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INSIDE

Evidence for Life in a Martian Meteorite?

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ABSTRACT

The controversial hypothesis that the ALH84001 meteorite contains relics of ancient martian life has spurred new findings, but the question has not yet been resolved. Organic matter probably results, at least in part, from terrestrial contamination by Antarctic ice meltwater. The origin of nanophase magnetites and sulfides, suggested, on the basis of their sizes and morphologies, to be biogenic remains contested, as does the formation temperature of the carbonates that contain all of the cited evidence for life. The reported nanofossils may be magnetite whiskers and platelets, probably grown from a vapor. New observations, such as the possible presence of biofilms and shock metamorphic effects in the carbonates, have not yet been evaluated. Regardless of the ultimate conclusion, this controversy continues to help define strategies and sharpen tools that will be required for a Mars exploration program focused on the search for life.

INTRODUCTION

Since the intriguing proposal last summer that martian meteorite Allan Hills (ALH) 84001 contains biochemical markers, biogenic minerals, and microfossils (McKay et al., 1996), scientists and the public alike have been treated to a variety of claims supporting or refuting this hypothesis. Occasionally, the high visibility of the controversy has overshadowed the research effort (e.g., Begley and Rogers, 1997), but I believe that science will benefit significantly from this experience. If the hypothesis is confirmed, it will rank among the major discoveries of all time. If not, McKay and his colleagues have still demonstrated that microparticles, soluble minerals, and possibly organic matter can survive on the red planet for billions of years, which provides a hopeful outlook for a Mars exploration program focused on the search for life.

This article reviews recently published research bearing on this important topic. Most of this literature exists only as conference abstracts and technical comments in scientific journals. There seems to be virtually no argument, at least within the planetary science community, that ALH84001 is a sample of the ancient (~4.5 Ga) martian crust (e.g., Mittlefehldt, 1994; McSween, 1994; Clayton and Mayeda, 1996; Goswami et al., 1997). This ultramafic igneous rock (Fig. 1) is crosscut by breccia zones containing small carbonate grains, which are the hosts for organic matter as well as reported biogenic materials and microfossils. This article addresses and expands upon the four lines of evidence for possible biologic activity cited by McKay et al. (1996).

ORGANIC MATTER

McKay et al. (1996) described fused hydrocarbon rings (polycyclic aromatic hydrocarbons, or PAHs) associated with the carbonates in ALH84001. The identification of specific molecules in a sample containing ~1 ppm PAHs ranks as a triumph of analytical ingenuity. Although PAHs do not play a significant role in the biochemistry of terrestrial organisms, they can form by geochemical transformation of certain hydrocarbons present in decayed organisms. PAHs also form by abiotic processes such as the combustion of fossil fuels, and they are common constituents of chondritic meteorite kerogens (Zenobi et al., 1989). Anders (1996) noted that PAHs are produced by pyrolosis (thermal decomposition) whenever graphite formation is kinetically inhibited. He further pointed out that the "few specific PAHs" from C_{14}

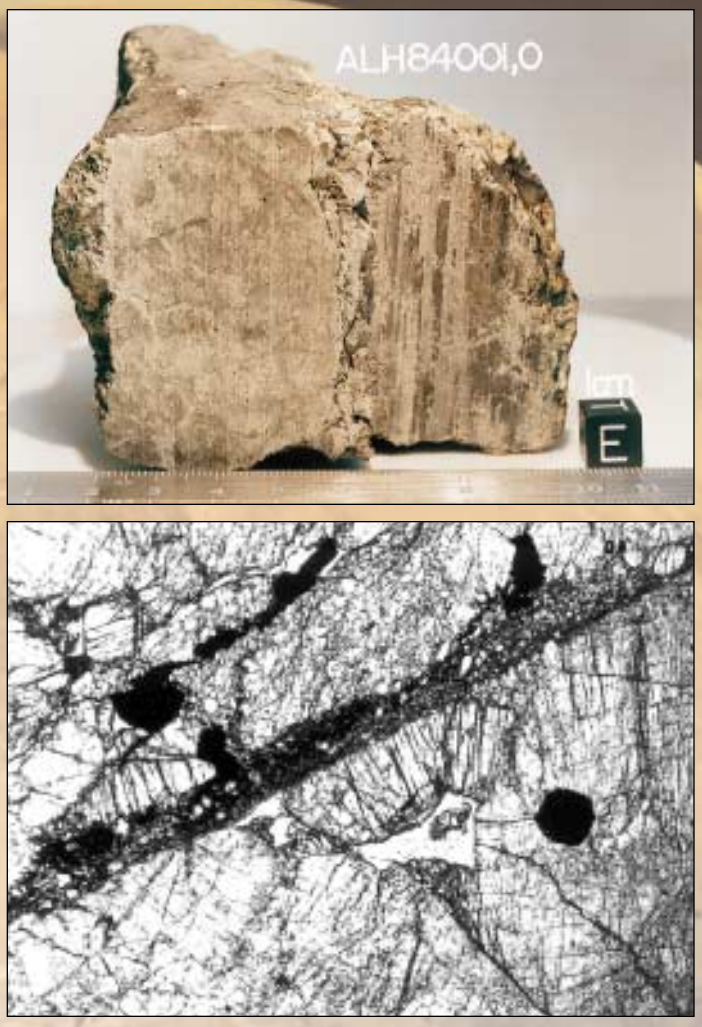

Figure 1. Mars is thought to be the parent body of a dozen igneous meteorites (achondrites). The ALH84001 achondrite was recovered in Antarctica in 1984, but it was not recognized as a martian sample until a decade later. This orthopyroxene cumulate rock (cube is 1 cm) is crosscut by fracture zones (see thin section view; long axis is ~0.5 cm), within which tiny carbonate globules were deposited. The carbonate grains are associated with organic matter and contain microparticles suggested to be martian nanofossils and biogenic minerals. *Photographs courtesy of NASA.*

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In Memoriam

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Portland, Oregon
December 17, 1996

Harold W. Dailey
Franklin, Georgia
January 27, 1997

John J. DeBenedetti
Laguna Hills, California
January 1996

James M. Kirby
Vallejo, California
April 16, 1997

G. Edward Lewis
Lakewood, Colorado
May, 1997

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John E. Riddell
Nova Scotia, Canada
March 1997

Waclaw Ryka
Warsaw, Poland
1996

William J. Stuart
South Australia
April 16, 1996

Livio Trevisan
Pisa, Italy
March 1997

Correction

In the April *GSA Today* (v. 7, no. 4) article "Global Seismic Tomography: A Snapshot of Convection in the Earth" by Stephen P. Grand, Rob D. van der Hilst, and Sri Widiyantoro, the beginning of the caption for Figure 1 (p. 1) should be: "Cross sections of mantle S-wave (A) and P-wave (B) velocity variations along a section through the southern United States." The published description reverses the S-wave and P-wave images.

Meteorite *continued from p. 1*

to C_{22} in ALH84001 suggested to be biogenic by McKay et al. (1996) comprise all homologs in this carbon number range, and thus do not require a selective (biological) source. Clement and Zare (1996) countered that differences in alkylation (the addition of side chains) of the low-mass and high-mass envelopes of the PAHs suggest both low- and high-temperature processing, which might arise through diagenesis of decomposed biologic matter. Bell (1996) suggested that abiotic PAHs could have accreted to Mars as constituents of organic-rich asteroid impactors, several of which still remain in martian orbit as the moons Phobos and Deimos.

New research has focused mostly on characterization of the organic matter in EETA79001, another martian meteorite found in Antarctica. Becker et al. (1997) extracted PAHs using a laser ionization technique similar to that used by McKay et al. (1996) for ALH84001. EETA79001 also contains a low-mass assortment of unalkylated PAHs with masses from C_{14} to C_{22}, as well as a weaker high-mass envelope. The abundance of PAHs (~1 ppm) is similar to that in ALH84001, although the relative proportions of specific PAHs inferred from the spectra are slightly different, possibly resulting from differences in ionization efficiencies for the distinct laser wavelengths used in the analyses. Becker et al. (1997) also performed experiments demonstrating that PAHs are selectively adsorbed onto carbonate. This finding, along with the determination that the assortment of PAHs in both martian meteorites is similar to that measured in Antarctic ice, suggests that the PAHs in both meteorites may result from organic contamination by ice meltwater. On the

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Meteorite *continued from p. 2*

basis of the low abundances of PAHs in ice, Wright et al. (1997a) suggested that the quantity of meltwater that would have to be flushed through the meteorite was prohibitive; however, Antarctic meteorites are sometimes found in puddles, and evaporation of this water would concentrate PAHs. The presence of optically active amino acids (almost exclusively L-enantiomers, the same forms found in terrestrial proteins) in EETA79001 (McDonald and Bada, 1995) supports the idea of organic contamination in the polar environment, and the measured carbon isotopic compositions of organic matter in both meteorites ($\delta^{13}C$ = –22‰ to –25‰; Wright et al., 1989; Grady et al., 1994) are indistinguishable from terrestrial values. The carbon isotopic composition of the carbon source (presumably the atmosphere, with $\delta^{13}C$ = ~ +40‰) implies a fractionation of >60‰ between it and organic matter (Grady et al., 1996). Isotopic effects of this magnitude on Earth require a complex community of organisms that includes methane-producing bacteria and methylotropic bacteria that convert methane into biomass. Such an interpretation for ALH84001 depends on the assumption that both the atmosphere and organic matter equilibrated with the same fluid. A previous announcement of even more extreme carbon isotopic fractionation in ALH84001 carbonate (widely reported in the British press as evidence for life) can now be explained as possible laboratory contamination (Wright et al., 1997b).

BIOGENIC MATERIALS

Another line of evidence for life in ALH84001 cited by McKay et al. (1996) is the presence within carbonates of nanophase magnetite grains morphologically similar to those produced by terrestrial magnetotactic bacteria. Coexisting sulfides (pyrrhotite and greigite were tentatively identified) within the carbonates were also suggested to be biogenic. McKay et al. (1996) argued that coprecipitation of magnetite and sulfides, with concomitant dissolution of carbonate (inferred from its porous microtexture), indicates disequilibrium and thus points to biologic mediation. The geochemical basis for this argument has been criticized by Anders (1996) and Browning and Bourcier (1997).

Bradley et al. (1996) presented transmission electron microscopic images of a variety of tiny magnetite whiskers (rods and ribbons) and platelets in ALH84001 carbonates, adding to the assortment of cuboid, teardrop, and irregular grains described by McKay et al. (1996). The morphologies of bacterially produced magnetite grains are generally species-specific (Bazylinski, 1995), so the diverse magnetite morphologies in this meteorite would imply a rich community of organisms. Bradley et al. (1996) suggested that the whisker morphologies containing internal structural defects (Fig. 2) and twins are unlike the characteristics of biogenic magnetite. Thomas-Keprta et al. (1997) noted that twinning does sometimes occur in biologically induced magnetite, and that at least one bacterium is known to produce magnetite rods, although the specific dislocations seen in ALH84001 magnetite whiskers have not yet been observed in biogenic grains.

Magnetotactic bacteria string crystallographically oriented magnetite grains together into chains (magnetosomes; Fig. 2) that increase the net magnetic moment, used for sensing Earth's geomagnetic field. Thomas-Keprta et al. (1997) interpreted five or six aligned cuboid particles in ALH84001 as a possible magnetosome, but without data on crystallographic orientations of the grains or evidence for the former existence of an organic membrane holding the chain together. However, the preservation of intact fossil magnetosomes is uncommon (Chang and Kirschvink, 1989).

Magnetotactic bacteria produce magnetite within their cells, but some other terrestrial bacteria form extracellular magnetite (Stolz et al., 1990). Vali et al. (1997) described extracellular magnetite produced in the laboratory by thermophilic bacteria; the diamond-shaped grains in these cultures show a wide range in size distribution and random arrangement, and were argued to be similar in size and morphology to magnetites in ALH84001 carbonates.

McKay et al. (1996) suggested that tiny grains of pyrrhotite inside the carbonates in ALH84001 may have formed by sulfate-respiring bacteria. Biogenic sulfides typically contain isotopically light sulfur, as terrestrial bacteria preferentially utilize ^{32}S in making excreted sulfide. Small grains of pyrite occurring outside the carbonates in ALH84001 have been inferred, on the basis of textural criteria, to have coprecipitated with carbonate (although Gibson et al. [1996] suggested that these were unrelated to the sulfides within carbonates). Measured sulfur isotopic compositions of the pyrite grains ($\delta^{34}S$ = +2‰ to +8‰; Shearer et al., 1996; Greenwood et al., 1997) appear to be inconsistent with biologic formation, unless the sulfate precursor was extremely isotopically heavy, the supply of sulfate was limited, or martian organisms utilized sulfur via different biochemical pathways.

