M. Thompson
Department of Geology
University of Delaware
Newark, DE 19716-2541

(302) 831-2585
thompson@bach.udel.edu

SOUTH-CENTRAL/ ROCKY MOUNTAIN SECTIONS

March 20–21, 1997
University of Texas, El Paso, Texas

Abstract Deadline:
November 25, 1996

Submit completed abstracts to:
Elizabeth Y. Anthony
Department of Geological Sciences
University of Texas
El Paso, TX 79968-0555

(915) 747-5483
anthony@geo.ltp.edu

SOUTHEASTERN SECTION

March 27–28, 1997
Auburn University, Auburn, Alabama

Abstract Deadline:
December 2, 1996

Submit completed abstracts to:
Charles E. Savrda
Department of Geology
Auburn University
Auburn, AL 36849-5305

(334) 844-4893
savrdce@mail.auburn.edu

NORTH-CENTRAL SECTION

May 1–2, 1997
The Concourse Hotel, Madison, Wisconsin

Abstract Deadline:
January 9, 1997

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

CORDILLERAN SECTION

May 21–23, 1997
Kona Surf Resort and Convention Center
Kailua-Kona, Hawaii

Abstract Deadline:
January 24, 1997

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

For information on any GSA meeting call the GSA Meetings Department

1-800-472-1988 or
(303) 447-2020, ext. 133
E-mail: meetings@geosociety.org
or see GSA's World Wide Web page at http://www.geosociety.org

1997 SECTION MEETING ABSTRACT FORM REQUEST

To: GSA Abstracts Coordinator, P.O. Box 9140, Boulder, CO 80301-9140
or E-mail: ncarlson@geosociety.org

Please send _____ copies of the 1997 GSA Section Meeting abstract form.

Name _____

Address _____

_____

City _____ State_____ ZIP _____

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
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Opportunities for Students		
first 25 lines	$0.00	$2.35
additional lines	$1.35	$2.35

Code number: $2.75 extra

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

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

The Caswell Silver
Research Assistant Professor
THE UNIVERSITY OF NEW MEXICO

The Department of Earth and Planetary Sciences, University of New Mexico, is seeking an outstanding earth scientist to fill the position of Caswell Silver Research Assistant Professor for a period of up to two years beginning in August, 1997. This research assistant professorship is a full-time, academic year endowed chair within the Department, supported by the Caswell Silver Foundation. Applicants must have the Ph.D. degree and be no more than 3 years past reception of that degree at the time the position begins, and be actively involved in innovative, high-quality research, as documented by an excellent publication record. Preference will be given to candidates whose work defines new directions in earth sciences research, addresses fundamental questions, and/or represents a synthesis of approaches from more than one subdiscipline of the earth sciences. During residence in the Department, the successful candidate will be expected to pursue his/her own research, and to interact with faculty and students in research seminars and in ongoing research programs. Thus, applicants must provide a clear demonstration of potential research interactions with members of the Department.

The Department of Earth and Planetary Sciences has 18 faculty, 6 research professors and 10 other research scientists and post-doctoral scientists. Analytical facilities are excellent (e.g., SEM, AEM, EMPA, SIMS, XRD, ICP-MS, radiogenic and stable isotope, paleomagnetism labs), and UNM is situated in a spectacular state and regional geologic setting. The Department has strong collaborative research programs with other departments at UNM, and with Sandia, Los Alamos and other national laboratories. Full-time, academic year salary, paid by the Silver Foundation, is competitive and negotiable, and additional funds are available for travel and research.

Applications including a detailed outline of proposed research and other potential activities, CV with publications and reprints, and a list of 5 people who may be contacted for letters of reference, should be sent to:

Dr. John W. Geissman,
Caswell Silver Research
Assistant Professorship Search
Committee Chair
Department of Earth and Planetary Sciences
University of New Mexico
Albuquerque, NM 87131.

The deadline for applications is October 1, 1996.
The University of New Mexico is an equal opportunity/affirmative action employer

Positions Open

HYDROGEOSCIENCE, VIRGINIA TECH

The Department of Geological Sciences at Virginia Polytechnic Institute and State University (Virginia Tech) continues to seek rolling applications to hire faculty as part of restructuring using opportunities created by retirements. At this time we are inviting applications for a second tenure-track faculty position in Hydrogeoscience (first hydro position filled in 1995-96). The position is at the Assistant Professor level only and the department intends to fill the position in the 1996-97 academic year. Candidates with a strong quantitative background in fluid flow/transport in subsurface porous/fractured media including multi-phase flow are encouraged to apply. A Ph.D. is expected at the time of appointment. Review of applications will begin July 1, 1996, and continue until the position is filled.

