Vol. 9, No. 2 February 1999

GSA TODAY

A Publication of the Geological Society of America

INSIDE

Hypercalcification: Paleontology Links Plate Tectonics and Geochemistry to Sedimentology

Steven M. Stanley
Lawrence A. Hardie
Morton K. Blaustein Department of Earth and Planetary Sciences, Johns Hopkins University, Baltimore, MD 21218

ABSTRACT

During the Phanerozoic Eon, the mineralogies of nonskeletal marine cements and oolites have oscillated on a 100–200 m.y. scale between aragonite ± high-Mg calcite (aragonite seas) and low-Mg calcite (calcite seas). Oscillations in the carbonate mineralogy of dominant reef-building and sediment-producing organisms are in harmony with the oscillations for nonskeletal carbonates. These oscillations, together with synchronous oscillations in the mineralogy of marine potash evaporites, can be explained by secular variation in the Mg/Ca ratio of seawater driven by changes in the spreading rates along midocean ridges. The temporal patterns for biocalcification have come to light through a focus on (1) simple taxa that exert relatively weak control over the milieu in which they secrete their skeletons, and (2) taxa that hypercalcify—i.e., secrete massive skeletons or are exceptionally productive, for example, in forming voluminous chalk deposits. Most major reef-building and sediment-producing taxa belong to both of these categories. It appears that the Mg/Ca ratio of seawater has not only controlled Phanerozoic oscillations in hypercalcification by simple taxa, such as calcareous nannoplankton, sponges, and bryozoans, but has strongly influenced their skeletal evolution.

INTRODUCTION

Following an era of specialization in the earth sciences, many conceptual advances are now emerging through interdisciplinary research. The flow of earth materials through chemical cycles, for example, links diverse scientific fields, as do sequences of causal relationships that connect noncyclical physical, chemical, and biological phenomena. We have concluded that Phanerozoic oscillations in the mineralogy of dominant reef-building and sediment-producing organisms can be linked to shifts in seawater chemistry controlled by changes in global spreading rates along mid-ocean ridges (Fig. 1).

An aragonitic brain coral, *Diploria strigosa,* of late Pleistocene age, from the Cockburn Town fossil coral reef, San Salvador Island, Bahamas. This reef formed during the most recent interval of aragontie seas. Photo by Al Curran, Smith College.

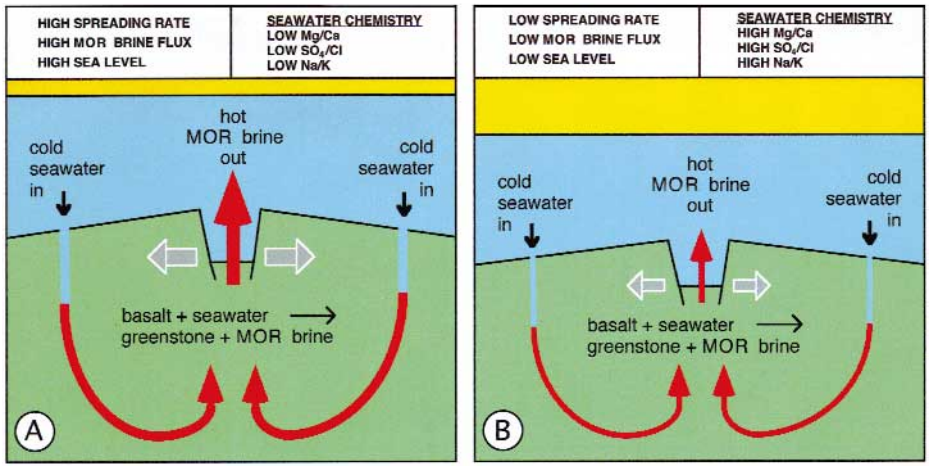


Figure 1. Effect of changes in the rate of seafloor spreading (ocean crust production) on global sea level, the flux of MOR hydrothermal brine, and the chemistry of seawater as predicted by Spencer and Hardie (1990) and Hardie (1996). A—high-spreading-rate conditions; B—low-spreading-rate conditions. Red arrows—MOR brine paths (thicknesses of the arrows are proportional to the brine flux but not to scale). Gray arrows proportional to spreading rates (not to scale).

In a seminal study of oolites and early marine cements, Sandberg (1983) showed that nonskeletal carbonate precipitation

Hypercalcification *continued on p. 2*

GSA TODAY
Vol. 9, No. 2 February 1999

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

SUBSCRIPTIONS for 1999 calendar year: Society Members: *GSA Today* is provided as part of membership dues. Contact Membership Services at (800) 472-1988, (303) 447-2020 or member@geosociety.org for membership information. Nonmembers & Institutions: Free with paid subscription to both *GSA Bulletin* and *Geology,* otherwise $50 for U.S., Canada, and Mexico; $60 elsewhere. Contact Subscription Services. Single copies may be requested from Publication Sales. Also available on an annual CD-ROM, (together with *GSA Bulletin, Geology,* GSA Data Repository, and an Electronic Retrospective Index to journal articles from 1972); $89 to GSA Members, others call GSA Subscription Services for prices and details. Claims: For nonreceipt or for damaged copies, members contact Membership Services; all others contact Subscription Services. Claims are honored for one year; please allow sufficient delivery time for overseas copies, up to six months.

STAFF: Prepared from contributions from the GSA staff and membership.
Executive Director: *Donald M. Davidson, Jr.*
Science Editors: *Suzanne M. Kay, Department of Geological Sciences, Cornell University, Ithaca, NY 14853; Molly F. Miller, Department of Geology, Box 117-B, Vanderbilt University, Nashville, TN 37235*
Forum Editor: *Bruce F. Molnia, U.S. Geological Survey, MS 917, National Center, Reston, VA 22092*
Director of Publications: *Peggy S. Lehr*
Managing Editor: *Faith Rogers*
Assistant Editor: *Vanessa Carney*
Production Manager: *Jon Olsen*
Production Editor and Coordinator: *Joan E. Manly*
Graphics Production: *Joan E. Manly, Leatha L. Flowers*

ADVERTISING: Classifieds and display: contact Ann Crawford, (303) 447-2020; fax 303-447-1133; acrawford@geosociety.org.

Issues of this publication are available as electronic Acrobat files for free download from GSA's Web Site, http://www.geosociety.org. They can be viewed and printed on various personal computer operating systems: MSDOS, MSWindows, Macintosh, and Unix, using the appropriate Acrobat reader. Readers are available, free, from Adobe Corporation: http://www.adobe.com/acrobat/readstep.html.

This publication is included on GSA's annual CD-ROM, *GSA Journals on Compact Disc.* Call GSA Publication Sales for details.

Printed in U.S.A. using pure soy inks.

50% Total Recoverd Fiber
10% Postconsumer

IN THIS ISSUE

In Memoriam

George W. Berry
Boulder, Colorado
January 2, 1999

Craig C. Black
Los Ranellos, New Mexico

William F. Grote
Banning, California
December 4, 1998

Tylor R. Kittredge
Panama
October 1998

Wilbur H. Knight
Jackson, Mississippi
May 1998

Leonard M. Gard, Jr.
Lakewood, Colorado
September 25, 1998

Harold W. Scott
Urbana, Illinois
October 30, 1998

Gonzalo Vidal
Uppsala, Sweden
January 1997

John F. Wosinski
Corning, New York

Hypercalcification *continued from p. 1*

in Phanerozoic seas has oscillated between aragonite and calcite (Fig. 2). It has been widely held that relatively low levels of atmospheric pCO_2 have produced "aragonite seas," while relatively high levels have produced "calcite seas" (Wilkinson and Algeo, 1989; Mackenzie and Morse, 1992). Calculations using the computer program PHRQPITZ (Plummer et al., 1988) show, however, that pCO_2 is not a viable control (Stanley and Hardie, 1998). Seawater of modern composition would be supersaturated with respect to calcite and undersaturated with respect to aragonite only for a narrow range of pCO_2, within which all values are more than an order of magnitude greater than that of the present—a level almost certainly not attained during the Cretaceous interval of calcite seas (Berner, 1994). In fact, such high levels of pCO_2 would cause aragonitic shells of organisms to begin dissolving immediately after their secretion. Furthermore, experiments show that for present-day seawater at 25 °C (Mg/Ca mole ratio = 5.17), raising pCO_2 from $10^{-4.5}$ to $10^{-1.0}$ atm simply lowers the $MgCO_3$ content of precipitated calcite from 12 to 7 mol% (Burton and Walter, 1991); it does not cause low-magnesium calcite to precipitate instead of aragonite.

It has long been recognized that changes in the Mg/Ca ratio of seawater can dictate whether calcite or aragonite precipitates from seawater. Experiments demonstrating this relationship (Füchtbauer and Hardie, 1976, 1980), which are in accord with data for natural saline lakes (Müller et al., 1972), indicate that, at 25 °C and present seawater ionic strength and atmospheric pCO_2, a ratio for Mg/Ca of ~2 separates a regime of calcite precipitation from a regime of aragonite ± high-Mg calcite precipitation (Fig. 3).

Spencer and Hardie (1990) introduced a quantitative model for calculating the chemistry of ancient seawater based on the premise that the composition of modern seawater results primarily from the mixing of average riverwater (a Ca-HCO_3 water) and mid-ocean ridge (MOR) hydrothermal brines (Na-Ca-Cl waters). This model predicts that relatively minor changes in the flux of MOR hydrothermal brines would change the Mg/Ca, Na/K, and Cl/SO_4 ratios in seawater enough to drastically alter the primary mineralogy of nonskeletal marine carbonates and evaporites.

CALL FOR NOMINATIONS

History of Geology Award

The History of Geology Award is presented annually to an individual who has made contributions of fundamental importance to our understanding of the history of the geological sciences. Outstanding contributions might include publication of papers or books of distinction that contribute new and profound insight into the history of geology (based either on original research or on a synthesis of existing knowledge); discovery of and making available to scholars of rare resource materials; providing comprehensive bibliographic surveys; editing a thematically integrated collection of articles; organizing meetings and symposia that generate interest in the history of geology; innovative research into original sources; creative interpretations of data; translations of key materials; and exceptional services to the GSA History of Geology Division.

To nominate a deserving individual, send a letter of nomination that describes the contributions that warrant the award, along with supporting materials, including the candidate's curriculum vitae to the chair of the award committee, Gerard V. Middleton, Dept. of Geology, McMaster University, 1280 West Main, Hamilton, ON L8S 4M1, Canada (middleto@mcmaster.ca; fax 905-522-3141). All nominations are valid for three years.

Nomination deadline: April 1, 1999.

POSITION AVAILABLE

EXECUTIVE DIRECTOR

The Geological Society of America (GSA) is seeking an individual to assume the duties of Executive Director as early as June 1, 1999. The selected individual will:

- Work with the Executive Committee and Council of GSA to implement a newly adopted Strategic Plan. Work closely with GSA Foundation Board and staff to coordinate and promote the directions and policies of the GSA Council.
- Maintain collaborative relationships with representatives of other national and international geoscience societies and organizations and actively pursue joint ventures that enhance the financial and scholarly status of the Society.
- Lead the GSA Headquarters staff of 65 persons. Articulate the vision and mission of the Society to staff and members through teamwork and collaborative efforts. Staff activities include membership services; meetings; publications; education, public policy, and outreach; marketing and strategic communications; financial services; and information technology.

The new Director will work at the GSA headquarters in Boulder, Colorado, and will hold a position with competitive compensation and benefits.

REQUIREMENTS

- Provide leadership to diverse groups such as committees, associated societies, staff, and volunteers through collaborative teamwork.
- Commitment to strong interpersonal communication among and between staff, members, and volunteers. Proven record of motivating staff to develop new sources of revenue and to use technology to improve efficiencies.
- Master's degree in geosciences; Ph.D. preferred. Extensive management experience and achievements in the areas of accrual budgeting, financial planning and investments, and personnel management. Additional preparation in education, marketing, and/or business management encouraged.
- Commitment to geoscience research, public outreach and education programs, and scholarly publishing.
- Familiarity with marketing and public relations.
- Demonstrated familiarity with the geoscience community and GSA programs.

Submit a resume, the names and addresses of three references, and a letter describing your interest in the position to:

Executive Director Search Committee
The Geological Society of America
P.O. Box 9140
Boulder, CO 80301-9140

The deadline for applications or nominations is March 15, 1999.

Mid-ocean ridges act as huge rock-fluid ion exchange systems for Ca^{2+} and Mg^{2+}, Ca^{2+} being released to the fluid and Mg^{2+} being consumed by the rock in the conversion of oceanic basalts to greenstones and amphibolites by interaction with hot seawater (Fig. 1). Low spreading rates (= low hydrothermal brine fluxes; Baker et al., 1995) should lead to elevated Mg/Ca mole ratios in seawater of the open oceans; if this ratio rose above ~2 for warm surface seawater, then aragonite ± high-Mg calcite would precipitate instead of low-Mg calcite (Fig. 2), as occurs in today's oceans. Conversely, high spreading rates (= high hydrothermal brine fluxes; Baker et al., 1995) should lower the Mg/Ca mole ratio in seawater; if this ratio dropped below ~2, then low-Mg calcite would precipitate instead of aragonite ± high-Mg calcite (as predicted, for example, for the Cretaceous Period; Fig. 2). Using first-order sea-level curves as a proxy for the record of ocean crust production during the Phanerozoic Eon, Hardie (1996) employed the Spencer-Hardie model to predict the mineralogies of nonskeletal marine carbonate ooids and cements as a function of secular changes in the Mg/Ca ratio of seawater. The results are in close agreement with Sandberg's (1983) periods of aragonite seas and calcite seas, as shown in Figure 2 (see also Hardie, 1996, Fig. 5).

Potash evaporites in the geological record fall into two main chemical groups: (1) KCl evaporites characterized by potassium chloride salts such as sylvite (KCl) and an absence of magnesium sulfate salts, and (2) $MgSO_4$ evaporites characterized by magnesium sulfate salts such as kieserite ($MgSO_4 \cdot H_2O$) (Hardie, 1996). These two evaporite types precipitate from two very different parent brines, Na-Ca-Mg-K-Cl brines ("calcium chloride" brines) and Na-Mg-K-Cl-SO4 brines, respectively, which lie on either side of a fundamental chemical divide, the "$CaSO_4$ divide" (Hardie and Eugster, 1970). Because both Mg^{2+} and SO_4^{2-} are extracted from seawater at mid-ocean ridges, whereas Ca^{2+} and K^+ are released, MOR hydrothermal brines are of the calcium chloride type. Therefore, during periods of high spreading rates, the elevated fluxes of MOR brine will drive seawater toward a calcium chloride composition that on evaporative concentration would produce KCl evaporites. On the other hand, low spreading rates would push seawater toward $MgSO_4$-enriched composition and precipitation of $MgSO_4$-type evaporites. Calculations based on the Spencer-Hardie model predict that KCl evaporites should have precipitated from calcite seas and $MgSO_4$

Hypercalcification *continued on p. 4*

Hypercalcification *continued from p. 3*

evaporites from aragonite seas. The rock record confirms this correspondence (Fig. 2; see also Hardie, 1996, Fig. 5). The fact that the Spencer-Hardie and Hardie models successfully predict the Phanerozoic history of two different families of nonskeletal minerals precipitated from seawater—carbonates and potash evaporites—makes a strong case that both models are fundamentally valid.

STRATEGIES FOR UNCOVERING TRENDS IN BIOMINERALIZATION

From sparse data, Wilkinson (1979) proposed a unidirectional Phanerozoic trend from calcite to aragonite for the dominant mineralogy of marine biocalcifiers. Although such a trend has not been apparent to more recent workers (Lowenstam and Weiner, 1989, p. 237), Wilkinson's data led Mackenzie and Agegian (1989, p. 20) to conclude that "the oscillatory trend seen in non-skeletal carbonate components … is not clearly apparent in the mineralogy of fossil organisms." Wilkinson's data also dissuaded Van de Poel and Schlager (1994) from claiming such a correspondence, although their survey of bioclasts in Mesozoic and Cenozoic carbonate rocks indicated maxima for aragonitic components in Triassic and late Cenozoic strata.

Rather than conducting a general survey, we adopted a double strategy to investigate the effects of seawater chemistry on biocalcification (Stanley and Hardie, 1998). First, we focused on what we call hypercalcifying tropical taxa. Forming one subset of this group are species that have secreted unusually massive skeletons for the higher taxa to which they belong; stony bryozoans of the Paleozoic are an example. A second, overlapping subset of hypercalcifiers includes species whose populations engage in rampant carbonate production. Reef builders and major sediment producers fall within this category.

As a second strategy, we hypothesized that relatively unsophisticated carbonate secretors—ones that exert weak control over the chemical milieu in which they secrete their skeletons—are strongly influenced by the Mg/Ca ratio and temperature of seawater. Significant here is the observation that magnesium increases with temperature in the skeletons of modern marine organisms, as in nonskeletal marine carbonates, but partition coefficients vary among taxa and the effect of temperature is inversely related to biological complexity (Chave, 1954).

Employing these two strategies, we uncovered a strong correspondence between the mineralogy of biologically simple hypercalcifying taxa and that of nonskeletal carbonates from Ordovician time to the present (Fig. 2). We conclude that although these taxa, including reef builders, need not have secreted skeletons that were in thermodynamic equilibrium with seawater, their skeletal productivity has been strongly influenced by the ambient Mg/Ca ratio. The taxa that yield this pattern share one deficiency: they are unable to remodel their skeletons through resorption during their ontogeny. It appears that the inability to remodel is linked to unsophisticated modes of biocalcification that also result in reliance on favorable seawater chemistry. Foraminifera, though otherwise simple organisms, are sophisticated skeletal secretors, which employ an "almost unparalleled" variety of basic modes of mineralization (Lowenstam and Weiner, 1989, p. 670) and also have the ability to remodel their tests; there is no apparent overall temporal relationship between their predominant mineralogy and the Mg/Ca ratio of seawater. Reef builders are probably heavily influenced by the ambient Mg/Ca ratio for two reasons. First, they must meet the basic demands of hypercalcification. Second, nearly all organisms able to flourish in the severe competitive battle for space within reef-building communities have succeeded through vegetative or colonial growth. Thus, these organisms have characteristically been simple forms, such as algae, sponges, and corals, which are unsophisticated carbonate secretors.

As described below, application of our strategies to the geologic record provides explanations for many previously puzzling

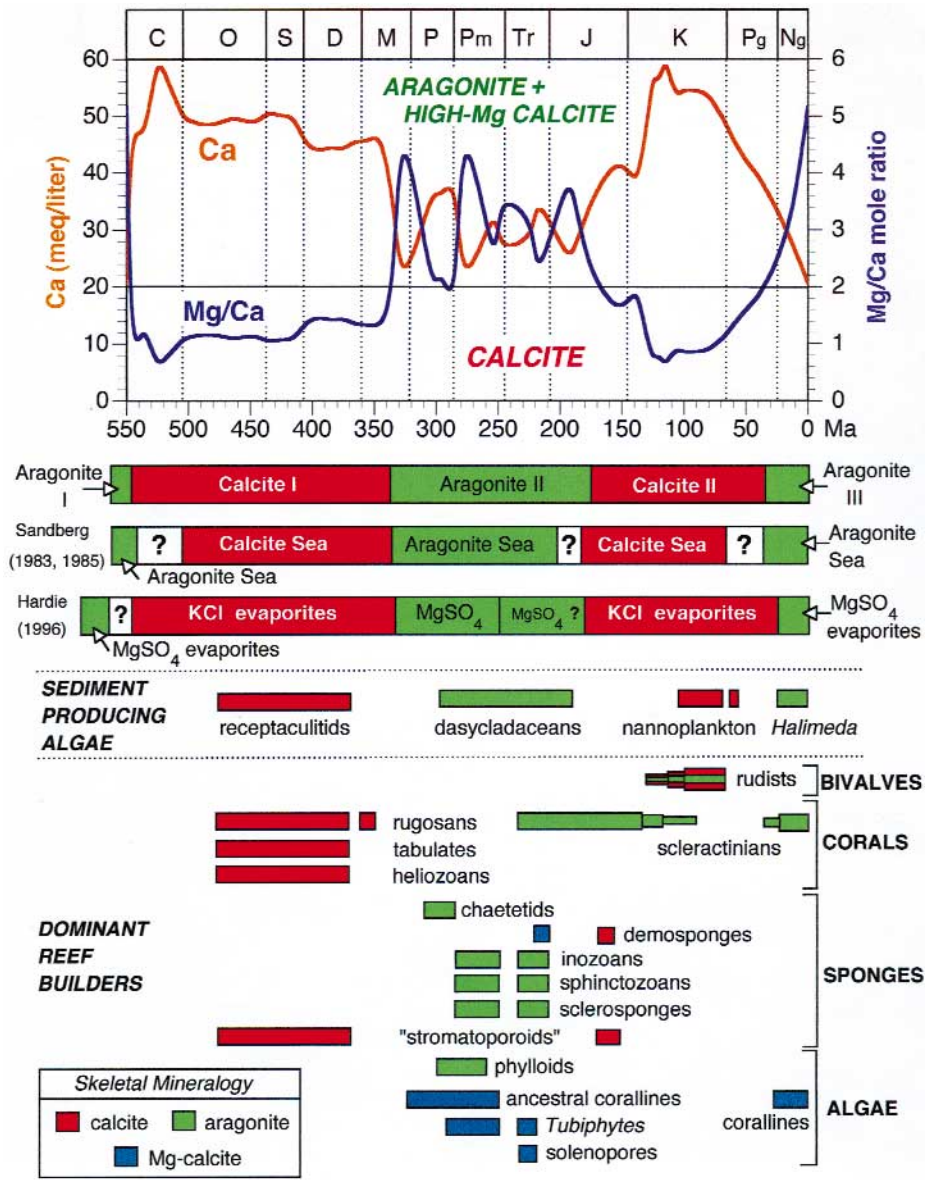


Figure 2. Correspondence between secular oscillations for the carbonate mineralogy of dominant hypercalcifying marine taxa, the mineralogy of marine evaporites and nonskeletal carbonates, and the Mg/Ca ratio and absolute concentration of calcium (Ca) in seawater as calculated by Hardie (1996). The boundary separating the nonskeletal nucleation fields of low-magnesium calcite (< 4 mol% $MgCO_3$), which we will term calcite, and high-Mg calcite (> 4 mol% $MgCO_3$) and aragonite is shown as a horizontal line at Mg/Ca = 2 (after Stanley and Hardie, 1998).

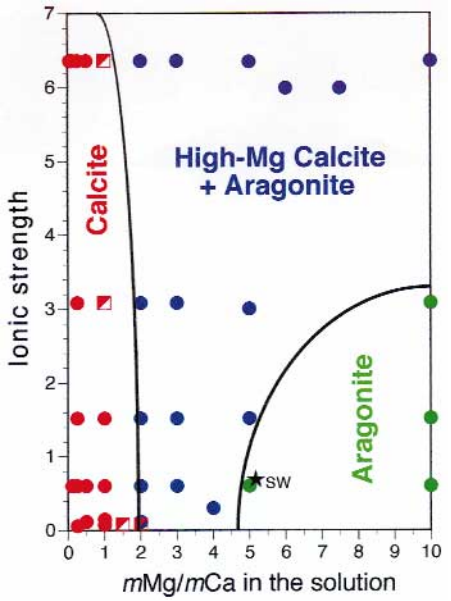


Figure 3. Experimentally determined nucleation fields of low-Mg calcite (red), high-Mg calcite + aragonite (blue), and aragonite (green) in $MgCl_2$-$CaCl_2$-Na_2CO_3-H_2O solutions at 28 °C, atmospheric pCO_2 and 1 atm total pressure (1976 unpublished data of Füchtbauer and Hardie). Red symbol—calcite with $MgCO_3$ content up to 4 mol%; half-solid red square—calcite with $MgCO_3$ content >4, <6 mol%. $MgCO_3$ content of high-Mg calcite in the blue symbol field increases systematically with increase in the Mg/Ca ratio in the aqueous solution (see Füchtbauer and Hardie, 1976, 1980). Black star—modern seawater (SW).

phenomena in the history of reef building and sediment production and in the evolution of calcareous taxa.

DOMINANT REEF BUILDERS

Before Late Ordovician time, reefs were built by taxonomically problematical taxa of uncertain mineralogy. For this reason, we began our analysis of the mineralogy of reef builders with the reef community that flourished from Late Ordovician to Late Devonian time in the calcite sea designated Calcite I (Fig. 2). In accordance with our hypothesis, this community was dominated by calcitic taxa: stromatoporoid sponges and several groups of calcitic corals (Oliver and Coates, 1987).

The Late Devonian mass extinction decimated the calcitic reef community. Late in the Mississippian Period, the Mg/Ca ratio of seawater shifted far into the aragonitic regime (Aragonite II), and new reef-building communities of aragonite and high-Mg calcitic algae and sponges emerged (Fig. 2). Members of these communities formed the enormous Horseshoe Atoll of central Texas and the Permian reef complex of west Texas. Aragonitic members of the same and similar taxa emerged as the reef-building community of the Middle Triassic, and in Late Triassic time aragonitic corals of the modern type (scleractinians) joined them as dominant reef builders (Stanley, 1988).

The only discrepancy between the mineralogy of dominant reef builders and that of nonskeletal carbonates is for Late Jurassic and Early Cretaceous time, when scleractinian corals persisted as major reef builders. The continued success of this aragonitic group probably resulted from two circumstances. First, the Mg/Ca ratio remained near the calcite-aragonite boundary during this interval. Second, the high absolute concentration of Ca^{2+} during this interval may have promoted nonequilibrium precipitation of all forms of calcium carbonate. In mid-Cretaceous time, when the Mg/Ca ratio descended to its lowest Phanerozoic level according to the calculations of Hardie (1996), corals relinquished to rudists their role as dominant reef builders (Scott, 1984). As bivalve mollusks, rudists were probably not strongly influenced by seawater chemistry. Thus, although shells of radiolitids, the most successful reef-building rudists of the Late Cretaceous, contained more calcite than aragonite (Kauffman and Johnson, 1988), it is most reasonable to view the rudists as beneficiaries of the decline of aragonitic reef-building corals that occurred when the Mg/Ca ratio dropped. Support for this interpretation comes from the previously unexplained failure of corals to build large reefs for more than 30 m.y. after the disappearance of the rudists at the end of the Cretaceous Period. Scleractinian corals existed in considerable diversity early in the Cenozoic Era, but produced only small, inconspicuous bioherms, even during the extremely warm Eocene interval. Not until early in the Oligocene did corals begin to produce massive reefs throughout the world (Frost, 1977), despite the fact that warm seas had contracted toward the equator (Zachos et al., 1994). At this time, the Mg/Ca ratio of seawater was rising far into the aragonitic regime (Fig. 2).

We have provided elsewhere a more detailed picture of the correspondence between the mineralogy of major reef builders and nonskeletal marine carbonates (Stanley and Hardie, 1998). Aspects of the pattern we have described were noted by Van de Poel and Schlager (1994) and Hallock (1997).

DOMINANT SEDIMENT PRODUCERS

The widespread deposition of massive chalk during Late Cretaceous time is another phenomenon of hypercalcification that has long defied explanation but can be accounted for by a change in seawater chemistry: it coincided with the interval during which the Mg/Ca ratio was at its lowest level during the past 500 m.y. (Fig. 2). Calcareous nannoplankton—potential chalk producers—had attained high taxonomic diversity during Early Cretaceous time but had failed to form massive chalk deposits. Following the setback of calcareous nannoplankton by the terminal Cretaceous extinction, massive chalk deposition resumed in early Paleocene time. Then, as the Mg/Ca ratio of seawater rose toward the aragonitic domain, widespread deposition of massive chalk ceased, and it failed to resume even during the exceptionally warm Eocene interval, when epicontinental seas were widespread.

The attribution of extensive chalk deposition to changes in seawater chemistry gains support from the observation that an increase in the concentration of dissolved Ca^{2+} enhances calcification by calcareous nannoplankton in the laboratory (Blackwelder et al., 1976). Additional support comes from two puzzling temporal patterns for coccoliths (Houghton, 1991). One of these is a polyphyletic decline in the mean size of coccoliths during the Cenozoic Era. The result was thinner calcitic encrustation of cells. The second pattern pertains to the genus *Discoaster*. Coccoliths of this genus were solid, circular shields early in the Cenozoic, but as the era progressed, they became increasingly diminished in volume by marginal embayments. By the time *Discoaster* became extinct in the Pliocene, all of its members secreted spindly, star-shaped coccoliths that covered only a small fraction of the cell surface (Fig. 4). These trends for coccoliths can be viewed as amounting to evolutionary osteoporosis, caused by an increase in the Mg/Ca ratio of seawater that was accompanied by a decline in the concentration of Ca^{2+} (Fig. 2).