McKay et al. (1997) recently proposed yet another kind of biogenic material in ALH84001—lacy network structures in acid-etched carbonates and pyroxenes which resemble microbially secreted organic polymers (biofilms). Although they contain carbon, an organic composition for these curious structures has not yet been established.

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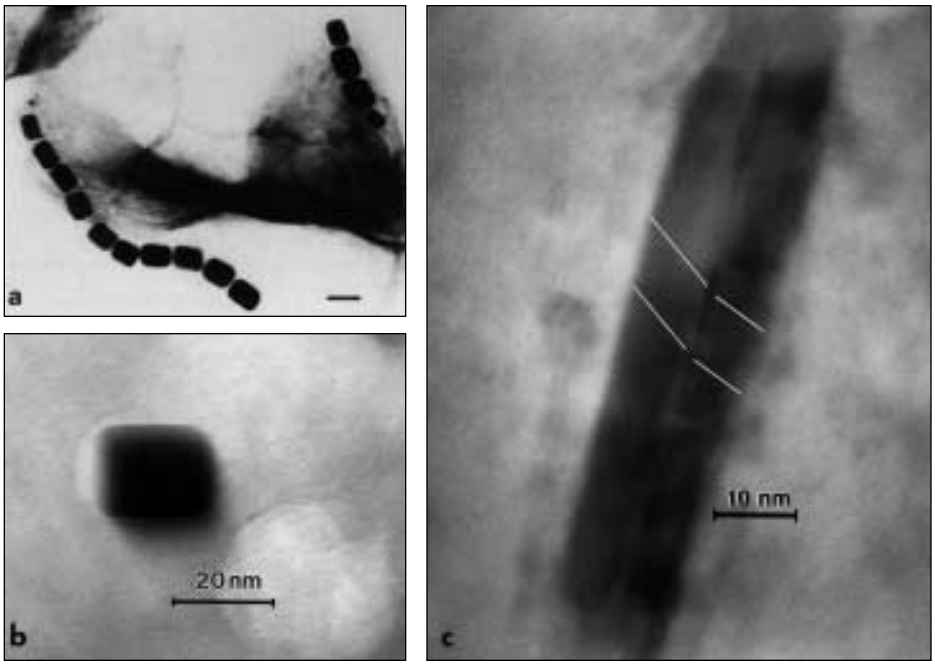

Figure 2. TEM images of single-domain magnetite grains within ALH84001 carbonates and in magnetotactic bacteria. a: Chains of crystallographically oriented nanophase magnetites in *Magnetococcus* bacterium are linked by lipid membranes (scale bar is 100 nm; from Stolz et al., 1990). b: Well-formed magnetite platelet in ALH84001 appears morphologically similar to some biogenic magnetites. c: Magnetite whisker in ALH84001 contains an axial screw dislocation, indicative of spiral growth, probably from a vapor. Lattice fringe orientations on either side of the dislocation (marked by white lines) are distinct. Platelet and whisker images from John Bradley (MVA, Inc.).

Meteorite *continued from p. 3*

NANOFOSSILS

Perhaps the most exciting suggestion by McKay et al. (1996) was that tiny "ovoid and elongated forms" in ALH84001 carbonates were nanofossils. Examination of uncoated microparticles in ALH84001 using atomic force microscopy (Steele et al., 1997) demonstrates that they are not artifacts of sample preparation. Although some microparticles in terrestrial carbonates have been described as nanofossils (e.g., Folk, 1993), the evidence is exclusively morphological, and the hypothesis remains controversial.

The microparticles described as nanofossils in ALH84001 are generally 30 to 150 nm in longest dimension, significantly smaller than terrestrial microorganisms. Only viral symbionts and spores that cannot be recultured are commonly of this size. The internal volumes of these microparticles are commonly thought by biologists to be too small to hold sufficient organic solute molecules to carry out the required metabolic and genetic functions (e.g., Morowitz, 1996). However, it is plausible that starved bacteria could have shrunk prior to their encapsulation within the carbonates. Thomas-Keprta et al. (1997) sidestepped the size issue by suggesting that elongated filaments in ALH84001 may be discarded bacterial appendages.

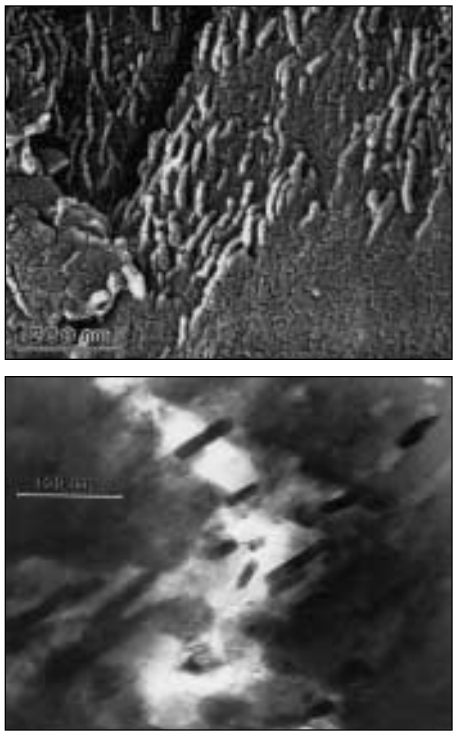

Figure 3. Comparison of an SEM image of putative nanobacteria in ALH84001 carbonates (above) and a TEM image of oriented magnetite whiskers in carbonates (below). Photomicrographs courtesy of NASA and John Bradley (MVA, Inc.), respectively.

The nanofossil controversy, although important in itself, may possibly be moot in the case of ALH84001. Bradley et al. (1997) proposed that the magnetite whiskers and platelets they observed in carbonates are the nanofossils described by McKay et al. (1996). No other microparticles with the sizes and morphologies of the nanofossils have been observed in the carbonates, and fields of oriented magnetite whiskers resemble published SEM images of nanofossils (Fig. 3). The spiral growth mechanism deduced from the presence of axial screw dislocations in magnetite whiskers (Bradley et al., 1996) argues against replacement of microorganisms by magnetite.

CONDITIONS OF CARBONATE FORMATION

The documentation of terrestrial and martian microfossils and biomarkers requires, among other criteria, that the paleoenvironment be a plausible one for biological activity (e.g., Knoll and Walter, 1996). Thus, understanding the formation conditions of the ALH84001 carbonate globules, which are the containers for virtually all of the evidence cited for life, is critical to the argument. Terrestrial organisms survive at temperatures generally below 120 °C, and it seems unlikely that extraterrestrial biota could exist at temperatures far in excess of this value. Constraining the temperature of formation for the carbonates has proved to be the most contentious subject to date.

Globular carbonates in ALH84001 are chemically zoned (Fig. 4), with calcite-ankerite cores and magnesite-siderite rims (Harvey and McSween, 1996). Granular carbonates are compositionally similar to globule cores and are concentrated in pockets and veins throughout the rock (McKay and Lofgren, 1997). Romanek et al. (1994) used the oxygen isotopic compositions of carbonates, determined from an acid dissolution model, to argue that they formed by reaction with aqueous fluids at temperatures <80 °C. Hutchins and Jakosky (1997) revised the carbonate formation temperatures to <250 °C on the basis of a model of atmospheric fractionation of oxygen and carbon prior to incorporation in carbonates. New ion microprobe analyses of oxygen isotopes in carbonate globules indicate highly variable compositions. In particular, Valley et al. (1997) reported $\delta^{18}O$ = +9.5‰ to 20.5‰, whereas Leshin et al., 1997 indicated values of +5.6‰ to +21.6‰. Valley et al. (1997) argued that precipitation of carbonates with these compositions suggests nonequilibrium processes at temperatures <300 °C. Leshin et al. (1997) explained a correlation of carbonate mineral chemistries with oxygen isotopes (Fig. 4) as possibly resulting from high-temperature processes.

Harvey and McSween (1996) noted that the apparent absence of hydrous phyllosilicates in ALH84001 was inconsistent with reaction of an aqueous hydrothermal fluid with an orthopyroxenite host rock. They favored a high-temperature reaction involving a CO_2-rich, supercritical fluid. Thomas-Keprta et al. (1997) described several nanometer-sized grains with basal spacings of 10–11 Å, which they interpreted as smectites. Such grains appear to be rare. Valley et al. (1997) described terrestrial carbonate veins that formed at low temperatures from aqueous fluids without producing hydrous minerals.

Comparisons of ALH84001 carbonate elemental compositions and phase equi-

Meteorite *continued on p. 5*

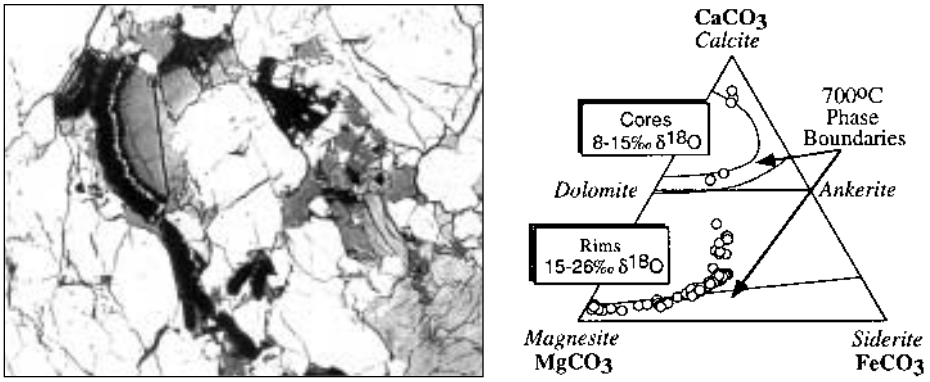

Figure 4. Backscattered electron image (above) of a zoned carbonate globule shows a core of calcite-ankerite (gray) and rim of magnesite (black)-siderite (white) (horizontal axis figure is ~150 µm; courtesy of David Mittlefehldt, Lockheed-Martin Engineering Science Services). Some carbonates have been fractured and disaggregated by shock. Elemental and oxygen isotopic compositional variations (from Harvey and McSween [1996] and L. Leshin [personal commun.], respectively) are illustrated in the figure below. The 700 °C phase boundaries are from Anovitz and Essene (1987); carbonate analyses bridging the gap between ankerite and siderite represent points overlapping several grains. Chemical zoning in carbonates has been cited as evidence for disequilibrium between zones, but the correlation between calcium content and oxygen isotopic composition may also be rationalized by closed-system fractionation within a fluid-poor system.

Meteorite *continued from p. 4*

libria, suggesting formation temperatures of >650 °C (Mittlefehldt, 1994; Harvey and McSween, 1996), have been criticized by some workers (McKay and Lofgren, 1997; Shearer et al., 1996; Treiman, 1997; Valley et al., 1997), who stressed that extensive zoning and isotopic heterogeneity make any attempt to use mineral-exchange geothermometry suspect. Disequilibrium would presumably also invalidate temperature constraints imposed by stable isotope fractionation (Romanek et al., 1994; Leshin et al., 1997). Kinetic control of growth might offer an explanation as to why different lines of evidence suggest distinct formation conditions.

Several other assessments of temperature have reached conflicting conclusions. The assemblage of tiny magnetite whiskers and platelets described in ALH84001 carbonates by Bradley et al. (1996) resemble grains of many substances condensed from vapors, and the spiral growth mechanism documented for some magnetite whiskers (Fig. 2) is consistent with vapor-phase growth. Natural magnetite whiskers have been described in terrestrial volcanic sublimates and grown experimentally from hot (<800 °C) fumarole gases.

Kirschvink et al. (1997) marshaled magnetic evidence in support of a low-temperature origin of ALH84001 carbonates. From a breccia zone they separated two joined orthopyroxene grains, one of which contained carbonate globules on its surface. Each pyroxene grain had stable natural remnant magnetization (NRM) with directions differing by 50° to 80°. These researchers concluded that the grains were not significantly heated after rotation in the breccia zone. Since the carbonates precipitated from fluids percolating through this crushed zone at some later time, they must have formed at low temperature. The NRM temperature constraint assumes that no rotation of grains occurred after carbonate formation. However, the carbonate globules themselves are sometimes fractured and fragmented (Fig. 4), allowing the possibility that associated pyroxene grains were rotated by shock following carbonate formation.

Scott et al. (1997) described shock-melted veins of plagioclase and silica glasses containing carbonate in ALH84001. They envisioned the carbonates having formed at high temperatures during an impact event. Their sample apparently did not contain the carbonate globules studied by McKay et al. (1996), but chemical zoning patterns suggest that these carbonates were part of the same generation. McKay and Lofgren (1997) likewise noted the presence of feldspathic glass, but their observation that the glass intrudes carbonate globules argues that shock melting postdated carbonate formation. The observation of shock metamorphism synchronous with or postdating carbonate formation implies that, however the carbonates in ALH84001 formed, they must have undergone significant temperature excursions.

