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INSIDE

Slope Failure and Shoreline Retreat During Northern California's Latest El Niño

*El Niño Response Group**
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ABSTRACT

Surface processes accelerated by severe storms during the 1997–1998 El Niño event scoured hillsides and damaged property across coastal California. Technological advances such as digital mapping, exemplified here for the San Francisco Bay area but applicable elsewhere, have enabled government agencies to better describe, monitor, and predict the effects of shoreline erosion and slope failure.

INTRODUCTION

Major storms struck California in 1997–1998, ravaging the coast and spawning floods and landslides (Fig. 1). By late spring, property losses statewide had exceeded $550 million, and 35 counties were declared Federal Disaster Areas. Mindful of severe winters past (Ellen, 1988) and the predicted El Niño anomaly, the U.S. Geological Survey (USGS) joined other agencies to anticipate new areas of hazard while sustaining monitoring efforts already in place across the state (http://www.usgs.gov/elnino.html). Here, we illustrate some of the winter's destructive geomorphic effects in the San Francisco Bay area (Fig. 2) and describe attempts to forecast them at a regional scale.

Our efforts targeted shoreline erosion and slope failure. Permanent loss of coastal land and the structures on it to winter storms is an ongoing problem in northern California. Large waves coincide with the seasonally high tides (and in El Niño years, a sea level raised by thermal expansion) to erode beaches and undercut sea cliffs already weakened by saturated soil. Two types of landslides are common in the Bay area. Debris flows are slurries that run rapidly downslope and form thin, ephemeral deposits; the slower-moving slumps, translational slides and earthflows, covering up to several square kilometers and involving surficial mantle and bedrock 1 to 50 m thick (Fig. 1), can persist for thousands of years (Varnes, 1978).

Coastal California's Mediterranean climate contributes to these damaging processes (Fig. 3). Normal Bay area pre-

El Niño *continued on p. 2*

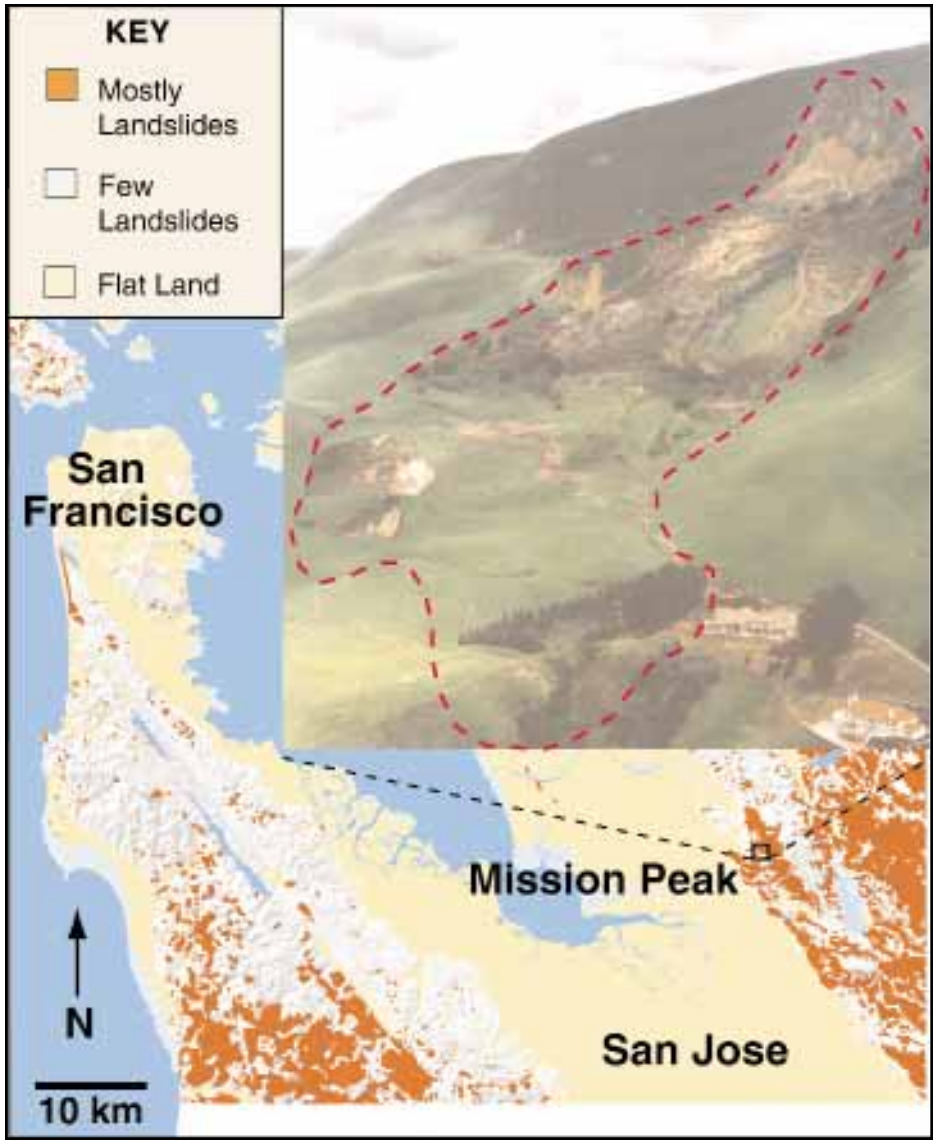

Figure 1. Existing landslides—slumps, slides, and earthflows (red) for part of San Francisco Bay area, on shaded-relief base (Wentworth et al., 1997). Photo: Reactivated 100-acre earthflow on Mission Peak, Fremont, and threatened homes (see Fig. 2 for location). In late March 1998, slide was still moving 1 m/day. Photo by J. D. Rogers.

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In Memoriam

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Davis, California
June 2, 1998

Philip Oxley
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June 19, 1998

Stuart L. Schoff
Maryville, Tennessee
June 28, 1998

Ruth B. Curtis
Boulder, Colorado
June 5, 1998

Hans Ramberg
Uppsala, Sweden
May 5, 1998

Ward C. Smith
Cupertino, California
June 25, 1998

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cipitation peaks in mid-winter at 15 cm (6 in.)/mo, while evapotranspiration reaches its maximum 10 cm (4 in.)/mo) six months later. This phase-shift exaggerates the seasonal difference in soil moisture, from a nearly desiccated state (less than 10 cm [4 in.], July through October) to saturated (25 cm [10 in.], January to mid-April), providing waterlogged ground conducive to landsliding, slumping of coastal bluffs, and flooding during winter rainstorms.

El Niño-warming of the eastern tropical Pacific further increases the seasonal contrast by sending extra precipitation into northern California (http://www.pmel.noaa.gov/toga-tao/el-nino/home.html). The 1997–1998 rainy season began

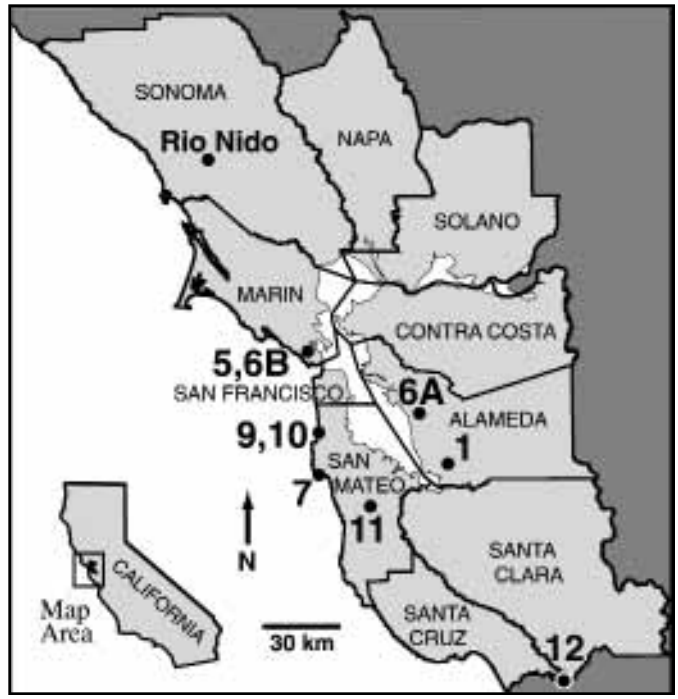

Figure 2. The 10-county San Francisco Bay region covered by new digital maps of existing landslides, debris-flow sources, shaded relief, slope angle, and rainfall thresholds. Numbers show locations of Figures 1 (photo), 5–7, and 9–12.

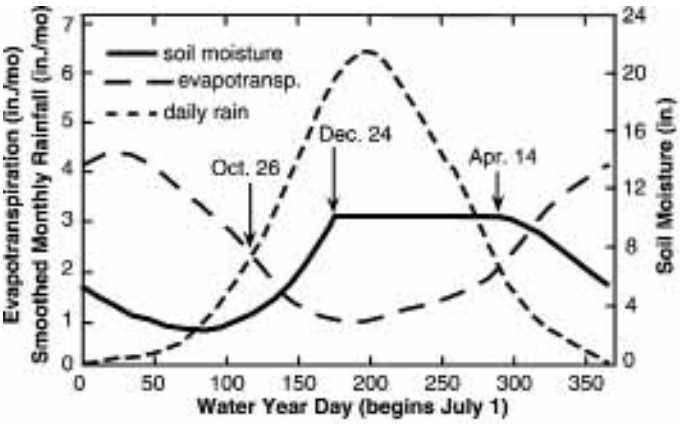

Figure 3. Preconditions for slope failure. Rainfall, evapotranspiration, and soil moisture for normal July 1–June 30 "water year" in uplands south of San Francisco (Wilson, 1997). Saturation (soil moisture ≥10 in.) for 1997–1998 winter (not shown) was achieved early, by December 8.

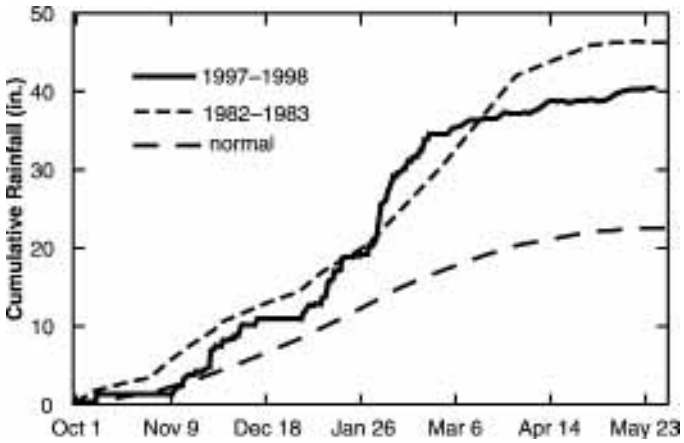

Figure 4. Winter rainy season in San Francisco Bay area, showing excess of rainfall for two El Niño years, 1982–1983 and 1997–1998, over that for normal year at Berkeley, California. Similar trends are observed across entire region. Data from NWS and NOAA.

normally in autumn, but turned unusually wet in late November (Fig. 4). By late January, rainfall totals were above those for January 1983, the last El Niño year. Frequent, heavy February rains far exceeded 1983 levels, bringing about the season's most damaging events. A drier March brought 1998 totals back below those for 1983, but were still well above normal, and light rains persisted into June. Total accumulation across the Bay region was about 200% of normal.

GETTING READY

Anticipating above-average winter rainfall for northern California (although El Niño does not necessarily bring the most damaging storms; Ellen, 1988), we began in September to prepare maps and refine existing techniques that locate areas most vulnerable to slope failure. To promote use of the new information before onset of the most severe (January) storms, we released all of it on the Internet as digital databases (http://elnino.usgs.gov/landslides-sfbay/). We also delivered paper maps and explanatory briefings to the state Office of Emergency Services and all ten counties (Fig. 2), and announced the information widely through local media and in meetings with the public and specialized groups.

The new Bay region maps required a digital elevation model (DEM), which we assembled from 35,000,000 heights (30 m spacing) from 200 small 7.5-minute DEMs. Its derivatives include shaded relief (Graham and Pike, 1997), ground-surface slope, and predicted locations of debris-flow source areas (Ellen et al., 1997). To further aid local decision makers in applying the information, we compiled the maps for major administrative units (counties) rather than by quadrangle (Brabb et al., 1972).

Also needed were maps that linked the debris-flow hazard to precipitation. Debris flows are triggered by rain that is both sustained and intense, but the amount/unit time necessary for failure (the "threshold") differs from site to site (Fig. 5). These differences exist because slopes in the Bay region reached equilibrium, and are now stable, under different conditions of precipitation, terrain, soil, and vegetation. Our new maps (Fig. 5) based on annual precipitation (Cannon, 1988) and number of rainy days (Wilson, 1997), show rainfall/debris-flow thresholds for rainfall durations of 6 and 24 h (Wilson and Jayko, 1997). The maps also locate 98 radio-telemetered rain gauges in the National Weather Service (NWS) ALERT (Automatic Local Evaluation in Real Time) network for the Bay area. Local agencies monitor the gauges during storms to determine whether rainfall is approaching threshold levels that may initiate debris flows.

DEBRIS FLOW

Most debris flows in coastal California begin as shallow landslides in wet colluvial soil perched on slopes exceeding 25° (Fig. 6; Ellen, 1988). A single major storm can trigger thousands of them if the soil is already very wet, as during January 3–5, 1982 (a non–El Niño year), when about 18,000 debris flows occurred around San Francisco Bay, killing 25 people and causing $65 million in property damage (Figs. 6, 7; Ellen, 1988). Summer wildfires further increase the hazard (Spittler, 1995), especially on chaparral hillsides in southern California where debris flows can be triggered earlier on burned than unburned ground and by briefer, less intense storms; no prior rainfall is necessary (http://geohazards.cr.usgs.gov/html_files/landslides/scfires/scfiresloc.html).

Our approach to predicting sources of future debris flows is broad-scale, based on measures of topographic form (Mark and Ellen, 1995; Dietrich et al., 1995). The source areas for shallow landslides that are capable of fluidizing are primarily steep slopes (Fig. 7) that concentrate moisture and thus tend to be concave (Fig. 8; Ellen, 1988). The map made from the new DEM (Fig. 6) infers source areas by measuring terrain slope and curvature (concavity) of actual debris-flow sources mapped from air photos after storms, and then delineating as potential sources those parts of the region with similar slope and curvature. Coarseness of the 30-m DEM, lack of data on watershed area, and the fact that debris flows travel well beyond their sources (Fig. 8) preclude using the map to pinpoint the hazard at specific sites.

Debris flows occurred at expected localities in 1997–1998, but far fewer than

El Niño *continued on p. 4*

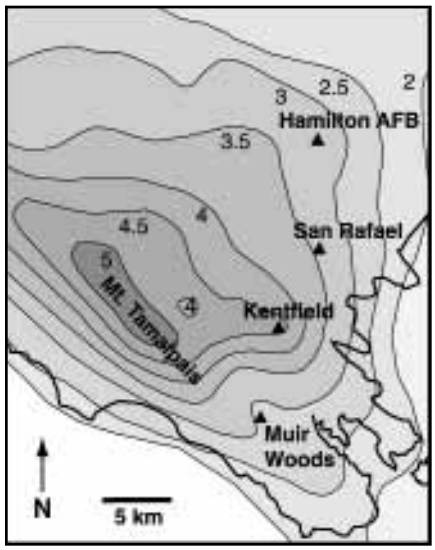

Figure 5. Rainfall thresholds for southern Marin County. Different amounts of rain (here, 2 to 5 in.) in the same period (6 h) are needed to upset the slope-stability equilibrium in different localities and trigger debris flows. Rainfall contours at 0.5 in. (12.5 mm) intervals. Triangles are ALERT rain gauges. After Wilson and Jayko (1997).

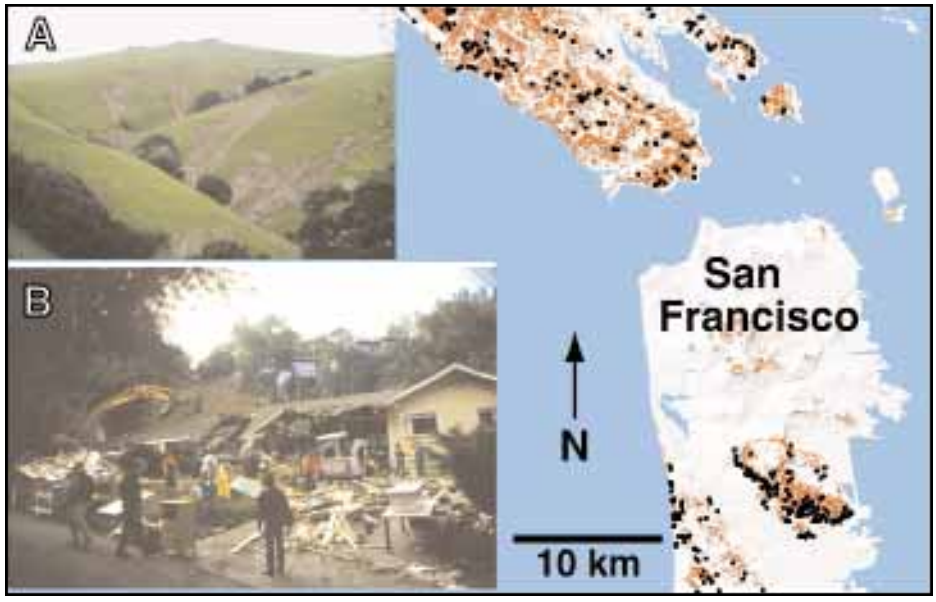

Figure 6. Debris flows. Source areas modeled from terrain slope and curvature (red) commonly coincide with debris-flow sources (dots) mapped after the January 1982 storm (Ellen et al., 1997). A. Source areas and tracks of 1998 debris flows in Alameda County (photo by S. D. Ellen). B. Home destroyed by 1998 debris flow in Marin County (photo by M. E. Reid).