The Mg/Ca model also provides an explanation for patterns of hypercalcification for green algae. Aragonitic codiaceans (especially *Halimeda*) produce vast quantities of carbonate sediment today, and dasycladaceans were so productive during Aragonite II that they have been regarded as the *Halimeda* of the Triassic (Elliott, 1984). On the other hand, the massive, calcitic receptaculitids were significant sediment producers throughout Calcite I.

EVOLUTIONARY TRENDS

The Cenozoic evolutionary trend toward weakly calcified nannoplankton species appears to reflect the influence of seawater chemistry (Fig. 4). Among cheilostome bryozoans, changes in the Mg/Ca ratio appear to have influenced the evolution of skeletal mineralogy. The cheilostomes originated as a calcitic group during the Cretaceous Period (Calcite II), although a few species of one subgroup secreted a combination of calcite and aragonite (Boardman and Cheetham, 1987). Fully aragonitic species did not arise until

Hypercalcification *continued on p. 6*

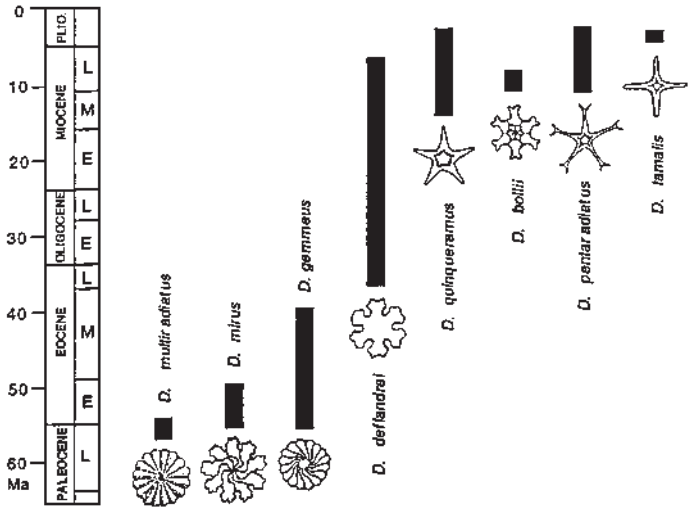


Figure 4. Stratigraphic ranges of typical species of *Discoaster,* a genus of calcareous nannoplankton whose calcitic skeletal elements underwent a striking net evolutionary trend during the sharp Cenozoic rise in the Mg/Ca ratio of seawater. Species with heavy, shield-shaped coccoliths gave way to species with delicate, star-shaped coccoliths. (Modified from Houghton, 1991.)

Hypercalcification *continued from p. 5*

the Eocene Epoch, when the Mg/Ca ratio of seawater had risen markedly. Today most cheilostome species secrete high-Mg calcite, but many tropical species secrete aragonite (Rucker and Carver, 1969); this distribution corresponds to the temperature pattern for nonskeletal precipitation of carbonates in laboratory experiments (Morse et al., 1997).

Several workers have noted that the mineralogy of calcareous sponges has frequently coincided with that of nonskeletal carbonates during the Phanerozoic (Reitner, 1987; Gautret and Cuif, 1989; Wood, 1991). Our survey suggests that calcareous sponges have in fact been at the mercy of seawater chemistry throughout their history (Fig. 2). During the Cretaceous, for example, all of them appear to have been calcitic, but all present-day representatives secrete aragonite, high-Mg calcite, or a combination of these minerals (Hartman, 1980).

Martin (1995) has noted that some suborders of foraminifera originated with skeletal mineralogies corresponding to those of nonskeletal carbonates, although, as we have already noted, there does not appear to be a strong temporal correlation between the Mg/Ca ratio of seawater and the mineralogy of highly productive foraminifera.

DISCUSSION

The fact that we have been able to connect many previously problematical phenomena with a single causal explanation gives credence to the Mg/Ca model. The results have additional biologic and geologic implications, some of which suggest promising avenues for future research.

For many taxa, degree of ecologic stability exhibited over tens or hundreds of millions of years seems to reflect the degree to which seawater chemistry has influenced skeletal mineralogy. Sophisticated carbonate secretors have the potential to optimize their skeletal structures without inhibition by the Mg/Ca ratio of seawater. Ammonoids, which secreted thin shells within which the gas pressure was about 1 atm, must have been served well by the relatively great bending strength of their nacreous aragonite. Ammonoids should therefore have benefited from their ability to secrete aragonite readily even in calcite seas. Thus, although being relatively independent of the ambient Mg/Ca ratio leaves a taxon such as the Ammonoidea unable to benefit from a favorable ratio, all else being equal, this independence confers long-term ecologic stability. Conversely, although unsophisticated carbonate secretors, such as algae, sponges, and corals, automatically benefit from the presence of a favorable Mg/Ca ratio, these forms also suffer severe declines when the ratio shifts to an unfavorable domain; they tend to follow a "boom-or-bust" pattern of productivity—and perhaps also taxonomic diversity—in the course of geologic time.

We think it likely that the Mg concentration in skeletons of taxa that secrete high-Mg calcite has been positively correlated with the Mg/Ca ratio of seawater back through Phanerozoic time, just as today the Mg concentration in calcite skeletons increases with increasing ocean temperature (Chave, 1954). Experimental growth of modern species under varying ambient Mg and Ca concentrations could shed light on this possibility by demonstrating lability in skeletal mineralogy for individual organisms. Study of the abundance of exsolved microdolomite and of trace elements in fossils may also expand our knowledge of skeletal Mg concentrations for extinct taxa.

Changes in carbonate productivity resulting from shifts in the Mg/Ca ratio of seawater must have affected the carbon cycle significantly in the course of geologic time. Today, a large proportion of carbonate and bicarbonate ions entering the ocean are incorporated into organic reefs. If, long after forming, reef carbonate becomes metamorphosed during orogenesis, it will release CO_2 to the atmosphere (Berner, 1994). The flux of oxidized carbon to reef carbonate reservoirs would have been reduced at times, such as the early Cenozoic, when an unfavorable Mg/Ca ratio suppressed reef building. Carbonate storage in reefs increased dramatically early in Oligocene time, following the shift from calcite to aragonite seas. At about the same time, through reduced productivity during the dramatic rise in the Mg/Ca ratio of seawater, nannoplankton began contributing progressively less carbonate to the deep sea for possible future subduction and release of CO_2. Thus, during the past 30 m.y. or so, the increasing Mg/Ca ratio of seawater has influenced the relative proportions of total carbonate that have accumulated in the deep sea and in shallow-water reefs, where the mean residence time for oxidized carbon is much longer.

ACKNOWLEDGMENTS

We thank Ronald E. Martin and George D. Stanley for helpful reviews of our manuscript.

REFERENCES CITED

Baker, E. T., German, C. R., and Elderfield, H., 1995, Hydrothermal plumes over spreading-center axes: Global distributions and geophysical inferences, *in* Humphries, S., et al., eds., Seafloor hydrothermal systems: Physical, chemical, biological and geological interactions: American Geophysical Union Monograph 91, p. 47–71.

Berner, R. A., 1994, GEOCARB II: A revised model of atmospheric CO_2 over Phanerozoic time: American Journal of Science, v. 294, p. 56–91.

Blackwelder, P. L., Weiss, R. E. and Wilbur, K. M., 1976, Effects of calcium, strontium, and magnesium on the coccolithophorid *Cricosphaera (Hymenomonas) carterae.* 1. Calcification: Marine Biology, v. 34, p. 11–16.

Boardman, R. S., and Cheetham, A. H., 1987, Phylum Bryozoa, *in* Boardman, R. S. and Rowell, A. H., eds., Fossil invertebrates: Palo Alto, California, Blackwell, p. 497–549.

Burton, E. A. and Walter, L. M., 1991, The effects of P_{CO_2} and temperature on magnesium incorporation in calcite in seawater and $MgCl_2$-$CaCl_2$ solutions: Geochimica et Cosmochimica Acta, v. 55, p. 777–785.

Chave, K. E., 1954, Aspects of the biogeochemistry of magnesium 1. Calcareous marine organisms: Journal of Geology, v. 62, p. 266–283.

Elliott, G. F., 1984, Climatic tolerance in some aragonitic green algae of the post-Palaeozoic: Palaeogeography, Palaeoclimatology, Palaeoecology, v. 48, p. 163–169.

Frost, S. H., 1977, Miocene to Holocene evolution of Caribbean Province reef-building corals: Proceedings, Third International Coral Reef Symposium, Miami, p. 353–355.

Füchtbauer, H., and Hardie, L. A., 1976, Experimentally determined homogeneous distribution coefficients for precipitated magnesian calcites: Application to marine carbonate cements: Geological Society of America Abstracts with Programs, v. 8, p. 877.

Füchtbauer, H., and Hardie, L. A., 1980, Comparison of experimental and natural magnesian calcites: Bochum, Germany, International Association of Sedimentologists, p. 167–169.

Gautret, P., and Cuif, J.-P., 1989, Les démosponges calcifiées des bioherms du Jurassique supérieur du

CALL FOR NOMINATIONS REMINDERS

Distinguished Service Award

The GSA Distinguished Service Award recognizes individuals for exceptional service to the Society. GSA Members, Fellows, Associates, or, in exceptional circumstances, GSA employees may be nominated for consideration. Any GSA member or employee may make a nomination for the award. Awardees are selected by the Executive Committee, and all selections are ratified by the Council. Deadline for nominations for 1999 is MARCH 1, 1999.

John C. Frye Environmental Geology Award

In cooperation with the Association of American State Geologists (AASG), GSA makes an annual award for the best paper on environmental geology published either by GSA or by one of the state geological surveys. The award is a $1,000 cash prize from the endowment income of the GSA Foundation's John C. Frye Memorial Fund.

The paper must be selected from GSA or state geological survey publications; it must be selected from those published during the preceding three full calendar years; and the nomination must include a paragraph stating the pertinence of the paper.

Nominated papers must establish an environmental problem or need, provide substantive information on the basic geology or geologic process pertinent to the problem, relate the geology to the problem or need, suggest solutions or provide appropriate land-use recommendations based on the geology, present the information in a manner that is understandable and directly usable by geologists, and address the environmental need or resolve the problem. It is preferred that the paper be directly applicable by informed laypersons (e.g., planners, engineers). Deadline for nominations for 1999 is MARCH 1, 1999.

National Awards

The deadline is April 30, 1999, for submitting nominations for these four awards: William T. Pecora Award, National Medal of Science, Vannevar Bush Award, Alan T. Waterman Award.

Memorial Preprints

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

Arthur A. Baker
J. David Love

Frederick Betz, Jr.
Rhodes W. Fairbridge

Thomas E. Bolton
Godfrey S. Nowlan, Charles H. Smith

Robert Sinclair Dietz
Steve Koppes

John Van Nostrand Dorr II
Jacob E. Gair

Charles Lum Drake
Bruce B. Hanshaw

Melvin (Mel) Friedman
John M. Logan, David W. Stearns

James D. Hume
Charles E. Stearns

Robert M. Kosanke
Aureal T. Cross, Jack A. Simon, Tom L. Phillips

Robert Luscher McMaster
John A. Peck

John Elliott Nafe
Jack E. Oliver

John Mason Parker III
Stephen G. Conrad

John Evans Riddell
Richard C. Schmidt

Robert H. Shaver
Donald E. Hattin, Carl B. Rexroad

Thomas A. Simpson, Sr.
Philip E. LaMoreaux, Everett Smith, Charles W. Copeland

sud Tunisien (Oxfordien de la région de Tataouine): Geobios, v. 22, p. 49–63.

Hallock, P., 1997, Reefs and reef limestones in earth history, *in* Birkeland, P., ed., Life and death of coral reefs: New York, Chapman and Hall, p. 13–42.

Hardie, L. A., 1996, Secular variation in seawater chemistry: An explanation for the coupled secular variation in the mineralogies of marine limestones and potash evaporites over the past 600 m.y.: Geology, v. 24, p. 279–283.

Hardie, L. A., and Eugster, H. P., 1970, The evolution of closed-basin brines: Mineralogical Society of America Special Publication 3, p. 273–290.

Hartman, W. D., 1980, Morphology of the skeleton: Sedimenta (University of Miami) VIII, p. 193–214.

Houghton, S. D., 1991, Calcareous nannofossils, *in* Riding, R., ed., Calcareous algae and stromatolites: Berlin and Heidelberg, Springer-Verlag, p. 217–266.

Kauffman, E. G., and Johnson, C. C., 1988, The morphological and ecological evolution of Middle and Upper Cretaceous reef-building rudistids: Palaios, v. 3, p. 194–216.

Lowenstam, H. A. and Weiner, S., 1989, On biomineralization: New York, Oxford University Press, 324 p.

Mackenzie, F. T., and Agegian, C. R., 1989, Biomineralization and tentative links to plate tectonics, *in* Crick, R. E., ed., Origin, evolution, and modern aspects of biomineralization in plants and animals: New York, Plenum Press, p. 11–27.

Mackenzie, F. T., and Morse, J. W., 1992, Sedimentary carbonates through Phanerozoic time: Geochimica et Cosmochimica Acta, v. 56, p. 3281–3295.

Martin, R. E., 1995, Cyclical and secular variation in microfossil biomineralization: Clues to the biogeochemical evolution of Phanerozoic oceans: Global and Planetary Change, v. 11, p. 1–23.

Morse, J. W., Wang, Q., and Tsio, M. Y., 1997, Influences of temperature and Mg:Ca ratio on $CaCO_3$ precipitates from seawater: Geology, v. 25, p. 85–87.

Müller, G., Irion, G., and Förstner, U., 1972, Formation and diagenesis of inorganic Ca-Mg carbonates in the lacustrine environment: Naturwissenschaften, v. 59, p. 158–164.

Oliver, W. A., and Coates, A. G., 1987, Phylum Cnidaria, *in* Boardman, R. S., and Rowell, A. H., eds., Fossil invertebrates: Palo Alto, California, Blackwell, p. 140–193.

Plummer, L. N., Parkhurst, D. L., Fleming, G. W., and Dunkle, S. A., 1988, A computer program incorporating Pitzer's equations for calculation of geochemical reactions: U.S. Geological Survey Water-Resources Investigations Report 88-4153, 310 p.

Reitner, J., 1987, A new calcitic sphinctozoan sponge belonging to the Demospongiae from the Cassian Formation (Lower Carnian; Dolomites, northern Italy) and its phylogenetic relationship: Geobios, v. 20, p. 571–589.

Rucker, J. B., and Carver, R. E., 1969, A survey of the carbonate mineralogy of cheilostome Bryozoa: Journal of Paleontology, v. 43, p. 791–799.

Sandberg, P. A., 1983, An oscillating trend in Phanerozoic nonskeletal carbonate mineralogy: Nature, v. 305, p. 19–22.

Sandberg, P. A., 1985, Nonskeletal aragonite and pCO_2 in the Phanerozoic and Proterozoic, *in* Sundquist, E. T. and Broecker, W. S., eds., The carbon cycle and atmospheric CO_2: Natural variations Archean to present: American Geophysical Union Monograph 32, p. 585–594.

Scott, R. W., 1984, Evolution of Early Cretaceous reefs in the Gulf of Mexico: Paleontographica Americana, v. 54, p. 406–412.

Spencer, R. J., and Hardie, L. A., 1990, Control of seawater composition by mixing of river waters and mid-ocean ridge hydrothermal brines, *in* Spencer, R. J., and Chou, I.-M., eds., Fluid-mineral interactions: A tribute to H. P. Eugster: Geochemical Society Special Publication 19, p. 409–419.

Stanley, G. D., 1988, The history of Mesozoic reef communities: A three-step process: Palaios, v. 3, p. 170–183.

Stanley, S. M., and Hardie, L. A., 1998, Secular oscillations in the carbonate mineralogy of reef-building and sediment-producing organisms driven by tectonically forced shifts in seawater chemistry: Palaeogeography, Palaeoclimatology, Palaeoecology v. 144, p. 3–19.

Van de Poel, H. M., and Schlager, W., 1994, Variations in Mesozoic-Cenozoic skeletal carbonate mineralogy: Geologie en Mijnbouw, v. 73, p. 31-51.

Wilkinson, B. H., 1979, Biomineralization, paleoceanography, and the evolution of calcareous marine organisms: Geology, v. 7, p. 524–527.

Wilkinson, B. H., and Algeo, T. J., 1989, Sedimentary carbonate record of calcium-magnesium cycling: American Journal of Science, v. 289, p. 1158–1194.

Wood, R. A., 1991, Problematic reef-building sponges, *in* Simonetta, A. M., and Morris, S. C., eds., The early evolution of Metazoa and the significance of problematic taxa: Cambridge, UK, Cambridge University Press, p. 113–124.

Zachos, J. C., Stott, L. C., and Lohmann, K. C., 1994, Evolution of early Cenozoic marine temperatures: Paleoceanography, v. 9, p. 353–387.

Manuscript received November 15, 1998; accepted December 7, 1998 ■

Making Visualization Accessible to Students

Daniel C. Edelson, Matthew Brown, Douglas N. Gordin, Duane A. Griffin
School of Education and Social Policy and Institute for the Learning Sciences, Northwestern University

Scientific Visualization for Learning

Scientific visualization technologies have had an enormous impact on the geosciences. Visualization as a technology for both investigation and communication has become almost ubiquitous. It is difficult to walk into the office of a geoscientist or open the pages of a geoscience journal without finding a computer-rendered visualization of scientific data. However, if you were to walk into a classroom, dorm room, or laboratory where students are working on their homework for a "geo" class, the odds of finding them constructing or analyzing visualizations the way scientists do is extremely low. Recognizing the potential value of scientific visualization as a technology to support science learning, we have been engaged for several years in the development of tools to make visualization and data analysis accessible to learners.

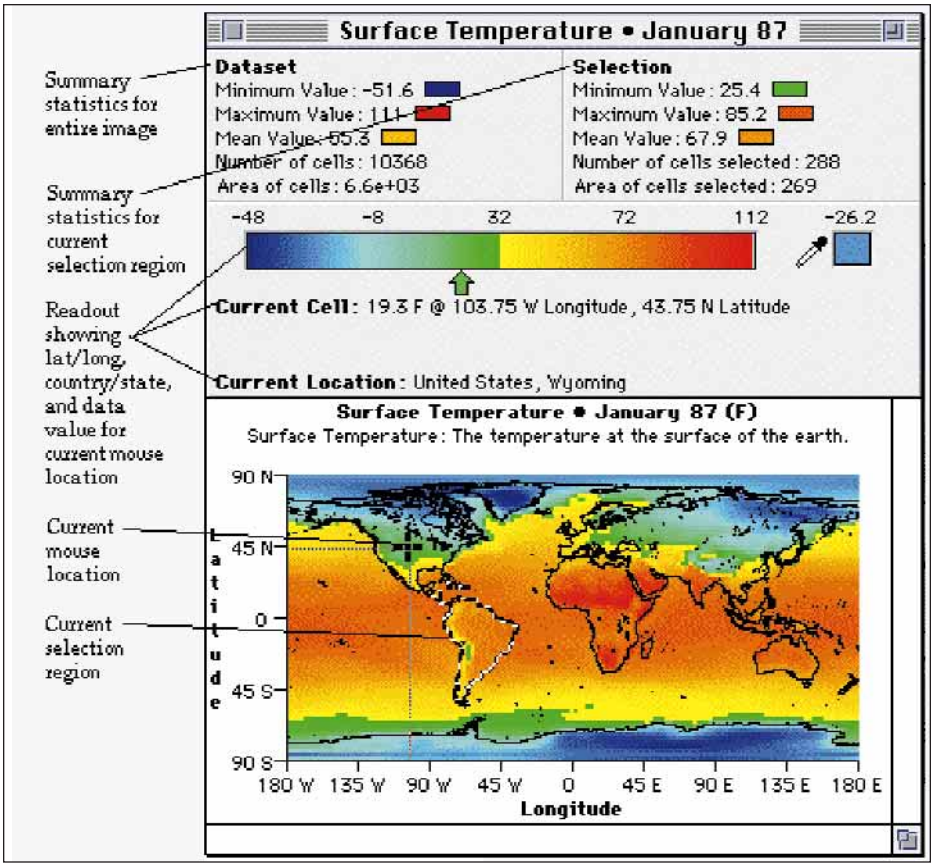


Figure 1. A WorldWatcher visualization window.

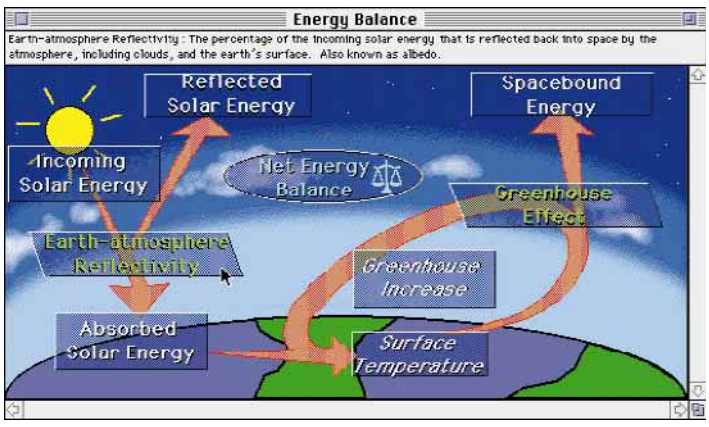


Figure 2. A WorldWatcher diagrammatic interface to a library of data illustrating Earth's energy budget. Clicking on any variable name in the diagram brings up a list of dates to select.

Visualization offers great promise for education (Gordin and Pea, 1995) for several reasons. The same advantages that scientific visualization offers to scientists also hold for students. Visualization exploits the power of the human visual system for finding patterns in imagery, allowing an individual to interpret data visually, without requiring sophisticated mathematical operations. Therefore, visualization can remove mathematical skills as a gatekeeper to working with scientific data. As a technology for scientific investigation, visualization provides the opportunity to engage students in authentic inquiry as part of the learning process. Participation in meaningful inquiry is increasingly being recognized as a critical component of science education, as evidenced by the prominent role of inquiry in the national science education standards (National Research Council, 1996). Inquiry activities allow students to better understand the practice of science and interpret the results emerging from scientific research. "Literacy" with visualization has become an important skill for both practicing scientists and informed citizens. On the one hand, the use and manipulation of visualization is growing across a broad range of scientific disciplines, as well as mathematics, information processing, and finance. On the other, images and animations produced through the techniques of scientific visualization are becoming increasingly common in both the print media and on television.

It hasn't been easy to bring visualization into the classroom, even if you have the appropriate technology infrastructure. If you are an earth or environmental science teacher at the secondary school or college level and you want to give your students the experience of working with scientific visualization, you have historically faced a frustrating choice. You can either teach your students how to use one of the powerful, general-purpose visualization tools used by scientists, or you can have them view visualizations with an image viewer. Teaching students to use scientists' tools is difficult, if not impossible, to do with many populations of students

CALL FOR NOMINATIONS

To reward and encourage teaching excellence in beginning professors of earth science at the college level, the Geological Society of America announces:

THE EIGHTH ANNUAL

Biggs Award

For Excellence In Earth Science Teaching For Beginning Professors

ELIGIBILITY: All earth science instructors and faculty at 2- and 4-year colleges who have been teaching full time for 10 years or less. (Part-time teaching is not counted in the 10 years.)

AWARD AMOUNT: An award of $750 is made possible as a result of support from the Donald and Carolyn Biggs Fund, the GSA Geoscience Education Division, and GSA's Education, Outreach, & Policy Programs. This award also includes up to $500 in travel funds to attend the award presentation at the GSA annual meeting.

NOMINATION PROCEDURE: For nomination forms contact Gwenevere Torres, Project Coordinator, Education, Outreach, & Policy Programs, Geological Society of America, P.O. Box 9140, Boulder, CO 80301, gtorres@geosociety.org..

DEADLINE: Nominations and support materials for the 1999 Biggs Earth Science Teaching Award must be received by April 30, 1999.

CALL FOR APPLICATIONS AND NOMINATIONS FOR

Geology Co-Editor

GSA is soliciting applications and nominations for the position of co-editor of *Geology*, to serve a three-year term, beginning in June 1999, as one of a two-editor team. Desirable characteristics for the successful candidate include:

1. Broad interest and experience in geology; international recognition
2. Iconoclastic; willing to take risks and try innovations
3. Familiar with many earth scientists and their work
4. Sense of perspective and humor
5. Organized and productive
6. Willing to work closely with GSA headquarters staff
7. Able to make decisions
8. Sense of fairness
9. Familiar with new trends in geoscience
10. Willing to consider nontraditional research in geosciences

GSA provides the editor with a small stipend as well as expenses for secretarial assistance, mail, and telephone.

If you wish to be considered, please submit a curriculum vitae and a brief letter describing why you should be chosen. If you wish to nominate another, submit a letter of nomination and the individual's written permission and c.v. Send nominations and applications to Peggy S. Lehr, Director of Publications, Geological Society of America, P.O. Box 9140, Boulder, CO 80301, *by April 14, 1999*.

and consumes precious time that any teacher would prefer to devote to learning science. On the other hand, image viewers, while they are easy to use, only allow students to view visualizations constructed by others, not to construct, customize, or manipulate them themselves. In other words, they do not allow students to work with visualizations in the way that scientists do. Recognizing the unsatisfactory nature of both of these alternatives for most teachers, we set out to create a visualization environment for geographic data that is designed specifically for students. Our goal was to create a software environment that provides the power of scientists' tools for the creation and customization of visualizations and the analysis of data, while providing the support and structure necessary to make these operations accessible to students at the high school and college level. Through a three-year, NSF-funded educational research project, we developed a geographic visualization and data analysis program, called WorldWatcher, that achieves this balance. WorldWatcher has been used successfully in middle schools, high schools, and colleges, requiring no more than 45 minutes of use to master its primary capabilities.

WorldWatcher

WorldWatcher is a tool for the visualization and analysis of gridded, geographic data (Fig. 1). The design of WorldWatcher has been focused on understanding the supports required by learners to enable them to engage in meaningful investigations with geographic data.

To support meaningful inquiries, we determined that a visualization environment must support the following operations:

- Customization of visualizations. In order to interpret data effectively through visual representations, learners must be able to customize those representations to highlight important patterns in the data. In WorldWatcher, users are able to modify the colors used to represent values, the range of values displayed, the spatial resolution, and the magnification of an image.
- Quantitative analysis of data. While a visual representation can dramatically improve a person's ability to interpret data, it is not a substitute for quantitative analytic techniques. WorldWatcher provides tools for simple statistical and arithmetic operations on data. It also allows users to identify specific regions within visualizations by specifying selection criteria.
- Alternative representations. Different representations of data can support different forms of analysis. Therefore, WorldWatcher provides multiple geographic projections for data, as well as alternative representations such as histograms, line plots, and scatter plots.
- Record keeping and documentation. Conducting a successful investigation requires that students be able to maintain records of their work. WorldWatcher provides a notebook facility that allows students to record their activities in the form of text, images of visualizations, and hypermedia links to data. This same notebook facility is used to provide documentation for the data and operations available in WorldWatcher.

These four criteria are not unique to a tool for students. They reflect the requirements for supporting inquiry and apply equally to scientists' tools. However, the goal of supporting science learning adds additional criteria. Because students lack the background knowledge that scientists bring to their use of visualization tools, WorldWatcher is designed to provide the additional support students require

SAGE Remarks *continued on p. 10*

SAGE Remarks *continued from p. 9*

(Edelson and Gordin, 1998). This support takes several forms. First, visualization windows provide contextual information including continent overlays, latitude and longitude markings, and an active readout displaying the current cursor location and underlying data values. Second, all data files in WorldWatcher are tagged with default visualization parameters that specify initial settings for the color scheme, range, units, and display resolution of the data. These default values enable learners to begin the interpretation of unfamiliar data without needing to identify appropriate visualization parameters first, as a scientist would. Third, WorldWatcher provides diagrammatic interfaces to its data libraries (Fig. 2). These diagrammatic interfaces play an important instructional role by visually illustrating the relationships among variables. Finally, WorldWatcher provides operations not found in scientists' tools that were created specifically to support educational activities. For example, WorldWatcher contains a facility that allows users to create new data using a paint program interface. This facility is used in learning activities in which learners "draw" maps to represent the state of their current understanding of a phenomenon or to represent hypothetical situations. WorldWatcher also allows learners to print out cut-and-fold images of two-dimensional visualizations that they assemble into three-dimensional polyhedral "globes."

