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Lithoprobe Leads to New Perspectives on Continental Evolution

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ABSTRACT

Lithoprobe, Canada's national earth science research project, was established in 1984 to develop a comprehensive understanding of the evolution of the northern North American continent. With rocks representing 4 b.y. of Earth history, the Canadian landmass and offshore margins provide an exceptional opportunity to gain new perspectives on continental evolution. Lithoprobe's 10 study areas span the country and geological time. A pan-Lithoprobe synthesis will bring the project to a formal conclusion in 2003. Each transect involves an integrated, collaborative, multidisciplinary scientific program. Two transects are highlighted here. The first, across southern British Columbia, illustrates elements of evolution of the Canadian Cordillera and the Cascadia subduction zone. A key result is that crustal rocks of accreted terranes are detached from their subducting lithosphere and attached as thin flakes to the craton. Accretion at Cascadia is characterized by both underplating and duplexing of old oceanic crust below the backstop and near-surface thrusting to form an accretionary wedge. The second, a lithospheric section across the southeastern Superior province of Quebec, provides direct evidence for plate tectonics in the Late Archean. Complementary studies indicate that the north-dipping collisional subduction zone(s?) imaged by reflection data stepped southward with time. Postcollisional modification of the lower crust occurred across the southern part of the region.

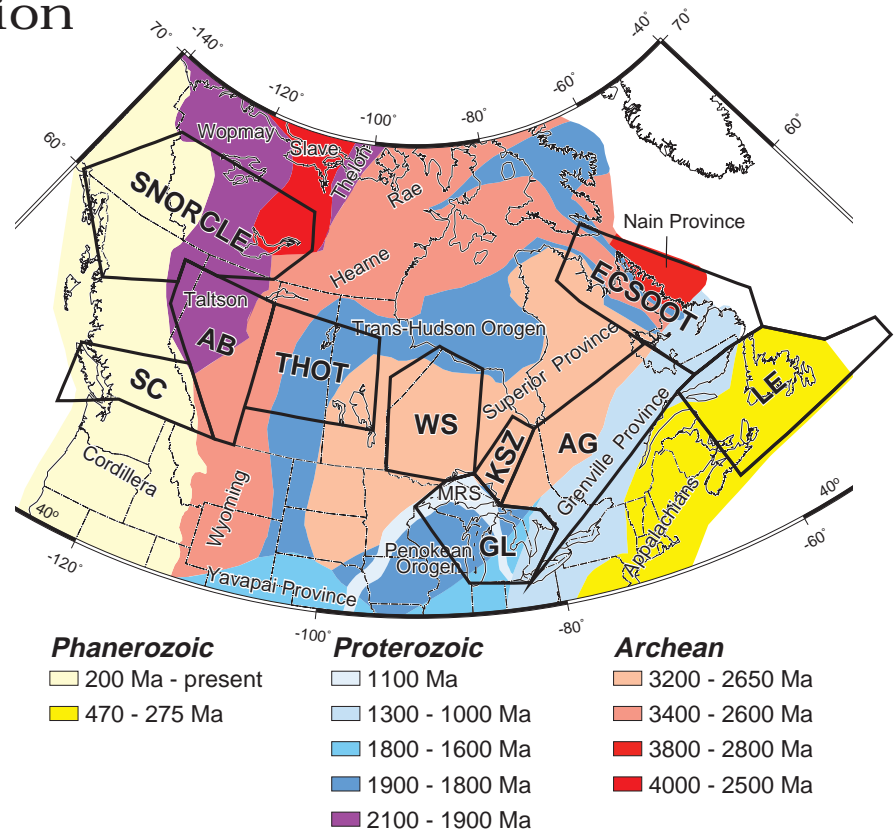


Figure 1. Location of Lithoprobe transects on a simplified tectonic element map of northern North America; MRS is mid-continent rift system. Transects: SC—Southern Cordillera; AB—Alberta Basement; SNORCLE—Slave—Northern Cordillera Lithospheric Evolution; THOT—Trans-Hudson Orogen; WS—Western Superior; KSZ—Kapuskasung Structural Zone; GL—Great Lakes International Multidisciplinary Program on Crustal Evolution (GLIMPCE); AG—Abitibi-Grenville; LE—Lithoprobe East; and ECSOOT—Eastern Canadian Shield Onshore-Offshore.

INTRODUCTION— THE LITHOPROBE PROJECT

Canada, with its diverse geology spanning 4 b.y. of Earth history, is unique in providing the opportunity to investigate continental evolution over an immense time period. The country is a mosaic of tectonic elements forming a complex jigsaw puzzle representing continental growth, destruction, and reorganization. Lithoprobe is providing the opportunity to address fundamental questions, with global implications, on how the current continental configuration was established and what tectonic processes were involved. The project began in 1984 and will end in 2003.

Understanding the tectonic development of northern North America requires collaborative application of multiple Earth Science disciplines to acquire comprehensive two-dimensional knowledge of units at the surface, as well as information in the third (depth) and fourth (time) dimensions. Lithoprobe brings together these ingredients in a series of 10 study areas (transects; Fig. 1), focused on geological features of Canada that represent globally significant tectonic processes. The study areas span the country from Vancouver Island to Newfoundland, from the northern United States to the Yukon and North-

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Lithoprobe continued from p. 1

west Territories, and cover 4 b.y. in time. Each region involves an integrated scientific program spearheaded by seismic reflection profiles. The program differs from other national seismic reflection profiling efforts such as COCORP (Consortium for Continental Reflection Profiling; U.S.), BIRPS (British Institutes for Reflection Profiling), DEKORP (Deutsches Kontinentales Reflexionsseismisches Program; Germany) and ECORS (Etude de la Crôte Terrestre en France per Méthode Sismique) in putting more emphasis on multidisciplinary approaches.

The transects of the Lithoprobe program address the cratonic core and growth of the North American continent. This core consists of six Archean (pre-2.5 Ga) provinces (Slave, Rae, Hearne, Wyoming, Superior, and Nain) that together form most of the crustal volume of the continent and are bound by a network of Paleoproterozoic orogenic belts (Fig. 1; Hoffman, 1989). Some of these belts are collisional zones involving extensive

reworking of the Archean crust, in some cases preserving only the deformed margins of formerly independent Archean microcontinents, whereas others include extensive tracts of juvenile oceanic lithosphere. The Mesoproterozoic Grenville province was added to the southeast side of this amalgamated core at about the time that the 1.1 Ga Midcontinent rift nearly split North America. The Paleozoic Appalachian terranes were attached to the eastern margin of the Grenville province following closure of the Iapetus Ocean and were left behind when the Atlantic Ocean opened during the Mesozoic. To the west, Mesoproterozoic to Paleozoic rifting and passive-margin formation preceded westward continental growth by Mesozoic terrane accretion (Fig. 2). East-directed subduction continues in this region today.

Each of the 10 Lithoprobe transect studies (Fig. 1) will culminate in a synthesis. Those for the GLIMPCE (Gibb et al., 1994), Kapuskasing Structural Zone (Percival, 1994), and Southern Cordillera (Cook, 1995) transects are complete. A synthesis of the Lithoprobe East Transect is near



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publication. Three regional syntheses of the Abitibi-Grenville transect have been published (Boerner et al., 1994; Ludden, 1994, 1995), and a final overview is in progress. Results of the THOT, Alberta Basement, and ECSOOT transects are still under analysis, and data collection will proceed for three more years in the Western Superior and SNORCLE transects.

The final component of the project will be a pan-Lithoprobe synthesis, similar to that of the European Geotraverse project (Blundell et al., 1992). This synthesis will include: (1) data and results for the landmass and offshore margins of Canada; (2) lithospheric cross sections including one ~5000 km long from the Pacific Ocean to the Labrador Sea (Fig. 3 is the first stage); (3) a reconstruction of the geometrical and kinematic evolution of the tectonic elements of northern North America; (4) investigations of the nature and mechanisms of tectonic processes associated with lithospheric evolution, including geodynamic modeling; and (5) comparison of Lithoprobe results with those worldwide.

Below, we highlight results from the Phanerozoic Southern Cordillera transect and the Archean component of the Abitibi-Grenville transect. Additional information on these and other Lithoprobe transects is available on the Web at <http://www.geop.ubc.ca/Lithoprobe> and associated, linked Web sites.

WESTWARD GROWTH OF NORTH AMERICA-SOUTHERN CORDILLERA TRANSECT

The western North American Cordillera is one of the world's great mountain systems. The principal stages in its formation involve Paleoproterozoic to Holocene tectonic processes (Gabrielse

and Yorath, 1991) that occurred on and adjacent to the Late Archean to Paleoproterozoic basement of the southwestern continuation of the present Canadian Shield. Extension-related rifting occurred in at least three periods in Meso- and Neoproterozoic and early Paleozoic time. Orogenic activity associated with extensive plutonism and volcanism took place from Devonian to Eocene time. Major compressional events occurred between the Middle Jurassic and Paleocene (170–60 Ma) as extensive Paleozoic and younger intraoceanic-arc and ocean-floor rocks were accreted to the North American continental margin. Between 100 and 40 Ma, large, right-lateral strike-slip faults that partly accommodated northward motion of the terranes relative to North America formed in the western Cordillera. At about 58 Ma, tectonism in the southern Cordillera underwent a fundamental transition from east-west shortening and crustal thickening to east-west stretching and crustal thinning. This change was associated with widespread magmatic-arc activity and exposure of metamorphic core complexes (high-grade rocks; e.g., see Hollister and Andronicos, 1997). Since the Eocene, the interior of the Cordillera has been relatively quiescent, whereas subduction beneath the western margin has produced the Cascades and Garibaldi-Pemberton volcanic belts. East-directed subduction of the Juan de Fuca plate continues today. These tectonic processes are reflected in the characteristic morphogeological belts and terrane elements shown in Figure 2.

The cross section in Figure 3 illustrates some of the primary scientific results from the Southern Cordillera transect. A key observation is that rock units mapped on the surface are decoupled from the mantle and, in some cases, the crust upon which they formed, and are attached

as thin flakes, or sheets, to the craton. In the eastern part, the decoupling surface (decoulement) steps downward from the front of the Foreland fold and thrust belt to the middle crust beneath the western Purcell Mountains of the Omineca belt (Cook et al., 1992). In the western Omineca belt and Intermontane belt, the decoulement penetrates the lower crust, perhaps to the Moho. Above the decoulement, collision-generated crustal-scale imbrication and antiformal structures occur. The existence of allochthons, thin relative to across- and along-strike dimensions, is confirmed by the profile. An unanswered question is the fate of the nearly 13 000 km of Pacific ocean plates that have converged with western North America in the past 180 Ma (Engelbreton et al., 1992), leaving only their upper parts as a contribution to the 500 km of westward continental growth.

A series of "windows" into the deep crust (core complexes) were formed by postorogenic Paleocene-Eocene extension. Remnants of middle to lower crust visible in these complexes can be tied to deep geophysical surveys. Perhaps the best studied are the Monashee and Valhalla complexes (e.g., Carr, 1995), where three crustal levels are exposed. The lower level includes North American Precambrian basement (1.8–2.1 Ga) and metasedimentary cover rocks. The middle level likely comprises metasedimentary rocks deposited near the North American margin. Upper-crustal-level rocks are preserved only in the hanging walls of the regional extensional faults and are associated with the accreted terranes. This basic picture, augmented by geometric information on deep crustal structure from seismic reflection (Cook et al., 1992) and refraction (Clowes et al., 1995) data, and by isotopic studies of magmatic rocks (Ghosh, 1995) indicates that cratonic lower crust (NA, Fig. 3) and Precambrian upper mantle are present beneath the Intermontane belt as far west as the Fraser strike-slip fault (Fig. 3).

In the Intermontane belt and belts farther east, the prevalent tectonic deformation is east-directed (vergent). In contrast, deformation in the Coast and Insular belts is dominantly west vergent (Fig. 3). The western Coast belt is dominated by plutonic rocks primarily derived from a depleted mantle source with little or no interaction with evolved continental material (Friedman et al., 1995). Seismically constrained gravity interpretations (Clowes et al., 1997) indicate that these plutons form a low-density layer up to 30 km thick that is underlain by a higher-density layer less than 10 km thick ("mafic residue," Fig. 3). Given that plutonism was a prolonged, episodic process that both predated and postdated convergence between the Insular and Intermontane

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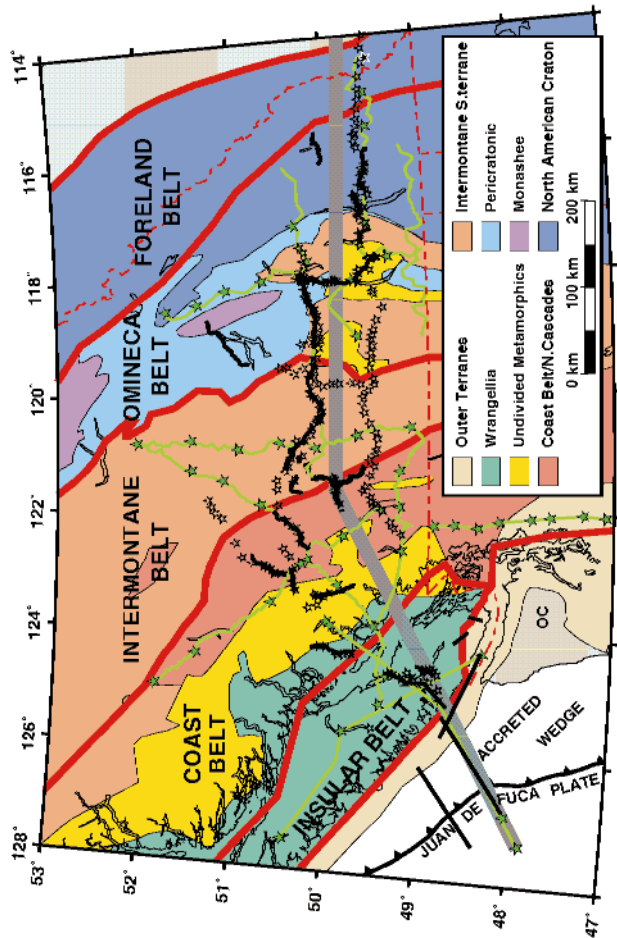


Figure 2. Simplified map of the southern Canadian Cordillera showing morphological belts and principal terrane elements. Black solid lines—seismic reflection profiles; light green lines, seismic refraction-wide-angle reflection profiles (shot points indicated by solid green stars); open stars—magnetotelluric station sites; OC—core of the Olympic Mountains, an exposed part of the accreted wedge; broad gray line—location of cross section in Figure 3.

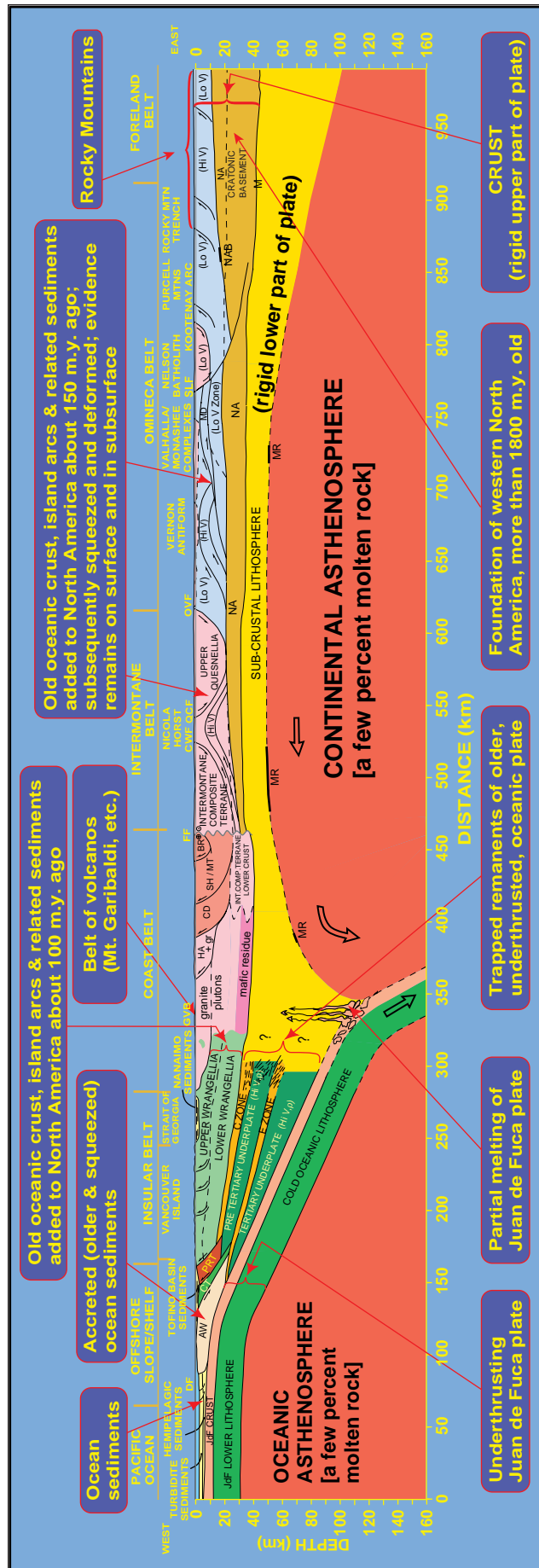


Figure 3. Interpreted lithospheric cross section from the Juan de Fuca plate to the Foreland belt. In the mantle, open arrows show possible material flow. AW—accreted wedge; BR—Bridge River terrane; CD—Cadwallader terrane; CT—Crescent terrane; CWF—Coldwater fault; DF—deformation front; FF—Fraser fault; gr, granites; GVB—Garibaldi volcanic belt; HA—Harrison terrane; Hi V, ρ —high velocity and density; JdF—Juan de Fuca plate; Lo V—low velocity; M—Moho; MD—Monashee decollement; MR—mantle reflector; MT—Methow terrane; NA—North American craton; NAB—North American basement reflector; OVF—Okanagan Valley fault; PRT—Pacific Rim terrane; QCF—Quilichena Creek fault; SH—Shuksan terrane; SLF—Slocan Lake fault. (A combined version of Figures 2 and 3 in poster format is available from Ron M. Clowes.)

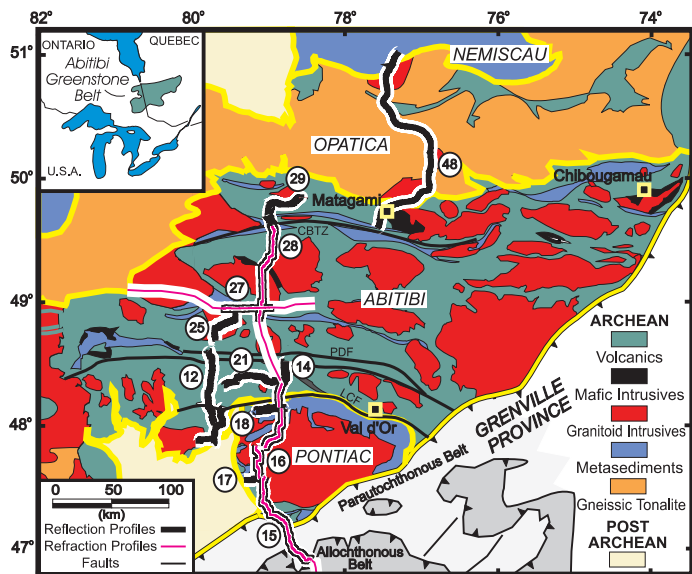


Figure 4. Simplified geological map outlining domains of the Nemiscau, Opatica, Abitibi, and Pontiac subprovinces of the Superior province and the Grenville province within the study area. Locations of seismic reflection profiles shown by numbered black lines (grayish where they overlap with locations of seismic refraction profiles shown by pink dots on white background). Fault zones: CBTZ—Casa Berardi; LCF—Larder-Cadillac; PDF—Porcupine-Destor.

becomes accreted to the subducting slab, thereby increasing the thickness of the mechanically defined lithosphere and providing a mechanism for driving convective flow of shallow asthenosphere.

FORMATION OF ARCHEAN LITHOSPHERE—THE ABITIBI SUBPROVINCE

The Middle-to-Late Archean period represents the most important time of growth of Earth's lithosphere. With an exposed area of 1.6 million km², the Superior province (Fig. 1), which formed between 3100 and 2650 Ma (Thurston and Chivers, 1990; Card, 1990), is the largest remnant of this period. It comprises a series of approximately east-trending granite-greenstone belts separated by metasediment- and granite-dominated subprovinces. The along-strike geological and geochemical similarities of the belts and a gradual younging to the south (Corfu and Davis, 1992) have led to the view that the Superior province grew southward through accretion of oceanic arcs and plateaus, the metasedimentary belts representing remnants of intervening accretionary wedge assemblages. The precise nature of this accretion remains subject to debate (Hoffman, 1989; Kimura et al., 1993; Percival et al., 1994; Jackson and Cruden, 1995) and is a focus of study in the southeastern part of the Superior province, part of the Abitibi-Grenville transect (Fig. 1). An ancillary result in this area is the demonstration of the applicability of seismic reflection data in mineral exploration (e.g., Milkereit et al., 1996; Perron and Calvert, 1997).

