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INSIDE

Evolution of the Sr and C Isotope Composition of Cambrian Oceans

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ABSTRACT

The recent proliferation of chemostratigraphic studies has clearly documented that systematic fluctuations in the strontium and carbon isotope composition of seawater have occurred throughout Earth history across a range of temporal scales. In particular, significant isotopic variation during key intervals of geologic time has provided unprecedented quantitative constraints on crustal and surficial processes, and enhanced chronostratigraphic resolution for intrabasinal and interbasinal correlations. We present the first set of high-resolution, seawater Sr and C isotope curves for the late Early through early Late Cambrian. These curves are defined in continuous exposures of marine carbonates in the Great Basin and southern Canadian Rockies, and they are used to better constrain primary variations in ocean chemistry during this time period. The Sr curve documents a rapid rate of increase through this period that is comparable to that recorded by the late Cenozoic seawater Sr proxy record of uplift and attendant weathering of the Himalaya-Tibetan Plateau. The Cambrian rise in Sr values is interpreted to record Pan-African–Brasiliano orogenesis, and reaches $^{87}Sr/^{86}Sr$ values that are higher than at any other time in Earth history. Numerous superimposed, smaller-scale oscillations may constrain the timing of individual short-term tectonic events. The C isotope curve for the same time interval reveals several previously unrecognized short-term fluctuations of up to 4‰. A sharp shift in $\delta^{13}C$ values near the Early-Middle Cambrian boundary indicates major paleoceanographic and climatic change associated with a trilobite mass extinction event. Used in concert, this set of high-resolution $^{87}Sr/^{86}Sr$ and $\delta^{13}C$ records provides complementary quantitative constraints for the chronology of Cambrian tectonic, paleoceanographic, paleoecologic, and biogeochemical events.

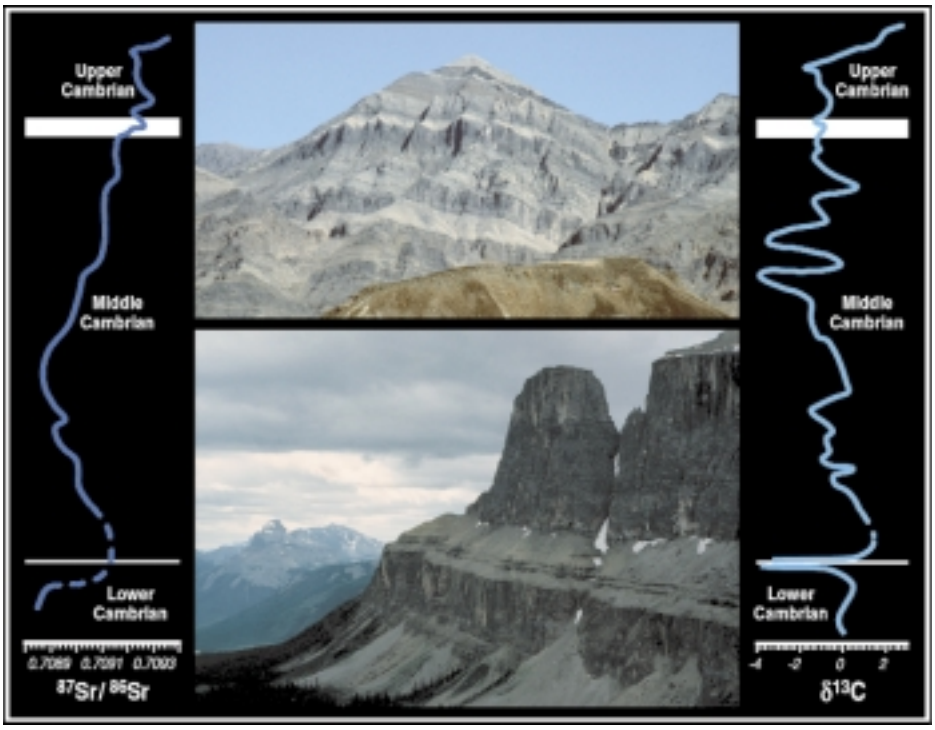

Figure 1. Representative mountain-front exposures of Middle to Upper Cambrian carbonates paired with Sr and C isotope stratigraphic variations through the study interval. Lower photo of Middle Cambrian Mount Whyte, Cathedral, Stephens, and Eldon formations exposed at Castle Mountain, southern Canadian Rockies. Upper photo of Middle to Upper Cambrian Bonanza King, Dunderberg, and Nopah formations exposed at Pyramid Peak, southern Great Basin, United States.

INTRODUCTION

Systematic variations in the Sr ($^{87}Sr/^{86}Sr$) and C ($\delta^{13}C$) isotopic composition of seawater have been documented by numerous chemostratigraphic studies across a range of temporal scales (e.g., Burke et al., 1982; Jacobsen and Kaufman, 1999; Hayes et al., 1999; Veizer et al., 1999). These "secular" isotopic variations are valuable proxies of paleoenvironmental change and paleotectonic events. They also provide valuable means of chronostratigraphic correlation in intervals plagued by a paucity of age-diagnostic biostratigraphic markers. The utility of $^{87}Sr/^{86}Sr$ and $\delta^{13}C$ values in well-preserved carbonate rocks as proxies resides in the processes that they record. Temporal variation in seawater $^{87}Sr/^{86}Sr$ is governed mainly by changes in the balance between Sr fluxes to the ocean from continental weathering and hydrothermal fluid-rock interaction at mid-ocean ridges (Palmer and Edmond, 1989). The $^{87}Sr/^{86}Sr$ composition of the volumetrically smaller seafloor hydrothermal flux is buffered at low values of ~0.703–0.705. Conversely, continental weathering, via riverine and groundwater fluxes, contributes Sr with high $^{87}Sr/^{86}Sr$ values (0.709–0.730) to the ocean. It is primarily the variation in the larger continental flux and its isotopic composition that has affected secular change in seawater

Cambrian Oceans *continued on p. 2*

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October 1999

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Vicksburg, Mississippi
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Cambrian Oceans *continued from p. 1*

$^{87}Sr/^{86}Sr$ values. The $^{87}Sr/^{86}Sr$ values of unaltered marine carbonate minerals directly record seawater $^{87}Sr/^{86}Sr$ values, given the negligible fractionation of Sr isotopes (Banner and Kaufman, 1994) and the homogeneity of Sr in seawater (DePaolo and Ingram, 1985).

Ocean-scale variation in the $\delta^{13}C$ composition of surface seawater on time scales of $>10^5$ yr primarily arises from changes in the long-term throughput of carbon in the ocean and the isotopic fractionation associated with partitioning of carbon into reduced and oxidized reservoirs (Kump, 1991; Kump and Arthur, 1999). These mechanisms are driven by continental weathering, global sedimentation rates, primary productivity, organic carbon burial, and ocean circulation mode, all of which in turn modulate atmospheric pCO_2 and hence climate. Thus, $^{87}Sr/^{86}Sr$ and $\delta^{13}C$ records are highly complementary proxies of surficial and crustal cycling as well as paleoclimate and paleoecologic change.

Seawater $^{87}Sr/^{86}Sr$ and $\delta^{13}C$ records for a number of important intervals of pre-Cretaceous time are of relatively low resolution, thus compromising their utility as paleoenvironmental proxies. The low resolution of these curves primarily reflects significant age uncertainties and the difficulty of obtaining a reliable marine signal due to diagenetic effects. In particular, the existing isotope curves for the late Early through early Late Cambrian need to be significantly refined, given that this was a time of dramatic change in Earth systems. Large-scale continental reorganization associated with the amalgamation of Gondwana (Unrug, 1997) and anomalously fast rotation (up to 90°) and latitudinal drift of continents (>30 cm/yr), driven by an inertial interchange true polar wander event (Kirschvink et al.,

Dialogue

Sara Foland, CEO

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At the Flatirons near Boulder, Colorado.

Stewardship: Finding a Balance

> "Prudence and good stewardship for the living world dictate that we start to chart our future soon, and in rather specific terms. We may or may not yet have the knowledge or wisdom to make all the right choices, but do we at least have the sense of purpose to begin?"
>
> —E-an Zen, GSA President, 1992–1993, in *The Earth Around Us: Maintaining a Livable Planet*

For several months, we have been discussing the values that guide our actions in GSA: science, stewardship, and service. These values are recognized in GSA's strategic plan, which focuses our actions over the next three to five years.

In the past two issues of *GSA Today,* we explored earth scientists' natural role as stewards of Earth. We also discussed our collective stewardship of earth science information, as members of a scientific society engaged in member research, publications, and programs. To expand our dialogue on stewardship, I want to share some thoughts with you now about stewardship for applied geologists. I feel particularly well qualified to do so, after spending nearly 20 years in the petroleum industry and in oil and gas exploration.

Who and What Are Applied Geologists? And Why Should We Talk About This?

The term "applied geologist" refers to those who directly apply their geoscience expertise in business and industry. Over one-third (36%) of GSA members fit this description; they work in petroleum geology, mineral or economic geology, environmental geoscience, and engineering. Many are employed by government and corporations, while others work as independent consultants.

It's important for GSA as a society to encourage dialogue and improve our overall understanding of the world of applied geology, because of the changing mix of employment opportunities we see in our field. The number of jobs in academia is shrinking, while demand for geoscience expertise in government and industry is increasing.

It's been my experience that applied geologists care about the environment, quality of life, and sustainability. The question is, how do we balance environmental awareness, resource demand and exploitation, and the economics of doing business in a commodity-based industry? From my perspective, it's all about balancing one's personal values on stewardship with those of the company and/or industry in which one works.

Pursuing a Career in Applied Geology

When interviewing for applied geoscience jobs, one is confronted with opportunities that may appear to be in conflict with our role as stewards of Earth. Here are suggestions for members who find themselves in this situation.

In order to make a values-based decision on a job offer, you must have credible information about the company. If possible, seek out information during the interview concerning how the company acted when faced with environmental challenges. Review the corporate record on past actions; this is a key to how the company may behave in the future.

Check to see if internship opportunities exist. Three- to six-month internships are a great way to get an insider's perspective on a company. You can see the corporate values in action and validate alignment with your personal values. You can also investigate how business decisions are made—who is involved and who is accountable for the results. In 17 years in the petroleum industry, my personal values never clashed with company action, as I felt I had a voice in setting and defining the corporate values.

GSA as a Forum for Debate

GSA holds a unique position and provides a focal point for members to discuss stewardship in all its aspects. We allow seemingly opposed groups—everyone from energy and mineral resource managers to environmental advocates—to meet in an open forum and explore tough issues without censorship. We intend to do this in an environment of mutual respect and joint problem solving, de-politicizing the term "stewardship."

1997), characterize this time interval. This tectonic forcing likely generated major changes in oceanic circulation, geochemistry, and primary productivity, as well as enhanced rates of continental weathering and organic carbon burial. Thus, accurate isotope curves are imperative for interpreting such significant environmental change.

To that end, we present detailed $^{87}Sr/^{86}Sr$ and $\delta^{13}C$ curves derived from continuous exposures of marine carbonate strata in the Great Basin and southern Canadian Rockies that significantly refine the resolution of existing Cambrian trends (Fig. 1). These newly defined seawater curves document previously unrecognized fluctuations, revealing a more dynamic evolution of Cambrian ocean chemistry than defined to date. Used in concert, these high-resolution $^{87}Sr/^{86}Sr$ and $\delta^{13}C$ records offer an unprecedented level of chronostratigraphic resolution for intrabasinal and interbasinal correlation and refined paleogeographic reconstructions, as well as provide quantitative geochemical constraints on paleoenvironment and paleoclimate change during the Cambrian.

CONSTRUCTION OF SEAWATER ISOTOPE CURVES

Cambrian carbonates in the Great Basin and southern Canadian Rockies have a complex burial history and hence potential for postdepositional chemical alteration. Thus, all samples in this study were petrographically and geochemically evaluated using previously defined criteria (Banner and Kaufman, 1994; Montañez et al., 1996) believed to be most effective in identifying components with the highest potential for yielding primary marine values. All samples were pretreated using ultrapure ammonium acetate, a cation exchange solution that preferentially removes readily leachable Sr from the surfaces, lattice, or fluid inclusions of Rb-rich clays and oxides, which are commonly associated in trace amounts with marine carbonates (description of methods available from Montañez et al. on request). Penecontemporaneous marine cements in algal bioherms and grainstones, and secondarily, very finely crystalline micrites were found to yield a best estimate of seawater $^{87}Sr/^{86}Sr$ and $\delta^{13}C$ values.

Relative age assignment of data in this study is based on the stratigraphic position of samples relative to one another within thick continuous sections. Constrained by all available biostratigraphy, samples were merged into a composite stratigraphic section constructed from ten sections in the southern Canadian Rockies and five sections in the Great Basin. The composite section was proportioned along a linear time axis by stratigraphic position

Cambrian Oceans *continued on p. 4*

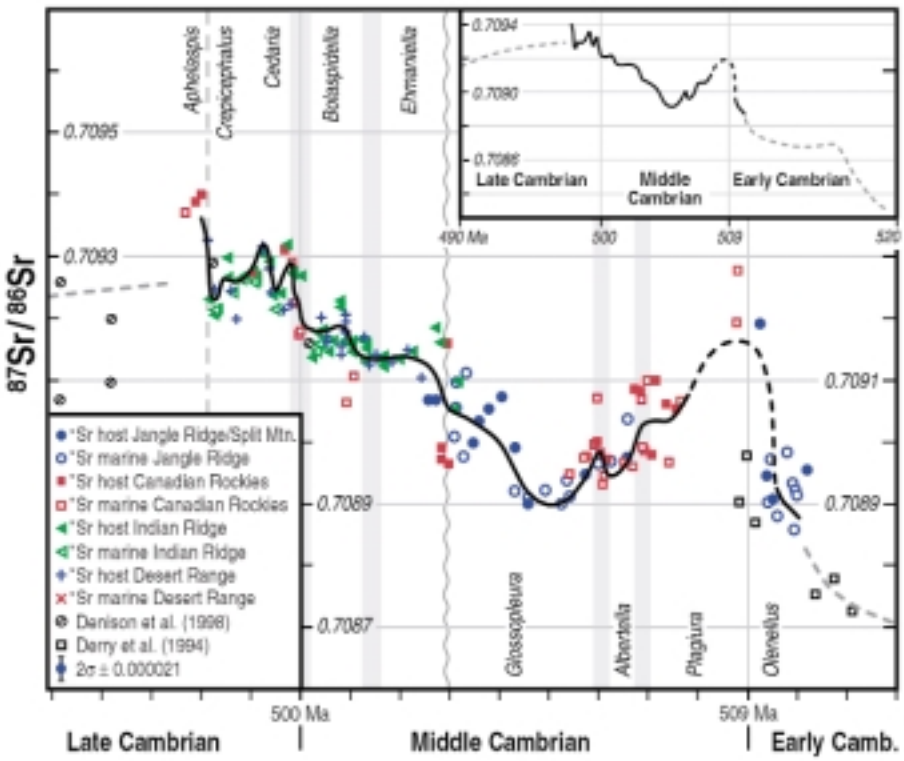

Figure 2. Temporal variations in $^{87}Sr/^{86}Sr$ values of samples determined to provide best estimate of primary marine isotope composition. Selected published Cambrian data for comparison. To facilitate comparison of $^{87}Sr/^{86}Sr$ results with published data, all $^{87}Sr/^{86}Sr$ values have been normalized to $^{87}Sr/^{86}Sr$ value of 0.710250 for NBS-SRM 987. Analysis of diagenetic calcite cements indicates that $^{87}Sr/^{86}Sr$ compositions of postdepositional waters ranged from less to more radiogenic than estimates of primary marine $^{87}Sr/^{86}Sr$ values and showed no systematic trends through the study interval. We present a five-point running average (black curve) through the data to show predominant isotopic trends. Inset shows best estimate of seawater secular Sr isotope curve for Cambrian Period (<520 Ma) based on compilation of data from this study (bold curve) and data presented in Derry et al. (1994) and Denison et al. (1998). Shaded bands separating trilobite biozones reflect uncertainty in absolute stratigraphic position of each biozonal transition. Representative analytical uncertainty for all $^{87}Sr/^{86}Sr$ values is based on replicate analyses of samples (avg. 2 σ_m = 21 x 10^{-6}, n = 19) and the NBS-SRM 987 standard ($^{87}Sr/^{86}Sr$ = 0.710260; 2 σ = 18 x 10^{-6}, n = 94). Strontium isotope analyses were conducted at University of Texas at Austin following procedures in Banner and Kaufman (1994). Procedural blanks for Sr (5 to 26 pg) were negligible for samples analyzed.

Cambrian Oceans *continued from p. 3*

of the chronometrically defined Lower to Middle Cambrian (509 Ma) and Middle to Upper Cambrian (500 Ma) boundaries (Bowring and Erwin, 1998; Davidek et al., 1998).