In addition to support for students, the design of WorldWatcher takes into account the needs of curriculum designers and teachers. For example, the same notebook facility that allows students to record their work was designed to be used by teachers or curriculum developers to create electronic "handouts" for students. These handouts can contain instructions, background information, and direct links to data. WorldWatcher also provides a suite of tools to allow nonprogrammers to assemble new WorldWatcher data libraries, build diagrammatic interfaces to these libraries, and create documentation and default display parameters for the data in the libraries. These tools are designed to enable scientists and curriculum developers to write new WorldWatcher curriculum units around any collection of raster (gridded) data.

Global Warming Curriculum

One of the primary curriculum development efforts for WorldWatcher has focused on the global warming controversy as a motivating context for earth and environmental science education. The Global Warming Project, designed in a partnership between teachers from the Chicago public schools and Northwestern University researchers, exemplifies our goal of integrating WorldWatcher into extended classroom investigations of real scientific issues. Lasting for six to eight weeks, the Global Warming Project places middle school and high school students in the role of scientific advisors to the secretary general of the United Nations, for help in finding out what the "global warming" issue really is about and what, if anything, should be done about it.

To accomplish this goal, students must investigate how Earth's climate works and how to detect any potential changes brought about by human activities. In a series of structured activities, students investigate the meaning of temperature change, the processes of energy transfer that control the climate on Earth, and the role of the atmosphere in maintaining Earth's climate balance. Along the way, students present a series of background briefings on their findings. At the conclusion of the unit, groups of students must each advise a specific nation about the risks that might accompany predicted global climate change, and they offer concrete, scientifically justifiable solutions for responding to or moderating these effects.

The Global Warming Project combines hands-on labs, class discussions, computer-supported investigations of global data sets, and simple climate models, with role playing and presentations in order to create a realistic setting for the investigation of hotly debated scientific issues. For example, in one set of activities, students conduct a traditional laboratory investigation of the effect of different colored materials on the absorption of light. They then apply the knowledge gained through this lab to global climate processes by investigating WorldWatcher data sets showing dominant ground cover, surface reflectivity, and absorbed solar energy for Earth. In the culminating activity for this part of the curriculum, they must combine these findings with other information about the Earth-Sun relationship, and—using graphs and scientific visualizations to illustrate their points—explain to the UN secretary-general the role that solar energy and physical geography play in determining surface temperatures. In other parts of the curriculum, students explore other relevant processes, such as the carbon cycle and the greenhouse effect, through similar combinations of computer-based and conventional activities.

Acknowledgments

The WorldWatcher software was written by Brian Clark. Roy Pea and Louis Gomez have also made critical contributions to the design of WorldWatcher and its accompanying curricula. This research was supported by the National Science Foundation program in Advanced Applications of Technology under grant RED-9453715. WorldWatcher is available at http://www.worldwatcher.nwu.edu/.

REFERENCES CITED

Edelson, D. C., and Gordin, D., 1998, Visualization for learners: A framework for adapting scientists' tools: Computers and Geosciences, v. 24, p. 607–616.

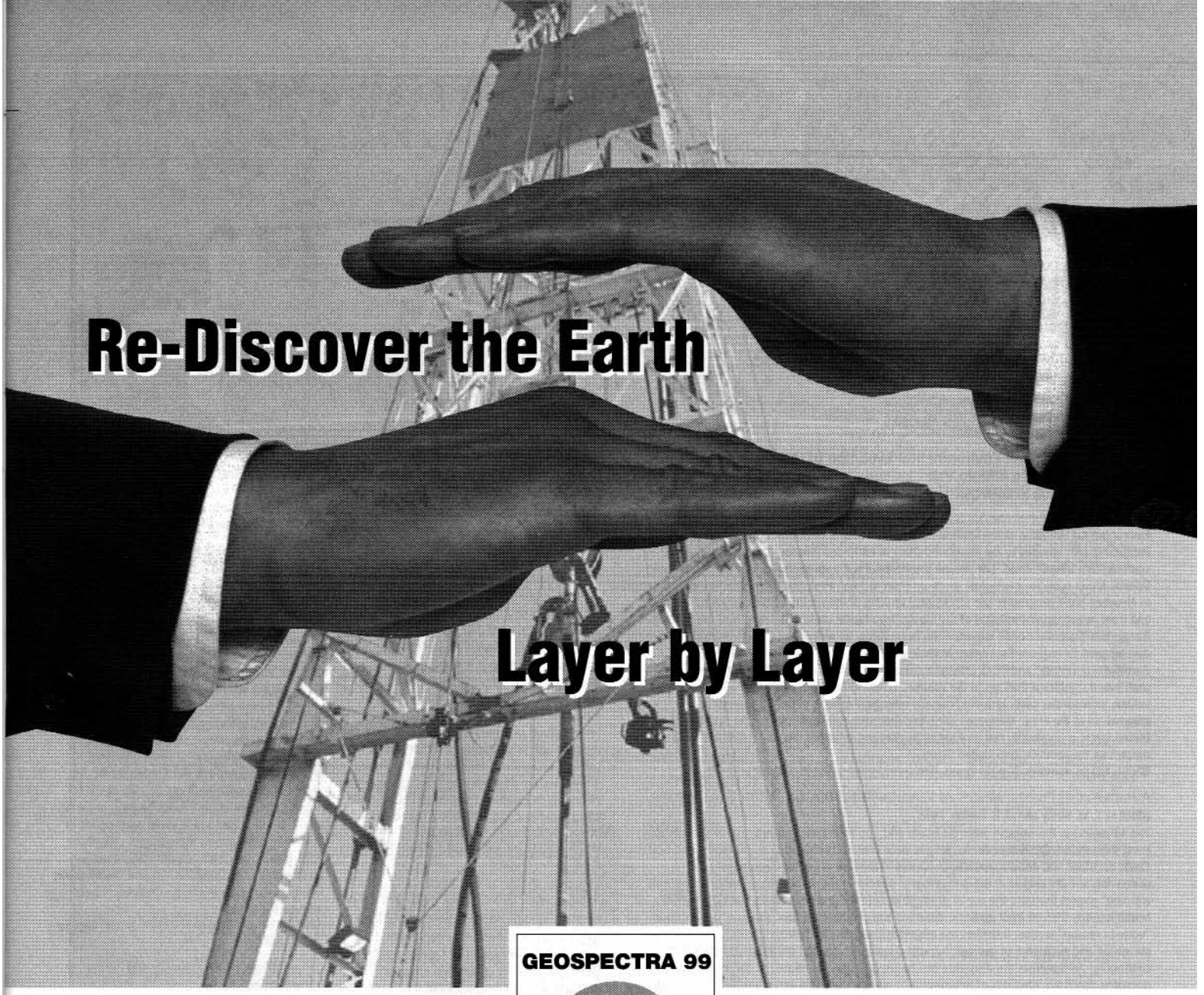
Gordin, D. N., and Pea, R. D., 1995, Prospects for scientific visualization as an educational technology: Journal of the Learning Sciences, v. 4, p. 249–279.

National Research Council, 1996, National Science Education Standards: Washington, D.C., National Academy Press. ■

Alternates Receive 1998 Student Research Grants

Each year when the Committee on Research Grants selects student grant recipients they also select an alternate group of recipients in the event that some of the grantees return part or all of their funds because they have received funding elsewhere or have changed their research plans. As the returned funds become available, they are re-awarded by the Research Grants Administrator to the alternates named by the committee.

In 1998 ten alternates received funding following the initial awarding of grants. They are: Peter Sak, Pennsylvania State University; Ziya Cetiner, University of Idaho; Kelly Christin MacGregor, University of California, Santa Cruz; Molly A. Trecker, University of California, Santa Barbara; Sally L. Letsinger, Indiana University; Andrew J. Hooper, University of North Carolina at Chapel Hill; Christopher M. Jengo, Bowling Green State University; Shafiul H. Chowdhury, Western Michigan University; Yiqiao Zou, New Mexico Institute of Mining and Technology; Garret L. Hart, University of Wisconsin—Madison.



GEOSPECTRA 99

International Trade Fair for Geotechnology and Applied Earth Science

A trade fair as plentiful as the earth itself. And as futuristic as the entire Geo industry itself. GEOSPECTRA 99 presents the entire spectrum for geotechnology and applied earth science. From deposit prospecting and exploration to rock engineering, tunneling, soil excavation and foundation. From geothermal energy to geosensors. From geoinformation technology and geoconsulting to geoengineering.
You will experience the complete range of products for technology, processing and equipment. Whether it is subsurface investigation, exploitation and protection of natural resources, geo-environmental technology, the use of former mine locations, remote sensing or geoinformation technology – GEOSPECTRA is the authority in all these areas.

• Subsurface investigation • Subsurface development and utilization – rock engineering and tunneling, soil excavation and foundation • Raw materials – prospecting and exploration, oil and gas, minerals and soils • Geothermal energy • Geosensors/ geo-environmental monitoring • Preventive geo-environmental technology • Waste disposal technology and land remediation Geotechnical and geoscientific software/geoinformation technology • Remote sensing, photogrammetry, surveying and cartography • Early warning systems and risk management • Geoconsulting/ environmental planning • Geoengineering

Excerpt from the list of exhibits

In time for the new millennium GEOSPECTRA is an integral part of the Technology Forum International, comprised of five thematically related trade shows: GIFA (foundry technology), METEC (metallurgical technology), THERMPROCESS (thermal processing technology) and MINETIME (mining technology).

Order your entrance passes and show directories in advance of the show at a 20 % discount!

Technology Forum International

GIFA 99 | METEC 99 | THERM PROCESS 99 | MINETIME 99 | GEOSPECTRA 99

Experience the future of our planet layer by layer. Düsseldorf awaits you!

June 9-15, 1999 Düsseldorf, Germany

For show information:
Messe Düsseldorf North America
150 North Michigan Avenue
Suite 2920
Chicago, IL 60601
Tel. (312) 781-5180
Fax (312) 781-5188
http://www.mdna.com

For hotel and travel information:
Travel Trade International
Tel. (212) 674-3476
Fax (212) 674-3477

Lufthansa
Official Airline

Messe Düsseldorf North Americ

WASHINGTON REPORT

Bruce F. Molnia, bmolnia@erols.com

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

An International Think Tank Takes a Glance at Education—OECD Indicators

The Organisation for Economic Co-operation and Development (OECD) is a 29-member international consortium (Australia, Austria, Belgium, Canada, Czech Republic, Denmark, Finland, France, Germany, Greece, Hungary, Iceland, Ireland, Italy, Japan, Korea, Luxembourg, Mexico, Netherlands, New Zealand, Norway, Poland, Portugal, Spain, Sweden, Switzerland, Turkey, United Kingdom, and United States) that provides a forum for governments "to discuss, develop and perfect economic and social policy." The member countries address common problems and attempt to coordinate domestic and international policies (i.e., establishing legally binding codes for free flow of capital and services). The forerunner of the OECD was the Organisation for European Economic Co-operation (OEEC), formed in the 1940s to administer American and Canadian aid under the Marshall Plan for the reconstruction of Europe. Since it evolved out of the OEEC in 1961, the OECD has worked to build strong economies in its member countries, improve efficiency, hone market systems, expand free trade, and contribute to economic growth in industrialized and developing countries.

A secretariat in Paris oversees exchanges between OECD member governments and provides for a flow of information and analyses between member nations. The 1,850 employees of the OECD Secretariat collect data, monitor trends, analyze and forecast economic developments, investigate social changes, and study evolving patterns in trade, environment, agriculture, technology, taxation, and education. These activities, which mirror the policy-making structures in the ministries of many governments, are performed in conjunction with national policy-makers who ultimately use the analyses.

Annually, the OECD analyzes the state of education within its member countries and reports its findings to provide international decision-makers with a scorecard showing where their countries rank and "reinforce accountability in national education systems." The latest review, Education at a Glance—OECD Indicators 1998 Edition, a 432-page analysis of education in 23 countries, was released in late November 1998. Some of its more interesting findings include:

- In the United States, Canada, Mexico, and Spain, high school graduation rates remain below 75%, although second-chance opportunities in Canada and the United States do allow dropouts the opportunity to complete high school at older ages. (The latest statistics I obtained from the U.S. Department of Education's National Center For Education Statistics showed that in the United States, for students age 18 to 24, an estimated 83% of whites, 77% of blacks, and 57% of Hispanics received high school diplomas.) By comparison, in Belgium, Finland, Japan, New Zealand, Norway, and Poland, high school graduation rates are above 93%.
- Indicators show a clear private economic gain from participation at higher levels of education. High unemployment in some European countries may be driving people to seek higher education in order to find jobs.
- In France, obtaining a baccalaureate, the equivalent of a U.S. high school diploma, ensures free enrollment in a university. The United States remains one of the highest spenders per student on education.
- The United States stacks up well in teachers' salaries—until the total spent on teachers' salaries is calculated as a percentage of overall wealth.
- In the United States, the disparities between the highest and lowest performing students are relatively large, increasing between the fourth and eighth grades. High-achieving and low-achieving pupils grow progressively further apart in performance while they are at school. The gap between the highest and lowest performing students is generally wider at age 13 than at age 9. In Korea, student performance at age 9 is relatively uniform. At age 13 it is more variable than in any other OECD country.
- Schools in some countries succeed in limiting this rise in dispersion. In Scotland and in Greece, student scores do not become significantly more dispersed over the four grade years.
- Indicators show a continuation of a recent trend of increased educational spending as a proportion of national income, particularly at the university level. This increase follows a several-decades trend of relatively stable spending.
- Universally, as education systems continue to expand to meet growing youth populations, governments are having difficulty meeting mounting bills for a greater number of students.
- Most countries are spending more. Between 1990 and 1995 education spending grew at a faster rate than national income in 14 out of 19 countries where information was available. In 10 countries, it grew more than 5% faster than income. However, in Italy and Turkey, spending relative to Gross Domestic Product (GDP) fell by 20% or more. GDP is the market value of all final goods and services produced within a country during a given period of time. Overall, educational spending accounts for at least 5% of the GDP.
- The increase in spending reflects rising educational aspirations. In countries where public funds are the primary source for financing education, serious pressure is being exerted on tight public budgets.

GSA ON THE WEB

Visit the GSA Web Site at http://www.geosociety.org. *From our home page you can link to many information resources. Here are some highlights:*

Check out GSA's Strategic Plan, recently posted on our Web site. For specifics of this plan, click on GSA Strategic Plan under the heading "What's Hot at GSA." Your comments are particularly welcome—please send them to stratplan@geosociety.org.

• "Educational expectancy"—the average number of years spent at school during childhood and youth—is rapidly rising. In the first half of the 1990s, it rose from an average of less than 15 to 16+ years in the OECD countries.
• The number of university students has increased in all countries between 1990 and 1996. In half of the countries, the increase is more than 30%.
• Although education is primarily publicly funded, private spending is becoming increasingly important and accounts, on average, for 9% of educational funds.
• Private spending accounts for more than half of final spending on university education in three countries—Japan, Korea, and the United States.
• On average, 34% of young people enroll in university-level studies; 22% emerge with a degree. About two-thirds of students enrolling in degree courses at universities actually complete them.
• University completion rates range from above 80% in Hungary, Japan, and the United Kingdom to below 40% in Italy.
• Having a well-educated parent at least doubles the chance of being well educated. This emerges from a new indicator of "inter-generational educational mobility," which compares number of adults who are university graduates to the highest educational level of their parents.
• Typically, people whose parents do not have a high school education have a lower than one-in-five chance of becoming university graduates. Those whose parents are university graduates have a two- to three-in-five chance of also becoming university graduates.
• Differences in level of educational completion correlate with future earnings and career success in adulthood. By mid-career, the level of education that adds most to individuals' earnings is university. On average, university graduates earn 20%–100% more than high school graduates.
• Adults who are university graduates also receive, on average, twice as much training as high school graduates, who in turn receive twice as much as those with less than a high school education. Thus, education combines with other influences to make adult learning least common among those who need it most.
• Across OECD countries, men who are university graduates have an average of six more years of employment than men who have not completed upper secondary education; for women the gap is 11 years.

This 1998 report, Education at a Glance—OECD Indicators 1998 Edition, is available from the OECD Media Relations Division, OECD Washington Center, 2001 L Street, NW, Suite 650, Washington, DC 20036-4922, (202) 785-6323, toll-free number for orders 1-800-456-6323. ■

GSAF UPDATE

Robert L. Fuchs, Foundation Trustee

Is There a Trust in Your Future?

A recent article in one of the national business magazines began with the question "Have you set up a trust?" and went on to state, "If you haven't, get cracking. No middle-class family should be without one."

Trusts have always been the financial tools of the rich, but inflation and changes in tax laws have lowered the income and/or asset level at which trusts start to make sense for many people. You may be one of these. There are several reasons why this has happened.

First, trusts are a very effective way to minimize taxes. As inflation has caused individual incomes and estates to increase, the estate tax exemption of $650,000 in 1999 has not kept pace with this increase. Many now find themselves above this exemption level. Estate and income taxes can be reduced by shifting assets to a charitable remainder trust or a life insurance trust, for example.

Trusts can be used to avoid probate. In about a third of the states, probate is a costly, time-consuming, uncomfortable process. A revocable living trust can transfer assets to heirs outside of a will, and this is usually done within a short time after death. Fees for lawyers and court administration are greatly reduced in the process, or even eliminated. Not only is such a trust important in states such as California, New York, and Florida, ownership of property in other states can cause your will to be probated in those states even though probate is not a significant problem in your state of residence.

Privacy is an attribute of the establishment of a trust. While probate records and real estate deeds are open to the public, trusts cast a cloak of secrecy over an estate. The world does not need to know what you have when you are alive, and to whom your assets are left.

Finally, a trust can be used to segregate your estate from certain heirs. This may be impossible to do in some states, where, for example, you cannot totally disinherit a spouse or children. Relatives who have been cut off have a much more difficult time attacking your trust than your will.

There are a number of trust types to suit particular needs in particular locations, such as the qualified terminable interest trust (QTIP), the generation-skipping trust, the kiddie trust for college tuition, and the grantor retained income trust (GRIT). This is the domain of estate attorneys. The revocable living trust may make a lot of sense for you if you live in one of the "heavy probate" states or have residences or property in more than one state. There is some work involved in setting one up, such as ensuring that all your assets are in fact transferred to the trust. However, your heirs may very well some day appreciate your time and effort.

The charitable remainder trust comes in two versions, the annuity trust (CRAT) or unitrust (CRUT). Either can provide significant tax advantages during your lifetime. The process of forming one of these trusts is not particularly difficult. First you create and transfer assets to a trust that names a charity or charities such as the GSA Foundation as the remainder beneficiary. The trustee, who could be you, the Foundation, or a third party, sells the assets and places the proceeds in income-producing securities (which can be tax-free municipal bonds). Recent lowering of the capital gains tax rate has made growth stocks an advantageous holding for CRUTs. The income stream from the trust is paid to you (or your spouse) for life, and the principal reverts to the Foundation after death. There is no capital gains tax to pay at the time of the asset sale; your trust receives the full value of the proceeds. In addition to deferring this tax, there is a year-of-gift tax deduction, adjusted for life expectancies and the future income stream. These tax advantages together can add up to a very powerful economic incentive to create a CRAT or a CRUT.

A panoply of literature and software is available if you want to learn more about trusts. Call the Foundation at (303) 447-2020, extension 154, and we can give you a few titles. In fact, we can send you an introductory booklet, "Trusts in Financial Planning," which can help you decide if there really is a trust in your future. You may use the accompanying coupon to order this booklet. ■

Digging Up the Past

Most Memorable geologic experience:

"What could be more memorable than meeting a geologist who was later to become your wife and geological partner?"

—Bruce F. Curtis

Donors to the Foundation, November 1998

Claude C. Albritton Memorial
Vance T. Holliday
John C. Kraft
Robert Gordon Schmidt

Biggs Excellence in Earth Science Education
James F. Brooks
Parvinder S. Sethi◆
Kurt M. Wilkie

Birdsall Award
George T. Cardwell
Larry A. Jackson
Stavros S. Papadopulos

Building Expansion
Gordon P. Eaton*◆

Cordilleran Section Endowment
Ian S. E. Carmichael◆
Paul E. Hammond◆

Allan V. Cox Student Scholarship Award
George R. Thompson*

Doris M. Curtis Memorial
Siegfried Muessig*
Ruth A. M. Schmidt*

Charles Lum Drake International Award
Robert H. Fakundiny
Peter S. Meyer◆

Shirley Dreiss Memorial
Mary Jo Baedecker
Philip C. Bennett*◆
Maryellen Cameron*◆
Alan R. Dutton
Robert H. Fakundiny
David B. Rogers

Dwornik Planetary Geoscience Award
John B. Adams
Ronald Greeley*
George E. McGill
James R. Zimbelman

GEOSTAR
Charles F. Bisbee
Gretchen Luepke
Walter C. Pusey III
James K. Roche◆
George R. Thompson*

History of Geology Award
Norman B. Cranford◆
Gretchen Luepke

Hydrogeology Division Award
Mary P. Anderson
Mary Jo Baedecker
Jean M. Bahr
John Van Brahana*
Anne E. Carey
James S. Dinger
Charles W. Fetter*
Mark S. McBride
Stavros S. Papadopulos
Robert W. Ritzi
Frank W. Schwartz*
John M. Sharp, Jr.
Edward A. Sudicky*
Chunmiao Zheng

Institute for Environmental Education
Gail M. Ashley
Aaron Bobar
James E. Evans
Ann I. Guhman
Gretchen Luepke
Charles C. Rich
Ruth A. M. Schmidt
Jung Ok Shin
Samuel E. Swanson*◆
F. Michael Wahl*◆

International Division Award
Holly J. Stein◆

*Century Plus Roster *(gifts of $150 or more).*
◆Second Century Fund.

John C. Frye Environmental Award
Michael R. Fisher
John P. Kempton

John T. Dillon Alaska Scholarship Award
Christopher C. Puchner
Sarah M. Roeske
Ruth A. M. Schmidt*

J. Hoover Mackin Award
Daniel S. Barker
Robert E. Boyer*
William B. Bull
P. Thompson Davis
Edwin H. East
Robert H. Fakundiny
William B. Hall
Harvey M. Kelsey III
James C. Knox
Mary E. Savina◆

Carol G. and John T. McGill Fund
Larry A. Jackson

Memorial Fund
Lillian D. Berg *in memory of Joseph W. Berg, Jr.**
Avery and Colette Drake, Jr. *in memory of Bruce B. Hanshaw**
Gordon W. Prescott◆

Minority Fund
Michele L. Aldrich*◆
Charles A. Baskerville
Ruth A. M. Schmidt

North-Central Section Endowment
North-Central Section*◆

Northeastern Section Endowment
Joseph E. Nadeau◆
William D. Romey◆

Penrose Conferences
Sigmund Snelson

Desmond and Judy Pretorius Fund
Anonymous*

Publications
Anonymous*
Albert G. Holba
Daniel J. Miller*
Donald D. Miller
Martin G. Miller*
Gerard M. Stampfli

Rip Rapp Archaeological Geology Award
Richard K. Dunn

Bruce L. "Biff" Reed Scholarship
John H. Fournelle

Research Grants
Charles A. Baskerville
Frederick B. Bodholt
Gary McG. Boone
William D. Carlson
Joan R. Clark
Ronald B. Cole
Charles W. Collinson
Brian J. Cooper
Russell C. Evarts*
John A. Fagerstrom
Martin B. Farley
Michael R. Fisher
Michael O. Garcia
Swapan S. Ghosh◆
Allen F. Glazner◆
Fraser E. Goff
William K. Hart
David F. Hess
William R. Holman
Elizabeth Jacobson
Myra Keep
Wayne Kemp
Robert Metz
William G. Minarik
Tina M. Niemi
Stephen F. Personius
Walter C. Pitman III
Donald B. Potter◆
Matt J. Pranter
Walter C. Pusey III
John R. Reid, Jr.
Harold H. Stowell
Desiree E. Stuart-Alexander
Bennie W. Troxel
Robert J. Twiss
Gregory S. Vandeberg
Albert E. Wood*

SAGE
Alicia K. Armstrong◆
Thomas M. Berg
Jeremy M. Boak◆
John R. Carpenter
Tom Ann Casey
Robert A. Christman
James A. Drahovzal
Eric K. Ericson
John L. Fauth
Gretchen Luepke
E. Allen Merewether
Roger B. Morrison
Daniel P. Murray
Michael J. Passow◆
Pamela Polite-Fisco
Charles C. Rich
Ruth A. M. Schmidt
Patricia O. Seaward
Sigmund Snelson

Southeastern Section Endowment
Paul Geoffrey Feiss◆
John P. Kempton◆

Shoemaker Memorial Fund for Crater Studies
Milford J. Benham◆
Mary G. Chapman

GEO-STAR
Supporting The Advancement of Research

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

☐ Enclosed is my contribution in the amount of $_____ for the _____ Fund.

☐ Please add my name to the Century Plus Roster (gifts of $150 or more).

☐ I would like to learn more about trusts. Please send me a copy of the booklet entitled "Trusts in Financial Planning."

PLEASE PRINT

Name _____

Address _____

City/State/ZIP _____

Phone _____

Joan R. Clark
Kelly M. Hazen◆
Gregory J. Leonard
Samuel T. Martner
James R. Underwood, Jr.◆
Nanci E. Witbeck*

Unrestricted
Francis D. Anderson
Thomas H. Anderson
Frank G. Andrews
Walter B. Ayers, Jr.◆
W. Robert A. Baragar
Manuel A. Barrantes
William A. Bassett
Thomas Beard
Edward Scudder Belt◆
Daniel Bernoulli
Charles F. Bisbee
D. L. Blackstone◆
John D. Bloch
Arthur L. Bloom
Arthur A. Bookstrom
T. Leo Broin
William P. Brosge*◆
Bruce A. Brown
Ian S. E. Carmichael*◆
Eric S. Cheney
Edward H. Chown
Kenneth W. Ciriacks*◆
Sandra H. B. Clark *in memory of Bruce B. Hanshaw*◆
Ronald J. Clendening◆
Susan Howes Conrad
Brian J. Cooper
Doak C. Cox
Richard Crook, Jr.
Graham R. Curtis
Jelle Zeilinga De Boer
Edward C. de la Pena
Robert W. Decker
Rodger E. Denison*◆
Bruce R. Doe
Julie M. Donnelly-Nolan
Mark T. Duigon
Roy E. Ervin
EXXON Exploration Company*
Paul Geoffrey Feiss*◆
Warren I. Finch
William S. Fyfe◆
Joseph S. Gates
Julian R. Goldsmith◆
William C. Goth
Lois T. W. Grady
Reinhard O. Greiling
Dennis H. Grindle
William R. Hackett
John K. Hall
William B. Hall
Paul E. Hammond◆
Joseph H. Hartshorn*◆
Richard L. Hay◆
Alan S. Horowitz◆
Peter J. Hudleston*◆
Cornelius S. Hurlbut, Jr.◆
Arthur Mekeel Hussey II
Larry A. Jackson
Allen H. Johnson
Lisle T. Jory
E. A. Keller
John P. Kempton◆
Kathryn C. Kilroy◆
Konrad B. Krauskopf◆
Ronald B. Krauth
Gary F. Land
Robert T. Littleton
Helen Tappan Loeblich*
Mark J. Logsdon*
Robert J. Malcuit
Ennio Marsella
Thane H. McCulloh
Edgar J. McCullough, Jr.◆
Roger B. Morrison
Sharon Mosher
Joseph E. Nadeau◆
James T. Neal
Occidental Oil & Gas Corporation*
Ocean Energy, Inc.*
William A. Oliver, Jr.*
Margaret M. O'Neill
William C. Overstreet◆
David H. Palmer◆
Jeffry A. Parsons
Charles B. Peeples III
William J. Perry, Jr.
Harriet E. Powell
D. P. Price
William C. Prinz
Walter C. Pusey III
William D. Romey◆
Gerald M. Ross
Sandra L. Rutherford
Takayuki Sakamoto
William M. Schill◆
David M. Scotford
Kenneth D. Seborowski
Charles E. Seedorff*
Seymour L. Sharps
Gordon G. Start
Rowland W. Tabor
Mya Mya Than◆
Theodoros Toskos
Bennie W. Troxel
Peter R. Vail
Bradley A. Wake
John H. Wall
A. L. Washburn◆
Fred Webb, Jr.
Malcolm P. Weiss◆
Raelyn E. Welch◆
John O. Wheeler
Robert T. White
William M. Whiting
Donald R. Wiesnet
Isaac J. Winograd
James C. Wise
Leonard Alton Wood
Margaret S. Woyski
Frederick P. Zoerner

Women in Science
Ruth A. M. Schmidt

GEOSCIENCES FOR THE COMPUTER AGE

CTI CENTRE FOR GEOGRAPHY, GEOLOGY AND METEOROLOGY, University of Leicester, UK (ed.)