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in the catastrophic storm of January 1982 (Figs. 6, 7, 8). In southern California, the abnormally severe erosion predicted by USGS was confirmed for 23 study areas burned in 1997 wildfires and then monitored during winter rains. Response ranged from flooding at canyon mouths to debris flows along canyon interiors. All ten counties around San Francisco Bay reported some debris flows, although only in the storm of February 2–3 did rainfall exceed mapped thresholds, and then in few places. This belt of intense debris-flow activity extended from the San Mateo coast, causing the sole known fatality, into northwest Santa Clara County, where a rain gauge recorded 10.75 cm (4.3 in.) in 12 h (threshold 9.25 cm [3.7 in.]).

One subsequent failure was spectacular. On the rainy evening and early morning of February 6–7, tons of mud, trees, and debris rumbled 200 m down a steep ridge in Sonoma County, destroying or damaging a dozen homes in the small town of Rio Nido. The series of debris flows originated near the ridge top, from the toe of a known active rotational landslide in weathered sandstone bedrock. Because the remaining landslide block—at 125 000 m^3, about 10 times the volume of the original debris flows—might fail catastrophically, 140 homes in the canyon below were evacuated.

To detect changes in landslide movement, monitor rainfall and ground water, and possibly anticipate massive failure, USGS installed a real-time data-collection system on the perched block (Reid and LaHusen, 1998). Twelve sensors adapted from remote monitoring of active volcanoes provide near-continuous measurements (LaHusen, 1996). Within a day of authorization, real-time data on the Rio Nido slide were arriving at USGS computers via radio telemetry, and within five days, data were accessible to Sonoma County geologists on their intranet. Sampled every second and transmitted routinely every 10 minutes, the information is sent immediately in the event of ground vibrations associated with massive landslide movement. The monitoring continues to date.

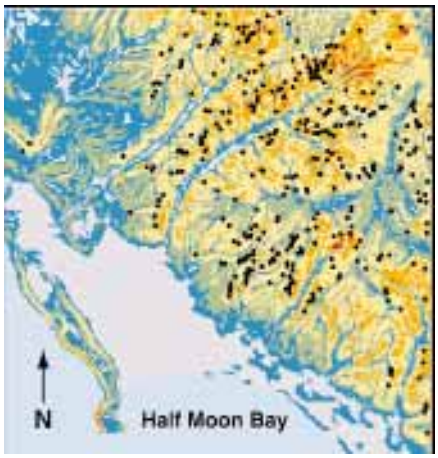

Figure 7. Coincidence of source areas for 1982 debris flows (dots) with steeper slopes in coastal San Mateo County. Slope angle ranges from 0% to 5% (violet) to over 70% (red). Compiled by S. E. Graham. Area shown is about 3 km across.

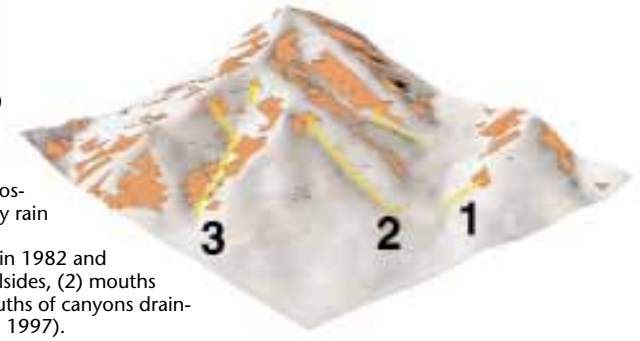

Figure 8. Source areas (red) and runout tracks (yellow) modeled from a digital elevation model for typical debris flows. The locations posing greatest risk during heavy rain are those where debris flows debouched most frequently in 1982 and 1998 storms: (1) bases of hillsides, (2) mouths of sidehill drainages, (3) mouths of canyons draining steep terrain (Ellen et al., 1997).

LOSSES ON THE COAST

Technological advances also have improved the ability to measure coastal change. Both before and after the 1997–1998 winter, USGS mapped long segments of the U.S. west coast by high-precision airborne laser radar (LIDAR) to obtain quantitative estimates of land lost to wave erosion. (Results are under evaluation.) Frequent low-altitude photography recorded the effects of each large storm. To further alert the public to potential hazards, USGS released a catalog of damage incurred along the San Mateo County coast during the 1982–1983 El Niño (Lajoie and Mathiesson, 1998).

Monthly 1997–1998 profiling of central California beaches has already revealed exaggerated seasonal changes. Normally, sand on west coast beaches is moved offshore by large waves during winter storms and returned by smaller waves in the calmer summer months. Last winter, surveys in Santa Cruz County documented up to a 4-m decrease in beach elevation and up to a 60-m retreat of the shoreline, about twice the normal amount (http://elnino.usgs.gov/coastal/). Monitoring of beach recovery continues to assess any permanent loss of sand.

Diminished beaches exposed much coastal land to damaging storm waves. Massive slope failure claimed several homes in Pacifica, which is fronted by a low sea cliff in Pleistocene fluvial sands and gravels overlain by Holocene dune sands (Figs. 9, 10). This fragile coast had been stable from 1853 to 1946. When 12 houses were built on the seaward side of Esplanade Drive in 1949, the street still lay 45 m east of the 20-m-high bluff. Although by 1973 this distance had halved, it changed little thereafter, even in 1982–1983 El Niño storms (Fig. 9).

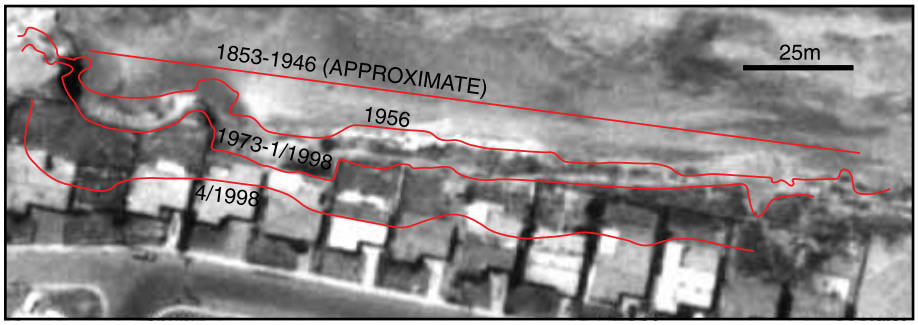

Figure 9. Historic retreat of sea cliff at Esplanade Drive, Pacifica, and the 12 houses imperiled (10 were condemned and demolished) in 1998. Aerial photo (1973) courtesy of K. R. Lajoie.

Figure 10. Doomed houses on Esplanade Drive, Pacifica, perched on retreating sea cliff, from beach below. Photo taken April 1, 1998, by K. R. Lajoie.

By early March 1998, however, six foundations were undercut and all but two homes condemned (Fig. 10). By April, the cliff had retreated up to 15 m, and parts of three houses had dropped to the beach.

The primary agent was heavy surf, which stripped the narrow beach and directly attacked soft sediments further weakened by ground-water saturation. Breaking waves undercut the cliff face, inducing block falls and slumps in the oversteepened bluff. Dry sand pouring from dune deposits highest in the section, just beneath the houses, accelerated the collapse. Retreat was greatest where a buried bedrock ridge deflected the abnormally high ground-water flow out of the cliff face, inducing erosive piping in two cohesionless sand beds lower in the section. This loss was not unique. Coastal dwellings just to the north in Daly City face a similar fate, and seven cliffside homes north of Sonoma County were destroyed in February 1998.

Figure 11. Ancient landslide reactivated in early 1998, at Scenic Drive, La Honda. Head scarp has deformed house in upper right. After Jayko et al. (1998).

SLUMP, SLIDE, AND EARTHFLOW

Landslides other than debris flows pose hazards to property (Figs. 1, 11, 12), but their slower movement rarely threatens life directly (Varnes, 1978). When they move—in response to such changes as increased water content, seismic shaking, added load, or removal of downslope support—slumps, slides, and earthflows (hereafter "landslides") can destroy foundations, offset roads, and break buried pipes as well as override property downslope.

Because one of the better predictors of movement is the presence of past landslide deposits (Nilsen and Turner, 1975), maps of old slides are helpful in locating potential hazards. Most of the 85,000 landslides around San Francisco Bay, shown on 1:12 000 to 1:62 500-scale maps (Pike, 1997), show no fresh movement. However, in any given year a few of them may be reactivated (Figs. 1, 11, 12), and new failures may occur. A 1:125 000-scale summary of Bay area landslides (Wentworth et al., 1997) revises the map of Nilsen et al. (1979), adding data and converting the original to digital form (Fig. 1). The new map distinguishes hillsides rich in evidence of movement from those with few recognized failures. The map is a generalized depiction of potential hazard; any area thus identified may require a detailed site analysis by a geotechnical engineer.

One such ancient landslide underlies much of the rural village of La Honda in San Mateo County (Fig. 11). Parts of the 1.25-km^2 complex have moved in historic times, and a segment measuring 160 m × 140 m and about 8 m deep was reactivated early in 1998 at the Scenic Drive locale (Jayko et al., 1998). Homes on the landslide began to deform even before the two weeks of heavy rain in early February, when deformation then accelerated from millimeters to centimeters per day and continued until rainfall slackened late in the month. Movement recommenced following March rains, and the slide was still moving slowly in April.

Landslides elsewhere across the state destroyed homes, disrupted utilities, and closed roads for months (40 breaks in the Pacific Coast Highway alone). On April 23, 1998, an ancient, previously mapped earthflow cut the pipelines supplying natural gas to 95% of Santa Cruz County (Fig. 12). (Only half of these residents lost service in the 1989 Loma Prieta earthquake.) Many damaging landslides occurred in southern California; they are being studied jointly by USGS and the state Division of Mines and Geology (http://geology.wr.usgs.gov/wgmt/elnino/scampen/products.html).

Waning of the prolonged 1997–1998 rainy season did not end the landslide hazard in the San Francisco Bay area. The

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Figure 12. Reactivated earthflow near town of Aromas (see Fig. 2 for location), that cut natural gas service to 60,000 Santa Cruz County residents on April 23, 1998. Photo by W. R. Cotton.

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water table in some places remained high or continued to rise, reactivating such ancient slides as Mission Peak (Fig. 1) and foretelling possible slope movements well into summer.

IMPACT AND PROSPECT

USGS digital maps dramatically sharpened public awareness of the links between surface processes and prudent land use in the Bay area. Newspapers carried maps showing landslide-prone terrain (from Fig. 1) overlapping areas zoned for residential construction, kindling anew the debate on suburban sprawl, stability of engineered hillslopes, and financial liability. In six months, the USGS El Niño Web site attracted 185,000 visits, a quarter of them in February alone. Local officials used the new information in pre-storm exercises to train emergency-service crews and, during storms, direct them to hillsides most likely to fail. The data also are being incorporated into county and municipal planning for disaster relief. During the height of the storm season, the Office of Emergency Services, USGS, and NWS maintained a hazard advisory system through daily telephone contact, and USGS Landslide Program staff assisted the Federal Emergency Management Agency at its Disaster Field Office in the state capitol.

Preliminary field surveys by USGS and local agencies in April and May estimated $140 million in damage across the Bay region from 470 major slope failures, mostly slumps, slides, and earthflows—debris flows were less important (in marked contrast to 1982). Hardest hit was San Mateo County, with 29 damaging slides, 31 homes condemned, and $45 million in losses. Many more small failures, many of them unreported, in undeveloped areas did not affect roads or dwellings.

Obstacles remain to reducing future losses, both in the Bay area and elsewhere. For example, no quantitative maps of landslide susceptibility exist on which to base public policy for the hazard and the elusive goal of landslide insurance. This need can be met by examining the multiple controls on slope failure (Brabb et al., 1972). Computer capabilities now enable us to combine landslide distribution, the properties of geologic materials, and terrain geometry to map landslide susceptibility and devise models of debris-flow runout (Soeters and van Westen, 1996). In west coast metropolitan areas, the possibility of a severe earthquake during the rainy season increases the urgency of such work.

Historically, quite apart from El Niño years, landslides and shoreline erosion accompany all large winter storms along the Pacific coast (Ellen, 1988). Our field studies, digital maps, and monitoring thus apply well beyond 1997–1998 and the Bay region. Slope failure is a land-use problem in all 50 states (Schuster, 1996), moreover, and much of the U.S. coastline is eroding. By mapping localities at risk and studying the processes and timing of accelerated geomorphic activity, USGS is preparing not only the San Francisco Bay region but Los Angeles, Seattle, and other growing urban centers to face the hazards posed by future storms. Just as Californians have learned to live, however uneasily, with earthquakes, a similar wary accommodation with slope failure and coastal retreat can be reached by residents everywhere.

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GSA ON THE WEB

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

See the Meetings page for information on the 1998 GSA Annual Meeting. Featured are: symposia and theme listings, abstracts information, field trips, short courses, special programs, registration information, and travel and housing information.

The abstract submittal deadline for the GSA 1998 Annual Meeting has passed. A total of 2,399 abstracts were received this year, 72% of them via our Web form. A list of all received is on the Web, under the "Meetings" heading. Watch this site for acceptance and schedule information.

JANUARY 18–24, 1999

Subduction to Strike-slip Transitions on Plate Boundaries

A Geological Society of America Penrose Conference, "Subduction to Strike-slip Transitions on Plate Boundaries," will be held January 18–24, 1999, in Puerto Plata, Dominican Republic. This location is within the active subduction to strike-slip transition area of the North America–Caribbean plate-boundary zone, so the conference will include a field trip along the primary strike-slip fault (Septentrional fault zone) within the plate-boundary zone. Shoreline features record recent activity of the offshore subduction boundary that included a magnitude 8.1 earthquake in 1946.

The meeting will assemble a multidisciplinary group of the world's leading experts from the United States, the Caribbean, New Zealand, Latin America, Europe, and other areas. The purpose is to foster discussion of new ideas and develop associations between ideas drawn from different disciplines in earth science. Talks and discussions will focus on a better characterization of the tectonic controls and deformational effects of subduction to strike-slip transition areas. Experts in geology, seismology, paleoseismology, geodesy, modeling of geological and geophysical data, and deep seismic imaging will discuss deformation at all levels in lithosphere and mantle of subduction to strike-slip transition areas. This information will provide insights into the seismogenic mechanisms for the large and commonly destructive earthquakes that affect these areas.

Pariticpants will focus on the manifestation of both tectonic styles in tectonically active areas including the Dominican Republic, Trinidad and eastern Venezuela, Panama and Costa Rica, the Scotia Sea, northern California, eastern Alaska, the western Aleutian arc and Kamchatka, Japan, Taiwan, the Marianas trench, New Guinea and Irian Jaya, New Zealand and the Macquarie Ridge, Indonesia, Thailand, Pakistan, and the Alpine-Mediterranean area. Experts on other transition areas or on non–site-specific modeling work are welcome as participants.

Discussion topics by keynote speakers and participants will include the following: (1) How is plate motion partitioned between outboard subduction systems and inboard strike-slip systems, and how do these features interact to produce the observed patterns of diffuse seismicity and active faulting? Is there any evidence for linked seismic events in the two systems? (2) Why are strike-slip to subduction transition areas characterized by deep trenches that are the sites of some of the world's largest gravity minima? (3) How does the behavior of subducted slabs in subduction to strike-slip transition areas affect upper crustal deformation in the transition region? What is the role of slab rupture at depth, interaction of two opposed slabs at depth, extension of subducted slabs, and completely detached slabs like the ones present in the mantle beneath the Dominican Republic? (4) What is the sedimentary and structural record of subduction to strike-slip transition along ancient plate boundaries? Is there a systematic and predictable progression of structures that indicates that such a transition has occurred? What clues from these ancient events can be used to better understand active boundaries? (5) What are the seismic and tsunami hazards associated with subduction to strike-slip transition areas? Can answers to tectonically related questions 1–4 above be used to better understand and perhaps reduce these hazards?

The conference is limited to 65 participants. We encourage interested graduate students to apply; some partial student subsidies will be available. The registration fee, which covers lodging, meals, field trips, and all other conference costs except personal incidentals, is not known at this time. Participants will be responsible for transportation to and from the conference. Further information on travel will be provided in the letter of invitation.