SECULAR Sr ISOTOPE CURVE

The temporal variation in the Sr isotope composition of late Early through early Late Cambrian oceans is defined by the $^{87}Sr/^{86}Sr$ values of best-preserved calcite marine components plotted on the most recent Cambrian time scale (Fig. 2). Our interpretation of the isotope trend as "secular" (i.e., recording temporal variation in the isotopic composition of the global oceans) is supported by the consistency of isotope trends between the two passive-margin–setting study areas separated by ~1600 km. The temporal resolution of the curves is optimized by the extraordinary stratigraphic continuity of the sampled sections (hundreds to thousands of meters; Fig. 1). Hence, this is the first continental-scale correlation of such temporally extensive and continuous Paleozoic Sr isotope trends and, as such, provides the most rigorous assessment of the global nature of the seawater Sr isotope curve. Further confidence for the veracity of the curve is provided by multiple sets of contemporaneous samples that have overlapping $^{87}Sr/^{86}Sr$ values (Fig. 2).

Seawater $^{87}Sr/^{86}Sr$ values through the late Early to early Late Cambrian define a non-monotonic rise, the values varying between a minimum of ~0.7089 and a maximum of ~0.7094 (Fig. 2). In this study, minimum $^{87}Sr/^{86}Sr$ values (0.70886–0.70895) characterize the latest Early Cambrian, and overlap with $^{87}Sr/^{86}Sr$ values previously defined from latest Early Cambrian carbonates of the Siberian platform (Derry et al., 1994). Seawater $^{87}Sr/^{86}Sr$ values may have risen rapidly to peak values of 0.70918–0.70927 coincident with the Early-Middle Cambrian transition. This short-term rise is defined tenuously, given the paucity of reliable samples available in this interval. This proposed rise in $^{87}Sr/^{86}Sr$ values warrants further evaluation, given that elevated $^{87}Sr/^{86}Sr$ values define this interval in several sections throughout the Cordilleran margin (this study; E. Fermann, 1999, personal commun.).

In the early Middle Cambrian, $^{87}Sr/^{86}Sr$ values decrease to a low point of ~0.7089 (mid-*Glossopleura* biozone), and then progressively increase through the latter half of the Middle Cambrian to a maximum of ~0.70925–0.70930 in the Late Cambrian *Cedaria* biozone. These maximum $^{87}Sr/^{86}Sr$ values are followed by a rapid decline to ~0.70920 before rising again to the highest recorded seawater values (ca. 0.70940) around 498 Ma. Notably, this maximum value is 0.00023 higher than that of present-day seawater ($^{87}Sr/^{86}Sr$ = 0.709174, adjusted to a NBS-SRM 987 value of 0.710250; DePaolo and Ingram, 1985).

TECTONIC AND CLIMATIC IMPLICATIONS OF CAMBRIAN SEAWATER $^{87}Sr/^{86}Sr$

The latest Early to early Late Cambrian seawater Sr isotope curve presented here is the continuation of a previously defined long-term rise in seawater $^{87}Sr/^{86}Sr$ values that began around 0.7063 in the late Neoproterozoic and continued through the Early Cambrian (Kaufman et al., 1993, 1996; Derry et al., 1994; Jacobsen and Kaufman, 1999). This rise (rate of 0.00002/m.y.) is interpreted to record uplift and attendant increased weathering associated with the Pan-African–Brasiliano orogeny (Edmond, 1992; Richter et al., 1992; Kaufman et al., 1993; Derry et al., 1994). The overall rate of rise in the newly defined part of the Cambrian seawater $^{87}Sr/^{86}Sr$ curve (0.00004/m.y.; Fig. 2) exceeds that of the preceding interval and is comparable to the Cenozoic rate over the past 23 m.y. (Fig. 3). The rapid rise in seawater $^{87}Sr/^{86}Sr$ values over the late Cenozoic is interpreted to record the cumulative effects of uplift of the Himalaya-Tibetan Plateau on erosion rate, climate, and continental weathering (Hodell et al., 1990; Richter et al., 1992). By analogy, the rapid Cambrian trend suggests that tectonic control on riverine Sr flux and its isotopic composition was the dominant driving mechanism. Increased erosion and silicate weathering associated with the Himalayan-scale, Pan-African–Brasiliano orogeny would have significantly increased the flux of radiogenic ^{87}Sr to the oceans.

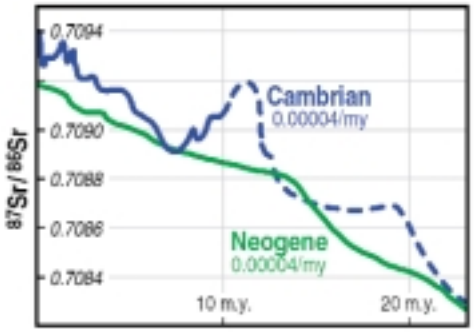

Figure 3. Comparison of seawater Sr isotope curves for latest Early through early Late Cambrian time with the late Cenozoic Sr curve (DePaolo and Ingram, 1985). Long-term rates of rise through ~23 m.y. period are comparable, but Cambrian rise is characterized by superimposed shorter term $^{87}Sr/^{86}Sr$ fluctuations, and reaches peak $^{87}Sr/^{86}Sr$ values that are unmatched in Phanerozoic time.

Our quantitative modeling suggests that an increase in the $^{87}Sr/^{86}Sr$ composition, rather than the magnitude of the riverine Sr flux, would have been required to maintain the estimated rate of rise and to attain the very high $^{87}Sr/^{86}Sr$ values observed for the early Late Cambrian. The Pan-African–Brasiliano orogeny, of late Neoproterozoic through Cambrian age, resulted in convergence and metamorphism of previously rifted Archean-Mesoproterozoic craton margins (Unrug, 1997). Uplift would have resulted in deep exhumation and erosion of these strongly metamorphosed mobile belts. The Sr released during weathering of these highly metamorphosed cratonal rocks would have been significantly more radiogenic than Sr released by weathering of average global continental rocks (cf. Edmond, 1992; Harris, 1995), and could have rapidly increased the $^{87}Sr/^{86}Sr$ composition of the riverine flux.

The evolutionary trend in Cambrian seawater $^{87}Sr/^{86}Sr$ values differs from the late Cenozoic in that the Cambrian curve exhibits considerable variability (Fig. 3). It is possible that recognizable Sr isotope fluctuations superimposed on the longer-term trend may provide constraints for the timing of discrete tectonic phases of the Pan-African–Brasiliano orogeny, for which considerable uncertainty exists. A tentatively defined short period of increased rate of rise (≥0.0002 in ~1 m.y.) across the Early-Middle Cambrian transition is followed by a progressive fall in $^{87}Sr/^{86}Sr$ values over ~4 m.y. of early Middle Cambrian time. This decrease in seawater $^{87}Sr/^{86}Sr$ values is possibly coincident with an episode of widespread rifting along the Weddell Sea–South African sector of the paleo-Pacific margin of Gondwana and the western margin of Laurentia (Grunow et al., 1996; Barnett et al., 1997; Curtis et al., 1999). Continental rifting and associated mafic to alkaline magmatism began during the latest Early Cambrian and extended into the Middle Cambrian. During this period, we infer a decrease in the $^{87}Sr/^{86}Sr$ composition of the continental Sr flux to the ocean, due to weathering of these young mantle-derived mafic rocks, coupled with an increase in the hydrothermal Sr flux, due to seawater interaction with MORB-like basalts at the subaqueous rift axes. Both processes would have driven seawater $^{87}Sr/^{86}Sr$ values downward.

The subsequent rapid rise during the latter half of the Middle Cambrian to peak values in the early Late Cambrian is interpreted to record the large magnitude of coeval orogenic events in Antarctica and Australia (Goodge et al., 1993; Curtis and Storey, 1996; Encarnacion and Grunow, 1996). If these proposed relationships can be further documented, then the shift from low seawater $^{87}Sr/^{86}Sr$ values to increasing values during the middle Middle Cambrian could place constraints on the timing of changing tectonic styles along the margins of Gondwana. Finally, the relatively short time span of the Cambrian radiogenic extreme (~497–500 Ma) may constrain the timing of the terminal phase of Pan-African orogenesis to the latest Cambrian (cf. Encarnacion and Grunow, 1996; Barnett et al., 1997).

INTEGRATION OF Sr AND C ISOTOPE CURVES

The $\delta^{13}C$ values of least-altered carbonate components define the first high-resolution, seawater secular C isotope curve for Middle Cambrian time (Fig. 4). Seawater $\delta^{13}C$ values through this time interval exhibit high-frequency fluctuations (shifts of up to >4‰) around a mean value of –0.5‰. Although the precise form of the long-term $\delta^{13}C$ and $^{87}Sr/^{86}Sr$ trends differ, both curves define a broadly similar progressive fall in values during the early Middle Cambrian that reach minima at different times in the middle Middle Cambrian (*Glossopleura*) (Fig. 4). A rapid increase in $\delta^{13}C$ values at the youngest part of the curve (*Crepicephalus-Aphelaspis* biozones) marks the initiation of a globally recognized positive C isotope excursion (inset, Fig. 4) (Brasier, 1992; Saltzman et al., 1998). This rapid rise in seawater $\delta^{13}C$ values is matched by a coincident rise in $^{87}Sr/^{86}Sr$ values.

Our secular C isotope curve defines a previously undocumented, rapid (~100 k.y.), large-magnitude shift (≥4‰) to negative $\delta^{13}C$ values in the terminal Early

Cambrian Oceans *continued on p. 6*

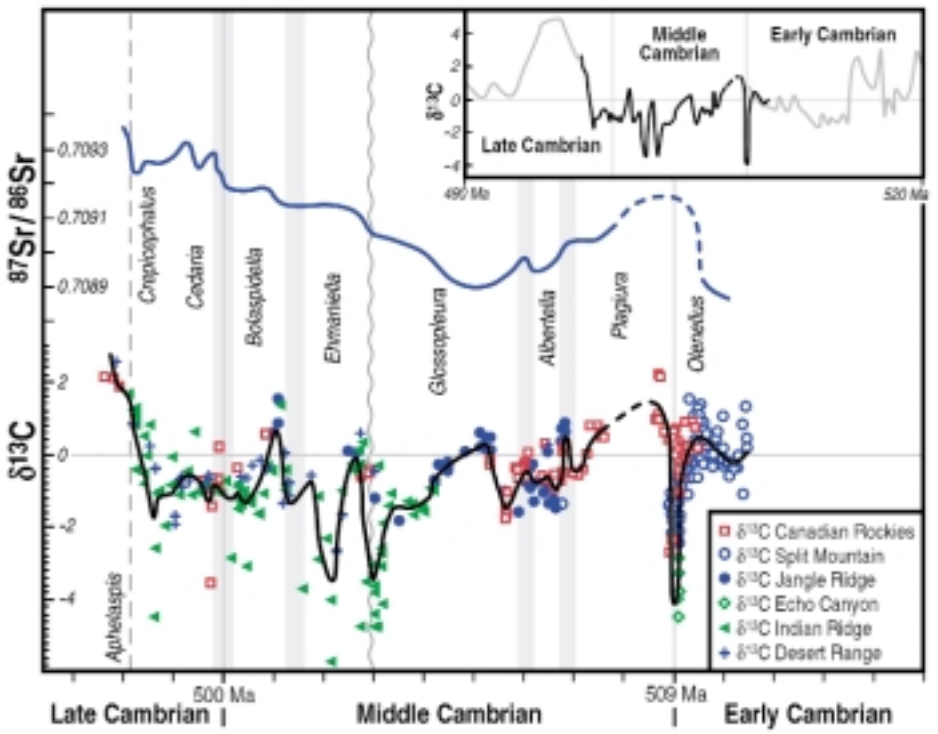

Figure 4. Secular variation in $\delta^{13}C$ values of samples used for Sr isotope analysis, as well as additional samples, that passed our petrographic and geochemical screening criteria for retaining primary marine $\delta^{13}C$ values but did not pass the criteria for Sr isotope analysis. Black curve is a five-point running average of $\delta^{13}C$ values; blue curve is five-point running average of $^{87}Sr/^{86}Sr$ values. Inset curve shows best estimate of seawater secular C isotope curve for Cambrian Period based on compilation of data from this study (bold) and data presented in Brasier and Sukhov (1998). Carbon isotope analyses were conducted at University of Southern California, University of Texas at Austin, and University of California, Davis. External precision (1 σ) for $\delta^{13}C$ was ±0.05‰.

Cambrian Oceans *continued from p. 5*

Cambrian. This negative C isotope excursion begins just prior to the oldest known mass extinction of trilobites and other less common community elements recorded at the Lower-Middle Cambrian boundary (Palmer, 1998). It is possible that the negative C isotope excursion is of even higher magnitude than currently defined, given that the Lower-Middle Cambrian boundary in our sampled sections is underlain by several meters of shale with few intercalated carbonates. This interval is being further evaluated by C isotope analyses of organic matter in shales and carbonates. The temporal relationship of the negative C isotope excursion to the tentatively defined rapid rise in seawater $^{87}Sr/^{86}Sr$ values during the terminal Early Cambrian cannot be clearly resolved, given that the C isotope trend was defined, in part, by marine components that were not suitable for Sr isotope analysis.

In the Great Basin sections (Split Mountain and Echo Canyon) where the C isotope anomaly is best defined, the Early to Middle Cambrian transition is considered relatively conformable, on the basis of preservation of all trilobite zones and lack of evidence of erosion. Erosion of time-equivalent successions worldwide during an early Middle Cambrian regression explains why this negative C isotope excursion has not been previously recognized despite it being among the largest magnitude Phanerozoic excursions. This isotope excursion is recorded in the Great Basin by the topmost few meters of thick (60–250 m) carbonate successions and sharply overlying, highly condensed shales with thin intercalated carbonate beds that extend across the Early to Middle Cambrian boundary. The carbonate-shale stratigraphic relationship records a rapid rise in relative sea level, which was previously recognized in other Laurentian and Siberian sections (Brasier and Sukhov, 1998; Landing and Bartowski, 1996). Evidence of prolonged environmental stress during the negative C isotope excursion is indicated by the lack of bioturbation in shales and the occurrence of carbonate shell beds that are interpreted to record episodic deposition of trilobite death assemblages (L. and M. McCollum, personal commun., 2000).

The negative C isotope excursion indicates that major paleoceanographic changes, and probably climatic changes, preceded the mass extinction at the end of the Early Cambrian. The negative C isotope excursion is interpreted as recording (1) the introduction of ^{13}C-depleted, anoxic waters onto shallow-water carbonate platforms during the latest Early Cambrian transgression, and (2) the associated decrease in organic C burial due to major biomass reduction (cf. Wilde and Berry, 1984; Kajiwara et al., 1994). An anoxic water column below the surface mixed layer may have developed in Early Cambrian oceans during the transgression, accompanied by sluggish circulation and strong stratification. These oceanic conditions would be favored by the low-latitude continentality and depressed meridional temperature gradients that likely characterized Early Cambrian greenhouse time (Railsback et al., 1990). In order to sustain the negative isotope excursion and prolong exposure of shallow-marine organisms to environmental stress, transgression may have occurred in a pattern of stepwise onlap, thus episodically introducing pulses of toxic waters from the anoxic layer onto normally ventilated parts of the platforms (cf. Wilde and Berry, 1984).

Carbonate $\delta^{13}C$ values at the peak of the negative isotope excursion (<–4‰) suggest that the ocean's isotopic composition ultimately approached that of the weathering input to the oceans ($\delta^{13}C$ of ~–5‰; Kump, 1991). This proposed increased influence of the riverine flux on the ocean's isotopic composition may reflect greatly reduced primary productivity and organic C burial rates in response to building environmental stress prior to the mass extinction. The subsequent shift to more positive $\delta^{13}C$ values in the earliest Middle Cambrian likely records the effects of (1) contraction of the oxygen-minimum zone during the subsequent early Middle Cambrian sea-level fall and attendant enhanced oceanic circulation, and (2) recovery of surface water productivity levels after environmental conditions improved sufficiently.

Superimposed on the long-term C and Sr trends are other short-term (±1 m.y.) fluctuations that are interpreted to record high-frequency changes in seawater $\delta^{13}C$ and $^{87}Sr/^{86}Sr$ values, given that they are defined in several sections throughout the Cordilleran passive margin (Fig. 4). Some of the short-term $\delta^{13}C$ and $^{87}Sr/^{86}Sr$ fluctuations (e.g., *Bolaspidella* and *Cedaria* biozones) exhibit similar but out-of-phase trends. The short-term increases in seawater $^{87}Sr/^{86}Sr$ values during this interval could reflect the influence of increased continental flux to the ocean. In turn, the associated short-term increases in $\delta^{13}C$ values may record increased oceanic nutrient levels, primary productivity, and organic C burial driven by increased continental flux and associated oceanic sedimentation. Conversely, periods of dampened surface water fluxes to the ocean and lowered global oceanic sedimentation rates could result in decreased seawater $\delta^{13}C$ and $^{87}Sr/^{86}Sr$ values. The mechanism linking these processes could have been short-term Cambrian sea-level oscillations (Montañez et al., 1996) or short-lived tectonic events and their effect on paleoceanographic conditions and organic carbon burial.