From north to south, the study region (Fig. 4) consists of: (1) the Nemiscau metasedimentary belt; (2) the Opatica plutonic belt, an amphibolite-grade meta-plutonic gneiss terrane; (3) the Abitibi subprovince, a low-grade granite-greenstone belt (world's largest; source of much of Canada's mineral wealth); and (4) the Pontiac subprovince, a metasedimentary and

Lithoprobe *continued from p. 3*

superterrane, one explanation for this layering is that it was produced by fractionation of arc-related magmas. Alternatively, widespread magmatic underplating associated with the subduction regime along western North America could have generated the high-density layer.

The part of the Southern Cordillera transect beneath Vancouver Island was the first major survey to cross an ocean-continent subduction zone. This study provided key insights into the mechanisms of the accretionary process (Green et al., 1986; Clowes et al., 1987; Hyndman et al., 1990). Two subparallel prominent reflectors (C Zone and E Zone in Fig. 3) that bound a zone of high seismic velocity are observed structurally above the subducting Juan de Fuca plate. These reflectors have been interpreted as delineating a slice of material detached from the subducting plate and added to the base of the accretionary complex beneath Vancouver Island. The study demonstrates that accretion at a young plate boundary is characterized by near-surface thrusting

(accretionary wedge) and crustal-scale subsurface duplexing analogous to that seen in fold-thrust belts. The geometry and physical characteristics determined in the Lithoprobe transect, together with subsequent results from Geological Survey of Canada studies, are leading to a better understanding of the megathrust earthquake cycle and the hazards associated with the Cascadia subduction zone (e.g., Hyndman and Wang, 1996).

Seismic wide-angle reflection data from the Southern Cordillera transect identify shallow mantle reflectors that are interpreted to represent the top of a shallow asthenospheric layer (Fig. 3; Clowes et al., 1995), consistent with earlier surface wave and geomagnetic studies. Below the central Coast belt, this warm, low-velocity asthenosphere must interact with the cold lithosphere of the subducting Juan de Fuca oceanic plate. In such a scenario, the mantle below the central Coast belt is a "sink" for both subducting lithosphere and the western limb of the mantle upwelling below the Intermontane and Omineca belts (see Gough, 1986). The asthenosphere in the "sink" is cooled by and

Lithoprobe *continued on p. 6*

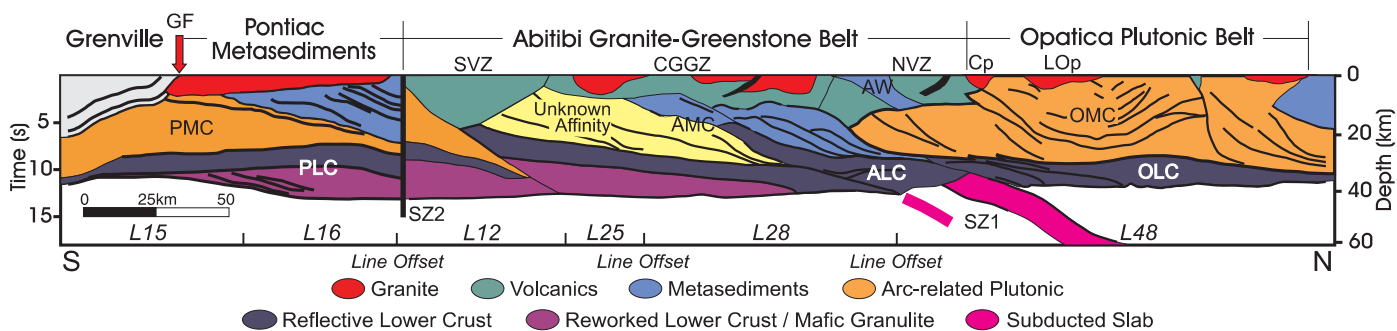


Figure 5. Composite interpretation of seismic sections across the Opatica plutonic belt, Abitibi granite-greenstone belt, Pontiac subprovince, and Grenville province; seismic line locations (L48, etc.) are shown in Figure 4. Irregular heavy black lines indicate seismic reflectors. ALC—Abitibi lower crust; AW—accreted wedge; CGGZ—central granite-gneiss zone; Cp—Canet pluton; GF—Grenville Front; LOp—Lac Ouescapis pluton; NVZ—northern volcanic zone; OMC—Opatica middle crust; OLC—Opatica lower crust; PMC—Pontiac middle crust; PLC—Pontiac lower crust; SVZ—southern volcanic zone; SZ1 and SZ2—suture zones 1 and 2.

plutonic domain. A composite cross section highlighting the structural features of the region is shown in Figure 5. The most spectacular result is a seismic image at the Abitibi-Opatca belt boundary (from L48, Fig. 5; see Calvert et al., 1995) where north-dipping reflectors extend from the base of the crust to depths of ~70 km in the upper mantle. Similar reflections in Phanerozoic and Proterozoic regions have been attributed to shear zones formed at subduction zones (Warner and McGeary, 1987; BABEL Working Group, 1993). Correlation of the mantle reflections below the Opatca belt (defining the "subducted slab," Fig. 5) with mid- to lower-crustal reflectors in the northern Abitibi belt (ALC and AMC) implies that these reflections represent a suture zone (SZ1) associated with underthrusting of the Abitibi belt beneath the Opatca belt. Following the general geodynamic modeling of Beaumont and Quinlan (1994), opposite vergent reflectivity within the Opatca crust (OMC) can be interpreted as "pro-thrusting" and "retro-thrusting" related to the same event. The seismic data provide evidence for modern-style plate tectonic processes in the Late Archean. Stitching plutons (Cp and LOp, Fig. 5) indicate that juxtaposition of the Opatca and Abitibi belts had occurred by 2700–2695 Ma (Davis et al., 1995). Prominent subhorizontal seismic reflections in the lowermost crust of the Opatca belt (OLC, Fig. 5) that are cut by faults extending into the middle crust indicate that the lower crust has retained its structure since these terranes were juxtaposed.

Whereas arc-related plutonic rocks dominate the Opatca belt, the Abitibi belt has a more heterogeneous character. On the basis of geological studies, the Abitibi subprovince is divided into three zones (Ludden and Hubert, 1986). The northern volcanic zone and central granite-gneiss zone consist mainly of 2759 to 2720 Ma volcanic and sedimentary suites (Mortensen, 1993). The seismic section for this region shows a poorly reflective uppermost crust, which is interpreted as volcanic and plutonic units (Fig. 5). The crust below is dominated by north-dipping reflections suggestive of a complex accretionary history. An interpreted accretionary wedge south of SZ1 (AW, Fig. 5) is consistent with northward underthrusting of terranes in a north-dipping subduction environment. However, the nature of the central core of the Abitibi middle crust is uncertain. Below the younger (2715–2705 Ma; Corfu et al., 1989) southern volcanic zone (SVZ, Fig. 5), the crust shows faint, incoherent reflectivity and is interpreted as a deep (up to 20 km) volcanic basin. This basin is the only evidence for large-scale postaccretion extension.

A second crustal suture zone, representing the inferred northern limit of arc-related Pontiac units, is interpreted at the Abitibi-Pontiac boundary (SZ2, Fig. 5). At 2698 to 2686 Ma (Mortensen and Card, 1993), the Pontiac metasedimentary rocks are younger than Abitibi units and occupy a significant volume of the crust. Their underthrust geometry suggests they represent a relict accretionary wedge that continued to evolve after the collision to the north had largely ceased. Stitching plutons along the Pontiac-Abitibi boundary indicate that the collision was largely complete by 2685 to 2680 Ma.

However, deformation at depth did not cease. U/Pb geochronology on exposed lower-mid-crustal rocks from the upthrust Kapuskasing structural zone (Krogh, 1994), the western boundary of the Abitibi subprovince, and from crustal xenoliths in kimberlites in the southern Abitibi belt (Moser and Heaman, 1997), indicates that units occur in the lower crust that are significantly younger than in the upper crust. Alternative interpretations are that: (1) the lower crust underwent late extension and recrystallization that was decoupled from the upper crust; or (2) late-stage mafic magmas were underplated and intruded as sills in association with lower crustal extension. Seismic refraction data (see Fig. 4) indicate velocities of >7.0 km/s for the deepest 8 km of crust below the south-central Abitibi (Winardhi and Mereu, 1997), supporting intrusion of mafic magmas. Above this region reflections are strong, but within it reflectivity decreases. The mafic intrusions, decreasing reflectivity (perhaps due to reworking), and Moser and Heaman's (1997) evidence for 2.4 Ga zircon overgrowths on Archean crustal xenoliths indicate that the lowermost crust of the southern Abitibi belt was affected by Huronian magmatism.

Geochronological information and the inferred suture zones are consistent with two alternative scenarios: (1) southward migration of a single north-dipping subduction zone that was closed by collision with the Pontiac arc; or (2) north-dipping subduction zones below both the Opatca and the southern Abitibi terranes, the latter one being closed by Pontiac collision. In either case, the mineralized volcanic sequences formed the top of the stack and were later intruded by plutons. These results provide strong evidence for Archean continental growth by arc accretion and subduction tectonics.

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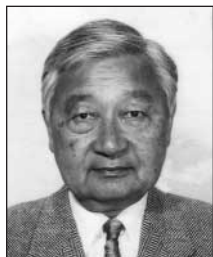
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1998 Honorary Fellows Named

The three geoscientists named as GSA Honorary Fellows for 1998 are Shigeo Aramaki, Victor Khain, and Werner-Friedrich Schreyer.

Shigeo Aramaki



Shigeo Aramaki's rise to international recognition as a premier volcanologist began with his classic dissertation on the volcano of Asama. He is well known for his studies and papers on

ash flow tuffs, calderas of Japan, and arc volcanism and caldera structure; many young scientists entering the field have sought him out as a mentor.

Aramaki was also one of the first geologists to determine temperatures of pyroclastic deposits using paleomagnetism, which inspired considerable research by other scientists on temperature estimation.

Born in Japan in 1929, Aramaki graduated from Tokyo Emperor University in 1955, and received his Doctorate of Science in 1961. He received the Geological Society of Japan award in 1973, was president of the Volcanological Society of Japan from 1986 to 1988, and also served as president of the International Association of Volcanology and Chemistry of the Earth's Interior from 1988 to 1993.

Aramaki is currently a professor at the Institute of Natural Sciences, at Nihon University in Japan. He has held positions at the University of Tokyo, the Earthquake Research Institute, and Hokkaido University.

Victor Khain



Victor Khain is credited with introducing the plate tectonic revolution to the Russian geologic community. He was one of the first scientists to apply plate tectonics to continental geol-

ogy, and is well known for producing excellent tectonic maps of the world as well as textbooks and atlases.

Born in 1914 in Baku, Azerbaijan, Khain became interested in petroleum geology upon entering the Industrial Institute of Azerbaijan. He graduated in 1935 and began his career as a petroleum geologist, working for both exploration and research companies.

During World War II, Khain served in the Soviet Army, where he worked on radar anti-aircraft defense. After military service, he began studying structure and tectonics; he received a Doctorate of Science from the Institute of Geology, Azerbaijan Academy of Sciences in 1947. He has published more than 40 books and monographs and more than 200 papers.

Khain is currently a principal researcher at the Institute of the Lithosphere, Russian Academy of Sciences. He is also professor emeritus at Moscow Lomonosov State University.

Werner-Friedrich Schreyer



Werner-Friedrich Schreyer, a pioneer in the field of experimental and metamorphic petrology, discovered that coesite, pyrope, and other index minerals found in white schists were formed

from cold subduction of crustal rock at depths greater than 100 km. He found that such deformed rock could return to the surface without completely losing its crustal identity.

Schreyer was born in 1930 in Nürnberg, Germany. He received his doctorate from the University of Munich in 1937, and honorary doctorates from the Universities of Hannover and Liege.

Schreyer began his career in the geosciences as a field geologist, his interests ranging from the Vredefort Crater to economic geology. He spent three years at the Carnegie Institution, where he was introduced to experimental petrology.

Schreyer was named Chair of Mineralogy at Bochum University in 1966, and succeeded in building a new department, where he has continued to produce studies in high-pressure experimental mineralogy and petrology and assisting his students, many of whom have become accomplished mineralogists. Schreyer is also an editor for *Contributions to Mineralogy and Petrology* and *Journal of Petrology*. ■

GSA Division News

Divisions will be recognizing the following individuals at the 1998 Annual Meeting in Toronto for their service to the Division and/or contributions to the geological sciences.

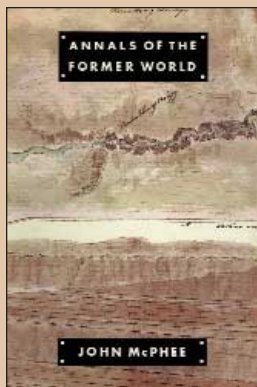
Hydrogeology Division
John A. Cherry
Distinguished Service Award
Stuart Rojstaczer
1999 Birdsall-Dreiss
Distinguished Lecturer

Quaternary Geology &
Geomorphology Division
Dale F. Ritter
Distinguished Career Award

For a listing of other award recipients to be honored at the Toronto meeting, see page 8 of the August 1998 issue, *GSA Today*.

BRING YOUR HOLIDAY GIFT LIST!

John McPhee Book Signing Scheduled



GSA is privileged to have internationally renowned author John McPhee in attendance at the Toronto Annual Meeting on Sunday, October 25 and Monday, October 26. By special arrangement with McPhee's publisher, Farrar, Strauss & Giroux, we will have copies of his newest book *Annals of the Former World* available at the GSA bookstore. During his visit, McPhee will be available to visit with meeting attendees and sign copies of his book on Sunday evening at the Foundation booth from 5:00 to 7:30, and on Monday at the GSA Bookstore from 10:00 to 11:00 a.m. and from 3:00 to 4:00 p.m.

Annals of the Former World collects in a single volume five commentaries about the geology of North America: "Basin and Range," "In Suspect Terrain," "Rising from the Plains," "Assembling California," and "Crossing the Craton." The first four were originally published in *The New Yorker*; the fifth appears for the first time in this book. Of special interest is McPhee's roster of "research assistants," most of whom are members of GSA: Anita Harris, Karen Kleinspehn, Dave Love, Eldridge Moores, and Randy Van Schmus.

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.

Strengthening U.S. Leadership In Information Technology

I am hopeful that the Congress and my Administration can work together to advance the leading edges of computational science to help us discover new technologies that can make this a better world. We have a duty—to ourselves, to our children, and to future generations—to make these and other farsighted investments in science and technology to take America into the next century well-equipped for the challenges and opportunities that lie ahead.

—President William Clinton, August 10, 1998

On August 10, the President's Information Technology Advisory Committee (PITAC), released a report that presents its agenda for ensuring America's leadership in the Information Age. This is to be accomplished by expanding government investments in long-term research and development in technologies such as computers, networks, and software. It is hoped that such investments will drive economic growth, generate new knowledge, create new jobs, build new industries, ensure our national security, protect the environment, and improve the health and quality of life. The PITAC, co-chaired by Bill Joy, founder of Sun Microsystems and Ken Kennedy of Rice University, is composed of 25 of the nation's top academic and industry computing and communications experts.

In accepting this report, President Clinton thanked the Committee for their work in developing a research agenda for the Nation, and renewed his commitment to make significant increases in funding for computing and communications research in the years ahead. "Our nation's economic future and the welfare of our citizens depend on continued advances and innovation in the information technologies which have produced so many remarkable developments in science, engineering, medicine, business, and education," the President said.

The PITAC report notes that the growth in today's information technology (IT) sector is leading the growth of all other sectors of the economy. The Federal Reserve reports that during the past five years, production in computers, semiconductors, and communications equipment quadrupled at a time when total industrial

production grew by 28%. These three industries account for one-third of the total growth in production since 1992.

In a June 1998 speech at the Massachusetts Institute of Technology, the President asked Neal Lane, Head of the Office of Science and Technology Policy and his new science advisor, to prepare a detailed plan on computing and communications research. He has directed Lane to work with our nation's scientific community, and to carefully consider the new research directions identified in the Committee's report.

The Committee stressed the importance of Clinton Administration initiatives in computing and communications such as the Next Generation Internet, the Department of Energy's DOE 2000 distributed computing program, and the National Science Foundation's Knowledge and Distributed Intelligence emphasis. This year, President Clinton has proposed budget increases for civilian research and development to keep America at the cutting-edge of science and technology. Specifically, the Committee recommended emphasis be placed on:

- Techniques for developing software that is more dependable and reliable;
- Communication systems which will be able to support billions of users and devices that are attached to the network;
- High-speed computers and software that can deliver useful performance that is a thousand times faster than today's most powerful supercomputers; and
- Research that ensures that America's workforce is properly prepared for the challenges and opportunities of the Information Age.

With respect to support and implementation of new Federal research initiatives, the Committee recommended new and diverse modes of funding, including diversification of the modes of research support to include more projects of broader scope and longer duration, funding virtual centers for Expeditions into the 21st Century, and establishing a program of Enabling Technology Centers. Recognizing the critical role that Federal research has played in developing modern computing, the Internet, and other Information Age technologies, the Committee urged the President to ensure that this momentum is maintained. The Committee argued for sharply increased support for basic research, giving highest priority to research on computer software. They also stressed the importance of allowing the research community to "live in the future" and tackle long-term, high-risk research challenges.

The Committee found with respect to setting Federal research priorities, that the total Federal information technology research and development investment is inadequate, and that Federal IT research and development is excessively focused on near-term problems. Specifically, with respect to research focal points and societal implications, the Committee found that the demand for software far exceeds the Nation's ability to produce it, the Nation depends on fragile software, the technologies to build reliable and secure software are inadequate, and the Nation is under-investing in fundamental software research. The Committee recommended that a variety of additional investments be made to enable fundamental improvements in the Nation's software quality and its development processes. In particular, major improvements must be made to methods for software development, verification and validation, maintenance, user interfaces to computing systems and electronically represented information, software for high-end computing, and software to support emerging ubiquitous and collaborative computing.

Specific recommendations included: funding more fundamental research in software development methods and component technologies, sponsoring a national library of software components in subject area domains, making software research a substantive component of every major IT research initiative, and supporting fundamental research in human-computer interfaces and interaction. One recommendation, labeled as a 'Major Recommendation' is to make fundamental software research an absolute priority.

The Committee found with respect to software research that the Internet has grown well beyond the intent of its original designers, our Nation's dependence

Washington Report *continued on p. 10*

Real Estate Gifts are Rock Solid

This is a great time for real estate—buying, selling, building, remodeling. Employment is high; people are confident. Across North America, businesses are growing and expanding or moving to new facilities. Families are investing in upgrading or replacing their homes. Housing starts are up, and interest rates are down. Home Depot is stocked to the rafters.

Interestingly, it's also a great time to give away real estate. But why would anyone want to give away a house, a farm, a cherished mountain cabin, or a four-unit apartment building? The value of real property—land, buildings, mineral rights and royalties—has appreciated in good economic times. People find themselves owning property assets worth far more than the original purchase price.

Recent changes in tax policy have provided some relief by deferring taxation of a portion of capital gains realized on the sale of a residence. But the relief applies only to principal residences and doesn't extend to vacation homes or income-producing properties. Nor does it reduce the potential for taxation on the value of any real property included in a decedent's estate. So there can be a significant economic benefit resulting from a gift of such property.

The less quantifiable benefit derives from making a meaningful investment in the work and future of a charitable beneficiary such as GSA. For those who have done well, doing good can be a source of important satisfaction.

If the "why" of a real property gift now seems more evident, the next obvious question is "how?" Not only how might this type of gift be made but, of even greater concern, how do donors accommodate the changes in their lives these gifts undoubtedly cause?

The "how" of the gifts is straightforward: Property may be transferred to the GSA Foundation outright and immediately by deed or outright in the future by will. It may also be transferred to a charitable trust and the benefit preserved to the donors for their lifetimes. By any of these means, donors (or their heirs) realize a charitable tax deduction as soon as the transfer is complete. Regardless of the means, and unless a donor has retained lifetime use of a residence placed in trust, upon completion of the transfer the GSA Foundation may sell the property, without incurring income or estate taxes, and invest the proceeds in securities to provide income payable to the donors and to GSA's scientific, educational, and outreach programs.

At the time of making a real property gift, whether the charitable benefit will be immediate or will be deferred, the donor can direct how the gift will be applied and to what purpose. The proceeds of sale may be dedicated entirely to current program uses or may be deposited to an endowment fund and only the earnings spent for program activities. Similarly, donors may direct gift funds to specific programs such as research grants or named awards recognizing professional achievement or may prefer that the funds be unrestricted, allowing GSA to allocate them where there is the most compelling need or opportunity.

Only you can decide if, when, and how a special gift to the GSA Foundation fits your long-range financial planning. Perhaps you have not yet thought about a gift of real estate. But if your assets include a house, farm, raw land, mineral rights, or other property of this kind, upon careful consideration you may find that a gift of such property may enable you to make a major contribution to the future of geology.

