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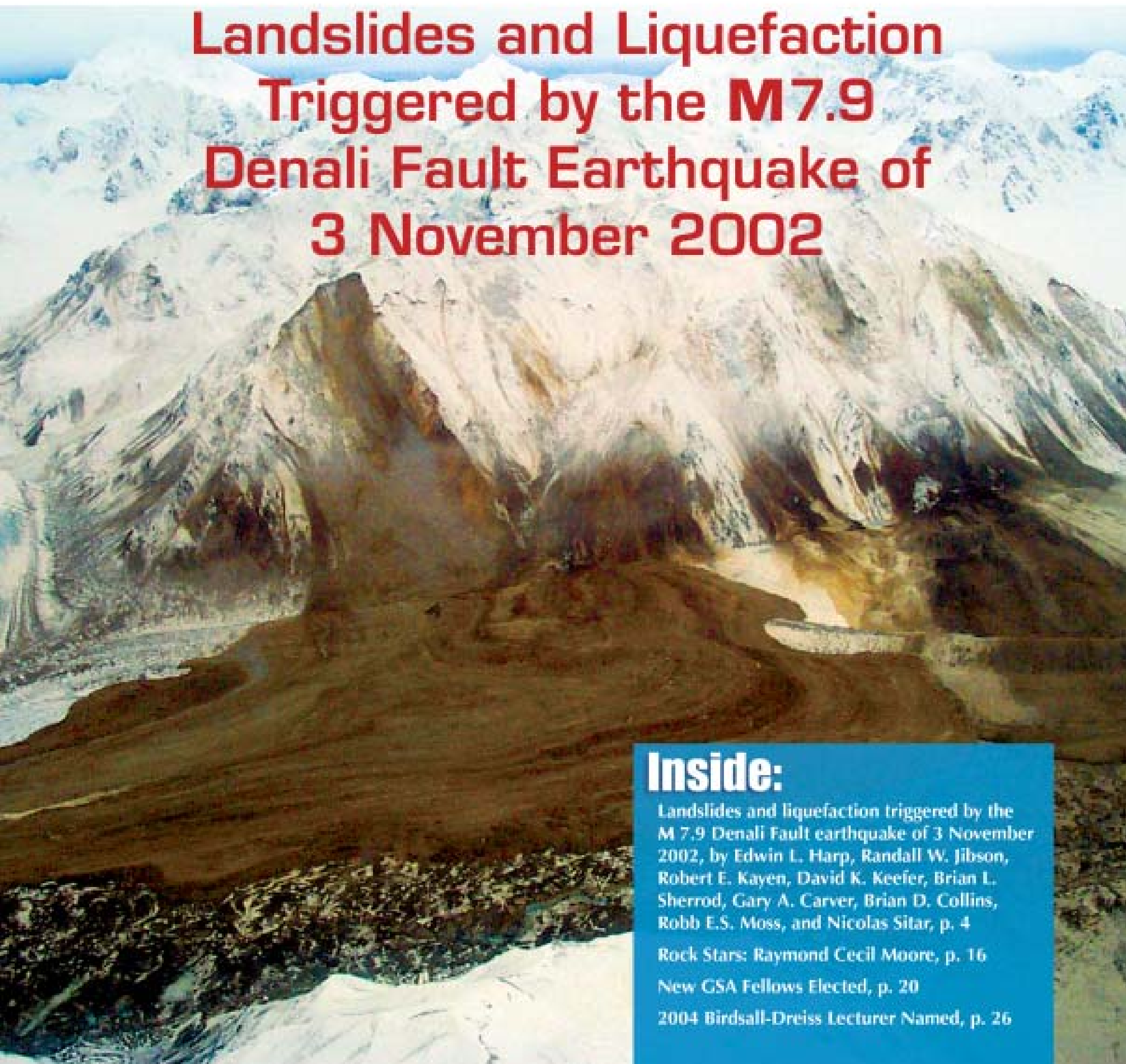

Landslides and Liquefaction Triggered by the M7.9 Denali Fault Earthquake of 3 November 2002