SUMMARY

The high-resolution Sr and C isotope curves presented in this paper significantly refine our understanding of the isotopic evolution of Cambrian seawater. These isotope curves document previously unrecognized fluctuations that strongly suggest periods of significant perturbation to the global Sr and C cycles during the late Early through early Late Cambrian. We suggest that future studies of Cambrian successions focus on certain biostratigraphically constrained intervals in order to (1) better define these short-term events in other basins as a test of their validity, (2) test the proposed relationships between observed changes in seawater $^{87}Sr/^{86}Sr$ and $\delta^{13}C$ values and crustal and surficial processes, and (3) refine the structure of less well-defined portions of the curves. Future radiometric studies are likely to elucidate the timing of discrete tectonic phases and the temporal relationships between these events and variations in seawater $^{87}Sr/^{86}Sr$ and $\delta^{13}C$ values. In turn, the new Sr and C isotope curves may clarify the mechanistic links between tectonic events, oceanic processes, and paleoclimatic conditions, and allow for determination of their rates of change.

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Cambrian Oceans *continued on p. 7*

NAS-NRC Committee Seeks Advice on International Geoscience Projects

Revitalization of the U.S. National Committee on Geological Sciences (USNC/GS) offers opportunities to raise the profile of geoscience internationally. Committee members note that because scientific communities are increasingly global, not national, more U.S. geoscientists are working on joint projects with foreign colleagues. These interactions are especially vital in geoscience, which requires work across international borders.

USNC/GS members recognize that many avenues already exist for international cooperation in the earth sciences, including the International Union of Geological Sciences (IUGS). However, other sciences, such as biology, astronomy, and physics, have gained more recognition than has geoscience for organized international ventures, not only with the general public but also with policymakers at home and abroad.

WHERE ARE THE OPPORTUNITIES?

The USNC/GS mission statement calls for the committee to advise the president of the National Academy of Sciences (NAS) on issues related to both the U.S. and international geoscience communities. The committee, working under the aegis of the NAS–National Research Council, will seek advice from the U.S. geoscience community, including those in industry, academia, and government. The committee needs to know of opportunities for U.S. geoscientists in the international geoscience community. Ensuring participation and representation in the International Union of Geological Sciences (IUGS) and its affiliated organizations, as well as the International Geological Congress, are priorities.

PEOPLE TO CONTACT

The USNC/GS includes scientists from government, industry, and universities; many of them are GSA members. Current committee members are Robin Brett, Farouk El-Baz, Mark Cloos, Ian Dalziel, Barbara John, Suzanne Kay, Patrick Leahy, Eldridge Moores, Richard Stegemeir, Larry Woodfork, and Peter Wyllie. The committee invites all geoscientists to participate in identifying opportunities for international efforts. Ideas that the committee should consider and requests for further information can be directed through Scott Spaulding, National Academy of Sciences staff member, at sspauldi@nas.edu. ■

Cambrian Oceans *continued from p. 6*

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Dynamic History of the Earth-Life System: A Report to the National Science Foundation on Research Directions in Paleontology

Report of NSF-sponsored workshop "Geobiology and the Earth Sciences in the Next Decade," March 6–9, 1999, Smithsonian Institution, Washington, D.C. Edited by Karl Flessa

Paleontology has accelerated on several fronts over the past decade. There have been remarkable developments, including new breadth and volume of empirical evidence, new conceptual approaches, more powerful analytic tools, and new technologies relevant to quantifying and modeling rates and patterns of changes in the Earth-life system. These developments mean paleontologists can now apply quantitative methods for accommodating known biases in sampling, for testing the significance of observed patterns, and for using empirical patterns to both generate and test hypotheses. Such quantitative approaches as new statistical methods, computer modeling, and the development of global and regional databases have transformed the discipline into one that would be unrecognizable to the fossil hunters of yore.

These advances in paleontology are now being coupled with those in related geoscience and life science disciplines. These disciplinary linkages set the stage for significant advances in understanding the evolution of biocomplexity, the dynamics of life on Earth, and the diverse ways in which life has driven, and been driven by, changes in Earth's oceans, atmosphere, and lithosphere over evolutionary time. To assess how prior events and past states have shaped the present condition and to predict future conditions, we must use the geologic record's unique archive of natural experiments about how the Earth-life system operates.

Paleontological Research Themes in the Next Decade

Four related research themes promise major advances in understanding and modeling the range of past states and the rates and mechanisms of change in the Earth-life system.

1. What rules govern biodiversity dynamics, and do those rules apply at all temporal and spatial scales? Through geologic time, global biodiversity, as measured by number of taxa, range of body forms, and ecological variety, has shown a net increase. However, although the general trend has been toward increasing biodiversity, the trajectory has been complex. The diversification of life has been interrupted by extinction events and by at least one prolonged episode of little change in the diversity of ocean life.

A concerted and broad-based effort is needed to tease apart the interplay of physical and biological processes that affect diversification. We need to test hypotheses on driving mechanisms and to develop the next generation of models that treat dynamics in terms of underlying components, such as origination and extinction rates, over a spectrum of spatial and temporal scales.

2. Why are major evolutionary innovations unevenly distributed in space and time? One of the most striking patterns emerging from paleontological analyses is that biological innovations—the breakthroughs that open new ecological opportunities and evolutionary pathways—do not arise randomly in space and time. Such innovations are associated with episodes of taxonomic diversification (the multiplication of species and higher groups) or the expansion of lineages into new habitats or lifestyles. Some of these innovations, such as photosynthesis, animal body plans, land plants, and mineralized skeletons in marine microplankton, undoubtedly drove changes in conditions on Earth's surface.

Figuring out what drives the uneven distribution of innovations requires finding out whether there are environmental and biotic controls on the timing and geographic distribution of innovation and determining how such innovations affect both ecosystems and biogeochemical processes.

3. How have biological systems influenced the physical and chemical nature of Earth's surface, and

how has biogeochemical cycling changed through time? The sedimentary record reveals a succession of worlds of radically different character, ranging from the exclusively microbial and oxygen-poor Archean to the highly heterogeneous modern system. These different environments include a huge diversity of morphologically and behaviorally complex multicellular organisms. The composition and preservational nature of the fossil record and the diversity, abundance, and temporal distribution of sediment types and geochemical signatures provide us a window onto the transitions from one world into the next.

The broad coincidence of major biological, sedimentary, and geochemical transitions throughout Earth history indicates that strong links exist between the biosphere and Earth's surface systems. Research efforts in the next decade will identify time intervals when significant changes took place in biological materials and in biogeochemical cycling, the short-term dynamics of these changes, the roles of biological innovations in generating patterns and rates of such cycling, and how steady states were maintained. Given the importance of microbial processes in shaping the Earth-life system, studies of molecular biomarkers and of isotopic records will be central to expanding our understanding of cycling in the Earth-life system.

4. How does the biosphere respond to environmental perturbations at regional and global scales? Rapid climatic changes, extra-terrestrial impacts, shifts in ocean chemistry, biological migrations, and other perturbations have repeatedly influenced the history of life—not just during mass extinctions, but during normal times as well. These environmental perturbations and the subsequent biotic responses are natural experiments that provide the raw data for a research agenda that includes calibrating biotic responses to different types and magnitudes of disturbance across a range of temporal and spatial scales.

A comparative, quantitative approach is needed to discover general, predictive rules for the biosphere's behavior. A variety of rigorous, empirically derived models, in which extinction rates and origination rates are critical factors, have been developed to account for these patterns. Now these models must be expanded and tested to explore the roles of factors such as initial states, geographic distribution of biotas, and environmental conditions in determining biotic responses to different kinds of perturbation. Our ability to sample the fossil record with ever-increasing spatial and temporal acuity now enables us to test and resolve these issues.

Applications of Paleontology to Understanding Current Environmental Perturbations

Paleontological and paleoenvironmental data provide vital information on baseline environmental conditions prior to human impact and on the long-term biotic consequences of environmental change. Holocene to late Pleistocene fossil assemblages provide information on the natural range of biotic and environmental variability, and dating techniques in this interval can provide annual- to millennial-scale resolution. Older fossil time series encompass an even broader range of environmental change and reveal the long-term consequences of environmental perturbations.

Facilitating Paleontological Research and Training in the Next Decade

Significant progress on these themes requires a balance of efforts, ranging from traditional single-investigator research through collaborative and interdisciplinary projects. Proposals from individuals and groups of scientists will continue to be highly productive vehicles for supporting research and training in paleontology, so support for such core research must be strengthened. The increased computational and analytical sophistication of paleontological research requires funding levels significantly higher than in the past, for both individuals and groups. A major new initiative in data compilation, dissemination, and analysis will allow researchers at all levels to benefit from and contribute to the ever-growing assemblage of data on Earth history.

Earth History Database Initiative

The construction of the Earth History Database (EHD), a central, multidimensional database that integrates global paleontologic data with data on paleogeography, geochemistry, paleoenvironment, geochronology, and a wealth of other aspects of Earth history, will provide a database of unprecedented versatility, power, and accessibility. This database is essential for testing hypotheses about linkages between different components of the Earth-life system and about the origins and evolution of biocomplexity.

The EHD Initiative will be a decade-long effort that will require its own physical and virtual infrastructure. Effective implementation of the initiative will require integrating existing databases, establishing protocols for adding new data, and supporting focused efforts to collect the new data needed to answer the questions raised above. An Earth History Database is key in facilitating research and disseminating results so as to maximize the benefits to the entire earth sciences research community.

Linking Paleontological Research to Education and Outreach

The public's fascination with fossils can be easily harnessed to teach both students and lay people about the workings and evolution of the Earth-life system. Such knowledge is essential to creating a scientifically literate citizenry because political decisions must be made on important environmental issues. Paleontologists can also play an important role in developing inquiry-based approaches to science education at all levels. The Earth History Database will provide a vital link between research and education, because the power of the Internet will make the record of Earth history available in every classroom. ■

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Engaging "My Neighbor" in the Issue of Sustainability Part V: Earth Systems: The Connectedness of Everything

A.R. Palmer, *Boulder, Colorado, and* ***E-an Zen,*** *Reston, Virginia*

At all scales, from microscopic to megascopic, from atoms to galaxies, natural processes are interconnected. The discrete categories that have given rise to the increasing proliferation of academic disciplines and subdisciplines are nothing more than an artifact of the human mind.

The concept of a grand scale of connectivity in natural systems is already familiar to most earth scientists. By contrast, laboratory-based studies commonly make efforts to simplify any system being studied so that cause-and-effect relationships can be brought into focus and verified by repeated observations. Although the two approaches are mutually complementary, this point has not always been made clear to students or the general public, much less political and social decision makers. Sadly, policy decisions that directly impact civilization today and Earth for generations yet to come too often make the mistake of assuming that we can independently alter or modify one element of a natural system and not expect changes elsewhere.

On the grand scale, the theory of plate tectonics brought together information from many seemingly independent scientific disciplines to present to the world a general conceptual framework for understanding everything from global climates and the genesis of mineral deposits to an understanding of many natural hazards and the peculiar patterns of present and past biogeography. The uplift of the Himalayas, the closing of the Isthmus of Panama, and the restrictions of Arctic oceanic circulation all significantly influence the system of global climate as strong feedback elements that positively and negatively contribute to maintaining equilibrium of a constantly changing dynamic system.

Dynamic crustal forces have played a role in the production of economically accessible concentrations of fossil fuels, mineral phosphates, and metallic minerals. We are constantly learning more about factors contributing to earthquakes and volcanic eruptions and the frequency and violence of their occurrences. Shifting geographical configurations as continents have broken up or merged and as global sea levels have risen and fallen over millennia have powerfully influenced biodiversity.

At the other end of the scale, molecular biology is showing that there are many genes common to all organisms, including humans, that affect our development in subtle ways. Some of the development of civilization can be attributed to the success of molecular biology and pharmacology in increasing the longevity of human beings. Unfortunately, compounds produced and consumed by human beings for their positive health benefits can also damage human beings and disrupt other living systems in unforeseen ways. Out of these studies of molecular biology has also come much of our understanding necessary for chemical and biological warfare. Our increasing understanding of the subatomic world has led to remarkable breakthroughs in medical technology, but also to terrible weapons of mass destruction.

The point of this year-long series of essays is to show the interconnectedness of a series of concepts that are not necessarily related in all of our minds and those of "our neighbors." The concepts of the global commons (essay I), the context of humanity (essay II), the consequences of doubling time (essay III), and the limits to resources (essay IV) are all interconnected components of a much larger concept—sustainability. There are more still to come. Together, they provide a basis for evaluating the challenges facing us during this new century if we continue to grow as we have been growing in both human population and resource consumption.

Because so many of the core concepts of sustainability are components of basic training in the earth sciences, earth scientists have a personal responsibility to make sure that these concepts and their interrelationships are understood and internalized by ourselves and "our neighbors"—or at least brought into the forefront of our consciousness. Natural processes are intricately related, and changes in one process or parameter can feed back to other processes and parameters, often with unanticipated consequences. Events in the oceans, such as temperature changes in the southwest Pacific, affect the atmosphere, which affects the terrestrial hydrosphere and biosphere. Events in the lithosphere, mountain uplift or volcanic eruptions, affect the atmosphere, oceans, and biosphere. Human activities affect all of these "spheres," even including the cryosphere; witness advances of glaciers, changing patterns of sea-ice flow, sea-level rise, permafrost stability, changes in snowfield area, etc.

The separate lines of inquiry formulated by various disciplines of the earth sciences, when viewed as a whole, are mutually dependent and complementary. We now call this big-picture perspective earth systems science. But we can take one further step and see that when we discuss the human impact on Earth and its ecosystems, even earth systems science is only a subset of the entire picture of environmental systems science. Other areas of natural science, social science, and political science and all the other areas of human inquiry that aspire to the designation "science" contribute to the consequences of our decisions in the personal and public domains. In our exploitation of Earth's endowments, we have the potential to unravel or tangle this complicated web if we fail to appreciate the interconnections.

Use the ideas in these essays in conversations with students, with colleagues at work or in other academic disciplines, with friends, and even with strangers—these are "our neighbors." The grass roots in a democratic system will require nurture if our common lawn, human civilization, is to have a future. Communicating our thoughts, understandings, and the spirit of inquiry as earth scientists can become a vital element of these interconnections, perhaps in unanticipated ways. ■

The 1999 General Membership Survey

Ann Cairns, *Director, Communications and Marketing*

GSA goals and objectives set by Council in 1998 require that we:

- assess where we are today,
- determine where we want to be, and
- make decisions that will move us in the right direction.

Whether we're focused on increasing the quality and vitality of meetings and publications or strengthening the role of geoscience in science education, we need a good base of information from which to begin.

In the fourth quarter of last year, GSA conducted a general membership survey. Stephanie Greenberg, senior research associate with the National Research Center in Boulder, worked with GSA headquarters staff to develop and implement the survey. A specialist in research methodology and statistics, she also analyzed the results and wrote the final report.

Following is an overview of what we did and some of what we learned.

Occupational Groups Surveyed	Questionnaire Topics
• Academic Institution	• Attitudes toward GSA as a scientific society
• Teacher K–12	• Satisfaction with selected aspects of GSA
• Student, graduate	• Format preferences and satisfaction with publications
• Student, undergraduate	• Attendance at and attitudes toward annual and section meetings
• Government	• Web site usage
• Corporate	• Attitudes toward gift-giving
• Self-employed	
• Retired	
• Other	

Survey Methodology

We surveyed current GSA members residing in the United States, generating a random sample from our iMIS membership database. International members weren't included because of the logistics associated with a mail survey and because of the number of specialized questions we would want to ask members living outside the United States. We plan to conduct a Web-based survey of international members that will focus on their attitudes and needs.

The sample of members selected to receive the questionnaire was stratified by occupation. This allowed us to look at the responses of particular groups of members on selected questions. It also gave us the option of going back later in order to further "mine the data" on specific groups, such as students and applied geologists.

Groups of members responded to the survey in roughly the same proportions they represent of GSA's total membership. Some weighting of responses was done, however, to correct for the fact that retired members responded in greater numbers, and that academics were somewhat underrepresented.

Report Highlights

- A strong majority of GSA members were satisfied with the organization overall and with many of its aspects. Nearly all planned to renew their membership. GSA was viewed as a valuable resource to its members, particularly in the form of the geoscience information it provides and its publications program. Some differences were observed in the levels of satisfaction among respondents in different age groups, occupations, and geographical regions. There were no significant differences based on gender.
- A high percentage of members were unable to rate their satisfaction with some GSA programs and services because they either did not know enough about them or had no opinion.

Submitting an Abstract for the 2000 GSA Annual Meeting in Reno?

The electronic submittal form is fast, easy, convenient, and secure, and you will get instant acknowledgment of receipt. The form is available at www.geosociety.org.

If you prefer, you can request a paper abstract form from the Abstracts Coordinator, ncarlson@geosociety.org, (303) 447-2020, ext. 161.

Abstract Deadlines

If you are submitting your abstract on paper, it *must* be at GSA no later than July 25.