Co-conveners are: ***Paul Mann,*** Institute for Geophysics, University of Texas at Austin, 4412 Spicewood Springs Rd., Austin, TX 78759, paulm@utig.ig.utexas.edu, (512) 471-0452, fax 512-471-8844; ***Nancy Grindlay,*** Dept. of Earth Sciences, University of North Carolina, 601 South College Road, Wilmington, NC 28403-3297, grindlayn@uncwil.edu, (910) 962-3736, fax 910-962-7077; ***James F. Dolan,*** Dept. of Earth Sciences, University of Southern California, Los Angeles, CA 90089-0740, dolan@earth.usc.edu, (213) 740-8599, fax 213-740-0011.

Application deadline is **September 1, 1998.** Invitations will be mailed to participants by October 1, 1998. Potential participants should send a letter of application to Paul Mann (address above), including a brief statement of interests, the relevance of the applicant's recent work to the themes of the conference, and a proposed title of their presentation (oral or poster; poster preferred). ■

Fifth Dibblee Medal Awarded

Dorothy L. Stout,
Cypress College, Cypress, California

GSA Fellow Clarence A. Hall, professor and dean emeritus at the University of California, Los Angeles, is the 1998 recipient of the Dibblee Medal presented May 1, 1998, at the Dibblee Luncheon held at the AAPG-SEPM meeting in Ventura, California.

Citationist John Crowell, University of California, Santa Barbara, stated that Hall has "made outstanding contributions to geology through geological mapping and the interpretation of his maps" for he is "a master in the difficult science and art of geological mapping which demonstrates regional significance."

In highlighting Hall's career, Crowell pointed out that Hall had produced more than a dozen quadrangle-sized maps in the west-central Coast Ranges and the White-Inyo Mountains of California, and has mapped along the North Pyrenean fault in southern France. His careful mapping and synthesis of complex country in coastal California from the Monterey Bay region to the Transverse Ranges resulted in "HALLmark" papers supporting large-scale strike slip on some of California's major faults and enabled identification of the Southern California allochthon.

In his response, emphasizing his love of geologic mapping and interpretation, Hall shared his philosophy of geologic mapping, for "the field is where geologic problems lie waiting to be found, rethought, or restudied. A geologic map is the essential foundation for studying geologic problems. Yet the useful scientific lifetime of a geologic map is rarely more than 25 to 50 years because new paradigms or new information and thought alter the interpretation of geologic features or cause new elements of the geology to be recognized for the first time; as examples, transform and detachment faults."

Hall concluded, "Remove geologic maps and the making of geologic maps from geology and you remove the essence of geology."

Previous recipients of the Dibblee Medal are Lehigh Hintze, (1994), Peter Rowley (1995), Jack Vedder (1996), and Parke Snavely, Jr. (1997). To learn more about the Thomas W. Dibblee Geologic Foundation, see http://dibblee.geol.ucsb.edu/.

GSA Names 1998 Medal and Award Recipients

Penrose Medal

Jack E. Oliver
Department of Geological Sciences
Snee Hall
Cornell University
Ithaca, New York 14853-1504

Day Medal

Edward B. Watson
Department of Earth and Environmental Sciences
Rensselaer Polytechnic Institute
110 Eighth Street
Troy, New York 12180-3590

Donath Medal (Young Scientist Award)

Terry Plank
Department of Geology
120 Lindley Hall
University of Kansas
Lawrence, Kansas 66045-2124

New Honorary Fellows

Shigeo Aramaki
Department of Earth Sciences
Nihon University
Sakura-josui, Setagaya-ku
Tokyo 156, Japan

Victor E. Khain
Institute of the Lithosphere
Russian Academy of Sciences
22 Starometny per
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Werner-Friedrich Schreyer
Institut für Mineralogie
Ruhr-Universität Bochum
Universitatsstrasse 150
44780 Bochum, Germany

Rip Rapp Archaeological Geology Award

Vance T. Holliday
Department of Geography
University of Wisconsin
550 N. Park Street
Madison, Wisconsin 53706-1491

Gilbert H. Cady Award (Coal Geology Division)

No award will be given in 1998

E. B. Burwell, Jr., Award (Engineering Geology Division)

Roger T. Saucier
4325 Winchester Road
Vicksburg, Mississippi 39180-8969

Lawson M. Smith
502 Winding Hills
Clinton, Mississippi 39056

Whitney J. Autin
Institute of Environmental Studies
Louisiana State University
Baton Rouge, Louisiana 70803-5705

George P. Woollard Award (Geophysics Division)

Thomas H. Jordan
Department of Earth, Atmospheric and Planetary Sciences
Massachusetts Institute of Technology
77 Massachusetts Avenue, 54-918
Cambridge, Massachusetts 02139

History of Geology Award

Hatten S. Yoder, Jr.
Geophysical Laboratory
Carnegie Institution of Washington
5251 Broad Branch Road, N.W.
Washington, DC 20015-1305

O. E. Meinzer Award (Hydrogeology Division)

Mary P. Anderson
Department of Geology and Geophysics
University of Wisconsin
Madison, Wisconsin 53706

G. K. Gilbert Award (Planetary Geology Division)

John B. Adams
Department of Geological Sciences
University of Washington
Seattle, Washington 98195

Kirk Bryan Award (Quaternary Geology and Geomorphology Division)

Vance T. Holliday
Department of Geography
University of Wisconsin
550 N. Park Street
Madison, Wisconsin 53706-1491

Structural Geology and Tectonics Division Career Contribution Award

Albert W. Bally
Department of Geology and Geophysics
Rice University, MS 126
6100 S. Main Street
Houston, Texas 77005-1892

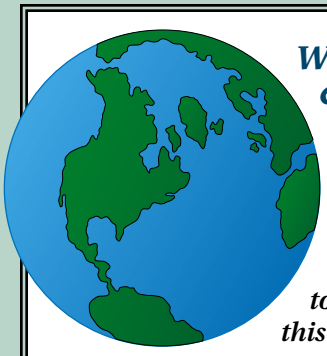
GSA Distinguished Service Award

James R. Clark
7195 Bridgeview Avenue
Las Vegas, Nevada 89117

June R. Forstrom
7705 East Baseline Road
Boulder, Colorado 80303

Charles J. Mankin
Oklahoma Geological Survey
University of Oklahoma
100 East Boyd Street, Room N-131
Norman, Oklahoma 73019-0628

George R. Hallberg
The Cadmus Group, Inc.
135 Beaver Street
Waltham, MA 02154



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COMMENTARY

The Pliocene-Pleistocene (Tertiary-Quaternary) Boundary Should Be Placed at About 2.6 Ma, Not at 1.8 Ma!

Roger Morrison, *Morrison and Associates, Golden, CO 80401*
George Kukla, *Lamont-Doherty Earth Observatory, Palisades, NY 10964*

Formal decision as to the stratigraphic level and international stratotype for the Pliocene-Pleistocene Epoch-Series boundary (PPB) is soon to be made by the International Commission on Stratigraphy (ICS) and the International Geological Congress (IGC), although the level where this boundary will be placed remains controversial. Being also a period-system boundary, it must meet the strict criteria of the International Stratigraphic Code and formal adoption by ICS and IGC. Key conditions are the unambiguous recognition and ease of correlation in as many marine and nonmarine terrains throughout the world as possible.

For decades, opinions among geologists about the PPB were as diverse as their beliefs about religion, morality—and presidents. In 1948 the IGC resolved that the PPB ought to be located in an Italian marine section, in the mistaken belief that northern invertebrate fauna would immediately appear in the Mediterranean at the onset of the first Neogene climatic deterioration, marking the beginning of the Pleistocene as the last Ice Age. In 1984, after 36 years of contention, the International Union on Geologic Stratigraphy adopted an emerged marine shelf-edge sequence at Vrica, near Crotone, Italy; the PPB was placed at the first appearance of "cold-guest" foraminifera *Hyalinea baltica* and *Globorotalia inflata.* The Vrica tephra layer and the top of the Olduvai geomagnetic Subchron indicate the age of this level at about 1.8 Ma. Accordingly, many geological organizations, including the U.S. Geological Survey, have provisionally adopted 1.8 Ma as the PPB level.

Nonetheless, geologists in many countries (New Zealand, China, South Africa, Germany, Netherlands, and others), unable to localize this horizon in their working areas, strenuously protested having the PPB placed at 1.8 Ma. In 1995 the Commission on Stratigraphy of the International Union for Quaternary Research (INQUA) resolved to fix the PPB at basal Gelasian Stage, 2.6 Ma, approximately coincident with the Gauss-Matuyama geomagnetic reversal, contingent upon finding a suitable international stratotype.

We argue that a PPB at 1.8 Ma is *woefully unsuitable* as the level for this period-system–epoch-series boundary. Far better will be a PPB at 2.6 Ma, for the following reasons.

1. The chief modern proxy of global climate state, the oxygen-isotope ratio of marine foraminifera, shows that a stepwise semiperiodic series of cooling events markedly intensified about 2.6 m.y. ago. After several million years of warm climate that never became colder than Pleistocene interglacials, small to moderate ice sheets developed in Europe and North America and the ^{18}O proxy of global ice volume shifted significantly. These globally important climatic threshold-crossing events are excluded from the Pleistocene by placing the PPB at 1.8 Ma, where there is no significant shift in climate.

2. A PPB at about 2.6 Ma is better marked paleontologically than one at 1.8 Ma on a worldwide basis. Around this time not only discoasters became extinct but in Mediterranean sequences also the forams *Globorotalia bononiensis* and *Neogloboquadrina atlantica.*

3. The most complete loess sequences in the world, in China and eastern Europe, show that loess deposition began soon after the Gauss-Matuyama (G-M) magnetic reversal and lasted intermittently into the Holocene. The start of significant loess deposition marks a major threshold crossing in the atmospheric circulation pattern in the northern hemisphere at around 2.6 Ma.

4. Although the PPB must be defined primarily on the basis of marine organisms, a boundary at 2.6 Ma is close to the G-M Chron boundary. This major geomagnetic reversal will be *the* most used proxy benchmark for the PPB. It can be identified far more readily in sequences throughout the world than the ambiguous top of the short Olduvai Subchron. This fact is especially important for geologists who work on land.

Synthesis. The crux of our argument is that a PPB at 1.8 Ma is not sufficiently well marked by globally recognizable stratigraphic criteria to become a practical worldwide epoch-series–period-system boundary. It is not marked by any distinctive litho- or biostratigraphic discontinuity accompanying a substantial global change in climate. In most North American stratigraphic sequences there are no criteria by which a PPB at this level could be identified. It has no significance in the glacial and climatic history (several glaciations were earlier); it is not marked by distinctive lithostratigraphic changes in sedimentation, or in pedogenesis, or in dispersal of plants or microtine rodents or other vertebrate faunas. Clearly it is so obscure that it is not suitable for a boundary of period-system rank.

There are two kinds of unquestioned worldwide markers for the PPB at about 2.6 Ma: the G-M reversal, and the prominent discontinuity between marine oxygen-isotope stages MIS 100 and MIS 101 just above the G-M reversal. They can be easily identified by accompanying faunal and floral shifts (warm–cold) in deposits throughout the world. Both markers have transient, indeterminate zones a few thousands of years long, but so also do all types of paleontologic criteria.

A PPB at about 2.6 Ma will be readily recognizable globally and far more useful to geologists and oceanographers throughout the world. It is a true climatostratigraphic boundary that represents a major shift in global air, ocean, and land climate systems. Placing the PPB at 2.6 Ma will accommodate the two classic concepts of the Quaternary Period, of it being the start of the last Great Ice Age (we are not through it yet), and that it is the Age of Man (earliest humanoids evolved near then).

Our feeling is that if the PPB somehow is defined at the 1.8 Ma level, eventually it will be found to be so impractical that it will be generally ignored, until it is replaced by a workable PPB at 2.6 Ma. The 1948 decision by the IGC should be reevaluated in the light of a wealth of new data and techniques (e.g., birth of magnetostratigraphy and new dating and climatometric methods) and intensive geoscience exploration on land and sea during the ensuing 50 years. ■

Tyler Prize Nominations Due Soon

Nominations are due September 15, 1998, for the Tyler Prize, awarded for (1) protection, maintenance, improvement, or understanding of ecological and environmental conditions anywhere in the world, or (2) discovery, further development, improvement, or understanding of known or new sources of energy. For information on how to nominate for the prize, see http://www.usc.edu/go/TylerPrize/ or contact tylerprz@usc.edu or (213) 740-6559, fax 213-740-1313. Self nominations are not accepted.

WASHINGTON REPORT

Bruce F. Molnia, *bmolnia@erols.com*

USGS Geologic Division Releases New Science Strategy

Geology for a Changing World, A Science Strategy for the Geologic Division of the U.S. Geological Survey, 2000–2010 (USGS circular 1172) is the new product of a 10-person Science Strategy Team charged with creating "a succinct strategy for the activities of the Geologic Division in the first decade of the next century (2000–2010), within the broad outlines of the 1996 USGS Strategic Plan." In addition to nine USGS employees, the team included George A. Thompson of Stanford University, 1996–1997 president of the Geological Society of America. According to the committee chair, Associate Chief Geologist for Science Steven R. Bohlen, the team's objective was to "develop a 10-year plan for the [Geologic Division's] scientific activities by anticipating broad national and global scientific issues and needs, identifying promising new research directions to address these needs, and evaluating the implications of these scientific directions on [division] staffing."

To develop the new strategy, the team looked both externally and internally. Externally, they examined recent reviews of USGS programs by groups such as the new National Academy of Science–National Research Council Committee on Future Roles, Challenges, and Opportunities for the USGS; science and strategic plans of earth science agencies of other countries; strategic planning documents of other federal agencies; and science and strategic plans of national and international earth science organizations, such as GSA. Internally, the team reviewed the new *Strategic Plan for the U.S. Geological Survey, 1997 to 2005,* published in June 1996, other USGS division plans, and draft versions of five-year program plans and past recommendations of the Geologic Division Science Advisory Committee.

Through a series of panel discussions, the Science Strategy Team heard from more than 250 people, including scientists and managers from within the Geologic Division and the USGS; leaders from within the U.S. Department of the Interior; representatives of other federal agencies, the Office of Science and Technology Policy, and the U.S. Congress; state geologists; industry leaders; faculty members; and professional societies.

Goals and Products

The new Geologic Division *Strategy* defines seven overlapping science goals and six operational objectives. Linked to each goal are at least two types of products that must be generated for the successful implementation of the goal and at least two types of strategic actions fundamental to its success. According to the *Strategy,* "By undertaking the scientifically challenging and vital research activities outlined in the new *Strategy*, the [division] can effectively address the Nation's most pressing science issues of the next decade." In general, these issues focus on understanding human interaction with the natural environment. The *Strategy's* goals build upon long-term USGS investments in basic research on the fundamental geologic processes controlling how Earth works. The *Strategy* states that its goals are consistent with the mandated role of the USGS as a federal science agency charged with providing long-term monitoring, research, and assessments. The goals are ambitious, and their success will require the Geologic Division to collaborate extensively with the other USGS divisions, other federal agencies, state geological surveys, and academic colleagues. Typically, investigations will be at the regional to national scale. However, localized studies and demonstration projects will also be conducted, either on federal lands or in other areas of national interest, to develop principles and methods that can be applied much more broadly.

The *Strategy*'s first three goals define future thrusts in traditional areas of national leadership for the Geologic Division studies of the nation's geologic hazards and natural resources: Goal 1—Conduct geologic hazard assessments for mitigation planning; Goal 2—Provide short-term prediction of geologic disasters and rapidly characterize their effects; Goal 3—Advance the understanding of the nation's energy and mineral resources in a global geologic, economic, and environmental context.

Goal 1 products are: (1) regional- and national-scale probabilistic maps and interactive databases; (2) deterministic scenarios to aid in local and regional planning efforts; (3) multihazard assessments for selected urban areas; and (4) vulnerability maps and interactive databases for geologic hazards. Goal 1 strategic actions are (1) conduct detailed geological and geophysical field investigations; (2) document the recent geologic history of major hazardous events in the United States in unified databases; (3) investigate factors controlling the geographic distribution, magnitude, and timing of hazardous geologic events; (4) determine the physical processes responsible for variations in local site response to natural hazards; and (5) develop and use consistent methods for local-, regional-, and national-scale hazard assessments for each type of hazard.

Goal 2 products are: (1) predisaster scenarios, (2) mid-disaster estimates, and (3) postdisaster documentation. Goal 2 strategic actions are: (1) significantly expand and upgrade monitoring capabilities; (2) create rapid response teams; (3) develop and implement strategies to use innovative remote-sensing technologies; and (4) focus research on the fundamental physical processes that result in or occur during natural disasters.