GEOGRAPHY INTERACTIVE: LEARNING AND TEACHING

Geography Interactive: Learning and Teaching (GILT) comprises a suite of innovative geographical courseware modules for use on the PC. These modules facilitate efficient and effective teaching and learning environments for core topics, concepts and techniques in introductory undergraduate geography courses. The CD-ROMs form a library of high quality transportable resources that use data visualization, dynamic representation and regular assessment exercises to enhance teaching and learning in geography and analogous disciplines. Each module covers a wide variety of foundation issues and topics in human geography, physical geography and geographical techniques.

GEOGRAPHICAL METHODS AND TECHNIQUES

Contents: Social Survey Design • Map Design • GIS: Introductions and Applications • House Hunting: The GIS Game • Making Sense of Information

1998/IBM-COMPATIBLE CD-ROM/$69.95
ISBN 3-540-14694-6

HUMAN GEOGRAPHY

Contents: International Economic Change • Social Change at an International Scale • International Inequalities • Regional Economic Change • Environmental Hazards.- Planning and Development in the Urban-Rural Fringe

1998/IBM-COMPATIBLE CD-ROM/$69.95
ISBN 3-540-14692-X

PHYSICAL GEOGRAPHY

Contents: Quaternary Environmental Change • Catchment Systems • Simulating Slope Development • Biogeography and Ecology • Weather and Air Quality • Global Tectonics

1998/IBM-COMPATIBLE CD-ROM/$69.95
ISBN 3-540-14693-8

GEOGRAPHICAL METHODS AND TECHNIQUES, HUMAN GEOGRAPHY AND PHYSICAL GEOGRAPHY SET

1998/THREE IBM-COMPATIBLE CD-ROMS
$169.00
ISBN 3-540-14688-1

SYSTEM REQUIREMENTS: PC: 486 PROCESSOR, 4 MB RAM (8 RECOMMENDED), WINDOWS 3.1 OR WINDOWS 95/98, 256 COLOR MONITOR AT A RESOLUTION OF 640 X 480.

JOURNALS

REGIONAL ENVIRONMENTAL CHANGE

Natural and Social Science Perspectives

Editor-in-Chief: **W. SALOMONS,** GKSS Research Center, Geesthacht, Germany

Regional Environmental Change focuses on the interactions of human and natural systems at the regional level within the context of global change. Regions examined include river catchments, estuaries, seas adjacent to deltas, and wetlands as well as the interactions between cities and their environment. Disciplinary as well as particular multidisciplinary approaches to the study of these systems will be considered.

ISSN 1436-3798 – ELECTRONIC ISSN 1436-378X
TITLE NO. 10113
1999, VOLUME 1, 4 ISSUES TOTAL
SUBSCRIPTION RATE: $265.00

SCIENCES OF SOILS

Managing Editor: **DR. THOMAS HINTZE,** Universität Trier, Germany

Sciences of Soils is a new multimedia electronic journal. It provides an international peer-reviewed online forum on a broad range of subjects of interest to soil scientists. *Sciences of Soils* benefits from the advantages of electronic publishing on the World Wide Web, which makes it ideally suited to scientific publishing, such as unlimited worldwide access, rapid publications of articles, almost unlimited pages, graphical features such as color figures and photos, coordinate sets for 3-D models, direct and easy communication between authors and readers, and complete multimedia presentation to expand the kind of information that can be presented. Journal articles will include new experimental results, descriptions of new experimental methods of pedagogical importance, and new interpretations of existing results.

ELECTRONIC ISSN 1432-9492 • TITLE NO. 10112
1999 SUBSCRIPTION RATES INCLUDES ONLINE ACCESS PLUS CD-ROM:
PERSONAL SUBSCRIPTIONS: $119.00
INSTITUTIONAL SUBSCRIPTIONS (INCLUDES PRINT ARCHIVE): $420.00

Both journals are accessible on the World Wide Web via **http://link.springer-ny.com**

Springer

http://www.springer-ny.com

H. FRATER, Düsseldorf, Germany

NATURAL DISASTERS

Natural disasters have existed throughout the world's history. Recently, humanity has been startled by a number of catastrophes – such as the Mount St. Helens eruption, hurricane Andrew, the earthquake in Kobe and floods along the Mississippi – where many people died and thousands became homeless. Using striking examples and specific use of multimedia elements, this CD-ROM teaches the user everything about the causes of earthquakes, volcanism, storms, floods and erosion. The alarming scale of these incidents is shown in numerous pictures and movies. In addition, interactive chapters allow the simulation of the possible consequences of rising sea-level or shifting climate zones.

1999/CD-ROM $54.95
ISBN 3-540-14609-1

H. FRATER, Düsseldorf, Germany

WEATHER AND CLIMATE

Cause, progress, effect, animation

The CD-ROM uses to a large extent an approach similar to textbooks on weather and climate, but includes the added experiences of multimedia events. The CD-ROM contains films, animated sequences and various models. Topics covered include air circulation, clouds and precipitation, air mass, frontal zone and polar front, cyclones and anticyclones, general atmospheric circulation, and climate change. Furthermore, the CD-ROM includes some interactive chapters and a detailed glossary, and in addition, the main menu is accessible from any application.

1999/CD-ROM $45.65 (TENTATIVE)
ISBN 3-540-14667-9

SYSTEM REQUIREMENTS FOR BOTH: WINDOWS 3.X OR WINDOWS 95, 486/33 OR HIGHER, 4 MB RAM (8 MB RECOMMENDED), SOUND CARD, MONITOR 640 X 480, 256 COLORS, CD-ROM (DOUBLE SPEED), MACINTOSH SYSTEM 7 OR HIGHER, 68030/25 OR HIGHER, 6 MB RAM (8 MB RECOMMENDED), MONITOR 640 X 480 256 COLORS, CD-ROM (DOUBLE SPEED), HYBRID MAC/WINDOWS

Four Easy Ways to Order:

CALL Toll-Free 1-800-SPRINGER, 8:30 AM - 5:30 PM ET or FAX 201-348-4505. Please mention S700 when ordering by phone.
E-MAIL your orders to orders@springer-ny.com.
WRITE to Springer-Verlag New York, Inc., Order Dept. S700, P.O. Box 2485, Secaucus, NJ 07096-2485
VISIT your local scientific bookstore or urge your librarian to order for your department.

Payment may be made by check, purchase order or credit card. Please enclose $4.00 for shipping (add $1.00 for each additional book) & add appropriate sales tax if you reside in CA, IL, MA, MO, NJ, NY, PA, TX, VA, and VT. Canadian residents please add 7% GST.

Remember...your 30-day return privilege is always guaranteed!

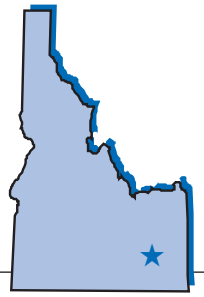
Prices subject to change without notice.

2/99 PROMOTION #S700

ROCKY MOUNTAIN SECTION, GSA
51st Annual Meeting

The Last Best Rocky Mountain GSA Meeting of the Millennium

Pocatello, Idaho
April 8–10, 1999
http://wapi.isu.edu/rm-gsa99



Idaho State University will host the 1999 Geological Society of America Rocky Mountain Section meeting in Pocatello, Idaho. The meeting will be held at Cavanaugh's Pocatello Hotel and Convention Center off Interstate Highways 86 and 15, approximately 150 miles north of Salt Lake City, 50 miles southwest of Idaho Falls, and 120 miles east of Twin Falls, Idaho. Flanked by foothills and mountains of the Bannock and Portneuf ranges, Pocatello is located in the valley of the Portneuf River near the margin of the Basin and Range and Snake River Plain geologic provinces.

SETTING AND ACCESS

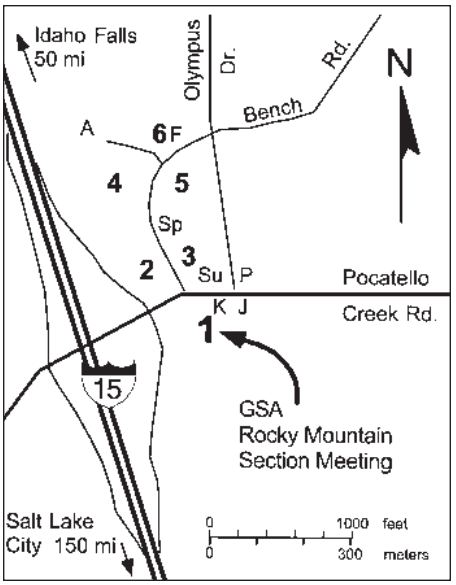
Pocatello is easy to access by air via 12 flights each day from Boise on Horizon Airlines, and from Salt Lake City on Skywest Airlines (Delta Connection). April weather in eastern Idaho is *always* beautiful; days are typically 40–60 °F; nights are cool, with possible frost, or light snow. We look forward to an enjoyable and productive meeting of "Poky '99—Spuds 'R' Us," The Last Best Rocky Mountain GSA Meeting of the Millennium. See you in Pocatello!

ACCOMMODATIONS

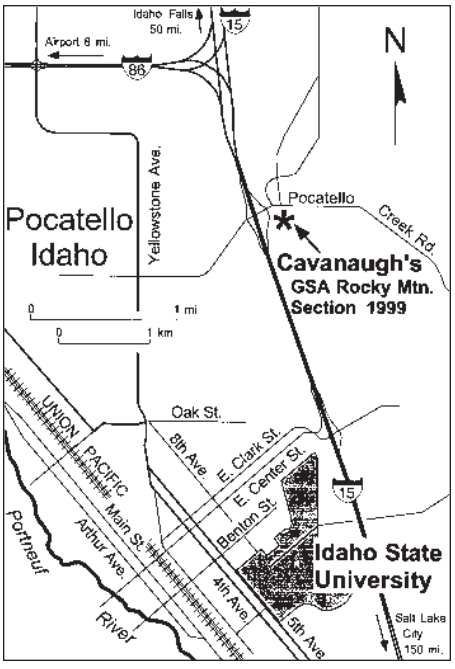
A block of rooms has been reserved at Cavanaugh's Pocatello Hotel and Convention Center for April 7 through 10, 1999. A special rate of $60 per room is guaranteed for GSA reservations made before March 29, 1999. All rooms feature coffee, irons, hair dryers, and dataports. Cavanaugh's is a full-service hotel with a restaurant, lounge, swimming pool, whirlpool, airport shuttle, and free parking. It is inexpensive and provides a convenient location for all activities related to the GSA meeting. Additional space is available in nearby hotels, all within a few minutes' walking distance. Attendees must settle with hotels on an individual basis (add 8% tax).

1. Cavanaugh's Pocatello Hotel
   (Meeting Headquarters)
   1555 Pocatello Creek Road
   Pocatello, ID 83201
   Phone (208) 233-2200
   Reservations (800) 325-4000
   FAX (208) 234-4524
   pocatellopark@sisna.com
2. Comfort Inn
   1333 Bench Road, Pocatello, ID 83201
   Phone (208) 237-8155
   Reservations (208) 237-8155
3. Pocatello Super 8 Motel
   1330 Bench Road, Pocatello, ID 83201
   Phone (208) 234-0888
   Reservations (800) 800-8000
4. Holiday Inn
   1399 Bench Road, Pocatello, ID 83201
   Phone (208) 237-1400
   Reservations (800) 200-8944
5. Ameritel Inn
   1500 Bench Road, Pocatello, ID 83201
   Phone (208) 234-7500
   Reservations (800) 600-6001
6. Best Western Cotton Tree Inn
   1415 Bench Road, Pocatello, ID 83201
   Phone (208) 237-7650
   Reservations (800) 622-6886

POCATELLO AREA



Restaurants, etc.: A = Applebees; F = Frontier Pies; Sp = Sandpiper; Su = Subway; P = Perkins; K = Circle K; J = Jack in the Box



REGISTRATION

Preregistration deadline:
March 5, 1999

Preregistration is recommended for field trips and special activities because of participation limits and required guarantees. Use the Preregistration Form provided in this announcement. Save time and money—preregister today!

Full payment must accompany registration. Unpaid purchase orders are not accepted as valid registration. Charge cards are accepted as indicated on the preregistration form. Please recheck the card number given, as errors will delay your registration. The confirmation card will be your receipt. No other receipt will be given.

Register one professional or student per form. Copy the form for your records.

Badges must be worn for access to all activities, 7 p.m. Wednesday through noon Saturday. Guest registration is required for those attending meeting activities, including technical sessions. Guest registrants must be accompanied by a registered attendee. A guest is defined as a nongeologist spouse or friend of a professional or student registrant.

Students and K–12 professionals must show a current ID on site in order to obtain these rates. Students or K–12 educators not having a current ID when registering on site will be required to pay the professional fee.

On-site registration will be available at Cavanaugh's from 4 to 7 p.m. Wednesday, 7:30 a.m. to 4 p.m. Thursday and Friday, and 7:30 to 11 a.m. Saturday.

Members pay less! You can join now or at the meeting. Come visit the GSA Mem-

Rocky Mountain *continued on p. 18*

Rocky Mountain *continued from p. 17*

bership Services area for new member applications, reinstatements, dues payment, address changes, questions, or concerns. Contact GSA for further information.

Cancellations, Changes, and Refunds

All requests for registration additions, changes, and cancellations must be made in writing and received by March 12, 1999. GSA will refund or credit preregistration fees for cancellations received in writing by that date. No refunds or credits will be made on cancellation notices received after March 12. Refunds will be processed after the meeting. There will be no refunds for on-site registration and ticket sales.

Accessibility for Registrants with Special Needs

GSA is committed to making every event at the 1999 Rocky Mountain Section meeting accessible to all people. Special requirements, such as an interpreter or wheelchair, will be provided upon request. Please let us know your needs by March 10, 1999.

WELCOMING PARTY

An informal ice-breaker reception will be held Wednesday, April 7, from 7 to 9 p.m. next to the indoor pool at Cavanaugh's. Don't miss this opportunity to visit old friends and make new ones. This will be a good opportunity to learn more about special events, spouse activities, and the sites around Pocatello. Light food and beverages will be served. Attendees must register before the party and will receive a complimentary beverage coupon.

GUIDEBOOK

A peer-reviewed monograph *Guidebook to the Geology of Eastern Idaho* (Scott Hughes and Glenn Thackray, editors) will be published by the Idaho Museum of Natural History in conjunction with the meeting. Articles will include scientific discussion and road logs to accompany the field trips, plus comprehensive field guides and articles that extend beyond the trips offered at the meeting. Cost for the guidebook is $25 purchased at the meeting, and $30 purchased after the meeting. All professional registrants for the meeting will receive a $10-off coupon for on-site purchase of the guidebook.

SPECIAL EVENTS

Rocky Mountain Section Banquet in Honor of Lehi Hintze. Cavanaugh's, Thursday, April 8, 7 p.m. Price: $20 (choice of beef roulades, chicken cordon bleu or vegetarian pasta primavera). Lehi Hintze has been a model of careful work, considerate mentoring, high integrity, and warm friendship for more than four decades. This banquet will feature remarks by Lehi, and will extend to him thanks and congratulations from the Rocky Mountain Section for his dedication and leadership in studies of the regional geology of Utah.

GSA Rocky Mountain Section Management Board Breakfast. Friday, April 9, 1999, 6:30–8 a.m., Cavanaugh's.

Idaho Association of Professional Geoscientists (IAPG) Annual Luncheon Meeting. Cavanaugh's, Friday, April 9, noon. Price: $12. IAPG is the only comprehensive geoscience organization in Idaho. A speaker will be arranged. There will also be an update from the Idaho State Board for Registration of Professional Geologists.

Fun Run or Walk (5 km run, 2 km walk). Friday, April 9, 5:30 p.m., hosted by the Idaho State University Geology Club. First prize is a discovery flight around Pocatello for the top finishers in male and female categories. Entry is FREE to registered meeting participants. For more information, contact Jordan Vaughn, Geology Club, Dept. of Geology, Idaho State University, Pocatello, ID 83209, (208) 236-3235.

Spuds 'R' Us Millennium Bash. Friday, April 9, 7:30 p.m.–midnight, hosted by the Idaho State University Department of Geology, at the Booth Barn located near the meeting. A shuttle van to and from Cavanaugh's will be provided. All attendees and their spouses or friends are welcome. Really live music is planned. Cost: $5.

TECHNICAL SESSIONS

Symposia

We have an exciting program of symposia dealing with geoscience in the intermountain West. Address general questions to Technical Program Chair Paul Link, Dept. of Geology, Idaho State University, Pocatello, ID 83209-8072, (208) 236-3846, linkpaul@isu.edu.

Past and Present Tectonics of the Circum-Yellowstone Bow Wave: Southwest Montana, Northwest Wyoming, and Southeast Idaho. Rob Thomas, Dept. of Environmental Sciences, Western Montana College of the University of Montana, Dillon, MT 59725-3598, (406) 683-7615, r_thomas@wmc.edu; Dave Lageson, Montana State University, Bozeman, (406) 994-6913, Lageson@montana.edu; Jim Sears, University of Montana, Missoula. The unifying theory of the Yellowstone–Snake River Plain hotspot and associated topographic bulge has spawned many types of studies. This symposium will cover the past 15 m.y. of tectonics, volcanism, and drainage development.

Tectonic and Magmatic Evolution of the Snake River Plain. Bill Bonnichsen, Idaho Geological Survey, University of Idaho, Moscow, ID 83844-3014, (208) 885-8928, billb@uidaho.edu; Craig White, Boise State University; Mike McCurry, Idaho State University. This oral and poster symposium, organized in conjunction with an upcoming Idaho Geological Survey memoir, will focus on magmatism and tectonics of the Snake River Plain, which crosses the edge of cratonic North America, and reflects much-debated mantle influence.

Lehi Hintze Symposium on the Geology of Utah. Bart Kowallis, Dept. of Geology, Brigham Young University, 258 ESC, Provo, UT 84602 (801) 378-8143, bkowallis@byu.edu. This symposium is dedicated to one of the fathers of Utah geology. Talks will cover all aspects of Utah geology, with an eye toward completeness and updating progress on many long-standing controversies, many of which relate to the long career of Lehi Hintze.

Active Tectonics in the Basin and Range. Bob Smith, 702 Browning Bldg., Dept. of Geology and Geophysics, University of Utah, 135 So. 1460 East, Salt Lake City, UT 84112-0111, (801) 581-7129, rbsmith@mines.utah.edu. This symposium will concentrate on active tectonism and neotectonics of the Basin and Range province, including recent advances in observations, models, and geologic manifestation of active intraplate extension. Topics include mechanisms of extension, especially how the Basin and Range is deforming today and how it fits into a framework of western U.S. deformation, seismicity, paleoseismicity, basin origin, geodetics, magmatism, epeirogeny, etc. The symposium, while regional in focus, is global in significance because of the emphasis on continental intraplate extension.

Proterozoic Rocks of Northern Idaho and Vicinity. Reed S. Lewis, Idaho Geological Survey, Moscow, ID 83842, (208) 885-7991, reedl@uidaho.edu; Mark McFadden, University of Idaho. Proterozoic rocks underlie much of northern Idaho and the surrounding area and are key to understanding the complex structural history of the region. Symposium topics include stratigraphy, structure, geochronology, and mineral deposits within the Proterozoic, with an emphasis on the Belt Supergroup and the Yellowjacket Formation.

REGISTRATION FEES

	Full	One day
Professional—		
Member	$60	$40
Nonmember	$60	$40
Student—		
Member	$30	$15
Nonmember	$30	$15
K–12 Professional	$30	$15
Guest or Spouse	$10	

Hydrologic, Geologic, and Biological Constraints on Waste Remediation Technologies at the Idaho National Engineering and Environmental Laboratory. Roy Mink, Idaho Water Resources Research Institute, University of Idaho, Moscow, ID 83844-3011, (208) 885-6431, iwrri@uidaho.edu; Dale Ralston, University of Idaho; Paul Link and John Welhan, Idaho State University. This symposium will focus on methods of characterizing and modeling the geology, contaminant hydrology and microbial ecology of the eastern Snake River Plain. Presentations will include geology, geophysics, geochemistry, hydrogeology, and microbiology of the regional aquifer system and its geologic environment and their application to hazardous and radioactive waste remediation.

Source-Water Protection in the Rocky Mountain Region: Unique Cases and Lessons Learned. Willis Weight, Dept. of Geological Engineering, Montana School of Mines of the University of Montana, Butte, MT 59701, (406) 496-4329, wweight@pol.mtech.edu. Geologically speaking, source-water topics in the Rocky Mountain region are especially intriguing. Limited supply and heterogeneous source terranes make for critical water-quality issues.

Paleozoic Stratigraphy, Structure, and Tectonics of Northeast Nevada. Walt Snyder, Dept. of Geosciences, Boise State University, Boise, ID 83725, (208) 385-3645; WSNYDER@bsu.idbsu.edu; Jim Trexler and Pat Cashman, University of Nevada, Reno. This symposium will cover not only the specifics of northeast Nevada, but also the big-picture upper Paleozoic framework. The presentations will include regional aspects of the Antler and Sonoma orogenies.

Glacial and Lacustrine Records of Late Pleistocene and Holocene Climate in the Western Interior. Glenn Thackray, Dept. of Geology, Idaho State University, Pocatello, ID 83209, (208) 236-3560, thacglen@isu.edu: Gary Gianniny, Bucknell University. Late Quaternary climate in western North America has been influenced by a variety of factors, including orography, ice-sheet effects, and large-scale oceanic and atmospheric circulation. This symposium will examine a variety of climatic proxy records from the western interior, with the aim of elucidating paleoclimatic patterns across the region during late Pleistocene and Holocene time.

Zeolites and Phosphate Mineral Deposits in Idaho. Mickey Gunter, Dept. of Geology and Geological Engineering, University of Idaho, Moscow, ID 83844-3022, (208) 885-6015. This symposium will cover a broad range of these two industrially important mineral groups. Papers will cover such aspects as crystal chemistry, mineral deposits, and applications, as well as environmental problems solved or created by these minerals.

Innovative Science Teaching in Idaho. Terry Kuroda, Meridian High School, 1900 West Pine, Meridian, ID 83642, (208) 888-4905. Some of the innovative members of the Idaho Science Teachers Association will present posters, talks, and workshops that will be of interest to K–12 educators at the elementary, middle school, and high school levels. Saturday morning, April 10.

Academic Service Learning in the Geoscience Curriculum. Sheila Roberts, Dept. of Environmental Sciences, Western Montana College of the University of Montana, Dillon, MT 59725, (406) 683-7017, s_roberts@wmc.edu; Dave Mogk, Montana State University, (406) 994-6916, mogk@montana.edu.

Academic service-learning promotes integration of research and service in undergraduate education. A well-designed project supports the curriculum, motivates students, and provides a professional service. Service learning is also an underutilized opportunity for outside funding. This half-day symposium-workshop will include talks to introduce the topic and provide successful case studies, funding ideas, and a work session on project design.

PROJECTION EQUIPMENT

Projection equipment will be provided for 2″ × 2″ slides that fit standard 35 mm carousel trays. Two slide projectors, an overhead transparency projector, and two screens will be available. Authors are strongly encouraged to bring their own carousel trays. A very limited number will be available in the speaker-ready room.

POSTER SESSIONS

Three one-half day poster sessions are planned. Each poster booth will contain one 4′ high × 8′ wide board.

EXHIBITS

Exhibits by businesses and education and government institutions will be adjacent to technical session rooms at Cavanaugh's. Exhibits will be open Wednesday, 5 to 8 p.m., Thursday and Friday, 8 a.m. to 5 p.m., and Saturday, 8 a.m. to noon. For further information, contact Joe Kruger, Dept. of Geology, Idaho State University, Pocatello, ID 83209-8072, (208) 236-3871, krugjose@isu.edu.

WORKSHOPS

ArcView GIS 3.1—Full Day. This all-day session on Wednesday, April 7, will cover the fundamentals of the newest release of ArcView. The workshop will be held in the newly constructed Idaho State University GIS Lab in the basement of Graveley Hall. A shuttle van will be available to and from Cavanaugh's. Cost: $50. Instructors: Keith Weber, (208) 236-2757, webekeit@isu.edu, and Michelle Byrd. Minimum: 10.

Introduction to ArcView GIS 3.1—Half Day. This introductory workshop on Saturday, April 10, 1 to 4 p.m., will cover the first half of the Wednesday workshop. Educators and meeting guests are encouraged to sign up for this session. The workshop will be held in the newly constructed GIS Lab in the basement of Graveley Hall on the Idaho State University Campus. A shuttle van will be available to and from Cavanaugh's. Cost: $25. Instructor: Michelle Byrd, byrdmich@isu.edu. Minimum: 10.

FIELD TRIPS

All field trips will depart from and return to the main parking lot of Cavanaugh's Hotel and Convention Center. For general questions regarding field trips, contact Glenn Thackray, Field Trip Chair, ISU Geology, (208) 236-3560; thacglen@isu.edu. For detailed information concerning a specific trip, please contact the trip leader. All field trip fees include transportation, lunch, and field trip guide.

Premeeting Trips

1. Past and Present Tectonics of the Greater Yellowstone Tectonic Parabola. Tuesday, April 6 (8 a.m.) through Wednesday, April 7 (6 p.m.). David R. Lageson and David Adams, Dept. of Earth Sciences, Montana State University, Bozeman, MT 59717, (406) 994-6913, lageson@montana.edu; Lisa Morgan and Ken Pierce, U.S. Geological Survey; Bob Smith, University of Utah.

This field trip will focus on new, ongoing research in structural geology, volcanology, geophysics, and active tectonics on the south side of the Snake River Plain. Highlights will include new $^{40}Ar/^{39}Ar$ ages on hotspot-derived ignimbrites, new thinking on large "gravity-slide" blocks in the Grand Valley and Jackson Hole, new research results on the Miocene calc-alkaline Jackson Hole volcanic field, new data on active deformation of Jackson Hole (hanging wall of the Teton normal fault), and information on the recently unveiled southeast Idaho lineament. In addition, aspects of pre-Neogene tectonic deformation in the Sevier and Laramide orogenic belts will be viewed and discussed in the context of "reactivation." Two days (overnight stay in Jackson). Cost: $120 (2 lunches, 1 night lodging). Limit: 23.

2. Teton Canyon, Mesa Falls, and the West Slope of the Teton Range, Idaho-Wyoming. Tuesday, April 6 (8 a.m.–6 p.m.). Glenn Embree and Roger Hoggan, Dept. of Geology, Ricks College, Rexburg, ID 83460, (208) 356-1904.

Rocky Mountain *continued on p. 20*

Rocky Mountain *continued from p. 19*

On this trip we will examine the geology of the eastern end of the Snake River Plain, the southern flank of the Island Park caldera, and the western slope of the Teton Range, Wyoming. Emphasis will be on the Pliocene and Pleistocene bimodal volcanism of the Yellowstone–Snake River Plain system. Large scale (>100 m amplitude) secondary deformation structures in the Huckleberry Ridge Tuff and subjacent units will be examined in detail. We will visit the Teton Dam site and discuss the causes of its 1976 failure. Weather permitting, we will examine the Archean through upper Paleozoic rocks and Pleistocene glacial features of the west slope of the Teton Range. This trip may be linked with trip 3, with overnight accommodations in Pocatello. Cost: $35 (1 lunch). Limit: 26.

3. Cedar Butte and Cogenetic Quaternary Rhyolite Domes of the Eastern Snake River Plain. Wednesday, April 7 (8 a.m.–6 p.m.). Michael McCurry, Idaho State University, (208) 236-3960, mccumich@isu.edu; Bill Hackett; Karl Hayden.

Quaternary rhyolites produced some of the most distinctive topographic and geologic components of the Eastern Snake River Plain. Beginning at East Butte, a 0.6 Ma rhyolite dome, we will describe the petrology, geochemistry, and volcanology of high-silica rhyolite domes, flows, and pyroclastic rocks along the axial volcanic zone of the area. Most of the trip will focus on Cedar Butte volcano, a volcanic center that produced a remarkably wide spectrum of volcanic rocks, ranging from basaltic trachyandesite to high-silica rhyolite. We will examine key parts of the volcano including a rhyolite lava flow, polymodal tephra cone, trachyandesite lava flow, and compositionally zoned dikes. Expect a long day in the field; bring boots for short hikes, binoculars, a camera, and sunscreen. This trip may be linked with trip 2, with overnight accommodations in Pocatello. Cost: $30 (1 lunch). Limit: 27.