CONCLUSIONS AND OUTLOOK

The question of whether ALH84001 contains evidence for early martian life remains unresolved. Part of the difficulty in addressing this problem relates to the highly interdisciplinary nature of the arguments, involving complex and sometimes arcane aspects of mineralogy, igneous and carbonate petrology, isotope geochemistry, microbiology and micropaleontology, organic chemistry, shock metamorphism, hydrogeology, and paleomagnetism. Another difficulty derives from the fact that we do not commonly observe and analyze rocks or, for that matter, fossilized or living organisms at these scales. As a result, there are not enough studies of terrestrial analogs to allow adequate interpretations of the data. There is now a serious attempt to supplement the terrestrial database with studies at these scales (e.g., Allen et al., 1997; Vali et al., 1997).

My own assessment is that two of the four lines of evidence cited by McKay et al. (1996)—the presence of extraterrestrial organic matter and of nanofossils in ALH84001—have been seriously challenged and possibly refuted, although others will disagree. Even if some martian organic matter is present, it may be impossible to disentangle its properties from the apparent overprint of terrestrial contamination. The mineralogical characterization of the nanofossils as magnetite whiskers and platelets requires independent confirmation. Before we can constrain the temperature of formation of the carbonates, it will be necessary to ascertain whether they formed by equilibrium or disequilibrium processes. In any case, the recognition that shock has affected this meteorite after carbonate formation suggests that the temperature history of the carbonates was more complex than has been appreciated. More studies of the morphology, structure, and chemistry of proposed biominerals and biofilms in ALH84001 are necessary before the origin of these materials can be specified.

Regardless of whether or not ALH84001 is ultimately judged to contain relics of ancient martian organisms, the report of McKay et al. (1996) has focused scientists' concentration (not to mention the attention of the rest of the world) on the possibility of extraterrestrial life. Mars is the most Earthlike of planets, and it is certainly within the realm of possibility that it once harbored microorganisms. NASA's planned Mars exploration program will directly address the question of life,

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GSAF UPDATE

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

From the Ground Up

In May, we reported on the 1996 fund-raising results. The accompanying chart shows the cumulative fund-raising results from the inception of the Second Century Fund campaign in 1992 to the end of April 1997, summarizing both the total gifts received and the sources of the gifts. The revenues include cash, pledges, program grants, and deferred gifts, reflecting the considerable variety not only of those who support GSA but also of the ways in which support can be given.

Revenue	1992–1995	1996	1997	Total
Second Century Fund				
Members	$2,278,375	$ 262,313	$ 50,816	$2,591,505
Other Individuals	$ 1,300	$ 3,226	$ 200	$ 4,726
Government	$ 544,512	$ 594,869	$ 0	$1,139,381
Foundations	$ 513,165	$ 16,000	$ 10,000	$ 539,165
Industry	$ 693,500	$ 74,712	$ 500	$ 768,712
Annual Campaign	$ 480,391	$ 104,522	$ 8,746	$ 593,659
Pardee Bequest	$2,677,309			$2,677,309
Total Revenues	**$7,188,552**	**$1,055,642**	**$ 70,262**	**$8,314,457**

Dummett Joins Foundation Board

The GSA Foundation is honored to welcome Hugo T. Dummett as its newest trustee. A member of GSA since 1985, Dummett has established an important career and reputation in minerals exploration.

A graduate of South Africa's University of Witwatersrand, Dummett worked in South Africa and Canada before pursuing postgraduate education at the University of Queensland in Australia. He came to the United States in 1977 as a senior geologist for Superior Oil's Minerals Division. Since 1989, Dummett has been affiliated with BHP Minerals, where he now serves as senior vice president and group general manager of the Exploration Group.

Dummett's contributions to his profession have been equally wide-ranging. He is a member of the Association of Exploration Geochemists, the Society of Economic Geologists, which named him as the 1996 Thayer Lindsley Distinguished Lecturer, the American Institute of Mining Engineers, the Geological Society of South Africa, and the USGS resource program advisory board to the National Academy of Sciences. In 1997, he was awarded the William L. Saunders Gold Medal by the Society for Mining, Metallurgy and Exploration.

The GSA Foundation is truly fortunate to be the beneficiary of such excellence and experience.

A Milestone

Since beginning the program in 1988, the GSA Foundation has awarded over $125,500 to the GSA sections for matching student travel grants. Each year, the grants assist college students to attend the section meetings and GSA's Annual Meeting. In 1997, the Foundation increased the amount of its awards to $4,000 per section.

The awards are paid from the unrestricted gifts GSA members make to the Foundation. This is another important benefit made possible by your generosity! ■

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among other topics, over the next decade. The controversy about possible biological activity in a martian meteorite is allowing the scientific community to reexamine its thinking and hone its skills for that effort.

ACKNOWLEDGMENTS

I appreciate thoughtful and constructive reviews by Peter Buseck, Andy Knoll, and John Valley.

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Rock Stars

A Life of Firsts: Florence Bascom

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Geologists know Florence Bascom (1862–1945) as "the first woman geologist in this country." Though Bascom was the second woman to earn a Ph.D. in geology in the United States (Mary Holmes earned a Ph.D. in geology from the University of Michigan in 1888), the moniker is appropriate. Bascom was the first woman hired by the U.S. Geological Survey (1896), the first woman to present a paper before the Geological Society of Washington (1901), the first woman elected to the Council of the Geological Society of America (elected in 1924; no other woman was elected until after 1945), and the first woman officer of the GSA (vice president in 1930). She was an associate editor of the *American Geologist* (1896–1905) and a four-starred geologist in the first edition of *American Men of Science* (1906), which meant that her colleagues regarded her as among the country's hundred leading geologists. After joining the Bryn Mawr College faculty, Bascom founded the college's geology department. This site became the locus of training for the most accomplished female geologists of the early 20th century.

Bascom was an expert in crystallography, mineralogy, and petrography. Trained by leaders in metamorphism and crystallography including Roland Irving and Charles Van Hise (University of Wisconsin), George Huntington Williams (Johns Hopkins), and Victor Goldschmidt (Heidelberg, Germany), she worked in these fields during their infancy. Her earliest contribution was her dissertation, in which she showed petrographically that rocks previously considered sediments were metamorphosed lava flows (Aldrich, 1990; Bascom, 1893). An expert on crystalline rocks of the Appalachian Piedmont, she published more than 40 research papers, including USGS Bulletins and Folios. Additionally, she published research on Piedmont geomorphology, particularly the provenance of surficial deposits.

Born in Williamstown, Massachusetts, in 1862, Florence was the youngest of six children of Emma Curtiss Bascom, suffragist and schoolteacher, and John Bascom, professor of oratory and rhetoric at Williams College. Her father supported the women's suffrage and temperance movements and advocated coeducation. In 1874, he became president of the University of Wisconsin. In 1875, the university admitted women, and in 1877 Florence enrolled. Like other women students, she had limited access to the library and gymnasium, and was prohibited access to classrooms already filled with men. She earned Bachelor's degrees in Arts and Letters (1882) and a Bachelor's degree in Science (1884).

Florence Bascom's early interest in geology is attributed to a driving tour with her father and his friend Edward Orton, a geology professor at Ohio State. Margaret Rossiter (1981) perceives Orton as a key individual in providing women access to the study of geology. Shortly thereafter, Florence studied geology at Wisconsin and earned a Master's degree in 1887. As Isabel Smith observed, it must certainly have been an exciting time to be a geology student; John Wesley Powell navigated the Colorado River, and Clarence King surveyed the 40th parallel and became the first director of the USGS (Smith, 1981).

In 1889, Bascom was permitted to take graduate school classes at Johns Hopkins University. Sitting behind a screen during classes so as not to "disrupt" male students, Florence must have been sustained by her research advisor, G. H. Williams, and by her father. In a letter dated September 1891, John Bascom wrote "… you better put a stone or two in your pockets to throw at those heads that are thrust out of windows" (Arnold, 1983). In 1893 she was granted the Ph.D.

Florence Bascom contemplates Yellowstone Lake (Wyoming) from Fishing Rock in 1915. *Sophia Smith Collection, Smith College.*

INTRODUCTION

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

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

—Robert N. Ginsburg, History of Geology Division

Though known for her contributions to understanding mountain-building processes, Bascom was also an educator. En route to her Ph.D., she taught at the newly founded Hampton Institute for Negroes and American Indians, now Hampton University (1884–1885), Rockford College (1887–1889) and Ohio State University (1893–1895). Recruited in 1895 to teach at Bryn Mawr, where geology was considered adjunct to other natural sc ences, she worked in storage space in a building newly constructed for biology, chemistry, and physics. Over two years, she developed a substantial mineral, rock, and fossil collection. She then proceeded to train a generation of young women who would ultimately succeed as professionals. Louise Kingsley, Katherine Fowler Billings, petrologists Anna Jonas Stose and Eleanora Bliss Knopf, crystallographer Mary Porter, paleontologist Julia Gardner (all at the USGS), petroleum geologist Maria Stadnichenko, Barnard's glacial geomorphologist Ida Ogilvie, Scripps College's Isabel Fothergill Smith, Bryn Mawr's Dorothy Wyckoff, and Anna Heitonen—these women studied and worked with Florence Bascom as a prelude to their careers.

Former students employed the words rigorous, incisive, and consistent to describe Bascom. With great expectations of her students, she was proud of their successes. In a 1931 letter to Professor Herman Fairchild, she wrote, " I have always claimed that there was no merit in being the only one of a kind.... I have considerable pride in the fact that some of the best work done in geology today by women, ranking with that done by men, has been done by my students.... these are all notable young women who will be a credit to the science of geology."

Heeding her father's suggestion that she "make work an immediate joy," geology, education, and Bryn Mawr were her life. Contemplative, she wrote, "The fascination of any search after truth lies not in the attainment, which at best is found to be very relative, but in the pursuit, where all the powers of the mind and character are brought into play and are absorbed in the task. One feels oneself in contact with something that is infinite and one finds a joy that is beyond expression in 'sounding the abyss of science' and the secrets of the infinite mind" (Smith, 1981).

Perhaps such thoughts brought quietude, for as Ida Ogilvie (1945) commented, "Probably no one will ever know all the difficulties that she encountered, but little by little she achieved her purpose of making her department one of the best in the country."

Bascom's contributions to Piedmont geology are still valued and utilized by geologists working in that area. Furthermore, as women struggle today to even the numbers in geology, whether in academia, government, or industry, we recall with admiration Florence Bascom's pioneer status.

Florence Bascom with compasses. *Sophia Smith Collection, Smith College.*

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Field trip in the Grand Canyon(?), 1906. Florence Bascom is second from front. *Sophia Smith Collection, Smith College.*

Penrose Conference Scheduled

Linking Spatial and Temporal Scales in Paleoecology and Ecology

May 14–18, 1998

A Geological Society of America Penrose Conference, "Linking Spatial and Temporal Scales in Paleoecology and Ecology," cosponsored by the Ecological Society of America and the Paleontological Society, will be held May 14–18, 1998, near Annapolis, Maryland.

This interdisciplinary conference will address the question of how understanding of patterns of modern and ancient species distributions and the processes that regulate those patterns are influenced by the spatial and temporal scales at which data are collected.

This issue lies at the interface of paleoecology and ecology, yet researchers in these disciplines only rarely have the opportunity to meet and discuss this important area of mutual interest. The time is particularly appropriate for such a conference because interest in macroecology and the interpretation of high-resolution paleoecological data for understanding global change processes and community organization through time is growing rapidly.

There is a wealth of untapped information available in both disciplines. This vast store of information awaits the synthesis of differing viewpoints, informed by differing spatial and temporal scales of observation. A major goal of this conference is to stimulate the collaborations required to generate such syntheses. Biodiversity assessment and conservation strategies are critically dependent upon understanding the scale and historical variability of the systems studied—topics that might be informed by paleontological data or theory. Models that attempt to explain what regulates diversity and how diversity gradients are established require a knowledge of both present-day pattern and historical background, creating necessary—but often overlooked—linkages between ecology and paleoecology. Ecological theories on the formation and dynamics of species assemblages have largely concentrated on processes operating over time scales that can be observed by individuals, either ignoring the rich, long-term records of paleoecology or utilizing them in overly simplistic ways. Conversely, interpretations of fossil assemblages have been greatly influenced by recent thinking about patch dynamics in populations, metapopulation theory, and various concepts of controls on community structure, often without much sophistication on the part of the paleoecological community concerning the strengths and limitations of these theories. How much is paleontological interpretation influenced by ignoring or minimizing the ecological importance of rare species? Is time-averaging of fossil assemblages a boon because it permits accumulation of even those rare species, or is it an unfortunate bias because it mixes spatial and temporal abundance patterns?