The present faculty, 19 full-time tenured and 2 part-time, have diverse strengths and represent economic geology, earthquake seismology, exploration geophysics, geochemistry, hydrogeosciences, mineralogy, paleontology, petrology, sedimentology, structural geology, and tectonics. For detailed information applicants are encouraged to visit the departmental home page at http://www.geol.vt.edu. The department offers B.S., M.S., and Ph.D. degrees in geological and geophysical sciences. Faculty are expected to teach introductory level undergraduate geoscience courses and undergraduate/graduate level courses in their areas of expertise. They are also expected to direct M.S. and Ph.D. candidates while developing and maintaining externally funded research programs. New faculty will play a central role in collaborating with complementary department/university programs and developing applied programs to prepare students for future job markets. Candidates must be able to demonstrate expertise in quantitative applications in the geosciences.

Interested applicants should send a letter of interest, curriculum vitae, transcripts, names of three references, a statement of anticipated research and teaching interests, along with a short essay explaining where the applicant would like to see him/herself within the geosciences in the 21st century. Applicants should send their application package to Cahit Çoruh, Chairman, Department of Geological Sciences, Virginia Tech, 4044 Derring Hall, Blacksburg, VA 24061-0420; Phone: 540-231-6894; TDD: 540-231-3749; fax: 540-231-3386; E-mail: coruh@vt.edu

Virginia Tech has a strong commitment to the principle of diversity and, in that spirit, seeks a broad spectrum of candidates including women, minorities, and people with disabilities. Individuals with disabilities desiring accommodations in the application process should notify Cahit Çoruh at the above address. Virginia Tech is an equal opportunity/affirmative action employer.

INSTITUTE OF GEOSCIENCES
UNIVERSIDADE OF SÃO PAULO

A vacancy exists for a full-time Lecturer Grade MS3 in the Geology Department. Candidates should have a Ph.D. and some teaching and research experience. The salary is R$2,400/month. The initial contract will have a duration of XX years. Duties include undergraduate and post-graduate teaching, orientation of undergraduate and post-graduate research students and research work. A knowledge of Portuguese is essential. Applications will be received up to 3 August 1996. Further details on necessary documents and on the selection process, which will take place in São Paulo, may be obtained from: Att: Prof. Wilson Teixeira, fax (55) (11) 8183993; E-mail: wteixeira@usp/br

EXECUTIVE DIRECTOR
UNIVERSITY OF ALABAMA MUSEUMS
THE UNIVERSITY OF ALABAMA
TUSCALOOSA, ALABAMA

The University of Alabama seeks an experienced museum administrator to serve as Executive Director of the University of Alabama Museums. The Executive Director oversees the University's museum system, which includes the Alabama Museum of Natural History, Moundville Archaeological Park, and the Paul W. Bryant Museum, with responsibility for a staff of 41 and an annual operating budget of $1.75 million. Candidates should have an understanding of museum policies and practices and demonstrated skill in leadership and management, communication, and strategic and fiscal planning. Qualified candidates must have an advanced degree, at least five years of museum administrative experience, and a successful record in public and private fund-raising, policy and program development, and personnel and budget management. Salary commensurate with experience. Excellent benefits. Review of applications will begin September 1. Position to be filled by January 1997. AA/EOE.

Submit letter of interest, resume, and references to: LaPaglia & Associates, Att: James B. Gardner, 320 East Main, Suite 203, Murfreesboro, TN 37130.

ATTENTION GEOLOGISTS PRACTICING IN THE STATE OF ALABAMA

On October 1, 1995, the Alabama Professional Geologists Act became law. Pursuant to the Act, all geologists who publicly practice geology in the State of Alabama, unless otherwise exempt, must become licensed. The Act specifies that for one year beginning on a date set by the Board, a grace or grandfather period will exist to allow geologists to be come licensed without meeting the examination requirements of the Act. Beginning in June 1996, the Alabama Board of Licensure will begin accepting applications from qualified individuals who seek licensure in Alabama. Application forms may be obtained from the Executive Secretary at the address given below. The application fee is $25.00 and must accompany the request for application materials.