4. Holocene Flood History, Geomorphology, and Holocene–Late Pleistocene Soils, Big Lost River and INEEL, Idaho. Wednesday, April 7 (8 a.m.–6 p.m.). Dean A. Ostenaa, Daniel R. Levish, and Ralph E. Klinger, Geophysics, Paleohydrology, and Seismotectonics Group, D-8330, U.S. Bureau of Reclamation, P.O. Box 25007, Denver, CO 80225, (303) 445-3177, fax 303-445-6478, dostenaa@do.usbr.gov; David T. Simpson, Woodward-Clyde Consultants; Erick A. Bestland and Linda E. Mark, Idaho State University.

On this field trip we will examine the stratigraphic and geomorphic record of Holocene floods on the Big Lost River at INEEL (Idaho National Engineering and Environmental Laboratory) in the context of using this information for applied flood hazard assessment. This will include opportunity for discussion on how to capture uncertainty in dating flood-plain alluvium, soils, and landforms; uncertainty in paleoflood discharge estimation and stable channel configuration; and incorporation of this information into flood frequency analysis. Other stops will focus on parts of the late Pleistocene soil chronosequence developed in Big Lost River alluvium at INEEL and the implications of this chronosequence for the timing and magnitude of glacial outburst floods. We will also look at eolian and lacustrine deposits and associated soils around the Birch Creek playa, the terminus of the Big Lost River, as indicators of the maximum extent of the Holocene playa and Lake Terreton. Cost: $50 (1 lunch). Limit: 19.

5. Folded and Faulted Salt Lake Formation Above the Miocene to Pliocene(?) New Canyon and Clifton Detachment Faults, Malad and Bannock ranges, Idaho. Wednesday, April 7 (8 a.m.–6 p.m.). Jeffrey C. Evans and Susanne U. Janecke, Dept. of Geology, Utah State University, Logan, UT 84322, (435) 797-3877, sjanecke@cc.usu.edu.

Explore the complexly folded and faulted basin-fill deposits of the Miocene-Pliocene Salt Lake Formation above two little-known detachment faults in the northeast corner of the northern Basin and Range province. Structural features include extensional folds with a bewildering range of orientations and multiple generations of normal faults. Notable stratigraphic features include unroofing sequences and rapid rounding of quartzite cobbles. The Sevier Desert detachment is a likely analog to this extensional system in age, structural setting, and overall geometry. Cost: $30 (1 lunch). Limit: 26.

6. Southeast Idaho Phosphate Field. Wednesday, April 7 (8 a.m.–6 p.m.). Ray Petrun, Solutia, Inc., Box 816, Soda Springs, ID 83246, (208) 547-3391, ext. 341, RMPETR@solutia.com; Al Haslam, Agrium Corporation.

This trip into southeastern Idaho will include a scenic and geologically varied drive from Pocatello south down Marsh Valley between the Portneuf and Bannock Ranges, then east following the Portneuf River into Gem Valley, through the Chesterfield Range, and into the Peale Mountains north of Soda Springs, Idaho. There we will tour two mines currently mining the Phosphoria Formation, a world-class phosphate deposit of Permian age. Field trip participants will have a chance to examine and discuss several exposed sections of the Phosphoria Formation and related units, as well as active mining and reclamation operations. Cost: $30 (1 lunch). Limit 26.

Postmeeting Trips

7. Rocks, Rails, and Trails 1: Lake Bonneville Flood and the Oregon Trail. Saturday, April 10 (12:30–6 p.m.), Paul Link and Chilton Phoenix, Idaho State University, (208) 236-3846, linkpaul@isu.edu.

This bus tour will cover the highlights of the geology and history of southeastern Idaho including the Lake Bonneville flood, Red Rock Pass, Bear River Massacre site, Last Chance Canal flume, Sheep Rock, and the Oregon Trail near Soda Springs. No strenuous walking. Teachers and the general public are especially invited. Cost includes a copy of *Rocks, Rails, and Trails* by Link and Phoenix. Cost: $25 (1 lunch). Limit 44.

8. Rocks, Rails, and Trails 2: The Oregon and California Trails and Hagerman Fossil Beds. Sunday, April 11 (9 a.m.–7 p.m.), Paul Link and Chilton Phoenix, Idaho State University, (208) 236-3846, linkpaul@isu.edu; Greg McDonald, Hagerman Fossil Beds National Monument.

The second half of this tour for geologists, teachers, and the general public will cover the Oregon and California Trail routes and geology through Massacre Rocks, Raft River, Silent City of Rocks, Shoshone Falls, Perrine Bridge, Thousand Springs, and Hagerman Fossil Beds National Monument. Lunch at Bath Rock will afford an opportunity to climb to the top of the rock, and sample the bathtub. Those wishing to take this climb need walking shoes with good tread. Cost includes a copy of *Rocks, Rails, and Trails* by Link and Phoenix (for those not participating in Part 1). Cost: $35 (1 lunch). Limit 44.

9. The Putnam Thrust Plate, Idaho: Dismemberment and Tilting by Tertiary Normal Faults. Saturday, April 10 (12:30 p.m.) through Sunday, April 11 (6 p.m.). Karl Kellogg, U.S. Geological Survey, Box 25046, MS 913, Denver, CO 80225, (303) 236-1305, kkellogg@usgs.gov; David Rodgers, Mark Kiessling, and Jim Riesterer, Idaho State University; Frank Hladky, Oregon Department of Geology and Mineral Industries.

This trip will focus on major contractional structures in the hanging wall of the Putnam thrust and how these structures were modified by Neogene extension. The thrust system, which involves Neoproterozoic to Triassic rocks, is characterized by multiple fault splays that may define a foreland dipping duplex. Rocks elsewhere in the thrust sheet are involved in a spectacular fold nappe defined by inverted and structurally thinned units. Normal faults and tilting associated with Basin and Range and Snake River Plain development were superimposed on the older thrust system, resulting in dismemberment and tilting of the contractional structures. Criteria to discriminate contractional and extensional structures will be emphasized throughout the trip. Several hikes across moderately steep terrain are planned. Participants will return to

Rocky Mountain *continued on p. 22*

PREREGISTRATION FORM

GSA Rocky Mountain Section

Pocatello, Idaho
April 8–10, 1999

Please print clearly • THIS AREA IS FOR YOUR BADGE

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

Employer/University Affiliation

City State or Country

Mailing Address (use two lines if necessary)

City State

ZIP Code Country (if other than USA)

Circle member affiliation: (A) GSA (B) AWG (C) NAGT (D) PS (E) SEPM

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

Name as it should appear on your guest's badge

City State or Country

Please inform us by March 10 of any special considerations that you or your guest require.

☐ I will need special considerations.

( ) – **Business Phone**

( ) – **fax**

( ) – Home Phone

Preregistration Deadline: March 5
Cancellation Deadline: March 12

MAIL TO: **GSA ROCKY MOUNTAIN SECTION MEETING, P.O. BOX 9140, BOULDER, CO 80301**

Remit in U.S. funds payable to: 1999 GSA Rocky Mountain Section Meeting
(All preregistrations must be prepaid. Purchase Orders not accepted.)

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

Card Number

Signature Expires

PREREGISTRATION FEES

	Full Meeting	One Day	Qty.	Amount
Professional Member	(10) $60 ☐	(11) $40 ☐	1	$
Professional Nonmember	(14) $60 ☐	(15) $40 ☐	1	$
Student Member	(30) $30 ☐	(31) $15 ☐	1	$
Student Nonmember	(32) $30 ☐	(33) $15 ☐	1	$
K–12 Professional	(60) $30 ☐	(61) $15 ☐	1	$
Guest or Spouse	(90) $10 ☐		1	$

SPECIAL EVENTS

1. Annual Banquet	April 8			
Beef roulades		(301) $ 20	__	$
Chicken cordon bleu		(302) $ 20	__	$
Vegetarian pasta		(303) $ 20	__	$
2. GSA Rocky Mtn. Management Board Breakfast	April 9	(304) FREE	__	$
3. IAPG Luncheon	April 9	(305) $ 12	__	$
4. Fun Run/Walk	April 9	(306) FREE	__	$
5. Spuds 'R' Us Millennium Bash	April 9	(307) $ 5	__	$

SPECIAL ACTIVITIES

1. Horseback Riding ☐ Morning preferred ☐ Afternoon preferred	April 8	(201) $ 32	__	$
2. Bird Watching	April 9	(202) $ 8	__	$
3. Idaho Museum of Natural History	April 9	(203) FREE	__	$

WORKSHOPS

1. ArcView GIS 3.1 (Full Day)	April 7	(601) $ 50	__	$
2. Introduction to ArcView GIS 3.1 (Half Day)	April 10	(602) $ 25	__	$

FIELD TRIPS

1. Past and Present Tectonics, Greater Yellowstone	April 6–7	(401) $120	1	$
2. Teton Canyon, Mesa Falls, West Slope Teton Range	April 6	(402) $ 35	1	$
3. Cedar Butte & Cogenetic Quaternary Rhyolite Domes	April 7	(403) $ 30	1	$
4. Holocene Flood History, Geomorphology, Big Lost River	April 7	(404) $ 50	1	$
5. Folded and Faulted Salt Lake Formation	April 7	(405) $ 30	1	$
6. Southeast Idaho Phosphate Field	April 7	(406) $ 30	1	$
7. Rocks, Rails, & Trails 1: Lake Bonneville, Oregon Trail	April 10	(407) $ 25	1	$
8. Rocks, Rails, & Trails 2: Ore., Calif. Trails, Hagerman Fossil Beds.	April 11	(408) $ 35	1	$
9. Putnam Thrust Plate, Idaho	April 10–11	(409) $ 65	1	$
10. Mafic Volcanism & Environmental Geology, Part 1	April 10	(410) $ 30	1	$
11. Mafic Volcanism & Environmental Geology, Part 2	April 11–12	(411) $ 55	1	$

FOR OFFICE USE

A _____ V _____ M _____
CK#_____

	DR	CR
Bal. A/R 1233		
Ref. A/P 2006		
Refund ck#		

TOTAL FEES REMITTED $_____

Rocky Mountain *continued from p. 20*

Pocatello for Saturday night lodging and meals, which are not included in the trip cost. Cost: $65 (2 lunches). Limit: 20.

10. Mafic Volcanism and Environmental Geology of the Eastern Snake River Plain, Part 1. Saturday afternoon, April 10 (12:30–6 p.m.). Scott Hughes, Idaho State University, (208) 236-4387, hughscot@isu.edu; Bill Hackett, WRH Consultants; Dick Smith, Lockheed-Martin Idaho Technologies Corporation; John Welhan, Idaho Geological Survey. Part 1 highlights Quaternary basaltic fissure eruptions that produced coalescent monogenetic shields, and phreatomagmatic eruptive centers that produced tuff cones and rings. Field stops will be at the Holocene Hells Half Acre lava field and the late Pleistocene Menan Buttes tuff cone complex. Discussion will focus on the construction of these volcanoes and the relation of eastern Snake River plain volcanism to the adjacent Basin and Range province. A no-host optional evening session with food and beverages is planned. Cost: $30 (1 lunch). Limit: 26.

11. Mafic Volcanism and Environmental Geology of the Eastern Snake River Plain, Part 2. Sunday, April 11 (8 a.m.) through Monday, April 12 (6 p.m.). Scott Hughes, Idaho State University, (208) 236-4387, hughscot@isu.edu, Bill Hackett, WRH Consultants; Dick Smith, Lockheed-Martin Idaho Technologies Company; Steve Anderson, U.S. Geological Survey.

Part 2 emphasizes Quaternary mafic volcanism on the axial volcanic zone and the Great Rift, dike-induced structures, phreatomagmatic eruptions, surficial processes, hydrogeology, and glacial cataclysmic flooding. Field stops will illustrate inflationary lava flow emplacement, basaltic shield growth, and fissure systems represented at several monogenetic lava fields. We will also visit Craters of the Moon lava field, a polygenetic and compositionally evolved eruptive system along the northern end of the Great Rift, and the Massacre volcanic complex, a sequence of basaltic tuffs and lava flows representing several phreatomagmatic vents along the Snake River. Participants will return to Pocatello for Sunday night lodging and meals, which are not included in the trip cost. A no-host optional evening session with food and beverages is planned. Cost: $55 (2 lunches). Limit: 26.

SPECIAL ACTIVITIES

Special activities are primarily offered for spouses and friends of meeting participants; however, they are not exclusive to meeting participants. Preregistration is suggested to get a head count. Besides the list below, there are many opportunities for family activities and travel in southeastern Idaho and surrounding areas. Popular geological and touring sites within 0–3 hours' drive include Yellowstone National Park, Jackson Hole, the Teton Range, Menan Buttes, Silent City of Rocks, Craters of the Moon National Monument, Sun Valley, Lava Hot Springs, Idaho Museum of Natural History, and Shoshone-Bannock Native American Reservation.

Horseback Riding, Thursday, April 8, Group 1 (morning) and Group 2 (afternoon); indicate which group is desired. Transportation to and from Cavanaugh's and a snack will be provided. Minimum: 4; maximum: 7. Cost: $32.

Bird Watching, Friday, April 9, 7 a.m.–noon. Chuck Trost, professor, Idaho State University Department of Biological Sciences, will show participants viewing sites for shorebirds and birds of prey within easy driving distance from Pocatello. Transportation to and from Cavanaugh's and lunch will be provided. Cost: $8.

Idaho Museum of Natural History, Friday, April 9, 2–4:30 p.m. This FREE outing will allow participants to visit the official state-supported museum located on the Idaho State University campus and to see some of the sites around the campus.

STUDENT TRAVEL SUPPORT

The GSA Rocky Mountain Section has funds to support travel to the meeting for students. Please submit requests to Ken Kolm, Div. of Environmental Science and Engineering Dept., Colorado School of Mines, Golden, CO 80401, kkolm@mines.colorado.edu. Applications must be received by *February 1, 1999.*

DETAILED INFORMATION

Other information concerning registration, lodging, activities, and the program will be provided in the Rocky Mountain Section *Abstracts with Programs.* Address general questions to Scott Hughes, Idaho State University, (208) 236-4387, hughscot@isu.edu; or visit our Web site at http://wapi.isu.edu/rm-gsa99, for additional details and information updates. ■

ORDER FORM—1999 *GSA Abstracts with Programs*

To purchase copies of *GSA Abstracts with Programs,* you may use this form. *Prepayment is required.* Members, provide member number and deduct your 20% discount. Check your records to make sure you have not previously purchased any of these publications on your dues statement, or through Publication Sales. No refunds for duplicate orders.

Meeting	Meeting Dates	List Price	Quantity	Amount
South-Central	3/15–3/16	$15		$
Northeastern	3/22–3/24	$15		$
Southeastern	3/25–3/26	$15		$
Rocky Mountain	4/8–4/10	$15		$
North-Central	4/22–4/23	$15		$
Cordilleran	6/2–6/4	$15		$
Annual Meeting (Denver)	10/25–10/28	$38.75		$
		Total		$
☐ Check here if GSA Member Members deduct 20%. It will not be applied later. →			–20%	$
Member # _____			TOTAL	$

SHIP TO:

Name _____

Address _____

_____

City _____ State ____ ZIP _____ Daytime Phone _____

METHOD OF PAYMENT:

☐ CHECK or MONEY ORDER (payable in U.S. funds on U.S. bank)

☐ Credit Card (Please print information)

MC VISA AmEx Diners (circle one) Exp. Date _____

Card No. _____

Signature of Cardholder _____

TO ORDER BY MAIL: Send this form to *GSA Publication Sales, P.O. Box 9140, Boulder, CO 80301-9140*

TO ORDER BY PHONE OR FAX *using a major credit card*
fax (24-hour line): 303-447-1133; or phone (303) 447-2020 or 1-800-472-1988 (8:00 a.m. to 4:30 p.m. MT)

ON-SITE PURCHASES may be made in the registration area at each meeting. Supplies are limited.

NORTH-CENTRAL SECTION, GSA 33rd Annual Meeting

Champaign, Illinois
April 22–23, 1999

The Illinois State Geological Survey, Department of Geology at the University of Illinois in Champaign-Urbana, and the U.S. Geological Survey Water Resources Division—Urbana, Illinois Office will host the 33rd Annual Meeting of the North-Central Section of the Geological Society of America. The meeting will be held at the Clarion Hotel and Convention Center in Champaign. Societies and organizations meeting with the North-Central Section include the Association for Women Geoscientists, Central Section of the National Association of Geoscience Teachers, Great Lakes Section of SEPM, and North-Central Section of the Paleontological Society. These organizations welcome you to Champaign-Urbana for two full days of scientific exchange, plus field trips and workshops.

SETTING

Champaign-Urbana (population 100,000), home of the main campus of the University of Illinois, is situated in east-central Illinois on a landscape consisting of broad, low end moraines and till plains formed during the retreat of the Wisconsin Episode glacier some 17,000 years ago. This glacial terrane is the setting for some of the world's richest farmland. Champaign-Urbana lies within the northern part of the Illinois Basin, a mineral-rich cratonic basin underlying much of Illinois and adjacent parts of Indiana and Kentucky. The University of Illinois campus is recognized widely as a major center for computing and technology and is a leader in building the national and global information superhighway. Visit our Web site (http://www.isgs.uiuc.edu/isgshome/fra1.html) to learn more about the history, culture, and opportunities in Champaign-Urbana.

REGISTRATION

Registration is required for all who participate in any event at the meeting, including technical sessions, symposia, workshops, field trips, exhibits, and planned social events.

Preregistration deadline:
March 19, 1999

Preregistration is encouraged to aid local committees in making final plans for the meeting. A discount is available to those who preregister by using the form provided in this announcement. Preregistration is required for field trips and workshops. Return the registration form provided herein with full payment by check or credit card to the Geological Society of America North-Central Meeting, P.O. Box 9140, Boulder, CO 80301-9140. Full payment MUST accompany registration. Please preregister only one professional, one student, or one K–12 professional per form. Guests preregistering for the meeting may register on the same form. A confirmation letter from GSA will be your receipt. Preregistration forms received after March 19, 1999, will be charged the on-site rate.

Early registration is strongly recommended for all field trips, workshops, and special activities because of limits on the number of participants.

Registration badges must be worn for access to all activities. Guest registration is required for attendance at the welcoming party, annual dinner, scheduled luncheons, and field trips. Guest rates are available for persons accompanying a professional, student, or K–12 professional registered for the meeting.

A current student ID is required to obtain student registration rates. Students who cannot produce a current student ID when they pick up their registration materials will be charged the full professional registration fee.

The *Abstracts with Programs* book may be purchased with your GSA membership renewal, or on site in the registration area.

Members pay less! You can join now or at the meeting. Come visit the GSA Membership Services area for new member applications, reinstatements, dues payment, address changes, questions, or concerns. Contact GSA for further information.

Access. The GSA North-Central Section is committed to making all events at the 1999 meeting accessible to all people interested in attending. The Clarion Hotel and Convention Center complies with all ADA requirements. If you have special requirements of any kind, please indicate this on the registration form or call Dennis R. Kolata at (217) 244-2189. We will be happy to make whatever arrangements we can to enable full participation in the meeting. If possible, please let us know by March 19, 1999, so that we will have time to make any necessary arrangements.

CANCELLATIONS, CHANGES, AND REFUNDS

All requests for registration additions, changes, and cancellations must be made in writing and received by March 26, 1999. Faxes to 303-447-0648 or 303-447-1133 will be accepted. Advance registrations will be refunded for all such cancellations.

North-Central *continued on p. 24*

MARK YOUR CALENDAR!

Shlemon mentors will be presenting one-day workshops during the GSA Northeastern, North-Central, and Cordilleran section meetings for graduate and senior undergraduate geology students on opportunities and challenges in applied geosciences.

Northeastern Section
March 21, 1999
North-Central Section
April 24, 1999
Cordilleran Section
to be announced

For more information, please contact Stacey Ginsburg at (303) 447-2020, ext. 194, or e-mail sginsburg@geosociety.org.

REGISTRATION FEES

	Advance*		On-Site	
	Full meeting	One day	Full meeting	One day
Professional Member	$65	$40	$75	$50
Professional Nonmember	$70	$45	$80	$55
Student Member	$30	$15	$35	$20
Student Nonmember	$35	$25	$40	$30
K–12 Professional	$25		$30	
Guest or Spouse	$10		$15	

**By March 19, 1999*

North-Central *continued from p. 23*

NO REFUNDS WILL BE MADE ON CANCELLATION NOTICES RECEIVED AFTER MARCH 26, 1999. Refunds paid by credit card will be credited according to the card number on the preregistration form. NO refunds will be given for on-site registration or ticket sales.

ON-SITE REGISTRATION SCHEDULE

Registration will be held in the lobby of University Hall at the Clarion Hotel and Convention Center. Registration hours are:
Wed., April 21 . . . . . 4:30 to 9 p.m.
Thurs., April 22 . . . 7:30 a.m. to 4:30 p.m.
Fri., April 23 . . . . . 7:30 a.m. to noon.

STUDENT PAPER AWARDS AND TRAVEL ASSISTANCE GRANTS

The North-Central Section of GSA will award $100 each for up to eight papers judged best in their respective technical session. The principal author and presenter must be a graduate or undergraduate student. Abstracts of papers submitted for consideration for these awards should be so indicated on the abstract form.

Grants for travel assistance of up to $200 (exclusive of field trip fees) are available to student members and associates of GSA. The assistance will be offered on a first-come, first-served basis, with priority given to students presenting oral or poster papers. To be eligible for travel assistance grants, students must be currently enrolled in an academic department and certify their student membership in GSA. Applications for travel assistance grants may be obtained from Jay D. Bass, Dept. of Geology, University of Illinois, 1301 W. Green St., Urbana, IL 61801-2999, (217) 333-3542, fax 217-244-4996, bass@hercules.geology.uiuc.edu. Applications for travel assistance must be received no later than March 12, 1999.

TECHNICAL PROGRAM

Questions regarding the technical program should be addressed to C. Pius Weibel, North-Central Section Program Coordinator, Illinois State Geological Survey, 615 E. Peabody Dr., Champaign, IL 61820, weibel@isgs.uiuc.edu. Technical sessions will begin at 8 a.m. on Thursday, April 22, 1999, and will conclude at 5 p.m. on Friday, April 23, 1999.

Symposia

Note: Illinois State Geological Survey address is 615 E. Peabody Dr., Champaign, IL 61820.

1. Karst Hydrology and Associated Water Quality in the Midcontinent. Samuel V. Panno, (217) 244-2456, panno@isgs.uiuc.edu, and C. Pius Weibel, (217) 333-5108, fax 217-244-2785, weibel@isgs.uiuc.edu, Illinois State Geological Survey.

2. Studies in Hydrogeology.
   A. Characterizing Agricultural Impacts on Shallow Groundwater Quality. Edward Mehnert, (217) 244-2765, mehnert@isgs.uiuc.edu, and William S. Dey, (217) 244-2779, fax 217-244-2785, dey@isgs.uiuc.edu, Illinois State Geological Survey.
   B. Modeling Geologic Environments for Hydrogeologic Applications. Donald A. Keefer, (217) 244-2786, dkeefer@isgs.uiuc.edu, and David R. Larson, (217) 244-2770, fax 217-244-2785, dlarson@isgs.uiuc.edu, Illinois State Geological Survey.
   C. Chemical and Isotopic Studies of Groundwater. Keith C. Hackley, (217) 244-2396, fax 217-244-2785, hackley@isgs.uiuc.edu, Illinois State Geological Survey; Thomas M. Johnson, (217) 244-2002, fax 217-244-4996, tmjohnsn@uiuc.edu, University of Illinois.
   D. Innovative Field Techniques and Equipment *(Posters).* Edward Mehnert, (217) 244-2765, fax 217-244-2785, mehnert@isgs.uiuc.edu, Illinois State Geological Survey.

3. Functional Morphology and Paleobiology of Extinct Vertebrates *(Sponsored by North-Central Section of the Paleontological Society).* James Farlow, (219) 481-6251, fax 219-481-6880, Farlow@ipfw.edu, Indiana University/Purdue University at Fort Wayne, Fort Wayne, IN 46805-1499.

4. Heinz A. Lowenstam Symposium on the Silurian System of the Central United States. Donald G. Mikulic, (217) 244-2518, fax 217-333-2830, mikulic@isgs.uiuc.edu, Illinois State Geological Survey; Joanne Kluessendorf, (217) 367-5916, fax 217-244-4996, jkluesse@uiuc.edu, University of Illinois.

5. Paleozoic Environments of the Midcontinent United States *(Sponsored by Great Lakes Section of SEPM).* Bruce W. Fouke, (217) 244-5431, fax 217-244-4996, bfouke@hercules.geology.uiuc.edu, Dept. of Geology, University of Illinois, 1301 W. Green Street, Urbana, IL 61801-2999; Zakaria Lasemi, (217) 244-6944, fax 217-244-2785, lasemi@isgs.uiuc.edu, Illinois State Geological Survey.

6. Coastal Geology in the Great Lakes Region: Accomplishments of the 20th Century: Challenges for the 21st Century. Michael J. Chrzastowski, (217) 244-2194, fax 217-244-0029, chrzasto@isgs.uiuc.edu, Illinois State Geological Survey.

7. Geologic Mapping in Glaciated Areas.
   A. Great Lakes Coalition on Geologic Mapping in Glaciated Areas. William W. Shilts, (217) 333-5111, fax 217-244-7004, shilts@isgs.uiuc.edu, Illinois State Geological Survey.
   B. Nature of the Sediment Record and How It Affects Mapping. Ardith K. Hansel, (217) 333-5852, hansel@isgs.uiuc.edu, and B. Brandon Curry (217) 244-5787, curry@isgs.uiuc.edu, Illinois State Geological Survey.
   C. The Importance of Geologic Mapping for Environmental Studies. Richard C. Berg, (217) 244-2776, fax 217-333-2830, berg@isgs.uiuc.edu, Illinois State Geological Survey.
   D. Geologic Mapping in Glaciated Areas: Advances and Applications *(Posters).* Barbara J. Stiff, (217) 244-2510, fax 217-333-2830, stiff@celadon.isgs.uiuc.edu, Illinois State Geological Survey; Peter T. Lyttle, (703) 648-6943, fax 703-648-6937, plyttle@usgs.gov, U.S. Geological Survey, Reston.

8. Tectonics and Seismicity in the Midcontinent U.S. John H. McBride, (217) 333-5107, fax 217-333-2830, mcbride@isgs.uiuc.edu, Illinois State Geological Survey.

9. Economic Geology of Mineral and Energy Resources of the Midcontinent United States. Subhash B. Bhagwat, (217) 333-7409, fax 217-333-2830, bhagwat@isgs.uiuc.edu, Illinois State Geological Survey.
   A. Construction Aggregates and Associated Minerals.
   B. Industrial Minerals Other Than Construction Aggregates.
   C. Fossil Fuels and Associated Minerals.
   D. Economics of Groundwater Resources.

10. Outreach: A Necessity for Our Profession *(Sponsored by Central Section of the National Association of Geoscience Teachers).* Myrna M. Killey, (217) 244-2409, killey@isgs.uiuc.edu, and Janis D. Treworgy, (217) 244-6942, janis@isgs.uiuc.edu, Illinois State Geological Survey, fax 217-333-2830.
   A. Oral Session.
   B. Poster Session—Hands-On and High-Tech Activities: Making Geoscience Readily Understandable.

11. Geoarchaeological Burial Processes. Donald L. Johnson, (217) 333-0589, dljohns@uiuc.edu, Dept. of Geography, University of Illinois, 220 Davenport Hall, Urbana, IL 61801; E. Arthur Bettis III, (319) 335-1578, art-bettis@uiowa.edu, University of Iowa.

12. Midwestern Geologists: Late 19th Century–Early 20th Century. Ralph L. Langenheim, Jr., (217) 333-1338, fax 217-244-4996, rlangenh@staff.uiuc.edu, Dept. of Geology, University of Illinois, 1301 W. Green St., Urbana, IL 61801-2999.

13. Is "Geology and Public Policy" Just Another Oxymoron? Thomas J. Evans, (608) 263-4125, fax 608-262-8086, tevans@facstaff.wisc.edu, Wisconsin Geological and Natural History Survey, 3817 Mineral Point Rd., Madison, WI 53705.