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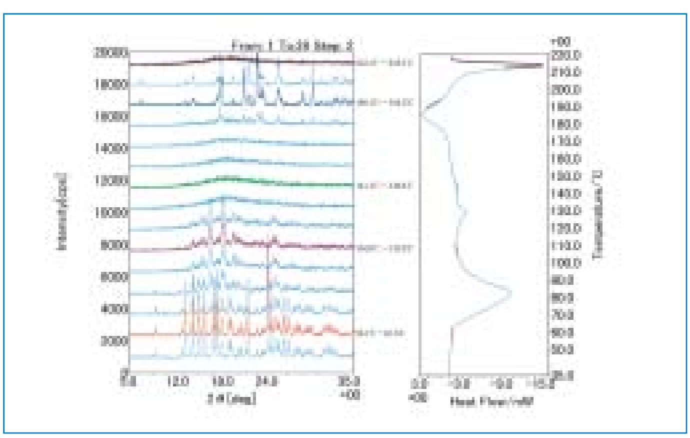

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Cover: Rock avalanches triggered by the 3 November 2002 Denali Fault earthquake in Alaska are spread across the 2.5-km-wide Black Rapids Glacier in the Alaska Range. The avalanches originated from steep mountainsides along the south side of the glacially carved valley, crossed the entire width of the valley, and draped over a 15 m-high medial moraine on the glacier. See "Landslides and liquefaction triggered by the **M** 7.9 Denali Fault earthquake of 3 November 2002" by E.L. Harp et al., p. 4–10.

SCIENCE ARTICLE

Landslides and liquefaction triggered by the M 7.9 Denali Fault earthquake of 3 November 2002

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ABSTRACT

The moment magnitude (**M**) 7.9 Denali Fault earthquake in Alaska of 3 November 2002 triggered an unusual pattern of landslides and liquefaction effects. The landslides were primarily rock falls and rock slides that ranged in volume from a few cubic meters to the 40 million-cubic-meter rock avalanche that covered much of the McGinnis Glacier. Landslides were concentrated in a narrow zone ~30 km wide that straddled the fault rupture zone over its entire 300 km length. Large rock avalanches all clustered at the western end of the rupture zone where acceleration levels are reported to have been the highest. Liquefaction effects, consisting of sand blows, lateral spreads, and settlement, were widespread within susceptible alluvial deposits extending from Fairbanks eastward several hundred kilometers. The liquefaction effects displayed a pattern of increasing concentration and severity from west to east and extended well beyond the zone of landslides, which is unusual. The contrasting patterns formed by the distributions of landslides and liquefaction effects initially seemed to be inconsistent; however, preliminary analyses of strong-motion records from the earthquake offer a possible explanation for the unusual ground-failure patterns that are related to three subevents that have been discerned from the earthquake records.

INTRODUCTION

South-central Alaska and the Alaska Range were severely shaken on the morning of 3 November 2003 by a (moment magnitude) **M** 7.9 earthquake.[1] The quake triggered more than 300 km of surface rupture along the Denali Fault and numerous landslides and liquefaction failures within the central part of the Alaska Range and surrounding areas (Eberhart-Phillips et al., 2003). Landslides triggered by the earthquake were mainly rock falls and rock slides containing different amounts of ice and snow. The most spectacular landslides triggered by the shaking were large rock and ice avalanches that occurred on the Black Rapids Glacier, the Gakona Glacier, the West Fork Glacier, and the McGinnis Glacier. These landslides ranged in volume from several hundred thousand cubic meters to 40 million cubic meters. Widespread liquefaction occurred within alluvial deposits of rivers and streams in and adjacent to the central Alaska Range and within artificial fills in the same area. Surface manifestations of liquefaction were mainly lateral-spreading cracks and sand boils. Subsidence effects also were observed in structures at Fielding Lake and along the Alaska Pipeline. Only one strong-motion seismometer was present within the near field. Patterns of triggered landslides and liquefaction effects taken together with teleseismic data provide most of the evidence of the variation of strong shaking.

PATTERN OF FAULT RUPTURE

The November 3 earthquake, one of the largest in U.S. history, resulted primarily from right-lateral movement on the Denali-Totschunda Fault system (Fig. 1). The Denali Fault is one of the longest strike-slip fault systems in the world; it consists of numerous strands along its 2000 km length and is comparable in size to the San Andreas Fault, which produced the M 7.8 San Francisco earthquake of 1906 (Miller et al., 2002). The Totschunda Fault, a major splay of the Denali Fault system, extends ~200 km from the U.S.-Canada border northwest to its junction with the Denali Fault at Mentasta Pass (Plafker et al., 1994; Plafker et al., 1977). The Denali and Totschunda Faults both display evidence of recent movement.