Data concerning spatial and temporal scaling in communities can be interpreted only in light of models that guide our understanding of pattern. A major emphasis of this conference will be not only to evaluate existing data sets on spatial and temporal scaling but to span the gap between data and theory of community dynamics. We will examine how data can best be collected with a goal of testing and refining these models, and we will consider how new models can focus our efforts in data collection and at the same time accommodate the real limitations of field data. Because of its highly interdisciplinary nature, this conference will be organized to maximize the amount of discussion and interaction time available. Plenary-type talks will be very limited: therefore participants interested in attending will generally be requested to present data sets or model results as posters. The meeting is being held near Annapolis to take advantage of two outstanding field-trip localities nearby: the Virginia Coastal Long Term Ecological Research Site (field-trip leader: Bruce Hayden) and the richly fossiliferous Miocene Calvert Cliffs (field trip co-leaders: Patricia Kelly and Susan Kidwell).

Participation in the conference will be limited to 80 people. Participation for some graduate students will be partially subsidized. Persons interested in attending should contact Andrew Cohen, Department of Geosciences, University of Arizona, Tucson, AZ 85721. Applications should consist of a curriculum vitae, a cover letter indicating your general areas of interest, and data sets or models you would be interested in presenting at the meeting. **The application deadline is December 15, 1997.** Formal invitations will be mailed no later than January 15, 1998. The registration fee, which will cover lodging, meals, ground transportation, field trip, and other conference costs, except personal incidentals, has not yet been established.

Co-conveners of the conference are: ***Andrew S. Cohen,*** Dept. of Geosciences, University of Arizona, Tucson, AZ 85721, (520) 621-4691, fax 520-621-2672, acohen@geo.arizona.edu; ***James H. Brown,*** Dept. of Biology, 167 Castetter Hall, University of New Mexico, Albuquerque, NM 87131, (505) 277-9337, fax 505-277-0304, jhbrown@unm.edu; ***Dale Springer,*** Dept. of Geography and Earth Science, Bloomsburg University, Bloomsburg, PA 17815, (717) 389-4108, fax 717-389-3028, dspringe@planetx.bloomu.edu; ***Peter Holterhoff,*** Dept. of Geosciences, Gould-Simpson Building, University of Arizona, Tucson, AZ 85721, (520) 621-4618, fax 520-621-2672, holterho@ccit.arizona.edu. ■

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. These reports present summaries of agency and interagency programs, track legislation, and present insights into Washington, D.C., geopolitics as they pertain to the geosciences.

Oceans and Security

A significant meeting for the U.S. ocean science community, Oceans and Security, was held on Capitol Hill May 19– 21, 1997. The meeting, sponsored by the Advisory Committee on the Protection of the Sea (ACOPS), Global Legislators for a Balanced Environment (GLOBE), and the Consortium for Oceanographic Research and Education (CORE), was hosted by Congressman Curt Weldon (R—PA). The meeting was attended by 90 foreign representatives from 28 countries and about 115 U.S. participants from government, academia, industry, and the NGO community. Distinguished U.S. speakers and panelists included Vice-President Al Gore, House Speaker Congressman Newt Gingrich (R—GA), Secretary of Defense William Cohen, Secretary of the Navy John Dalton, Senator Jeff Bingaman (D—NM), Congressman George Brown (D—CA), Congressman Sam Farr (D—CA), Congressman Wayne Gilchrist (R—MD), Congressman Patrick Kennedy (D—RI), Congressman Floyd Spence (R—SC), Congressman Dana Rohrabacher (R—CA), Chief of Naval Operations Admiral Paul Gaffey, Deputy Under Secretary of Defense Sherri Goodman, NOAA Administrator James Baker, Assistant Secretary of State Eileen Claussen, USGS Director Gordon Eaton, and NSF Assistant Director Robert Corell.

Foreign participants came from Australia, Belgium, Brazil, Cambodia, Canada, China, Colombia, Costa Rica, Croatia, Denmark, India, Japan, Korea, Mexico, Mozambique, Netherlands, New Zealand, Norway, Philippines, Portugal, Russian Federation, Seychelles, South Africa, Sweden, Thailand, Ukraine, and the United Kingdom. International organizations represented included the United Nations (UN), UN Environmental Programme (UNEP), UN Development Programme (UNDP), the World Bank, the International Oceanographic Commission (IOC), the Organization of American States (OAS), and the Commission of the European Union (EU). Distinguished foreign participants included Lord Stanley Clinton-Davis, new United Kingdom Minister of Trade, Portuguese Deputy Prime Minister and Minister of National Defense Antonio Vitorino, UN Assistant Secretary General Nay Htun, and UNEP Director Elizabeth Dowdeswell.

A primary purpose of the meeting was to raise the level of awareness on Capitol Hill about ocean partnerships, both domestic and international (see November 1996 Washington Report), and about the upcoming "Year of the Oceans." The United Nations has proclaimed 1998 as the "Year of the Oceans."

In his welcoming remarks, Congressman Weldon stressed the theme of oceanographic partnerships. He emphasized the need to progress more aggressively in strengthening ocean research and to provide the scientific community with greater access to previously classified data. He stated that military and environmental concerns should be dovetailed and existing capabilities united to enhance the capability for effective ocean management. He concluded by saying that by the year 2000, a new movement to protect the

Oceans *continued on p. 12*

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Oceans *continued from p. 11*

oceans should be established, and in particular, environmental awareness and education should permeate every community, every activity, and every country, in order to leave a solid legacy of a clean ocean and a stable global environment.

The meeting addressed four key themes: Economic Security, Environmental Security, Food Security: Fisheries, and Research and Defense. Half-day panels addressed these themes in the geographic context of the seas of the Americas, seas of the Russian Federation, Pacific Ocean, and Indian Ocean. Keynote speeches, presented for each theme, showed how closely related and intertwined the four themes are.

Andrew Steer, Director of Environment at the World Bank presented the keynote speech on Economic Security. He stated that global dependency on coastal and marine ecosystems for food and livelihoods, coupled with an increased vulnerability of human settlements and investments to human-induced shifts in ocean processes such as climate change and sea-level rise, require that appropriate environmental management frameworks and economic policies be put in place to secure sustainable development of marine and coastal resources. This is becoming even more critical as about 2/3 of the world's population is concentrated in the coastal zone. He described a series of priorities for the international community: (1) implement international conventions such as the UN Convention on the Law of the Sea, (2) invest in knowledge, (3) reform economic policies that undermine sustainable use of marine resources, (4) invest directly in marine conservation, (5) apply new tools for coastal and marine management, (6) ensure adequate funding, and (7) coordinate efforts regionally.

Laurence Mee, Coordinator of the Global Environmental Fund (GEF) Programme for Environmental Management and Protection of the Black Sea presented the keynote speech on Environmental Security. He stated that if mankind was to avoid serious deterioration in human security in the next century, a change in many aspects of lifestyle would be required in order to reduce waste production, eliminate overconsumption, and improve the protection of natural habitats and landscapes. He added that in the aquatic environment, particularly urgent action is required to mitigate environmental "hot spots," but that action should not be restricted to conflict resolution. An understanding of the root causes of environmental degradation, coupled with individual and collective commitment to take action to address these issues, would inevitably lead to an improvement in long-term security.

Scott Parsons, Assistant Deputy Minister, Department of Fisheries and Oceans, Canada, stated that food security from the world's oceans and aquaculture will depend on the implementation of new integrated approaches to resource conservation and management. Production from world fisheries was now stabilizing after a fivefold increase over the past half century. Technological innovations and development of a global market for fish products had combined with activities unrelated to fishing to place unprecedented stress on world fish resources. These include overfishing, habitat loss due to pollution and physical degradation, and changes in the marine environment, such as El Niño.

Admiral Gaffney presented the Research and Defense keynote speech. He stated that environmental issues are becoming more and more important in the formulation of national policy and defense policy. Environmental degradation, scarcity, urbanization, and spread of infectious diseases, among other factors, contribute to world instability, often leading to conflicts, often drawing neighbors and allies into regional turmoil. Gaffney stated that U.S. defense environmental programs were becoming an important topic in which to engage military forces from all over the world, including those of new democracies. All must understand environmental issues and conditions that may generate conflict, in order that conditions for peace may be maintained in their place.

House Speaker Newt Gingrich began his presentation by stating that science and navies have always been closely linked. Without the assistance of the British Navy, Darwin would never have been able to travel to the Galapagos and would not have made the key observations that led to the development of his theory of evolution. Gingrich stated that "we know remarkably little about remarkably large parts of the oceans." He told the scientific community to "be bold, not practical in their thinking and planning." He said that Congress would provide the practical eye to the ideas of the scientific community. Gingrich proposed three priority initiates for the ocean science community and described a four-part action plan to achieve the success of the initiatives: (1) the development of a world database that could lead to the formulation of a "virtual ocean." Gingrich predicted that such a system would require about 20 years to implement. This "system" should be available to all nations and contribute decisively to a global understanding of the oceans; (2) the development of an International Biodiversity Year (IBY) patterned on the International Geophysical Year (IGY) of the 1950s. He suggested that the concept of the IBY could be developed over the next five years. The result of the IBY would be an order of magnitude increase in the understanding of world biodiversity; and (3) a global analysis and development by each nation of a cost-benefit analysis of activities in the environmental sector.

The panels and plenary sessions resulted in more than 70 recommendations and a Potomac Declaration: Towards Enhanced Ocean Security into the Third Millennium. The Declaration was submitted to the Special Session of the UN General Assembly held in June. A follow-on meeting to the Oceans and Security Meeting will be held in January 1998 in Stockholm, Sweden, to launch the "Year of the Oceans," to act on the numerous recommendations, and to implement the Potomac Declaration. ■

Institute for Environmental Education

Global Impacts of Mining and Urbanization on Fluvial and Coastal Systems—The San Juan Case Study

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

At scales ranging from local watersheds to the entire world, environmental stresses imposed on natural resources are fundamental concerns to managers and planners, earth scientists, members of the business community, government officials, and citizens. Throughout the Holocene, land-surface changes often have been dominated by human activities, particularly agriculture. In addition to deforestation, land degradation, and soil erosion associated with farming, major transformations of landscapes and of fluvial and coastal systems are increasingly evident in areas of human habitation and mineral extraction. More recent global history indicates that the environmental effects of urbanization and related activities of mining, quarrying, and infrastructure development are principal factors promoting change in the nature and processes of Earth's surface.

One international environmental geological project that addresses Earth-surface problems caused by population growth is ESPROMUD (Earth-Surface Processes, Materials Use, and Urban Development: understanding the human contribution to global geomorphological change). The ESPROMUD project is part of the Ecosystem Processes and Biodiversity cluster within the scientific program of SCOPE (the Scientific Committee on Problems of the Environment). Major objectives of the ESPROMUD project are to compile and evaluate information regarding the effects of urbanization and extractive industries on Earth-surface processes, to identify gaps in the understanding of these effects, and to develop models that relate environmental impact to stages of population growth and economic development. These objectives are being met through studies of areas that exhibit problems related to urban expansion and mineral extraction.

As part of the 1996 Annual Meeting of the Geological Society of America, in Denver, Colorado, ESPROMUD and GSA's Institute for Environmental Education cosponsored the theme session "Global Impacts of Mining and Urbanization on Fluvial and Coastal Systems." Purposes of the session were (1) to inform the geoscience community of the purpose and functions of SCOPE projects, (2) to disseminate results of research coming out of ESPROMUD and related activities, (3) to provide a forum in which members of ESPROMUD could assess progress, and (4) to provide an opportunity for planning future activities.

IMPACTS OF DEVELOPMENT: A CASE STUDY

The San Juan area of northeastern Puerto Rico, including drainage basins that provide water and mineral resources to the metropolitan area, is a case study of the ESPROMUD project. This area was selected to illustrate the burden that can be placed on hydrologic, geologic, and biologic resources by rapid, loosely regulated urban growth, and how, in turn, poorly planned use of the resources may inhibit further economic development. Specific goals of the San Juan case study are to describe and quantify the magnitudes of the direct and indirect people-driven changes that have resulted from urbanization, to evaluate the influence of the changes on geomorphic and hydrologic processes, to assess the consequences of the changes 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 pertinent information from representative urban areas. An essential element of the San Juan case study, therefore, is to compile data summarizing urban growth and the impacts of that growth on water and mineral resources.

The history of and problems related to urban expansion in northeastern Puerto Rico have been closely tied to changes in economic activities on the island, and thus to the extraction of available water and mineral resources needed for economic development.