Goal 3 products are: (1)national, issue-specific, and total-cost assessment of the nation's petroleum, coal, and selected metallic and industrial mineral resources; (2) geological, geophysical, and geochemical maps, surveys, and syntheses of carefully selected geographic areas in support of resource assessments; (3) quantitative global assessments of oil and gas resources and selected high-value mineral resources; and (4) integrated life-cycle models of selected mineral and energy commodities. Goal 3 strategic actions are: (1) evaluate national and global trends in energy and mineral resource use; (2) focus geoscience field investigations on carefully selected geographic areas in support of national resource assessments; (3) focus interdisciplinary research on the key geologic processes that control the origin and distribution of energy sources and mineral deposit types with present or anticipated high demand; and (4) develop quantitative total-cost assessment methods. Note that the first goal integrates knowledge about the potential location, size, and frequency of a geologic hazard with knowledge of a region's or site's vulnerability to the effects of such an event, whereas the second goal addresses the role of the Geologic Division in providing timely information on both the likely and the actual geologic effects of disasters in the short term before, during, and after a hazardous event.

Goal 3 points the division toward a position that most other "first world" geological surveys have already been forced to adopt. By embracing a global perspective on natural-resource supply and demand, the division will enhance its ability to inventory Earth resources, both domestic and international. The *Strategy* points out that "[s]uch assessments must be backed by fundamental studies of the

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character and distribution of natural resources, as well as the economic benefits and environmental consequences of their development."

Goal 4, Anticipate the environmental impacts of climate variability, relates to global climate change. Goal 4 products are: (1) national- and regional-scale reconstructions of past climates (precipitation and temperature) and past environments (landforms and vegetation); (2) quantitative regional assessments of vulnerability to climate change and likely environmental impact scenarios; (3) high-resolution time series of past climatic conditions; and (4) national and regional maps showing possible early-warning indicators of climate change. Goal 4 strategic actions are: (1) reconstruct key past climates under a range of conditions and compare these to atmospheric general-circulation model results; (2) identify areas highly sensitive to climate variability and determine critical thresholds of temperature and precipitation changes that can induce vegetation and geomorphic changes; (3) refine data on the magnitude and frequency of climate and paleoecological changes during the Holocene to higher resolution; (4) collaborate with other agencies to expand long-term baseline mapping of key climate-change indicators; and (5) study the fundamental processes and key biogeochemical cycles governing climate change and climate-related hazards, with emphasis on the terrestrial domain.

The *Strategy* states that the fourth goal defines a leadership role for the USGS within the U.S. National Global Change Program in carrying out regional- to national-scale syntheses and producing reconstructions of past climates from terrestrial records and assessments of the potential impacts of climate change or variability.

The last three goals address societal issues that the USGS anticipates will be of growing importance in the next decade, owing to increasing concerns over quality of life: Goal 5—Establish the geologic framework for ecosystem structure and function; Goal 6—Interpret the links between human health and geologic processes; and Goal 7—Determine the geologic controls on ground-water resources and hazardous waste isolation.

Goal 5 products are: (1) maps of surficial and shallow-subsurface lithologic, mechanical, and geochemical properties of ecological significance for selected ecosystems; (2) models of geologic and geochemical processes that affect ecosystem functions; (3) geochemical baselines of metals and other contaminants; (4) rates of faunal and floral change during recent geologic history determined from paleontological and geochemical studies; and (5) assessments of fundamental geologic fluxes that affect ecosystem dynamics. Goal 5 strategic actions are: (1) develop partnerships with scientists outside the Geologic Division; (2) focus geologic mapping of both bedrock and surficial deposits in ecosystem gradients; (3) determine rates of floral, faunal, and other environmental changes; (4) conduct fundamental research to understand the roles of surface geology and geomorphology and surficial geologic processes; and (5) investigate biogeochemical cycles in ecosystems focusing on the sediment-soil interface and on elemental pathways.

Goal 6 products are: (1) lay-oriented and publicly accessible summaries of the geology, geochemistry, and health effects of selected potentially toxic elements, mineral phases, and organic compounds; (2) nationally consistent, regional-scale environmental geology and geochemistry databases and maps; (3) integrated geological, geochemical, and biological assessments of regions where contaminated sediments may accumulate; and (4) national and/or regional, geology-based health

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A River Runs Through It

***David J. Verardo**, 1997–1998 GSA Congressional Science Fellow*

The native inhabitants called it Nch'i Wana, the Great River, also known today as the Columbia River. It flows from its headwaters in southeastern British Columbia for 200 miles to the Pacific Ocean. It drains an area of nearly 260,000 square miles. It is the lifeblood of the Pacific Northwest; supporting recreation, providing power, and sustaining a fishery. Its value extends beyond simple economics, as the Great River is a cultural talisman for many Americans.

In part of its watershed, however, the Columbia River offers a less bucolic and public dimension. For 35 miles through desert country near Richland, Washington, the Columbia winds its way through the Hanford Nuclear Reservation. Here the serenity of the Great River belies the turbulent past and ambivalent future of the land along its banks that is described by the U.S. Department of Energy (DOE) as "the single largest environmental and health risk in the Nation." Discussion of the Hanford site pits technocrat against philosopher over the value of the site's nuclear mission in securing peace and prosperity through technology. In a twisted mix of politics, power, economics, and science surrounding all things Hanford, what is often overlooked is that the site is a prominent example of one of the first lessons learned in the sandbox; clean up your mess.

The Hanford site, encompassing 560 square miles, has a long history of nuclear science research dating back to the secret Manhattan Project that produced plutonium for American nuclear weapons. Hanford contains over 1,600 contaminated liquid and solid waste sites; more than 500 of these are situated within one-half mile of the Columbia River. During Hanford's plutonium production years (1943–1989), nearly 450 billion gallons of radioactive and other hazardous liquids were intentionally discharged into the vadose zone through engineered drainage structures such as cribs, trenches, ponds, and retention basins. That is enough waste to fill a lake the size of Manhattan to a depth of 80 feet (~24 meters). Much of the radioactive and otherwise hazardous waste is located in the 200 sites within the central plateau. Here, approximately 350 billion gallons of waste were discharged to the soil. These sites also contain 177 large underground storage tanks that hold 54 million gallons and 200 million curies of

River *continued on p. 13*

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assessments. Goal 2 strategic actions are: (1) increase cooperative research efforts with specialists in human health, toxicity, epidemiology, and other life sciences; (2) continue research on the geologic occurrence, geoavailability, environmental mobility and degradation, and health effects of potential toxins; (3) determine the transport mechanisms and ultimate fate of sediment-associated contaminants; and (4) understand the role of geology and geologic processes in the development and release of potential pathogens.

Goal 7 products are: (1) basin-scale, nationally consistent maps showing the three-dimensional distribution of hydrogeologic properties; and (2) three-dimensional hydrogeologic maps and conceptual models of fluid flow and ground-water contamination associated with hazardous-waste disposal sites and other sources. Goal 7 strategic actions are: (1) conduct geological mapping, geophysical imaging, geochemical testing, and borehole measurements in support of ground-water resource and contamination studies in critical areas; (2) investigate the fundamental geologic factors controlling subsurface fluid flow in sedimentary basins and other deposits; (3) conduct multidisciplinary research on the origin, development, and hydrologic properties of fracture and fault systems; and (4) conduct investigations to understand the links between geochemical, biological, and hydrogeologic processes.

Goals 5, 6, and 7 are seen as exciting partnership opportunities whereby the Geologic Divieion can take advantage of the new USGS role as the nation's earth science and biological science agency.

The strategy behind goal 7 is that because many of the pathways for material flux in the environment are related to water, an understanding of the geologic controls on water movement in the upper crust will benefit human and ecosystem health. Additionally, the understanding will help to assure the quality and quantity of U.S. ground water.

The *Strategy* states that the Geologic Division's ability to respond to each of these societally driven goals requires a sustained investment in documenting the present and past state of Earth and in using this information to predict future changes. For example, geologic mapping, which has long been a division strength, is essential to achieving all seven goals. Meeting these goals will necessitate a commitment to technological innovation and a broadening of expertise through interagency collaboration, training, and visiting scientist and postdoctoral programs.

Objectives

The *Strategy* does not contain a detailed implementation plan; however, it does describe six operational objectives, each with strategic actions. The *Strategy* states that these objectives will improve the usefulness and accessibility of information created by Geologic Division activities and will promote the flexibility and vitality of the staff. Objective 1—Greatly enhance the public's ability to locate, access, and use maps and data, by (a) ensuring that programmatic database-management objectives are consistent with division and USGS objectives and that diverse data systems can be integrated seamlessly; (b) expanding the National Geologic Map Data Base; (c) moving rapidly toward consistent data structures and standards for all division and USGS products and maps; (d) exploring cooperative agreements for data archiving and distribution; and (e) extending the function of digital maps. Objective 2—Maintain a first-rate earth-system science library, by (a) creating a publicly available system for computerized searches; (b) increasing holdings necessary for investigations of environmental science and biological resource issues; and (c) considering instituting a cost-recovery system for non-USGS customers. Objective 3—Effectively transfer the knowledge acquired through Geologic Division science activities, by (a) establishing temporary duty assignments for division staff with state and other federal agencies; (b) devising an effective strategy for working with media representatives; (c) cultivating relationships with Congress and the Executive Branch; (d) identifying capable spokespersons to work effectively with the media; and (e) coordinating outreach and

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River *continued from p. 12*

high-level nuclear waste. As much as 1.0 million gallons of waste containing 1.0 million curies have leaked into the vadose zone. In addition, over 496,000 cubic yards of solid waste containing 4.8 million curies of radioactive material are buried in trenches here.

In the 200 sites, the vadose zone ranges from 200–300 feet thick and comprises two major geological formations. The uppermost unit is the highly permeable Hanford Formation composed of coarse sands and gravels. The lowermost unit is the Ringold Formation, composed of partially cemented silt, sand, and gravel with low to moderate permeability. Past discharges have resulted in the contamination, above federal drinking water standards, of about 85 square miles of groundwater at the Hanford Reservation.

Liquid wastes containing radionuclides with long half-lives were intentionally discharged to the ground on the assumption that the vadose zone would

River *continued on p. 14*

Washington Report *continued from p. 12*

education efforts with earth science professional societies. Objective 4—Promote vitality and flexibility of the scientific staff, by (a) striving for a diverse and balanced workforce to ensure programmatic and fiscal flexibility; (b) creating a formal postdoctoral program; (c) maintaining scientific leadership and developing the skills required to cross disciplinary boundaries; (d) maintaining an appropriate balance of research and support staff; and (e) creating a scientist exchange program. Objective 5—Promote interdisciplinary research, by (a) preparing an integrated division science plan, (b) enhancing the flow of expertise between programs; and (c) encouraging rotation of managers and scientists outside the division. Objective 6—Institute internal and external reviews, by (a) reactivating the division Science Advisory Committee; and (b) soliciting input on division activities from a variety of organizations and disciplines.

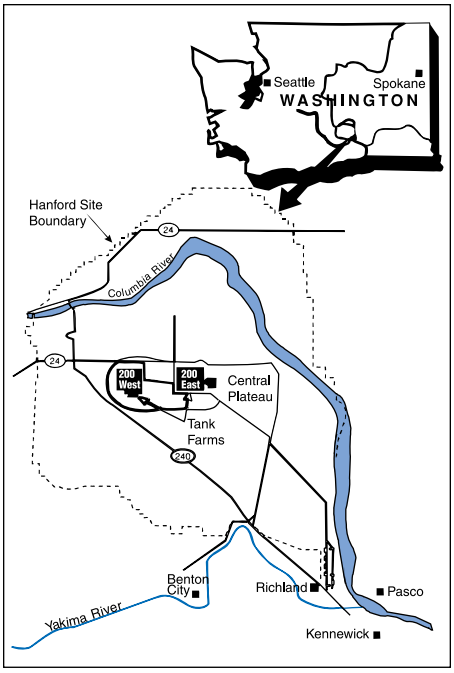
The *Strategy* concludes with the statement, "Acquisition of scientific knowledge through research, assessment, and insightful monitoring and the effective communication of that knowledge to planners and decision makers will allow the [Geologic Division] and its partners to assist the Nation in meeting a complex, challenging, and promising future." The *Strategy* can be obtained on the World Wide Web at http://pubs.usgs.gov/circular/c1172. ■

River *continued from p. 13*

act as an effective barrier to contaminant migration to the underlying water table and the Columbia River. Despite repeated warnings from Hanford technical review panel members beginning in the late 1980s, DOE maintained, even as late as a 1996 draft environmental impact statement, that contaminants such as cesium "were assumed to be largely immobile in the vadose zone." DOE assumed, largely on the basis of computer modeling, that wastes from the leaking underground tanks would not reach the groundwater for 10,000 years. Mounting physical evidence, however, brought the fallacy of this assumption to light in a very public manner following the release of indisputable borehole data.

In September 1997, DOE reported that the vadose zone barrier hypothesis was invalid and radioactive waste had migrated through the vadose zone. Cesium-137 was evident at a depth of 142 feet (~ 44.5 meters) and technetium-99 at a depth of 177 feet (~ 54 meters) below the underground storage tank farms. In essence, repeated discharge and persistent tank leaks over a period of 50 years turned large portions of the vadose zone into an unregulated *de facto* waste repository wherein dangerous contaminants were on the move. This latest revelation spurred a new round of citizen ire and congressional inquiry into the strategy of waste cleanup at the site.

In March 1998, the General Accounting Office (GAO) released a report, commissioned by U.S. Senators John Glenn and Ron Wyden, regarding waste cleanup and vadose zone protection at Hanford. The report focused on leakage from underground storage tanks, and it examined the adequacy of DOE's understanding of waste migration through the vadose zone and its strategy for investigating vadose zone conditions. In its report, "Understanding of Waste Migration at Hanford is Inadequate for Key Decisions," the GAO found that "DOE's own reviews concluded what outside experts had been saying for years; the Department's understanding of how wastes move through the vadose zone to the groundwater was inadequate to make key technical decisions on how to clean up waste at the Hanford site in an environmentally sound and cost-effective manner." In addition, the report found "no comprehensive plan to assess the vadose zone" and few studies of the vadose zone. The report further stipulated that DOE could not credibly estimate the long-term risk to the public or select efficient cleanup strategies unless vadose zone conditions were understood. Although not news to DOE and contractors involved with cleanup, the GAO report was a stinging public revelation of technical and management problems within the project.



Source: Based on a map provided by DOE.

In April 1998, DOE responded to the GAO with a report, "Management and Integration of Hanford Site Groundwater and Vadose Zone Activities." The report outlines a new comprehensive and inte-

River *continued on p. 15*

River *continued from p. 14*

grated technical strategy to investigate vadose zone conditions and waste migration. Key to the DOE plan is an expanded role for external review panels similar to those in place at Yucca Mountain and the Waste Isolation Pilot Project to help guide the technical decision pathway. The latest plan calls for organizing a review panel composed of experienced vadose zone specialists from government, industry, and academia who can make specific recommendations to DOE. Equally important, the panel must be consulted on proposed cleanup actions that might impact the vadose zone. The idea is to garner comments prior to costly action, and to preclude the situation recognized by Mark Twain when he remarked "It is the first wrong steps that count."

The technical situation at the Hanford site is far more complex than briefly and narrowly described above. Not all agree how DOE should achieve successful waste remediation, and there is no lack of competing interests in Hanford cleanup. There are issues of cleanup strategy and vision, safety for workers and those downwind of the site, regional economic vitality through jobs at the site and through river resources, cultural heritage, stability of federal funding, and lack of trust in the "process" that has caused some to become self-described whistle blowers. Some call for the abolition of DOE while some support complete privatization of waste cleanup. There are accusatory fingers pointing between the two Washingtons.

Unfortunately, in many professional settings, job performance is often linked to creation of products, not removal of byproducts. The perception is that production of waste is an unfortunate result of creating wealth and that cleanup simply diminishes wealth. Clearly, both technical and policy leaders share in the responsibility for Hanford cleanup. Closure on environmental remediation, necessitated by years of nuclear weapons research and development, will remain elusive until the notion is embraced that Hanford cleanup is a national priority and the final cost of freedom. ■

Dave Verardo, 1997–1998 GSA Congressional Science Fellow, serves on the staff of Senator Ron Wyden (D—OR). *This one-year fellowship is supported by GSA and by the U.S. Geological Survey, Department of the Interior, under Assistance Award No. 1434-HQ-97-GR-03188. The views and conclusions contained in this article are those of the author and should not be interpreted as necessarily representing the official policies, either expressed or implied, of the U.S. government or GSA.* *You can contact Verardo by mail at 717 Hart Senate Building, Washington, DC 20510, by phone at (202) 224-3430, or by e-mail at david_verardo@wyden.senate.gov.*

Geopals Program Offers Opportunity To Aid Foreign Students

***L. Lynn Chyi,** Geopal Program Coordinator of the GSA International Division*

The Geopals program, begun by the GSA International Division in 1991, allows GSA members to sponsor Student Associate membership for foreign geology students studying in North America. An important aspect of the program is that GSA sponsors are encouraged to communicate with their Geopals, seeking to reinforce the department's educational efforts while they study in North America, and taking an interest in their professional development. We believe that Geopals will play an important role in helping to build professional and personal bridges to geoscientists in other countries.

The program consists of two separate but related parts, that of nominating and that of sponsoring a foreign student.