For further information about gifts of real property, please contact the GSA Foundation office by phone (303) 447-2020, ext. 183, or by e-mail at vbrown@geosociety.org. ■

Washington Report *continued from p. 9*

on the Information Infrastructure is increasing daily, the US cannot safely extend what we currently know to more complex systems, and learning how to build large-scale, highly reliable and secure systems requires research. To support the growing demand and dependence on the information infrastructure, advances are needed in at least five major dimensions:

- Scaling to provide robust, high-speed access, with assured quality-of-service when required. These advances will improve the quality of interaction.
- Scaling to provide multi-faceted access. This scaling will create new ways for people to connect.
- Scaling to provide ubiquitous access. These advances will increase the number of people with continuous access to information.
- Scaling of the infrastructure services to reliably handle many users and requests. These services include authentication, resource directories, search

engines, banking, and many others. Advances in this area will improve the quality of information.

- Scaling of the security infrastructure to safeguard intellectual property rights, to protect against all types of failures or attacks, and to provide privacy of access when needed.

The Committee's recommendations to deal with this software crisis include: expanding the Next Generation Internet testbeds to include additional industry partnerships in order to foster the rapid commercialization and deployment of enabling technologies, and increasing funding in research and development of core software and communications technologies aimed directly at the challenge of scaling the information infrastructure.

The Committee recommends that a substantial funding increase be invested in the following three key research areas that are critical to scaling the information infrastructure:

Scalability—Improving the information infrastructure for the Nation requires

using the highest performance to meet the practical needs of millions of simultaneous users. The future information infrastructure will consist of elements that are of much greater diversity and represent as much as a million or more factors of improvement in performance than those of today. Research is needed to better understand how to build models of these large, complex systems. Traffic characterization models and models of the effect of aggregate demand are needed, as well as the ability to simulate a network under various conditions. Also needed are test and measurement tools, as well as supporting standards that provide flexibility and scalability. Software algorithms for scalable and secure services require improved schemes for filtering vast amounts of information, for coping with inaccurate data and with intrusions, and for processing huge numbers of user transactions.

Physical distribution—A better information infrastructure will emphasize geographical distribution with its limitations

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Digging Up the Past

Most memorable early geologic experience:

Seismic work using State vehicles in Southern Illinois fluorspar district in early '50s required getting clearance in moonshine country by announcing destinations in local bars.

—Robert Johnson



on bandwidth, increase in latency of communication, and additional challenges in secure and reliable communication. As the number of computers connected to the network increases, addressing and routing becomes more difficult, especially as hosts become mobile, as applications become more demanding, and as networks seek to provide multiple levels of service to meet different application needs. Allocating network capacity and dealing with congestion also become more problematic as usage expands. Lastly, ensuring interoperability—the ability of heterogeneous hardware and multi-vendor software to interoperate—will become more challenging. Research is needed to achieve progress in each of these areas. Government can also play an important role by supporting testbeds, such as the Next Generation Internet (NGI), and demonstration projects that allow early deployment of maturing technologies.

Usability—The fundamental challenge to greater acceptance and use of information technologies is to make them

more usable. The acceptance and popularity of Web browsers demonstrate the importance of user models, human factors, and other areas where research is critically needed. To achieve an information infrastructure in the fullest sense—an information infrastructure that reaches ordinary citizens—these efforts must be extended to address intuitive models of use and user interface technologies to enable a class of information appliances that will become a part of everyday life. Intelligent information retrieval systems, systems for understanding speech and pictures, and systems for enabling intelligent dialogues between people and computer systems are capabilities that will build on the High Performance Computing and Communications Initiative (HPCCI) research and enhance the usefulness and level of use of the information infrastructure. In addition, research and development of software technologies such as security, privacy, network measurement and management, database management, transaction processing, application inte-

gration, and other capabilities may be less directly visible to individuals, but are essential to making computing and communications facilities more usable.

In responding to the President's direction, Lane said "I concur with the Committee's conclusion that research in computing and communications merits expanded support and is as important to America's position of leadership in the 21st Century as any area of research. We must rededicate ourselves to cutting-edge R&D in information technology, or other nations could pass us by, and that is a risk the United States cannot afford."

The PITAC report will provide Federal agencies with a compelling set of research goals which will provide valuable guidance as they prepare plans for our year 2000 budget. A copy of the Committee's report is available on the World Wide Web at <http://www.ccic.gov>. ■

Fast Forward: Geosciences in the 21st Century

Cathleen May, Director, IEE

"One thing I have learned in a long life: that all our science, measured against reality, is primitive and childlike—and yet it is the most precious thing we have."

—Albert Einstein

The turn of a century is historically a time of societal reflection, focusing our attention on real and perceived change. At the close of the 20th century, change confronts us daily, whether we are paying attention or not. For example, the increasingly global economy and advanced information technology cause the stock market to behave in unprecedented and unpredictable ways that affect each of us regardless of our personal exposure. The temporal window used as a basis for predicting cyclic market fluctuations and longer-term trends was simply too short to capture the factors that might predict 500-point drops in the Dow triggered by news from the Russian economy. When individual investors can trade, over the Internet, a single stock as many times in one day as they choose for a flat rate of \$8.00, the old rules for predicting market behavior no longer apply.

The burgeoning global population and its increased demands on the resources of the planet are also factors that will effect unprecedented change on human behavior. As we enter the 21st century, however, we cannot afford *not* to pay attention to directional changes in resource consumption and availability, and our impact on the function of the ecosystems that sustain us. If we are to try to predict the unprecedented, our "window" must enlarge to encompass as many vectors of change as conceptually possible. This need virtually prescribes unprecedented approaches in the earth sciences. These must include synthetic collaboration *among* the earth sciences, with sibling sciences, and with seemingly distant disciplines. Prediction is a risky business, however. Just as "timing the market" is an approach best left to the most risk-averse investor, forecasting change in the Earth system is not for the faint-hearted. Fortunately, many geoscientists are intellectually adventurous and socially committed to the challenge. These are exciting times for members of the earth sciences community. And this is a particularly gratifying time to become a member of the headquarters staff of our Geological Society of America.

As the new director for policy and environmental issues and the Institute of Environmental Education (IEE), it is my job to help our members bring their sci-

ence into relevant interactions with sibling disciplines, other scientific fields, and society. Toward that end, the Institute for Environmental Education sponsors topical symposia and sessions for disseminating the results of collaborative and integrated science. IEE also sponsors forums of interaction among thinkers in disparate disciplines. The task of providing such venues at the Annual Meeting in Toronto was accomplished by the advance work of former IEE director Dan Sarewitz, the diligence and enthusiasm of acting director Elizabeth Knapp, and the dedication of committed GSA members before I joined the headquarters staff this past summer. I am proud to convey the results of their efforts, by announcing a daily roster of exciting and timely forums, symposia, theme sessions, and special events throughout the GSA Annual Meeting. We encourage your attendance and participation, and I invite your comments following the meeting. Please contact me at cmay@geosociety.org, or through Stacey Ginsburg at sginsbur@geosociety.org.

Sunday, October 25
1:30 to 5:30 pm.



IEE ANNUAL ENVIRONMENTAL FORUM:

The Sustainability Challenge I: Energy for the 21st Century. When will global oil production peak? How robust are predictions of peak production? What are the myths and realities regarding alternative energy sources? What should be our priorities for use of a declining oil supply? Can the transition to an economy without oil be peaceful? A panel of eight distinguished speakers from academia, industry, and the social sciences will address these questions. We encourage audience participation from the floor at scheduled intervals. The Forum is cosponsored by the Committee on Geology and Public Policy and its ad hoc Critical Issues Committee.

Monday, October 26

Natural Sources of Mercury and Arsenic: Significance in Regional Cycles and Environmental Assessments. Arsenic and mercury occur as volatile and water-soluble chemical species, facilitating their dispersal under

both natural and anthropogenic circumstances. Researchers will present studies of the occurrence of these elements, particularly in groundwater, their effects on biogeochemical cycles, and potential bioremediation techniques. Theme session sponsored by IEE. 8:00 a.m. to noon.

Groundwater Sustainability. Researchers will examine sustainability of groundwater sources of different types and scales from arid to humid regions, and from the Colorado Plateau to urban watersheds. Sustainability issues will be explored in terms of both volume and quality. Theme session sponsored by GSA Hydrogeology Division cosponsored by IEE. 10:00 a.m. to 12:00 noon.

Hydrogeologic Controls on Ecosystems. Hydrogeology and geologic setting control biological, biogeochemical, and physical processes as well as the distribution and composition of communities in many ecosystems. This session addresses the effect of hydrogeologic processes on ecosystem development and health, and the effects of hydrogeologic perturbations. Theme session sponsored by GSA Hydrogeology Division and IEE. 1:30 to 5:30 pm.

Breaking Down Barriers: Communicating Relevant Geoscience Issues to the Public II. This symposium is one of a triad of venues (see theme and poster session listings below) in which earth scientists will present successful efforts to facilitate learning among non-geoscientists. The focus is on innovative products and programs that are improving scientific literacy through access to geoscientific information. All three sponsored by Education, Outreach, and Policy Programs, and cosponsored by IEE. Symposium: 1:30 to 5:30 p.m.

Breaking Down Barriers: Communicating Relevant Geoscience Issues to the Public I. This poster session provides a close-up look at some of the innovative methods used by imaginative earth scientists to convey geoscientific information to non-specialists. Authors will be present from 9:00 to 11:00 a.m. Posters will be displayed from 8:00 a.m. to noon.

Tuesday, October 27

Research Opportunities in the Earth Sciences: A Ten-Year Vision. This symposium is designed to assist the National Science Foundation and the National Research Council develop a long-term vision for basic research in the earth sciences. This vision will form the basis of

a new long-range plan for NSF's Earth Sciences Division. Don't miss this chance to hear some of our profession's most influential leaders identify and discuss major trends and opportunities in the 21st century. Sponsored jointly by NSF and the NRC, and cosponsored by IEE. 8:00 a.m. to noon.

Breaking Down Barriers: Communicating Relevant Geoscience Issues to the Public II. This theme session expands on topics discussed in Monday's symposium. Fully one-half of the session is allocated to discussion, for which audience participation is a must, so please attend as an active participant. 8:00 a.m. to noon.

Conversations with the Earth: Philosophers and Geoscientists in Dialogue on the Role of the Earth Sciences in Society. Three earth scientists and three philosophers will explore the role of geology, at its most elemental, in society and culture. Expect philosophical perspectives from the scientists, and observations on the nature of science from the philosophers. Aesthetics, ethics, politics, the scientific method—the symposium is an invigorating look at fundamental concepts that inform our individual scientific approaches. Sponsored by IEE and the International Association for Environmental Philosophy. 1:00 to 5:00 p.m.

Developing Sustainability Curricula: A Challenge for Earth Science Educators. What is “sustainability” and how do we teach about it? Is it a societal value, and if so, can it ethically be taught within the paradigm of objective science? Earth scientists may well be the group best equipped to develop and teach principles of sustainable resource stewardship. What are the challenges of such a role, and how can we meet them? Sponsored by National Association of Geoscience Teachers; cosponsored by IEE and the ad hoc Critical Issues Committee. 1:30 to 5:30 p.m.

Education about the Environment: What Works. Thirteen posters will demonstrate educational success in teaching about the environment. Subjects range from the use of Quick Time Virtual Reality technology to teach geologic mapping, to interdisciplinary field courses, to self-reflection as an educational tool. Sponsored by NAGT and IEE. 1:30 to 5:30 p.m.

Wednesday, October 28

Don't miss your chance to meet with our Congressional Science Fellow, David Verardo, and to learn from his experiences in *From the Outcrop to the Hill: A Year of Correlating Science and Public Policy*. Also on hand will be incoming Science Fellow, Kai Anderson. Sponsored by Committee on Geology and Public Policy and IEE. Noon to 1:00 p.m.

IEE Annual Environmental Forum

Sunday, October 25, 1:00–5:00 p.m.

The Sustainability Challenge I: Energy for the 21st Century

“Can We Make It?: The Political Realities of Shrinking Oil and Gas Supplies”

— Mike McCormack

“Shell Solar—Making Energy Available to All” — Roy N. Levitch

“Alternative Energy Sources: Myths and Realities” — Walter L. Youngquist

“The Decline of Hydrocarbon Man — The Growing Importance of Renewables, Using Less, New Lifestyles” — C. J. Campbell

“How Good Are Estimates of Petroleum Resources?”

— Thomas S. Ahlbrandt

“Timing of the Decline of Global Oil Production” — John D. Edwards



Following David Verardo's messages is the **Geology and Public Policy Forum: Geoscience Ethics in Environmental and Natural Resource Issues.** How do we fulfill our roles as citizen-scientists? What ethical considerations confront scientists who want to contribute to the resolution of environmental issues? Victor Baker (current GSA President) and Eldridge Moores and David Stephenson (past presidents) will discuss our ethical and scientific participation in democratic processes. Two panelists from outside the earth sciences will lend perspective and social dimension to the discussion. Sponsored and convened by GSA's Committee on Geology and Public Policy; sponsored by IEE. 1:30 to 3:30 p.m.

Thursday, October 29

GSA's International Division and Coal Division, the U.S. Geological Survey, and the Geological Survey of Canada bring you **Environmental Quality vs. Economic Development: The Role of Coal in Developing Nations.** Issues of environmental quality and energy development simply cannot be considered outside their economic context. Nowhere do these issues collide with more impact than in developing nations. Please don't leave Toronto without paying attention to one of the most critical suites of scientific-social-economic issues facing our truly global professional community in the 21st century. IEE is proud to cosponsor this important symposium. 8:00 a.m. to noon.

The events above offer many opportunities to consider the issues we face as our profession enters into more lively interactions with each other, sibling sciences, and the social sciences. If your eye is on change and your professional goals include new challenges and opportunities, please attend as many of the IEE-sponsored and co-sponsored events as you can while in Toronto. We're convinced you'll walk away thinking. ■

FUNDING OPPORTUNITIES IN THE HYDROLOGIC SCIENCES THROUGH THE NATIONAL SCIENCE FOUNDATION

Wednesday, October 28 from 3:00 to 5:00 p.m., Room 716B, Metro Toronto Convention Centre.

Presiding: L. Douglas James, Program Director, National Science Foundation (NSF), Hydrologic Sciences

Have a great hypothesis? Need funding? Unsure about funding mechanisms? If so, you need to attend this session. The session will begin with opening remarks by James on current funding opportunities in the hydrologic sciences, followed by an open question-answer-discussion period. If you're nearing completion of your Ph.D., in a post doctorate position, struggling to achieve tenure, or just looking for new opportunities, then you need to take advantage of this chance to meet and question the program director of a major source of funding in the hydrologic sciences. Don't be shy, come to learn or come prepared with specific questions, comments, and/or concerns about current and future research funding in our field.



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What Is Unique About Geological Reasoning?

Robert H. Dott, Jr., Department of Geology and Geophysics, University of Wisconsin, Madison, WI 53706

Is geology science? Not according to Ernest Rutherford, who a century ago said “There is physics and stamp collecting.” Nor to Lord Kelvin, who asserted, “Nothing is science if it cannot be quantified.” Is geology, then, merely natural history and its practitioners little different from Victorian amateur collectors? Not if we define science simply by the combination of its subject of study, nature, and the formulation and testing of hypotheses. It has long been argued that all sciences are derivative from, or can be reduced to, physics. Geology is clearly derivative to the degree that it accepts as the basis for analysis of the earth the laws of physics and chemistry, but many authors have argued that it has unique modes of reasoning and unique laws of its own. In trying to emulate physics, Bucher (1933) went so far as to formulate no less than 46 Laws of Diastrophism. Undeniably such guiding rules as Steno’s stratigraphic laws, Walther’s law, and the law of the graded river are very important, but they are subordinate to fundamentals like Newton’s law of gravitation, the laws of thermodynamics, and Mendeleev’s periodic law of the elements.

Postmodernism has so blurred the meaning of different kinds of knowledge (see Wilson, 1998) that we must be clear about what is science. Freshman textbooks venerate the so-called scientific method as consisting, in order, of objective data gathering, experimentation, explanation or theory, and prediction. In reality, science rarely has progressed in such orderly fashion. This sterile myth leaves no place for hunch, intuition, serendipity, prejudice, vigorous advocacy, nor rancor, all of which have played important roles in the history of science. There is no more eloquent description of how scientific investigations really proceed than that of John Playfair (1802):

“... the work of theory and observation must go hand in hand, and ought to be carried on at the same time, more especially if the matter is very complicated, for there the clue of theory is necessary to direct the observer. Though a man may begin to observe without any hypothesis, he cannot continue long without seeing some general conclusion ... he is led also to the very experiments and observations that are of the greatest importance ... (and) the criteria that naturally present themselves for the trial of every hypothesis” (p. 524–525).

The traditional notion of science has long had a physics bias emphasizing experimentation, quantification, and pre-

diction as the most essential attributes of science and the hypothetico-deductive method as the only valid approach to scientific reasoning. Each generation of geologists has worried about what, if anything other than the geo-, is unique about our science. Deep time, the fossil record, uniformitarianism, the method of multiple working hypotheses, and historical science are among the special claims. We need to look further for differences, for geology certainly is much more than simply applied physics and chemistry. Through the encouragement of Victor Baker and Kenneth Taylor, I have adapted here a talk on this subject that I presented at a Penrose Conference on the History of Geology (Laporte et al, 1994).

WHAT IS EARTH SCIENCE?

As early as 1837, philosopher William Whewell recognized profound differences among the sciences. Today we may use the terms *analytical* and *synthetic* science to highlight such a distinction. The former stresses quantitative data and testable, predictive hypotheses, *which inevitably oversimplify*; in so doing, they impose an idealized order upon nature. Synthetic sciences rely chiefly upon qualitative, descriptive data with verbal and diagrammatic arguments, which strive to do justice to the great complexity of nature (Hallam, 1989; Schumm, 1991). To distinguish these two aspects within the earth sciences, Bucher (1941) coined the useful terms *timeless* and *timebound*, Laudan (1987) chose *causal* and *historical*. Thus crystallographers, together with some geophysicists and geochemists, do practice timeless, analytical science using the epistemology of physics and chemistry. Paleontologists and stratigraphers at the opposite extreme are very much timebound and strive to synthesize a bewildering diversity of incomplete historical data. As a consequence, their explanations have a more probabilistic character and, like the detective’s clues, their evidence is largely circumstantial.

Most earth scientists fall somewhere between the causal and historical poles. In reality, nearly all of us move back and forth between the two extremes, practicing both timeless and timebound science. Everyone of us to some degree is concerned with history, even the geophysicist. Paleomagnetism is clearly historical, but once present lithosphere plates were delineated in the late 1960s, geophysicists became intensely interested in tracking

plate motions back through time and in discussing the histories of ocean ridges and subduction zones.

G. G. Simpson gave modern specificity to the special character of historical science (e.g., Simpson, 1963), and since then its importance for the earth sciences has been examined extensively (Watson, 1969; Kitts, 1977; Gould, 1986; Laudan, 1987; Hallam, 1989). Historical science deals with results of past events and attempts to deduce their causes—the opposite of timeless or causal science, which predicts or forecasts results from known causes. In simplest terms, the distinction is between prediction and postdiction or retrodiction with the assumption of uniformity of kinds of causes through time providing the logical basis for historical inference. It is obvious that stratigraphy and paleontology are very concerned with reconstructing the past, but specialists like metamorphic petrologists also practice postdiction when they infer the past chemical and physical conditions of formation of some mineral. Other historical sciences include evolutionary biology, archaeology, and cosmology as well as the long-standing practice of hindcasting in meteorology and oceanography.

The principle of uniformity is an operational assumption that we make in order to study the past. “The uniformity required is not (necessarily) in nature’s activities, but in our account of them” (Goodman, 1967, p. 94). The term *uniformitarianism*, which was coined by Whewell in a critical review of Charles Lyell’s *Principles of Geology* (1830), refers to the historical artifact of Lyell’s assumption of an extreme uniformity of intensity as well as of kinds of processes. Whewell rejected this as too restrictive just as geologists have rejected it for the past 150 years. Today we should use some other term, such as *actualism* for the uniformity of kinds of processes (only), and retire *uniformitarianism* to the archives.

Why Lyell championed his extreme position so vigorously has long puzzled geologists. Baker (1998) followed Laudan (1987) in arguing that to make geology respectably scientific, Lyell took cues from Isaac Newton’s *vera causa* principle, the consideration only of true and sufficient causes, and a strict kind of induction advocated by philosophers David Hume and John Stuart Mill. Given the prevalence in the early 19th century of biblical and fanciful romantic explanations of geological phenomena with unconstrained cataclysmic violence, Lyell’s appeal only to the kinds and intensities of present causes is understandable and perhaps laudable, for, as Goodman (1967) argued, the assumption of uniformity is a special case of simplicity or parsimony, the familiar Occam’s Razor. Lyell’s extreme unifor-

Reasoning continued on p. 16

mity was the most parsimonious and conservative point of departure for studying the past. I believe that because of challenges by Whewell and others, what began as a premise or method became for Lyell a theory about Earth history, which he spent his entire career defending. Although not so stated by him, implied consequences of such a theory include the gradualistic and steady-state views of Earth history, which have so profoundly influenced thinking up to the present time. Because Earth is obviously dynamic and change occurs, if directionality is rejected, then a dynamic equilibrium or steady state must be implied (as Lord Kelvin perceived clearly), and organic evolution would be unacceptable.