The **M** 7.9 mainshock was preceded by a **M** 6.7 foreshock on 23 October 2002 (Fig. 1) on the Denali Fault. The epicenter of the mainshock was ~25 km east of the foreshock. The mainshock consisted of multiple subevents (Kikuchi and Yamanaka, 2002). The first subevent was a **M** 7.2 thrust event near the Susitna Glacier. This event then triggered a second subevent (Fig. 1), a right-lateral rupture on the Denali Fault near the West Forks Glacier. During a third subevent (Fig. 1), right-lateral rupture propagated eastward along the Denali Fault for 225 km (Frankel et al., 2002) and continued for ~50 km southeastward on the Totshunda Fault. Right-lateral slip averaged ~3.5 m and ranged from 0.5 to almost 9 m. A maximum of ~3.5 m of vertical movement occurred as both thrust and normal slip. Old degraded fault scarps (Plafker et al., 1977) observed at many places were re-ruptured during the November 3 event.

The fault ruptured across the route of the Trans-Alaska pipeline (TAPS). The

[1]Boldface "M" indicates moment magnitude. Standard "M" used when the type of magnitude is not specified.

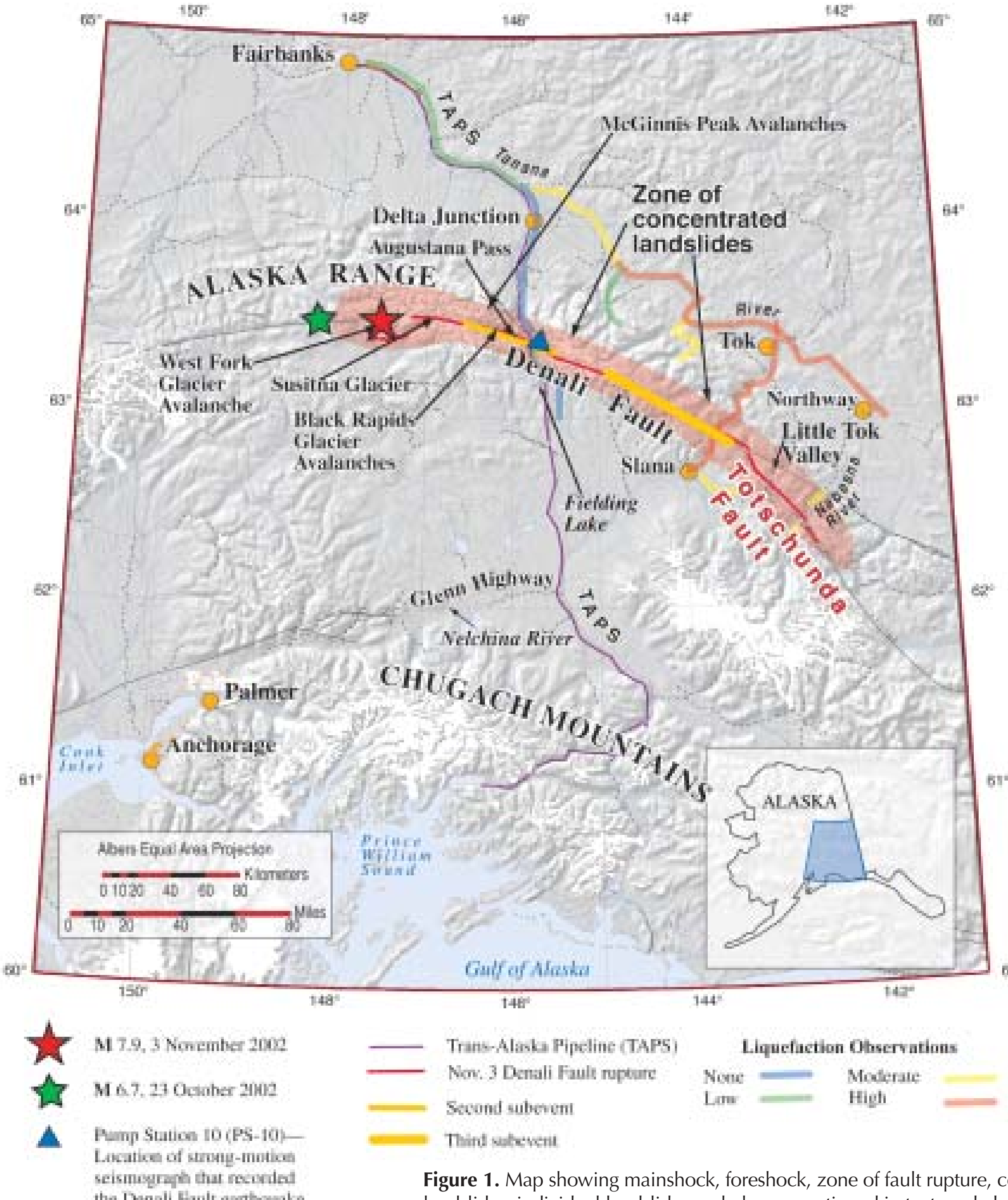

Figure 1. Map showing mainshock, foreshock, zone of fault rupture, concentrated landslides, individual landslides and places mentioned in text, and observations of liquefaction effects triggered by the Denali Fault earthquake of 3 November 2002.

pipeline's earthquake monitoring system and pipeline personnel initiated an automatic shut-down after the earthquake. Supports for the pipeline were damaged, causing the pipeline to sag in a few places, but the pipeline did not break and alarm systems worked as designed. Some minor subsidence of the pipeline occurred due to liquefaction within artificial fill ~500 m south of the fault rupture. The pipeline was designed and built to withstand the effects of a M 8.0 earthquake generating as much as 8 m of slip.