How To Nominate a Geopal

The Student Committee of the International Division welcomes nominations of foreign graduate students, preferably those with strong credentials, who otherwise wouldn't be able to afford GSA membership fees. We request that the sponsor and the student be from different departments, as an additional means of building bridges within North America on this collaborative project. A nominator or sponsor need not be a member of the International Division of GSA, but priority will generally be given to International Division members' nominations. An additional reason that we encourage you to join the International Division is that you may help to provide guidance, and may participate actively in some of its varied programs.

How To Sponsor a Geopal

1. If you are on a university campus, tell the chair or GSA Campus Representative that you want to be a sponsor. If you are not on a campus, or if you do not have a Campus Representative, call or write to Gabor C. Tari, Amoco Production Co., 501 WestLake Blvd., Houston, TX, (281) 366-4572, fax 281-366-2949, gctari@amoco.com. Tari will send a sponsor form and a student application form to the designated chair or Campus Representative in the student's department. You may also contact and be paired with a nominated student on the committee's list.

2. When the forms are completed and signed by the chair or Campus Representative in the student's department, they will be sent to the sponsor, who will enclose a check as a tax-deductible contribution, made payable to GSA Foundation—Geopals. The sponsor will check one of two boxes:

Level of Commitment:
☐ $55—dues and *Geology*
☐ $75—dues, *Bulletin*, and *Geology*

Length of Commitment:
☐ 1998 dues, one year only
☐ 1998 dues and subsequent years as a student

The sponsor then sends the package to: Geopals Program, c/o Membership Services, Geological Society of America, P. O. Box 9140, Boulder, CO 80301. If the intended supporting level is different from the above, sponsors can send their donations directly to the International Division Fund, GSA Foundation.

Two Programs for Foreign and American Exchange

If the student committee of the International Committee can help you in facilitating other contacts in international student-oriented projects, contact L. Lynn Chyi, Geopals Program Coordinator, Student Committee, Geological Society of America, Department of Geology, University of Akron, Akron, OH 44325-4101, (330) 972-7635, fax 330-972-7611, LChyi@UAkron.edu.

Valerie G. Brown, *Vice President and Director of Development, GSA Foundation*

Little Things Mean a Lot!

We may tend to pay most of our attention to GSA's mainline programs—the research grants, the education and outreach initiatives of SAGE and IEE—that compose the greatest share of the Foundation's distribution budget. Sometimes, however, we should pay attention to the smaller activities, those in which a modest investment has a big impact.

These may be one-time opportunities, as with GSA's donation of books and periodicals to Colorado State University after its library was seriously damaged by a flood. Occasionally we become involved with an ongoing commitment such as the Science Journals Donation Program. This project secures donations of a wide variety of scientific journals to subscribers in Eastern Europe and central Eurasia.

We are in the midst of explosions of knowledge across the entire scientific spectrum. Yet in countries reorganizing following the dissolution of the former Soviet Union, more than 400 libraries, universities, and research institutions lack the funds for adequate acquisitions of the books and journals that report the newest emerging knowledge.

At present, GSA provides annual subscriptions to *Geology* to the Charles University Geology Library in the Czech Republic, the Institute of Geology and Geophysics in Bucharest, Romania, and the Geological Survey of Slovakia. There are many more on the list of 400 that could profit from our help. We recently have had requests for additional donated subscriptions for Albania, Bosnia-Herzegovina, Macedonia, and Yugoslavia, all countries whose academic infrastructures have been devastated by civil wars.

The costs of the subscriptions are underwritten from the Foundation's discretionary funds, which is to say from unrestricted donations. One gift of $75, or three gifts of $25, can ensure a year of *Geology* for the geoscience students and professionals in places struggling to maintain intellectual parity.

We have remarked before that every dollar of every gift has equal investment value when translated into action. Similarly, application of small aggregates of gift dollars can yield significant and rewarding dividends to the beneficiaries. ■

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Digging Up the Past

First teaching job interview—Hamilton College.

Senior Faculty Committee Member:
"I don't know any geology, but collected crinoids in a creek bottom as a boy."

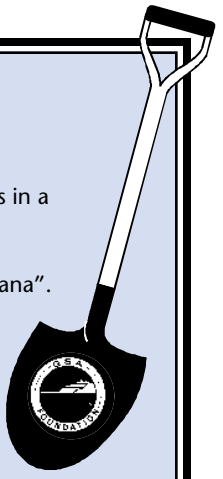
Oxley:
"You must have grown up in Crawfordsville, Indiana".

Senior Faculty Committee Member:
"How did you know?"

Oxley:
"Famous fossil locality"

Got the job.

—Phil Oxley



In Memoriam

Philip Oxley

GSA Foundation Trustee Philip Oxley died on June 19, 1998, in Wilmington, Delaware, after a brief illness. His personal and professional accomplishments were widely known and admired among his peers.

Upon graduation from Denison University in 1943, Phil joined the U.S. Navy. At the conclusion of active duty he returned to his education, earning an M.A. and a Ph.D. from Columbia University. His extraordinary career was distinguished both in academia and in the oil and gas industry, but his heart belonged to fishing.

Phil was appointed to the Foundation's Board of Trustees in 1990 to fill the remaining term of Roy Huffington. Subsequently elected to continued service, at the time of his death he was in the last year of his second full term. In addition to GSA, Phil was actively engaged with Denison University, AAPG, the Institute for International Education, and Trout Unlimited.

Phil Oxley was a generous benefactor, a thoughtful leader, and a gracious friend. His GSA Foundation colleagues are among the many who will miss him.

Gifts in memory of Phil Oxley may be sent to the GSA Foundation at P.O. Box 9140, Boulder, Colorado, 80301.

Bruce B. Hanshaw 1930–1998

Bruce Hanshaw

Bruce B. Hanshaw, McLean, Virginia, died on July 18, 1998, while on vacation at Trout Lake, near Ophir, Colorado. Hanshaw was a GSA Fellow and active leader on numerous committees. He was second vice president of the GSA International Division and a campaign advisor for the Second Century Campaign. As available, further information will be posted on the GSA Web site at www.geosociety.org.

For information about contributions in Bruce's memory, please contact the GSA Foundation, P.O. Box 9140, Boulder, CO 80301, (303) 447-2020, ext. 154, drussell@geosociety.org.

PENROSE CONFERENCE, JUNE 1999

Terrane Accretion Along the Western Cordilleran Margin: Constraints on Timing and Displacement

One of the most fundamental controversies in North American tectonics today concerns the role of allochthonous terranes and the degree of latitudinal terrane displacement during the Mesozoic to Tertiary development of the Cordillera. Estimates of the timing and magnitude of terrane displacement and accretion vary widely, and are the subject of intense debate among Cordilleran geoscientists. This debate is particularly active in the Canadian and northwestern U.S. Cordillera, where a major discrepancy exists between geologic and paleomagnetic interpretations of mid-Cretaceous to Eocene terrane paleogeography. However, the problem of reconstructing Cordilleran paleogeography is not confined to the northwestern terranes. The timing and magnitude of terrane accretion and translation along the western margin are critical issues for workers throughout the North American Cordillera, including Mexico, coterminous United States, Canada, and Alaska. Resolution of the controversy requires integration of numerous data sets from widespread localities, and this GSA Penrose Conference "Terrane Accretion Along the Western Cordilleran Margin: Constraints on Timing and Displacement," June 21–27, 1999, in Seattle and Winthrop, Washington, is intended to bring researchers together for the dissemination of ideas, discussion of techniques, and analysis of projects designed to address the issue.

Following an introductory icebreaker in Seattle, participants will take a field trip across the North Cascades, through the Methow terrane and into the Okanogan Complex along the western margin of the Intermontane superterrane. Winthrop is in the scenic Methow Valley adjacent to the North Cascades, close to the Insular-Intermontane superterrane boundary.

Sessions will provide a spatial overview of Cordilleran terranes from south to north; regional perspectives on the temporal and spatial constraints on terrane accretion; the processes and methodologies utilized in studies of terrane accretion and translation; and controversies in accretionary tectonics and terrane translation. A mid-meeting field trip will give participants an opportunity to evaluate issues and techniques as they apply to the Intermontane-Insular superterrane boundary at the southern end of the Canadian Cordillera.

The conference is limited to 80 participants. The registration fee, which will cover lodging, meals, field trips, and all other conference expenses except personal incidentals, is not expected to exceed US $700. Participants will be responsible for transportation to and from Seattle.

Application deadline is November 15, 1998. Please include a title and brief statement of the proposed presentation and preference for inclusion in a location or methodology session. In order to facilitate workshop organization, we would also appreciate if participants included what they perceive as the most critical questions that need resolution. All participants are encouraged to present a poster on current research relevant to the topic of terrane accretion and translation, and significant time will be allocated to poster discussion. We encourage the participation of graduate students working on topics of terrane accretion; partial student subsidies will be available.

Co-conveners are ***J. Brian Mahoney,*** Dept. of Geology, University of Wisconsin—Eau Claire, Eau Claire, WI, 54702-4004, mahonej@uwec.edu; ***Julie A. Maxson,*** Dept. of Geology, Lawrence University, Appleton, WI 54192, maxsonj@lawrence.edu; ***Basil Tikoff,*** Dept. of Geology and Geophysics, Rice University, Houston, TX 77005-1892, btikoff@geophysics.rice.edu. Invitations will be mailed to participants by December 15, 1998. Potential participants should send a letter of application to Brian Mahoney (address above). ■

New GSA Members

The following 653 members were elected by Council action during the period from October 1997 to May 1998.

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Katherine A. Kelley
Scott Kelley
Louise H. Kellogg
Scott J. Kendzierski
Muhammad A. Khan
Mark A. Kiessling
Irene P. Kijak
Randy L. Kilian-Smith
Won-Sa Kim
Eileen Kincaid
Ruth A. Kirkby
Margaret H. Kloska
James C. Knight
Richard H. Knight
Paul O. Knorr
Karen Knuuti
Barry P. Kohn
Edward J. Kohut
David A. Korejwo
Eduardo A. M. Koutsoukos
Robert N. Kowalkowski
Sharon L. Kozak
Andrew L. Kozlowski
Michael A. Krol
Eric L. Kruger, Jr.
Stephen F. Kulinski
Alan G. Kunze
Peter C. LaFemina
Susan M. Landon
Stephen R. Lane
Jennifer C. Latimer
Natalie E. Latysh
Michael T. Leach
Dal-Heui Lee
Hee-Kwon Lee
Hyomin Lee
Michael T. Lee
Leonardo Legarreta
Adam C. LeGrande
Marna K. Lehnert
Robert S. Leighty
Amanda J. LeNay
Robert J. Leventry
David W. Leverington
Shoshana Z. Levin
Gaylia H. Levkoff
Michael E. Lewis
Roger Lewis
David J. Ley
Sonjia M. Leyva
Bo Li
Olav B. Lian
Joseph Licciardi
Bruce S. Lieberman
Adam F. Light
Bin Lin
Heather A. Lin
WenLong Liu
Darren R. Locke
Mark A. Loewen
William S. Logan
Kimberly A. Lohuis
Caroline M. Loop
Monica G. Lopez de Luchi
Darline Lott
K. Matthew Louth
Cole K. Lovett
Crystal G. Lovett
Fabio Lozano
Laura C. Lozano-Velazquez
Guoping Lu
George M. Lukert
Jose L. Macias
Erika L. Madaski
Eric J. Magnusson
Markus Maier
Jody V. Maliga
Simon Manoyan
Tara P. Marden
Lucia Marinangeli

James R. Marlatt
Allen W. Marquette
Michael J. Marsh
James D. Marshall
Aaron J. Martin
Daniel R. Martinioni
Jeffrey M. Marts
Erik P. Mason
Jason A. Mastrine
David L. Matchen
Scot A. Mathis
Mark E. Mathison
Crystal A. Mattox
Joseph A. Maule
Mike B. Maxwell
Rachael A. Mays
Maxine E. McBrinn
Lon A. McCarley
Theodore C. McCarthy III
Patricia E. McCartin
Wendy G. McClellan
Jeremy A. McCreary
Eileen M. McGowan
Michael F. McHugh
John P. McKiness
Marjorie Jackson McKinney
Travis L. McLing
James L. McMindes
Carl A. Medoza
Andrew L. Mehlhop
Erwin A. Melis
Ted S. Melis
Marc D. Melker
Sarah C. Meyer
Melvin C. Milaor
Monica P. Miley
Ann Marie Miller
Jennifer Diane Miller
Kevin B. Miller
Mary K. Millus
Raymond J. Minarovic, Jr.
Karen J. R. Mitchell
Martin L. Mitchell
Aleksandra Moch
Charles E. Montgomery
Melanie Moreno
Deborah J. Morrow
Lisa S. Morrow
Melissa J. Morse
Allan E. Morton
Roger L. Moses
Angela M. Moss
Claire E. Muirhead
Kevin R. Mulligan
Stephen C. Myers
Joe M. Namlick
Charles E. Narwold
Mohammed O. Nassief
Cheryl A. Naus
Jay R. Neuhaus
Nathan A. Niemi
Josef Nievoll
Melissa M. Nihsen
Francis Nimmo
Lee C. Nordt
Jon S. Novick
Trish A. Nuskievicz
Michael P. O'Connell
Diane D. O'Connor
Catherine H. O'Dell
Michael L. O'Neal
Susan D. Oakley
Emily M. Oatney
Karen R. Olson
Peter A. Omenda
Holly A. Orndorff
Robert E. Page
James L. Palandri
Scott W. Parks
Fatima Patel
Andrew P. Patrick
Karen F. Patterson
Robert T. Pavlowsky
Samuel T. Peavy
James M. Peck
Mike Peffer
Sharon D. Perez-Suarez
Dominic A. Perruccio
Carl Petersen
Candace A. Peterson
Kristine M. Peterson
Mark A. Petrie
Michael S. Petronis
Stephen D. Pierson
Jeffrey T. Pietras
Michelle A. Pike
Timothy J. Piwowar, Jr.
Michael P. Poland
Victor J. Polyak
John J. Ponczynski
David E. Pratt
Nicole E. Preuss
Alan P. Price
Jeffrey S. Price
Linda F. Prosperie
Giacomo Prosser
Michael H. Pulver
Warren C. Purdy
Jodi L. Purser
Andrew I. Quarles van Ufford
Luis Quintana
C. P. Rajendran
Frank C. Ramos
Penelope K. Ramos
Andrew S. Reeve
Eduard G. Reinhardt
Jon C. Reiten
James Repka
Thomas H. Reppe
Darin M. Reuter
Amy L. Rhodes
Robert M. Riberdy
Tracy A. Rice
David R. Richards
Toby A. Rickabaugh
Richard D. Ricketts
Eric M. Riggs
David A. Rightmer
Robena D. Robinett
James P. Robinson
Richard S. Robinson
Kristen A. Rocha
Javier Rodriguez
Jonathan Paul Rogers
Denise M. Romano
Julia A. Rosdeutscher
Robert M. Roseen
Gregory T. Roselle
C. Elizabeth Ross
Thomas P. Ross
Roland M. Rueber
Jaime Rueda-Gaxiola
Garry L. Running IV

New GSA Fellows

The following 38 Fellows were elected by Council action during the period from October 1997 through May 1998.