Both William Whewell and C. S. Peirce criticized Lyell's induction on grounds that he sought facts to support his theory of a uniformitarian Earth. They believed, instead, that nature's facts should be the only guide to scientific inference. For example, if the geomorphic facts or results observed in the Scablands of Washington State imply a flood orders of magnitude greater than any ever observed in the present, we should trust what nature tells us. Assuming only that the fundamental principles of hydraulics have been uniform in kind through time, we can infer the nature of such an unwitnessed historical event—even quantitatively! This process of reasoning, whereby we observe historical effects and then infer past causes or past conditions, Peirce termed *retroduction*, in contradistinction to *induction*. Whereas Lyell's induction sought facts to support his theory, retroduction uses facts to seek a theory. The difference is profound, even if subtle. It allows us to accept unwitnessed cataclysmic events, and believe that Earth was bombarded by countless bolides in the past, that it once had an anaerobic atmosphere, and that Mars once had running water on its surface. Finally, it even means that catastrophism, in the sense of not restraining the intensities of processes, was a better premise than Lyell's extreme uniformitarianism (Baker, 1998)!

Explanation in historical science emphasizes criteria different from those in causal science. Because historical hypotheses about events already completed are not falsifiable in the sense of philosopher Karl Popper, it is alleged that studies of Earth history can not qualify as science. Popper has been challenged, however, on grounds that *verification* of a historical hypothesis is as valid a means of testing as *falsification* (Kitcher, 1982).

Analogy is fundamental for reasoning from the present to the past with uniformity of processes as a premise. Frodeman (1995) emphasized the importance of analogy and the method of hypothesis

for developing historical narratives. Such narratives provide a context within which geological details must make sense in terms of an overall coherence. Moreover, he argued, feedback reasoning is important, whereby an overall interpretation is built from specific, detailed observations, and then individual pieces are themselves reevaluated in terms of the whole. The method of formulating and testing multiple working hypotheses is an invaluable tool for disciplined historical reasoning and is implicit in Frodeman's stepwise reasoning process. Although first formalized by geologists (Gilbert, 1886; Chamberlin, 1890), the use of multiple hypotheses is hardly unique to the earth sciences, as Sherlock Holmes could testify.

Prediction has long been venerated as an essential element of science, yet it may seem irrelevant in historical science. In reality, however, prediction is employed here, too, albeit in a more limited sense. For example, the field geologist regularly predicts what will be found on the other side of a hill or on the opposite shore of an ocean, on the basis of what has already been observed. Indeed, the best field work involves the constant posing and testing of questions, which often become statements of expectation, a form of prediction. There is no finer example than that of James Hutton, who predicted from his developing theory of Earth the existence of the famous angular unconformity *before* he had ever actually observed one in the field! Today, prediction has taken on a new, and more literal, meaning in the earth sciences because of the impetus for forecasting future climatic scenarios by extrapolation from paleoclimatic evidence.

A handmaiden of prediction is replication. Although our inferences are inevitably probabilistic, we have not been so conscious of statistical rigor regarding sample size and quantified confidence statements as have biologists and sociologists, who are faced with similar problems (Strahler, 1987). Replicability actually is built subtly into our culture; for example the geologic map provides the basis for replication of field observations.

What about experimentation so long idolized as an essential attribute of science? The conventional notion of an experiment, which is simply a procedure for the controlled observation of natural phenomena, has more limited application in the historical sciences. The huge scale of most natural systems both in space and time, as well as the complexity imposed by multiple variables and feedbacks, restricts the relevance of experimentation, especially for past events. We can not go back in time and rerun history under varied conditions as we can repeat the first-ever petrologic melting experiments by James Hall, in the 1790s, when he melted basalt in a sealed gunbarrel. Petrologic and sedimentologic laboratory experiments,

which have been employed in geology ever since Hall, have relevance for earth historians by providing important insights about timeless processes that, by analogy, provide explanations, even quantifiable ones, for the products of past events.

Like many of the standards of what is scientific, the conventional conception of experiments for testing hypotheses has been too restrictive. For example, geophysicists have long conducted "experiments" in which planned arrays of instruments are deployed over a large region to investigate the deep structure of particular regions of the earth. If we emphasize "controlled observation" in our definition, then surely these do qualify as experiments. Scale problems can be alleviated somewhat by instrumenting sizable segments of natural systems, the most spectacular example being the carefully planned, multidisciplinary 1996 Grand Canyon experiment; the controlled-release of a large volume of water from Glen Canyon Dam tested working hypotheses about renourishment of sand bars and ecological effects upon the biota.

Important insights have also been gained from the alert exploitation of serendipitous opportunities or unplanned experiments. The 1990 spill of 80,000 Nike shoes from a container ship in the northern Pacific Ocean provided valuable details about surface currents as shoes arrived upon the beaches of western North America. Another unusual opportunity was provided by the fortuitous appearance of mudlump islands in Pyramid Lake, Nevada, which were similar to ephemeral islands long known at the mouths of Mississippi River distributaries (Born, 1972). Every earthquake that is recorded by seismographs represents an unscheduled, if not completely unplanned, experiment from which knowledge about the earth is gained through instrumental data.

GROUND TRUTH AND TOOLS OF THE TRADE

For any field-based science, ground truth lies in geographic places and specimens or recorded data tied to those places. Repositories of data include, besides museums and laboratories, also maps, structural and stratigraphic diagrams, photographs, and tabulations of physical and chemical measurements. The sense of place cannot be overemphasized for field sciences, but it is often misunderstood. A geologic map, for example, not only records the field observations of its maker, but also reflects interpretation. Inevitably every geologic map is theory-laden and is itself time-bound, for it reflects current fashions of theory, which change over time. A succession of geologic maps of the same area, even if prepared by the same worker, will

differ significantly as concepts of structure and stratigraphy change.

The collection of field data and its interpretation are by no means the simplistic, purely descriptive tasks commonly envisioned by outsiders. Especially eloquent personal characterizations of field work can be found in Cloos (1953) for geology and in Scholz (1997) for geophysics. Peter Lipman's words concerning three decades of investigation of the enormous Creede, Colorado, volcanic caldera complex, exemplify Frodeman's stepwise geological reasoning:

"Trying to figure out which rocks came from where in any region is a messy job, because the rock record is full of gaps that need to be bridged and irrelevant details that need to be ignored. To work effectively, geologists need some kind of conceptual framework to tell them what they can safely overlook and what to look for next. So while they try to piece together the big story of the rocks, geologists tell themselves smaller provisional stories—working hypotheses about what their observations might ultimately mean.... Which volcanic ash sheet had come from which volcano? Which sheets had come from the same explosions, and in what order?" (Lipman, 1997, p. 33).

Geology is a very geometric science and relies heavily upon visual, diagrammatic devices for portrayal of data. Rudwick (1976) showed how important the development of a visual language was to our science. As technological advances have provided a growing variety of sophisticated analytical tools, types of data more like those of physics and chemistry have come to play an increasing role in earth science. As in other sciences, new tools have profoundly affected the development of geology by allowing us to investigate realms of nature not previously accessible, making it possible to ask new questions as well as to reexamine old ones. The optical petrographic microscope invented around 1850 was the first great tool for geology, and arguably the most profound.

With the increasing use of instrumental tools, numerical data, and mathematical analyses, one might suppose that earth science is evolving toward an entirely causal science, and that the older, time-bound geology is destined to become extinct. As revolutionary as the new tools have been, however, specimens and measurements derived from a field context still provide the ultimate ground truth, and the problems that are addressed with the new tools remain fundamentally geologic in character, and so are largely time-bound. Although geology can justly revel in its new, powerful toys and quantification, it is still the historical science of the earth. In our rush to be modern, we may overlook the fact that students still need to be grounded in traditional fundamentals of their science even as they learn to use the latest techniques of their field.

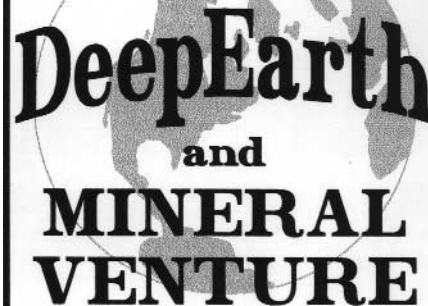
AN EVOLUTIONARY WORLD VIEW

Earth scientists are schizoid, being part causal and part historical scientists, and they necessarily must vary the mix from time to time. Lyell's extreme uniformitarianism served a valuable function in challenging early 19th-century biblical and fanciful catastrophic geology by advocating the parsimonious method of explanation only in terms of present causes. His extreme restriction of intensity and rate of change, however, was immediately challenged by Whewell on logical grounds, soon recognized by geologists as overly constraining, and attacked by Kelvin as a violation of the second law of thermodynamics. On geologic and paleontologic grounds, Thomas Huxley also recognized the error of Lyell's steady state Earth when, in 1869—just 10 years after Darwin's *Origin of Species* appeared—he asserted that Earth, as well as life, must be viewed as irreversibly evolutionary. Popular metaphors like "time's arrow" and "time's cycle" should be replaced by a three-dimensional "time's helix," in which short-term phenomena can be thought of as oscillating in a quasi-steady state fashion around the long-term mean directional vector of an evolutionary helix.

In spite of the apparent emancipation announced by Huxley, Lyell's overly restrictive uniformitarianism continued to haunt geological thinking well into the 20th century. It discouraged consideration of extraterrestrial causes of earthly phenomena, retarded the acceptance of possible past conditions qualitatively different from present ones (e.g. an anaerobic atmosphere), and continued to constrain the allowable intensity and rates of past changes as illustrated most dramatically by the 30-year rejection of J Harlan Bretz's explanation of the Scablands of Washington State. Lyell's gradualism blinded us to just how punctuated are both the sedimentary and fossil records (Dott, 1983). Moreover, any singular historical event was viewed with suspicion due to a subtle influence of Lyellian thinking; I believe that one reason for the early rejection of continental drift was that it seemed to have happened but once. Finally, the great appeal for geologists of repetitive or cyclic phenomena reflects not only our innate human desire for order, but also a kind of simplicity for which Lyell conditioned us.

Lyell's ghost haunts us in another way. Modern creationists pretend that his restrictive uniformitarianism is still geology's basis for rejecting biblical catastrophism. Ironically, however, they seize upon Lyell's appeal only to "present causes" in order to assert that science can only concern itself with phenomena that are happening and are observable today. They then conclude not only that evolutionary biology and paleontology are not science, but inevitably *all* timebound studies of

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nature and its history likewise can not be science! Lyell would be horrified at this perversion of his epistemology.

CONCLUSIONS

Each science is defined both by *what* aspect of nature it studies and by *how* it studies, but the history of any science and its personalities also distinguishes it. The feuds not only provide colorful entertainment, but also give important insights into critical issues and the nature of evidence available as well as the modes of reasoning and discourse used at particular times. Contrasts in temperament of our intellectual ancestors are always insightful and often inspiring. Consider this one: "Dr. Black dreaded nothing so much as error, and Dr. Hutton nothing so much as ignorance; that the one was always afraid of going beyond the truth, and the other of not reaching it" (Playfair, 1805, p. 95-96).

Among the many claims for epistemological uniqueness among the sciences, the importance of postdiction or retrodiction surely does set historical or time-bound sciences apart from the timeless, causal ones. The earth sciences are a complex mix of these two end members, so they must invoke the epistemology of

Reasoning *continued on p. 18*

Reasoning *continued from p. 17*

both according to the problem at hand. Labels such as “derived science” or “descriptive science” or “inexact science” should not intimidate us. Ours is a complex, multivariate subject, and there is always chance variation in the real world; therefore, our conclusions are inevitably probabilistic. Chaos theory recognizes that most of nature is so nonlinear in its workings that physics, too, is not so exact as was commonly imagined, and its practitioners recognize that their laws are only models of reality.

Long ago, philosophers showed that it is logically impossible for any science to establish absolute truths about nature. Postmodernism has taken this reality to an extreme, in arguing, in effect, that we can know nothing because all knowledge, including science, is merely a construction of the human mind. Scientists are not likely to be so persuaded, however, for they trust what nature says to them. Most arguments about scientific “truth” and, I fear, much elementary teaching of science tends to miss the real point of the scientific process. While it is psychologically appealing to “know the truth,” the proper role of theory in science is to guide the ongoing exploration of nature; skepticism is more appropriate than certitude. A successful prediction is no assurance that truth has been discovered, only that the proposition that generated the prediction was logically sound. But even if a theory is proven wrong and is discarded, it still would have been a valuable theory if it had helped to push forward the frontiers of inquiry. Through the endless process of hypothesis testing, the oft-cited self-correcting character of science, we hope to approach nearer to an understanding of nature. But no one, especially students, should be allowed to believe that any final, absolute truth is achievable. A dogmatic arrogance too-commonly conveyed by scientists about truth is counterproductive in that it provides a lightning rod for creationists, postmodernists, and hostile politicians (Dott, 1981). Rather than misrepresenting science as a dry catechism of certainties, we should emphasize the excitement of the quest for answers to our questions. The joy is in the chase, for, as Robert Louis Stevenson said, “It is better to travel hopefully than to arrive.”

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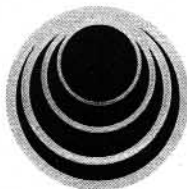
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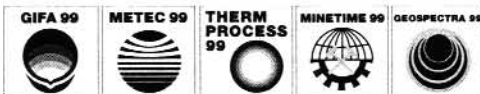
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Excerpt from the list of exhibits

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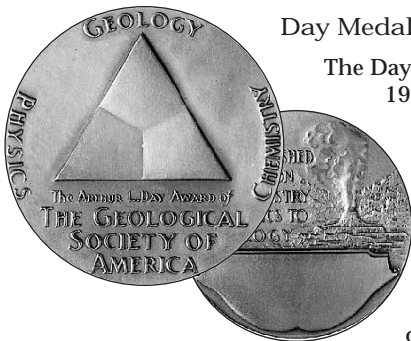
GSA Penrose Medal, Day Medal, and Honorary Fellows



Penrose Medal

The Penrose Medal was established in 1927 by R. A. F. Penrose, Jr., to be awarded in recognition of eminent research in pure geology, for outstanding original contributions or achievements that mark a major advance in the science of geology. The award is made only at the discretion of the Council. Nominees are selected by the Council

and may or may not be members of the Society. Penrose's sole objective in making the gift was to encourage original work in purely scientific geology, which is interpreted as applying to all scientific disciplines represented by the Society. Scientific achievements should be considered rather than contributions in teaching, administration, or service. Mid-career scientists who have already made exceptional contributions should be given full consideration for the award.



Day Medal

The Day Medal was established in 1948 by Arthur L. Day to be awarded annually, or less frequently, at the discretion of the Council, for outstanding distinction in contributing to geologic knowledge through the application of physics and chemistry to the solution of geologic problems. Day's

intent was to recognize outstanding achievement and inspire further effort, rather than reward a distinguished career. Scientific achievements should be considered rather than contributions in teaching, administration, and service.

Honorary Fellows

Geologists who have distinguished themselves in geological investigations or in notable service to the Society may be elected as Honorary Fellows. In practice, nearly all candidates are non-North Americans who live and work outside of North America. The most noteworthy exceptions were astronauts. Most Honorary Fellows have been elected after many years of outstanding and internationally recognized contributions to the science. The program was established by the GSA Council in 1909, and since then, except during a few war years, one or more Honorary Fellows have been elected annually. The Council of the Society encourages the membership to submit names of qualified candidates for this honor. In preparing a nomination, it is imperative that the original research and scientific advances of the candidate be stressed. All supporting data, especially degrees received, publications, positions, etc., should also be verified by the nominator.

How to Nominate

To ensure thorough consideration by the respective committees, please submit for each candidate a brief biographical sketch, such as used in *American Men and Women of Science* and *Who's Who in America*, a summary of the candidate's scientific contributions to geology that qualify the individual for the award, and a selected bibliography of no more than 20 titles.

A nomination for any one of these three awards *must be supported* by signed letters from each of five (5) GSA Fellows or Members in addition to the person making the nomination. The letters may be attached to the nomination form or may be sent to the Executive Director separately. For Honorary Fellow nominations, please verify degrees received, publications, positions held, etc. The names of unsuccessful candidates proposed to the Council by the respective committees will remain for consideration by those committees for three years. For those still under consideration, it is recommended that an updated letter of renomination be sent to the Executive Director.

The nomination form (p. 21) is also available on the GSA Web site at <http://www.geosociety.org>, in the Administration Section. The deadline for receipt of nominations at the office of the Executive Director is February 1, 1999. ■

About the Honorary Fellow Program

On page 21 you will find a form to be used in nominating candidates for Honorary Fellowship in the Geological Society of America. Each year this honor is bestowed on non-North Americans who live and work outside of North America and have distinguished themselves in geological investigations or in notable service to the Society. Under exceptional circumstances, North Americans have been named Honorary Fellows. This amendment to the bylaws was made in 1969 when the Apollo II astronauts who first walked on the moon were elected.

The program was established by the GSA Council in 1909, and since then, except during a few war years, one or more Honorary Fellows have been elected annually. Most

Honorary Fellows have been elected after many years of outstanding and internationally recognized contributions to the science. At present there are 62 living geologists who have received this honor.

The Council of the Society encourages the membership to submit names of qualified candidates for this honor. In preparing a nomination, it is imperative that the original research and scientific advances of the candidate be stressed. All supporting data, especially degrees received, publications, positions, etc., should also be verified by the nominator. Use the form on page 21 for nominating a candidate for Honorary Fellowship.

THE GEOLOGICAL SOCIETY OF AMERICA
Nomination for Penrose Medal, Day Medal, or Honorary Fellowship
(please circle one)

NAME OF CANDIDATE: _____

ADDRESS: _____

Telephone: _____

REQUIRED INFORMATION (Please attach)

BIOGRAPHICAL INFORMATION

Suggested sources: *American Men and Women of Science, Who's Who in America*
GSA Service Record (obtainable from headquarters)
Other

SUMMARY OF SCIENTIFIC CONTRIBUTIONS TO GEOLOGY
Not more than 200 words.

SELECTED BIBLIOGRAPHY
No more than 20 titles.

LETTERS OF SUPPORT

Nominations for any one of these three awards MUST BE SUPPORTED by signed letters from five (5) GSA Fellows or Members in addition to the person making the nomination. The letters may be attached to this nomination form or may be sent to the Executive Director separately. Supporting letters must discuss the original research and scientific advances of the candidates. Please also verify all other supporting data.

Name of person making the nomination: _____ Phone: _____

Address: _____

Date: _____ Signature: _____

Letters of support will be submitted by:

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

RETURN TO: GSA Executive Director, P.O. Box 9140, Boulder, CO 80301, Phone: (303) 447-2020

DEADLINE: Completed nominations must be received by **February 1, 1999**. To be considered, nomination materials must meet the above criteria. Reprints or articles will not be accepted.

Young Scientist Award (Donath Medal)



The Young Scientist Award was established in 1988 to be awarded to a young scientist (35 or younger during the year in which the award is to be presented) for outstanding achievement in contributing to geologic knowledge through original research

that marks a major advance in the earth sciences. The award, consisting of a gold medal called the Donath Medal, and a cash prize of \$15,000 was endowed by Dr. and Mrs. Fred A. Donath.

For the year 1999, only those candidates born on or after January 1, 1964, are eligible for consideration. In choosing candidates for the Young Scientist Award, scientific achievement and age will be the sole criteria. Nominations for the 1999 award must include:

- biographical information,
- a summary of the candidate's scientific contributions to geology (200 words or less),
- a selected bibliography (no more than 10 titles),
- supporting letters from five scientists in addition to the person making the nomination.