LANDSLIDES TRIGGERED BY THE EARTHQUAKE

The violent, prolonged shaking from the Denali Fault earthquake triggered thousands of landslides from the steep slopes of the Alaska Range and surrounding areas. The distribution of landslides was determined by reconnaissance from both fixed-wing aircraft and helicopter. The landslides ranged in size from a few cubic meters of dislodged rock to large rock avalanches of 5–40 million cubic meters triggered from steep rock cliffs bordering large valley glaciers. Avalanche deposits of rock and ice blanketed large sections of the Black Rapids and McGinnis Glaciers.

An unusual aspect of the landslides triggered by this earthquake was their narrow concentration along the fault rupture. Normally, an earthquake of this magnitude would be expected to trigger abundant landslides over a very broad region extending perhaps 350 km from the fault and covering an area of 25,000 to perhaps 75,000 km^2 (Keefer, 1984,

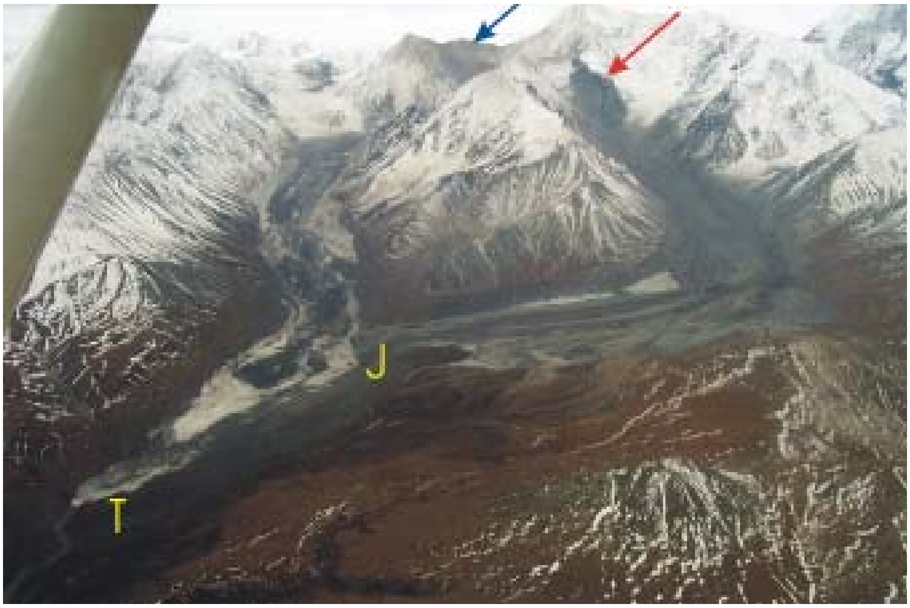

Figure 2. McGinnis Peak landslides. Two huge rock avalanches originated from different flanks of McGinnis Peak. The avalanche to the right (red arrow denoting head scarp) is composed mainly of rock and is ~40 million m^3 in volume. The runout path of this avalanche is ~10 km. The avalanche to the left (blue arrow denoting head scarp) has more ice and snow included within the avalanche debris. The landslides converged in the lower left part of the photo (J), and the avalanche on the left continued down to the toe of McGinnis Glacier (T).