The San Juan case study focuses on the 802-km-square Loiza drainage basin, the largest of Puerto Rico, and the adjacent and mostly urbanized 67-km-square Rio Piedras Basin. Streams draining these basins, and the coastal zone into which they discharge, have been affected strongly by population growth of Puerto Rico's capital city, San Juan, and nearby metropolitan areas. Urban growth intensified during two recent periods: (1) after 1953 when construction of Carraizo Dam on the Rio Grande de Loiza increased the supply of municipal water by impounding stream flow in Loiza Reservoir (or Lago Loiza), and (2) in the 1960s in response to ground-water development that supported industrial expansion. Carraizo Dam and the Loiza Reservoir were originally constructed for hydroelectric power generation. The reservoir, which collects runoff from the upper 540 km of the basin, increased the water contribution to the urban area by nearly 60%. The ground-water resources were developed from karstic limestone that occurs in near-coast areas of Puerto Rico. The history of and problems related to urban expansion in northeastern Puerto Rico have been closely tied to changes in economic activities on the island, and thus to the extraction of available water and mineral resources needed for economic development.

Seven of 20 papers at the theme session focused on the ESPROMUD case study for the San Juan area. The first, by Maria Angeles Alonso Diago, documented physical characteristics, land use, and pop-

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ulation-growth histories of the San Juan area, and reasons why the San Juan area is an example pertinent to global trends in urbanization. Her paper, "Induced surface-process changes in Rio Loiza Basin, Puerto Rico," anticipated succeeding, in-depth discussions on urban growth, resulting soil disturbance, erosion, and sedimentation in a major water-supply reservoir of San Juan, and the possible social and economic consequences of future water shortages due to reduced reservoir storage capacity.

WATER SUPPLY PROBLEMS

Detailed discussions of the San Juan–Loiza Basin case study began with "Land use, upland erosion, and reservoir sedimentation, Lago Loiza, Puerto Rico," by A. C. Gellis, R. M. T. Webb, W. J. Wolfe, and S. C. I. McIntyre. The authors found that Lago Loiza, the principal water supply reservoir of the San Juan metropolitan area, has lost 47% of its storage capacity to unanticipated rapid sedimentation. Causes of the sedimentation have been soil disturbance and erosion induced by agriculture, urban expansion, and mass movements triggered by tropical cyclones. At present, projections suggest that Lago Loiza will be filled with sediment early in the next century.

Hydrologic problems accompanying population increases and urban expansion were described by W. R. Osterkamp. His paper, "Water-supply and water-quality problems related to urban growth, Loiza Basin, Puerto Rico," examines the difficulties faced by the San Juan area in providing potable water to its expanding population. This study suggests that the effects of shifting to an industrial economy are also causing water shortages and the reduced potential for urban growth both in San Juan and elsewhere in Puerto Rico.

Mass wasting, generally triggered by hurricanes, is documented by M. C. Larsen, as a major process contributing sediment to Lago Loiza. His paper, "An extreme case of mass wasting in the humid tropics: The agriculturally developed Cayaguas watershed, Puerto Rico," demonstrates that as much as 75% of the sediment released by mass movement during the past 70 years in northeastern Puerto Rico remains as colluvium and alluvium in lowlands. This stored material represents a supply of sediment that, if remobilized during periods of high runoff, may continue to cause sediment deposition in Lago Loiza and in some flood-plain areas of Rio Grande de Loiza well into the 21st century.

Carroll Ann Hodges and W. R. Osterkamp, in "Mining and quarrying in the San Juan/Loiza Basin area, Puerto Rico, related to urban growth," noted that mineral extraction in Puerto Rico is limited at present to sand, gravel, and other rock resources necessary for construction and related infrastructure development. Terrestrial sources of alluvial deposits, however, are nearly depleted, a difficulty that may result in the mining of offshore supplies of sand, deterioration of riverine, coastal, and nearshore marine habitats, and inadequate supplies of building materials to meet construction needs for the expanding urban area. The scarcity of mobile sand and gravel to replenish stores of bottom land and coastal sediment may also have an inhibiting effect on tourism and related elements of the economy that depend on a continuing flux of sediment from uplands.

In "Impacts of mining and urbanization along the north coast of Puerto Rico: A case study of the San Juan metropolitan area," R. T. M. Webb and R. A. Morton identify problems of destroyed wetlands, degraded water and sediment quality, altered water circulation patterns, accelerated beach retreat, increased risk of storm overwash, and the construction of engineering structures to mitigate hazards caused by coastal-zone modifications. Among the changes that have led to these problems in San Juan are the dredging of lagoons, the mining of sand from beaches, dunes, and river valleys, and the near elimination of fluvial-sediment discharge to the coast owing to extractions upstream and the impoundment of sediment in reservoirs such as Lago Loiza. Environmental restoration measures to offset the negative impacts of urbanization include wetland reconstruction, diversion of contaminated wastewater formally discharged to San Juan Bay, and the possible dredging of sediment from Lago Loiza.

A final paper dealing with the San Juan case study, "Global impacts of mining and urbanization on coastal systems—A conceptual model" by R. A. Morton, extended specific observations of coastal change to the general case. The model recognizes that the alteration of coastal processes by human activities largely depends on tidal range and wave conditions, and less strongly on terrain and climate. Impacts by human development on coastal systems are important because they tend to disrupt sediment supplies, accelerate soil loss, degrade water and sediment quality, modify current and wave patterns, and increase the relative rise in sea level. Morton stresses that the modeling of impacts from mining and urbanization and the prediction of future conditions require an accounting of the natural and artificial mass movements of materials imported into, exported out of, and transferred within the coastal zone, including the direct and indirect transfers from fluvial systems.

GLOBAL IMPLICATIONS?

Additional papers during the session focused on other regions and processes and included such findings as:

- Worldwide human activities accounted for a net storage of water during the last half century that has minimized the rate of observed relative sea-level rise.
- In areas including Malaysia, Japan, and Korea, human translocation of materials in rapidly expanding urban centers exceeds the large-scale natural transfers of surficial materials by earthquakes and high rainfall.
- As a result of human activities, denudation rates in the Besaya Basin, Spain, increased by 4 to 5 orders of magnitude, and flood frequencies increased 4 to 7 times.
- Long-term fluvial responses to sediment loading in the American and Sacramento rivers, California, are complex and typically involve histories punctuated by periods of both aggradation and degradation, depending on the time of the study relative to the timing and volume of sediment released by mining.
- Environmental contamination in Idaho's Coeur d'Alene Valley decreased in time through a combination of improved mining practices and the ability of nature to dilute the pollution.
- Implementation of environmental regulations and improved manufacturing techniques in the Great Lakes region are causing a decrease in the accumulation rates of contaminated sediment.

The San Juan case study seems to suggest that urbanization tends to exploit available resources in such a manner as to be self-limiting. Puerto Rico, a water-rich island, continues to be burdened with a deficiency of municipal water supplies, construction materials, and construction sites that can sustain urban and industrial expansion. Terrestrial sources of sand and gravel are nearly depleted, and limited limestone resources are being actively mined. An implication is that improperly regulated urban expansion contributes to the exhaustion of local resources, while diversion of water and mineral resources to San Juan from other parts of the island necessarily curtails growth of other urban areas. An expanding population accompanied by a purposeful change from an agrarian economy to an industrial emphasis has reduced agricultural production and therefore has increased Puerto Rico's dependence on food imports. The changes in land use and economic direction promoted rapid urban population increases, and infrastructure in support of the population growth has been inadequate to keep pace. Thus, deficiencies in the municipal water-delivery and sewage systems and the scarcity of raw materials for continuing

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Call for Field Trip Guidebook and Continuing Education Manual Editors

Two editorships recently approved by the GSA Committee on Publications and GSA Council may generate two new publications series for the Society.

The Field Trip Guidebook editor will establish and maintain criteria standards and guidelines for a formal guidebook series (similar to that of the Society of Economic Geologists). It is anticipated that field trip leaders at the GSA Annual Meeting will have the option of electing to publish their guidebook in the series. The editorship will be supported for all reasonable costs as well as registration to the annual meeting or expenses of an annual field trip of choice.

The Continuing Education editor will solicit course notes from courses presented at the GSA Annual Meeting, to be published in book form utilizing GSA publication standards (similar to the Mineralogical Society of America series). The editorship will be supported for all reasonable costs and will have discretionary support linked to pages published in a given year.

It is anticipated that these series will begin when and if editors are identified and approved for a three-year term. Interested applicants should contact:

Donald M. Davidson, Jr.
Executive Director
The Geological Society of America
Phone: (303) 447-2020, ext. 139
E-mail: davidson@geosociety.org

1998 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 (1998)
Victor R. Baker, Tucson, Arizona

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Gail M. Ashley, Piscataway, New Jersey

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Murray W. Hitzman, Golden, Colorado

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Douglas W. Burbank, University Park, Pennsylvania
John M. Bartley, Salt Lake City, Utah

COUNCILOR (1998–2000), POSITION 3
Stephen C. Porter, Seattle, Washington
Allison R. (Pete) Palmer, Boulder, Colorado

COUNCILOR (1998–2000), POSITION 4
Bruce A. Blackerby, Fresno, California
Joaquin S. Ruiz, Tucson, Arizona

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infrastructure development are discouraging further urban growth in northeastern Puerto Rico.

Collectively, the papers presented at this theme session demonstrate that the environmental impacts of mining and urbanization of fluvial and coastal systems are similar throughout the world, and several recurring themes are evident. Surface alterations tend to increase natural hazards such as landslides, flooding, and erosion. In developing countries, small-scale mining that is unregulated or illegal accounts for a large percentage of minerals and building materials extracted and the total area of disturbed land.

Complete abstracts and author information for this session are available in the 1996 *GSA Abstracts with Programs,* v. 28, no. 7, p. A79–A81, A200–201. ■

About People

GSA Member **Charles S. Bartlett,** Abingdon, Virginia, has been elected president of the newly formed Southern Appalachian Geological Association (SAGA). Member **Fred Webb,** Appalachian State University, is the North Carolina representative to the group.

The International Association of Volcanologists has awarded its highest honor, the Thorarinsson Medal, to GSA Fellow **Richard V. Fisher,** University of California, Santa Barbara.

Bates (Maine) College has honored GSA Member **Lois K. Ongley** with its Kroepsch Award for Excellence in Teaching.

Fellow **Karl A. Riggs,** Starkville, Mississippi, has been appointed International Man of the Year 1996–1997 by the International Biographical Centre (Cambridge, UK).

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Designed primarily for field use, the chart nevertheless indicates the range of rock colors for all purposes and is accurate for wet or dry specimens. Chiefly used to describe medium- to fine-grained rocks, it is also helpful in working with coarse-grained rocks.

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Canada

Donath Medal
(Young Scientist Award)

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Universidade de São Paulo
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Brazil

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BIRPS Bullard Laboratories
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United Kingdom

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Boulder, Colorado 80301

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Faith E. Rogers
Geological Society of America
3300 Penrose Place
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Bennie W. Troxel
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Rip Rapp Archaeological Geology Award

Tjeerd H. van Andel
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University of Cambridge
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United Kingdom

Gilbert H. Cady Award
(Coal Geology Division)

Alexander R. Cameron
Research Scientist Emeritus
Geological Survey of Canada
3519 Benton Dr., NW
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Canada

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Robert L. Schuster
U.S. Geological Survey (Retired)
1941 Golden Vue Drive
Golden, Colorado 80401

A. Keith F. Turner
Department of Geology and Geological Engineering
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1516 Illinois Street
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United Kingdom

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Granville, Ohio 43023-1438

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U.S. Geological Survey
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Reston, Virginia 20191

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Tempe, Arizona 85287-1404

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Tucson, Arizona 85721

Structural Geology and Tectonics Division Career Contribution Award

Hans Ramberg
Murklevagen 5
Uppsala S-75646
Sweden

Research and Fellowship Opportunities

Research Opportunities for Undergraduates in Tropical Lake Studies

The Nyanza Project is a new summer research training program for undergraduates, sponsored by the International Decade of East African Lakes (IDEAL) and funded by the National Science Foundation and the Lake Tanganyika Biodiversity Project. This 6-week program is open to sophomore–senior level undergraduates of any nationality attending a U.S. college or university, or to students from the countries surrounding Lake Tanganyika (Tanzania, Burundi, Zambia, and Zaire), who are interested in continuing research careers in any aspect of aquatic sciences (limnology, ecology and evolutionary biology, conservation biology, geolimnology, and paleolimnology). Students who are members of underrepresented minority groups are particularly encouraged to apply. The program will take place at Kigoma, Tanzania, to take advantage of research opportunities at Lake Tanganyika. Students who are accepted into the program will have their airfare, room and board and research expenses paid by the project and will be given a stipend. Applications for the 1998 program (June 1–July 10) will be accepted until January 1, 1998.

For further information, contact: (for U.S. student inquiries) The Nyanza Project, Dept. of Geosciences, University of Arizona, Tucson, AZ 85721, phone (520) 626-7312, fax 520-621-2672, nyanza@geo.arizona.edu, http://www.geo.arizona.edu/nyanza; or (for African student inquiries) Lake Tanganyika Biodiversity Project, P.O. Box 90, Kigoma, Tanzania, phone 255-695-2992, fax 255-695-2993, ltbp@twiga.com, http://www.nri.org/Lake_Tanganyika.