The nomination form (p. 23) is also available at our Web site at <http://www.geosociety.org>, in the Administration Section. Nominations for the 1999 Young Scientist Award must be received at GSA headquarters by *February 1, 1999.* ■

GSA Medalists and Honorary Fellows

Richard A. F. Penrose, Jr., Medalists

1927 Thomas Chrowder Chamberlin	1941 Norman Levi Bowen	1956 Arthur Holmes	1971 Marshall Kay	1986 Laurence L. Sloss
1928 Jakob Johannes Sederholm	1942 Charles Kenneth Leith	1957 Bruno Sander	1972 Wilmot H. Bradley	1987 Marland P. Billings
1929 <i>No award given</i>	1943 <i>No award given</i>	1958 James Gilluly	1973 M. King Hubbard	1988 Robert S. Dietz
1930 Francois Alfred Antoine Lacroix	1944 Bailey Willis	1959 Adolf Knopf	1974 William Maurice Ewing	1989 Warren Bell Hamilton
1931 William Morris Davis	1945 Felix Andries Vening-Meinesz	1960 Walter Herman Bucher	1975 Francis J. Pettijohn	1990 Norman D. Newell
1932 Edward Oscar Ulrich	1946 T. Wayland Vaughan	1961 Philip Henry Kuenen	1976 Preston Cloud	1991 William R. Dickinson
1933 Waldemar Lindgren	1947 Arthur Louis Day	1962 Alfred Sherwood Romer	1977 Robert P. Sharp	1992 John Frederick Dewey
1934 Charles Schuchert	1948 Hans Cloos	1963 William Walden Rubey	1978 Robert M. Garrels	1993 Alfred G. Fischer
1935 Reginald Aldworth Daly	1949 Wendell P. Woodring	1964 Donnel Foster Hewett	1979 J Harlen Bretz	1994 Luna B. Leopold
1936 Arthur Philemon Coleman	1950 Morley Evans Wilson	1965 Philip Burke King	1980 Hollis D. Hedberg	1995 John C. Crowell
1937 <i>No award given</i>	1951 Pentti Eskola	1966 Harry H. Hess	1981 John Rodgers	1996 John Robert Lawrence Allen
1938 Andrew Cowper Lawson	1952 George Gaylord Simpson	1967 Herbert Harold Read	1982 Aaron C. Waters	1997 John D. Bredehoeft
1939 William Berryman Scott	1953 Esper S. Larsen, Jr.	1968 J. Tuzo Wilson	1983 G. Arthur Cooper	1998 Jack E. Oliver
1940 Nelson Horatio Darton	1954 Arthur Francis Buddington	1969 Francis Birch	1984 Donald E. White	
	1955 Maurice Gignoux	1970 Ralph Alger Bagnold	1985 Rudolf Trümpy	

Arthur L. Day Medalists

1948 George W. Morey	1959 Sir Edward C. Bullard	1970 Gerald J. Wasserburg	1980 Henry G. Thode	1990 William S. Fyfe
1949 William Maurice Ewing	1960 Konrad B. Krauskopf	1971 Hans P. Eugster	1981 Donald L. Turcotte	1991 Ian Carmichael
1950 Francis Birch	1961 Willard F. Libby	1972 Frank Press	1982 Eugene M. Shoemaker	1992 Susan Werner Kieffer
1951 Martin J. Buerger	1962 Hatten Schuyler Yoder	1973 David T. Griggs	1983 Harmon Craig	1993 Hugh P. Taylor, Jr.
1952 Sterling Hendricks	1963 Keith Edward Bullen	1974 A. E. Ringwood	1984 Wallace S. Broecker	1994 David Walker
1953 John F. Schairer	1964 James Burleigh Thompson, Jr.	1975 Allan Cox	1985 Freeman Gilbert	1995 Thomas J. Ahrens
1954 Marion King Hubbard	1965 Walter H. Munk	1976 Hans Ramberg	1986 E-an Zen	1996 Robert A. Berner
1955 Earl Ingerson	1966 Robert M. Garrels	1977 Akiho Miyashiro	1987 Don L. Anderson	1997 Edward Irving
1956 Alfred O. C. Nier	1967 O. Frank Tuttle	1978 Samuel Epstein	1988 Claude J. Allègre	1998 Bruce E. Watson
1957 Hugo Benioff	1968 Frederick J. Vine	1979 Walter M. Elsasser	1989 Dan McKenzie	
1958 John Verhoogen	1969 Harold C. Urey			

Young Scientist Award (Donath Medalists)

1989 Mark Cloos	1991 Brian Philip Wernicke	1993 Michael Gurnis	1995 Ward Earl Sanford	1997 Edouard G. Bard
1990 Leigh Handy Royden	1992 John Peter Grotzinger	1994 An Yin	1996 Paul R. Bierman	1998 Terry A. Plank

Honorary Fellows

Edwin "Buzz" Aldrin	Umberto G. Cordani	Emilie Jäger	Desmond A. Pretorius	Eugen Seibold
John R. L. Allen	Bruno d'Argenio	Victor E. Khain	B. P. Radhakrishna	Ali Mehmet Celal Şengör
Shigeo Arimaki	Gabriel Dengo	Ihsan Ketin	Hans Ramberg	Boris Sergeevich Sokolov
Neil Armstrong	Kingsley C. Dunham	Teiichi Kobayashi	Victor A. Ramos	Richard L. Stanton
Jean A. Aubouin	Stanislaw Dzulynski	Hans Laubscher	John G. Ramsay	Rashid A. Khan Tahirkehl
Daniel Bernoulli	François Ellenberger	Hanno Martin	Alfred Rittmann	Paul Tapponnier
Krzysztof Ludwik Birkenmajer	Hans Füchtbauer	Dan P. McKenzie	Alexander B. Ronov	Bernard P. Tissoit
Alfonso Bosellini	William S. Fyfe	Michael W. McElhinny	Rupert W. R. Rutland	Livio Trevisan
George Malcolm Brown	Augusto Gansser	German K. Müller	Kristján Sæmundsson	Rudolf Trümpy
S. Warren Carey	David Headley Green	Mervyn Silas Paterson	Rushdi Said	Guangzhi Tu
Maria Bianca Cita	Francisco Hervé	Leo Y. Picard	Hitoshi Sakai	Harry B. Whittington
Michael Collins	Dorothy Hill	Wallace S. Pitcher	Mircea Sandulescu	Alwyn Williams
William Compston	Ferenc Horvath	Jean Piveteau	Harrison Hagan Schmitt	Yang Zun-yi
Douglas Saxon Coombs	Kenneth J. Hsü	Isabella Premoli-Silva	Werner-Friedrich Schreyer	
P. G. Cooray	Valdar Jaanusson			

THE GEOLOGICAL SOCIETY OF AMERICA
Nomination for 1999 Young Scientist Award (Donath Medal)

NAME OF CANDIDATE: _____ Date of birth: _____
For the year 1999, only those candidates born on or after January 1, 1964, are eligible for consideration.

ADDRESS: _____

REQUIRED INFORMATION (Please attach)

BIOGRAPHICAL INFORMATION

Provide in a format similar to that found in *American Men and Women of Science, Who's Who in America*.

SUMMARY OF SCIENTIFIC CONTRIBUTIONS TO GEOLOGY

Not more than 200 words.

SELECTED BIBLIOGRAPHY

No more than 10 titles.

LETTERS OF SUPPORT

Nominations for the Donath Medal **MUST BE SUPPORTED** by signed letters from five (5) scientists in addition to the person making the nomination. The letters may be attached to this nomination form or may be sent to the Executive Director separately.

Name of person making the nomination: _____

Address: _____

Date: _____ Signature: _____

Letters of support will be submitted by:

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

RETURN TO: GSA Executive Director
P.O. Box 9140
Boulder, CO 80301
Phone: (303) 447-2020

DEADLINE: Completed nominations must be received by **February 1, 1999**. To be considered, nomination materials must meet the above criteria. Reprints or articles will not be accepted.

Call for Nominations for 1999 GSA Distinguished Service Award

The GSA Distinguished Service Award was established by Council in 1988 to recognize individuals for their exceptional service to the Society. GSA Members, Fellows, Associates, or, in exceptional circumstances, GSA employees may be nominated for consideration. Any GSA member or employee may make a nomination for the award. Awardees will be selected by the Executive Committee, and all selections must be ratified by the Council. Awards may be made annually, or less frequently, at the discretion of Council. This award will be presented during the Annual Meeting of the Society. Letters of nomination and any supporting information should be addressed to Executive Director, GSA, P.O. Box 9140, Boulder, CO 80301.

Deadline for nominations for 1999 is March 1, 1999.

Recipients to date:

- 1988..... *Campbell Craddock, Robert D. Hatcher, Jr.
Eldridge M. Moores, William A. Thomas*
- 1990..... *William B. Heroy, Jr.*
- 1991..... *Dorothy M. Palmer*
- 1992..... *A. R. (Pete) Palmer*
- 1993..... *Michel T. Halbouty*
- 1994..... *F. Michael Wahl*
- 1995..... *John E. Costa, Henry T. Mullins,
Arthur G. Sylvester*
- 1996..... *David M. Fountain, Royann (Gardner) Cygan
Louis C. Pakiser, Jr., Anthony Reso*
- 1997..... *Robert L. Fuchs, Richard A. Hoppin
Faith E. Rogers, Bennie W. Troxel*
- 1998..... *June R. Forstrom, Charles J. Mankin,
George R. Hallberg*

Call For Nominations — National Awards for 2001

(Deadline: April 30, 1999)

Nominations for the national awards described below are being solicited for 2001. Each year GSA members have been invited to participate by recommending possible candidates.

Those who wish to make nominations are urged to do so by sending background information and vitae, and specifying the award for which the candidate is being submitted by April 30, 1999, to the GSA External Awards Committee, P.O. Box 9140, Boulder, CO 80301, (303) 447-2020, fax 303-447-1133. The nomination process is coordinated by AGI on behalf of its member societies, and a roster of candidates will be finalized by the AGI Member Society Council at its spring 2000 meeting for nomination to the respective offices sponsoring the national awards.

WILLIAM T. PECORA AWARD

The Pecora Award, sponsored jointly by NASA and the Department of the Interior, is presented annually in recognition of outstanding contributions of individuals or groups toward the understanding of Earth by means of remote sensing.

The award recognizes contributions of those in the scientific and technical community as well as those involved in the practical application of remote sensing. Consideration will be given to sustained or single contributions of major importance to the art or science of the understanding of Earth through observations made from space.

NATIONAL MEDAL OF SCIENCE

The medal is awarded by the President to individuals "deserving of special recognition by reason of their outstanding contributions to knowledge in the physical, biological, mathematical, engineering, or social and behavioral sciences."

There are now many younger American scientists and engineers who may be reaching a point where their contributions are worthy of recognition. The committee is giving increasing attention to these individuals as well as to those outstanding women and minority scientists who deserve recognition.

VANNEVAR BUSH AWARD

The Vannevar Bush Award is presented from time to time to a person who, through public service activities in science and technology, has made an outstanding contribution toward the welfare of mankind and the nation.

The award is given to a senior statesman of science and technology and complements the NSF's Alan T. Waterman Award, which is given to a promising young scientist. The two awards are designed to encourage individuals to seek the highest levels of achievement in science, engineering, and service to humanity.

The nomination should be accompanied by a complete biography and a brief citation summarizing the nominee's scientific or technological contributions to our national welfare in promotion of the progress of science.

ALAN T. WATERMAN AWARD

The Waterman Award is presented annually by the NSF and National Science Board to an outstanding young researcher in any field of science or engineering supported by NSF.

Candidates must be U.S. citizens or permanent residents and must be 35 years of age or younger, OR not more than five years beyond receipt of the Ph.D. degree by December 31 of the year in which nominated.

Candidates should have completed sufficient scientific or engineering research to have demonstrated, through personal accomplishments, outstanding capability, and exceptional promise for significant future achievement.

Remember: Background information and vitae of nominated candidates should be sent by April 30, 1999, to the GSA External Awards Committee, P.O. Box 9140, Boulder, CO 80301. ■

YOU Can Help Direct GSA's Future



The GSA Committee on Nominations requests your help in compiling a list of GSA members qualified for service as officers and councilors of the Society. The committee requests that each nomination be accompanied by basic data and a description of the qualifications of the individual for the position recommended (vice president, treasurer, councilor).

Nominations for 1999 officers and councilors must be received at GSA headquarters no later than FEBRUARY 15, 1999.

Please send nominations and back-up material to Administrative Department, Geological Society of America, P.O. Box 9140, Boulder, CO 80301.

ROCKY MOUNTAIN SECTION, GSA 51st Annual Meeting

Pocatello, Idaho
April 8–10, 1999

Idaho State University will host the 1999 Rocky Mountain Section meeting of the Geological Society of America in Pocatello, Idaho. The meeting will be held at the Cavanaugh's Pocatello Hotel and Convention Center (Quality Inn) within easy walking distance to restaurants and other hotels. 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. Popular geological and touring sites no more than 3 hours' drive away 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, the Idaho Museum of Natural History, and the Shoshone-Bannock Native American Reservation.

SETTING

The Snake River Plain is a 100-km-wide topographic and volcanic depression where Quaternary basaltic volcanic rocks, along with interbedded eolian, alluvial, and lacustrine sediments, were deposited on Miocene-Pliocene rhyolitic ash-flow tuffs that are now exposed only in ranges along the margins of the plain. Basaltic lava flows from monogenetic shield volcanoes make up most of the stratigraphy, although other important Quaternary volcanic features include rhyolitic domes, phreatomagmatic volcanoes, and polygenetic eruptive centers (such as Craters of the Moon) composed of pyroclastic cones and chemically evolved lavas. Mountains and valleys associated with the Basin and Range Province bound the depression on the north and south and trend perpendicular to the eastern Snake River Plain axis. The Basin and Range province in the greater Pocatello area exposes a wide variety of geologic features, including Proterozoic to Mesozoic sedimentary rocks, folds and faults formed through Mesozoic thrust faulting and Cenozoic extension, Miocene syntectonic basin fill, and spectacular deposits of the late-Pleistocene Bonneville Flood.

The meeting site is near the edge of city commercial activity with convenient access to 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. Travel by air is convenient and available to Pocatello.

CALL FOR PAPERS

Technical papers are invited for presentation in conventional theme sessions, various symposia, and poster presentations. Oral and poster presentations will address all aspects of Snake River Plain, Basin and Range, and Rocky Mountain geology. There will be 15 minutes allowed

for presentations, followed by 5 minutes for discussion. Details of poster sessions will be provided to the participants.

REGISTRATION AND ACCESSIBILITY

Preregistration by mail will be handled by the Geological Society of America Meetings Department, P.O. Box 9140, Boulder, CO 80301-9140. Registration details and forms will be published in *GSA Today* in January 1999. Members pay less! Join GSA now or at the meeting. Contact Membership Services for further information. On-site registration will begin the evening of April 7, 1999. For additional information, please contact John Welhan, Registration Chairperson, (208) 236-4254, welhjohn@isu.edu, Idaho Geological Survey, Dept. of Geology, Idaho State University, Pocatello, ID 83209-8072.

GSA is committed to making every event at the 1999 Rocky Mountain Section meeting accessible to all people. Special needs, such as an interpreter or wheelchair, will be provided upon request. Please contact General Chair Scott Hughes, (208) 236-4387, hughscot@isu.edu, Dept. of Geology, Idaho State University, Pocatello, ID 83209-8072.

FIELD TRIPS

Contact trip leaders for details; the address for ISU trips is: Dept. of Geology, Idaho State University, Pocatello, ID 83209-8072. Direct any general inquiries to Field Trip Chair Glenn Thackray, (208) 236-3560, thacglen@isu.edu, at the ISU departmental address above.

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. Contact Scott (hughscot@isu.edu) or Glenn (thacglen@isu.edu) if you intend to submit a manuscript. Requirements for submittal will be provided upon request. Manuscripts due: *September 1, 1998.*

Premeeting

1. Past and Present Tectonics of the Circum-Yellowstone Bow Wave: SW Montana, NW Wyoming, and SE Idaho. Two or three days. Dave Lageson, (406) 994-6913, Lageson@montana.edu, Dept. of Earth Sciences, Montana State University, Bozeman, MT 59717; and others.

2. Tertiary Extension in Southwestern Montana. One day (possibly in conjunction with field trip 1). Rob Thomas, (406) 683-7615, r_thomas@wmc.edu, Dept. of Environmental Sciences, Western Montana College of the University of Montana, Dillon, MT 59725-3598.

3. Geology of Teton Canyon, Mesa Falls Area. One day. Glenn Embree, (208) 356-1905, and Roger Hoggan, Dept. of Geology, Ricks College, Rexburg, ID 83460-0510.

4. Folding and Faulting Above the Miocene New Canyon and Clifton Detachment Faults, Malad Range, Idaho. One day. Jeff Evans and Susanne Janecke, (435) 797-3877, sjanecke@cc.usu.edu, Dept. of Geology, Utah State University, Logan, UT 84322-4505.

5. Cedar Butte and Silicic Domes on the Eastern Snake River Plain. One day. Mike McCurry, (208) 236-3960, mccumich@isu.edu, Idaho State University; and others.

6. Geology of Thatcher Basin and Cache Valley. One day. Paul Link, (208) 236-3846, linkpaul@isu.edu, and Glenn Thackray, Idaho State University; Darrell Kaufman, Northern Arizona University.

7. Economic Geology of the SE Idaho Phosphate District. One day. Ray Petrun, Solutia, P.O. Box 816, Soda Springs, ID 83276, (208) 547-3391; Al Haslam, Agrium Corporation.

Postmeeting

8. Geology Along the Oregon Trail in Idaho. One and a half days. Paul Link, (208) 236-3846, linkpaul@isu.edu, Idaho State University; Chilton Phoenix, Pocatello; Greg McDonald, Hagerman Fossil Beds National Monument.

9. Cretaceous Shortening and Miocene Extension of the Putnam Thrust Sheet. One and a half days. Dave Rodgers, (208) 236-3565, roddgavi@isu.edu, Idaho State University; Karl Kellogg, U.S. Geological Survey.

Rocky Mountain *continued on p. 26*

Rocky Mountain *continued from p. 25*

10. Mafic Volcanism and Environmental Geology of the Eastern Snake River Plain. Two and a half days. Scott Hughes, (208) 236-4387, hughscot@isu.edu, Idaho State University; Richard Smith, INEEL; Bill Hackett, WRH Associates; Steve Anderson, U.S. Geological Survey.
11. Urban Geology of the Portneuf Valley. One and a half days. John Welhan, (208) 236-4254, weljohn@isu.edu, Idaho Geological Survey, Idaho State University, Pocatello, ID 83209-8071; Kurt Othberg, Idaho Geological Survey, Moscow; Roy Mink, University of Idaho, Moscow.

SYMPOSIA

The following symposia topics have been submitted, and it is anticipated that other specialized topics will be added. Although authors are requested to designate a technical session, we encourage abstracts to be submitted in other topics. General questions concerning symposia should be addressed to Technical Program Chair Paul Link, (208) 236-3846, linkpaul@isu.edu, Dept. of Geology, Idaho State University, Pocatello, ID 83209-8072. Prospective authors should contact individual chairs listed below; see address above for those at ISU.

1. Past and Present Tectonics of the Circum-Yellowstone Bow Wave: SW Montana, NW Wyoming, and SE Idaho. Dave Lageson, Rob Thomas, Jim Sears (see field trips 1 and 2 above).
2. Tectonic and Magmatic Evolution of the Snake River Plain. Bill Bonnicksen, (208) 885-8928, billb@uidaho.edu, Idaho Geological Survey, University of Idaho, Moscow, ID 83844-3014; Craig White, Boise State University; Mike McCurry, Idaho State University.
3. Lehi Hintze Symposium on the Geology of Utah. Bart Kowallis, (801) 378-8143, bkowallis@byu.edu, Dept. of Geology, Brigham Young University, 258 ESC, Provo, UT 84602.
4. Active Tectonics in the Basin and Range. Bob Smith, (801) 581-7129, rbsmith@mines.utah.edu, 702 Browning Bldg., Dept. of Geology and Geophysics, University of Utah, 135 So. 1460 East, Salt Lake City, UT 84112-0111; John Byrd, Exxon Exploration Co., Houston.
5. Mesoproterozoic Rocks of Northern Idaho and Vicinity. Reed Lewis, (406) 782-2438, 900 West Quartz, Butte, MT 59701; Mark McFadden.
6. Waste Remediation Technologies in the Idaho National Engineering and Environmental Laboratory. Roy Mink, (208) 885-6431, iwri@uidaho.edu, Idaho Water Resources Research Institute, University of Idaho, Moscow, ID 83844-3011; Dale Ralston, University of

Idaho; Paul Link and John Welhan, Idaho State University.

6. Hydrology in the Intermountain West. Willis Weight, (406) 496-4329, wweight@pol.mtech.edu, Dept. of Geological Engineering, Montana School of Mines of the University of Montana, Butte, MT 59701.
7. Paleozoic Stratigraphy, Structure, and Tectonics of NE Nevada. Walt Snyder, (208) 385-3645, Dept. of Geosciences, Boise State University, Boise, ID 83725; Jim Trexler and Pat Cashman, University of Nevada, Reno.
8. Glacial and Lacustrine Records of Late Pleistocene Climate in the Intermountain West. Glenn Thackray, (208) 236-3560, thacglen@isu.edu, Idaho State University.
9. Zeolites and Phosphate Mineral Deposits in Idaho. Mickey Gunter, (208) 885-6015, Dept. of Geology and Geological Engineering, University of Idaho, Moscow, ID 83844-3022.
10. EDMAP Posters in Idaho. John Bush, (208) 885-6192, Dept. of Geology and Geological Engineering, University of Idaho, Moscow, ID 83844-3022.
11. Academic Service Learning in the Geoscience Curriculum. Sheila Roberts, (406) 683-7017, s_roberts@wmc.edu, Dept. of Environmental Sciences, Western Montana College of the University of Montana, Dillon, MT 59725; Dave Mogk, Montana State University.
12. Idaho Earth Science Teachers Association. Terry Kuroda, (208) 888-4905, Meridian High School, 1900 West Pine, Meridian, ID 83642.
13. Multimedia Use in Geoscience Education. Michael Kelly, (520) 523-8205, Michael.Kelly@nau.edu, CREATE Project, Northern Arizona University, Flagstaff, AZ 86011-5694.