If you submit electronically, your abstract must be at GSA by August 1.

Programs that need greater visibility and demonstration of their value include educational outreach, professional and career development services, and professional service opportunities offered by GSA.
- Members favor greater GSA involvement in raising public awareness of the value of geoscience. They viewed this activity as an important aspect of GSA, but were only moderately satisfied with the organization's efforts to-date.
- GSA members wanted more rather than less variety in the location of annual meetings. Cost is a significant factor in attending meetings—more than half of all members pay some portion of their own expenses. Respondents also favor looking for ways to make meetings less costly for students.
- There was a high degree of satisfaction with the publications program, and it was viewed as one of the most important aspects of membership in GSA. *Bulletin* and *Geology* received high marks for quality and prestige. Respondents also indicated a desire for more variety in the types of articles published. Readers of the journals wanted more rather than fewer options in accessing the periodicals. They most frequently wanted a choice between print and online access; few preferred online access only. (*Note:* The GSA *Bulletin* and *Geology* are now available online.)
- More than half of the respondents had visited GSA's Web site in the past year. Improving the number and quality of links to a variety of other geoscience information sources was the most frequent suggestion for improving the Web site.

What's Next

Survey results were shared with Council, GSA Foundation Trustees, and selected committees, in addition to staff. We used the results in business plan development for the Programmatic Overview Committee in the early spring, and we will continue to analyze the data as needs arise.

We thank everyone who took the time to fill out the questionnaire, which was long. We'll repeat the survey periodically in order to monitor progress on issues raised, but before we do it again, we'll shorten it to reduce completion time.

Thanks also to those of you who wrote carefully considered responses to the open-ended questions in the survey. Your commitment to GSA came through loud and clear, and it is an inspiration to all the staff working on your behalf. ■

Survey Statistics

Questionnaires mailed:	3,330
Questionnaires returned:	797
Response rate:	24%
Maximum confidence interval:	3.5% at 95% level of confidence
Data analysis:	Standard descriptive statistics; chi-square test of statistical significance

Respondents' Overall Satisfaction with GSA

% Very Satisfied + % Satisfied

Age Group	Overall Satisfaction
Less than 25 years	93%
25–29 years	95%
30–39 years	81%
40–49 years	75%
50–59 years	79%
60+ years	83%
Occupation	**Overall Satisfaction**
Academic	80%
Government	82%
Corporate (Energy and Minerals)	75%
Corporate (Other)	75%
Self-employed	78%
K–12 Teacher	91%
Student—Undergraduate	94%
Student—Graduate	91%
Retired	87%
Other	76%
Region	**Overall Satisfaction**
Cordilleran	81%
Rocky Mountain	77%
North-Central	83%
South-Central	93%
Northeastern	76%
Southeastern	90%

GSA International Division Is Key in Globalization

GSA is going global, and the International Division is playing a key role in this initiative. The division's activities at the GSA Annual Meeting include helping to support financially non–North American speakers to participate in division-cosponsored technical sessions, organizing a reception for international participants and division members, and cosponsoring the exhibits of the International Survey Program. The division is also helping Central, North, and South Americans to attend the International Geological Congress in Brazil in August 2000, through the generosity of a donor who has given money to the International Division in honor of Charles L. Drake.

If you are interested in GSA's global initiative and in working with geoscientists from non–North American countries, consider becoming a member of the International Division. Increased membership will allow expansion of such programs as aiding international attendees to participate in and enrich technical sessions at GSA Annual Meetings. Joining is simple for GSA members. Send $10 (dues for one year) along with your name and address to Membership Services, Geological Society of America, P.O. Box 9140, Boulder, CO 80301-9140. You can also join by contacting GSA at member@geosociety.org or by calling 1-888-443-4472. See the GSA Web site at www.geosociety.org/sectdiv/divisions/htm for more information and to link to the division Web page.

The International Division welcomes donations. Tax-deductible gifts can be sent to the GSA Foundation (same address as above) for the International Division Award Fund or for the Drake Fund, which provides assistance for young foreign geoscientists to attend the GSA Annual Meeting (this year in Reno, Nevada). Donations to either fund can be designated as endowment funds or unrestricted funds for immediate use.

Send comments and suggestions about International Division activities to division President Suzanne M. Kay (smk16@Cornell.edu), First Vice-President Eldridge Moores (moores@geology.ucdavis.edu), and Second Vice-President Lee Allison (lallison@kgs.ukans.edu). For further information on contributions, contact division treasurer M. Dean Kleinkopf (phone and fax: 480-785-5968, md.kleinkopf@worldnet.att.net). ■

2000 GSA Committees and Representatives

Executive Committee

Mary Lou Zoback—President and Chair; Sharon Mosher—Vice-President; Gail M. Ashley—Past President; David E. Dunn—Treasurer; Rob Van der Voo—Council Member-at-Large; Sara S. Foland—CEO and GSA Liaison to Committee; Kristina L. Hiesterman—Governance Support Team Leader and GSA Liaison Assistant

Annual Program Committee

Rob Van der Voo—Chair, 2000–2001; Larry T. Middleton, 1999–2001; John E. Costa, 2000–2002; Darrel S. Cowan, 2000–2002. *Ex officio:* G. Lang Farmer—1999 Tech. Prog. Co-Chair, 1998–2000; Craig H. Jones—1999 Tech. Prog. Co-Chair, 1998–2000; Robert Karlin—2000 Tech. Prog. Chair, 1999–2001; Robert S. Young—2001 Tech. Prog. Chair, 2000–2002; Richard Schweickert—Local Committee, General Chair, 2000; Sara S. Foland—CEO; Kathy Ohmie Lynch—Director of Meetings and GSA Liaison to Committee; Amanda Jimenez—Meetings Coordinator and GSA Liaison Assistant; Nancy Carlson—Abstracts Coordinator

Audit Committee

Joaquin S. Ruiz—Chair, 2000; Stephen G. Wells, 1999–2001; Mary P. Anderson, 2000–2002; George Herbert Davis—Committee on Investments Rep., 1998–2001; David B. MacKenzie—GSAF Board of Trustees Rep., 1997–2002. *Ex officio:* David E. Dunn—Treasurer; Sara S. Foland—CEO and Acting GSA Liaison to Committee

Committee on the Budget

David E. Dunn—Chair and Treasurer, 2000; Samuel S. Adams, 1996–2000; Arden L. Albee, 1998–2002; Rena Bonem, 2000–2002; David B. MacKenzie, 1999–2003. *Ex officio:* Sara S. Foland—CEO and Acting GSA Liaison to Committee; To be determined—Controller, Financial Services

Committee on Committees

John M. Sharp, Jr.—Chair; Arthur W. Snoke; Jill S. Schneiderman; Sharon D. Carr; Roger J. Cuffey; Sally J. Sutton; Kristina L. Hiesterman—Governance Support Team Leader and GSA Liaison to Committee; Barbara J. Richards—Administrative Assistant and GSA Liaison Assistant

Committee on Continuing Education

David S. McCormick—Chair, 2000; Stephen G. Wells, 1998–2000; James E. Barrick, 1999–2001; Anthony W. Walton, 1999–2001; T. John Rowland, 2000–2002; James M. Ellis, 2000–2002; Kathy Ohmie Lynch—Director of Meetings and GSA Liaison to Committee; Edna Collis—Continuing Education Coordinator and GSA Liaison Assistant

Committee on the Arthur L. Day Medal Award

Carol Simpson—Chair, 2000; E. Calvin Alexander, Jr., 1998–2000; Jon P. Davidson, 1998–2000; Julie D. Morris, 1998–2000; Michael Gurnis, 1999–2001; Kenneth P. Kodama, 1999–2001; Richard G. Fairbanks, 2000–2002; Kristina L. Hiesterman—Governance Support Team Leader and GSA Liaison to Committee; Barbara J. Richards—Administrative Assistant and GSA Liaison Assistant

Committee on Education

Steve C. Good—Chair, 2000; Maureen Allen—Primary School Teacher, 1998–2000; Brian Poelker—Middle School Teacher, 1999–2001; Katie KellerLynn—Member-at-Large, 1999–2001; Chuck Wagner—High School Teacher, 2000–2002; Elizabeth A. Haynes—Student, 2000–2002; Elizabeth L. Ambos—Cordilleran Section Representative; Vacant—Rocky Mountain Section Representative; Sherman P. Lundy—North-Central Section Representative; Diane R. Smith—South-Central Section Representative; John B. Reid—Northeastern Section Representative; John Callahan—Southeastern Section Representative. *Ex officio:* Sharon Mosher—GSA Vice-President; Conferee: To be determined—Educational Programs Coordinator; Cathleen L. May—Director, Science, Education, and Outreach and GSA Liaison to Committee; Holly Devaul—Program Officer, Education and GSA Liaison Assistant

Committee on External Awards

Noel P. James—Chair and Penrose Medal Comt. Rep.; Carol Simpson—Day Medal Comt. Rep.; Division Representatives: Vacant (Coal Geology); Scott F. Burns (Engineering Geology); G. Randy Keller (Geophysics); Vacant (Geoscience Education); James W. Skehan, SJ (History of Geology); Alan R. Nelson (Quaternary Geology & Geomorphology); Kristina L. Hiesterman—Governance Support Team Leader and GSA Liaison to Committee; Barbara J. Richards—Administrative Assistant and GSA Liaison Assistant

Committee on Geology and Public Policy

James E. Evans—Chair, 2000; Virgil A. Frizzell, Jr., 1998–2000; Sally J. Sutton, 1998–2000; Paul Geoffrey Feiss, 1999–2001; Rachel Burks, 1999–2001; Patricia H. Kelley, 1999–2001; David F. Nicklin, 2000–2004; Lou Gilpin, 2000–2004. Past Congressional Science Fellows: David Verardo, 1999–2001; Kai S. Anderson, 2000–2001. Section Representatives: Susan D. Halsey (Northeastern); Thomas J. Evans (North-Central); Christine E. Turner (Rocky Mountain); John D. Kiefer (Southeastern); Jerome V. DeGraff (Cordilleran); Vacant (South-Central). Peter F. Folger—Past Chair. Conferees: Allison R. Palmer—Ad Hoc Committee on Critical Issues; David Applegate—AGI GAP Liaison to Committee; Sharon Mosher—Vice-President and Council Liaison to Committee. *Ex officio:* To be determined—IEE Program Coordinator; Cathleen L. May—Director, Science, Education, and Outreach and GSA Liaison to Committee; Karlon Blythe—Program Officer, Outreach and Mentoring and GSA Liaison Assistant

Committee on Honorary Fellows

Michael A. Dungan—Chair, 2000; Donald R. Lowe, 1998–2000; Hans J. Hofmann, 1999–2001; Gabor Tari, 1998–2000; Umberto G. Cordani, 2000–2002; Eldridge M. Moores, 2000–2002; *Ex officio:* Ian W.D. Dalziel—International Secretary; Kristina L. Hiesterman—Governance Support Team Leader and GSA Liaison to Committee; Barbara J. Richards—Administrative Assistant and GSA Liaison Assistant

Committee on Investments

George Herbert Davis—Chair, 2000; R. Thayer Tutt, Jr., 1996–2001; Samuel S. Adams, 1999–2001; Vacant, 2000–2001; Frederick T. Graybeal, 2000–2002. *Ex officio:* David E. Dunn—Treasurer; Brian J. Skinner—GSA Foundation designee; Sara S. Foland—CEO and Acting GSA Liaison to Committee

Committee on Membership

Bruce A. Bouley—Chair, 2000; Andrew M. Gombos, Jr., 1999–2001; Michele L. Aldrich, 2000–2001; Rena M. Bonem, 2000–2002; James Wright Horton, Jr., 2000–2002; Bart J. Kowallis, 2000–2002; Lisa E. Park, 2000–2002; Nancy S. Williams—Director, Member Services and GSA Liaison to Committee; Joanna Conley—Member Research and Development Project Coordinator and GSA Liaison Assistant

Committee on Minorities and Women in the Geosciences

Mary E. Dowse—Chair, 1998–2000; Joseph C. Cepeda, 1998–2000; James B. Finley, Jr., 1998–2000; Lisa A. Rossbacher, 1998–2000; Arthur G. Goldstein, 1999–2001; Frank R. Hall, 1999–2001; Lois J. Wardell, 1999–2001; Lisa D. White, 1999–2001; Carol B. de Wet, 2000–2002; Conferees: Rhea Lydia Graham—Councilor and Council Liaison to Committee; To be determined—Educational Programs Coordinator; Cathleen L. May—Director, Science, Education, and Outreach and GSA Liaison to Committee; Stacey Ginsburg—Program Officer, Student Opportunities and GSA Liaison Assistant

Committee on Nominations

B. Clark Burchfiel—Chair, 2000; Marcus E. Milling, 1999–2000; James N. Connelly, 1999–2000; Jane Selverstone, 2000–2001; Jorge J. Aranda-Gomez, 2000–2001; Arthur W. Snoke, 2000; Kristina L. Hiesterman—Governance Support Team Leader and GSA Liaison to Committee; Barbara J. Richards—Administrative Assistant and GSA Liaison Assistant

Committee on Penrose Conferences

Fred M. Phillips—Chair, 2000; Thomas W. Gardner, 1998–2000; Naomi M. Oreskes, 1998–2000; Fred M. Phillips, 1998–2000; Paul L. Koch, 1999–2001; John M. Bartley, 2000–2002; Lois J. Elms—Consultant; Kathy Ohmie Lynch—Director of Meetings and GSA Liaison to Committee

Committee on the Penrose Medal Award

Noel P. James—Chair, 2000; Russell S. Harmon, 1998–2000; Leonard F. Konikow, 1998–2000; Mary J. Kraus, 1998–2000; Richard K. Bambach, 1999–2001; Douglas W. Burbank, 1999–2001; Walter D. Mooney, 2000–2002; Kristina L. Hiesterman—Governance Support Team Leader and GSA Liaison to Committee; Barbara J. Richards—Administrative Assistant and GSA Liaison Assistant

Joint Technical Program Committee

Associated Society Representatives: Paul Loubere, Cushman Foundation; Patrick V. Brady, Susan L.S. Stipp, Geochemical Society; Sharon Tahirkheli, Geoscience Information Society; Larry M. Anovitz, John T. Cheney, Mineralogical Society of America; Steve Semken, National Association of Geoscience Teachers; Carol Tang, Paleontological Society; Greg B. Arehart, Society of Economic Geologists. Division Representatives: Art Bettis III, Archaeological Geology; Leslie F. Ruppert, Coal Geology; Duane A. Eversoll, Terry West, Engineering Geology; Alan G. Jones, Geophysics; Michele L. Aldrich, History of Geology; Anne E. Carey, Robert W. Ritzi, Hydrogeology; Ralph P. Harvey, David A. Kring, Planetary Geology; Peter U. Clark, Craig Kochel, Quaternary Geology and Geomorphology; Carol de Wet, Michael C. Pope, Sedimentary Geology; Laurel Goodwin, Jane Selverstone, Structural Geology and Tectonics. Representatives-at-Large: Robert A. Larson, Carol Wicks, Environmental Geoscience; David M. Bush, Marine Geology; Lisa Ely, Paleoceanology and Paleoclimatology; Robert Michael Easton, Precambrian Geology; Cathleen L. May, Public Policy. *Ex officio:* Craig H. Jones, 1999 Technical Program Chair; Robert Karlin, 2000 Technical Program Chair; Robert S. Young, 2001 Technical Program Chair; Sara S. Foland, CEO; Kathy Ohmie Lynch, Director of Meetings and GSA Liaison to Committee; Nancy Carlson, Abstracts Coordinator

Committee on Publications

Allison R. Palmer—Chair, 2000; Harry Y. McSween, Jr., 2000–2002; Stephen G. Wells, 2000–2002; Suzanne Kairo, 2000–2002; Abhijit Basu—Editor, Books, 1998–2001; Allen F. Glazner—Co-Editor, *Bulletin*, 1999–2002; Ben Van der Pluijm—Co-Editor, *Geology*, 2000–2003; John M. Sharp, Jr.—Co-Editor, *Environmental & Engineering Geoscience*, 1998–2000. Conferees: Peg Lehr, COO and Director of Publications and GSA Liaison to Committee; Connie J. Manson—GIS Representative; Christa Stratton, Senior Administrative Assistant and GSA Liaison Assistant

Committee on the GSA Public Service Award

Gail M. Ashley—Chair, 2000; Committee Representatives: To be determined—Education; To be determined—Geology and Public Policy; To be determined—Minorities and Women in Geosciences; To be determined—Ad hoc Critical Issues; To be determined—Ad hoc Goal 2 Integrated Science Task Force; Kristina L. Hiesterman—Governance Support Team Leader

2000 Committees *continued on p. 16*

2000 Committeees *continued from p. 15*

and GSA Liaison to Committee; Barbara J. Richards—Administrative Assistant and GSA Liaison Assistant