El Paso Energy Corporation Law Fellowship

The Natural Resources Law Center of the University of Colorado School of Law invites applications for the El Paso Energy Corporation Law Fellowship for spring semester (January–May) 1998. The Fellow will spend a semester in residence at the School of Law, researching a topic concerning oil and gas, minerals, energy, or related public land law. While in residence, the Fellow will participate in activities of the Law School and the Center, and will have an opportunity to exchange ideas with faculty and students in both formal and informal sessions. The Fellow is expected to produce written work suitable for publication in a professional journal. Criteria for evaluation of proposals include the applicant's professional and educational qualifications and demonstrated writing ability; importance and relevance of the proposed topic to the field; and the likelihood of producing written work that leads to better understanding of issues and improved practice, or policy in the field. Candidates may be from business, government, legal practice or universities. A stipend of $20,000 plus benefits is available for the semester, along with secretarial and research assistance. The School of Law offers office space, use of all University of Colorado libraries and other facilities, and participation in Natural Resources Law Center programs. In addition, the Fellow will be in proximity to several important agencies and experts, within and outside the university, who are performing research in the energy and natural resources fields. Candidates should submit a proposal in the form of a letter or statement describing a research project, along with a resume. One or more (a maximum of three) letters of support should be submitted directly. Address applications and letters to Kathryn Mutz, Natural Resources Law Center, Campus Box 401, Boulder, CO 80309-0401. Application deadline is August 31, 1997.

For additional information, contact: Kathryn Mutz, (303) 492-1287, fax 303-492-1297, kathryn.mutz@colorado.edu.

Earthquake Hazards Reduction Fellowship

Under a cooperative agreement with FEMA, the Earthquake Engineering Research Institute offers a 1998 Professional Fellowship to provide an opportunity for a practicing professional to gain greater skills and broader expertise in earthquake hazards reduction, either by enhancing knowledge in the applicant's own field or by broadening his or her knowledge in a related, but unfamiliar discipline. This fellowship is aimed at the career professional and is designed to bring together an experienced practitioner with professionals conducting significant research, providing an opportunity to enrich the applicant's knowledge and skills and broaden the research base with challenges faced in practice. The Professional Fellowship is *not* intended to fund work toward a degree. The fellowship provides a stipend of $30,000, commencing in January 1998, to cover tuition, fees, and relocation and living expenses for a six-month period. Applicants must provide a detailed work plan for a research project that would be carried out in the six-month period. The Fellow will be expected to produce a written report upon completion of the project. All applications must be accompanied by a professional resume and letter of nomination from the faculty host(s) at the cooperating educational institution(s). Faculty members should also indicate the institution's ability to provide research facilities, including library, work space, telephone, and computer access. Applicants must hold U.S. citizenship or permanent resident status.

Candidates may obtain an application form from the Earthquake Engineering Research Institute, 499 14th St., Suite 320, Oakland, CA 94612-1934, (510) 451-0905, fax 510-451-5411, eeri@eeri.org, or from EERI's Web site at http://www.eeri.org. Deadline for receipt of all application materials at EERI is September 5, 1997. Announcement of the award will be made October 17, 1997.

International Lithosphere Program Projects

The Inter-Union Commission on the Lithosphere (ICL) invites proposals for new projects to be conducted under the auspices of the International Lithosphere Program (ILP). Established in 1980 by the International Council of Scientific Unions (ICSU), the ILP seeks to elucidate the nature, dynamics, origin, and evolution of the lithosphere through international, multidisciplinary research projects and coordinating committees.

Since 1990, ILP projects have been operating under the umbrella of four program themes: (1) Geoscience of Global Change; (2) Continental Dynamics and Deep Processes; (3) Continental Lithosphere; (4) Oceanic Lithosphere. ILP provides each project leader with a small amount of money (about $5000/year) for administration and travel. Further financial support for scientific investigations, conferences, and workshops must be sought from national and international funding agencies; experience suggests that ILP's "stamp of approval" offers considerable credibility to grant applications.

Information on current ILP projects can be obtained from the 1995 ILP Annual Report, which is available from ILP Secretary General Joerg Erzinger or through ILP's home page at http://www.gfz-potsdam.de/pb4/ilp/. All ILP projects must have an international character and should address issues of interest to both parent unions (IUGG and IUGS).

Research Opportunities
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Research Opportunities
continued from p. 19

The ILP is now accepting suggestions for four to five new projects to begin in 1998. A nonexclusive list of potential research topics is described in the 1995 Annual Report. Project proposals based on these and other topics would be most welcome. Each proposal should be no longer than four pages and contain information on the project's objectives, duration (maximum 5 years) and expected participants, together with short comments explaining how the project will address ILP's principal goals and program themes. The proposed leader and co-leaders of the project should also submit one-page curriculum vitae. Further information on ILP activities and guidelines is available from ILP Secretary General Joerg Erzinger (ILP Secretariat, GeoForschungsZentrumPotsdam, Telegrafenberg A540, 14473, Potsdam, Germany, phone: 49-331-288-1421, fax 49-331-288-1474; ilp@gfz-potsdam.de) or ILP President Alan Green (Institute of Geophysics, ETH-Hoenggerberg, CH-8093, Zurich, Switzerland, phone 41-1-633-2657, fax 41-1-633-1065, alan@augias.geo.phys.ethz.ch. Proposals should arrive at the ILP Secretariat in Potsdam by July 31, 1997, for initiation of projects in January 1998, and by December 31, 1997, for initiation of projects in July 1998. ■

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 1997 GSA Annual Meeting in Salt Lake City, Utah.

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, 1997. 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 22 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 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 23. 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 1997, the cost of a printout of one or two specialty codes is $175. (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 Salt Lake City, Utah, October 20–23). 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. ■

American Institute of Professional Geologists Now GSA Associated Society

The GSA Council has accorded the American Institute of Professional Geologists Associated Society status. Organizations can associate with GSA for the purpose of cooperation in annual, section, or division meetings, and in publications.

The American Institute of Professional Geologists (AIPG), founded in 1963, is dedicated to promoting geology as a profession. It presently has more than 5,000 members in the U.S. and abroad, organized into 37 regional Sections. The Institute adheres to the principles of professional responsibility and public service and is the only international organization that certifies the competence and ethical conduct of geological scientists in all branches of the science with members employed in industry, government, and academia.

The Institute holds an annual meeting and actively lobbies at the state and federal level on issues of interest to geologists. AIPG also provides materials designed to enhance the knowledge and professional skills of its members, as well as distributing publications involving geologically related matters of public concern.

Officers for 1997 are: President Jonathan G. Price, President-Elect Stephen M. Testa, Vice President Dennis Pennington, Secretary Robert H. Fakundiny, Treasurer Robert M. Colpitts, Jr., Editor J. Dale Nations.

Stanford University, Stanford California

Geophysics, Rockphysics & Reservoir Properties of Gas Hydrate Zones Under The Ocean

Workshop to review and discuss the use of marine seismic data and well logs to evaluate location, amounts, potential productivity of methane from or under hydrates, as well as mechanical stability of hydrated ocean bottom sediments. Meeting announcement and registration at: http://pangea.stanford. edu/~margaret/srbhomepage.html

Deadline for Applications and Abstracts
August 15

Sponsor
Amos Nur
c/o Geophysics Dept
Stanford University,
Stanford, CA 94035-2215;
amos.nur@stanford.edu
fax 415/723-1188

The Geological Society of America
3300 Penrose Place • P.O. Box 9140 • Boulder, Colorado 80301

FOR ACCOUNTING USE ONLY

Rec. $30 $60

Ck # _____

GSA _____

Add. _____

Ltr. _____

APPLICATION FOR EMPLOYMENT MATCHING SERVICE

(Please type or print legibly with **black ink**)

TITLE Dr. ☐ Mr. ☐ Ms. ☐ Mrs. ☐ Miss ☐ **DATE** _____

NAME (last name first) _____ **E-MAIL** _____

MAILING ADDRESS _____

_____

CITY _____ **STATE** _____ **ZIP CODE** _____

DATE AVAILABLE _____ **TELEPHONE (** **)** _____ / _____ **VISA** _____

area code Business Home If not U.S. citizen, list visa

EXPERIENCE Must use specialty codes listed below.
Choose three that best describe your expertise in order of importance.

1. _____ **2.** _____ **3.** _____

PRESENT SPECIALTY
Choose one from codes listed below _____

YEARS EXPERIENCE IN THIS SPECIALTY _____

PRESENT EMPLOYER _____

TYPE OF POSITION DESIRED (Check as many boxes as apply.)

Interested in: ☐ Academic ☐ Government ☐ Industry ☐ Other

Specific interest: ☐ Administration ☐ Exploration/Production ☐ Field ☐ Research ☐ Teaching

Will accept employment in: ☐ U.S. only ☐ U.S. with foreign assignments ☐ Either

GIVE NUMBER OF YEARS EXPERIENCE FOR ANY OF THE FOLLOWING THAT ARE APPLICABLE

Administrative_____ Exploration/Production_____ Field_____ Research_____ Teaching_____ Total geological experience_____

KNOWLEDGE OF FOREIGN LANGUAGES: ☐ French ☐ German ☐ Russian ☐ Spanish ☐ Other_____

ACADEMIC TRAINING

College or University	Degree (rec'd or expected)	Year	Major	Minor

Postgraduate work beyond highest degree in (field) _____ **Number of years** _____

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

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

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.

Fee: $30 if you are a Member or Student Associate of GSA in good standing (Member #_____), $60 if you are not a member of GSA. Payment in U.S. funds (check, money order, or charge information ***must accompany form***).

Make check payable to the Geological Society of America. ≈ This application will be active for one year.

☐ Check/Money Order ☐ MasterCard ☐ VISA ☐ American Express or Optima

Card Expires Mo/Yr | Card Number

Signature _____
Required for credit card payment

_____
Date

I agree to release GSA or their representatives from responsibility for errors that may occur in processing or distributing these data. I understand that GSA makes ***no guarantee*** of contact by an employer in this service. I agree to notify GSA Employment Service immediately of (1) change of address, (2) acceptance of a position.

Signature ***(required)*** _____ I will/will not attend the 19_____ GSA Annual Meeting in _____

The Geological Society of America
3300 Penrose Place • P.O. Box 9140 • Boulder, Colorado 80301

EMPLOYER'S REQUEST FOR EARTH SCIENCE APPLICANTS

(Please type or print legibly)

NAME _____ **DATE** _____

ORGANIZATION _____

MAILING ADDRESS _____

CITY _____ **STATE** _____ **ZIP CODE** _____ **TELEPHONE (** **)** _____
area code Number

E-MAIL _____ **FAX (** **)** _____

SPECIALTY CODES (see list below)
List the specialty code numbers that you wish to order, or ☐ check here if you want the entire file of applicants in *ALL* specialties.

1. _____ 2. _____ 3. _____ 4. _____ 5. _____ 6. _____

POSITION DATA: What position(s) do you expect to fill? _____

In what area(s)? _____

Degree requirements _____ Number of positions available _____

SPECIALTY CODES

100 Economic Geology
101 coal geology
102 geothermal, etc.
103 metallic deposits
104 nonmetallic deposits
105 mining geology
120 Engineering Geology
150 Environmental Geology
160 Public Education & Communication
200 General Geology
220 Geochemistry
221 organic
222 high temperature
223 low temperature
224 stable isotopes
225 geochronology
250 Geomorphology
300 Geophysics
301 seismic
302 gravity/magnetics
303 seismicity
304 paleomagnetism
320 Hydrogeology
321 hydrochemistry
322 ground water
323 surface water
330 Library
350 Mathematical Geology
351 computer science
352 statistical geology
400 Mineralogy
401 crystallography
402 clay mineralogy
410 Museum (curator)
420 Oceanography
421 marine geology
422 coastal geology
450 Paleontology
451 invertebrate
452 vertebrate
453 micropaleontology
454 paleobotany
455 paleoecology
500 Petroleum Geology
501 exploration
502 subsurface strat.
520 Petrology
521 igneous
522 metamorphic
523 sedimentary (clastic)
524 sedimentary (carb.)
525 experimental
550 Planetology
575 Quaternary Geology
600 Regional Geology
620 Remote Sensing
621 photogeology
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:
☐ Academic ☐ Government ☐ Industry ☐ Other _____

***Minimum* degree required:**
☐ None ☐ B.A. or B.S. ☐ M.A. or M.S. ☐ Ph.D.

***Minimum* professional experience:**
☐ None ☐ 1–5 years ☐ 6-plus years

Experience desired (years):

	None	1–5	6-plus
Administrative	☐	☐	☐
Exploration/Production	☐	☐	☐
Field	☐	☐	☐
Research	☐	☐	☐
Teaching	☐	☐	☐

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

Foreign Languages: ☐ French ☐ German ☐ Russian ☐ Spanish ☐ Other _____ ☐ Not required

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I am interested in interviewing applicants through the GSA Employment Service at the 19____ Annual Meeting in _____.