ABSTRACTS

Abstracts are limited to 250 words and must be submitted on official GSA abstract forms, available from Abstract Coordinator, Geological Society of America, P.O. Box 9140, Boulder, CO 80301, (303) 447-2020, ncarlson@geosociety.org. An original and five copies are required for each abstract. Only one paper may be presented by each individual, although a person may be coauthor of additional papers. Please send abstracts to Paul Link, Dept. of Geology, Idaho State University, 785 South 8th St., Pocatello, ID 83209-8072.

ABSTRACT DEADLINE:
December 29, 1998

PROJECTION EQUIPMENT

Projection equipment will be provided for standard 35 mm slides. Two projectors and two screens will be available. Authors are encouraged to provide their own carousel if possible, although a lim-

ited number will be available. Special needs, such as LCD projection or video presentation, may be accommodated if sufficient notice is provided.

EXHIBITS

Exhibit space will be available for a cost of \$50 for an area about 12 by 12 feet. For further information, contact Joe Kruger, (208) 236-3871, krugjose@isu.edu, Dept. of Geology, Idaho State University, Pocatello, ID 83209-8072.

STUDENT TRAVEL SUPPORT

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

Applications must be received by
February 1, 1999.

SPECIAL EVENTS and GUEST PROGRAMS

A welcoming reception will be held on Wednesday evening, April 7, 1999. A banquet honoring Lehi Hintze will be held Thursday evening, April 8, following the Symposium on the Geology of Utah. There will be an Idaho State University alumni party Friday evening, April 9, hosted by the ISU Department of Geology. Other alumni receptions are encouraged. Additional activities will be available, including possibly one or more road trips to Lava Hot Springs, Sun Valley, or Jackson Hole.

ACCOMMODATIONS

Rooms have been reserved for the meeting at the Pocatello Park Hotel and Convention Center. Additional space is available in nearby hotels. See the meeting Web site (address below) and the final announcement.

DETAILED INFORMATION

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

NORTH-CENTRAL SECTION, GSA 33rd Annual Meeting

Champaign, Illinois
April 22–23, 1999

The Illinois State Geological Survey and the Department of Geology at the University of Illinois at Champaign-Urbana will host the 33rd Annual Meeting of the North-Central Section of the Geological Society of America. The meeting will be held in 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.

CALL FOR PAPERS

Papers on all topics listed on the GSA abstract form are invited from students and professionals for presentation in oral or poster sessions. Presentations that may fit into one of the symposia (invited and volunteered papers) are also solicited. Those interested in presenting a paper or poster in a symposium should contact the symposium convener and indicate on the abstract form that the abstract be included in a particular symposium. Special sessions focused on specific themes or subjects will be arranged by the local program committee after review of the abstracts. Oral presentations will be allotted 15 minutes followed by 5 minutes for discussion. Two four-hour poster sessions are planned for each day.

SYMPOSIA

The mailing address for all at the Illinois State Geological Survey 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, weibel@isgs.uiuc.edu, Illinois State Geological Survey, fax 217-244-2785.

2. **Studies in Hydrogeology.**

A. **Characterizing Agricultural Impacts on Shallow Groundwater Quality.**

Edward Mehnert, (217) 244-2765, mehnert@isgs.uiuc.edu; William S. Dey, (217) 244-2779, dey@isgs.uiuc.edu, Illinois State Geological Survey, fax 217-244-2785.

B. **Modeling Geologic Environments for Hydrogeologic Applications.**

Donald A. Keefer (217) 244-2786, dkeefe@isgs.uiuc.edu; David R. Larson, (217) 244-2770, dlarson@isgs.uiuc.edu, Illinois State Geological Survey, fax 217-244-2785.

C. **Chemical and Isotopic Studies of Groundwater.**

Keith C. Hackley, Illinois State Geological Survey, (217) 244-2396, fax 217-244-2785, hackley@

isgs.uiuc.edu; Thomas M. Johnson, University of Illinois, (217) 244-2002, fax 217-244-4996, tmjohnsn@uiuc.edu.

D. **Innovative Field Techniques and Equipment (Posters).** Edward Mehnert, Illinois State Geological Survey, (217) 244-2765, fax 217-244-2785, mehnert@isgs.uiuc.edu.

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

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

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

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

7. **Geologic Mapping in Glaciated Areas.**

A. **Midwest Coalition on Geologic Mapping in Glaciated Areas.** William W. Shilts, Illinois State Geological Survey, (217) 333-5111, fax 217-244-7004, shilts@isgs.uiuc.edu.

B. **Nature of the Sediment Record and How It Affects Mapping.** Ardith K. Hansel, (217) 333-5852, hansel@isgs.

uiuc.edu; B. Brandon Curry (217) 244-5787, curry@isgs.uiuc.edu; Illinois State Geological Survey, fax 217-333-2830.

C. **Importance of 3-Dimensional Mapping for Environmental Geology.**

Richard C. Berg, Illinois State Geological Survey, (217) 244-2776, fax 217-333-2830, berg@isgs.uiuc.edu.

D. **Geologic Mapping in Glaciated Areas: Advances and Applications (Posters).**

Barbara J. Stiff, Illinois State Geological Survey, (217) 244-2510, fax 217-333-2830, stiff@celadon.isgs.uiuc.edu; Peter T. Lyttle, U.S. Geological Survey, Reston, Virginia, (703) 648-6943, fax 703-648-6937, plyttle@usgs.gov.

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

9. **Economic Geology of Mineral and Energy Resources of the Midcontinent United States.** Subhash B. Bhagwat, Illinois State Geological Survey, (217) 333-7409, fax 217-333-2830, bhagwat@isgs.uiuc.edu. 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 National Association for Geoscience Teachers Central Section.*) Myrna M. Killey, (217) 244-2409, killey@isgs.uiuc.edu, 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 Exciting for Students.**

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

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

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

14. **Special Poster Session on Undergraduate Research.** (*Sponsored by Council on Undergraduate Research.*) These posters, written and presented by undergraduate students, will form a separate

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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, Dept. of Geography-Geology, University of Nebraska at Omaha, Omaha, NE 68182, (402) 554-2457, fax 402-554-3518, bshuster@cwis.unomaha.edu.

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 panels, each 4 × 4 feet, made of soft particle board, and arranged at table height. Poster sessions will be located in the same area as exhibits and will be available for viewing for four hours.

ABSTRACTS

Abstracts must be submitted camera-ready on official GSA abstract forms in accordance with the instructions on the forms. Abstract forms are available from Abstracts Coordinator, Geological Society of America, P.O. Box 9140, Boulder, CO 80301-9140, (303) 447-2020, ncarlson@geosociety.org, from C. Pius Weibel, North-Central Section Program Coordinator, Illinois State Geological Survey, 615 E. Peabody Dr., Champaign, IL 61820, weibel@isgs.uiuc.edu, and from GSA Campus Representatives at most colleges and universities in the North-Central Section region. There is no fee for submitting an abstract.

ABSTRACT DEADLINE:
January 11, 1999

Send one original and five copies to North-Central Section Program Coordinator C. Pius Weibel, at the address given above. Abstracts submitted for inclusion in symposia should be sent directly to the first symposium organizer listed for each symposium. Contributors desiring acknowledgment of receipt of the abstract should include a stamped, self-addressed envelope or postcard.

WORKSHOPS

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

2. Exploring the Solar System in the Classroom: Hands-On Approach. Cassandra R. Coombs, Dept. of Geology, College of Charleston, 58 Coming Street, Charleston, SC 29424, (803) 953-8279, coombsc@cofc.edu; Eileen Herrstrom, University of Illinois, (217) 244-6172, fax 217-244-4496, herrstro@uiuc.edu.
3. SEPM Short Course—Tidal Rhythmites. Erik P. Kvale, (812) 855-1324, kvalee@indiana.edu, and Maria Mastalerz, (812) 855-9416, mmastale@indiana.edu, Indiana Geological Survey, 611 Walnut Grove, Bloomington, IN 47405, fax 812-855-2862; Allen W. Archer, Kansas State University, (785) 532-2244, aarcher@ksu.edu; Norman C. Hester, Indiana University, Bloomington.

FIELD TRIPS

The trips listed here are provisional. A final list of trips, schedules, and costs will be available in the January 1999 issue of *GSA Today*. Field trip coordinators are Janis D. Treworgy, (217) 244-6942, janis@isgs.uiuc.edu; and Myrna M. Killey, (217) 244-2409, killey@isgs.uiuc.edu, Illinois State Geological Survey, fax 217-333-2830.

The mailing address for all at the Illinois State Geological Survey is 615 E. Peabody Dr., Champaign, IL 61820.

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, fax 217-333-2830; Vince Gutowski, Dept. of Geology and Geography, Eastern Illinois University, Charleston, IL 61920, (217) 581-3825, cfvpg@eiu.edu.

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, fax 217-244-2785; Carol Wicks, Dept. of Geological Sciences, University of Missouri—Columbia, (573) 882-3231, geosccw@showme.missouri.edu.
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, fax 217-333-2830.
4. The Silurian Depositional Environments and Sequence Stratigraphy of the Northern Edge of the Illinois Basin. Donald G. Mikulic, Illinois State Geological Survey, (217) 244-2518,

fax 217-333-2830, mikulic@isgs.uiuc.edu; Joanne Kluessendorf, University of Illinois, (217) 367-5916, fax 217-244-4996, jkluesse@uiuc.edu.

5. Neotectonics of the Southern Illinois Basin. W. John Nelson, Illinois State Geological Survey, (217) 244-2428, fax 217-333-2830, jnelson@isgs.uiuc.edu; Richard W. Harrison, MS 926A, U.S. Geological Survey, Reston, VA 22092, (703) 648-6928, rharriso@usgs.gov; David Hoffman, Missouri Department of Natural Resources, Division of Geology and Land Survey, P.O. Box 250, 111 Fairgrounds Rd., Rolla, MO 65401, (573) 368-2144, nrhoffd@mail.dnr.state.mo.us.
6. Depositional Facies and Sequence Stratigraphy of the Middle Mississippian Warsaw Shale and Salem, St. 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, and Joseph A. Devera, (618) 985-3394, jdevera@siu.edu, Illinois State Geological Survey, fax 217-244-2785.

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 sessions. 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.

The North-Central Section of GSA, in cooperation with the GSA Foundation, offers travel assistance grants up to \$200 (exclusive of field trip fees) to Student Associates of GSA. Assistance will be offered on a first-come, first-served basis, and priority will be 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 Street, 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*.

PROJECTION EQUIPMENT

Two standard 35-mm carousel projectors for 2 × 2-inch slides and two viewing screens will be provided in each meeting room. An overhead projector for transparencies will also be available for each room. A speaker ready room equipped with projectors will be available for review

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and practice. Each carousel to be used in an oral presentation should be identified with the speaker's name, session number, and speaker number and must be ready for use at the beginning of the technical session.

BUSINESS MEETINGS AND SOCIAL EVENTS

The GSA North-Central Section Management Board will hold its business meeting with breakfast on Thursday morning, April 22, 1999, beginning at 7:00 a.m. The location will be published in the *Abstracts with Programs* volume.

A Welcoming Reception will be held on Wednesday evening April 21, 1999. The Annual Banquet will be held on Thursday evening, April 22, preceded by a social hour beginning at 6:00 p.m. A special address will follow dinner and a brief business meeting.

The Paleontological Society North-Central Section and the SEPM Great Lakes Section will meet jointly for lunch at noon on Thursday, April 22. The GSA North-Central Section Campus Representatives breakfast and meeting will be held Friday morning, April 23, 1999, at 7:00 a.m. Also planned are a luncheon (Friday) for the Central Section of the National Association of Geoscience Teachers and an Association for Women Geoscientists breakfast meeting.

HOUSING

A large block of rooms has been reserved in the Clarion Hotel and Convention Center, and special room rates have been negotiated. Blocks of rooms also have been reserved at several other hotels in the vicinity of the convention center. A list of names, telephone numbers, and room rates will be available in the January 1999 issue of *GSA Today*. Registrants are responsible for making their own housing arrangements and are encouraged to stay at the Clarion Hotel, where most activities related to the meeting will be held.

REGISTRATION, ACCESSIBILITY, AND ABSTRACTS BOOK

PREREGISTRATION DEADLINE:
March 19, 1999.

The registration form will be in the January 1999 issue of *GSA Today*. Members pay less! Join GSA now or at the meeting. Contact Membership Services for further information.

GSA is committed to making every event at the 1999 North-Central Section meeting accessible to all persons interested in attending. You can indicate special requirements, such as an interpreter or wheelchair accessibility, on the registration form.

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

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 and is a hub for Greyhound Bus and is served by Amtrak from Chicago or New Orleans.

DETAILED INFORMATION

Detailed information concerning registration, hotel and motel accommodations, alternative opportunities in Champaign and central Illinois, technical sessions, symposia, field trips, and workshops will appear in the January 1999 issue of *GSA Today*. Check our Web site at <http://www.isgs.uiuc.edu/isgsroot/gsa-site/gshome.html>. Inquiries, requests, or suggestions should be directed to Dennis R. Kolata, General Chair, GSA North-Central Section, Illinois State Geological Survey, 615 East Peabody Dr., Champaign, IL 61820, (217) 244-2189, fax 217-333-2830, kolata@isgs.uiuc.edu. ■

1999-2000
GSA

CONGRESSIONAL SCIENCE FELLOWSHIP

The Geological Society of America is accepting applications for the 1999-2000 Congressional Science Fellowship. The Fellow selected will spend a year, or, optionally, 16 months in the office of an individual member of Congress, a congressional committee, or a congressional support agency for the purpose of contributing scientific and technical expertise to public policy issues and gaining firsthand experience with the legislative process. The American Association for the Advancement of Science conducts an orientation program to assist the Fellow seeking a congressional staff position in which he or she can work on major legislative issues.

CRITERIA

The program is open to highly qualified Ph.D. earth scientists. Candidates are expected to show exceptional competence in some area of the earth sciences, have a rather broad professional background, be cognizant of many matters outside their particular area, and have a strong interest and some experience in applying scientific knowledge toward the solution of societal problems.

AWARD

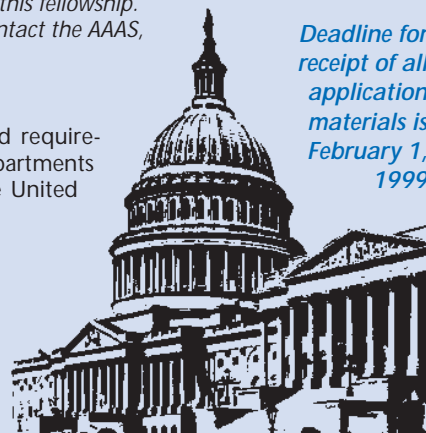
The 1999-2000 GSA Congressional Science Fellow will receive a one-year stipend of \$42,000, or \$56,000 for 16 months. The Fellow will also receive limited allowances for health insurance, relocation, and travel. The fellowship is funded by GSA and by a grant from the U.S. Geological Survey.

(The fellowship is available only to U.S. citizens, and employees of the USGS are ineligible to apply for this fellowship. For information about other programs, contact the AAAS, or the Geological Society of America.)

TO APPLY

Procedures for application and detailed requirements are available in the geology departments of most colleges and universities in the United States or upon request from:

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



Deadline for receipt of all application materials is February 1, 1999

GSA Divisions and Sections Award Grants for 1998

Leah Carter, GSA Grants Administrator

Division Research Grants

Nine of the twelve GSA divisions offer grants for outstanding student research within the fields of the respective divisions. Recipients of these grants for 1998 are listed below. The three divisions that do not currently offer any awards to students are Geoscience Education, History of Geology, and the International Division.

ARCHAEOLOGICAL GEOLOGY DIVISION

The Archaeological Geology Division awarded two grants this year. A student travel grant was awarded to William J.

Chadwick, University of Delaware, for his project "Ground Penetrating Radar Reveals the Relationship between Sea-level Rise and the Prehistoric Occupation of Relict Recurved Spits, Cape Henlopen, Delaware" which will be presented in the division's technical session at the GSA Annual Meeting in Toronto.

The Claude C. Albritton, Jr., Memorial Student Research Award goes to Sarah C. Sherwood, University of Tennessee, for her project "Depositional History of Dust Cave, Alabama." The Claude C. Albritton, Jr., Memorial Fund was established at the GSA Foundation in 1991 with contributions from the family and friends of

Claude Albritton. The division continues to seek contributions to the fund in his memory to provide scholarships for graduate students in the earth sciences and archaeology.

COAL GEOLOGY DIVISION

There have been no accepted nominations for the Antoinette Lierman Medlin Research Award or the Medlin Field Award.

ENGINEERING GEOLOGY DIVISION

The student research grant awarded by the Engineering Geology Division for an outstanding research proposal in 1998 was presented to Stanley J. Galicki from the University of Mississippi, for his project "Temporal Equivalent Geochemical and Dendrochemical Analysis and Correlation of Heavy Metal Loading in a Wetland Sediment Profile, Sky Lake, Humphreys County, Mississippi."

GEOPHYSICS DIVISION

The Geophysics Division presented the Allan V. Cox Student Research Award this year for an outstanding student research proposal submitted to the GSA Research Grants Program to Michael S. Petronis, University of New Mexico, for his project "Paleomagnetism and Structural History of the Silver Peak Range, West-Central Nevada."

HYDROGEOLOGY DIVISION

Awards for outstanding student research from the Hydrogeology Division were presented this year to four students: Robert Andress, Iowa State University, for "Nitrate Fate and Transport in Groundwater within a Riparian Management System in Central Iowa"; Sunil Mehta, University of Kentucky, for "Determining the Mechanism and Extent of Regional Salinization in the Ogallala Aquifer, Southern High Plains, Texas"; Remo Nardini, George Washington University, for "Use of Geographic Information Systems in the Analysis of Groundwater Chemistry and its Relationships to Lithology and Land Use, Loudoun County, Virginia"; and Matthew M. Uliana, University of Texas at Austin, for "The Influence of Structural Features on Interbasin and Regional Groundwater Flow in the Southern Salt Basin and Toyah Basin of West Texas."

PLANETARY GEOLOGY DIVISION

The Planetary Geology Division presents the Stephen E. Dwornik Best Student

1999 RESEARCH GRANTS PROGRAM FOR STUDENTS



The primary role of the Research Grants Program is to provide partial support for research in earth science by graduate students at universities in the United States, Canada, Mexico, and Central America. GSA strongly encourages women, minorities, and persons with disabilities to participate fully in this grants program. Eligibility is not restricted to GSA members. New application forms are available each fall in the geology departments of colleges and universities offering graduate degrees in earth sciences. Forms are mailed to GSA Campus Representatives, department secretaries, and chairpersons in the United States, Canada, and Mexico. Application forms and information will be available on GSA's Web page <http://www.geosociety.org> as of December 1, 1998. Applications may be downloaded from the Web but may **not** be submitted by e-mail. They are also available upon request from the Research Grants Administrator, Geological Society of America, P.O. Box 9140, Boulder, Colorado 80301. Please use only the current 1999 application and appraisal forms.

Confidential evaluations from two faculty members are required from candidates for the M.S. or Ph.D. degree and must accompany applications submitted. PLEASE USE THE "APPRAISAL OF APPLICANT" FORMS, WHICH ACCOMPANY THE 1999 APPLICATION FORMS. APPLICATION FORMS WILL NOT BE ACCEPTED BY FACSIMILE OR E-MAIL.

The Geological Society of America awarded over \$300,000 in grants in 1998. The grants went to 187 students doing research for advanced degrees. The average amount awarded was \$1654. The largest grant was \$2500, but there is no predetermined maximum amount. Funding for this program is provided by a number of sources, including GSA's Penrose and Pardee endowments, the National Science Foundation, industry, individual GSA members through the GEOSTAR and Research Grants funds, and numerous dedicated research funds that have been endowed at the GSA Foundation by members and families.

The Committee on Research Grants will meet in April to evaluate applications and award grants. In April, all applicants for grants will be informed of the committee's actions by the Executive Director of the Geological Society of America.

ALL APPLICATIONS MUST BE SUBMITTED ON THE 1999 FORMS AND POSTMARKED BY FEBRUARY 1, 1999

Grants continued on p. 31

Paper Awards annually to students who are U.S. citizens and are pursuing advanced degrees in Planetary Sciences. The awards are presented each year for papers given in March at the Lunar and Planetary Science Conference. Recipients of the 1998 awards are Nancy L. Chabot, University of Arizona, for the best oral presentation for her paper "The Effect of S on the Solubility of K in Metal," and Michelle E. Minitti, Brown University, for the best poster presentation for "Assessment of Shock Effects on Hornblende Water Contents and Isotopic Composition." Recipients of the awards are presented with a citation and a \$500 cash prize in an awards ceremony held at NASA Headquarters in Washington, D.C., early in the summer.