Ronald L. Bruhn
Cahit Coruh
William P. Dillon
Jean-Claude Dionne
Cortland F. Eble
C. Patrick Ervin
Cynthia A. Evans
Donald M. Fisher
Michael P. Foose
Philip C. Goodell
Frederick T. Graybeal
Jeffrey S. Hanor
Michael F. Hochella, Jr.
John A. Hole
Mark D. Johnson
Robert Kerrich
Timothy J. McCutcheon
M. Meghan Miller
Robert B. Mixon
Steven F. Olson
Mark A. Person
Hermann W. Pfefferkorn
David W. Phelps
Jose A. Salfity
Richard W. Saltus
Klaus J. Schulz
Walfried M. Schwerdtner
Kurt Servos
William D. Sevon
John A. Tarduno
David L. Trauger
Clifford I. Voss
Harold R. Wanless
William W. Whitley
Bruce H. Wilkinson
James E. Wright
Sandra J. Wyld
Half Zantop

Kelly A. Rust
Regina M. Ryan
Isabelle Sacramentogrilo
Hee Sagong
Craig E. Saunders
David L. Sawicki
Robert M. Schapiro
Allison B. Schill
Sarah A. Schlichtholz
Karen R. Schmitt
Michael J. Schnieders
Lindsay Schoenbohm
William W. Schroeder
Andi Schuerzinger
Peter A. Schultz
Phil R. Schweitzer
Nina Serman
H. James Sewell
Bruce A. Shabino
Stacy H. Shafer
Dean E. Shanklin
Rajesh Sharma
Tracy S. Shirley
ShayMaria M. Silvestri
Christopher J. Simpson
Suvinay K. Sinha
Darren B. Sjogren
Steven J. Skotnicki
Michael Slattery
Andris J. Slesers
James F. Slezak
Stephen E. Smail
Kevin J. Smart
Jennifer L. Smith
Joshua B. Smith
Marian M. Smith
Michael Smoliar
Dustin G. Smyth
Darin C. Snyder
Jeffrey A. Snyder
Nikolas K. Sokol
Luigi A. Solari
Chad C. Soliz
Alejandro E. Soto
Beth A. Spear
Jeff L. Spencer
Blanka Sperner
Roger K. Spivey
Brad A. Sporleder
Lisa E. Spracklin
Alan Spraggins
Jill O. Stachura
Andrew G. Stack
C. Russell Stafford
Kenneth R. Stalder
Josette Stanley
Don W. Steeples
Theodore R. Steinke
Allan Stephens
Robert S. Sternberg
Emily M. Stewart
Uwe Strecker
Christian A. Strobl
John O. Strong
Laura Ann Stuart Leslie
Maureen A. Stuart
Diana J. Sturm
M. Pete Suess
Toshihiko Sugai
Michael A. Summerfield
Gloria J. Summers
William D. Surratt
Roger Swart
David W. Sweeten
Neil J. Tabor
Paul J. Tackley
Samuel J. Talbert
Peter W. G. Tanner
Christine Tappen
Paul Tapponnier
Rozemarijn F. A. Tarhule
Lucius H. Taylor
Dennis O. Terry, Jr.
E. Robert Thieler
Douglas M. Thompson
Bai Tian
Susan M. Timmons
Keith L. Tischler
Alan L. Titus
Shinji Toda
John Townend
Carolyn R. Trayler
Chin-Ho Tsai
Silvio Tschudi
Andrei Tudoran
Eva-Lena Tullborg
Allison R. Tumarkin
David Tupper
Aleta van Riper Turner
Robert J. Tuttle
Trenton N. Twedt
James A. Tyburczy
Emmanuel E. Udoh
Maria E. Uhle
Chad A. Underwood
Jon W. Van de Grift
Dixon Van Hofwegen
William P. Van Liew
Leah May B. Ver
Jan M. Vermilye
William T. Viitala
Michael J. Vollinger
Albert F. Waibel
Todd E. Wallbom
Douglas J. Walsh
Charles W. Ward
Thad A. Wasklewicz
Cheryl L. Waters
Laura E. Webb
Jennifer M. Weber
Mark Webster
Kathy C. Weinberg
Richard A. Welch
Robert E. Welsh
Micah A. Weltmer
Robert L. West
Brian D. Westhoff
Kelly D. Wheeler
Lisa L. White
Noel C. White
Robert E. Whittemore
Joanne C. Wilkin
Holly K. Williams
William J. Willis
Virginia D. Winslow
Victoria Wise
Chris Wojick
Virginia Wong
Michele M. Wood
Marcia G. Wyatt
Koshi Yamamoto
Catherine H. Yansa
Dawn A Youngblood
Yong Jae Yu
Zhongbo Yu
Hongbin Zhan
Natalie B. Zieske
Jennifer A. Zwiebel ■

BOOK REVIEWS

Geochemistry of Hydrothermal Ore Deposits (third edition). *Edited by Hubert L. Barnes. Wiley, New York, 1997, 972 p., $115.*

This is a new edition of a book that first appeared in 1967 with the intention of summarizing state-of-the-art research on hydrothermal ore-forming processes. Providing such a view is a tall order, considering the breadth of techniques used to study hydrothermal ores and the speed with which the state of knowledge has evolved. As he did in the first two editions of this book, H. L. Barnes has compiled review papers from leaders in the many subdisciplines of hydrothermal geochemistry. Although many of the 17 chapters expand upon themes visited in earlier editions, each offers substantial modernization, and there is very little direct overlap with the prior versions. Several topics are covered by new authors with new perspectives; for example, chapter 2, Sources of Hydrothermal Components: Heavy Isotopes, by G. L. Farmer and D. J. DePaolo, parallels chapter 2 of the second edition, on plumbotectonics by Zartman and Doe, but integrates the relevant research on Sr and Nd heavy isotopes since 1979. Likewise, the chapters Hydrothermal Alteration and Its Relationship to Ore Fluid Composition, by M. H. Reed; Gangue Mineral Transport and Deposition, by J. D. Rimstidt; Sulfide Ore Mineral Stabilities, Morphologies and Intergrowth Textures, by D. J. Vaughan and J. R. Craig; and Hydrogeology and Geochemistry of Ore Genesis in Sedimentary Basins, by G. Garven and J. P. Raffensperger provide new insights into topics addressed earlier by Helgeson, Holland and Malinin, Barton and Skinner, and Hanor.

The chapters contributed by authors who wrote for earlier editions illustrate with particular clarity how far the state of the art has come, due largely to advances in microanalytical and experimental techniques, numerical modeling, and isotopic methods. Among these are Magmas and Hydrothermal Systems, by C. W. Burnham, which offers a satisfying elaboration of the chapter in the second edition; Oxy-

New GSA Student Associates

The following 216 student Associates became affiliated with the Society during the period from October 1997 to May 1998.

Kalsoum A. Abbasi
Lisa M. Adamo
Julie A. Adgurson
Khashayar Ahvari
Lesa A. Bagby
Erinn M. Banks
Matthew A. Barner
Daniel J. Beaudoin
Thomas P. Becker
Jacob S. Benner
Valerie A. Bennett
Amy E. Benoit
Richard H. Benson
Brent A. Berge
Eric M. Blackburn
Matthew T. Bleakley
Mark T. Bolivar
Mary L. Borzi
Alexander S. Bradley
Michelle H. Brewer
Joel A. Brieske
Julie Brown
Adam K. Bucki
Nathan E. Burnside
Malia B. Burrows
Luis F. Camacho
Sarah J. Cardamon
Sarah K. Carmichael
Tina L. Carrick
Ping Y. Chang
Denise S. Chidester
Kaneen E. Christensen
Ryan D. Christensen
Cynthia A. Colbert
Christopher R. P. Collet
Robert J. Conner
James E. Conolly
Tim D. Cope
David A. Cornell
Andrew J. Crittenden
Peter B. Davis
P. Allison Dean
James F. DeAngelo
Aisha H. Dennis
Nathalie N. Derrick
Laura A. Dietz
Mimi N. Divjak
Lisa J. Duke
Michelle J. Dwyer
Rana Farshoukh
Kristin L. Ferri
Timothy J. Fives
Ricardo S. Flores
Bryan J. Flynn
Jennifer E. Folta
Nancy K. Forsberg
Philip E. Foster
Ranae L. Friend
Phyllis E. Gaskin
Matt I. Gavette
Gregory Giuliani
Jeffrey K. Goodman
Zakhia X. Grant
Michael D. Graveyly
Jessica K. Graybill
Matthew A. Gregory
Eric S. Gustafson
Markus G. Hagedorn
Christopher S. Hauptfleisch
Amanda M. Heasley
Kirk A. Heim
Jennifer L. Hensinger
Stephen M. Hensler
Scott W. Herman
Rebecca J. Heumann
Erin K. Hiatt
Susan M. Hinesley
Miriam E. Hornstein
Brian G. Hough
Craig M. Hovey
Andrea H. M. Hulshof
Grey P. Ingram
Matt C. Jacobs
Ryan T. Jakubowski
Shannon R. Jock
Adam N. Johnson
Christopher L. Johnson
Steven C. Johnson
Sarah E. Johnston
Sean E. Keneally
Melody J. Kent
Amanda E. Kilgore
Maria A. Koons
Sarah E. Kopczynski
Anthony G. Koval
Lena Krutikov
Tara L. Kuhn
Michelle M. Lake
Robert W. Lambert
Joanna R. Latham
Sebastien Lavoie
Melanie A. Leach
Brian G. Lebreck
Carrie E. Lee
Lai Man Lee
John V. Leone
Alanna P. Lester
Gordon Levin
John S. Linker
Peter Lissitschenko
Vanesa D. Litvak
Daniel M. Litzenberg
Andrew M. Lorrey
Sara E. A. Lyle
Elizabeth A. Madsen
Eric S. Magdar
Elizabeth A. Magno
Frank J. Marascia
Robert J. Mark
Lisa D. McAuliffe
Joseph C. McCarthy
Luke J. McCartney
Louise P. McGarry
John A. Miatech
Koreen M. Mielke
Tanya C. Mieras
Michael J. Miller
Zachary J. Miller
Dorene L. Montler
David T. Moore
Adam P. Morse
Jason R. Mulkey
Angela P. Murillo
Robert M. Myers
Angelyn Nebeker
Joy D. O'Donnell
Jeffrey J. Olejnik
Jennifer R. Olejnik
Elisabeth V. Osborn
Niki L. Pace
Judith M. Paiva
Daniel A. Parsons
John P. Pasmore
Benjamin H. Passey
Yvonne E. Paul
Adam E. Pearsall
Jeffrey C. Perkins
J. Vincent Perryman
Noah E. Petro
Christine M. Philips
David S. Pinkus
Christa J. Placzek
Chris Pollatos
Martina G. Prinzhorn
Richard M. Quesada
Terrie L. Ragins
Jose Norberto Ranalli
Melvin E. Rauch, Jr.
Harold A. Ray
Mark A. Record
Nancy R. Reese
Donald E. Rehmer
Geoffrey Reichold
Jeff P. Reinprecht
Monica K. Relle
Stephanie A. Reynolds
Anabella A. Rivara
Amelia C. Robinson
James D. Robinson
Nickolas R. Rogers
Shannon R. Rose
Demetra O. Salisbury
Nicholas J. Salkowski
Brenda K. Saville
Maria Scalzitti
Justine L. Schneider
Gunther J. Schnorr
Matthew O. Schrenk
Kathy L. Schwager
Philip G. Scoggins
Dave R. Scott-Queckett
Nicole M. Seibert
Michell R. Sequera
Danielle K. Sheheen
Maria S. Skidmore
Heather Laurina Smith
Shane V. Smith
Rachel C. Stansbery
Kiera Strohm-Herman
Toni M. Sullivan
Anne E. Swasey
Seth D. Tanner
Randal B. Thomas
Anne C. Tillery
Anne R. Tocker
Mark S. Trevor
Charles B. Trout
Matthew J. Tucker
Tiffany Tye
Erik A. Vander Horst
Mark D. Vanderbilt
Jodi M. VanderVelden
Elisheva C. Verdi
Joseph B. Vilcheck
Deborah J. Waiting
Kristoffer T. Walker
Nathaniel S. Wanner
Mary-Morning F. Washburn
Amy L. Weislogel
Heather L. Welhouse
Beth A. Wenell
Carrie Anne White
Lee A. White
Philipp Wilflingseder
Judy L. Wilkinson
Howard O. Wilson
Rick L. Wilson
Jennifer R. Wingate
Heidi A. Woelfel
Rebecca L. Yates
Mary Lynn Yurko
Kurt K. Zeiler
Darla K. Zelenitsky
Vladimir B. Zivkovic ■

gen and Hydrogen Isotope Relationships in Hydrothermal Mineral Deposits, by H. P. Taylor Jr.; Sulfur and Carbon Isotopes, by H. Ohmoto and M. B. Goldhaber; Thermal Aspects of Ore Formation, by L. A. Cathles; Metal Transport by Hydrothermal Ore Fluids, by T. M. Seward and H. L. Barnes, a brief and lucid summary of the state of knowledge of metal complexing and deposition mechanisms; and Fluid Inclusion Studies of Hydrothermal Ore Deposits, by E. Roedder and R. J. Bodnar, which pays particular attention to the promise of many new techniques for fluid-inclusion analysis that have developed in recent years.

Five of the chapters warrant special mention. Three of these, Geothermal Systems and Mercury Deposits, by H. L. Barnes and T. M. Seward; Submarine Hydrothermal Systems and Deposits, by S. D. Scott; and Ore-forming Brines in Active Continental Rifts, by M. A. McKibben and L. A. Hardie, cover important topics not addressed in earlier editions of the book. The Origin and Evolution of Fluids in Magmatic-Hydrothermal Systems, by the late Werner Giggenbach, provides an elegant and accessible overview of this unusually creative scientist's work. As he did in earlier editions, Barnes has also highlighted an important emerging field, with Organic Matter in Hydrothermal Ore Deposits, by P. Landais and A. P. Gize.

The volume also comes with a 3.5" diskette containing 17 files, in various PC-compatible formats, of thermodynamic data used in figures in the text; these data provide a convenient and useful starting point for calculating figures of interest.

The first and second editions of this book set and maintained a new standard for graduate-level texts on the hydrothermal geochemistry of ore deposits. Barnes has succeeded again in providing a view of where we've come from, where we are, and where we are probably going in our quest to understand the formation of ores from hydrothermal fluids. This knowledge does not come cheaply, but having so much current and valuable material in a single volume is well worth the cost. There is little of consequence in the field that cannot be accessed through this volume. It will be a reference of unique value for many years to come, and it is the obvious textbook for any graduate course on hydrothermal geochemistry. Barnes and his coauthors are to be congratulated for their skill and effort in bringing the "Barnes volume" splendidly up-to-date.

Andrew Macfarlane
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Remote Sensing: Principles and Interpretation (third edition). *By Floyd F. Sabins. W. H. Freeman and Company, New York, 1997, $83.95.*

Remote sensing, as defined by Floyd Sabins in this third edition of *Remote Sensing: Principles and Interpretation* is "the science of acquiring, processing and interpreting images and related data, obtained from aircraft and satellites, that record the interaction between matter and electromagnetic radiation." Once again, Sabins has written a remote-sensing textbook that is a tour de force, standing head and shoulders above the competition. The current edition, appearing 10 years after the previous one, contains 50% new and up-to-date material. The book is organized into 14 chapters: The first eight cover principles of remote sensing, starting from basic concepts of electromagnetic radiation and proceeding to theories of radar technology and image processing. Theoretical concepts are well presented and illustrated, requiring only an undergraduate knowledge of physics and mathematics; yet they are thorough enough to provide an in-depth understanding. The next six chapters cover topical applications of remote sensing, including meteorological, oceanographic, environmental, oil and mineral exploration, hazards, and land use. Discussions on the use of thermal infrared data from various satellite sensors came in handy for me, as I tackled writing a high-school–level review of thermal remote sensing from space. Sabins's

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LETTERS

The Name Game—Parsimony and Public Communication

The Edwards Group, a carbonate-rock unit that underlies most of South-Central Texas, comprises several hydrologically distinct karst aquifers (including the artesian system supplying San Antonio, the largest city in the U.S. solely dependent on groundwater). Its caves and springs harbor endangered vertebrates, invertebrates, and plants; it also is a major stone resource and a petroleum reservoir.

Maintenance of adequate quality and quantity of this groundwater resource is not assured for competing future demands, and conflicts periodically involve the state legislature, regional water-conservation districts, local governments, and the courts. But alas, geologic information often is lost in the fray, and confusion is abetted by the daunting array of names under the rubric of "Edwards" (the *Geologic Atlas of Texas* subdivides the Edwards Group into at least nine formations across the state).

For overview reports, we recommend employing the precepts of Occam's Razor to apply the most general, widely recognized name—in this instance, the Edwards Limestone. Such usage runs counter to strict rules of stratigraphic nomenclature, but the trade-off is concise, effective communication with the general public and with the profession at large. The Edwards is a name that is recognized by most informed people of central Texas, whereas formation names such as Kainer, Segovia, or McKnight are lost on the lay public and on most geologists elsewhere (just as Texas geologists may recognize the Madison Limestone by name but not the Lodgepole or the Marble Canyon). For the Edwards, nomenclature is complex enough, political battles are heated enough, and the stakes are high enough to bend our rigid rules for the sake of emphatic communication!

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Patrick L. Abbott
San Diego State University
San Diego, CA 92182

Ice-ring Shadows

Hoffman and others (*GSA Today,* [v. 8, no. 5, p. 1–9] May 1998) contributed a useful list of hypotheses relating Neoproterozoic carbonates and glacial diamictites. But wait, there's more! The late Richard P. Sheldon, in a never-published manuscript ca. 1983, suggested Saturn-like ice rings that would cast low-latitude winter shadows, with obliquities comparable to those of today. The glacial-carbonate relation would involve not only shadow margins but the waxing and waning of rings. Dick was led to the model by observation of Proterozoic sequences of India, and was devising tests involving varve couplets, formed at locales that saw two shadows per year. As I understand it, the hypothesis is most similar to the high-obliquity model (Hoffman and others' #1) but is more consistent with close association of carbonates and glacial deposits and could produce both high- and low-latitude glaciers.

Eric Force
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long-term involvement in the oil exploration business is evident in the emphasis on geologic applications and the inclusion of an appendix on basic geology; however, the overall breadth of material covered is one of the strengths of this book, and makes it a valuable resource for anyone interested in remote sensing and its many applications, not just geologists.

Accompanying the book is a large laboratory manual, designed to complement the text when used in a classroom setting. The exercises are keyed to each chapter, and they provide a useful hands-on reinforcement of the concepts introduced and developed in the text. Here too, there is an emphasis on geologic applications, particularly interpretation of areas with exposures of sedimentary rocks. Additional exercises on interpretation of radar images, land use, and oceanography, among others, round out the coverage.