Committee on Research Grants
Allen F. Glazner—Chair, 2000; Brian G. Katz, 1998–2000; Jim E. O'Connor, 1998–2000; James G. Schmitt, 1999–2001; Daniel K. Holm, 2000–2002; John F. Bratton, 2000–2002; Marith Cady Reheis, 2000–2002; Conferees: Russell C. Kelz—National Science Foundation; Cathleen L. May—Director, Science, Education, and Outreach and GSA Liaison to Committee; Leah Carter—Research Grants and Awards Administrator and GSA Liaison Assistant

Treatise on Invertebrate Paleontology Advisory Committee
John Pojeta, Jr.—Chair, 1995–2001; William I. Ausich, 1997–2000; Richard Arnold Davis, 1993–2000; Sara S. Foland—CEO; Conferee: Peg Lehr—COO and Director of Publications

Committee on the Young Scientist Award (Donath Medal)
J. Leslie Smith—Chair, 2000; Judith L. Hannah, 1998–2000; W. Berry Lyons, 1998–2000; Joaquin S. Ruiz, 1999–2001; J. Casey Moore, 2000–2002; Charles R. Bacon, 2000–2002; Kristina L. Hiesterman—Governance Support Team Leader and GSA Liaison to Committee; Barbara J. Richards—Administrative Assistant and GSA Liaison Assistant

Ad Hoc Committee on Long Range Planning—Publications
David Fastovsky—Chair; Gail M. Ashley; B. Clark Burchfiel; Lee Kump; Joaquin S. Ruiz; David Soller; Doug Walker; Mary Lou Zoback. Conferees: Sara S. Foland—CEO; Peg Lehr—COO and Director of Publications; Faith Rogers—Managing Editor

Ad Hoc Committee on Critical Issues
Allison R. Palmer—Chair; Mary Barber; Kenneth L. Conca; Anthony de Souza; George W. Fisher; William S. Fyfe; R. - Gordon Gastil; Carroll Ann Hodges; Donald Kennedy; Susan W. Kieffer; Emlyn Koster; Arthur H. Lachenbruch; Cathleen L. May; Eldridge M. Moores; Richard B. Norgaard; Daniel Sarewitz; Jill S. Schneiderman; Dorothy L. Stout; George A. Thompson; Wesley Ward, Jr.; E-An Zen

Ad Hoc Committee on Goal 2 Task Force for Integrated Service
Mary Barber; Lewis E. Gilbert; George M. Hornberger; Daniel Sarewitz; Steven M. Stanley; Vera P. John-Steiner; Christine Turner; Mary Lou Zoback. Conferee: Cathleen May

Call for GSA Committee Service—2001

The GSA Committee on Committees wants your help. The committee is looking for potential candidates to serve on committees of the Society or as GSA representatives to other organizations. You can help by volunteering yourself or suggesting the names of others you think should be considered for any of the openings and submitting your nomination on the form on page 18. Younger members are especially encouraged to become involved in Society activities.

Listed on page 17 are the number of vacancies along with a brief summary of what each committee does and what qualifications are desirable. If you volunteer or make recommendations, please give serious consideration to the special qualifications for serving on a particular committee. *Please be sure that your candidates are Members or Fellows of the Society and that they meet fully the requested qualifications.*

Volunteering or Making a Recommendation

All nominations received at headquarters by July 10, 2000, on the official one-page form will be forwarded to the Committee on Committees. *Council requires that the form be complete.* Information requested on the form will assist the committee members with their recommendations for the 2001 committee vacancies. Please use one form per candidate (additional forms may be copied). The committee will present at least two nominations for each open position to the Council at its November meeting in Reno, Nevada. Appointees will then be contacted and asked to serve, thus completing the process of bringing new expertise into Society affairs.

Graduate Students Encouraged to Volunteer!

Graduate students are now eligible to serve on GSA Committees as full members. All graduate students are encouraged to volunteer or nominate others for committee service.

Ad Hoc Committee on Education Task Force
Robert Ridky—Chair; Gail M. Ashley; Cathleen L. May; Greg Wheeler; Mike Smith; Judy Hannah; Judy Scotchmoor; Steven Good; William Prothero

GSA Member of the American Geological Institute (AGI) Member Society Council
Mary Lou Zoback, 1999–2001

GSA Member of the AGI Education Advisory Committee
Cathleen L. May—GSA Director, Science, Education, and Outreach

GSA Member of the AGI Government Affairs Program Advisory Committee
Virgil A. Frizzell, Jr., 1998–2000

GSA Representatives to the American Association for the Advancement of Science (AAAS)
Section E—Geology and Geography: B. Clark Burchfiel, 2000–2003; Section W—Atmospheric and Hydrospheric Sciences: John G. Weihaupt, 2000–2003

GSA Representatives to the AAAS Consortium of Affiliates for International Programs (CAIP)
Ian W.D. Dalziel—International Secretary; Sara S. Foland—GSA Staff Liaison

GSA Representatives to the North American Commission on Stratigraphic Nomenclature (NACSN)
David T. King, Jr., 1997–2000; Ardith K. Hansel, 1998–2001; Walter L. Manger, 1999–2002

GSA Representative to the *Treatise* Editorial Advisory and Technical Advisory Boards of the Paleontological Institute
John Pojeta, Jr.—Chair, *Treatise on Invertebrate Paleontology* Advisory Committee

GSA Representatives to the Joint ASCE–GSA–AEG Committee on Engineering Geology (American Society of Civil Engineers, Association of Engineering Geologists)
Vacant—2000–2002; Vacant—2000–2002

GSA Representative to the U.S. National Committee on Scientific Hydrology
David A. Stephenson, 1990–; John M. Sharp, Jr. (alternate)

GSA and AASG Selection Committee for the John C. Frye Memorial Award in Environmental Geology (Association of American State Geologists)
Frank E. Kottlowski—Chair and AASG representative; Richard C. Berg—GSA representative, 1998–2000; Larry D. Fellows—AASG representative ■

2001 Committee Vacancies

The GSA Council acknowledges the many member-volunteers who, over the years, have stimulated growth and change through their involvement in the affairs of the Society.

Each year GSA asks for volunteers to serve on committees, and many highly qualified candidates express their willingness to serve. Not everyone can be appointed to the limited number of vacancies; however, members are reminded that there are also opportunities to serve in the activities and initiatives of the sections and divisions. Annually, the Council asks sections and divisions to convey the names of potential candidates for committee service to the Committee on Committees.

Continuing Education (1 member-at-large vacancy)

Directs, advises, and monitors the Society's continuing education program, reviews and approves proposals, recommends and implements guideline changes, and monitors the scientific quality of courses offered. Committee members should be familiar with continuing education programs or have adult-education teaching experience.

Arthur L. Day Medal Award (3 member-at-large vacancies)

Selects candidates for the Arthur L. Day Medal Award. Committee members should have knowledge of those who have made "distinct contributions to geologic knowledge through the application of physics and chemistry to the solution of geologic problems."

Education (1 Rocky Mountain Section representative vacancy)

Stimulates interest in the importance and acquisition of basic knowledge in the earth sciences at all levels of education and promotes the importance of earth-science education to the general public. Committee members work with other interested scientific organizations and science teachers' groups to develop precollege earth-science education objectives and initiatives.

Geology and Public Policy (3 vacancies—two members-at-large and one Washington, D.C., metro area member)

Translates knowledge of earth sciences into forms most useful for public discussion and decision making. Committee members should have experience in public-policy issues involving the science of geology. They should also be able to develop, disseminate, and translate information from the geologic sciences into useful forms for the general public and for the Society membership; they should be familiar with appropriate techniques for the dissemination of information.

Honorary Fellows (3 member-at-large vacancies)

Selects candidates for Honorary Fellows, usually non–North Americans. Committee members should have knowledge of geologists throughout the world who have distinguished themselves through their contributions to the science.

Membership (1 member-at-large vacancy)

Evaluates membership benefits and develops recommendations that address the changing needs of the membership and attract new members. Committee members must be able to attend one meeting a year. Previous experience in benefit, recruitment, and retention programs is desired.

Minorities and Women in the Geosciences (4 member-at-large vacancies)

Stimulates recruitment and promotes positive career development of minorities and women in the geoscience professions. Committee members should be familiar with minority and female education and employment issues and have expertise and leadership experience in such areas as human resources and education.

Nominations (2 vacancies—one member-at-large and one Councilor or former Councilor)

Recommends to the Council nominees for the positions of GSA Officers and Councilors. Committee members should be familiar with a broad range of well-known and highly respected geological scientists.

Penrose Conferences (4 vacancies—two members who have convened past Penrose Conferences and two members who have attended at least two or more Penrose Conferences)

Reviews and approves Penrose Conference proposals and recommends and implements guidelines for the success of the conferences.

Penrose Medal Award (3 member-at-large vacancies)

Selects candidates for the Penrose Medal Award. Committee members should be familiar with outstanding achievements in the geological community that are worthy of consideration for the honor. Emphasis is placed on "eminent research in pure geology which marks a major advance in the science of geology."

Research Grants (3 member-at-large vacancies)

Evaluates research grant applications and selects grant recipients. Committee members must be able to attend the spring meeting and should have experience in directing research projects and in evaluating research grant applications.

Treatise on Invertebrate Paleontology Advisory Committee (1 vacancy—paleontologist)

Advises the Council, the Committee on Publications and the *Treatise* editor in matters of policy concerning this publication.

Young Scientist Award (Donath Medal) (2 member-at-large vacancies)

Selects candidates for the Young Scientist Award. Committee members should have knowledge of young scientists with "outstanding achievement(s) in contributing to geologic knowledge through original research that marks a major advance in the earth sciences."

Representative to the North American Commission on Stratigraphic Nomenclature (1 vacancy)

Must be familiar with and have expertise in stratigraphic nomenclature.

Representative to the AASG Selection Committee for the John C. Frye Memorial Award in Environmental Geology (1 vacancy)

Assists with selection of John C. Frye Memorial Award candidates. ■

GSA ON THE WEB

Visit the GSA Web site at www.geosociety.org.
From our home page you can link to many information resources.

Submit your abstract for Summit 2000, the GSA Annual Meeting in Reno, Nevada. Look for a link in the What's Hot pull-down menu.

Look in the Meetings area for information on the GSA and Geological Society of London International Conference in Edinburgh, Scotland.

We have a new Field Forum, September 14–19, 2000. Get all the information from the conferences section of the Professional Development area.

Download forms for GSA committee nominations from the About Us area.

NOMINATION FOR GSA COMMITTEES FOR 2001

(One form per candidate, please. Additional forms may be copied.)

Name of candidate _____
(Please print)

Address _____

_____

Phone ( ) _____

Fax ( ) _____

E-mail _____

COMMITTEE(S) BEING ☐ VOLUNTEERED or ☐ NOMINATED FOR (please check):

Committee(s):

Comment on special qualifications (please print):

☐ GSA Fellow Section affiliation:

☐ GSA Member Division affiliation(s):

Brief summary of education (please print):

Brief summary of work experience (include scientific discipline, principal employer—e.g., mining industry, academic, USGS, etc.) (please print):

If you are VOLUNTEERING to serve GSA, please give the names of 2 references (please print):

Name:_____

Phone: ( ) _____

E-mail:_____

Name: _____

Phone: ( ) _____

E-mail:_____

If you are NOMINATING SOMEONE other than yourself to serve GSA, please give your name, address, phone number, and e-mail (please print):

Name: _____

Address: _____

_____

Phone: ( ) _____

E-mail:_____

DEADLINE: Please return this form to GSA Headquarters, Attn: Administrative Services, P.O. Box 9140, Boulder, CO 80301-9140, by July 10, 2000. *Form must be complete to be considered.*

2000–2001 Section Officers

Cordilleran Section
Susan M. DeBari, Chair; To be elected, Vice-Chair; Bruce A. Blackerby, Secretary; Margaret E. Rusmore, Past Chair

Rocky Mountain Section
Gary A. Smith, Chair; To be elected, Vice-Chair; Kenneth E. Kolm, Secretary; Donald W. Hyndman, Past Chair; Ian M. Lange, Past Vice-Chair

North-Central Section
Robert G. Corbett, Chair; Robert S. (Skip) Nelson, Vice-Chair; Robert F. Diffendal, Jr., Secretary; Robert D. Hall, Past Chair; Joseph F. Pachut, Jr., Past Vice-Chair

South-Central Section
Doy L. Zachry, Jr., Chair; Kevin M. Urbancvyk, Vice-Chair; Elizabeth Y. Anthony, Secretary-Treasurer; Calvin G. Barnes, Past Chair

Northeastern Section
Walter A. Anderson, Chair; David C. Roy, Vice-Chair; Kenneth N. Weaver, Secretary-Treasurer; Robert D. Jacobi, Past Chair

Southeastern Section
Larry D. Woodfork, Chair; Edward F. Stoddard, Vice-Chair; Harold H. Stowell, Chair-Elect; Donald W. Neal, Secretary-Treasurer; Gail S. Russell, Past Chair

GSA FOUNDATION UPDATE

Donna L. Russell, *Director of Annual Giving*

Funds Combined To Assist Women Geoscientists

Heeding the adage about the sum being greater than its parts, the Foundation has combined two funds that assist women geoscientists. The Women in Science fund, established in 1983, and the Doris M. Curtis Memorial Fund, established in 1991, have been combined into one fund—the Doris M. Curtis Memorial Fund for Women in Science. At the end of December 1999, the combined net assets for the new fund totaled $49,723.

The fund honors Doris Curtis, the first female president in GSA's history, who was a pioneer throughout her life. She attained leadership positions in many scientific organizations historically dominated by men. When she died in 1991, she was a partner in a lucrative consulting firm, Curtis & Echols, in Texas.

Foundation 1999 Distribution Highlights

Support from the GSA membership has enabled the Foundation to give support to many programs during 1999. Here are the highlights:

Research Grants	$83,600
Matching Student Travel Grants	$23,927
Science and Outreach	$186,583
Publications	$6,500
GSA Distinguished Awards	$30,378
Meetings Support	$47,000
Support to GSA	$75,453
Division Awards and Special Funds	$55,398

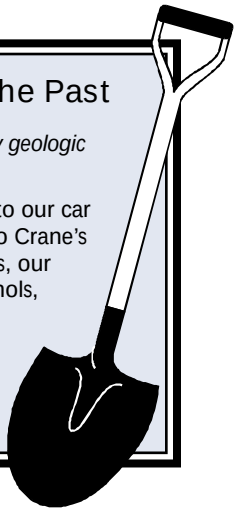
A very special thank you to all the donors who have supported the Foundation and have made these awards possible. ■

Digging Up the Past

Most memorable early geologic experience:

"When we returned to our car from an all-day trip to Crane's Beach, Massachusetts, our leader, Robert L. Nichols, had to convince the sheriff we weren't jacking deer."

—John R. Reid, Jr.



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LETTERS

Young et al. (Hurricanes Dennis and Floyd: Coastal Effects and Policy Implications, *GSA Today*, v. 9, no. 12, p. 1–6, December 1999) are well aware that coastal hazards are unlikely to be obviated by a new Hurricane Impact Scale. They articulated the real problem in several places:

- "the public must bear the cost of cleanup and infrastructure" (Abstract, p. 1)
- "North Carolina Governor Jim Hunt declared that federal funds ... were needed immediately" (p. 4)
- "The speaker of the North Carolina State Senate ... stated ... that beach and road-building money was needed immediately." (p. 4)
- "The island infrastructure ... [was] largely destroyed after having been replaced by federal funding after Fran in 1996.... [T]he federal recovery costs to replace infrastructure on this island will be large." (p. 5)
- "the public must still pay to repair infrastructure" (Conclusions, p. 6).

Why must federal tax revenues be used to "encourage beachfront development" (p. 3) and to rebuild infrastructure of local value, doomed to recurrent replacement? The explanation, if not the answer, lies in the nature of our government. We pride ourselves on the checks and balances of our system, but there are no checks on the wasting of tax revenue on natural processes. Local and national politicians get reelected by disbursing disaster relief funds; distant politicians negotiate quid pro quo's. Their dominant technical advice comes from the Corps of Engineers, an entity that many believe encouraged inappropriate floodplain development, that is considered to have a finger-in-the-dike approach to the lower Mississippi River, and that has a large economic stake in "structural mitigation."

What is necessary is a "taking"—not the taking of private lands by governments at an inflated market value, but the taking of responsibility for their actions by landowners and local governments.

William Locke
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wlocke@montana.edu

We applaud Gail Ashley's presentation of a multidisciplinary geoarchaeological project (Geologists Probe Hominid Environments, *GSA Today*, v. 10, no. 2, p. 24–25, 28–29), but we are disturbed by her statement that research at the intersection of geology, biology, anthropology, and hydrology is "new science." Geoarchaeologists have been working at this interdisciplinary boundary for at least the last few decades (the Archaeological Geology Division of GSA was established in 1977), and geographers have claimed research in this field for most of the 20th century. Kirk Bryan was crossing this disciplinary divide as early as 1920, and European scientists were working in this field at the beginning of the 20th century. We are afraid readers of Dr. Ashley's article might not appreciate that there is a well-established literature in this discipline as well as a GSA divsion with endowments, awards, scholarships, and a Web page (www.geog.ukans.edu/gsa/gsa.htm).