QUATERNARY GEOLOGY AND GEOMORPHOLOGY DIVISION

The Quaternary Geology and Geomorphology Division awarded the J. Hoover Mackin Grant to Noah Snyder, MIT, for "Channel Response to Varying Uplift, King Range, Northern California." Two Arthur D. Howard Research Grants were awarded this year. Recipients are Yarrow Axford, Utah State, for "Late Quaternary Glacier Fluctuations and Vegetational Changes in NW Akum Mountains, SW Alaska"; and Sarah Linfield Brown, University of Vermont, for "Lacustrine Records of Holocene Hillslope Erosion in New England."

SEDIMENTARY GEOLOGY DIVISION

The Sedimentary Geology Division presented its 1998 award for an outstanding student research proposal to Jennifer M. Elick, University of Tennessee, for her project "Paleopedology and Sedimentology of the Cap-aux-Os and Fort Prevel Members of the Battery Point Formation (Early Devonian, Emsian), Gaspé Bay, Quebec, Canada."

STRUCTURAL GEOLOGY AND TECTONICS DIVISION

The Structural Geology and Tectonics Division presented its 12th annual awards for outstanding student research this year to Delores M. Robinson, University of Arizona, for "Investigating the Origin of the Chainpur Thrust through Structural and Petrogenetic Examinations, Western Nepal Himalaya"; and Kevin Mahan, University of Utah, for "Emplacement Mechanisms for a Granite Intrusion: The McDoogle Pluton, Central Sierra Nevada, California."

Section Research Grants

Four of the six GSA regional sections award grants for research to students attending colleges and universities within

AMS 1999 Annual Meeting To Emphasize Climate and Global Change

The American Meteorological Society 1999 annual meeting will feature an assortment of symposia and conferences, including sessions on climate and human health, atmospheric chemistry, public awareness of weather and climate prediction, and paleoclimate studies in the Americas. The meeting will be in Dallas, Texas, January 10–15, 1999. GSA will be a cosponsor. For more information, see the calendar section of this issue, p. 34.

each section's respective geographical boundaries. The Cordilleran and Rocky Mountain Sections do not currently offer student research grants. Grants awarded in 1998 by the other sections are listed below.

NORTH-CENTRAL SECTION

The North-Central Section awarded grants for undergraduate research projects to students who attend a college or university within the North-Central Section geographic area. Research proposals are submitted and evaluated competitively. Recipients for 1998 are: Paul R. Hanson, University of Wisconsin—Milwaukee; Melodie Hessling, Saint Louis University; Kristy Tramp, University of Nebraska—Lincoln; Julie Welch, University of Nebraska at Omaha; Melissa A. Hays, University of Akron; James Essex, Miami (Ohio) University; Jeffrey M. Rahl, University of Dayton; and Kelly L. Bergman, University of Nebraska—Lincoln.

SOUTH-CENTRAL SECTION

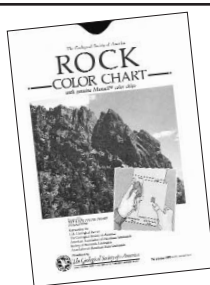
The South-Central Section has not yet determined the 1998 award recipients. The results will be published in the November issue of *GSA Today*.

NORTHEASTERN SECTION

The Northeastern Section awarded grants to six undergraduate students. The 1998 recipients are: Riley Brown, University of Maine; Kevin Eastham, Juniata College, Pennsylvania; Nicole Senczakiewicz, Kean College of New Jersey; Hannah J. Thomas, Mount Holyoke College, Massachusetts; Bryn Welker, Bloomsburg University, Pennsylvania; and Donald Alexander Wood, Acadia University, Nova Scotia, Canada.

SOUTHEASTERN SECTION

GSA's Southeastern Section awarded research grants to 12 students this year. The 1998 recipients are: Jonathan Remo, West Virginia University; Andrey Bekker, Virginia Polytechnic Institute; Jennifer Elick, University of Tennessee; James Hogan, University of Tennessee; Jessica Huckmeyer, Vanderbilt University; Amber Huntoon, University of North Carolina; Brannon McDonald, Auburn University; Sunil Mehta, University of Kentucky; Bruce Rohrbach, University of Tennessee; Leanne Spurgeon, West Virginia University; Doug Tinkham, University of Alabama; and Cheryl Waters, University of North Carolina. ■



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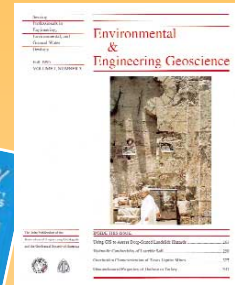
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See p. 29 for details

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1999 Penrose Conferences

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January 18–24, Strike-slip to Subduction Transitions on Plate Boundaries: Tectonic Setting, Plate Kinematics, and Seismic Hazards, Puerto Plata, Dominican Republic. Information: Paul Mann, Institute of Geophysics, University of Texas, Bldg. 600, 4412 Spicewood Springs Road, Austin, TX 78759-8500, (512) 471-0452, fax 512-471-8844, paulm@utig.ig.utexas.edu.

March

March 25–31, Mid-Cretaceous to Recent Plate Boundary Processes in the Southwest Pacific, Arthur's Pass, New Zealand. Information: Suzanne L. Baldwin, Dept. of Geosciences, University of Arizona, Tucson, AZ 85721, (520) 621-9688, fax 520-621-2672, baldwin@geo.arizona.edu.

June

June 21–27, Terrane Accretion along the Western Cordilleran Margin: Constraints on Timing and Displacement, Winthrop, Washington. Information: J. Brian Mahoney, Dept. of Geology, University of Wisconsin, Eau Claire, WI 54702-4004, (715) 836-4952, fax 715-836-2380, mahonej@uwec.edu.

August

August 17–22, The Marine Eocene-Oligocene Transition, Olympia, Washington. Information: Donald R. Prothero, Dept. of Geology, Occidental College, 1600 Campus Road, Los Angeles, CA 90041, (213) 259-2557, fax 213-259-2704, prothero@oxy.edu.

November

November 21–27, Volcanic Rifted Margins, Sana'a, Yemen. Information: Martin Menzies, Dept. of Geology, Royal Holloway, University of London, Egham Hill, Egham, Surrey TW 20 OEX, United Kingdom, 44-1784-443105, fax 44-1784-471780, menzies@gl.rhnc.ac.uk.

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1998 Meetings

October

October 7–10, American Association of Petroleum Geologists Eastern Section Meeting, Columbus, Ohio. Information: Larry Wickstrom, Ohio Geological Survey, (614) 265-6598, larry.wickstrom@dnr.state.oh.us, http://www.dnr.state.oh.us/odnr/geo_survey/aapg98.htm.

1999 Meetings

January

January 10–15, American Meteorological Society 79th Annual Meeting & Exhibition, Dallas, Texas. Information: AMS, 45 Beacon Street, Boston, MA 02108, (617) 227-2425, fax 617-742-8718, hallgren@ametsoc.org.

February

February 13–18, Glacial-Interglacial Sea level Changes in Four Dimensions: Quaternary Sea Levels, Climate Change & Crustal Dynamics, Algarve, Portugal. Information: Josip Hendekovic, European Science Foundation, 1 quai Lezay-Marnesia, 67080 Strasbourg Cedex, France, +33 3 88 76 71, fax +33 3 88 36 69 87, euresco@esf.org, <http://www.esf.org/euresco>.

February 21–26, GEOSAS-III: 1999, Third South Asia Geological Congress, Lahore, Pakistan. Information: F. A. Shams, Institute of Geology, Punjab University, Lahore 54590, Pakistan, (92-42) 586-6809, fax 92-42-631-2233, geology1@paknet1.ptc.pk.

March

March 24–26, 14th Himalaya-Karakoram-Tibet Workshop, Kloster Ettal, Germany. Information: Lothar Ratschbacher, Institut für Geologie, Universität Würzburg, Pleicherwall 1, D-97070, Würzburg, Germany, +49 931 312580, fax +49

931 312378, lothar@geologie.uni-wuerzburg.de, <http://www.geologie.de>.

March 14–17, Symposium on the Application of Geophysics to Engineering and Environmental Problems, Oakland, California. Information: SAGEEP, 7632 E. Costilla Ave., Englewood, CO 80112, (303) 771-2000, fax 303-843-6232, <http://www.sageep.com>.

April

April 16–19, National Fossil Exposition XXI, Western Illinois University, Macomb, Illinois. Information: Allyn Adams, 612 West 51st Street, Davenport, IA 52806 (319) 391-5443 or Karl Stuekerjuergen, 1503 265th Ave., West Point, IA 52656 (319) 837-6690.

June

June 5–9, International Workshop for a Climatic, Biotic, and Tectonic Coring Transect of Triassic-Jurassic Pangea, Wolfville, Nova Scotia, Canada. Information: Paul Olsen, Lamont Doherty Earth Observatory, Rt. 9W, Palisades, NY 10964, (914) 365-8491, fax 914-365-2312, polsen@ldeo.columbia.edu, <http://www.ldeo.columbia.edu>.

June 26–July 1, Clay Minerals Society 36th Annual Meeting, Purdue University, West Lafayette, Indiana. Information: Patricia Jo Eberl, Clay Minerals Society, P.O. Box 4416, Boulder, CO 80306, (303) 444-6405, fax 303-444-2260, peberl@clays.org.

November

November 7–10, Fourth USA/CIS Joint Conference on Environmental Hydrology and Hydrogeology, San Francisco, California. Information: American Institute of Hydrology, 2499 Rice Street, Suite 135, St. Paul, MN 55113-3724, (651) 484-8169, fax 651-484-8357, AIHydro@aol.com, <http://www.aihydro.org>. (Abstracts deadline: February 28, 1999.)

GSA SECTION MEETINGS — 1999

SOUTH-CENTRAL SECTION

March 15–16, 1999, Lubbock, Texas. Submit completed abstracts to James Barrick, Dept. of Geosciences, Texas Tech, Lubbock, TX 79409-1053, (806) 742-3107, ghjeb@ttu.edu. Abstract deadline: December 15, 1998.

NORTHEASTERN SECTION

March 22–24, 1999, Providence, Rhode Island. Submit completed abstracts to Anne I. Veeger, Dept. of Geology, University of Rhode Island, Green Hall, Kingston, RI 02881, (401) 874-2187, veeger@uriacc.uri.edu. Abstract deadline: December 8, 1998.

SOUTHEASTERN SECTION

March 25–26, 1999, Athens, Georgia. Submit completed abstracts to Michael F. Roden, Dept. of Geology, University of Georgia, Athens, GA 30602-2501, (706) 542-2416, mroden@uga.cc.uga.edu. Abstract deadline: December 14, 1998.

ROCKY MOUNTAIN SECTION

April 8–10, 1999, Pocatello, Idaho. Submit completed abstracts to Paul Link, Dept. of Geology, Idaho State University, 785 South 8th Ave., Pocatello, ID 83209-8072, (208) 236-3846, linkpaul@isu.edu. Abstract deadline: December 29, 1998.

NORTH-CENTRAL SECTION

April 22–23, 1999, Champaign-Urbana, Illinois. Submit completed abstracts to C. Pius Weibel, Illinois State Geological Survey, 615 E. Peabody Dr., Champaign, IL 61820-6964, (217) 333-5108, weibel@isgs.uiuc.edu. Abstract deadline: January 11, 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.

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Dedicated to Clarence A. Hall, Jr., who transformed the White Mountain Research Station in California to a nationally prominent research facility and served as the station's director for 15 years while concurrently serving as the department chair, dean, and professor at the University of California, Los Angeles. Hall's seminal contributions include recognition and documentation of ~115 km of dextral slip on the San Simeon-Hosgrei fault; demonstration of the offset of Neogene molluscan provinces and paleo-isotherms along the San Andreas system; and synthesis of the geology and invertebrate paleontology of the central California Coast Ranges and hypothesis of the existence of the southern California allochthon.

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Crossing Divides

CALL FOR FIELD TRIP PROPOSALS

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

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CALL FOR SHORT COURSE PROPOSALS

Due December 1, 1998

The GSA Committee on Continuing Education invites those interested in proposing a GSA-sponsored or cosponsored course or workshop to contact GSA headquarters for proposal guidelines. Courses may be conducted in conjunction with all GSA annual or section meetings. We are particularly interested in receiving proposals for the 1999 Denver Annual Meeting or the 2000 Reno Annual Meeting.

Proposals must be received by December 1, 1998. Selection of courses for 1999 will be made by February 1, 1999. For those planning ahead, we will also consider courses for 2000 at that time.

For proposal guidelines or information, contact:
Edna Collis, Continuing Education Coordinator, GSA headquarters,
1-800-472-1988, ext. 134, ecollis@geosociety.org

DENVER MINI-CALENDAR

1998

November 1 — Theme Proposal Information in November *GSA Today*. Electronic Symposia/Topical Session Proposal Form available on the GSA Web site

December 1 — Short Course Proposals due to GSA

1999

January 6 — Symposia and Topical Proposals due to Technical Program Chairs

April 1 — Call for Papers published and distributed

May 1 — Electronic Abstract Submittal Form available on the GSA Web site

June 1 — Registration and housing information printed in June *GSA Today*

July 12 — Abstracts Deadline

September 17 — Preregistration and Housing Deadline

FUTURE GSA MEETINGS

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2001 Boston, Massachusetts, November 5–8

2002 Denver, Colorado, October 28–31

2003 Seattle, Washington, November 2–5

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POSTDOCTORAL POSITION IN SILICON STABLE ISOTOPE BIOGEOCHEMISTRY UNIVERSITY OF CALIFORNIA, SANTA BARBARA

We seek someone to help us understand why Si dissolved in the oceans is enriched in Si-30 relative to the Si in igneous and metamorphic rocks; a question that is fundamental to progress in quantifying the biogeochemical cycle of Si. The position entails analysis of isotopic fractionations occurring during the processes (weathering, clay and phylolith formation, etc.) that transform Si in rocks into dissolved Si that washes into the ocean. The work involves application of a technical breakthrough in measuring isotopes in dissolved and particulate Si (Anal. Chem. 68, 3746-3750, 1996). We seek an individual with background in geochemistry, soils or clay mineralogy, preferably with experience with stable isotopes, and an interdisciplinary interest. Send resume, including the names of 3 references, to Oliver Chadwick, Geography Dept., University of California, Santa Barbara, CA 93106. E-mail queries about the position can be sent to Chadwick (oac@geog.ucsb.edu) or to the other 2 principals on the project, Mic DeNiro (deniro@magic.geol.ucsb.edu) or Mark Brzezinski (brzezins@lifesci.lscf.ucsb.edu). Position open until filled. Preliminary interviews will be conducted with qualified individuals at the Geological Society of America meeting in Toronto in October, 1998 or by phone for those not attending GSA. Initial appointment is for 1 year, with additional year (funding in place) contingent on satisfactory progress. An EO/AA employer.

GRAND VALLEY STATE UNIVERSITY ENVIRONMENTAL GEOLOGIST

Tenure-track assistant professor of geology position beginning fall 1999, contingent upon funding. Ph.D. required. Expertise desired in either ground or surface water processes. Preference will be given to candidates with expertise in GIS, computer applications (e.g. aquifer mapping or modeling), hydrologic field methods, and/or global systems and cycles. Industry experience and a working knowledge of environmental regulations are desired. A strong commitment to teaching and doing research with undergraduate students is essential. The successful candidate will teach hydrogeology, environmental geology, and introductory geology courses and will lead in the development of an environmental emphasis in the geology major and new courses.

The department currently is comprised of seven faculty members, a lab supervisor, and 70+ majors, divided between geology and earth science or group science education. Of the geology majors, approximately half go to graduate school, and half obtain positions in the environmental field.

Send letter of application, a vitae, a succinct statement of teaching philosophy, and the names, addresses, e-mail addresses, and phone numbers of three references to: Patricia Videtich, Chair, Department of Geology, Grand Valley State University, Allendale, Michigan 49401. Applications must be postmarked by November 23.

GVSU is an Affirmative Action/ADA and Equal Opportunity Employer.

ASSISTANT PROFESSOR OF STRUCTURAL GEOLOGY / ACTIVE TECTONICS
Responsibilities will include advising M.S. and undergraduate research, academic-year teaching of the sophomore-level core introductory field geology course, structural geology and other courses of the candidate's choosing. Preferred candidates will approach structural problems using both field and analytical methods and bridge current departmental interests in crustal studies/petrology and surface processes. Ph.D. required. Specific expertise could include: quantitative analysis, geophysics, and geochronology. A dedication to integrating high quality research and teaching at the undergraduate and Master's levels is important. Apply with CV and names of 3 references by December 15, 1998 to: Chair, Search Committee, Department of Geology, University of Vermont, Burlington, VT 05405.

GLOBAL SEDIMENTARY SYSTEMS UNIVERSITY OF CALIFORNIA, RIVERSIDE

The Department of Earth Sciences, University of California, Riverside, invites applications for tenure-track position at Assistant Professor rank. The applicant must hold a Ph.D. and have a strong commitment to excellence in both research and teaching. We seek an individual with primary research interests in marine sedimentary rocks, linking global paleoenvironmental and ecological change through study of the stratigraphic record. A strong field or core-based research orientation is desirable. The successful candidate will be expected to foster interaction with ongoing research in paleobiology, geomorphology, Quaternary geology, stratigraphy, biogeography, and geochemistry. Teaching responsibilities will include undergraduate offerings in sedimentology and stratigraphy as well as graduate courses in the area of specialty.

Information about Earth Sciences at UCR is available on the web at <http://cnas.ucr.edu/~earth/es.html>. Applications, including a vitae, statement of research and teaching interests, and full contact information of three referees should be sent by November 30, 1998, to: Dr. Mary Droser, Chair, Global Sedimentary Systems Search, Department of Earth Sciences, University of California, Riverside, California, 92521. E-mail contact: mary.droser@ucr.edu. The University of California is an equal opportunity employer.

ASSISTANT PROFESSOR GEOLOGY UNIVERSITY OF RHODE ISLAND

The Geology Department at the University of Rhode Island invites applications for a new tenure-track faculty position beginning in the Fall of 1999. This position, within the newly formed College of the Environment and Life Sciences, reflects the commitment to expanding its programs in the environmental sciences. We seek applicants whose primary interest is in the field of organic contaminant hydrogeology. A Ph.D. in hydrology, geology, or within the environmental sciences is required at the time of appointment. The following are also required: potential for developing an externally funded and nationally recognized research program in hydrogeology; an undergraduate degree (or equivalent) in geology; training and research experience in hydrogeology, organic chemistry, and contaminant transport; the ability to teach an upper-division course in environmental organic chemistry and a graduate-level course in solute/contaminant transport; a strong commitment to quality instruction. The following are preferred: post-doctorate experience; a record of peer-reviewed publications and research funding; teaching experience. For information about the Department of Geology, refer to our web site: <http://www.uri.edu/cels/gel>. Interested candidates should submit a curriculum vitae, transcripts, a statement of research and teaching interests and the names of four referees by 10/30/98 or until position is filled to: Anne Veeger, Search Committee Chair (Log # 021336). University of Rhode Island, P.O. Box G, Kingston, RI 02881. The University of Rhode Island is an AA/EEO employer and is committed to increasing the diversity of its faculty, staff and students. Persons from under-represented groups are encouraged to apply.

SOUTHERN ILLINOIS UNIVERSITY, CARBONDALE
The Department of Geology invites applications for a tenure-track position in paleobiology at the assistant professor level, starting August 16, 1999. Applicants must hold a Ph.D. or show that they will complete all degree requirements by August 16, 1999. If the successful candidate has not completed all requirements for the Ph.D.

degree by August 16, 1999, he/she will be appointed for one year as instructor at a reduced salary. The successful candidate must have demonstrated teaching ability and the existence of, or potential for, developing an externally funded research program of high quality. Areas of research emphasis may include but are not limited to paleobiology, biostratigraphy, and global change. Teaching duties will include invertebrate paleontology and paleoecology, introductory undergraduate geology courses, and upper level and graduate courses in the emphasis area. Applicants should submit a curriculum vitae, a statement of teaching and research interests, and the names and addresses of at least three referees to: Dr. James R. Staub, Search Committee Chair, Department of Geology, Mail Code 4324, Southern Illinois University, Carbondale, IL 62901-4324; fax 618-453-7393; e-mail: jstaub@geo.siu.edu. Applications will be accepted until December 7, 1998 or until the position is filled. Information about the Department and its programs can be found at: <http://www.science.siu.edu/geology/index.html>. Southern Illinois University is an Equal Opportunity, Affirmative Action Employer.

HYDROGEOLOGY / ENVIRONMENTAL STUDIES UNIVERSITY OF THE PACIFIC

The Department of Geology & Geography at the University of the Pacific invites applications for a tenure-track position at the rank of Assistant Professor in the area of hydrogeology and environmental studies. A Ph.D. is required at the time of appointment, August, 1999. This position represents an expansion of the geology curriculum as a result of the retirement of a geography professor.

Teaching responsibilities will include upper division courses in hydrogeology as well as general education, introductory courses in one or more of the following: physical geology, environmental science, oceanography, physical geography, meteorology.

We seek an individual who has the potential to be an outstanding teacher, dedicated to the highest quality interaction with undergraduate students in classroom, laboratory, and field settings. The individual must also have a demonstrated ability to pursue an active research program that can involve undergraduates. It is expected that the successful candidate will take an active role in an expanding environmental studies program that involves the departments of geology & geography, biology, philosophy, history, and economics.