Despite being designed for an introductory university course in remote sensing, *Remote Sensing* will find a welcome and valued place on my bookshelf. It is a complete and up-to-date reference source, with citations to the scientific literature and contacts for commercial suppliers of remote-sensing data. And it is my one place to look for theoretical treatments as well as interpretation methods.

Michael Abrams
Jet Propulsion Laboratory
Pasadena, CA 91109

Glimpses into the Obvious. *By Sherman Wengerd. Goosefoot Acres Press, Cleveland, Ohio, 1998, $27.90 (paperbound).*

Should you be interested in an entertaining autobiography that is conversational in style, at times witty, iconoclastic, and insightful, occasionally politically incorrect, but always rife with enthusiasm for living, then Sherman Wengerd's book could be for you. The volume is not as professionally centered as Pettijohn's *Memoirs of an Unrepentant Field Geologist* or Longyear's *Mesabi Pioneer*; rather, Sherm has woven a broad fabric tracing both his life and career (he died in 1995).

And an interesting life it was—upbringing in Ohio within a Pennsylvania Dutch family, nine years spent as a roofer in his youth, advanced education at the College of Wooster and at Harvard, private pilot, U.S. Naval Reserve, jug hustler and seismic surveyor, university professor (University of New Mexico), and consultant. In this memoir, Sherm consistently reveals his unending zest for living and exploration of the world about him. He was decidedly opinionated and the volume contains many quotations as well as pointed observations on various subjects.

Those among us who have bridged academics and consulting in the geosciences will appreciate the "real-world" perspective with which Sherm viewed his academic surroundings and the deliberative passion he held for his consulting work. Yet I think the value of his tale lies in his ability to tell it with consistency and enthusiasm. I particularly enjoyed his commentaries on chestnuts, his father's admonitions on avoiding pickpockets, his disdain of academic bureaucracy, and his obviously enjoyable life with his wife, Florence, and her family (her father was Kirtley Mather, geologist and political activist).

The book is easy to read and entertaining. Unfortunately the photo illustrations did not reproduce well.

Donald M. Davidson, Jr.
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Environmental and Engineering Geophysics. *By Prem V. Sharma. Cambridge University Press 1997, xxiv + 475 p., hardcover $100; paperback, $44.95.*

This textbook covers precisely what its title implies. Such a book has been needed for more than a decade and will help professors whose specialties and expertise are peripheral to near-surface geophysics. For example, the book has separate chapters on ground-penetrating radar (GPR) and electromagnetics (EM), subjects either omitted from or scarcely mentioned in Burger's *Exploration Geophysics of the Shallow Subsurface* (1992).

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Book Reviews *continued from p. 24*

Sharma's book also is intended as "a valuable reference work for professional earth scientists, engineers, and town planners" (cover quote). As a text for undergraduates, it serves reasonably well; as a reference work for professionals, however, the book falls somewhat short. Specifically, the material on shallow-reflection seismology is quite dated, owing primarily to the phenomenal development of seismic instrumentation over the past 10 years. Similarly, EM and GPR have undergone rapid changes during the 1990s.

Basic information concerning the theory and application of all relevant near-surface geophysical methods is given, including a segment on shallow borehole logging. Except for the section on GPR, the theoretical discussion is not significantly different from treatments that have been available in classic textbooks for more than 10 years. When I read the section on seismology, it became clear that the book was not written by a seismologist. In all likelihood, experts in EM or GPR could say the same about the sections covering their respective fields of study. However, sometimes introductory materials are best presented by an author who focuses less narrowly on a topic than would a specialist.

Missing from this book is an effort to integrate the various geophysical methods into a logical approach to solving an environmental or engineering problem. A token effort was made, in the form of a single table and a brief, superficial discussion in the first chapter. The opening chapter also includes a geological time chart, which appears to be either out of place or superfluous.

Overall, the book is well constructed and nicely illustrated in black and white. The paperback pricing is competitive. The reference list, while not exhaustive, is a good beginner's guide to the contemporary literature of near-surface geophysics. In addition, Sharma's book reads well, and the number of typographical errors is acceptably small.

If students are primarily undergraduates or have not yet had a geophysics class, this book deserves serious consideration as a text for a course in environmental or engineering geophysics. If, however, the class is composed primarily of graduate students in geophysics, the three-volume SEG work *Geotechnical and Environmental Geophysics* edited by Stan Ward (1990), augmented by class notes, might be more appropriate.

Don W. Steeples
University of Kansas
Lawrence KS 66045 ■

GSA Section Meetings — 1999

Call for Papers

Send volunteered abstract to the addresses shown. For invited (symposia) abstracts, follow instructions provided to you by convener.

SOUTH-CENTRAL SECTION
March 15–16, 1999
Holiday Inn Civic Center
Lubbock, Texas

Abstract Deadline
December 15, 1998

Submit completed abstracts to:
James Barrick
Department of Geosciences
Texas Tech
Lubbock, TX 79409-1053
(806) 742-3107
ghjeb@ttu.edu

NORTHEASTERN SECTION
March 22–24, 1999
Westin Hotel
Providence, Rhode Island

Abstract Deadline
December 8, 1998

Submit completed abstracts to:
Anne I. Veeger
Department of Geology
University of Rhode Island,
Green Hall
Kingston, RI 02881
(401) 874-2187
veeger@uriacc.uri.edu

SOUTHEASTERN SECTION
March 25–26, 1999
Athens Classic Convention Center
Athens, Georgia

Abstract Deadline
December 14, 1998

Submit completed abstracts to:
Michael F. Roden
Department of Geology
University of Georgia
Athens, GA 30602-2501
(706) 542-2416
mroden@uga.cc.uga.edu

ROCKY MOUNTAIN SECTION
April 8–10, 1999
Quality Inn Pocatello Park Hotel
Pocatello, Idaho

Abstract Deadline
December 29, 1998

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

NORTH-CENTRAL SECTION
April 22–23, 1999
Chancellor Hotel and Conference Center
Champaign-Urbana, Illinois

Abstract Deadline
January 11, 1999

Submit completed abstracts to:
C. Pius Weibel
Illinois State Geological Survey
615 Peabody Dr.
Champaign, IL 61820
(217) 333-5108
weibel@isgs.uiuc.edu

CORDILLERAN SECTION
June 2–4, 1999
University of California—Berkeley
Berkeley, California

Abstract Deadline:
February 19, 1999

Submit completed abstracts to:
George Brimhall
Dept. of Geology & Geophysics
University of California
Berkeley, CA 94720-4767
(510) 642-5868
brimhall@socrates.berkeley.edu

1999 SECTION MEETING ABSTRACT FORM REQUEST

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

Please send _____ copies of the 1999 GSA Section Meeting abstract form.

Name _____

Address _____

_____

City _____ State_____ ZIP _____

August *BULLETIN* and *GEOLOGY* Contents

The Geological Society of America
BULLETIN
Volume 110, Number 8, August 1998

MOVING? Don't risk missing a single issue of *GSA Today* or other publications! If you're planning on changing your address, simply write in your new address and mail this coupon along with your subscription mailing label (use label from this newsletter) to: GSA, Membership Services, P.O. Box 9140, Boulder, CO 80301-9140. Or you may call with your change of address information—(303) 447-2020 or 1-800-472-1988 or e-mail us at member@geosociety.org.

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GEOLOGY

VOLUME 26
NO. 8
P. 673–768
AUGUST 1998

Forum

CALENDAR

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

1998 Penrose Conferences

September

September 13–17, **Ophiolites and Oceanic Crust: New Insights from Field Studies and Ocean Drilling Program,** Marshall, California. Information: Yildirim Dilek, Dept. of Geology, Miami University, Oxford, OH 45056, (513) 529-2212, fax 513-529-1542, dileky@muohio.edu.

1999 Penrose Conferences

January

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, South Island of New Zealand. Information: Suzanne L. Baldwin, Department of Geosciences, University of Arizona, Tucson, AZ 85721, (520) 621-9688, fax 520-621-2672, baldwin@geo.arizona.edu.

June

June 18–24, **Terrane Accretion along the Western Cordilleran Margin: Constraints on Timing and Displacement**, Winthrop, Washington. Information: J. Brian Mahoney, Department 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, Department 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, Department 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.rhbnc.ac.uk.

1998 Meetings

September

September 14–16, **2nd Middle East Refining and Petrochemicals Conference and Exhibition,** Manama, Bahrain. Information: Arabian Exhibition Management, WLL, P.O. Box 20200, Manama, Bahrain, 973-550033, fax 973-553288, aeminfo@batelco.com.bh, http://www.batelco.com.

October

October 4–8, **MODFLOW '98 International Conference,** Golden, Colorado. Information: Office of Special Programs and Continuing Education, Colorado School of Mines, Golden, CO 80401, (303) 273-3321, fax 303-273-3314, space@mines.edu, http://www.mines.edu/Outreach/Cont_Ed or www.mines.edu/IGWMC/.

October 13–16, **III Seminario Minero Sonora 2000, Mining and Development of Mexico in the XXI Century,** Hermosillo, Sonora, Mexico. Information: Association of Mining, Metallurgical, and Geological Engineers of Mexico, Sonoran Chapter, Mario Campos, President, Calle Aldama #73, Col. San Benito, Hermosillo, Sonora, Mexico, 52-62-105510, fax 52-62-141666, fquerol@rtn.uson.mx.

1999 Meetings

February

February 10–12, **Dynamics of Fluids in Fractured Rocks: Concepts and Recent Advances International Symposium,** Berkeley, California. Information: Boris Faybishenko, Lawrence Berkeley National Laboratory, Earth Sciences Division, One Cyclotron Road, Mail Stop 90-1116, Berkeley, CA 94720; bfayb@lbl.gov; http://www.esd.lbl.gov/witherspoon. *(Extended abstracts [2–4 pages] deadline: September 1, 1998.)*

March

March 23–24, **Silurian, Devonian, and Mississippian Geology and Petroleum in the Southern Midcontinent,** Norman, Oklahoma. Information: Kenneth S. Johnson, Oklahoma Geological Survey, University of Oklahoma, 100 East Boyd St., Room N-131, Norman, OK, 73019, (405) 325-3031 or (800) 330-3996, fax 405-325-7079.

April

April 10–14, **7th Multidisciplinary Conference on Sinkholes and the Engineering and Environmental Impacts of Karst,** Harrisburg, Pennsylvania. Information: Gayle Herring, P. E. LaMoreaux and Associates, Inc., 106 Administration Rd., Oak Ridge, TN 37830, (423) 483-7483, fax 423-483-7639, pelaor@usit.net, http://www.uakron.edu/geology/karstwaters/7th.html. *(Abstract deadline: August 21, 1998.)*

April 19–22, **In Situ and On-Site Bioremediation Fifth International Symposium**, San Diego, California. Information: The Conference Group, (800) 783-6338 or (614) 424-5461, fax 614-488-5747, conference-group@compuserve.com. *(Abstracts deadline: August 31, 1998.)*

April 26–28, **Thrust Tectonics '99,** Egham, Surrey, UK. Information: K. R. McClay, Royal Holloway University of London, Egham, Surrey TW20 0EX, UK, phone 44-1784-443618, fax 44-1784-438925.

April 28–30, **Geosynthetics 1999**, Boston, Massachusetts. Information: Jeanne McGovern, Geosynthetics Associate, Industrial Fabrics Association International, 1801 County Road B W, Roseville, MN 55113-4061, (612) 222-2508, (800) 225-4324, fax 612-631-9334, jlmcgovern@ifai.com, http://www.ifai.com.

May

May 26–28, **Geological Association of Canada–Mineralogical Association of Canada Joint Annual Meeting,** Sudbury, Ontario. Information: P. Copper, Dept. of Earth Sciences, Laurentian University, Sudbury, Ontario P3E 2C6, Canada, (705) 675-1151, ext. 2267, fax 705-675-4898, gacmac99@nickel.laurentian.ca.

June

June 3–5, **3rd International Conference on Analysis of Discontinuous Deformation (ICADD-3),** Vail, Colorado. Information: Bernard Amadei, University of Colorado, Dept. of Engineering, CB 428, Boulder, CO, 80309-0428, (303)

Calendar *continued on p. 29*

Environmental & Engineering Geoscience Contents

Metro Toronto Convention Centre
Sheraton Centre Toronto Hotel

Preregistration Deadline:
September 18

Technical Program Schedule:
September GSA Today and the Web

Registration and Housing information:
June GSA Today

Headquarters Services

In addition to the regular exhibit hall hours, GSA staff will also be on hand Thursday, from 9:00 a.m. to 2:00 p.m., to provide GSA services and opportunities to GSA members and meeting attendees.

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GSA FUTURE MEETINGS

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Late-Breaking Research Sessions

Exciting new data or breakthroughs over the summer?

Present your work at the GSA Annual Meeting this fall!

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

- An abstract on late-breaking research may be submitted electronically after September 1 until midnight, September 30, 1998.
- Abstracts may not be submitted on paper or by e-mail; they must be submitted using the Web form: http://www.geosociety.org/meetings/98
- Space will be limited and selection will be based on scientific merit.
- The author must provide a brief explanation of why the abstract deserves consideration after the usual deadline for this meeting.
- The presentation will be **poster mode only**, and will be put with the appropriate discipline poster session. These posters will be announced as "Late-Breaking Research," with booth number, at poster session entrances.
- Because of scheduling limitations, the policy is that only one volunteered paper may be presented in either oral or poster mode for the overall meeting. If you already had a volunteered abstract accepted, please do not submit another—even if the second one is "news."

Abstract Fee: For this meeting, a nonrefundable abstract fee of $50 must accompany each Late-Breaking Research abstract submitted. Our Web-template form will ask for credit-card information. Our *secure server* system for transmission of your credit-card data will fully protect your confidential information.

Schedule: Abstracts will be reviewed by the Technical Program Chairs for 1998 and 1999. Electronic acceptance notices will be sent out the first week in October with the place and time of presentation. The date and time will depend on where your paper best fits scientifically. We will try to provide a time for your paper together with others of similar relevance.

Publication: These abstracts will be published on the Web along with the other annual meeting abstracts, and paper copies will be made available on site in Toronto. They will not be published in the *Abstracts with Programs* volume.

1999 DENVER, COLORADO

GSA ANNUAL MEETING AND EXPOSITION

OCTOBER 25–28
COLORADO CONVENTION CENTER

GENERAL CO-CHAIRS
Mary J. Kraus, David Budd,
University of Colorado

TECHNICAL PROGRAM CHAIRS
Craig Jones, G. Lang Farmer,
University of Colorado

DUE DATE FOR PARDEE KEYNOTE SYMPOSIA AND TOPICAL SESSION PROPOSALS: JANUARY 6, 1999
Electronic Proposal Form Available November 1, 1998.

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:

Alan Lester
Department of Geological Sciences
University of Colorado
Campus Box 399
Boulder, CO 80309-0399
(303) 492-6172
fax 303-492-2606
alan.lester@colorado.edu

Bruce Trudgill
Department of Geological Sciences
University of Colorado
Campus Box 399
Boulder, CO 80309-0399
(303) 492-2126
fax 303-492-2606
bruce@lolita.colorado.edu

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. Continuing Education 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

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

Calendar *continued from p. 27*

492-7734, fax 303-492-7317, amadei@spot.colorado.edu, http://www.tmn.com/~arma.

June 6–9, **37th U.S. Rock Mechanics Symposium,** Vail, Colorado. Information: ExpoMasters, 7632 E. Costilla Ave., Englewood, CO 80112, (303) 771-2000, fax 303-843-6212, mcramer@expomasters.com.

June 20–24, **Coastal Sediments '99**: Scales of Coastal Sediment Motion and Geomorphic Change, Long Island, New York. Information: Nicholas C. Kraus, USAE Waterways Experiment Station, Coastal & Hydraulics Laboratory (CEWES-CC), 3909 Halls Ferry Road, Vicksburg, MS 39180-6199, (601) 634-2016, http://www.coastalsediments.org.

June 21–24, **International Gemological Symposium,** San Diego, California. Information: Dona Dirlam, Gemological Institute of America, 5345 Armada Dr., Carlsbad, CA 92008, (760) 603-4154, fax 760-603-4256, ddirlam@gia.edu. *(Abstract [poster] deadline: October 1, 1998.)*

June 21–24, **Fourth International Airborne Remote Sensing Conference and Exhibition**, Westin Hotel, Ottawa, Ontario. Information: ERIM Airborne Conferences, Box 134008, Ann Arbor, MI 48113-1008, (734) 994-1200, ext. 3234, fax 734-994-5123, wallman@erim-int.com, http://www.erim-int.com/CONF/conf.html.

July

July 11–16, **Meteoritical Society 62nd Annual Meeting,** Johannesburg, South Africa. Information: W. U. Reimold, Dept. of Geology, University of the Witwatersrand, Private Bag 3, P.O. Wits 2050, Johannesburg, South Africa, phone 27 11 716 2946, fax 27 11 339 1697, 065wur@cosmos.wits.ac.za.