We would also like to point out that geoarchaeology has largely evolved from the parallel multidisciplinary research described by Dr. Ashley to integrated interdisciplinary research that can answer questions regarding the coevolution of ecology, culture, economy, and the physical landscape. These interdisciplinary research goals are achieved when scientists are willing to cross their own language and cultural barriers from the conception of a project. We agree with Dr. Ashley that only interdisciplinary research can answer paleoenvironmental questions of importance to the evolution of hominids, humans, culture, and economy. Additionally, this work will help us to understand the potential environmental impacts of intensive and extensive modern land use so that we may avoid having to repeat human-induced environmental catastrophes of the past.

Lisa Wells, Paul Goldberg,
Christopher Hill, Bill Johnson, Reid Ferring
GSA Archaeological Geology Division
Management Board

Ashley replies: I am sorry that Wells et al. chose to focus on just one example in the editorially constrained synopsis of my presidential address on the subject of interdisciplinary research. As a longtime member and supporter of the GSA Archaeological Geology Division, I am well aware of the contributions of geoarchaeologists in the past century and intended no slight.

My intended message was that the road to successful interdisciplinary research leading to "new science" is particularly difficult, as all sciences are now in transition. In the geosciences, this transition is from observational and descriptive science to the quantitative and predictive. Of necessity, interdisciplinary efforts are also caught up in this transition. I actually used different examples (physics, social sciences, geology, and biology) in my oral presentation from those in the published version. However, the examples chosen are less important than recognizing that the transition to quantitative and predictive science is fraught with difficulties and is irreversible, but as scientists we are all part of it.

Gail M. Ashley
Rutgers University
New Brunswick, NJ 08903

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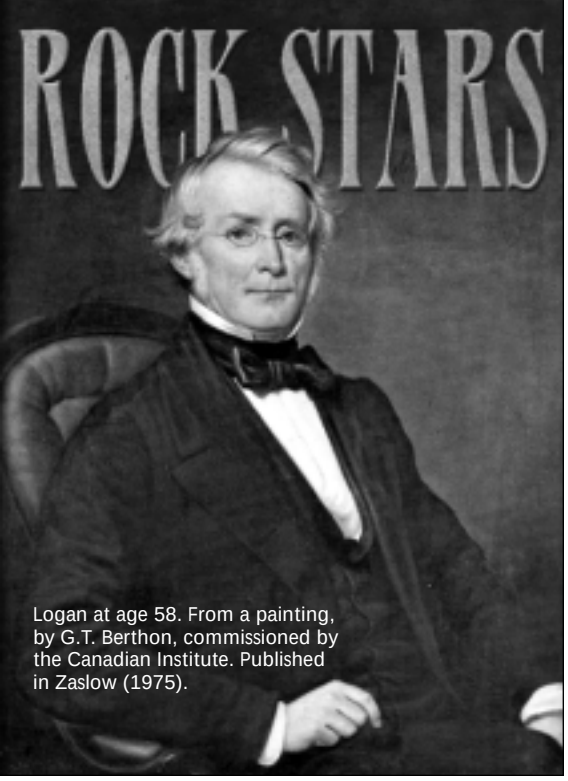


Logan at age 58. From a painting, by G.T. Berthon, commissioned by the Canadian Institute. Published in Zaslow (1975).

Sir William Edmond Logan, Father of Canadian Geology: His Passion Was Precision

Charles H. Smith, *Geological Survey of Canada (retired), Ottawa, ON, Canada K1H 5P5, chsmith@istar.ca*

William Edmond Logan (1798–1875) was a self-taught geologist who entered the geological profession following more than 20 years in accounting and copper-smelter management. His practice of geology arose from a desire to understand the sources of coal and ores. Because eminent British geologists recognized his abilities, he was selected (1842) to establish the Geological Survey of Canada. Logan directed the Survey for over a quarter of a century, and his achievements as a geologist, administrator, and force in Canada's economic development gained him national and international renown.

Early Years

Logan was born in 1798 in Montreal, the son of a prosperous baker and property owner. Education was a priority for the family; at age 16, Logan was sent to high school in Edinburgh, Scotland, where he excelled. At age 18, he enrolled in Edinburgh University, attending classes in logic, chemistry, and mathematics. Although his academic achievement was high, he left after one year to follow commercial pursuits in London, in the counting house of his uncle, Hart Logan.

First Job

From 1817 to 1831, Logan worked diligently in London, developing business skills and assuming management responsibilities. Despite long working hours, he continued to study geometry and drawing, pursuits that later contributed to the quality of his geological maps and field sketches. Logan's bookkeeping strengths later paid dividends: He kept accounts in perfect order during his leadership of the Geological Survey of Canada. Approaching retirement, he remarked, "After I am dead no one will be able to find faults with my books of accounts."

As time permitted, he learned French, Italian, and Spanish, and he traveled in France, Italy, and, later, Spain. Logan was also fond of painting and music; he sang well and played the flute. When opportunities arose, he enjoyed the outdoors—hunting and long hikes.

Interest in Geology

Logan's attraction to practical geology began at age 33 when he joined another of his uncle Hart's business interests, the Forest Copper Works in Wales. There he was exposed to the work of practical miners and surveyors in the coal fields. His metamorphosis to a geologist is documented by comments in letters to family members: "I shall go down to Wales, where ... I shall spare no pains to make myself master of every branch of the business, and as it is of a scientific nature, I am pretty sure I shall like it" (1831). By 1833, he was joint manager of the Copper Works. He wrote to his brother in Montreal, "Here I am, out of the world altogether, and attending to nothing else but the making of copper and digging coal from morning to night.... The study of the ores of copper has gradually led me to that of mineralogy and geology, and of specimens in both departments I have become a bit of a collector. Now if you could assist me with a few of Canadian origin I should be obliged."

Logan soon established his geological reputation in southern Wales. He was a founder of the Swansea Philosophical and Literary Institution and honorary curator of its Geological Section. Elected to the Geological Society of London in 1837, he wrote to his brother, "I have become a bit of a geologist of late years, and am now entitled to write after my name F.G.S.—being a Fellow of the Geological Society.... The locality to which I have especially directed my attention is this immediate neighbourhood, of which, during the leisure hours, I am gradually getting up a geological survey and sections. If I ever return to Canada again I shall geologize there." That same year, he exhibited his geological maps of the Glamorganshire coal field at the meeting of the British Association for the Advancement of Science, in Liverpool; the maps came to the attention of Henry De la Beche, director of the Ordinance Geological Survey of Great Britain. Logan's maps and sections were considered of such high quality that they were published without alteration as official Survey documents, bearing his name. They became a model for the Survey map series.

While mapping Welsh coal seams, Logan noted the invariable presence of underclays, containing peculiar vegetable remains, in the footwall of each coal seam. These findings, presented to the Geological Society of London in 1840, established the formation of coal *in situ*, and they place Logan among the pioneers of geological science.

Appointment to Conduct a Geological Survey of Canada

In 1838, following the death of his uncle, Logan resigned his position in Swansea. He pursued other business interests and provided advice, without remuneration, to the Ordinance Geological Survey. His future plans were uncertain. In 1841, he visited coal fields in Pennsylvania and Nova Scotia, and determined that his views about Welsh coals and underclays applied to North American deposits. When he learned that £1,500 had been earmarked to begin a geological survey of Canada, he wrote to De la Beche and others about the job.

Trans-Atlantic communications moved quickly. In March 1842, Canadian Governor General Sir Charles Bagot wrote to the Colonial Office in London, inquiring about Logan's qualifications. The response was immediate and overwhelming. Four leading British geologists—De la Beche (Geological Survey), William Buckland (Oxford), Adam Sedgwick (Cambridge), and Sir Roderick Murchison (Geological Society of London)—all submitted glowing references, on the basis of Logan's work in Wales. Murchison wrote, "Mr. Logan is highly qualified ... to point out the applications of geology ..., an object of the highest importance in a country like Canada, the mineral wealth of which is now so little known." Logan accepted the position on April 14, 1842, now considered the birth date of the Geological Survey of Canada. His transition to professional geologist was complete.

Early Years of the Geological Survey

Establishing the Geological Survey of Canada, under the physical and political conditions of the 1840s, was no task for the frail or faint-hearted. Logan realized he must demonstrate the practical value

of the geological survey to the government and the public. To his credit, he met this huge physical and intellectual challenge in a superior way.

Working days and field seasons were long, and conditions were primitive. Beyond the settled areas, travel was largely by canoe or on foot. The geology was virtually unknown. The lack of topographical maps required detailed measurements by pace, compass, Rochon micrometer, and barometer to represent the land surface; these were supplemented by astronomical observations. Although Logan was small physically, he was energetic, of strong constitution, and able to endure hardship.

Even when he was not in the field, Logan's working hours were long. He established quarters in Montreal, where he plotted maps, prepared reports, examined fossil and mineral specimens, reviewed the work of his assistants, and met members of the public. The initial funding for the Survey was insufficient, and Logan frequently used his own money for travel, hiring assistants, and purchasing supplies. He lobbied legislators and worked unceasingly on a new Survey bill, passed in 1845, that provided £2,000 annually for the next five years.

By 1850, Logan could report to the Governor General that with the aid of assistants Alexander Murray and James Richardson, as well as Indians and woodsmen, he had examined the Gaspé Peninsula, parts of the Eastern Townships south of the St. Lawrence River, and areas around lakes Ontario, Erie, Huron, and Superior. Three major geological units had been defined—folded Paleozoic rocks of Gaspé and the Eastern Townships (Eastern Division); flat-lying Paleozoic rocks extending west from Montreal to Lake Huron (Western Division); and Primitive (Precambrian) rocks to the north (Northern Division). Important observations and conclusions were presented on their stratigraphy and structure, on the absence of coal, and on the potential for copper in the Lake Superior region. Logan produced detailed maps, annual reports of progress, and a catalogue of economic minerals and deposits of Canada. A museum was established in Montreal containing "a large and valuable collection of specimens ... to illustrate the minerals, rocks and fossils of the districts examined." The museum was put to good use to educate legislators and the public on the practical benefits of Logan's surveys.

Exhibitions and Rewards

For Logan, the 1850s were marked by alternating demands on his time. First, he had to continually justify the Geological Survey and its needs to political bodies in turmoil. At times the Survey was on the brink of extinction. Fortunately, Logan was an excellent witness and lobbyist. Second, he oversaw presentations of Canada's resource wealth and scientific capability to the international community (London, 1851; Paris, 1855). The earlier work of the Survey, leading to the preparation of a catalogue of Canadian economic minerals, coupled with Logan's interest in the public display of minerals, fossils, and rocks, made him a logical person for these time-consuming duties. He had less personal time for field work, but his achievements and honors led to extraordinary years for the Survey. Geology in Canada grew in status, as did Canadians' pride in their country. Logan was elected a Fellow of the Royal Society (1851), was named to the French Legion of Honor by Emperor Napoleon III (1855), was knighted by Queen Victoria (1856), and received the Wollaston Medal of the Geological Society of London (1856). In Canada, he was lauded by the newspapers and the public, and he received an Honorary Doctor of Laws from McGill University.

Completing the Geology of Canada

The 1860s brought renewed political turmoil and ongoing fiscal woes to the Survey. Logan found it necessary to retrench and reduce field activities, while completing a major publication on the geology of Canada. The massive *Geological Survey of Canada: Report of Progress from its Commencement to 1863* (1863, 983 p.) incorporated contributions of Logan, Billings, Hunt, Murray, and others. Work on the accompanying maps continued through 1868 (causing considerable eyestrain for Logan). The report, written for a broad public audience, received glowing praise in the press and the scientific community for its content and precision. The Survey was seen to have completed its original purpose of "making the geological survey of Canada," as Canada was politically defined at the time, and it was ready to focus on studies of special problems.

Closing Years

Following completion of the 1863 report, and despite declining health, Logan led the Geological Survey until 1869 (age 71). He continued field studies in the Eastern Townships. He oversaw the start of the evolution of the Geological Survey of the Province of Canada toward the larger Geological Survey of the Dominion of Canada, with responsibilities stretching "from sea to sea." Following retirement, he continued to provide advice and, on occasion, to serve as acting director. In 1874 he returned to Wales to live with his sister. There, while planning to drill a 950-foot hole, at his own expense, to resolve a stratigraphic sequence in the Eastern Townships, his health failed. He died on June 22, 1875, at the age of 77.

Logan's name lives on in countless publications and topographical features (Mount Logan, in the Yukon, is Canada's highest mountain). Geological terms also bear his name (Logan's line, Logan sills, weloganite, *Loganograptus logani*). Logan medals are awarded by the Geological Association of Canada and McGill University. Other examples abound.

Logan was a self-motivated learner with a passion for precision, and these attributes are the foundation of his remarkable accomplishments. He raised Canadians' pride in their geological endowment and competence and in their stature in the international community. He laid the groundwork for the Geological Survey of Canada, which continues the work Logan began.

For more on Logan:

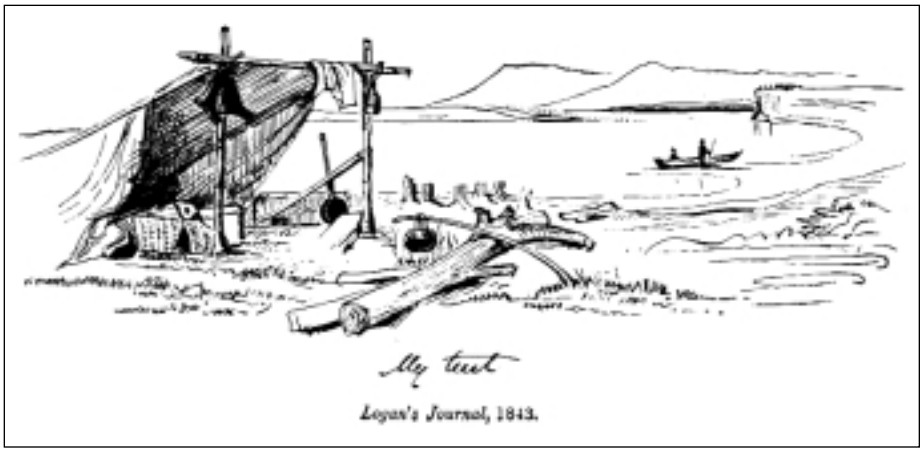
Geological Survey of Canada, 2000, Sir William Logan: www.nrcan.gc.ca/gsc/logan.

Harrington, B.J., 1883, Life of Sir William E. Logan Kt.: Montreal, Dawson Bros, 432 p.

Torrens, H.S., 1999, William Edmond Logan's geological apprenticeship in Britain 1831–1842: Geoscience Canada, v. 26, p. 97–110.

Winder, C.G., 1998, Logan's birthday: http://publish.uwo.ca/~cwinder/logan/.

Zaslow, M., 1975, Reading the rocks: Toronto, Macmillan Company of Canada, 599 p.



Logan to De la Beche, April 20, 1844: "I worked like a slave all summer [Gaspé, 1843] ... inhabiting an open tent, sleeping on the beach in a blanket sack with my feet to the fire, seldom taking my clothes off, eating salt fish and ship's biscuit, occasionally tormented by the mosquitoes." GSC photo 1110111.

Call for Applications and Nominations for GSA *Bulletin* Editor

The GSA *Bulletin* seeks a coeditor, beginning January 1, 2001. The new editor will replace the editor whose term ends in 2000 and will serve a four-year term. A phased transition should begin in the summer of 2000.

The GSA *Bulletin* has a 112-year history of excellence in publication of definitive works related to all aspects of geoscience. Part of GSA's mission is to bring together different earth sciences in a forum for scientific inquiry and discussion, and the *Bulletin* editors will be charged with continuing this tradition while helping Society staff find the best ways to provide comprehensive manuscripts in the electronic environment.

Editor Duties

1. Continue to maintain excellence of journal content through active solicitation of diverse and definitive manuscripts.
2. Ensure stringent peer review and expeditious processing of manuscripts.
3. Make final acceptance or rejection decisions after consideration of recommendations of reviewers and Associate Editors.
4. Correspond with authors regarding revisions and expeditious return of final manuscripts. Maintain active correspondence with current and potential contributors.
5. Select contents for each issue that will interest the broadest audience possible.
6. Select and maintain an active board of Associate Editors.
7. Report to the Committee on Publications on manuscript topic trends and issues specific to the *Bulletin*.

Editor Qualities

1. Broad personal background and active research in the geological sciences. Broad knowledge of geological research activities of scientists both nationally and internationally.
2. Interest in electronic publishing and in maximizing *Bulletin* content for print and electronic media.
3. Willingness to try new techniques to enhance author and reader satisfaction (e.g., theme issues).
4. Excellent organizational skills and ability to manage significant manuscript flow to ensure timely publication of papers. Ability to supervise editorial assistant to ensure that schedules are maintained.
5. Ability to remain tactful and helpful to authors, yet create and maintain stringent acceptance and rejection policies.
6. Willingness and capability to coordinate working schedules with a coeditor.
7. Willingness to invest about one day per week on *Bulletin*-related activities.
8. Objectivity and scientific maturity.