PROJECTION EQUIPMENT

Two standard 35 mm carousel projectors for 2″ × 2″ slides and two viewing

screens will be provided in each meeting room. An overhead projector for transparencies will be available for each room as well. A speaker-ready room equipped with projectors will be available for review of slides and overheads and for speaker preparation. Each carousel to be used in an oral presentation should be clearly identified with the speaker's name, session number, and speaker number. Carousels must be turned in to the projectionists at the beginning of the appropriate technical session.

Speakers are encouraged to load slides in their own carousels. A few carousels will be available for loan to those unable to supply their own, but these will be loaned out on a first-come, first-served basis and *must* be returned to the speaker-ready room immediately following the technical session in which they are used.

POSTER SESSIONS

Students and professionals are encouraged to take advantage of this effective means of presentation. Please indicate *poster session* on the GSA abstract form. Each poster booth will contain two attached panels, each 4 × 4 feet, made of soft particle board and arranged at table height. Poster sessions will be in the Alumni Room of the Clarion Hotel and Convention Center. Posters will be available for viewing for four hours during each session.

Special Poster Session on Undergraduate Research *(Sponsored by the Geology Division of the Council on Undergraduate Research).* These posters, written and presented by undergraduate students, will form a separate poster session or be part of another poster session, depending on the response. Co-authored papers for which the student is senior author will also be considered. Undergraduate students who have been involved in research are strongly urged to submit abstracts on their research projects, activities, techniques, and/or preliminary results. For additional information, contact Robert D. Shuster, (402) 554-2457, fax 402-554-3518, bshuster@cwis.unomaha.edu, Dept. of Geography-Geology, University of Nebraska at Omaha, Omaha, NE 68182.

WORKSHOPS

Preregistration is encouraged so that organizers may prepare adequate numbers of printed materials. Additional information can be obtained from the organizers, whose names and addresses are given below.

1. Great Lakes Section—SEPM Short Course—Tidal Rhythmites. Erik P. Kvale (812) 855-1324, kvalee@indiana.edu, and Maria Mastalerz (812) 855-9416, fax 812-855-2862, mmastale@indiana.edu, Indiana Geological Survey, 611 Walnut Grove, Bloomington, IN 47405; Allen W. Archer, (785) 532-2244, aarcher@ksu.edu, Kansas State University; Norman C. Hester, Indiana University, Bloomington.

This one-day course will focus on the recognition, depositional setting, and significance of modern and ancient tidal rhythmites. Tidal rhythmites consisting of very thin to thickly laminated sediments that preserve distinct tidal periodicities are known from a variety of modern (meso- to macrotidal) and ancient (Precambrian, Paleozoic, and Cretaceous) depositional settings. Many examples of ancient tidal rhythmites have been found in successions once thought to have been totally nonmarine. Thus, their recognition has obvious implications for the understanding of depositional environments and paleogeography.

Exercises and discussions will range from physical (cores and slabs) to analytical (time-series, geochemical, geophysical log, and petrological analyses). Techniques will be presented for studying tidal rhythmites, their depositional context, the recognition of astronomically forced tidal cycles, and the application of tidal, rhythmite-bearing facies to sequence stratigraphy, basin analysis, paleoclimatology, and paleoastronomy. Discussions will also include the economic implications of the occurrence of tidal rhythmites and associated facies to the exploration and production of energy resources (hydrocarbons and coal). Specifically, we will discuss what the recognition of tidal, rhythmite-bearing facies implies regarding sandstone geometries and architecture within estuarine and tide-dominated deltaic systems as well as their association with freshwater deposits such as low-sulfur coals. Formal presentations by the instructors will be combined with group exercises and discussions utilizing cores, geophysical logs, and slabs. Wednesday, April 21, 1999, 8 a.m. to 5 p.m., Patio Room, Clarion Hotel and Convention Center; $45 for students (includes course notes, lunch, two coffee breaks; does not include SEPM Tidal Rhythmite poster); $67 for professionals (includes course notes, lunch, two coffee breaks, and SEPM Tidal Rhythmite poster).

2. Exploring the Solar System in the Classroom: Hands-On Approach. Cassandra R. Coombs, (803) 953-8279, coombsc@cofc.edu, Dept. of Geology, College of Charleston, 58 Coming St., Charleston, SC 29424; Eileen Herrstrom, (217) 244-6172, fax 217-244-4996, herrstro@uiuc.edu, University of Illinois.

Have you ever wondered what another planet's surface looked like, or how it formed? Come explore our solar system in a fun-filled, action-packed, day-long workshop. We will use numerous hands-on activities to explore geologic processes that operate on Earth and on other bodies in our solar system. Workshop activities are targeted at teachers of grades 4–8, pre-service teachers, and others who work with upper elementary and secondary teachers and students. Participants will receive classroom materials including recent posters, maps, slide sets, activity workbooks, and much more. Saturday, April 24, 1999, 8 a.m. to 5 p.m., Grange Room, Clarion Hotel and Convention Center, $10 (includes lunch).

3. Introduction to Geographic Information Systems: Applications for Geologic Mapping. Robert J. Krumm, (217) 333-4085, fax 217-333-2830, krumm@isgs.uiuc.edu, Illinois State Geological Survey, 615 E. Peabody Dr., Champaign, IL 61820.

This workshop will be targeted at people who are either just beginning to work with GIS or are still looking at GIS. It will provide an introduction to basic concepts, issues, and acronyms, and in particular, will focus on the use of GIS to support geologic mapping activities. The workshop will not include hands-on instruction, but we will present a number of on-line software demonstrations. We will present an overview of GIS technology including software, hardware, and digital databases. We will provide information on no-cost and low-cost software and data, as well as Internet GIS applications, including how to find on-line databases and how to serve maps on the World Wide Web. In addition, we are prepared to address other specific topics, and we welcome input from those attending the workshop. If you have specific ideas or suggestions for topics that you would like to see addressed in this workshop, please contact Robert Krumm. Saturday, April 24, 1999, 9 a.m. to 4 p.m., Illinois State Geological Survey, Conference Room (Room 101), $35 (includes lunch).

4. Roy Shlemon Mentors in Applied Geology Program: Workshop for Students *(Sponsored by the Institute for Environmental Education).* This program brings experienced geologists currently practicing in various fields of applied geology (Mentors) together with graduate and advanced undergraduate geology students for a one-day workshop that focuses on professional opportunities and challenges in the applied geosciences. Thomas A. Prickett, internationally known consulting groundwater hydrologist, will present the workshop. There is no charge to students; however, preregistration is required as space may be limited. Use the registration form included in this announcement. Saturday, April 24, 1999, 8 a.m. to 5 p.m., Champaign-Krannert-Urbana Rooms, Clarion Hotel and Convention Center; no charge; includes lunch.

North-Central *continued on p. 26*

North-Central *continued from p. 25*

FIELD TRIPS

Field trip coordinators are Janis D. Treworgy (217) 244-6942, janis@isgs.uiuc.edu, and Myrna M. Killey (217) 244-2409, fax 217-333-2830, killey@isgs.uiuc.edu, Illinois State Geological Survey, 615 E. Peabody Dr., Champaign, IL 61820. All inquiries about field trip arrangements should be directed to Janis Treworgy. All trips begin and end at the east entrance to the Clarion Hotel and Convention Center, 1501 South Neil St., Champaign, IL 61820. Parking is available at the hotel. Trip charge includes van or coach transportation, double occupancy lodging on overnight trips, guidebook, meals, and snacks (except as indicated for each trip).

Premeeting

1. Glacial Sediments, Landforms, Paleosols, and a 20,000-Year-Old Forest Bed in East-Central Illinois. Ardith K. Hansel,(217) 333-5852, hansel@isgs.uiuc.edu, and Richard C. Berg, (217) 244-2776, berg@isgs.uiuc.edu, Illinois State Geological Survey, 615 E. Peabody Drive, Champaign, IL 61820, fax 217-333-2830; Vince Gutowski, (217) 581-3825, cfvpg@ux1.cts.eiu.edu, Eastern Illinois University.

We will traverse classic Wisconsin Episode end moraines, till plains, and lake plains from Champaign southward to the Shelbyville moraine and make a brief loop beyond the moraine to view the more dissected Illinoian till plain. En route, we will visit Charleston Quarry, where a buried 20,000-year-old forest rooted in the Farmdale Geosol overlies the last interglacial soil. Depressions in the Farmdale Geosol (mastodon footprints?) will be examined, as well as proglacial lacustrine, fluvial, and subaqueous flow deposits beneath subglacial till that contains sand lenses and bodies (deformed subglacial channel fills?). After lunch at Fox Ridge State Park, where a series of ravines in the Shelbyville moraine can be seen, we will visit Tuscola Quarry, where deposits of three glacial episodes and four nonglacial episodes are exposed. Mapping techniques in terrain with few exposures will be discussed at this stop.

Depart at 8 a.m. on Wednesday, April 21, and return by 4:30 p.m. Hard hats required at quarry stops. Cost: $45.

Postmeeting

2. Geology, Hydrology, and Water Quality of the Karst Regions of Southwestern Illinois and Southeastern Missouri. Samuel V. Panno, (217) 244-2456, panno@isgs.uiuc.edu, and C. Pius Weibel, (217) 333-5108, weibel@isgs.uiuc.edu, Illinois State Geological Survey, 615 E. Peabody Dr., Champaign, IL 61820, fax 217-244-2785; Carol Wicks, (573) 882-3231, geosccw@showme.missouri.edu, University of Missouri, Columbia; James E. Vandike, (573) 368-2194, Missouri Department of Natural Resources, Division of Geology and Land Survey.

Classic karst terrains, replete with large, closely spaced sinkholes, extensive cave systems, and large springs await the participant. Compare and contrast the landscapes of the Illinois loess-covered, Mississippian limestones with Missouri's thinly covered, Ordovician dolomites that bound the Mississippi River valley. Explore the well-decorated, branch-work labyrinth of Illinois Caverns. Investigate a cave spring that becomes a picturesque waterfall as it plunges 50 feet down a tufa-encrusted, limestone bluff. Discover why 60% of all wells drilled in the Illinois sinkhole plain produce undrinkable water. Prepare to experience karst geology and hydrogeology from the surface and subsurface, and don't forget your hiking boots, hard hat, and flashlight.

Depart Saturday, April 24, at 7 a.m. (no breakfast included) and return Sunday, April 25, by 6 p.m. Cost: $150.

3. Quaternary Geology, Geomorphology, and Climatic History of Kane County, Illinois. B. Brandon Curry, (217) 244-5787, curry@isgs.uiuc.edu, and David A. Grimley, (217) 244-7324, grimley@isgs.uiuc.edu, Illinois State Geological Survey, 615 E. Peabody Dr., Champaign, IL 61820, fax 217-333-2830; Jay Stravers, (815) 753-7927, fax 815-753-1945, jay@geol.niu.edu, Northern Illinois University.

We will use a multidisciplinary approach to understand the Quaternary geology and landforms of Kane County, a rapidly developing area west of Chicago. We will examine the sedimentary facies of four glacigenic diamicton units and sorted sediment, and relate these units to recent 1:24,000-scale mapping. Of special interest are (1) an interstadial deposit that contains 15,000-year-old seeds, leaves, ostracodes, and molluscs that lived under tundra conditions, (2) several 25,000-year-old spruce tree stumps in the Farmdale Geosol above the Sangamon Geosol, and (3) the late glacial and postglacial climatic history and paleohydrology of Nelson Lake. We will stop at the threatened spring-fed trout ponds of Fisherman's Inn and traverse several moraines, the Kaneville esker, ice-stagnation topography, lake basins, outwash channels, and the gorgeous Fox River Valley.

Plan A. Depart from Champaign on Friday, April 23, at 5:30 p.m. and return to Champaign Saturday, April 24, by 9:30 p.m. Dinner both nights is en route, but not included in trip cost. If you drive your own car to St. Charles and wish to lodge with the group, please register for Plan A; the price difference is just the cost of the motel (double occupancy). Cost: $115.

Plan B. Depart from Super 8 Motel in St. Charles, Illinois on Saturday, April 24, at 7:45 a.m. and return to Super 8 by 5 p.m. Cost: $75.

4. Silurian Depositional Environments and Sequence Stratigraphy of the Northern Edge of the Illinois Basin. Donald G. Mikulic, (217) 244-2518, fax 217-333-2830, mikulic@isgs.uiuc.edu, Illinois State Geological Survey, 615 E. Peabody Drive, Champaign, IL 61820; Joanne Kluessendorf, (217) 367-5916, fax 217-244-4996, jkluesse@uiuc.edu, University of Illinois.

We will visit classic exposures in northeastern Illinois that have played an important role in determining the Silurian sequence stratigraphy and depositional history of the region. Taking advantage of the extensive quarry exposures, we will examine the entire Silurian section. The Thornton reef, which is one of the best-exposed Paleozoic reefs in the world, will be highlighted. Many seminal concepts of reef paleoecology were formulated at this reef by Heinz Lowenstam and others. Understanding reef growth there has aided the economic development of the aggregate and petroleum industries in the Great Lakes area.

Depart Friday, April 23, at 6:30 p.m. (after dinner) and return Saturday, April 24, by 7:30 p.m., with a dinner stop en route (not included in cost). Cost: $85.

5. Neotectonics of the Southern Illinois Basin. W. John Nelson, (217) 244-2428, fax 217-333-2830, jnelson@isgs.uiuc.edu, Illinois State Geological Survey, 615 E. Peabody Drive, Champaign, IL 61820; Richard W. Harrison, (703) 648-6928, rharriso@usgs.gov, U.S. Geological Survey, Reston; David Hoffman, (573) 368-2144, nrhoffd@mail.dnr.state.mo.us, Missouri Department of Natural Resources.

This two-day trip will highlight Quaternary tectonic faulting just north of the active New Madrid seismic zone in southeastern Missouri and southern Illinois. We will visit trenches and stream banks that display multiple episodes of deformation ranging from early Tertiary through Holocene. These findings demonstrate that tectonic activity has occurred in different regions of the northern Mississippi embayment area at various times during the Quaternary. The New Madrid seismic zone is only the most recent manifestation of this activity.

Depart Friday, April 23, at 5:30 p.m. (includes dinner en route) and return Sunday, April 25, by 5 p.m. Cost: $170.

6. Depositional Facies and Sequence Stratigraphy of the Middle Mississippian Warsaw Shale and Salem, St.

North-Central *continued on p. 28*

PREREGISTRATION FORM

GSA North-Central Section

Champaign-Urbana, Illinois
April 22–23, 1999

Please print clearly • THIS AREA IS FOR YOUR BADGE

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

Employer/University Affiliation

City State or Country

Mailing Address (use two lines if necessary)

City State

ZIP Code Country (if other than USA)

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

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

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

Name as it should appear on your guest's badge

City State or Country

Please inform us by March 19 of any special considerations that you or your guest require.

☐ I will need special considerations.

( ) – **Business Phone**

( ) – **fax**

( ) – Home Phone

Preregistration Deadline: March 19
Cancellation Deadline: March 26

MAIL TO: **GSA NORTH-CENTRAL SECTION MEETING**
P.O. BOX 9140, BOULDER, CO 80301

Remit in U.S. funds payable to: 1999 GSA North-Central Section Meeting
(All preregistrations must be prepaid. Purchase Orders not accepted.)

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

Card Number

Signature Expires

PREREGISTRATION FEES

	Full Meeting	One Day	Qty.	Amount
Professional Member*	(10) $65 ☐	(11) $40 ☐	1	$
Professional Nonmember	(14) $70 ☐	(15) $45 ☐	1	$
Student Member*	(30) $30 ☐	(31) $15 ☐	1	$
Student Nonmember	(32) $35 ☐	(33) $25 ☐	1	$
K–12 Professional	(60) $25 ☐		1	$
Guest or Spouse	(90) $10 ☐		1	$

*Member fee applies to any current Professional OR Student Member of GSA or Associated Societies listed at left. Discount does not apply to guest registrants.

SOCIAL EVENTS

1. GSA N-C Section Management Board Breakfast	April 22	(301) FREE	1	$
2. Paleontological Society/SEPM Luncheon	April 22	(302) $ 12	__	$
3. Annual Banquet	April 22	(303) $ 22	__	$
4. AWG Breakfast	April 23	(304) $ 10	__	$
5. GSA N-C Campus Reps Breakfast	April 23	(305) FREE	1	$
6. NAGT Luncheon	April 23	(306) $ 11	__	$

WORKSHOPS

1. GL Section SEPM Course—Tidal Rhythmites	April 21			
	Professional	(601) $ 67	__	$
	Student	(601) $ 45	__	$
2. Exploring the Solar System: Hands-On Approach	April 24	(602) $ 10	__	$
3. Intro to Geographic Information Systems	April 24	(603) $ 35	__	$
4. Roy Shlemon Mentors Program	April 24	(604) FREE	1	$

FIELD TRIPS

1. Glacial Sediments, Landforms, Paleosols	April 21	(401) $ 45	1	$
2. Geology, Hydrology, Water Quality—Karst Regions	April 24–25	(402) $150	1	$
3. Quaternary Geol., Geomorphol., Climate History	April 24			
	Plan A	(403) $115	1	$
	Plan B	(404) $ 75	1	$
4. Silurian Depositional Environments, Illinois Basin	April 23	(405) $ 85	1	$
5. Neotectonics of the Southern Illinois Basin	April 23–25	(406) $170	1	$
6. Depositional Facies, Sequence Stratigraphy	April 24–25	(407) $ 125	1	$

FOR OFFICE USE

A _____ V _____ M _____
CK#_____

	DR	CR
Bal. A/R 1233		
Ref. A/P 2006		
Refund ck#		

TOTAL FEES REMITTED $_____

North-Central *continued from p. 26*

Louis, and Ste. Genevieve Limestones in Western Illinois. Zakaria Lasemi, (217) 244-6944, lasemi@isgs.uiuc.edu; Rodney D. Norby, (217) 244-6947, norby@isgs.uiuc.edu; Joseph A. Devera, (618) 985-3394, jdevera@siu.edu; and Hannes E. Leetaru, (217) 333-5058, leetaru@isgs.uiuc.edu, Illinois State Geological Survey, 615 E. Peabody Dr., Champaign, IL 61820, fax 217-244-2785; Bruce W. Fouke, University of Illinois at Urbana-Champaign.

This trip will focus on the depositional facies of the middle Mississippian (Meramecian) formations as seen in roadcuts and quarries in the East St. Louis area of Illinois. We will discuss litho- and biostratigraphic relationships, examine oolitic shoals and the shoaling-upward cycles within the Salem and Ste. Genevieve Limestones, analyze sequence stratigraphic relationships, present the regional structural picture, examine faults, and discuss depositional facies in relation to limestone resources and hydrocarbon reservoirs.

Depart Saturday, April 24, at 7 a.m. (no breakfast included) and return Sunday, April 25, by 5 p.m. Hard hats required at quarry stops. Cost: $125.

BUSINESS MEETINGS AND SOCIAL EVENTS

All special events and business meetings will be held at the Clarion Hotel and Convention Center. A Welcoming Reception will be held on Wednesday evening, April 21, 1999, 6 to 8:30 p.m., in the Alumni Room.

The GSA North-Central Section Management Board will hold its business meeting with breakfast on Thursday morning, April 22, 1999, in the Skylight Room, beginning at 7 a.m.

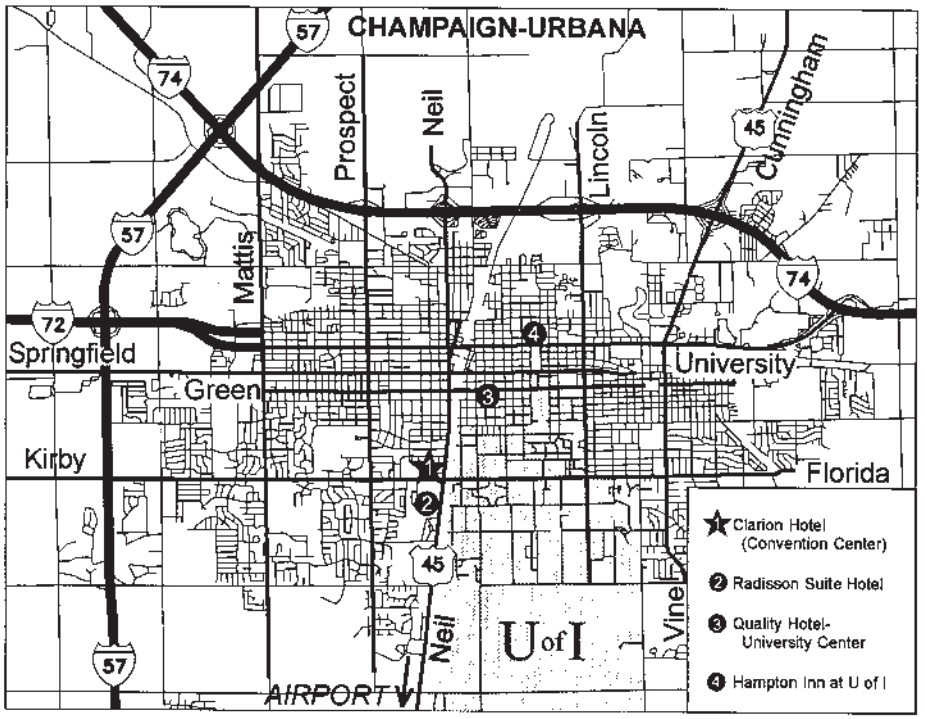
The North-Central Section of the Paleontological Society and the Great Lakes Section of SEPM will meet jointly for lunch at noon on Thursday, April 22, in the Skylight Room. Please register in advance for this luncheon. Cost: $12.

The Annual Banquet will be held in the Skylight Room on Thursday evening, April 22, preceded by a social hour beginning at 6 p.m. Please register in advance. Cost: $22.

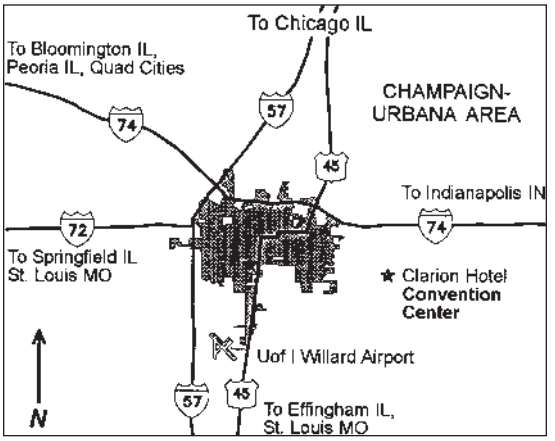
A Special Address will follow the Annual Banquet at 8 p.m. in the Wisconsin Room on the main floor and accessible to those who do not attend the banquet. There is no charge for attendance at this event.

Breakfast meetings are scheduled for 7 a.m., Friday, April 23, for GSA North-Central Section Campus Representatives in the Patio East Room (no charge) and the Association for Women Geoscientists in the Patio West Room (cost: $10). Preregistration is required for both.

A luncheon will be held at noon Friday, April 23, in the Patio Rooms for the Central Section of the National Association of Geoscience Teachers. Cost: $11.



CHAMPAIGN-URBANA AREA MAPS



SPECIAL ACTIVITIES AND EVENTS

Alternative opportunities for registrants and guests will be available during the meeting, including informally organized and hosted trips to sites of interest in the Champaign-Urbana area. Registration is not required for these ad hoc events, but those who might be interested should leave their local address and telephone number at the Registration Desk in the lobby outside University Hall at the Clarion Hotel and Convention Center.

MEALS

There are numerous restaurants within easy walking distance of the Clarion Hotel and Convention Center. A selected list of restaurants with additional information on price ranges, available ethnic cuisines, and addresses will be included in the registration materials available at the meeting.

ACCOMMODATIONS

A large block of rooms has been reserved at the Clarion Hotel and Convention Center, the meeting center and location of all major meeting events, and smaller blocks of rooms have been reserved at other nearby hotels. Meeting registrants and guests are responsible for making their own lodging arrangements. Reservations should be made no later than March 20, 1999, to guarantee the special room rates that have been negotiated for this meeting. Be sure to indicate that you are participating in the North-Central Section of the Geological Society of America meeting to receive the special room rate. Meeting registrants are encouraged to take advantage of the more economical and convenient facilities at the Clarion Hotel and Convention Center by registering to stay at the meeting center.

1. Clarion Hotel and Convention Center. 1501 South Neil St., Champaign, IL 62820, (217) 352-7891; $49 Single, $60 Double, $80 Triple.
2. Radisson Suite Hotel. 101 Trade Centre Dr., Champaign, IL 62820, (217) 398-3400; $62 Single, $72 Double.
3. Quality Hotel—University Center. 302 E. John St., Champaign, IL 62820, (217) 383-2277; $56 Single, $64 Double.
4. Hampton Inn at U of I. 1200 W. University Ave., Urbana, IL 61801, (217) 337-1100; $59 Single, $65 Double.

GETTING TO CHAMPAIGN

The Clarion Hotel and Convention Center is located in Champaign adjacent to the campus of the University of Illinois. Champaign is reached by major highways including I-74, I-72, I-57, U.S. Hwy. 150, and U.S. Hwy. 45. Champaign is served by several airlines via the University of Illinois Willard Airport, is a hub for Greyhound Bus, and is served by Amtrak from Chicago or New Orleans.

PARKING

Parking at the Clarion Hotel and Convention Center is abundant and free to registrants who are also staying in the hotel.

EXHIBITS

Exhibits of educational and commercial organizations will be on display in the Alumni Room of the Clarion Hotel and Convention Center close to the symposia, technical sessions, and displays and in the same room as the poster sessions. Exhibit space must be reserved by *March 19, 1999*. For further information, contact Jennifer K. Hines, (217) 244-2410, fax 217-244-0802, hines@isgs.uiuc.edu, Illinois State Geological Survey, 615 East Peabody Dr., Champaign, IL 61820.

ADDITIONAL INFORMATION

Visit our Web site at http://www.isgs.uiuc.edu/isgsroot/gsa-site/gsahome.html for the latest information. Inquiries, requests, or suggestions should be directed to General Chair Dennis R. Kolata, (217) 244-2189, fax 217-333-2830, kolata@isgs.uiuc.edu, GSA North-Central Section, Illinois State Geological Survey, 615 East Peabody Dr., Champaign, IL 61820. ■

Ophiolites and Oceanic Crust: New Insights from Field Studies and Ocean Drilling Program

Conveners
Yildirim Dilek, Department of Geology, Miami University, Oxford, OH 45056, dileky@muohio.edu
Eldridge M. Moores, Department of Geology, University of California, Davis, CA 95616, moores@topaz.ucdavis.edu
Don Elthon, National Science Foundation, Arlington, VA 22230, delthon@nsf.gov
Adolphe Nicolas, Université Montpellier II—CNRS, 34095 Montpellier, France, tectono@dstu.univ-montp2.fr

Ophiolites have been of particular importance in the reconstruction of ancient plate boundaries ever since their recognition as on-land fragments of oceanic lithosphere. The internal architecture of well-preserved ophiolite complexes shows that ophiolites are good structural analogues for oceanic crust, providing three-dimensional exposures and age relations to study the nature of extensional tectonics and magmatic construction in oceanic spreading environments. Thus, ophiolites complement significantly our knowledge of the architecture and generation of oceanic crust that is derived mainly from seismic images and drill holes at mid-ocean ridges. However, the geodynamic setting of many ophiolites remains controversial, as a result of petrological and geochemical observations that imply magmatic affinities to subduction zone settings, rather than mid-ocean ridge environments. Recent multidisciplinary studies of intact ophiolites and drilled core samples of modern oceanic crust from various mid-ocean ridge and subduction zone settings have provided significant information on the mantle heterogeneity, magma chamber processes, melt migration, and geochemical evolution of magma in these modern tectonic settings and in ancient spreading environments, thus leading toward a better understanding of oceanic crust formation and toward resolving the structural-geochemical conundrum. Within this context, we organized a Geological Society of America Penrose Conference to bring together a multidisciplinary group of geoscientists from the communities of ophiolite geology and marine geology and geophysics to reevaluate the existing models on oceanic crust generation, ophiolite formation, and ophiolite-ocean crust analogy; to explore the possibility of reaching a new consensus on the architecture of oceanic lithosphere; and to discuss the significance of ophiolites and oceanic crust for the present plate tectonic processes and for processes in the geological past. The timing of this meeting nearly coincided with the 25th anniversary of the first Penrose Field Conference on ophiolites, during which the definition of an ophiolite was developed.