Alabama Board of Licensure for Professional Geologists; Attention: Keith Warren, Executive Secretary, 660 Adams Avenue, Suite 254, Montgomery, AL 36104 (Mailing address: Post Office Box 175, Montgomery, AL 36101-0175). Telephone: (334) 264-0730; fax 334-263-6115.

GEOLOGY MINOR PROGRAM
COOORDINATOR / LECTURER

The Department of Geology and Geophysics at the University of Minnesota seeks an energetic, outgoing individual with an M.S. or a Ph.D. (preferred) in Earth Sciences and one year teaching experience to develop and coordinate a series of environment-oriented earth science courses aimed at sophomore/junior level non-geology majors. The new courses can be used to satisy a Geology minor requirement, and are designed to examine the relationships between geologic processes or Earth resources and society. Examples include *Climate Change and Human History, Water and Society,* and *Humans as Geologic Agents.*

The successful applicant will work with faculty to develop innovative ways to enhance instruction, especially of non-science students and teach 1-2 courses each quarter. The 10-month, non-tenure track appointment will be for 3 years with a possibility for renewal, and carries full health and life insurance benefits. The appointment will begin December 1, 1996. Interested persons are invited to send a letter of application describing their teaching interests and experience along with a copy of resume and a list of three references by August 31, 1996, to Dr. Emi Ito, Department of Geology and Geophysics, University of Minnesota, 310 Pillsbury Drive, S.E., Minneapolis, MN 55455. Questions can be directed to her at eito@maroon.tc.umn.edu. The University of Minnesota is an equal opportunity educator and employer.

CALIFORNIA INSTITUTE OF TECHNOLOGY
Assistant Professor of Geology

Applications are being accepted for a tenure-track faculty position in geology in the Division of Geological and Planetary Sciences at the Assistant Professor level. The initial appointment is for four years. It is possible that a candidate with exceptional qualifications may be considered for a position at a higher level. A strong commitment to innovative research utilizing the geological record to investigate fundamental processes in the evolution of earth and to teaching at both the undergraduate and graduate level are expected. We are particularly interested in scientists whose work relates to (1) development of quantitative methods for understanding processes in the deep crust and upper mantle; and (2) surficial systems, with emphasis on the development and evolution of geomorphic surfaces, chemical sedimentation, and the record in sediments of climatic and earth dynamic processes.

A curriculum vitae including a list of publications, a brief description of proposed research activities, and names of three referees should be sent to Professor Edward M. Stolper, Chairman, Division of Geological and Planetary Sciences, Mail Stop 170-25, California Institute of Technology, Pasadena, California 91125.

The California Institute of Technology is an Equal Opportunity/Affirmative Action Employer. Women, minorities, veterans, and disabled persons are encouraged to apply.

STRATIGRAPHY / BASIN ANALYSIS

The Department of Geological Sciences of Rutgers, The State University of New Jersey (New Brunswick) seeks to fill an anticipated tenure-track position at the Assistant Professor level in the field of Stratigraphy and Basin Analysis beginning in September 1997. Exceptionally accomplished applicants at more senior levels will be considered.

We seek candidates with proven research capability in integrating geochemical, geophysical, and stratigraphic data. While the subdiscipline is open, we desire expertise in isotopic stratigraphy, magnetostratigraphy, biostratigraphy, or cyclostratigraphy to complement current faculty strengths. The successful candidate should interact with ongoing regional and inter-regional studies; these include current projects on the rift, passive margin, and foreland basins represented in the New Jersey region and their global counterparts. Our goal is to establish and maintain a gas mass spectrometry or magnetostratigraphy/multisensor track laboratory in collaboration with the new faculty member. In addition to developing an innovative, forward-looking research program, a solid commitment to undergraduate and graduate teaching is required.

A curriculum vitae, statement of research interests, and the names of four references should be sent by 15 November, 1996, to Dr. Kenneth G. Miller, Chair of the Search Committee, Department of Geological Sciences, Rutgers University, Piscataway, NJ 08855-1179. Rutgers University is an equal opportunity/affirmative action employer.