If you are interested in this opportunity to help guide the *Bulletin*, one of the premier geoscience journals, submit a resume and a brief letter describing relevant qualifications, experience, and objectives. If you are nominating someone, include a letter of nomination and the nominee's written permission and resume. Send nominations and applications to Peggy S. Lehr, Chief Operating Officer/Director of Publications, Geological Society of America, P.O. Box 9140, Boulder, CO 80301 by May 15, 2000.

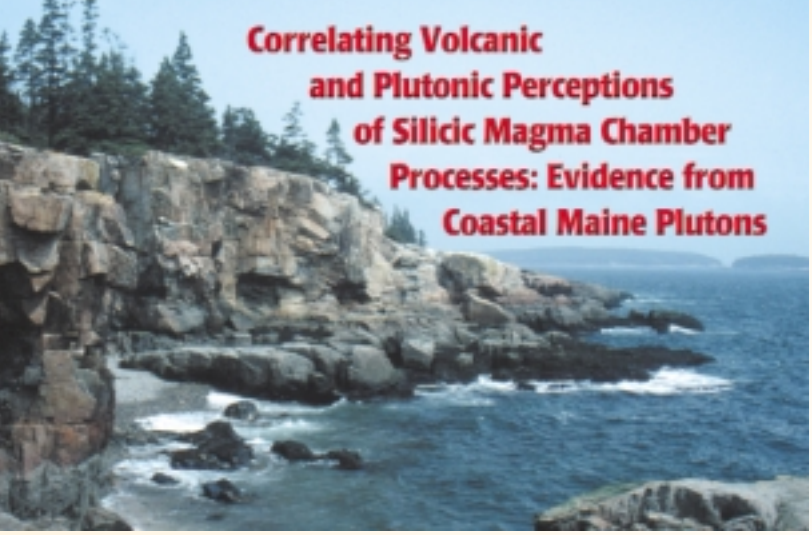


Photo: Coastal exposures of the Gouldsboro granite in Acadia National Park, Maine. Large silicic enclaves have been deeply eroded by wave action into the prominent caves above the high tide mark. Photo by Bob Wiebe.

GSA FIELD FORUM

Ellsworth, Maine

Dates: September 14–19, 2000

Leaders: Bob Wiebe, Geological Sciences, Franklin and Marshall College; Don Snyder, Geological Sciences, University of Michigan; David Hawkins, Department of Geology and Geography, Denison University; Tod Waight, Danish Lithosphere Centre

This forum will concentrate on the evidence for silicic magma chamber processes in the exceptional coastal exposures of shallow granitic plutons located in Maine. Parts of these plutons contain sections up to several kilometers thick that provide stratigraphic records of crystal accumulation and periodic injection of mafic magma and preserve spectacular magma mingling relations.

These relations appear to be the plutonic record of mafic replenishment events so widely inferred from the study of silicic eruptive systems. While it is becoming increasingly recognized that comparable features are widespread in granitic plutons of all ages and tectonic settings, most petrologists are unaware of the potential impact of these magma chamber processes on the compositions of silicic volcanic and plutonic rocks. The forum will explore the implications of these stratigraphic sequences for the mineralogical and geochemical evolution of silicic magma chambers and the possible impact of the magma chamber processes on the chemical and mineralogical evolution of silicic volcanic rocks and granitic plutons. A diverse group of scientists interested in field, geochemical, experimental, and theoretical aspects of silicic plutonic and volcanic systems will include volcanologists and fluid dynamicists, as well as the more traditional workers on silicic plutonic rocks—those who focus on field, structural, petrographic, geochemical, and isotopic studies of granites.

Some basic questions we plan to address are:

- Is it possible to recognize the signature of a volcanic event in a plutonic system (and vice-versa)?
- How do silicic magmas differentiate?
- How do injections of basic magma interact, both physically and chemically, with silicic magmas?
- What are the factors that influence the geochemical and isotopic signatures of silicic magmas?
- What do the field relations and structures in granitic plutons tell us about the emplacement of granitic magma and the solidification of silicic magma chambers?

Itinerary

Thursday, September 14. Participants should attempt to fly into Bangor, Maine, before 6:00 p.m., in time for dinner and orientation. Vans will provide transport from the airport to the White Birches Motel.

Friday, September 15. The entire day will be spent on Mount Desert Island (Acadia National Park), examining the Cadillac Mountain intrusive complex, which exposes both the base and upper levels of a composite pluton with gabbro, diorite, and granite. We will examine (1) mafic-silicic layered rocks in the gabbro-diorite unit, near the base of the complex (mafic replenishments into a silicic magma chamber), (2) the "shatter zone" (possible evidence for roof collapse during an explosive eruption), and (3) intermediate and silicic enclaves in the high-level Cadillac Mountain granite (are these disrupted samples of hybrid magmas from the base of the chamber?).

Saturday, September 16. Although dominantly gabbroic in composition, the Pleasant Bay layered intrusion contains many layers of granitic and intermediate (hybrid) rocks, which demonstrate that it formed by extensive injections of basaltic magma into a silicic magma chamber. Four stops are designed to show the widest range of interactions between resident granitic material and mafic replenishments, including (1) hybrid layers that grade upward from chilled basaltic magma to granite, (2) mafic layers pierced by granitic pipes fed from underlying crystal mush, and (3) extensive networks of composite dikes consisting of chilled mafic magma in a granite host.

Sunday, September 17. In contrast to the first two intrusions, mafic input into the Gouldsboro granite-gabbro complex has produced little obvious hybridization; gabbro is present only at the base of the intrusion and consists of discrete chilled pillows and sheets. We will examine (1) the transition between interlayered granite-gabbro and the overlying massive granite, (2) the abundant, large silicic enclaves at the highest exposed levels of the granite, and (3) several examples of composite dikes with mafic margins and silicic interiors. These dikes appear to have formed when a basaltic dike penetrated the active silicic chamber, permitting escape of viscous silicic magma from along the margins of the chamber.

Monday, September 18. In the Corea rapakivi granite, including minor gabbroic rocks near the base of the pluton, we will examine (1) interactions between mafic replenishments and granitic magma with large K-feldspar crystals, (2) a higher-level contact of the granite with metavolcanic rocks where rapakivi textures are absent at the contact and become common toward the center of the granite, (3) depositional features and hybrid enclaves within the granite.

Tuesday, September 19. Transport to airport.

Logistics, Participants and Costs

Each day we will have breakfast at 7:00 a.m. and attempt to leave no later than 8:00 a.m. White Birches Motel will provide substantial box lunches and drinks. We anticipate dinners at about 7:00 p.m. and opportunities for discussion and informal presentations afterward, in a room provided with slide and overhead projectors. Hiking is not strenuous, and participants in reasonably good physical condition will be able to visit all localities. Participants must make their own travel arrangements to and from Bangor, Maine. A registration fee of $630 will cover all meals, lodging, field trip transportation, and park fees.

The forum is limited to 30 participants in order to permit easy access to outcrops and opportunities for discussion by all. Participation of graduate students is encouraged. Those interested should send a letter of application to Bob Wiebe. Selection of participants will be made by the field forum leaders; notification of acceptance will be no later than June 15, 2000. To reserve a place, the registration fee is due by *August 1, 2000*.

For Information, Application, and Registration

Contact Bob Wiebe, Dept. of Geological Sciences, Franklin and Marshall College, Lancaster, PA 17604-3003, (717) 291-3820, fax 717-291-4186, r_wiebe@acad.fandm.edu. ■

Call For Nominations

Farouk El-Baz Award for Desert Research

The GSA Quaternary Geology and Geomorphology Division seeks nominations for the Farouk El-Baz Award for Desert Research. The award rewards excellence in research in desert geomorphology worldwide and is intended to stimulate research in desert environments by recognizing an individual whose research has significantly advanced the understanding of the Quaternary geology and geomorphology of deserts. Although the award primarily recognizes achievement in desert research, the funds that accompany it may be used for further research; in 2000 the award will include $10,000. The award is normally given to one person, but it may be shared by two people if the recognized research was the result of a coequal partnership.

Nominations

Any scientist from any country may be nominated for the award. Because the award recognizes research excellence, self-nomination is not permitted. Neither nominators nor nominees need be members of the Geological Society of America.

Nominations must be accompanied by supporting documentation: a statement of the significance of the nominee's research, a resumé, letters of support, and documentation of published research results that have significantly advanced our knowledge of the Quaternary geology and geomorphology of desert environments.

Deadline for nomination is May 15, 2000. Send nominations to Alan Nelson, U.S. Geological Survey, MS 966, Box 25046, Denver, CO 80225, anelson@usgs.gov. ■

CORRECTION

The April 2000 issue of *GSA Today* incorrectly listed the sponsorship of GSA Annual Meeting Topical Session 115, Frontiers in the Palynological Sciences. The correct sponsorship for this session is the American Association of Stratigraphic Palynologists (AASP). GSA apologizes to this society and its members for the error.

Volunteer Opportunity: Geology at a Scout Ranch

The Rocky Mountain Association of Geologists in association with Philmont Scout Ranch needs volunteers to spend a week in the back country of northern New Mexico introducing backpacking scouts to the science of geology. Volunteers stay at back-country camps. Spouses are welcome to accompany volunteers, and spouses and/or children can enroll in the Philmont Training Center and participate in programs at base camp during the volunteer's week.

For more information call or e-mail:
Ed Warner (720) 904-0560
ewarn@ix.netcom.com.

2000 GEOVENTURES

GeoTrip

Giant Steps Through Time

Dublin, Ireland • September 16–October 1, 2000

Scientific Leaders:

John Morris, Barry Long, Brian McConnell, Conor MacDermot, and Pat O'Connor, Geological Survey of Ireland, Dublin; Patrick McKeever, Ian Mitchell, and Terry Johnston, Geological Survey of Northern Ireland. Coordinators: Enda Gallagher, Geological Survey of Ireland, gallaghe@tec.irlgov.ie; Jay M. Gregg, Dept. of Geology and Geophysics, University of Missouri—Rolla, greggjay@umr.edu

This cooperative trip between the Geological Surveys of Ireland and Northern Ireland will be led by eight professional geologists. All are experienced field trip leaders and acknowledged as leading experts in their respective fields within Irish geology.

Cliffs of Moher. Photo by Jay Gregg.

Description

Participants will be introduced to the wonderful diversity of Ireland's geology, contained within a surprisingly small area. To examine the same assortment of geological localities in the United States would require a considerable trek—perhaps from coast to coast. Not only is Ireland's geology diverse, it also contains numerous classic geologic localities, many of which we will visit during this trip. Participants will see the rocks that neptunists and vulcanists argued over, including Ireland's geologic jewel—the Giant's Causeway in Antrim. Equally impressive are the classic igneous ring complexes and volcanic centers of counties Louth, Armagh, and Down, including Slieve Gullion and Carlingford, which were among the first such features described anywhere in the world. The granites of counties Donegal and Galway exhibit a variety of granite emplacement mechanisms and include the localities where granitization was first proposed. How exactly does an orogeny work? The story of the Grampian orogeny can be read in rocks from Antrim in the northeast across to Galway on the west coast. Ireland's west coast, from Donegal to Clare, reveals many other geologic treasures, including a prograding deltaic sequence, exceptional fossil preservation, and karstic features. All these features are contained in a spectacular glaciated landscape, which, when combined with Ireland's unique culture, history, and folklore, adds a delightful extra dimension to the trip.

Fees and Payment

$4,300 for GSA Members; $4,400 for nonmembers. A $300 deposit is due with your reservation and is refundable through July 1, less $50 processing fee. The total balance is due August 1, 2000. FIRM minimum: 20; maximum: 25. Included: Round-trip airfare from Atlanta to Dublin; guidebook; ground transportation; lodging for 14 nights, based on double occupancy; and meals for 14 days. For registration, contact Edna Collis, ecollis@geosociety.org.

GeoTrip

Deformation, Dinosaurs, and Darwin

Photo by James H. Reynolds.

Salta, Argentina
July 24–August 13, 2000
21 days, 20 nights

Scientific Leaders:

James Reynolds, Magstrat, LLC, Webster, North Carolina, and Brevard College, Brevard, North Carolina; Dorothy L. Stout, Cypress College, Cypress, California

Fees: $3,900* for GSA members; $4,000 for nonmembers

GeoHostel

Valley of Fire in Southern Nevada, Toroweap Valley of the Grand Canyon, Zion & Bryce Canyon National Parks of Southern Utah

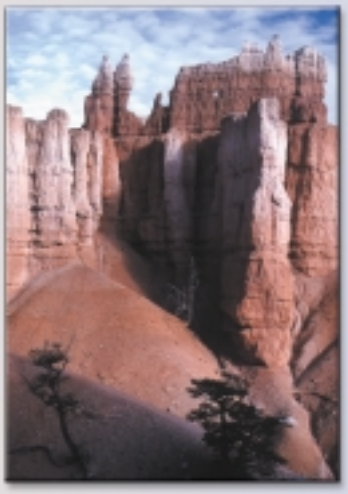


Photo by Martin Miller.

Dixie College,
St. George, Utah
June 10–15, 2000
5 days, 6 nights

Scientific Leaders:

Spence Reber, Chevron USA (retired); Janice Higgins, Dixie College, St. George, Utah

Fees: $800 for GSA members; $900 for nonmembers

2001 • Boston

2001 GSA Annual Meeting
Boston, Massachusetts

November 5–8, 2001
John B. Hynes Veterans Memorial Convention Center

General Chair
Christopher Hepburn
Boston College

Technical Program Chair
Robert S. Young
Western Carolina University

Due Date for Pardee Keynote Symposia and Topical Proposals:
January 9, 2001

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E-mail: meetings@geosociety.org
Web site: www.geosociety.org

Call for Field Trip Proposals
We are interested in proposals for half-day, single-day, and multi-day field trips, beginning or ending in Boston and dealing with all aspects of the geosciences.

Please Contact Field Trip Co-Chairs
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Department of Geology
Earlham College
Richmond, IN 47374
(765) 983-1231, fax 765-983-1497
westd@earlham.edu

Richard (Dick) Bailey
Department of Geology
Northeastern University
Boston, MA 02115
(617) 373-3181, fax 617-373-4378
r.bailey@nunet.neu.edu

GeoVentures Registration

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

Name

Institution/Employer

Mailing Address

City/State/Country/ZIP

Phone (business/home)

Guest Name

GSA Member #

	Deposit Per Person	No. of Persons	Total Paid Deposit
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GT005—Ireland	$300	____	$_____
	TOTAL DEPOSIT		$_____

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Positions Open

DEPARTMENT OF EARTH AND OCEAN SCIENCES
UNIVERSITY OF BRITISH COLUMBIA

Applications are invited for one or more tenure-track positions. We seek individuals who have proven ability or exceptional potential in research, excellent communication skills for teaching, and leadership potential in order to augment and complement current activities in the department. We seek outstanding applicants who will establish vigorous and well-funded research programs and enhance the interaction between the various research programs within our department. The priority fields for these appointments and non-exclusive examples of areas of expertise sought are as follows: (1) Mineral deposits geology — chemistry of ore fluids, stable isotope geochemistry, applied geochemistry, metallogenic analysis; (2) Applied geophysics — theoretical, computational and experimental examination of Earth's near-surface properties and structure; application to environmental, exploration and engineering geophysics; (3) Organic geochemistry — origins of hydrocarbons and carbon-rich sediments, early diagenesis of organic compounds, metal-phytoplankton interactions on the molecular scale, stable isotopes and organic compounds as tracers of organic processes and/or climate change; (4) Geological engineering (geotechnical) — remote sensing, geotechnical or geophysical methods to characterize weak rock and coarse soils. This appointment may be jointly with a second department.

Outstanding candidates in other areas that fall within the long-range hiring plan of the department (see www.eos.ubc.ca) may also be considered. Appointments will be at the assistant professor level except in the case of exceptionally well-qualified females who may be appointed at a higher rank. We particularly encourage women to apply as we may be able to expand our hiring program through the Natural Sciences and Engineering Research Council (NSERC) University Faculty Awards Program. Applicants must possess a Ph.D.

In accordance with Canadian immigration requirements, priority will be given to Canadian citizens and permanent residents of Canada. UBC hires on the basis of merit and is committed to employment equity. We encourage all qualified persons to apply. These positions are subject to final budgetary approval. Applications including a resumé, a statement of research interests, and the names of three referees should be sent to Dr. Robert M. Ellis, Head, Department of Earth and Ocean Sciences, 6339 Stores Road, University of British Columbia, Vancouver, B.C., Canada V6T 1Z4, by June 15, 2000.