Interested individuals should send a letter of application summarizing teaching and research interests and teaching philosophy, a curriculum vitae, and arrange for three letters of reference to be sent to: Lydia K. Fox, Chair, Department of Geology & Geography, University of the Pacific, 3601 Pacific Ave., Stockton, CA 95211. Review of applications will begin immediately and continue until an appointment is made. The University of the Pacific is an equal opportunity/affirmative action employer and welcomes applications from members of underrepresented groups.

FACULTY POSITIONS STRUCTURAL GEOLOGY AND GEOPHYSICS STATE UNIVERSITY OF NEW YORK AT BUFFALO

The Department of Geology invites applications for two tenure-track faculty positions, structural geology and geophysics, starting in September 1999 at the Assistant Professor level. The successful candidates will demonstrate a potential for research and teaching, which will both complement and integrate with our existing programs in volcanology and environmental geology. Existing research includes studies of active volcanoes, analysis of neotectonics, characterization of fractured rock systems, remediation of ground water, and applications of basin analysis. The geology home page gives more details of our departmental research and teaching program (<http://wings.buffalo.edu/academic/department/geology/>). Teaching duties for both positions will involve undergraduate and graduate level courses in their respective specialties. The salary and the initial University contribution to the candidates/research equipment will be very attractive. Successful candidates must have the Ph.D. degree as of the date of appointment. Apply with a statement of teaching and research goals and a curriculum vitae, including published research, grant support, and names of at least three references to: Chair, Search Committee, Department of Geology, State University of New York at Buffalo, 876 Natural Sciences Complex, Buffalo, NY 14260-3050. We will begin evaluating applicants on December 20, 1998.

The State University of New York is an Equal Opportunity/Affirmative Action Employer and encourages applications from women and minorities.

**CALIFORNIA DEPARTMENT OF CONSERVATION
SUPERVISING GEOLOGIST**

The California Department of Conservation, Division of Mines and Geology, invites applications for a Supervising Geologist position in Sacramento, California. The Division is responsible for a broad range of practical applications of geology, especially geologic and earthquake hazards.

The Division is seeking a registered geologist or geophysicist certified by the California Board of Geologists and Geophysicists. The candidate must possess strong marketing and information dissemination skills and have experience in administering outreach programs. The position will be responsible for supervising the Division's local government outreach program, the Library and Publications Unit, and the Los Angeles and San Francisco regional offices, including their libraries. The position will be responsible for ensuring technical quality of publications, maps, and surveys and inventories. The position will supervise a staff of 20 and manage a budget of approximately \$2 million.

Responsibilities include supervising the Division's outreach program. The position will also supervise the conversion of analog products to digital formats and assist in the development of our internet presence.

The position will direct the production and distribution of *California Geology*, overseeing editing, graphic layout, etc., and will have frequent contact with authors and public. The position will supervise the Division's two regional offices which are responsible for information dissemination to the public.

The salary range for this position is (\$4484-\$5901 monthly). Please submit a Standard State Application (form 678) / Resume to: Department of Conservation/Division of Mines and Geology, Attention: Eric Jarvis, 801 K Street, MS12-30, Sacramento, CA 95814. Form 678 can be obtained by contacting the State Personnel Board Job Line at (916) 653-1018 or Eric Jarvis at (916) 445-1401. Additional information can be obtained from the internet at <http://www.spb.ca.gov>.

ASSISTANT PROFESSOR IN PALEONTOLOGY

The Department of Geology at the University of Iowa invites applications for a full-time tenure-track Assistant Professorship with a specialty in micropaleontology or invertebrate paleontology. The appointment will begin in August 1999. We seek an outstanding researcher and teacher whose approach is both quantitative and specimen-based, and who will work with other faculty to improve our strong graduate program in paleontology and sedimentary geology. In addition to developing an active, externally-funded program of research, the successful candidate will be expected to teach three courses per academic year. These will include: (1) an upper-level undergraduate/graduate course in biostratigraphy, micropaleontology or invertebrate paleontology, (2) team-participation in Evolution and History of Life, a general education course, and (3) a graduate seminar in paleontology. He/she will also be expected to contribute both to our Paleontology Repository as well as to new departmental initiatives in the environmental sciences and climate change. Applicants should have a Ph.D. or be in the final stages of completing the degree. Women and minorities are especially encouraged to apply. Applicants should send a complete resume (including a bibliography and statement of teaching and research interests) and have at least three letters of recommendation sent to: Dr. Holmes Semken, Search Committee Chair, Department of Geology, University of Iowa, Iowa City, IA 52242-1379 (phone: (319) 335-1818; fax: 319-335-1821). The closing date for applications is December 1, 1998, and screening of candidates will begin immediately thereafter and continue until the position is filled. The University of Iowa is an Affirmative Action-Equal Opportunity Employer.

**FLUVIAL GEOMORPHOLOGIST DESERT RESEARCH
INSTITUTE (DRI) UNIV. OF NEVADA SYSTEM**

DRI's Quaternary Sciences Center seeks a Fluvial Geomorphologist, at Asst., Assoc., or Full Research Prof. level. Ph.D. in geology, physical geography, or related discipline required. Appointee must support position through grants and contracts, so ability to develop funded research in one or more of the following is requisite: paleoenvironmental interpretation of fluvial stratigraphy and landforms; water-shed landscape dynamics; flood geomorphology; applied problems of watershed management; anthropogenic impacts to riverine environments; and coupled field-based/modeling studies relating to geomorphology and sediment transport. Must collaborate with other scientists and participate in/teach grad. education in hydrologic Sci. at Univ. of NV-Reno.

Review of aps begins 11/98 with decision soon thereafter. Submit c.v.; letter describing research interests, grants and contracts experience, teaching record; and contact information on 4 references to: Recruitment Ofc., DRI, 7010 Dandini Blvd., Reno, NV 89512. Refer to #P30-015 in all correspondence. DRI offers a competitive salary and excellent benefits. For details, visit us at <http://www.dri.edu>.

**SEDIMENTOLOGIST
UNIVERSITY OF ILLINOIS, CHICAGO**

The Department of Earth and Environmental Sciences, University of Illinois at Chicago, seeks a process-oriented sedimentologist for an Assistant Professor, tenure-track appointment, starting Fall, 1999. We are interested in candidates who will develop a strong research program. The appointee is expected to teach at the undergraduate and graduate levels. A Ph.D. is required. Applicants should send a resume, statements outlining research and teaching interests, and names of at least four references, to: Steven L. Forman, Sedimentology Search Chair, University of Illinois at Chicago, Department of Earth and Environmental Sciences, 845 W. Taylor Street, M/C 185, Chicago, IL 60607-7059. For more information about the Department, see our web page: www.uic.edu/depts/geos/. For fullest consideration, submit by October 15, 1998, or until the position is filled. UIC is an affirmative action/equal opportunity employer.

MINERALOGY/PETROLOGY DENISON UNIVERSITY

The Department of Geology and Geography invites applications for a tenure-track appointment at the Assistant Professor level, to begin in the Fall semester of 1999; a Ph.D. is required. Primary teaching responsibilities include mineralogy, petrology, and introductory physical geology. Other subjects which would complement our program include economic geology and geochemistry. Our department stresses a balance of classroom, field, and laboratory experiences for our majors, and we seek a colleague who will contribute to and collaborate with us on all these components of undergraduate geoscience education. Denison is a selective liberal arts college strongly committed to and supportive of excellence in teaching and active faculty research which involves undergraduate students.

Candidates should submit a letter of application, including a discussion of their approach to teaching and research in a liberal arts setting, along with a vitae, academic transcripts and the names, addresses, e-mail and phone numbers of three or four references—to Tod A. Froliking, Chair, Department of Geology and Geography, Denison University, Granville, OH 43023; (740) 587-6217; froliking@denison.edu. Application materials must arrive by December 1, 1998, for full consideration, interviews will be held on campus in late January. Early applications are strongly encouraged as we hope to meet with candidates at the GSA meeting in Toronto. Denison is an affirmative action/equal opportunity employer.

**KANSAS STATE UNIVERSITY
ASSISTANT PROFESSOR**

The Department of Geology at Kansas State University invites applications for a tenure-track Assistant Professor position to start fall, 1999 (pending final approval by the University administration). We are looking for a dynamic, energetic geoscientist with expertise in one of the following: tectonics and sedimentation, basin analysis, petroleum geology, or geophysics. The successful candidate will be expected to develop an active, externally funded research program, and to teach one introductory-level course and one upper-level undergraduate or graduate-level (master's) course in his or her field of expertise per semester. A field component to teaching and research is encouraged, and collaboration with faculty in Geology or in other departments at K-State is considered essential. The Ph.D. in geology is required. K-State is located in the tall-grass prairie of the Flint Hills in northeastern Kansas. See <http://www.ksu.edu/geology/> for information about the Geology Department and Kansas State University, which is a land grant university. Applications, including a resume and publication list, statements of research and teaching interests, copies of relevant publications, and names, phone numbers, and addresses (postal and e-mail) for three referees, should be received by November 9, 1998. Applications or requests for further information should be directed to Jack Oviatt, Department of Geology, Kansas State University, Manhattan, KS 66506-3201 (joviatt@ksu.edu). Women and minorities are encouraged to apply. Kansas State University is an equal opportunity/affirmative action employer.

**QUATERNARY GEOLOGIST
CALIFORNIA STATE UNIVERSITY, FULLERTON**

The Department of Geological Sciences at California State University, Fullerton, invites applications for a tenure-track position starting August 1999. Applicants should have the following credentials and capabilities (1) A Ph.D. in geology; (2) An interest in achieving excellence in teaching; (3) Expertise in: surficial processes, Quaternary stratigraphy and sedimentation, paleoclimatology, and/or tectonic geomorphology; we are most interested in a person expert in non-glacial Quaternary geology; and (4) Strong quantitative and computer skills with a field-based research emphasis.

Teaching responsibilities will include physical geology, field geology, and courses in the applicant's area of expertise. The ability to teach remote sensing/GIS, oceanography, or meteorology is a plus. Before applying, see the full text of this announcement at <http://geology.fullerton.edu/geology/>.

To apply, please send the following: (1) A detailed curriculum vitae; (2) A letter telling us about yourself and detailing how you meet the qualifications outlined above; (3) A statement about teaching that includes a discussion of relevant course work and/or experience in preparation for teaching, a list of courses you would feel comfortable teaching, and a statement of your teaching philosophy; (4) A statement of your future research plans and goals; and (5) The names, addresses, phone numbers, and e-mail addresses of at least three references familiar with your teaching and research potential.

Send application to: Dr. Brady Rhodes, Chair, Search Committee, Dept. of Geological Sci., CSUF, P.O. Box 6850, Fullerton, CA 92834-6850. Applications will be accepted until November 15, 1998. We will interview applicants at the GSA Meeting in Toronto, October 26-29, 1998.

CSU, Fullerton is an Affirmative Action/Equal Opportunity Employer. All personnel policies conform to the requirements of Executive Order 11246, the Americans with Disabilities Act (ADA) of 1990, Title IX of the Higher Education Amendments of 1972 and other federal regulations regarding nondiscrimination.

POSTDOCTORAL OPPORTUNITIES

The U.S. Geological Survey, Geologic Division, is conducting a national competition to find outstanding scientists, who have recently completed doctorate-level research, to fill 1-2 year contractual positions as guest Research Associates. The objective of the program is to provide guest Research Associates of unusual promise and ability a formal opportunity to conduct research in an area of their choice that falls within the realm of Geologic Division's long-term scientific strategy goals as follows: Conducting geologic hazard assessments for mitigation planning; providing short-term prediction of geologic disasters and rapidly characterize their effects; advancing the understanding of the Nation's mineral and energy resources in a global, geologic, economic, and environmental context; anticipating the environmental impacts of climate variability; establishing the geologic framework for ecosystem structure and function; interpreting the links between human health and geologic processes; and determining the geologic controls on ground water resources and hazardous waste isolation. Approximately five (5) Research Associate opportunities are available. The principal duty stations will be Reston, VA, Denver, CO, or Menlo Park, CA, depending on the candidate's chosen research area. Limited opportunities, however, may be available at other field locations. Compensation will be in fixed weekly stipends for the geographic area in which they work. Approximate stipend amounts are as follows: Reston, VA \$820.00; Denver, CO, \$855.00; and Menlo Park, CA, \$886.00. Awardees are offered a services contract initially for 12 months. However, a 1-year extension may be granted at the discretion of the USGS should funds be available.

For more information about the program and the application materials required, complete details are provided in the Postdoctoral Research Associateship Program Announcement which is available on the web at <http://geology.usgs.gov/postdoc/> or you may call (703) 648-6630 to request a copy.

The U.S. Geological Survey is an equal opportunity employer. Qualified applicants will receive consideration without regard to race, creed, color, age, sex, national origin, political preference, labor-organization affiliation or non-affiliation, marital status, or non-disqualifying handicap.

**WASHINGTON STATE UNIVERSITY
NOTICE OF VACANCY TWO FULL-TIME
TENURE TRACK POSITIONS**

The Department of Geology, Washington State University, seeks to fill two full-time, tenure-track faculty positions at the Assistant Professor level. The successful candidates must have an earned doctorate, will demonstrate commitment to excellence in research and teaching, and the ability to generate external research funding. Both will be expected to teach undergraduate and graduate courses in their areas of specialty, and to take a significant role in teaching and administering our popular introductory course. We encourage applications from scientists working with both ancient and modern systems. Position 1 will be filled with a candidate with expertise in the general area of carbonate sedimentology/stratigraphy. Applicants should have expertise in one or more of the following areas: diagenesis, paleoclimatology, paleontology, paleoecology, and global change. The successful candidate will be responsible for undergraduate paleontology and historical geology instruction, and will participate in teaching of undergraduate and graduate sed-strat courses.

Position 2 will be filled by a candidate with expertise in the general area of geochronology. Applicants should be proficient in modern isotopic dating and analytical methods, preferably ICP-MS and/or laser ablation techniques. The successful candidate will be expected to participate in securing funding for equipment acquisitions. Teaching responsibilities, in addition to physical geology, will include courses in application of geochronologic methods to geological processes.

With these appointments, we seek to build on existing strengths in clastic sedimentology, paleoclimatology, cosmogenic dating, igneous petrology, volcanology, low-T geochemistry, analytical geochemistry, economic geology, hydrogeology, and structural geology. Strong curricular and research ties exist with the Department of Geology and Geological Engineering at the neighboring University of Idaho, and at Washington State University branch campuses at Vancouver and Tri-Cities.

The Department currently has 13 FTE and several adjunct faculty. Existing facilities in the Geoanalytical Laboratory include a newly upgraded electron microprobe, automated XRF and XRD, quadrupole ICP=MS, and an automated gas source mass spectrometer for stable isotope analysis. Additional facilities include a FTIR spectrometer, CL and epifluorescence scopes, a gas-flow fluid inclusion stage, and gas chromatographs for organic work. Local and regional geology and geography offer diverse research opportunities in the northern Rocky Mountains, the Columbia River Plateau, the northern Basin and Range, and the active volcanoes of the Cascade Range.

Applications for the carbonate sedimentology/stratigraphy position should be addressed to David Gaylord, Chair, Carbonate Sedimentology/Stratigraphy Search Committee, OR for the geochronology position to John Wolff, Chair, Geochronology Search Committee, Department of Geology, Washington State University, Pullman, WA 99164, U.S.A.

Applications should include a full curriculum vitae, a statement of teaching and research philosophy, and the names, addresses and e-mail addresses of 4 referees, and must be received by January 1, 1999. Washington State University employs only U.S. citizens and lawfully authorized non-U.S. citizens. All new employees must show employment eligibility verifications as required by the U.S. Immigration and Naturalization Service. Washington State University is an equal opportunity/affirmative action educator and employer. Members of ethnic minorities, women, Vietnam era or disabled veterans, persons of disability and/or persons the ages of 40 and over are encouraged to apply.

UNIVERSITY OF FLORIDA ASSISTANT PROFESSOR

The Department of Geology invites applications for a tenure-track assistant professor position in the general area of sedimentary geology to begin with or during the 1999-2000 academic year. Preference will be given to quantitative, process-oriented scientists who will develop strong and innovative research programs, and exhibit a strong commitment to teaching undergraduate and graduate students. We are particularly interested in scientists whose research investigates fundamental earth processes in a quantitative way. Possible specialties include sedimentology; sedimentary geochemistry, including biogeochemistry; environmental geology; seismic stratigraphy; basin evolution, etc. In addition, consideration will be given to those whose research complements existing research strengths of the Department, e.g., paleoclimatol-

ogy/paleoceanography, crustal evolution/chemical geodynamics, paleomagnetism/tectonophysics, isotope geology, and environmental geology. More information on the department is available at <http://web.geology.ufl.edu>.

Qualified candidates should send a letter of interest, including a statement of research and teaching goals, a curriculum vitae, and the names and addresses of three references by January 15, 1999 to: Dr. Paul Mueller (mueller@geology.ufl.edu), Department of Geology, Box 112120, University of Florida, Gainesville, FL 32611, (352) 392-2231; fax 352-392-9294.

The University of Florida is an equal opportunity employer; qualified women and minorities are especially encouraged to apply.

**ENDOWED PROFESSORSHIP AND
CHAIR OF GEOLOGY
COLBY COLLEGE**

COLBY COLLEGE seeks a dynamic individual to join the Department of Geology as the first endowed associate or full professor in the Department, beginning September 1, 1999. The successful candidate will also serve as chair of the department for a 3- or 6-year term.

Applicants for this position should be established scientists with a reputation for excellence in both teaching and research. Areas of expertise are open, but should complement the strengths of the two existing and continuing department members in mineralogy/ petrology and economic geology and in Quaternary geology and paleoecology. Applicants with primary expertise in paleontology, sedimentology/stratigraphy, structural geology, or hydrogeology/environmental geology are particularly encouraged to apply; expertise in two or more of these fields will strengthen an application. The department plans to launch a search for the fourth tenure-track slot in autumn, 1998, under the leadership of the new chair.

Colby College is a highly selective, nationally ranked private, residential, undergraduate, liberal arts institution with an enrollment of approximately 1750 full-time students, of whom some 35 are declared majors within the Department of Geology. The College is located within the Maine Slate Belt of the northern Appalachians; Paleozoic sediments, metasediments and intrusives dominate the geologic record of the state, with a surficial blanket of late Quaternary glacial and postglacial sediments.

All Colby faculty are expected to maintain active research programs and the successful candidate must be able to direct research appropriate for undergraduates; the Department currently requires all majors to undertake and complete independent research as part of their course of study.

To apply, please send letter of intent and complete CV, including the names of at least three persons whom the search committee may contact as references on teaching

and research; candidates will be contacted prior to writing to referees. Address applications to: Chair of Search Committee, Dept. of Geology, Colby College, 5800 Mayflower Hill, Waterville, Maine 04901-8858. The Committee will begin evaluating applicants on 1 October, 1998, and continue until the position has been filled.

Colby College is an AA/EQ employer and especially encourages applications from women and minorities. For more information on the College and Department, please visit our Web site at <http://www.colby.edu>. Additional information pertaining specifically to this position may be found at <http://www.colby.edu/geology/vacancy.html>.

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Opportunities for Students

Two Graduate Research Assistantships (one at the Ph.D. level and one at the M.S. level) in Environmental Soil chemistry are available for Spring 1999. Students will participate in laboratory-based research on co-migration of trace metals and humic substances in aquifer materials. The investigation will involve sorption studies, spectroscopic characterization, and transport experiments. A strong background in chemistry and soil science is required of students in both assistantships. Previous degree(s) in soil science, chemistry, or geochemistry are preferred. Contact Dr. M. L. Thompson, Department of Agronomy, Iowa State University, Ames, IA 50011-1010. Phone (515) 294-2415, fax 515-294-9573, e-mail: mlthomps@iastate.edu.

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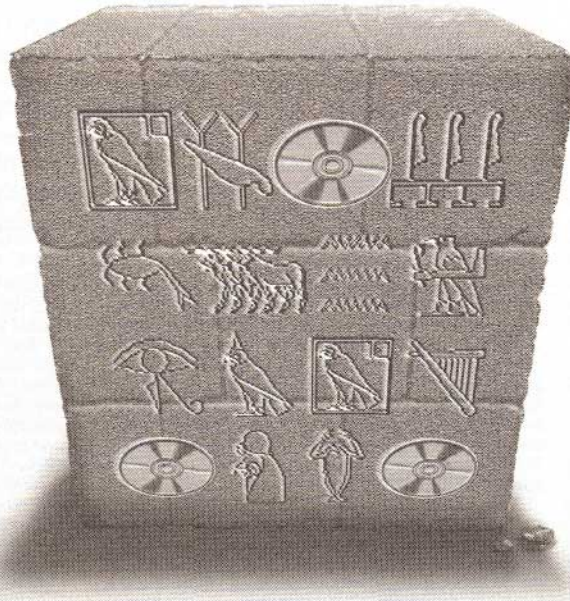
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