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

Signature (required) _____

Date _____

Total fee enclosed . . . . . **$** _____

Or invoice requested . . . . . **$** _____

July *BULLETIN* and *GEOLOGY* Contents

The Geological Society of America
BULLETIN
Volume 109, Number 7, July 1997

CONTENTS

GEOLOGY
VOLUME 25
NO. 7
P. 577–672
JULY 1997

Environmental & Engineering Geoscience Contents

Volume III, Number 1, Spring 1997

GSA Section Meetings — 1998

Call for Papers

NORTHEASTERN SECTION

March 19–21, 1998
Holiday Inn By the Bay,
Portland, Maine

Abstract Deadline:
November 14, 1997

Submit completed abstracts to:
Marc C. Loiselle
Maine Geological Survey
22 State House Station
Augusta, ME 04333-0022
(207) 287-2801
marc.c.loiselle@state.me.us

SOUTHEASTERN SECTION

March 30–31, 1998
Charleston Civic Center,
Charleston, West Virginia

Abstract Deadline:
November 21, 1997

Submit completed abstracts to:
Peter Lessing
WV Geological & Economic Survey
P.O. Box 879
Morgantown, WV 26507-0879
(304) 594-2321
lessing@geosrv.wvnet.edu

NORTH-CENTRAL SECTION

March 19–20, 1998
Ohio State University, Columbus, Ohio

Abstract Deadline:
November 14, 1997

Submit completed abstracts to:
David H. Elliot
Department of Geological Sciences
Ohio State University
125 South Oval Mall
Columbus, OH 43210
(614) 292-5076
delliot@magnus.acs.ohio-state.edu

CORDILLERAN SECTION

April 7–9, 1998
California State University,
Long Beach, California

Abstract Deadline:
December 12, 1997

Submit completed abstracts to:
James C. Sample
Department of Geological Sciences
California State University
Long Beach, CA 90840
(562) 985-4589
csample@csulb.edu

SOUTH-CENTRAL SECTION

March 23–24, 1998
University of Oklahoma,
Norman, Oklahoma

Abstract Deadline:
December 1, 1997

Submit completed abstracts to:
Judson Ahern
School of Geology & Geophysics
University of Oklahoma
100 E. Boyd St., Suite 810
Norman, OK 73019-0628
(405) 325-3253
jahern@ou.edu

ROCKY MOUNTAIN SECTION

May 25–26, 1998
Northern Arizona University,
Flagstaff, Arizona

Abstract Deadline:
December 12, 1997

Submit completed abstracts to:
Wendell Duffield
U.S. Geological Survey
2255 Gemini Road
Flagstaff, AZ 86001
(520) 556-7000
wduffield@iflag2.wr.usgs.gov

1998 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 1998 GSA Section Meeting abstract form.

Name _____

Address _____

_____

City _____ State_____ ZIP _____

CALENDAR

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

1997 Penrose Conferences

September

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

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

1997 Meetings

July

July 16–19, **Geo-Logan '97** (American Society of Civil Engineers Geo-Institute Annual Technical Conference), Logan, Utah. Information: Sara Hansen or Vicki Wiser, 1-800-538-2663.

August

August 25–27, **Hydrogeology of Washington State 2nd Symposium,** Olympia, Washington. Information: Nadine Romero, Washington State Dept. of Ecology, (360) 407-6116, nrom461@ecy.wa.gov.

September

September 30–October 4, **Association of Engineering Geologists 40th Annual Meeting,** Portland, Oregon. Information: Gary Peterson, (503) 635-4419, garyp@squire.com; http://geoweb.tamu.edu/aeg/.

October

October 6–9, **Ecuador Mining '97,** Cuenca, Ecuador. Information: George H. Roman, *Engineering & Mining Journal,* 29 N. Wacker Dr., Chicago, IL 60606-3298, (773) 342-1167 or (312) 726-2802, fax 773-342-5744 or 312-726-2574, ghroman@msn.com.

October 7–10, **Mining Equipment, Processing of Mineral Resources, New Technology, Ecology** (ETER-97) 3rd International Exhibition and Symposium, St. Petersburg, Russia. Information: Vladimir Lelis, P.O. Box 215, 199004, St. Petersburg, Russia, phone 7-812 355-7952, fax +7-812 213-5926, 112-2348, root@restec.spb.su, http://www.restec.ru/.

October 21–22, **Geophysics, Rock Physics & Reservoir Properties of Gas Hydrate Zones Under the Ocean,** Stanford, California. Information: Amos Nur, c/o Dept. of Geophysics, Stanford University, Stanford, CA 94035-2215, amos.nur@stanford.edu, fax 415-723-1188, http://pangea.stanford.edu/~margaret/srbhomepage.html. *(Abstracts deadline: August 15, 1997.)*

November

November 12–14, **19th New Zealand Geothermal Workshop,** Auckland, New Zealand. Information: Convenors, c/o Geothermal Institute, University of Auckland, Private Bag 92019, Auckland, New Zealand, fax 64-9-373-7436, geo.wshop@auckland.ac.nz, http://www.auckland.ac.nz/gei/.

1998 Meetings

January

January 26–29, **Tailings and Mine Waste '98,** Fort Collins, Colorado. Information: Linda Hinshaw, Dept. of Civil Engineering, Colorado State University, Fort Collins, CO 80523-1372, (970) 491-6081, fax 970-491-3584 or 7727.

March

March 18–20, **GSA Northeastern Section Meeting,** Portland, Maine.

March 19–20, **GSA North-Central Section Meeting,** Columbus, Ohio.

March 23–24, **GSA South-Central Section Meeting,** Norman, Oklahoma.

March 30–31, **GSA Southeastern Section Meeting,** Charleston, West Virginia.

Calendar *continued on p. 30*

GSA ANNUAL MEETINGS

1997

Salt Lake City, Utah ◆ October 20–23

Salt Palace Convention Center ◆ Little America Hotel

GSA Student Associate Member Travel Grants

The GSA Foundation has awarded matching grants to the six GSA Sections. The money, when combined with equal funds from the sections, is used to assist GSA Student Associates traveling to GSA meetings. The following sections offer assistance for travel to the Annual Meeting in Salt Lake City. The remaining two sections offer assistance to their section meeting. For information and deadlines, contact your section secretary.

- North-Central—George Hallberg, (319) 335-4500, ghallber@uhl.uiowa.edu
- Northeastern—Kenneth Weaver, (410) 554-5532, kweaver438@aol.com
- South-Central—Rena Bonem, (817) 755-2361, bonemr@baylor.edu
- Southeastern—Harold Stowell, (205) 348-5098, hstowell@wgs.geo.us.edu

GSA Continuing Education Courses — Register now!

1. **Analysis of Veins in Sedimentary Rocks—An Introduction for Structural Geologists.** Saturday, October 18 and Sunday, October 19. Salt Palace Convention Center. Cosponsored by *Structural Geology and Tectonics Division*. **Faculty:** David V. Wiltschko, John W. Morse, and Will Lamb, Texas A&M University, College Station; Danny M. Rye, Yale University. **Limit:** 40. Fee: $280, students $260; includes course manual and lunch both days. CEUs: 1.6.

2. **Techniques of Geostatistical Estimation and Simulation Applied to Environmental Geology.** Saturday, October 18 and Sunday, October 19. University of Utah. Cosponsored by *Engineering Geology Division*. **Faculty:** Sean A. McKenna and Christopher A. Rautman, Sandia National Laboratories. **Limit:** 25. Fee: $320, students $300; includes course manual and lunch both days. CEUs: 1.6.

3. **Computer Visualization of Three-Dimensional Deformation and Application to Upper-Crustal Settings.** Saturday, October 18 and Sunday, October 19. Salt Palace Convention Center. Cosponsored by *Structural Geology and Tectonics Division*. **Faculty:** Steven F. Wojtal, Oberlin College; Basil Tikoff, Rice University. **Limit:** 30. Fee: $380, students $360; includes course manual, computer software, and lunch both days. CEUs: 1.6.

4. **Applications of Environmental Isotopes to Solving Hydrologic and Geochemical Problems.** Sunday, October 19. Salt Palace Convention Center. Cosponsored by *Hydrogeology Division*. **Faculty:** Carol Kendall and Thomas D. Bullen, U.S. Geological Survey, Menlo Park. **Limit:** 50. Fee: $205, students $155; includes course manual, lunch, and casual post-course reception. CEUs: 0.8.

5. **Buck Rogers, Field Geologist: 21st Century Electronic Wizardry for Mapping and Field Data Collection.** Sunday, October 19, 8:00 a.m. to 5:00 p.m. Salt Palace Convention Center. Cosponsored by *History of Geology Division*. **Faculty:** John H. Kramer, Condor Earth Technologies, Inc., Sonora, California; Todd Fitzgibbon, U.S. Geological Survey, Menlo Park. **Limit:** 35. Fee: $230, students $210; includes course manual and lunch. CEUs: 0.8.

6. **Dynamical Systems Modeling for Undergraduate Education: From Coleman Coolers to Computers.** Sunday, October 19. New Horizons Computer Facility. Cosponsored by *National Association of Geoscience Teachers*. **Faculty:** Alexandra Moore, Hartwick College; Louis A. Derry and Andrew J. Kurtz, Cornell University. **Limit:** 30. Fee: $280, students $260; includes course manual and lunch. CEUs: 0.8.

7. **Environmental Issues at Modern and Historic Mining Sites.** Sunday, October 19, 8:00 a.m. to 5:00 p.m. Salt Palace Convention Center. **Faculty:** Donald D. Runnells, Clinton L. Strachan, Edward F. Redente, and Thomas A. Shepherd, Shepherd Miller, Inc., Fort Collins, Colorado. **Limit:** 50. Fee: $200, students $180; includes course manual and lunch. CEUs: 0.8.

8. **Geology of Coal Bed Methane: The Perspective from Basin and Thermal History Studies.** Sunday, October 19. Salt Palace Convention Center. Cosponsored by *Coal Geology Division*. **Faculty:** Charles E. Barker, U.S. Geological Survey, Denver; Andrew R. Scott and Roger Tyler, Bureau of Economic Geology, University of Texas at Austin. **Limit:** 50. Fee: $200, students $180; includes course manual and lunch. CEUs: 0.8.

9. **Geomorphic Applications of In Situ–Produced Cosmogenic Isotopes.** Sunday, October 19. University of Utah. Cosponsored by *Quaternary Geology and Geomorphology Division*. **Faculty:** Paul R. Bierman, University of Vermont; Alan R. Gillespie, University of Washington. **Limit:** 30. Fee: $260, students $240; includes course manual, computer files, and lunch. CEUs: 0.8.

10. **Visualization in the Geosciences.** Sunday, October 19. Salt Palace Convention Center. **Faculty:** Paul J. Morin, University of Minnesota; Mark McBride, Groundwater Metrics, Silver Springs, Maryland. **Limit:** 50. Fee: $325, students $305; includes course manual and lunch. CEUs: 0.8.

11. **Paleosols for Sedimentologists.** Sunday, October 19. Salt Palace Convention Center. Cosponsored by *Sedimentary Geology Division*. **Faculty:** Greg H. Mack and H. Curtis Monger, New Mexico State University. **Limit:** 30. Fee: $195, students $175; includes course manual and lunch. CEUs: 0.8.

12. **Practical Remote Sensing for Geology.** Sunday, October 19. Salt Palace Convention Center. Cosponsored by *Quaternary Geology and Geomorphology Division*. **Faculty:** James M. Ellis, The MapFactory, Inc., Walnut Creek, California. **Limit:** 30. Fee: $240, students $220; includes course manual and lunch. CEUs: 0.8.

Call for Papers: *April and June* GSA Today

Preregistration Deadline: *September 19*

Technical Program Schedule:
September GSA Today *and the Web*

Registration and Housing information: *June* GSA Today.

Register Today!

Announcing ... Late-Breaking Research Sessions

for Salt Lake City 1997 GSA Annual Meeting
October 20–23, 1997, Salt Palace Convention Center

Exciting new data or breakthroughs over the summer?

Present your work at the GSA Annual Meeting this fall!

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

- An abstract on late-breaking research may be submitted after September 1 until midnight, September 30, 1997.
- Abstracts must be submitted using the Web form; they may not be submitted on paper or by e-mail: http://www.geosociety.org
- Space will be limited and selection will be based on scientific merit.
- The author will be asked to provide a brief explanation of why the abstract deserves consideration after the usual deadline for this meeting.
- The author may designate either oral and/or poster, although space limitations may require reclassification.
- Because of scheduling limitations, you may present only one volunteered paper in oral or poster mode. If you have already had a volunteered abstract accepted, please do not submit another.