2002). In this earthquake, the majority of landslides clustered in a narrow band ~30 km wide that straddles the fault for more than 300 km (Fig. 1). Only a few rock falls were found at greater distances from the fault, despite the fact that highly susceptible, steep slopes of intensely fractured rock are abundantly present beyond the observed 15 km limit on each side of the fault. The most distant triggered landslides we observed were a few scattered rock falls in the Chugach Mountains near Palmer, Alaska, ~250 km southwest of the fault. The pattern of landslides suggests that shaking levels necessary to trigger abundant rock falls and rock slides were focused in a narrow band centered along the fault zone rather than extending radially outward for great distances. With few seismic instruments in this region, the pattern of landsliding may be one of the best indicators of the pattern of ground shaking.

By far the most impressive landslides were large rock avalanches that spilled onto glaciers in the Alaska Range. These were reminiscent of avalanches triggered by the 1964 **M** 9.2 Alaska earthquake in the Chugach Range (Tuthill and Laird, 1966). All of the 2002 avalanches were located along the fault rupture between the first and second subevents. The largest of these, the McGinnis Peak landslide (scar shown by arrow in Fig. 2), involved ~40 million m^3 of metamorphic rock and 10% glacial ice that collapsed from a southeast ridge of McGinnis Peak, struck the glacier below the rock face, and then flowed ~10 km down the glacier (Fig. 2). About 7 km into its travel path, the avalanche debris followed a turn of ~70° in the glacier valley and ran up on the valley walls on the outside of the turn 60–80 m, indicating a high velocity of movement. Snow 50–70 m high on valley walls was covered with dust, suggesting that the landslide generated a thick dust plume in front of it. Avalanches triggered by other earthquakes have moved at speeds of up to 250–300 km per hour (Plafker et al., 1971). The toe of the McGinnis Peak