WANTED: Geoscientists. Are you in need of a new direction? Begin with a GSA Continuing Education Course. See the June issue of *GSA Today* for registration and information about the courses to be offered at the GSA Annual Meeting in Denver, October 21-31. Or contact Edna Collis at GSA: 1-800-472-1988 or 303-447-2020 ext. 134, E-mail: ecollis@geosociety.org, or fax 303-447-0648.

Opportunities for Students

Graduate Assistantships. Due to an unusually large number of M.S. completions during this last year, the Department of Geosciences at Northeast Louisiana University has Graduate Assistantships available for 1996-1997. These include tuition waivers. The Department offers a M.S.; particular strengths of the Department include: Hydrogeology/Environmental Geology; Micropaleontology/Biostratigraphy; Paleoecology/Taphonomy; Sedimentology/Physical Stratigraphy; Geoarchaeology. For additional information about the Department, faculty, facilities, etc., visit our home page at T-P://hurricane.net2.nlu.edu/~geos/geoscience. html. To apply, contact Dr. M. Kontrovitz at Department of Geosciences, Northeast Louisiana University, Monroe, LA 71209; (318) 342-1878; E-mail: geokontrovitz@alpha.nlu.edu

Do you have an opportunity for a student? Your first 25 lines are ***FREE****!. Contact the GSA Advertising Department. Copy is due by the first of the month, one month prior to issue.*

Calendar *continued from p. 27*

April

April 6–9, **Sinkholes and the Engineering and Environmental Impacts of Karst** Sixth Conference, Springfield, Missouri. Information: B. F. Beck, P. E. LaMoreaux & Assoc., Inc., P.O. Box 4578, Oak Ridge, TN 37831-4578, (423) 483-7483, E-mail: pelaor@use.usit.net.

April 14–18, **Plumes, Plates and Mineralization** International Symposium, Pretoria, South Africa. Information: S. A. De Waal, fax 27-12-433430, E-mail: ppm97@scientia.up.ac.za.

June

June 15–21, **Eleventh International Clay Conference,** Ottawa, Ontario. Information: Jeanne Percival, Geological Survey of Canada, 601 Booth St., Ottawa, Ontario K1A 0E8, Canada, fax 613-943-1287, E-mail: ICC97@gsc.emr.ca.

June 15–21, **Clay Minerals Society 34th Annual Meeting,** Ottawa, Ontario. Information: Hideomi Kodama, Center for Land & Biological Research, Agriculture Canada C.E.F., Ottawa, Ontario K1A 0C6, Canada, (613) 995-5011, fax 613-995-1823, E-mail: kodama@ncccot.agr.ca.

June 18–19, **Late Quaternary Coastal Tectonics,** London, UK. Information: Iain Stewart, Dept. of Geography & Geology, Brunel University, Borough Rd., Isleworth TW7 5DU, UK, phone 44-181-8910121, fax 44-181-5699198, E-mail: iain.stewart@brunel.ac.uk.

June 18–20, **Water Pollution Modelling, Measuring and Prediction** Fourth International Conference, Bled, Slovenia. Information: Liz Kerr, WATER POLLUTION 97 Conference Secretariat, Wessex Institute of Technology, Ashurst Lodge, Ashurst, Southampton SO40 7AA, UK, phone 44-1703-293-223, fax 44-1703-292-853, E-mail: wit@wessex.witcmi.ac.uk, Web: http://www.witcmi.ac.uk (choose conference information link). (*Abstract deadline: August 30, 1996.*)

June 22–25, **Tectonics, Stratigraphy & Petroleum Systems of Borneo** International Workshop, Bandar Seri Begawan, Brunei. Information: James W. Granath, Conoco, Inc., 600 North Dairy Ashford, Houston, TX 77079-6651, (713) 292-6695, fax 713-293-1333, E-mail: granajw@howwe.dnet.dupont.com.

June 23–27, **Engineering Geology and the Environment** International Symposium, Athens, Greece. Information: Hellenic Committee of Engineering Geology, Athens 1997 Symposium Secretariat, P.O. Box 19140, GR-117 10, Athens, Greece, phone 30-1-3813900 or 3804375 or 9225835, fax 30-1-3813900 or 9242570. (*Abstract deadline: September 30, 1996.*)

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