The conference, "Ophiolites and Oceanic Crust: New Insights from Field Studies and Ocean Drilling Program" was convened in Marshall, California, September 13–17, 1998. It brought together 86 earth scientists, with backgrounds ranging from structural geology, tectonics, and geophysics to petrology and geochemistry. Participants, of whom 12 were students, came from 12 countries.

PRESENTATIONS AND PANEL DISCUSSIONS

The conference was organized into five major sessions: 1—Structural and magmatic processes at oceanic spreading centers; 2—Ophiolite–ocean crust analogy and field observations; 3—Petrology and geochemistry of oceanic crust and ophiolites; 4—Hydrothermal alteration and mineralization of oceanic crust and ophiolites; 5—Active margin tectonics, orogeny, and emplacement mechanisms of ophiolites. The invited talks introduced an overview of current ideas, observations, and interpretations on various themes and case studies related to these topics. In addition, the two evening sessions on Ophiolites and the Sedimentary Record (Robert Coleman and Emile Pessagno, Jr.) and Current Thoughts on the California Coast Ranges (John Shervais, Ray Ingersoll, and Clifford Hopson) highlighted some of the unresolved questions and outstanding controversies on the geological evolution of the Jurassic ophiolites and the Mesozoic active margin tectonics of the western United States, and provided a stimulus for the field trip to the California Coast Ranges on the third day of the meeting. Another informal evening session gave us an opportunity to learn about the geology of oceanic crust exposed on Macquarie Island (Australia) through Rick Varne's (University of Tasmania) slide presentation. A daily panel discussion facilitated exchange among the diverse participants. This format was most effective in providing a forum that promoted active participation of all attendees and cross-pollination of ideas from investigators in both oceanic and continental terranes and diverse approaches of field geology, geochemistry, and geophysics.

In the first session, Ken Macdonald presented the evidence and significance of off-axis volcanic activity for melt distribution beneath mid-ocean ridges and for the evolution of oceanic crust. He noted that the highly asymmetric zone of primary melting at the East Pacific Rise near 17°S, as deduced from the MELT (Mantle Electromagnetic and Tomography) experiment, mimics the asymmetric distribution of seamount chains and the asymmetry in seafloor subsidence in the area. He concluded that processes occurring as deep as 200 km beneath the oceanic crust may have an imprint on the seafloor that can be mapped. Jeff Karson emphasized the complexity and the heterogeneity of the internal structure of both modern oceanic crust and ophiolite. This complex structure is an artifact of highly asymmetric magmatic and tectonic processes operating at mid-ocean ridges which create "tectonic windows," major faulted escarpments on the seafloor, where crustal and mantle structures can be investigated in three dimensions. Henry Dick presented a comparison of structural and magmatic processes at spreading centers, as seen from in situ lower oceanic crust and shallow mantle. He discussed the occurrence of large variations in the stratigraphy of the ocean crust at slow-spreading ridges, reflecting along-axis transport of melt in the lower crust from a central intrusive center, and the significance of synmagmatic deformation in melt transport and igneous differentiation. These observations indicate that the evolution of slow-spreading oceanic crust deviates significantly from the Penrose ophiolite paradigm. Peter Kelemen addressed the topics of magmatic processes and melt transport in the mantle and the nature of crust-mantle transition. He discussed the probability of porous flow processes controlling the first-order geometry of melt-transport networks beneath ridges and producing trace element enrichments.

In the second session, Eldridge Moores discussed the significance of the scale and distribution of mantle heterogeneity for the generation of ophiolitic magmas. The composition of magmas at spreading centers may depend upon a complex tectonic history lasting for millions of years. Moores stated that geochemical indicators must be used integrally in concert with geological informa-

tion to obtain the most robust tectonic interpretation of a given ophiolite. Tjerk Peters presented the geology of the Masirah ophiolite on the southeast Arabian continental margin and discussed its evolution at a ridge-transform intersection in the proto–Indian Ocean. The unusually thin (~500 m) plutonic sequence in the Masirah ophiolite might have been related to a weak magma supply as a result of the "cold-edge effect" of the bounding continental blocks, rather than tectonic thinning. Jean Bédard described syntectic assimilation processes and magmatic differentiation patterns in the plutonic sequence of the Bay of Islands (Newfoundland) ophiolite and discussed their significance in development of melt evolution and crustal heterogeneity at all scales. This discussion suggests that the assumption of fractional crystallization being the only process controlling melt evolution may generate incorrect calculations of parental melts, leading to erroneous conclusions about mantle sources and processes. Hans Schouten compared the structure of the volcanic stratigraphy drilled in Ocean Drilling Program (ODP) Hole 504B at the Costa Rica Rift and in Hole CY-1/1A in the Troodos ophiolite, Cyprus, and suggested that the contrasting kinematic histories and deformation in the lavas and sheeted dikes in 504B and near CY-1/1A may reflect their contrasting mechanical response to lava burial, rather than faulting.

Julian Pearce began the third session by summarizing new and published methods, each of which yields a geochemical fingerprint that can be related to present tectonic settings empirically and/or using petrogenetic reasoning. He discussed several modern analogues for oceanic crust formation in suprasubduction-zone environments and the processes affecting arc magma composition in these settings. Elisabetta Rampone presented an overview of the petrogenesis of the Ligurian ophiolites in the Apennines of Italy and discussed the occurrence of the Jurassic MORB-type oceanic crust in the Internal Liguride belt and variably old subcontinental lithospheric mantle in the External Liguride belt. The data thus suggest that the Ligurian ophiolites do not represent the remnants of mature oceanic lithosphere, but rather an early stage of ocean crust formation in the Ligurian Tethys. Stephen Edwards addressed melt migration and reaction in conductive mantle lithosphere with a specific reference to the Bay of Islands ophiolite and discussed the potential of these processes to cause significant chemical modification of melt and mantle at shallow depth. Paul Robinson reviewed the structure, stratigraphy, and petrology of lower oceanic crust, formed at the Southwest Indian Ridge, that has been drilled in ODP Hole 735 B, and compared its characteristics to those of well-known ophiolites. He concluded that the cored section from the Southwest Indian Ridge is unlike typical "Penrose-type ophiolites" and that ophiolites representing an ultra-slow-spreading ridge environment might not have been preserved in the rock record.

In the fourth session, Jeff Alt discussed the mechanism and effects of hydrothermal alteration in seafloor spreading environments as recorded in young oceanic crust and ophiolites. He reviewed the main differences between hydrothermal effects in oceanic and ophiolitic crust. Many ophiolites have a higher grade of metamorphism of volcanic rocks and more continuous geothermal and metamorphic gradients than are seen in oceanic crust. The primary volatile contents of the rocks, the abundances of mafic phases and glassy groundmass, styles of faulting and fracturing, and multiple phases of intrusion and eruption may contribute to these differences. Rachel Haymon discussed the importance of shallow crustal magma supply and delivery configuration to ridge-crest hydrothermal systems, on the basis of observations from the East Pacific Rise and the Semail ophiolite. She concluded that the distribution and geochemical character of hydrothermal alteration on ridge crests are fundamentally different in magma-rich, dike-dominated segments (fast-spreading), compared to magma-starved, fault-dominated segments (slow-spreading). Debbie Kelley discussed the geochemical, isotopic, and thermal history of fluids circulating in the oceanic crust from magmatic to hydrothermal vent conditions and the role of these fluids in crustal development and microbial processes. Her discussion suggests that lower oceanic crust is a potentially major reservoir for abiogenic methane in submarine hydrothermal systems, and that carbon-bearing fluids in gabbros may provide a critical energy source for diverse microbial populations in the sub-seafloor. Susan Humphris presented thermal and geochemical mass balances for the TAG active hydrothermal mound and discussed their implications for the time of formation, the size of reaction zone, and the heat source of a seafloor large massive sulfide deposit. Her calculations suggest that there is an insufficient amount of new material intruded at the ridge axis each year at steady state to provide the heat necessary to drive a large hydrothermal system (1000 MW), and therefore heat must be extracted either from individual magma bodies or from heat stored at depth in the crust. She then utilized this discussion to constrain the growth of large ophiolite-based massive sulfide deposits.

In the final session, Nicola Godfrey presented generalized crustal-scale cross sections of the Great Valley in California at different latitudes which are based on seismic-reflection, bore hole, gravity, and aeromagnetic data, and discussed the 600-km-long, 70-km-wide ophiolitic slab beneath the Great Valley forearc basin. The existence of such an extensive ophiolitic slab beneath the Great Valley basin has strong implications for the tectonics of the coeval ophiolites in the Sierra Nevada foothills on the east and the Coast Ranges on the west, and for the Mesozoic active-margin tectonics of the western United States. Bradley Hacker reviewed the recent data on the thermochronology and thermobarometry of the metamorphic sole of the Semail ophiolite which imply extremely rapid subduction (~200 km/m.y.) beneath a very young oceanic crust. The key questions still remaining are the magnitude, style, and age of extension of the Semail ophiolite, and the timing of high-pressure metamorphic events. Adolphe Nicolas presented a comparative study of the inferred microplate tectonics of the Semail ophiolite, the Easter Island microplate, and the Magellan Plateau, and discussed the kinematics of rapid rotation at spreading centers and rotation-related compressional deformation at the tip of propagating ridges. Ophiolites that display evidence for large rotations (i.e., Troodos, Semail) soon after their igneous accretion might have originated as a result of microplate tectonics. Alan Smith reviewed the current models on ophiolite emplace-

Ophiolites *continued on p. 32*

Penrose Conference Participants

Jeffrey Alt
Neil Banerjee
Jean Bédard
Donna Blackman
Françoise Boudier
Roger Buck
John Chen
James Cochran
Robert Coleman
Henry Dick
Arjan Dijkstra
Grenville Draper
Stephen Edwards
Andrew Fisher
Martin Fisk
Gretchen Frueh-Green
Patricia Fryer
Harald Furnes
Jennifer Georgen
A. Mohamad Ghazi
Kathryn Gillis
Nicola Godfrey
David Goldberg
Robert Gregory
Bradley Hacker
Gregory Harper
Ron Harris
Rachel Haymon
Ben Holtzman
Clifford Hopson
Susan Humphris
Steve Hurst
Ray Ingersoll
Tenuaki Ishii
Barbara John
Jeffrey Karson
Peter Kelemen
Deborah Kelley
Martin Kleinrock
Astri Jaeger Kvassnes
Jian Lin
Ken Macdonald
Bruce Malfait
Craig Manning
Rodney Metcalf
Jay Miller
Thomas Moore
Pierre Nehlig
Julie Newman
Yujiro Ogawa
Julian Pearce
Emile Pessagno, Jr.
Tjerk Peters
Philippe Pezard
Stephen Phipps
Victor Ramos
Elisabetta Rampone
Paul Robinson
Sarah Roeske
Daniel Kent Ross
Jane Scarrow
Hans Schouten
Anjana Shah
John Shervais
Alan Smith
Jonathan Snow
Rachel Sours-Page
Piera Spadea
Debra Stakes
Marnie Sturm
Guenter Suhr
Damon Teagle
Craig Thomas
Ricardo Tribuzio
Brian Tucholke
Rick Varne
Scott Veirs
John Wakabayashi
Timothy Wallin
Scott White
Aaron Yoshinobu
Rovert Zierenberg

Ophiolites *continued from p. 31*

ment mechanisms and discussed the involvement of two distinct subduction phases during the terminal obliteration of ocean floor. The origin of the forces that lead to the relative velocities appropriate for ophiolite emplacement is likely large-scale changes in the geometry and relative velocities at plate margins.

The poster sessions provided an opportunity for participants to present case studies and their results on different aspects of the topics of the five major sessions, and an effective way of initiating and stimulating discussions. The content varied from the geophysics of oceanic core complexes, thermal effect of a melt lens at Moho, estimations of strain rates in the uppermost mantle, and processes of shear-zone development in oceanic lithosphere, to the nature of magma—hydrothermal transition in ophiolites and oceanic crust, textural and chemical evidence for microbial alteration of the upper oceanic crust, PGE and Os isotope systematics of the oceanic mantle, isotope evidence for recent contamination of the mantle beneath the Southern Chile Ridge, evidence for delivery of unpooled fractional melts to the oceanic crust as recorded in gabbros, and significance of serpentine and blueschist mud volcanism in convergent margins.

The first panel discussion addressed some overarching questions, such as how melt is focused beneath spreading segments and how it is diffused into the crust; how melt is translated into lower crustal structure; the mode and nature of brittle and ductile behavior of lower crust and upper mantle and associated hydrothermalism; causes and consequences of episodicity; diagnostic features to distinguish the tectonic setting of ophiolites and to determine the spreading rate and magma budget in paleo–spreading environments; and differentiating spreading-related structures from emplacement-related structures in ophiolites. The second panel discussion focused on melt transport mechanisms in the mantle and crust; constraints on the age of ophiolite generation and emplacement; what controls serpentinization and the depth of seawater penetration into the upper mantle; what the reaction zone is and how a sufficient volume of fluid moves through it; what makes large ore deposits in oceanic crust and ophiolites; how mantle temperatures, viscosity, and flow in suprasubduction zone settings differ from those at mid-ocean ridges; what we know about the architecture of suprasubduction zone settings; and how distinct the compositions of suprasubduction zone magmas are from those of mid-ocean ridges. The final panel discussion started with a short reminiscence by each panel member, who had participated in the first Penrose field conference on ophiolites in 1972; they also gave a short account of the progress made in ophiolite and ocean crust studies since then. These discussions and the statements by other participants confirmed that the original Penrose definition of *ophiolite* has been very useful and remains effective in ophiolite–ocean crust comparisons, as long as the term is used independently of its origin and/or tectonic significance. The Penrose definition needs to be expanded, however, to include more information about the geological context of individual complexes as revealed in the underlying and overlying rock units.

FIELD EXCURSION

The third day of the conference was devoted to field examination of the Coast Range ophiolite and ophiolitic rocks within the Franciscan Complex. The Coast Range ophiolite is a good example of the "ophiolite conundrum," as abundantly demonstrated by the presentations of Shervais, Ingersoll, and Hopson during the conference. Proposed emplacement mechanisms (as well as the general regional geological setting) for the Coast Range ophiolite differ from those of typical "Tethyan-type" ophiolites. The Coast Range ophiolite structurally overlies the Franciscan subduction complex, rather than the continental margin. The Great Valley ophiolite, on the other hand, appears to overlie the continental margin (Godfrey). The structural complexity of the ophiolitic–subduction complex contact, as well as the present-day geometry of the contact, is a product of a series of complex tectonic interactions, including its major reactivation during the late Cenozoic transform regime.

Following an introductory presentation on the regional and local geology of the California Coast Ranges by Moores and John Wakabayashi, participants had an opportunity to examine one of the rare occurrences of a sheeted dike complex in the Coast Range ophiolite in Mt. Diablo, as well as a depositional contact of the basal Great Valley Group sedimentary rocks on volcanic rocks of the Coast Range ophiolite in the Oakland Hills. At Tiburon, participants observed the mantle base of the Coast Range ophiolite in which serpentinized peridotites are present at the structurally highest horizon in the Franciscan subduction complex. Blocks of eclogite, amphibolite, and blueschist occur as tectonic inclusions in the serpentinite. At the Nicasio Reservoir, a >1-km-thick pillow basalt section and an underlying gabbro possibly represent part of a seamount that was incorporated into the Franciscan complex in late Mesozoic–early Cenozoic time.

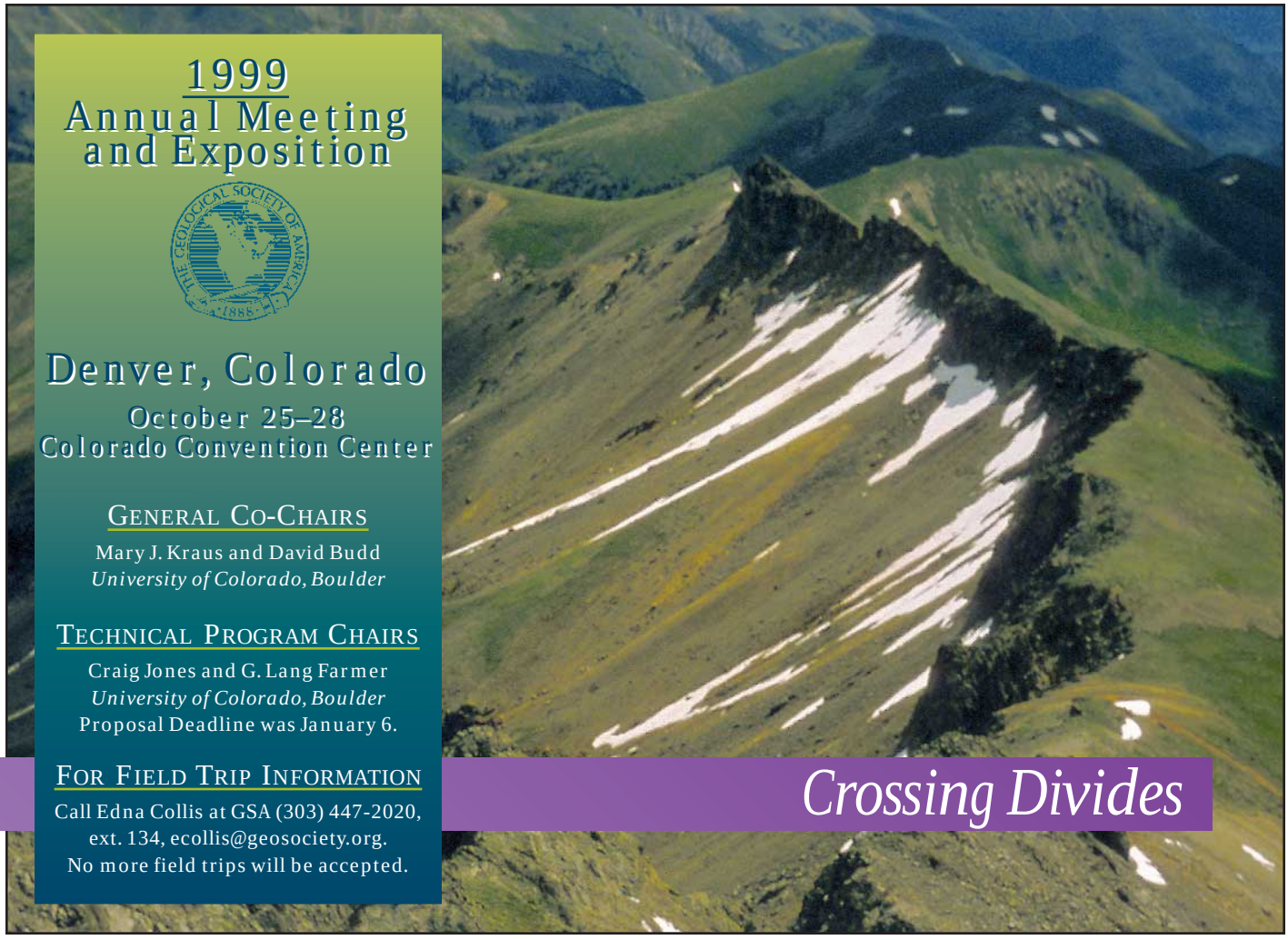
SUMMARY

Participants collectively agreed that more integrated and interdisciplinary studies of modern oceanic crust and ophiolites are needed to foster collaboration between the members of the marine geology and geophysics community and ophiolite geologists in order to address the questions that arose during the panel discussions. Systematic and detailed structural, kinematic, petrological, and geophysical process-oriented studies both in ophiolites and modern oceanic crust are important for modeling oceanic systems. Of particular significance for future studies are establishing objective criteria for structural reference frames (paleohorizontal and younging direction) in oceanic rocks, finding ways to constrain pressure-temperature-time paths for oceanic mafic and ultramafic rocks, and better defining the geological significance of the geophysical models for oceanic crust structure.

Scientific drilling in the oceans has been instrumental in advancing our knowledge of the oceanic lithosphere. The priorities of future deep-earth sampling in the marine environment include drilling an intact section of modern oceanic crust, preferably 3 km into the basement, drilling the plutonic foundation of oceanic crust, and drilling into the complete crust and crust-mantle boundary (goals of the "Mohole" project), and finally a comprehensive program aimed at a fuller understanding of the structural and compositional variations in modern and ancient oceanic crust in relation to ophiolites.

ACKNOWLEDGMENTS

We thank the Geological Society of America for sponsoring the conference and providing funds to enable student participation, and the Joint Oceanographic Institutions/USSAC and the Marine Geology and Geophysics Program of the National Science Foundation for provision of grants to support travel by participants and for field trip preparation. We thank Lois Elms (Western Experience, Inc.) and the staff of the Marconi Conference Center (California State Parks) for effective and efficient logistics throughout the meeting. John Wakabayashi kindly helped us organize and run an informative and stimulating field trip in the California Coast Ranges. We thank RMC Lonestar Company for help in arranging a stop on the field trip at the Clayton Quarry in Mt. Diablo to examine a well-exposed sheeted dike complex. We are grateful for the support and input provided to us by the participants before, during, and after the conference. We thank them all for the synergy and excitement they brought to the meeting and for sharing their knowledge and observations with the community. ■



1999 Annual Meeting and Exposition

Denver, Colorado

October 25–28
Colorado Convention Center

General Co-Chairs

Mary J. Kraus and David Budd
University of Colorado, Boulder

Technical Program Chairs

Craig Jones and G. Lang Farmer
University of Colorado, Boulder
Proposal Deadline was January 6.

For Field Trip Information

Call Edna Collis at GSA (303) 447-2020, ext. 134, ecollis@geosociety.org.
No more field trips will be accepted.

Crossing Divides

FUTURE GSA MEETINGS

2000 Reno, Nevada, November 13–16
2001 Boston, Massachusetts, November 5–8
2002 Denver, Colorado, October 28–31
2003 Seattle, Washington, November 2–5

FOR INFORMATION ON ANY GSA MEETING CALL THE
GSA MEETINGS DEPARTMENT
1-800-472-1988 or • (303) 447-2020, ext. 113
fax 303-447-0648 • meetings@geosociety.org
Or see GSA's Web page at http://www.geosociety.org

1999 GSA SECTION MEETINGS

SOUTH-CENTRAL SECTION — March 15–16, 1999, Lubbock, Texas. Information: Calvin Barnes, Dept. of Geosciences, Texas Tech, Lubbock, TX 79409-1053, (806) 742-3106, gical@ttu.edu. *Preregistration deadline: February 5, 1999.*

NORTHEASTERN SECTION — March 22–24, 1999, Providence, Rhode Island. Information: O. Don Hermes, Dept. of Geology, University of Rhode Island, Green Hall, Kingston, RI 02881, (401) 874-2192, dhermes@uriacc.uri.edu. *Preregistration deadline: February 12, 1999.*

SOUTHEASTERN SECTION — March 25–26, 1999, Athens, Georgia. Information: Samuel E. Swanson, Dept. of Geology, University of Georgia, Athens, GA 30602-2501, (706) 542-2415, sswanson@uga.cc.uga.edu. *Preregistration deadline: February 19, 1999.*

ROCKY MOUNTAIN SECTION — April 8–10, 1999, Pocatello, Idaho. Information: Scott S. Hughes, Dept. of Geology, Idaho State University, 785 South 8th Ave, Pocatello, ID 83209-8072, (208) 236-4387, hughscot@fs.isu.edu. *Preregistration deadline: March 5, 1999.*

NORTH-CENTRAL SECTION — April 22–23, 1999, Champaign-Urbana, Illinois. Information: Dennis R. Kolata, (217) 244-2189, fax 217-333-2830, kolata@isgs.uiuc.edu. *Preregistration deadline: March 19, 1999.*

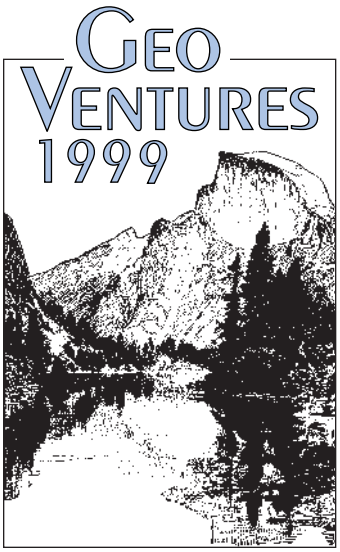
CORDILLERAN SECTION — June 2–4, 1999, Berkeley, California. Submit completed abstracts to: George Brimhall, Dept. of Geology & Geophysics, University of California, Berkeley, CA 94720-4767, (510) 642-5868, brimhall@socrates.berkeley.edu. *Abstract deadline: February 19, 1999.*

February *BULLETIN* and *GEOLOGY* Contents

The Geological Society of America
BULLETIN
Volume 111, Number 2, February 1999

GEOLOGY

VOLUME 27
NO. 2
P. 97–192
FEBRUARY 1999



For GSA Members and Friends

CALL TODAY! HOLD A SPOT FOR YOURSELF AND FRIENDS

1999 GeoVentures Fee Schedule

	GeoTrip Geology of Hells Canyon	GeoHostel Lewis & Clark Expedition
Dates	June 17–25	July 17–22
No. of Days	9	6
Member Fee	$1400	SOLD OUT
Nonmember Fee	$1500	$800
Deposit	$200	$100
Balance Due	May 1	June 1
100% Deposit refund date (less processing fee)	before April 1 ($50)	before June 1 ($20)

We encourage you to make your decision as soon as possible.

Single or Shared Accommodation: Some trip fees are based on double occupancy. However, if you wish single accommodations, a limited number of rooms are available at extra cost on a first-come, first-served basis. In the case of double occupancies, we will do our best to help find a suitable roommate, but if none is found, the single rate will apply.

Age Requirement: Participants must be at least 21 years old.

Health Recommendations and Special Needs: You must be in good physical and mental health. Any physical condition requiring special attention, diet, or treatment must be reported *in writing* when the reservation is made. We will do our best to accommodate special needs, including dietary requirements and physical disabilities. Please feel free to discuss your situation with us; however, we reserve the right to decline any person as a member of a trip. We also reserve the right to require a person to withdraw from the trip at any time when such action is determined to be in the best interests of the health, safety, and general welfare of the group.

Air Travel: We urge you to make air travel arrangements via Lethia K. Estigoy of Conventions in America (CIA). Her direct telephone number is (619) 232-4298, flycia@scitravel.com. Lethia is ready to help you find the least expensive routing to your destination. Please call her for a no-obligation price quote at the above number or at CIA's toll-free number 1-800-929-4242. The fax number is 619-232-6497.

Cancellation Processing Fee: Deposits and payments are refundable, less processing fee, up to the cut-off date. Termination by an individual during a trip in progress for any reason whatsoever will not result in a refund, and no refund will be made for unused parts of the trip.

Full Itineraries: A detailed itinerary and helpful travel information are available from GSA. Please feel free to contact Edna Collis, GSA Professional Development Department, at 1-800-472-1988, ext. 134, or (303) 447-2020, fax 303-447-0648, ecollis@geosociety.org.

See p. 36 and 37 for trip descriptions.

REGISTER TODAY!