September–October

September 26–October 2, **VII International Symposium on Mesozoic Terrestrial Ecosystems,** Buenos Aires, Argentina. Information: Georgina Del Fueyo, Av. Angel Gallardo 470, 1405 Buenos Aires, Argentina., imposio@musbr.org.secyt.gov.ar.

FUTURE GSA MEETINGS

2000 Reno, Nevada
November 13–16

2001 Boston, Massachusetts
November 5–8

2002 Denver, Colorado
October 28–31

2003 Seattle, Washington
November 2–5

October

October 13–17, **7th International Symposium on Fossil Algae**, Nanjing, China. Information: Mu Xi-nan, Nanjing Institute of Geology and Palaeontology, Academia Sinica, 39 East Beijing Road, Nanjing 210008, China, fax 86-25-335-7026, algae@pub.jlonline.com.

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

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Positions Open

HYDROGEOSCIENCES, VIRGINIA TECH

The Department of Geological Sciences at Virginia Polytechnic Institute and State University (Virginia Tech) extends its search for an Assistant Professor (tenure-track) in Hydrogeosciences.

The successful candidate must have expertise in data collection and quantitative analysis of field observations. Areas of interest include: Environmental geochemistry of natural aquifer systems in sedimentary and fractured crystalline terranes, multiphase fluid flow in aquifer systems using deterministic and stochastic techniques, deterministic/stochastic modeling of fluid-flow systems in petroleum reservoirs.

A Ph.D. is required at the time of appointment. Application closing date is September 1, 1998. Interested applicants should send a letter of interest, curriculum vitae, transcripts, names of three references, a statement of anticipated research and teaching interests, along with a short essay explaining where the applicant would like to see him/herself within the geosciences in the 21st century. Applicants should send their application package to Cahit Coruh, Chairman, Department of Geological Sciences, Virginia Tech, 4044 Derring Hall, Blacksburg, VA 24061-0420; Phone: 540-231-6894; fax: 540-231-3386; E-mail: coruh@vt.edu. For detailed information about the Department, applicants are encouraged to visit the Department's Home Page at http://www.geol.vt.edu/.

Virginia Tech is an equal opportunity/affirmative action employer.

HARVARD UNIVERSITY
DEPARTMENT OF EARTH & PLANETARY SCIENCES
JUNIOR FACULTY POSITION (REVISED 8/98)

The Department of Earth and Planetary Sciences at Harvard University seeks to fill a faculty position at the assistant or untenured associate professor level. We are interested in candidates who investigate the processes and evolution of the Earth and planets through studies of the physical and chemical properties of rocks, minerals, and melts. The incumbent will be expected to develop a strong research program and to teach at the undergraduate and graduate levels. Applicants should send a statement of research and teaching interests, curriculum vitae and the names of three referees to Prof. Roberta Rudnick, Chair, Petrology Search Committee, Department of Earth and Planetary Sciences, Harvard University, 20 Oxford Street, Cambridge, MA 02138. Applications should be received by September 15, 1998. Harvard University is an Affirmative Action/Equal Opportunity Employer. We particularly encourage applications from women and minorities. For more information about the department you may visit our web site at: www.eps.harvard.edu.

UCLA
NEOTECTONICS FACULTY POSITION

The Department of Earth and Space Sciences, University of California, Los Angeles, invites applications for a ladder faculty position at the assistant or associate professor level in the general areas of neotectonics, paleoseismology, quantitative geomorphology, and surficial processes. We are particularly interested in candidates who can integrate field observations with one of the following disciplines: (1) quantitative modeling of landform evolution due to interaction of neotectonics and surficial processes, (2) monitoring surface deformation and evolution using space geodetic techniques (e.g., radar interferometry, SPOT imagery, GPS), (3) modeling crustal and mantle dynamics using patterns and histories of Quaternary land surface deformation, (4) earthquake hazard assessments, and (5) Quaternary chronology of land surfaces and dating offset geologic features along active faults. The Department has active programs in monitoring and forecasting of southern Californian earthquakes, the tectonics of Asia and North American Cordillera, mantle dynamics, and planetary sciences. Interested applicants should send a resume, a list of three references, and other relevant documentation to: Neotectonics Search Committee, Department of Earth and Space Sciences, P.O. Box 1567, University of California, Los Angeles, CA 90095-1567.

Deadline for applications is September 1, 1998. The University of California is an equal opportunity employer.

STRUCTURAL GEOLOGY -- PETROLEUM GEOLOGY
WEST VIRGINIA UNIVERSITY

The Department of Geology & Geography invites applications for a tenure-track faculty position in structural geology. The appointment will be at the level of beginning assistant professor, effective January or August 1999, and the Ph.D. degree is required at the time of appointment.

We are seeking an individual who is adept in both quantitative and field approaches to geological research and teaching. This individual will be expected to collaborate with others in the department and to establish linkages with the petroleum industry. The successful candidate will have demonstrated research capabilities in structural geology and petroleum geology, and he or she should be able to effectively teach undergraduate courses in these two fields and supervise M.S. and Ph.D. students. The candidate should be able to teach a large section of introductory geology and to participate in the team-teaching of our capstone field camp. In addition, the successful candidate must attract external research funding. Additional information is available on-line at http://www.geo.wvu.edu.

Interested candidates should submit a curriculum vitae including a list of publications, grants, a statement of teaching and research interests, transcripts from graduate schools, and contact information for five references to: Dr. Richard Smosna, Chair of Search Committee, Department of Geology & Geography, Box 6300, West Virginia University, Morgantown, WV 26506. Review of applications will begin on September 1 and will continue until the position is filled. West Virginia University is an equal opportunity/affirmative action employer.

HARVARD UNIVERSITY
DEPARTMENT OF EARTH & PLANETARY SCIENCES
NEAR-SURFACE PROCESSES

The Department of Earth and Planetary Sciences at Harvard University seeks to fill a faculty position at the assistant or untenured associate professor level in the geology, geophysics and/or geochemistry of near-surface processes. Areas of interest include, but are not limited to, sedimentary geology, tectonic geomorphology, neotectonics, volcanology, glaciology, geobiology, and isotope geochronology. The successful candidate will be expected to develop a strong research program and to teach at the undergraduate and graduate levels. Applicants should send a statement of research and teaching interests, curriculum vitae, and the names of three referees to: Prof. Paul F. Hoffman, Chair, Near-Surface Processes Search Committee, Department of Earth and Planetary Sciences, Harvard University, 20 Oxford St., Cambridge, MA 02138 (617-495-3636). Deadline for applications is September 15, 1998. Harvard University is an Affirmative Action/Equal Opportunity Employer. We particularly enclurage applications from women and minorities. For more information about the Department, visit our web site at: www.eps.harvard.edu.

GEOLOGY
CUNY STATEN ISLAND
SEARCH REOPENED

The Department of Applied Sciences of the College of Staten Island, a senior college of The City University of New York, seeks candidates for an anticipated tenure-track position as assistant professor of Geology, beginning February or September 1999. CSI is located on a new 204-acre campus equipped with first-rank teaching and research facilities. Required: Ph.D. in Geology with postdoctoral experience preferred, demonstrated commitment to research,grants, and publication; and excellence in undergraduate teaching. The new faculty member will be expected to have credentials that qualify for appointment to the CUNY doctoral faculty. The successful candidate will be expected to teach undergraduate geology courses to liberal arts students, establish a vigorous and productive research program, and interact with members of the environmental science, engineering, and/or physics faculty. Preference will be given to the following fields of research: Environmental Geosciences, Geophysics, Engineering Geology, and Hydrology. Salary range: $38,587–$52,213, commensurate with qualifications. Review of applications will begin immediately and continue until the position is filled. Send letter of application that describes teaching experience and research interests, curriculum vitae, and the names, addresses, and telephone numbers of at least three references to Professor A. Ohan, Chair, Geology Search Committee, Department of Applied Sciences, College of Staten Island/CUNY, 2800 Victory Blvd., Staten Island, NY 10314. EEO/AA/ADA employer. Liz Seder, College of Staten Island/CUNY South Administration (1A) room 202, 2800 Victory Blvd., Staten Island, NY 10314; tel (718) 982-2331; fax 718-982-2274; e-mail seder@postbox.csi.cuny.edu

PROCESS GEOMORPHOLOGIST

The Maryland Geological Survey invites applications for the position of Geologist III or IV (Geomorphology option). The work will be divided between small-watershed research for the Maryland Geological Survey (MGS) and stream restoration projects for the Watershed Restoration Division (WRD), both organziations being part of the Maryland Department of Natural Resources (DNR). The successful candidate will devote equal time to: (1) planning, coordinating, and conducting investigations of non-biological processes of small watersheds, the interaction of these processes, and the influence they have on the streams that drain the watersheds; and (2) planning and designing stream restoration projects and providing technical assistance to various governmental agencies and to others in the implementation of stream restoration activities. This position will collaborate with other State, County, Federal, and academic small-watershed programs. Minimum qualification: Geologist III Master's degree in the field of geology with geomorphology emphasis plus 2 years experience, or Ph.D. with geomorphology specialization. Geologist IV Master's degree plus 4 years experience, or Ph.D. with 2 years experience. Starting base salary: Geologist III, $30,257. Geologist IV, $35,061. Merit system with benefits. Send resume and employment application request to: Ms. Jeanne Gary, Administrative Officer, Maryland Geological Survey, 2300 St. Paul Street, Baltimore, MD 21218. Deadline for applications is September 15, 1998. The state of Maryland is an 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 - Tod A. Frolk-

ing, Chair, Department of Geology and Geography, Denison Universty, Granville, OH 43023; (740) 587-6217; frolking@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.

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 sediemnts, metasediments and intrusives dominate the geologic record of the state, with a surficial blanket of late Quaternary glacigenic 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/EO 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.

GEOMORPHOLOGIST -- DARTMOUTH COLLEGE

The Department of Earth Sciences at Dartmouth College invites applications for an entry level, tenure-track position at the rank of assistant professor in geomorphology. Fields of particular interest include, but are not limited to, landscape/climate interaction, tectonic geomorphology, and geologic hazards. The successful candidate will be expected to demonstrate excellence in both teaching and research, develop a vigorous externally funded research program, and advise student research at the BA, MS, and Ph.D. levels. A strong field component of research is essential.

Send curriculum vitae, list of publications, description of teaching and research interests and objectives, and the names, addresses (including street address), e-mail addresses and fax/phone numbers of at least three references to: Search Committee, Department of Earth Sciences, Dartmouth College, 6105 Fairchild Hall, Hanover, NH 03755. E-mail: earth.sciences@ dartmouth.edu; web pages: http://www.dartmouth. edu/~earthsci.

Applications will be accepted until October 15, 1998. The appointment will be effective July 1, 1999.

Dartmouth College is an equal opportunity/affirmative action employer. Women and minorities are encouraged to apply.

OREGON DEPARTMENT OF GEOLOGY AND MINERAL INDUSTRIES

The Oregon Department of Geology and Mineral Industries is recruiting for an experienced field geologist in Baker City, Oregon. The position will involve geologic mapping/investigations statewide. Applicants with a broad range of expertise will be favored. This position has a salary range of $2765 to $3865 per month.

The position's chief duty will be to develop peer-reviewed geologic maps and geologic hazard and mineral resource reports for publication. Position will be responsible for preparation of some grant and contract proposals. Applicants should be familiar with digital methods for preparing geologic maps and 3-dimensional geologic framework models. Candidates should also be well versed in Cenozoic continental volcanic provinces and Quaternary surficial deposits.

Successful applicant will need to be able to work with the public in individual and group settings and be able to explain complex geologic concepts to non-technical people. Position will involve some technical presentations. Applicants must be registered or capable of being registered as a professional geologist in Oregon. Master's degree in geology or related geoscience field with 2 years experience or relevant coursework/experience required. Resumes and references to be mailed to Oregon Department of Geology and Mineral Industries, 1831 First Street, Baker City, OR 97814 (541-523-3133, fax 541-523-5992). Application forms and job announcements will be mailed to applicants. Applications must be submitted by October 15, 1998.

The Oregon Department of Geology and Mineral Industries is an equal opportunity employer. The Department is responsible for ensuring that accurate geologic and geological hazard and resource data is made available to the public in a timely manner.

ASSISTANT PROFESSOR OF STRUCTURAL GEOLOGY / ACTIVE TECTONICS

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

LOW-TEMPERATURE GEOCHEMISTRY
HARVARD UNIVERSITY
DEPARTMENT OF EARTH & PLANETARY SCIENCES

The Department of Earth and Planetary Sciences at Harvard University seeks to fill a faculty position in the general area of low-temperature geochemistry. The appointment will be made at the assistant or untenured associated professor level. Candidates from all fields of low-temperature geochemistry are encouraged to apply: areas of interest include, but are not limited to, biogeochemistry, geochronology (particularly of surficial and sedimentary processes), continental weathering and continent-ocean exchanges, and applications of cosmogenic isotopes to surficial processes. The successful candidate will be expected to develop a strong research program and to teach at the undergraduate and graduate levels. Applicants should send a statement of research and teaching interests, curriculum vitae, and the names of three referees to: Geochemistry Search Committee, Department of Earth and Planetary Sciences, Harvard University, 20 Oxford Street, Cambridge, MA 02138. Applications should be received by September 15, 1998. Harvard University is an Affirmative Action / Equal Opportunity Employer. We particularly encourage applications from women and minorities. For more information about the department, you may visit our web site at: www.eps.harvard.edu.

QUATERNARY GEOLOGIST

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.

NRC To Study Basic Research Opportunities in Earth Sciences at NSF

At the request of the Earth Sciences Division of the National Science Foundation (NSF), the National Research Council (NRC) is conducting a study that will evaluate opportunities for basic research in the solid-earth sciences at the National Science Foundation. The study, which is expected to be completed in late 1999, will form the basis of a new long-range plan for NSF's Earth Sciences Division. It will be written by a committee operating under the auspices of the NRC Board on Earth Sciences and Resources.

The committee will (1) identify priority research opportunities in the solid-earth sciences as they relate to the responsibilities of the Earth Sciences Division; (2) consider the role of the NSF in the context of related activities being conducted or sponsored by other government agencies, industry, and international partners; and (3) explore linkages between research and societal needs. In order to meet this charge, efforts will be made to obtain input from members of the scientific community. For example, the NRC and the NSF will cosponsor sessions at several major scientific conferences, including the GSA 1998 Annual Meeting in Toronto.

For more information about this NRC activity, contact Anthony R. de Souza, (202) 334-2744, adesouza@nas.edu).

Preregistration Due
September 18

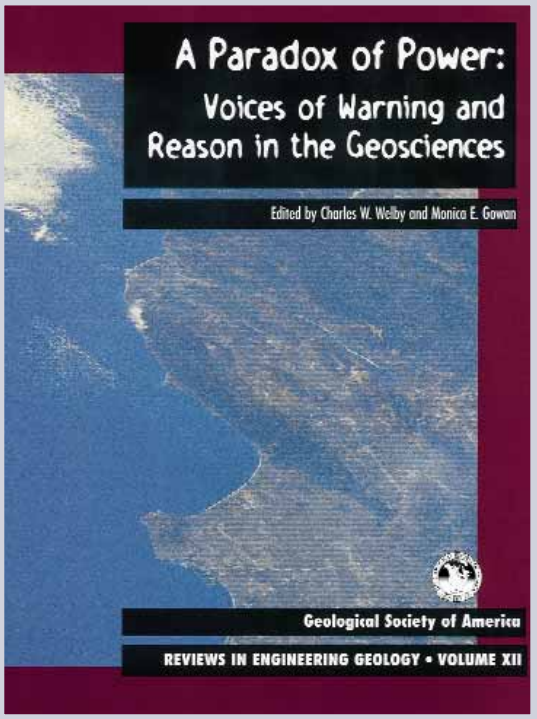
See June *GSA Today* or Web site for:
- Technical Program
- Short Courses
- Field Trips
- Exhibits
- Registration
- Housing and Travel

Technical Program Schedule
September *GSA Today* and the Web

FOR INFORMATION:
GSA Meetings Department, P.O. Box 9140, Boulder, CO 80301, • (303) 447-2020, (800) 472-1988, meetings@geosociety.org, http://www.geosociety.org/meetings/98

1998 ANNUAL MEETING AND EXPOSITION **October 26–29, 1998**

EDITED BY
Charles W. Welby and Monica E. Gowan, 1998



The 13 papers in this volume illustrate issues and opportunities confronting geologists as they bring their knowledge and understanding to bear in matters related to public health and welfare. Public decisions and decision-making processes in the face of geologic complexity and uncertainty are the subject of the first group of papers. In the second group, several "voice of warning" papers illustrate the use of geologic knowledge and research to warn the public of health hazards derived from geologic materials and processes. A third group of papers, in the "voice of reason" section, describes use of geologic knowledge to help lower the costs of mitigation and avoidance of geologic hazards. Finally, ethical and philosophical questions sometimes confronting geoscientists are discussed in a fourth group of papers, which address issues of "truth" as related to the legal process and questions about the adequacy of information in making decisions about long-term radioactive waste disposal.

REG012, 192 p., indexed, ISBN 0-8137-4112-2, $64.00, Member price $51.20

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