UNIVERSITY OF CALIFORNIA, LOS ANGELES
DEPARTMENT OF EARTH AND SPACE SCIENCES

W.W. Rubey Faculty Fellowship — The Department of Earth & Space Sciences at the University of California, Los Angeles, is pleased to announce the availability of the W.W. Rubey Fellowship. The Fellowship is a two-year appointment at the rank of Adjunct Assistant Professor, which, in exceptional circumstances, may lead to a tenure-track position. The Fellow will have a reduced teaching load and ample opportunity for independent research and interaction with the faculty members of the department. Funds will be available to support travel and some research expenses. The appointment can begin on or after July 1, 2000.

Young scientists who are close to finishing their Ph.D. degrees or have received their Ph.D. degrees within the past three years are eligible to apply. Although research and teaching interests of the applicants can be in any field of earth and space sciences, the following areas may accommodate the needs of the department: (1) ocean-continent interaction, tectonics and surficial processes, (2) geologic (chemical, biological, and physical) processes related to the evolution of the continents, the oceans, and the oceanic/continental lithosphere, and (3) observational and theoretical research in geophysics, space physics, and planetary sciences.

Applications should include a curriculum vitae, publication list, short statement of teaching and research objectives, and names and addresses of three referees, and be directed to: W.W. Rubey Faculty Fellowship Search, Department of Earth and Space Sciences, UCLA, P.O. Box 951567, Los Angeles, CA 90095-1567

Applications will be accepted on a continuing basis, but consideration of dossiers will commence May 15, 2000. UCLA is an equal opportunity/ affirmative action employer: women and minority candidates are particularly encouraged to apply.

Sedimentology Faculty Position — The Department of Earth & Space Sciences at the University of California, Los Angeles (UCLA) invites applications for a faculty position in the areas of sedimentology, stratigraphy, and basin analysis. While all aspects of sedimentology will be considered, we are particularly interested in candidates whose research is field-based and aimed at solving problems of regional significance. We are seeking a candidate who complements our present faculty working on large-scale physical, chemical, and biological interactions involving tectonics, climate change, and evolution of Earth and life. Necessary qualifications include a Ph.D. degree and demonstrated intellectual leadership and teaching skill. The level of appointment will be commensurate with experience and distinction, but a senior appointment is preferred. Applications should include a curriculum vitae, the names and addresses of three referees, and a statement of research and teaching interests, and be directed to: Sedimentology Search Committee, Department of Earth and Space Sciences, UCLA, P.O. Box 951567, Los Angeles, CA 90095-1567.

Applications will be accepted on a continuing basis, but consideration of dossiers will commence May 15, 2000. UCLA is an equal opportunity/affirmative action employer; women and minority candidates are particularly encouraged to apply.

Stable Isotope Faculty Position — The Department of Earth and Space Sciences, Institute of Geophysics and Planetary Physics (IGPP), and Institute of the Environment (IoE) at the University of California, Los Angeles (UCLA) invite applications for a ladder faculty position in stable isotope geochemistry. Necessary qualifications include demonstrated leadership in the development and application of state-of-the-art, high-precision mass spectrometer and related techniques. Possible fields of interest include the application of isotopic techniques to biogeochemical, environmental, lithospheric, and solar-system studies , and to processes of the present and past. An interest in conducting broad-scope collaborations with present faculty is highly desirable. The level of appointment will be commensurate with experience and qualifications. Joint appointment to the IGPP can be made for scientists involved in novel research fields that cross traditional disciplinary boundaries or to the IoE in the case of scientists with a strong linkage to environmental issues. The applicant should enclose a curriculum vitae, publication list, short statement of teaching and research objectives, and names and addresses of three potential references. Applications should be directed to: Stable Isotope Search Committee, Department of Earth and Space Sciences, UCLA, P.O. Box 951567, Los Angeles, CA 90095-1567.

Applications will be accepted on a continuing basis, but consideration of dossiers will commence May 15, 2000. UCLA is an equal opportunity/affirmative action employer; women and minority candidates are particularly encouraged to apply.

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Mineral Physics Faculty Position — The Department of Earth and Space Sciences (ESS) and Institute of Geophysics and Planetary Physics (IGPP) at the University of California Los Angeles (UCLA) invite applications for a ladder faculty position in mineral physics, including such specialties as flow laws, equations of state, phase relations, anisotropic elasticity, and/or thermal and electrical conductivity. Consideration will be given to both experimental and computational approaches. Necessary qualifications include the Ph.D., demonstrated intellectual leadership and teaching skill, and laboratory or computational experience. The abilities to conduct investigations at high pressure and/or on multicomponent rocks are desirable. The level of appointment will be commensurate with experience and distinction but a junior appointment is preferred. Joint appointment to the IGPP can be made for scientists involved in novel research fields that cross traditional disciplinary boundaries. The applicant should enclose a curriculum vitae, publication list, short statement of teaching and research objectives, and names and addresses of three potential references. Applications should be directed to: Mineral Physics Search Committee, Department of Earth and Space Sciences, University of California, P.O. Box 951567, Los Angeles, CA 90095-1567.

Applications will be accepted on a continuing basis, but consideration of dossiers will commence May 15, 2000. UCLA is an equal opportunity/affirmative action employer; women and minority candidates are particularly encouraged to apply.

DIRECTOR / STATE GEOLOGIST,
UTAH GEOLOGICAL SURVEY

Provides direction and leadership to statewide programs for the Utah Geological Survey; programs include: Applied Geology (Engineering Hazards), Environmental Sciences (Groundwater and Paleontology), Mapping Geology, Economic Geology and Geologic Extension Service; and implements UGS Board policies. MINIMUM QUALIFICATIONS: Bachelor's degree (Master's/Ph.D. preferred) in geology or related field; 10 years professional experience in geological field, including six years of progressive managerial experience. Knowledge and skills in the following areas: geologic principles and techniques; state and national scientific trends in the geologic field; political processes; administrative, leadership, and interpersonal effectiveness; communication including writing, public speaking, meeting facilitation, media and public relations; creating, implementing, and managing budgets; and personnel, strategic, and project management skills. Working conditions require extensive travel both in and out of state. Salary: $61,533 to $89,992/year with an excellent benefit package. This is an appointment position. Additional details may be obtained by visiting www.nr.state.us.ut or by calling (801) 538-7210. Interested applicants should submit a cover letter and resume to the Department of Natural Resources, Human Resource Office, c/o Carlos Rodriguez, Human Resource Manager, 1594 West North Temple, Suite 316, Salt Lake City, Utah 84116. Review of applications will begin June 1 and will continue until the position is filled.

TENURE-TRACK POSITIONS IN OCEANOGRAPHY /
MARINE SCIENCES, TEXAS A&M UNIVERSITY

The Department of Oceanography at Texas A&M University at Galveston invites applications for two nine-month tenure-track assistant professor positions, one in coastal geological oceanography and the other in marine organic geochemistry/chemical oceanography. The candidates must have a Ph.D. in oceanography or a related field, establish and sustain an externally funded research program, and have a strong commitment to excellence in teaching and mentoring graduate and undergraduate students. The successful applicants will teach undergraduate courses (e.g., organic chemistry or geology/geological oceanography) and graduate courses in their field of expertise. More information can be found on the Web site http://www. tamug.tamu.edu/mars/position.html. TAMUG is an equal opportunity, affirmative action employer.

MINERALOGIST-PETROLOGIST-GEOCHEMIST
NORTHWEST MISSOURI STATE UNIVERSITY

The Department of Geology/Geography at Northwest Missouri State University seeks a tenure-track assistant professor in geology beginning August 2000. We seek candidates with a specialization in mineralogy, petrology, and geochemistry. A Ph.D. in geology is required at the time of appointment (position will be non–tenure track instructor without completion of Ph.D.), along with a strong interest and potential excellence in undergraduate teaching and developing a research program that focuses on undergraduate students. Responsibilities include teaching mineralogy with lab, petrology with lab, and an introductory course (geology or earth science) with labs. Candidates adept with broad-based applications of and interest in teaching geochemistry desirable.

The electronic campus places computing facilities in every faculty office and every residence hall room. The Geology/Geography Department offers degree programs leading to a B.A. or B.S. in geology or geography. For more information, refer to http://www.nwmissouri.edu/~geopage.

Applicants should send a letter of application, resume/curriculum vitae, transcripts of academic work, and three letters of recommendation to Geology Search Committee Chair, Department of Geology and Geography, Northwest Missouri State University, 800 University Drive, Maryville, MO 64468-6001. Phone: (660).562-1201 or (660).562-1723. Review of applications and supporting materials began April 17, 2000, and will continue until the position is filled. Salary is competitive and will depend on qualifications and experience.

Northwest Missouri State University is an equal opportunity employer and encourages women and minorities to apply.

VACANCY
GEO-MICROBIOLOGIST, U.S. GEOLOGICAL SURVEY
RESTON, VA 20192

The U.S. Geological Survey seeks applicants for a Ph.D. geo-microbiologist position to work on the roles of microorganisms in the cycling of metals in near-surface environments, and to conduct research in the broad area of metal–organic matter interactions and aqueous-metal release. We desire applicants who are broadly interdisciplinary and will establish linkages between geo-microbiology and a broad range of geological sciences. Present focus is on providing research linkages with active areas of multidisciplinary work on acid-mine drainage and toxic metal cycling processes (As, Hg). The ideal candidates would have experience in biogeochemical and biomineralogical reactions, be able to identify microorganisms in geological materials, and determine microorganism abundance, diversity, and mineral association involved with metal release, transport, and fixation processes. Candidates will also examine the role of microorganisms in the formation of weathering products in near-surface environments. Successful candidates will utilize molecular biological approaches to identify and examine microorganisms from these environments.

Applicants are sought with skills and experience in the following areas: (1) Microbiology and molecular biological techniques and diagnostic bacterial methods, including microbiologic field methodologies and established laboratory techniques. (2) Geochemistry, mineralogy, organic geochemistry, and hydrology. (3) Techniques for isolation of microorganisms from geological materials. (4) Microbial remediation techniques and how geologic systems support microorganisms.

This is a permanent position, with starting salary at $51,204.

Additional information and application procedures for vacancy number H-00-517 can be obtained on our Web site: http://www.usajobs.opm.gov. This vacancy closes May 26, 2000.

Contact: Office of Personnel (703) 648-6131.

The U.S. Geological Survey is an equal-opportunity employer.

VICE-PRESIDENT OF ENGINEERING

Responsible for theory and calculations in areas of geophysics, calculus, subsurface electrical resistivity and isoresistive geophysical interpretation as they pertain to artificial electric field measurement. Correlate results of field survey with geometric anomalies, variations, and other geological parameters of survey area. Correlate with results from other applied methodologies in the area and define geologic structure and properties of the subsurface materials. Responsible for training of survey analysts in these areas. Required: Ph.D. in geophysics. Minimum two (2) years' field experience in isoresistive technique and interpretation of resistivity values to attain results profiles. Complete knowledge of High Definition Scan System and working knowledge of associated proprietary software, GeoGraphs. $34.62/hr; 45 hrs. week, 8:00 am to 5:00 pm. Two copies of resume to: DWE-ALC, File #C101419; P.O. Box 7972, Madison, WI 53707-7972.

OPERATIONS MANAGER

Responsible for implementation and organization of operations and training for High Definition Geo-Scan System and proprietary software. Assist in production of training aides in these areas including manuals, audio/visual and electronic media. Continued understanding of analytic methods for processing of survey data and assistance in interpretation of results as needed. Process surveys within proprietary software as needed. Required: One (1) year of experience in areas of isoresistive geophysical survey methods, corresponding collection of data and interpretation of results. Experience in training on High Definition GeoScan System and corresponding software. $17.31/hr; 45 hrs. week, 8:00 am to 5:00 pm. Two copies of resume to: DWE-ALC, File #C101418; P.O. Box 7972, Madison, WI 53707-7972.

HIGH DEFINITION GEOSCAN SYSTEM OPERATOR

Operate High Definition GeoScan System for isoresistive geophysical surveys. Responsible for working knowledge and maintenance of analog and digital geophysical measuring devices. Coordinate all aspects of field surveys. Assist in transfer of data from scan system to proprietary software and interpretation of results. Train personnel on use of High Definition Scan System. Assist in final results and associated illustrations. Maintain inventory of replacement parts for GeoScan System and perform necessary repairs. Required: One year of experience with high definition scanning system in isoresistive field surveys. Experience in maintenance of high definition Scanners and their internal electronics. $17.31/hr; 45 hrs. week, 8:00 am to 5:00 pm. Two copies of resume to: DWE-ALC, File #C101417; P.O. Box 7972, Madison, WI 53707-7972.

GEOSCAN SOFTWARE INSTRUCTOR

Operate and train personnel on GeoGraphs proprietary software. Responsible for interpretation of field survey data by means of GeoGraphs software and subsequent illustration of results by use of CAD and additional graphics-based software. Assist in collection of isoresistive field data and operation of High Definition Scan System. Responsible for transfer of field data into GeoGraphs software. Assist in description of final results of field surveys. Required: Minimum one year of experience in 3-dimensional imaging software specific to geophysics industry. Experience in CAD and other graphics-related programs. Technical writing experience. $17.31/hr; 45 hrs. week, 8:00 am to 5:00 pm. Two copies of resume to: DWE-ALC, File #C101416; P.O. Box 7972, Madison, WI 53707-7972.

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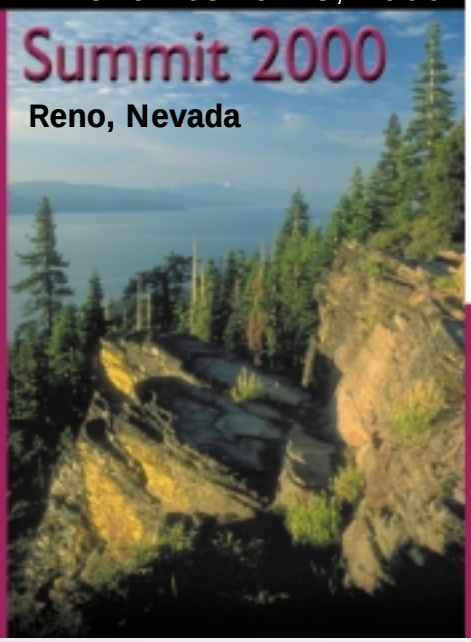
GSA Annual Meeting and Exposition
November 9–18, 2000



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1999 GSA Publications

GSA has 16 exciting new publications available for purchase through the GSA Bookstore. Each edition will become a valuable addition to your personal geology library.

GSA Field Guide 1: Colorado and Adjacent Areas (1999 Annual Meeting, Denver)
David R. Lageson, Alan P. Lester, Bruce D. Trudgill

FLD001, 208 p., 0-8137-0001-9, List price $25.00, Member price $20.00

Planetary Petrology and Geochemistry (The Lawrence A. Taylor 60th Birthday Volume)
G.A. Snyder, C.R. Neal, W.G. Ernst

IBS002, 277 p., 0-9665869-1-3, List price $89.95, Member price $71.96

Pre-Mesozoic Ice Ages: Their Bearing on Understanding the Climate System
John C. Crowell

MWR192, 112 p., 0-8137-1192-4, List price $46.00, Member price $36.80

Late Cenozoic Xianshuihe-Xiaojiang, Red River, and Dali Fault Systems of Southwestern Sichuan and Central Yunnan, China
Erchie Wang, B.C. Burchfiel, L.H. Royden

SPE327, 114 p., 0-8137-2327-2, List price $41.00, Member price $32.80

Himalaya and Tibet: Mountain Roots to Mountain Tops
Allison Macfarlane, Rasoul Sorkhabi, Jay Quade

SPE328, 336 p., 0-8137-2328-0, List price $70.00, Member price $56.00

Geologic Evolution of the Barberton Greenstone Belt, South Africa
Donald R. Lowe, Gary R. Byerly

SPE329, 324 p., 0-8137-2329-9, List price $60.00, Member price $48.00

The Mid-Atlantic Piedmont: Tectonic Missing Link of the Appalachians
David W. Valentino, Alexander E. Gates

SPE330, 146 p., 0-8137-2330-2, List price $60.00, Member price $48.00

Norumbega Fault System of the Northern Appalachians
Allan Ludman, David P. West, Jr.

PE331, 214 p., 0-8137-2331-0, List price $55.00, Member price $44.00

Evolution of the Cretaceous Ocean-Climate System
Enriqueta Barrera, Claudia C. Johnson

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Cenozoic Basins of the Death Valley Region
Lauren A. Wright, Bennie W. Troxel

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Tectonosomes and Olistostromes in the Argille Scagliose of the Northern Apennines, Italy
Gian A. Pini

SPE335, 73 p., 0-8137-2335-3, List price $25.00, Member price $20.00

Glacial Processes Past and Present
David M. Mickelson, John W. Attig

SPE337, 216 p., 0-8137-2337-X, List price $38.00, Member price $30.40

Classic Cordilleran Concepts: A View from California
Eldridge M. Moores, Doris Sloan, Dorothy L. Stout

SPE338, 500 p., 0-8137-2338-8, List price $97.85, Member price $78.28

Mesozoic Sedimentary and Tectonic History of North-Central Mexico
Claudio Bartolini, James Wilson, Timothy Lawton

SPE340, 388 p., 0-8137-2340-X, List price $99.00, Member price $79.20

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