Abstract Fee: For this meeting, a nonrefundable abstract fee of $50 must accompany each Late-Breaking Research abstract submitted. Our Web-template form will ask for credit-card information. We have installed one of the best-known and most respected Secure Server systems for transmission of your credit-card data to fully protect your confidential information.

Schedule: Abstracts will be reviewed by the Annual Program Committee. Electronic acceptance notices will be sent out the first week in October giving the place and time of presentation. Late-Breaking Research Sessions (oral and poster) will be held on Thursday, October 23, 1997.

Publication: The abstracts will not be published in the abstract volume, although they will be published on the Web along with the Web abstracts and paper copies will be made available on site.

1998

Toronto, Ontario, Canada

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

General Chair:
Jeffrey J. Fawcett, *University of Toronto*

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

Due date for symposia and theme proposals:
January 2, 1998

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

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

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

Call For

CONTINUING EDUCATION COURSE PROPOSALS

Due December 1, 1997

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 1998 Toronto Annual Meeting or the 1999 Denver Annual Meeting.

Proposals must be received by December 1, 1997. Selection of courses for 1998 will be made by February 1, 1998. For those planning ahead, we will also consider courses for 1999 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.

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**
WWW: **http://www.geosociety.org**

Attention!

authors ... editors ... and ... contributors to GSA's older volumes

Many GSA publications are going out of print now that our Last Chance Sale is over. Bulk quantities of several titles are now available for sale. These are offered under the following conditions:

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OFFERS MUST BE RECEIVED BY AUGUST 15, 1997

Calendar *continued from p. 27*

April

April 7–8, **Pennsylvanian and Permian Geology and Petroleum in the Southern Midcontinent,** Norman, Oklahoma. Information: Kenneth S. Johnson, Oklahoma Geological Survey, University of Oklahoma, 100 E. Boyd St., Room N-131, Norman, OK 73019, (405) 325-3031 or 1-800-330-3996, fax 405-325-7069.

April 7–9, **GSA Cordilleran Section Meeting,** Long Beach, California.

April 13–17, **Seventh International Kimberlite Conference,** Cape Town, South Africa. Information: Dept. of Geological Sciences, University of Cape Town, Private Bag, Rondebosch, 7700, South Africa, e-mail 7ikc@geology.uct.ac.za, phone (27)-21-650-2931; fax: 27-21-650 3783, or James Gurney, phone (27)-21-531-3162, fax 27-21-531-9887.

May

May 3–7, **34th Forum on the Geology of Industrial Minerals,** Norman, Oklahoma. Information: Kenneth S. Johnson, Oklahoma Geological Survey, University of Oklahoma, 100 E. Boyd St., Room N-131, Norman, OK 73019, (405) 325-3031 or 1-800-330-3996, fax 405-325-7069.

May 17–22, **American Society for Surface Mining and Reclamation 15th National Meeting,** St. Louis, Missouri. Information: Dianne Throgmorton, Coal Research Center, Southern Illinois University, Carbondale, IL 62901-4623, (618) 536-5521, fax 618-453-7346, diannet@siu.edu. *(Abstract deadline: September 15, 1997.)*

End of May, **GSA Rocky Mountain Section Meeting,** Flagstaff, Arizona.

June

June 29–July 2, **15th Caribbean Geological Conference,** Kingston, Jamaica. Information: Trevor Jackson, 15th Caribbean Geological Conference, c/o Dept. of Geography & Geology, University of the West Indies, Kingston 7, Jamaica, fax 809-977-6029.

July

July 11–17, **IAVCEI International Volcanological Congress '98,** Rondebosch, South Africa. Information: Secretariat, IAVCEI 1998, Dept. of Geological Sciences, University of Cape Town, Rondebosch, South Africa, fax: 27-21-650-3783, ivc98@geology.uct.ac.za, http://www.uct.ac.za/depts/geolsci/ivc98/.

August

August 23–28, **6th International Conference on Paleoceanography,** Lisbon, Portugal. Information: Fatimá Abrantes, Assoc. Portuguesa de Paleoceanografia, Apt. 7618 Alfragide, 2700 Amadora, Lisbon, Portugal, phone 351-1-346-3915, fax 351-1-342-4609, icp6fatima@mail.telepac.pt.

October

October 6–9, **German Geological Society 150th Annual Meeting,** Berlin, Germany. Information: Johannes Schroeder, Inst. für Angewandte Geowissenschaften II, Ernst-Reuter-Platz 1, D-10587 Berlin, Germany, phone 49-30-314-23650, fax 49-30-314-21107, Geo-Berlin-98@tu-berlin.de.

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

78th AMS Annual Meeting

JANUARY 11–16, 1998 ❧ PHOENIX, ARIZONA

The 78th Annual Meeting of the American Meteorological Society will be held in Phoenix, Arizona, January 11–16, 1998. GSA is a cosponsor of the meeting.

For more information: AMS Meetings
45 Beacon Street, Boston, MA 02108
(617) 227-2426, fax 617-742-8718.

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.

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Positions Open

MINERALOGY/PETROLOGY/STRUCTURAL GEOLOGY
The Department of Geology and Geophysics,University of Missouri-Rolla, announces a tenure-track position at the assistant professor level. The successful candidate must hold the Ph.D., will be expected to teach mineralogy, petrology, and/or structural geology at the undergraduate level, and will develop a graduate research program (M.S. and Ph.D.) in one of those areas. Additional information regarding the position and department can be obtained from our Web page <http://www.umr.edu/~geo-geop/> or by writing to: Chairman, Department of Geology and Geophysics, University of Missouri-Rolla, Rolla, MO 65409-0410. The deadline for application is September 15, 1997. UMR is an Equal Opportunity Employer.

ASSISTANT PROFESSOR OF HYDROLOGY
New Mexico Institute of Mining and Technology invites applications for a new tenure-track position in the Hydrology Program. The position is a joint appointment between the Department of Earth and Environmental Science and the Geophysical Research Center, a state-funded research agency. Applicants should have a Ph.D. in the Earth Sciences or a related field at the time of appointment. We seek candidates with expertise in water/land surface interactions (e.g., watershed hydrology, hydrogeomorphology, or hydroclimatology) who have strong quantitative skills and an interest in field problems. Excellence in research and potential for future growth are the most important qualifications. Responsibilities will include developing an active program of extramurally funded research, supervising and supporting graduate students, and teaching two upper-division or graduate courses per year. The successful candidate will join a program of five full-time Hydrology faculty, eight adjunct faculty, and 30 graduate students. Hydrology is part of the Department of Earth and Environmental Science, consisting of 16 faculty and 150 undergraduate and graduate students. Additional geoscience professionals on campus include the 28 staff members of the Bureau of Mines, New Mexico's geological survey. For futher information on the position and on New Mexico Tech see http://griffy.nmt.edu/Hydro/ position.html. Applicants should submit a letter of interest, resume, college transcripts, and the names of three references to New Mexico Institute of Mining and Technology, Human Resources, 801 Leroy Pl., Wells Hall Box C-048, Socorro, New Mexico 87801. To receive full consideration all materials must be received by 1 September 1997. New Mexico Tech is an equal opportunity/affirmative action employer.

Director of Curriculum Development

American Geological Institute

The American Geological Institute invites applications for the position of Director of Curriculum Development from geoscience educators with experience in K–12 Earth-science curriculum development and management of large educational projects. A doctoral degree in the geosciences or Earth science education is required, and classroom experience is preferred.

This position provides an unparalleled opportunity for an Earth science professional committed to advancing the status of science education in the nation's schools based on the National Science Education Standards and the educational goals of AGI and its Member Societies.

The successful candidate will manage AGI's K–12 curriculum development projects from AGI headquarters in Alexandria, Virginia. S/he will interact on a day-to-day basis with project investigators, directors of other state and national education programs, professional societies, and private sector supporters. S/he will provide intellectual oversight on the content, pedagogy, assessment, and publishing of project-related materials in cooperation with project investigators. S/he will also manage logistical and financial operations of funded projects. The successful candidate will also be expected to identify and develop support for new program-related activities.

Applicants should send a letter of interest, vita, and names/addresses of three references to the AGI Education Search Committee, American Geological Institute, 4220 King Street, Alexandria, VA 22302-1502 (fax 703-379-7563). Appointment is anticipated no later than September 1997. Review of applications will begin immediately. Applications will be accepted until the position is filled. For more information about AGI, its programs and activities, visit our Web site at <http://www.agiweb.org/>. AA/EOE.

CALL FOR *GSA Today* Correspondent for Student Matters

GSA seeks a Member or Fellow willing to coordinate and be responsible for a regular (monthly) contribution for *GSA Today* dealing with matters of interest to undergraduate and graduate student members of the Society. GSA headquarters will provide support for operations of this enterprise. We anticipate a one-year obligation beyond 1997, but we hope to begin publishing contributions this year.

Interested parties should send a statement of interest and a short vita to the address below. The position will remain open until a suitable candidate is identified.

Executive Director
Geological Society of America
P.O. Box 9140
Boulder, CO 80301
davidson@geosociety.org

1997 Geological Society of America

Annual Meeting and Exposition

Salt Lake City, Utah
October 20–23

Abstracts Due
July 8

Preregistration Due
September 19

Program Schedule
September GSA *Today* and the Web

See June GSA Today for information on:
- Technical Program
- Continuing Education Courses
- Field Trips
- Exhibits
- Registration
- Lodging and Travel

or see the GSA Web site:
www.geosociety.org

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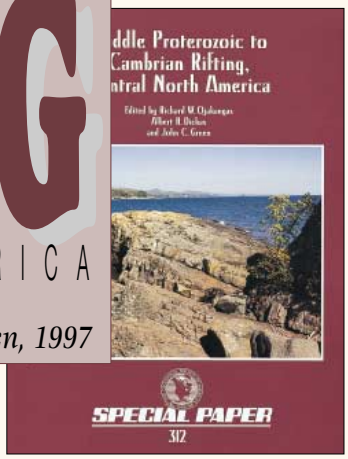
MIDDLE PROTEROZOIC TO CAMBRIAN

RIFTING

CENTRAL NORTH AMERICA

EDITED BY

R. W. Ojakangas, A. B. Dickas, and J. C. Green, 1997

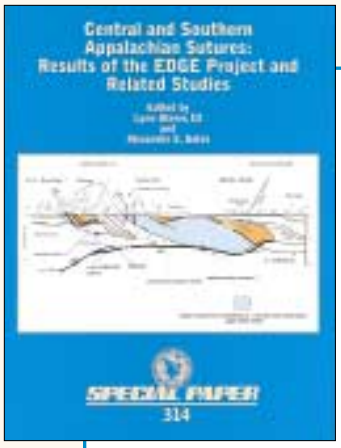


Most of these papers, presented at the Tenth International Basement Tectonics Conference, deal with a wide variety of aspects of the 1.1 Ga Midcontinent Rift System of North America, including tectonics, strain analysis, sedimentology, geophysics, and economic geology, and how they interrelate. The remaining contributions concern other rift-related structures and rock units in the North American midcontinent that date from the time of rifting into the Cambrian. Many of the significant features described in this book are buried under Paleozoic and Quaternary strata and are known chiefly from geophysical surveys and scattered drilling. These papers provide new insights and interpretations for the foundations of the U.S. continental midsection.

SPE312, 328 p., paperback, indexed, ISBN 0-8137-2312-4. Nonmembers $100.00; GSA Members $80.00

CENTRAL AND SOUTHERN APPALACHIAN SUTURES

RESULTS OF THE EDGE PROJECT AND RELATED STUDIES



edited by L. Glover, III and A. E. Gates, 1997

In 1962 Harry Hess's *History of Ocean Basins* gave a mechanism and a measure of credibility to the ancient hypothesis of continental drift. The new model has been successful in explaining Mesozoic and Cenozoic tectonics; therefore, it is remarkable that today there exists no general agreement on the number, age, and location of older Appalachian sutures. This volume contributes to understanding these sutures. Topics include: the nature of metavolcanic Carolina-Avalon terrane and its problematic western boundary in the Piedmont of central Georgia; the Cambrian(?) emplacement of Carolinian rocks against Laurentia in southern Virginia; and reactivation of the southern Virginia suture as a major zone of crustal weakness that moved during every subsequent tectonic event. Two papers argue against a suture in the Blue Ridge and suggest that the Laurentian plate boundary is the central Piedmont suture. A regional paper interprets the "Taconic"-Carolinian suture and the Laurentian margin through the central Appalachians and offshore continental margin.

SPE314, 142 p., ISBN 0-8137-2314-0. Nonmembers $50.00; GSA Members $40.00

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