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 #

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

	Deposit Per Person	No. of Persons	Total Paid Deposit
GH991—Hells Canyon	$200	____	$_____
GH992—Dillon **SOLD OUT**	$100	____	$_____
	TOTAL DEPOSIT		$_____

☐ I've enclosed no deposit, but I'm interested. Please send information.
☐ VISA ☐ MasterCard ☐ American Express

Credit Card # Exp. Date

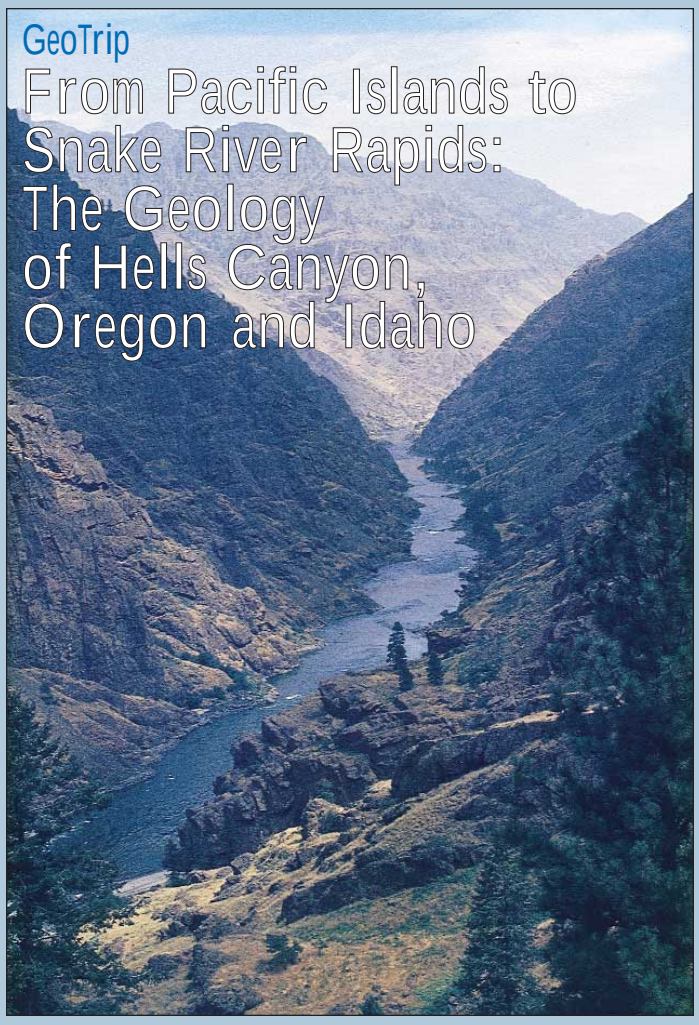
Signature

MAIL OR FAX REGISTRATION FORM AND CHECK OR CREDIT CARD INFORMATION TO:
1999 GSA GeoVentures,
GSA Professional Development Department
P.O. Box 9140,
Boulder, CO 80301
fax 303-447-0648

MAKE CHECKS PAYABLE TO: GSA 1999 GeoVentures

GeoTrip

From Pacific Islands to Snake River Rapids: The Geology of Hells Canyon, Oregon and Idaho



Hells Canyon. *Photo by Tracy Vallier.*

June 17–25, 1999 • 9 days, 8 nights

Scientific Leader: *Tracy Vallier,*
Lewis-Clark State College, Lewiston, Idaho

Field trip leader *Tracy Vallier* began his studies in Hells Canyon 35 years ago and recently completed a guidebook, *Islands and Rapids: A Geologic Story of Hells Canyon,* published by Confluence Press, Lewis-Clark State College, Lewiston, Idaho. Tracy retired in 1997 from the U.S. Geological Survey, where he worked as a marine geologist with interests in island arcs and deep-sea processes. Before joining the USGS, Tracy taught at Indiana State University and worked with the Deep Sea Drilling Project at Scripps Institution of Oceanography. He taught at Whitman College in Walla Walla, Washington, during autumn 1998, and he is now an adjunct professor at Lewis-Clark State College in Lewiston, Idaho.

Description

One hundred miles of rugged outcrops are exposed in Hells Canyon of the Snake River between Oxbow, Oregon, and the mouth of the Grande Ronde River in Washington. Arguably the deepest major river canyon in the lower 48 states, the Snake River flows more than 8,000 feet below the highest peak of the adjacent Seven Devils Mountains. Explore the viscera of an Early Permian through Middle Jurassic volcanic massif that formed along the magmatic axis of the Blue Mountains island arc. See the dike zones that crystallized beneath the volcanoes, visit volcano-root plutons, study the Permian, Triassic, and Jurassic strata that include a 500-meter-thick Upper Triassic limestone, and put your hand on the Permian-Triassic unconformity. Review the evidence that the pre-Tertiary rocks are exotic to North America. Lava flows of the Miocene Columbia River Basalt Group that overlapped the exotic terrane now perch on canyon rims and, in places, line the steep canyon walls near river level. The canyon is growing deeper as uplift outpaces stream erosion. Landslide, slump, avalanche, alluvial fan, terrace, Bonneville flood, and Mazama ash deposits chronicle the late Quaternary and Holocene. Indian and European histories complement the geology and add to the breadth of the trip. This is an exceptional hiking and rafting trip for the physically fit person to see Hells Canyon and to learn about its geology. June is a beautiful time to visit the canyon, and the weather should be cooperative. Bears, cougars, wild sheep, turkeys, eagles, deer, and elk are among the animals that might be seen. Bring a bathing suit and fly rod if inclined to swim or fish.

Schedule

Thursday, June 17: Travel to Boise, Idaho. Board bus at 3:00 p.m. for three-hour ride to Halfway, Oregon. Stay at the Halfway Motel. Dinner at Canyon Outfitters. Your leader, Tracy Vallier, will present a slide lecture and video program after dinner.

Friday, June 18: Breakfast at Canyon Outfitters. Roadside field trip along the southern 22 miles of Hells Canyon between Oxbow, Oregon, and the Hells Canyon Dam. Dinner at Canyon Outfitters. Return to Halfway Motel.

Saturday, June 19: Breakfast at Canyon Outfitters. Bus ride to the launch site below Hells Canyon Dam. Raft Wild Sheep Rapids. Camp at Granite Creek.

Sunday, June 20: Hike through the Wild Sheep Creek Formation. Boat to Rush Creek landslide and hike to the top. Return to the rafts and float to Sheep Creek campsite.

Monday, June 21: Hike to outcrops where the Permian-Triassic unconformity is exposed. Return to rafts and float to Suicide Point. Hike two miles through the Permian Cougar Creek dike complex to the Kirkwood Creek campsite.

Tuesday, June 22: Boat to Upper Pittsburg Landing. Moderate hike (one-half mile and 600 feet elevation gain) to observe the entire geologic framework of the Pittsburg Landing area. Hike one mile downhill to a petroglyph site on a Bonneville flood terrace. Board rafts at Lower Pittsburg Landing and float to Tryon Creek campsite.

Wednesday, June 23: Moderate hike up Tryon Creek to observe outcrops of the Wild Sheep Creek Formation and possibly to collect ammonite molds in fine-grained sedimentary rocks. Return to rafts and float through a Triassic gabbro, several miles of the Miocene Columbia River Basalt Group (Imnaha Formation), and Triassic plutons. Float to China Bar campsite.

Thursday, June 24: Hike to mine tunnel where secondary copper minerals can be seen. Return to the rafts and float to Mountain Chief Mine and Eureka Bar, where mining history and a unique Hells Canyon settlement will be discussed. Float to Cottonwood Creek, passing the mouths of the Imnaha and Salmon rivers. Optional strenuous climb to the Triassic-Jurassic unconformity, where rocks of the Jurassic Coon Hollow Formation overlie the Triassic Wild Sheep Creek Formation. Dinner awaits at the Cottonwood Creek campsite.

Friday, June 25: Float through the Jurassic Coon Hollow Formation, a small Late Jurassic quartz diorite pluton, and then through the Wild Sheep Creek and Doyle Creek Formations and the Upper Triassic Martin Bridge Limestone. Arrive at the takeout point, Heller Bar, by noon for lunch, and then board the bus for the ride back to Boise, arriving at approximately 6:00 p.m.

Lodging, Meals, and Transportation

Canyon Outfitters, Inc. will provide all meals, field instruction, professional river guides, river-related equipment (including camping gear), and transportation from Boise, Idaho beginning at 3:00 p.m. on Thursday, June 17 through arrival back in Boise on Friday, June 25, at approximately 6:00 p.m.

Lethia K. Estigoy of Conventions in America (CIA) is familiar with the trip itinerary and can handle all reservations in and out of Boise. Call Lethia direct at (619) 232-4298, flycia@scitravel.com.

Physical Requirements

This trip includes several difficult, always optional, hikes that are usually less than two miles round trip from the boats. Although

GeoHostel

Geology of the Lewis and Clark Expedition—

The Three Forks of the Missouri River to the River of No Return, Montana and Idaho

SOLD OUT

Along the Lewis and Clark Trail in southwest Montana. *Photo by Rob Thomas.*

Western Montana College of the University of Montana, Dillon, and Stagecoach Inn, Salmon, Idaho
July 17–22, 1999, (Saturday through Thursday)
5 days, 6 nights

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

Rob Thomas is currently an associate professor and chair of the Department of Environmental Sciences at Western Montana College in Dillon. Rob developed an interest in the geology of the Lewis and Clark Expedition as a result of 13 years of research and teaching in southwestern Montana. His focus has been on the origin and timing of extensional tectonism in southwestern Montana, the dynamics of carbonate platform development and destruction, Cambrian mass extinctions, and field-based geoscience program development.

Sheila Roberts is currently an associate professor of geology in the Department of Environmental Sciences at Western Montana College in Dillon. Her focus has been on Pleistocene paleoclimates recorded in saline lacustrine sediments. Sheila is also a strong advocate for service-learning in the geosciences, and has mentored her students on a number of community service projects along the Lewis and Clark trail in southwestern Montana. As a native Montanan, Sheila is an enthusiastic and knowledgable guide to the history and geology of the Lewis and Clark Expedition.

Description

From 1804 to 1806, Meriwether Lewis and William Clark journeyed through the recently acquired Louisiana Territory on the order of President Thomas Jefferson. Arguably, the pivitol leg of the expedition was in present-day Montana and Idaho, from the three forks of the Missouri River, over the Continental Divide, to the River of No Return. This trip is a geological and historical tour of that famous landscape. Our expedition will have two base camps, Dillon, Montana, and Salmon, Idaho. The geological component of this GeoHostel will include field trips to see Archean metamorphic rocks, Proterozoic and Phanerozoic sedimentary rocks, Quaternary glacial deposits, hot springs and caverns, Sevier and Laramide compressional structures, and Tertiary extensional structures associated with the northern edge of the Yellowstone hotspot track. The historical component will include stops at important landmarks from the Lewis and Clark Expedition such as the Three Forks, Beaverhead Rock, Clark's Lookout, Camp Fortunate, and the Continental Divide. The trip will also include a full-day raft trip on the Salmon River—the "River of No Return"—to see the spectacular geology of the river's canyon.

Lodging, Meals, and Ground Transportation

The group will stay on Saturday, Sunday, Monday, and Thursday nights at Western Montana College, Dillon, and on Tuesday and Wednesday nights at the Stagecoach Inn in Salmon, Idaho. All lodging is based on single occupancy or doubles for couples. Meals will include plenty of hors d'oeuvres at the Welcoming Reception and Orientation on Saturday evening, daily breakfasts and sack lunches, dinner on Sunday, and a hearty farewell dinner on Thursday evening. Field trip transportation will be provided in air-conditioned, 15-passenger vans.

Alternative Housing in Dillon, Montana

Costs of alternative (non–Western Montana College) housing would be *in addition* to the GeoHostel fee. Reservations should be made directly by the registrant. Several motels are located in Dillon. GSA has reserved a small block of rooms at the following properties:

Centennial Inn, A Victorian Bed & Breakfast. Advance reservations are strongly recommended. Call the Centennial Inn direct at (406) 683-4454. Current double-room rate is $75.00 per night.

Best Western Paradise Inn. Advance reservations are strongly recommended. Call Best Western direct at (406) 683-4214. Current double-room rate is $57.00 per night.

Fee and Payment

$750 for GSA Members. $800 for Nonmembers.
A $100 deposit is due with your reservation and is refundable through June 1, less $20 processing fee. Total balance is due: June 1. Maximum number of participants: 32.

Included: Classroom programs and materials; field trip transportation; lodging for six nights (single-occupancy, or double for couples); breakfast and lunch daily, dinner on Sunday, river raft trip, and welcoming and farewell events.

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

See p. 35 for registration form.

at a reasonable pace, with many points to rest and to explore the geology, these hikes should be undertaken only by persons in good health who are physically active. Verification of health coverage will be required. No rafting experience is necessary.

Fee and Payment

GSA Member: $1,400 *Nonmember: $1,500*
Based on 17 people. The trip may cost more if there are fewer registrants. A $200 deposit, due with your reservation, is refundable through April 1, 1999, less $50 processing fee. Total balance due May 1, 1999. Minimum age: 21.

Included: All meals beginning with dinner on June 17 and ending with lunch on June 25. Transportation by bus from Boise to Halfway and from Heller Bar back to Boise. All river equipment including tents, dry bags, sleeping bags, sleeping pads, and geological reading materials, including, *Island & Rapids—A Geologic Story of Hells Canyon,* by your leader, Tracy Vallier.

Not included: Airfare to and from Boise, Idaho.

See p. 35 for registration form.

CLASSIFIED ADVERTISING

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

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

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

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

Situations Wanted

GEOSCIENTIST, Asset Builder/Manager, proven oil & gas record, US and Abroad, On-shore and Off-Shore. Respond (318) 981-4678.

Positions Open

HASLEM POSTDOCTORAL FELLOWSHIP

A postdoctoral research position in Paleontology is available in the Department of Geology and Geological Engineering and Museum of Geology at the South Dakota School of Mines and Technology. A Ph.D. with specialization in Paleontology is required and preference will be given to candidates with research interests in, or that can be applied to, paleontological studies of the Great Plains and adjacent northern Rocky Mountain region.

This full year appointment, renewable up to 3 years, is being offered at a salary of approximately $30,000 plus benefits. Review of applicants will begin on April 15, 1999 and the fellowship will start on September 1, 1999. Applications will be reviewed and considered until the position is filled.

Applications should include curriculum vitae and the names of three references, submitted to Dr. James E. Fox, Chairman, Department of Geology and Geological Engineering, South Dakota School of Mines and Technology, Rapid City, SD 57701. The South Dakota School of Mines and Technology is an equal-opportunity/affirmative action employer and encourages women and minorities to apply.

NORTHERN KENTUCKY UNIVERSITY
PETROLOGIST/MINERALOGIST

Position as a tenure-track Assistant Professor in geology begins August, 1999. Ph.D. in geology and teaching experience in geology required. Applicants should possess a strong commitment to undergraduate teaching and conducting a modest research program. Teaching experience in mineralogy, igneous and metamorphic petrology is desirable. Successful candidate will teach introductory courses in geology, advanced undergraduate courses and labs (petrology, mineralogy, optical mineralogy and structural geology), lead field trips, and collaborate with faculty from various disciplines in the development and teaching of integrative science courses. Send letter of application, curriculum vitae, a separate statement of teaching philosophy and research interests, and the names, addresses, phone numbers, and e-mail addresses of three references to: Dr. John Filaseta, Chair of Geology Search Committee, Department of Physics and Geology, Northern Kentucky University, Highland Heights, KY 41099-1900. Applications will be accepted until Feb. 23, 1999. Additional information about the university and department can be found at: http://www.nku.edu/~physics/.

Northern Kentucky University's goal is to become a pre-eminent learner-centered metropolitan university with a primary focus on the intellectual, ethical and career development of its students. By offering its students broad access with the opportunity to succeed, the University actively contributes to the social, economic and cultural vitality of the northern Kentucky/greater Cincinnati region and the entire Commonwealth of Kentucky. In support of these commitments, the University encourages and supports a culture of scholarly achievement, intellectual freedom and creative problem solving. As part of a commitment to its own multicultural community, the University aggressively seeks to enhance our aspirations and hire those who will take pleasure and pride in making its priorities an integral part of their professional lives. NKU is an AA/EOE. Women and minorities are strongly encouraged to apply.

CALIFORNIA INSTITUTE OF TECHNOLOGY
ASSISTANT PROFESSOR OF PLANETARY SCIENCE

The Division of Geological and Planetary Sciences of the California Institute of Technology is seeking a planetary scientist for a tenure-track faculty position as assistant professor; however, exceptionally well qualified applicants may also be considered at the associate or full professor level. Initial appointment is for four years and completion of the Ph.D. is required. We are seeking highly qualified candidates who are committed to a career in research and teaching. Any outstanding individual with a commitment to increasing our knowledge of the solar system is welcome to apply.

We are especially interested in individuals whose research links existing or new techniques with current programs in the Division. Three examples are listed below:

(1) Remote observations of planets, including Earth, from space. We are interested in candidates who have experience and/or interest in designing instruments and analyzing data from spacecraft and who will aggressively seek involvement in planetary missions. Caltech's connection with JPL is a valuable resource.

(2) Observational planetary astronomy aimed principally at outer solar system bodies, protoplanetary disks around young stars, and searches for other planetary systems. Here Caltech's telescopes and association with JPL offer unmatched opportunities.

(3) Exploration of Mars and preparation for sample return. There are intellectual opportunities associated with Mars exploration. The nation has embarked on an ambitious program based at JPL to explore Mars over the next few decades, culminating in sample returns. The Divison's strength in geochemistry and planetary science provides a strong base of support.

Applications should include a curriculum vitae, a list of papers published and submitted (with refereed papers indicated), a brief essay describing the applicant's research interests and the program of research he or she proposes to carry out at Caltech, and the names and addresses of at least three references (including e-mail addresses if possible).

Applications should be sent to Professor E. M. Stolper, Mail Stop 170-25, California Institute of Technology, Pasadena, CA 91125, USA.

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

FORT LEWIS COLLEGE
ASSISTANT PROFESSOR OF GEOLOGY

Tenure-track position anticipated Fall, 1999. Ph.D. required. Primary teaching responsibilities include stratigraphy, sedimentology, paleontology, historical geology. Must be active in research/scholarly work, especially undergraduate research. Expertise in petroleum geology, environmental geology, hydrogeology, structural geology, or geophysics desirable. Additional teaching obligations may include general education courses. Send letter of application, resume, statement of teaching and research goals, and names and addresses of three references, postmarked by February 15, 1999, to: Dr. Douglas C. Brew, Department of Geology, Fort Lewis College, 1000 Rim Drive, Durango, CO 81301-3999. Official transcripts will be requested of semi-finalists. FLC is an AA/EOE.

UNIVERSITY OF TORONTO AT SCARBOROUGH
PHYSICAL SCIENCES DIVISION
ENVIRONMENTAL SCIENCE

Applications are invited for a tenure-track faculty position in Environmental Science at the University of Toronto at Scarborough, Division of Physical Sciences. The appointment, at the Assistant Professor level, would be effective starting January 1, 2000. A completed Ph.D. is expected. The successful candidate will have teaching and research interests in Soil Science, with ancillary teaching and research interests in one or more of the following: Geomorphology, Soil Chemistry, Soil or Sediment Contamination/Remediation; Soil Mineralogy.

Candidates should send their curriculum vitae, statements of teaching and specializations and research interests, and arrange to have letters from three referees forwarded before June 1, 1999 to: Professor James Thompson, Chair, Division of Physical Sciences, University of Toronto at Scarborough, Scarborough, ON., M1C 1A4, phone: (416) 287-7197; fax 416-287-7204; e-mail: jthompso@ scar.utoronto.ca

In accordance with Immigration Canada requirements, this advertisement is directed towards Canadian Citizens and Permanent residents of Canada. In accordance with its Employment Equity Policy, the University of Toronto encourages applications from qualified women and men, members of visible minorities, aboriginal peoples and persons with disabilities.

FACULTY APPOINTMENT — TENURE-TRACK
GEOLOGY/ENVIRONMENTAL SCIENCE

Bellevue Community College (BCC), a two-year college in the beautiful and thriving Puget Sound region of Washington state, invites applications for a teaching position in Geology/Environmental Science to begin Fall Quarter 1999. BCC is the third largest of the state's 48 public and private post-secondary institutions. The college enrolls approximately 18,000 students (9,000 FTEs) in nearly 70 program areas. BCC is diverse, innovative, and renowned for quality instruction. A Masters Degree in geology or closely related earth science field is required. For more information and application forms, please call our 24-hour Jobline at (425) 643-2082, or check our Homepage at www.bcc.ctc.edu/joblist, or leave a TDD/TTY message at (425) 603-4184. Bellevue Community College is an Equal Opportunity Employer and operates under an Affirmative Action Plan, in accordance with applicable federal and state laws and regulations. The college strongly encourages all qualified applicants to apply.

LAKE TAHOE COMMUNITY COLLEGE
EARTH SCIENCES INSTRUCTOR

Now accepting applications for a full-time, tenure-track instructor to begin Fall 1999. Starting salary: $38,492-$47,608. District application required. Apply by 3/04/99. Contact Personnel Services. One College Dr., So. Lake Tahoe, CA 96150, (916) 541-4660 x226 or E-mail: ferguson@ltcc.cc.ca.us. AA/EOE.

TENURE-TRACK FACULTY POSITION
EDINBORO UNIVERSITY OF PENNSYLVANIA

The Department of Geosciences at Edinboro University seeks applications for a tenure-track Instructor/Assistant Professor with expertise and teaching experience in one or more of the following areas: remote sensing, soils, paleolimnology or quaternary geology beginning August 1999. Salary and benefits are excellent and competitive. Applicants should have ability and desire to teach introductory geology courses as well as upper level courses in area of expertise. Ph.D. in geology required, ABD considered. Preference given to candidate who can integrate applied technology in teaching and research. Demonstration of excellent teaching skills as part of the interview is required.

In accordance with the terms of the collective bargaining agreement between the State System of Higher Education and APSCUF, you may be assigned to perform work at off-campus sites and/or provide instruction through distance education.

Specifiy Position #170-0892 and send a letter of application, current vitae, transcripts and names/addresses/telephone numbers of three current references to Dr. Eric Randall, Dean of Science, Management, and Technologies, Edinboro University of Penn., Department GSA, Edinboro, PA 16444. Application Deadline: March 19, 1999. Visit our home page at http://www.edinboro.edu/AA/EOE/M/F/V/D

GEOLOGY/MATH — LEE COLLEGE

The Math, Engineering and Sciences Division of Lee College, a public 2-year Community College, located in Baytown, 20 miles East of Houston, Texas, invites applications for a regular contract appointment in Geology/Math. The successful candidate will have at least a Master's Degree in Geology or related field and adequate credits to teach developmental and/or college math. Preference will be given to candidates with 18 graduate hours in geography, teaching experience at the community college level, a background in GIS, and a strong demonstrated commitment to field geology as an instructional tool. Teaching responsibilities include physical, historical, environmental, introductory geology and developmental or college mathematics. Off campus, night and weekend sections may be assigned. The starting salary range will be $31,947 to $38,611, depending upon degrees and experience. Excellent college benefits will accrue with this position. Qualified candidates must submit a current resume, cover letter, copies of applicable transcripts or evaluation of foreign transcripts (official transcripts required upon employment) and contact information on 3 professional references to: Personnel Office, Lee College, P.O. Box 818, Baytown, TX 77522-0818; Telephone: (281) 425-6875; fax 281-425-6568.

ENVIRONMENTAL GEOLOGY
TENURE-TRACK POSITION
ENVIRONMENTAL SCIENCE AND TECHNOLOGY
TEMPLE UNIVERSITY

The new College of Science and Technology of Temple University is undergoing a major expansion of its interdisciplinary program in Environmental Science and Technology. We invite applications for three tenure-track positions, one each in Geology, Biology, and Engineering. Successful candidates will have an interest in achieving excellence in teaching and research. They are expected to continue or develop an active, externally funded research program involving both undergraduate and graduate students. Appointments are possible at any academic level, appropriate to experience. Applicants for Associate Professor or Professor must have an externally supported research program and a substantial publications record.

The Department of Geology seeks applications from field-oriented environmental geologists with specializations in estuarine and coastal processes, sedimentation and stratigraphy, surface water hydrology, surficial processes, or global cycling. The position is to complement existing strengths in hydrogeology, geochemistry, stratigraphy, and environmental geophysics. The individual is to teach undergraduate courses in geology and graduate courses in their field of specialization.

Applicants should send a curriculum vitae, publication list, a statement of research interests and teaching philosophy, and the names, telephone numbers, and postal and e-mail addresses of four references to the Chair of the Search Committee, Department of Geology, Temple University, Philadelphia PA 19122. Consideration began on February 1, 1999 and will continue until the position is filled.

Additional information may be obtained from: David Grandstaff, (215) 20408228, grand@vm.temple.edu, or www.temple.edu/geology.

Temple University is an equal opportunity/affirmative action employer. Applications from women and members of underrepresented minorities are encouraged.

RESEARCH GEOLOGIST
USGS, GLOBAL CHANGE AND CLIMATE TEAM

The U.S. Geological Survey Global Change and Climate Team is seeking a Research Geologist, GS-1350-11 to work on an existing project involving the paleoclimatic interpretation of Quaternary palynological and plant macrofossil records from North America, with an emphasis on the arid and semi-arid western United States. Applicants must posses a degree in geology plus 20 additional semester hours in any combination of mathematics, physics, chemistry, biological science, structural, chemical, civil, mining or petroleum engineering, computer science, planetary geology, comparative planetology, geophysics, meteorology, hydrology, oceanography, physical geography, marine geology, and cartography. In addition, applicants must have an appropriate Master's or equivalent graduate degree OR 1 year specialized experience equivalent to the GS-9 level in the Federal service. The following knowledges, skills and abilities are desirable for this position: 1) Knowledge of Quaternary palynological and/or Quaternary macrofossil research. 2) Knowledge of Microsoft Access database and Microsoft Excel spreadsheet software on a PC or Macintosh platform and demonstrated skill with ArcInfo or ArcView GIS software. 3) Knowledge of Quaternary paleobotanical and paleoclimatic research techniques and literature in North America. 4) Ability to communicate results to other scientists and the public by publication and/or presentation

This is a TERM position not-to-exceed 13 months with the possibility of renewal for up to 4 years with a starting salary range of $41,201 to $53,560 depending upon qualifications. A complete copy of the vacancy announcement #USGS-CR-99-104-D and application requirements can be found on-line at <http://www.usajobs.opm.gov/> or may be requested by calling Natalie Mashburn at (303) 236-5900 ext. 362. Interested persons should submit a complete application and college transcripts to: U. S. Geological Survey, P.O. Box 24046, MS 612, Attn: Personnel Office, Denver, CO 80225. Applications must be received by February 26, 1999. U.S. citizenship is required. U.S. Geological Survey is an Equal Opportunity Affirmative Action Employer.

Consultants

GEOSCIENTIST, proven, cost-effective experience, ground water, oil & gas, environmental and natural resource projects, US and Abroad. Respond (318) 981-4678.

Services & Supplies

LEATHER FIELD CASES. Free brochure, SHERER CUSTOM SADDLES, INC., P.O. Box 385, Dept. GN, Franktown, CO 80116.

DON'T KILL YOURSELF with the carcinogenic bromides, like tetrabromoethane for mineral separation. Use water-based non-toxic high-density agent Sodium Polytungstate. Density ranges from 1.0 to 3.1 g/ml and up to 4.0 g/ml in combination with Tungsten Carbide. Sometu. Phone (818) 786-7838; Fax 818-786-4343; website: www.sometu.com; e-mail sometu@aol.com

Opportunities for Students

Research Grants Available. The Colorado Scientific Society invites graduate students to apply for research grants, to be awarded in April 1999. Applicants must be enrolled in a Masters or Ph.D. program at an accredited college or university. Approximately eight grants, ranging from $500 to $1200 each, will be awarded for field-oriented research on the geology, geochemistry, and geophysics of the Rocky Mountain region. In addition, grants as large as $1000 are awarded for engineering geology research (with no restriction on the geographic area of interest), and one grant as large as $1000 is offered for studies of the Heart Mountain Fault in northwest Wyoming. Interested students can obtain application forms and grant information directly from the Society website at http://shell.rmi.net/~css/ or by mail from the Chair of the Memorial Funds Committee, Colorado Scientific Society, P.O. Box 150495, Lakewood, CO 80215-1405. Deadline for applications is March 20, 1999.

NASA Planetary Biology Internships. The Marine Biological Laboratory, Woods Hole, Massachusetts, invites applications from graduate students and seniors accepted to graduate programs for awards of $2200 plus travel to participate in research at NASA centers and collaborating institutions for approximately 8 weeks. Typical intern programs include: global ecology, remote sensing, microbial ecology, biomineralization, and origin and early evolution of life. Application deadline: 1 March 1999. For information/applications, contact: Michael Dolan, Planetary Biology Internship, Department of Biology, Box 3-5810, University of Massachusetts, Amherst, MA 01003-5810. E-mail: pbi@bio.umass.edu. Tel (413) 545-3223. An Equal Opportunity/Affirmative Action Employer.

AVAILABLE JUNE 1999

CLASSIC CORDILLERAN CONCEPTS:

A VIEW FROM CALIFORNIA

A unique volume commemorating the GSA Cordilleran Section Centennial with classic papers on Cordilleran geology and an update by leading geologists in the field.

The book highlights the impact of Cordilleran geoscientists and their science on the global geologic framework. The editors selected 19 classic papers that made landmark contributions to the understanding of geologic processes. Each paper is reproduced together with a contemporary commentary about the status of the subject today.

PC/MAC-compatible CD includes

- detailed full-color images of the San Andreas fault
- animation of the tectonic evolution of the San Andreas system and Southeast Asian region
- spectacular photographs of the Cordillera and related regions provided by NASA
- interesting selection of old California maps

valuable bonus!

edited by
Eldridge M. Moores
Doris Sloan
Dorothy L. Stout

The Geological Society of America

commemorating the Cordilleran Centennial, June 1999