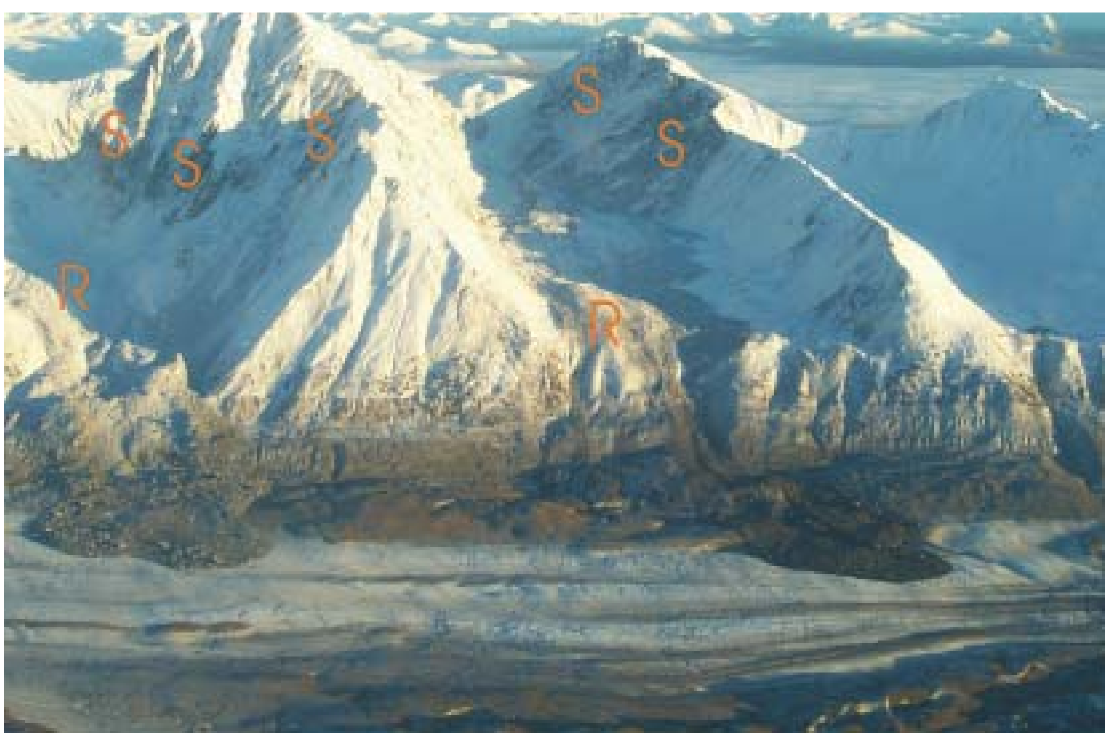

Figure 3. Rock avalanches deposited on the surface of the West Fork Glacier near the earthquake epicenter. “S” indicates source areas within the cirques where recent snow obscures their features. “R” indicates runout paths of the avalanche deposits.

Figure 4. Deposit of one of the West Fork Glacier avalanches consisting primarily of huge blocks. The block shown (with a person for scale) is ~20 m in longest dimension.

rock avalanche eventually butted up against another similar rock and ice avalanche that was triggered from the southern ridge of the peak. The toe of this avalanche traveled another kilometer past this junction almost to the toe of McGinnis Glacier. This avalanche contained significantly more ice and snow, perhaps as much as 30% of the volume of the deposit.

When we compared the runout distance of the McGinnis Peak rock avalanche with those of other avalanches worldwide, using data from Shaller (1991) and Evans and Clague (1988), we find that the McGinnis Peak rock avalanche plots within the data cluster of landslides similar in volume, indicating that its runout distance is not exceptional despite the entire runout path being on ice.

Several other large rock avalanches were triggered from granite slopes along the south margin of the Black Rapids Glacier. The three largest of these landslides each had volumes of several million cubic meters. They cascaded down steep rock slopes, crossed a lateral moraine at the valley's margin, and then spread out ~2.5 km across the glacier-filled valley, coming to rest against the opposite valley wall. The deposits were uniformly thin, 2–3 m in most areas, including where the avalanche debris spread up and over a 15 m high medial moraine. The earthquake opened deep fissures adjacent to some of the landslide source areas above Black Rapids Glacier. These fractures delineate incipient landslides even larger than those triggered in the November 3 earthquake that may reactivate in future earthquakes, heavy rainfall, or snowmelt episodes.

Two large rock avalanches were triggered above the West Fork Glacier (Fig. 3) from near-vertical slopes in two glacial cirques, shown in Figure 3. As the dislodged rock moved rapidly down the cirques, debris from the avalanche to the left in Figure 3 became airborne for a short distance as it traveled over the lateral moraine at the edge of the valley and spread out as it fell onto the glacial surface. Parts of the lee side of this lateral moraine were undisturbed by the avalanche, indicating that at least some of the avalanche debris must have been airborne to avoid impact with this part of the moraine. The deposit of this avalanche mainly consisted of large blocks of metamorphic rock (possibly as much as 70% by volume); some individual blocks were more than 20 m on a side (Fig. 4). Thicknesses of the deposits ranged between 3 and 15 m.

LIQUEFACTION OF HOLOCENE RIVER DEPOSITS

Liquefaction-induced ground failures were widespread throughout east-central Alaska to distances well beyond the 15 km limit from the rupture that is shown by most other landslides. Liquefaction is a phenomenon that occurs in a buried layer of unconsolidated, water-saturated, generally small to medium sand-sized sediment during prolonged shaking in an earthquake. In liquefaction, the sedimentary particles in the buried layer reorient themselves to occupy less space and force water out of pore spaces. Overlying layers that are unsaturated or more consolidated (or frozen) find themselves rafted on a layer of liquefied soil that has little or no shear strength and become destabilized, moving downhill (lateral spreading) and fracturing to allow the water to escape in sand boils. Liquefaction from the Denali Fault earthquake induced debris flows, lateral-spreading failures, and sand boils.

The distribution of liquefaction effects depended upon the location of susceptible deposits, which were mainly alluvial deposits along the rivers in the area and also included lake-margin sediments and artificial fill. Reconnaissance by air and by driving parts of the sparse surface road network suggested that liquefaction effects extended out from the surface rupture for ~100–120 km; however, this limit is not well determined. In addition to liquefaction features, soil slides and flows were observed within fine-grained deposits along the banks of the Nelchina River south of the Glenn Highway, ~200 km from the zone of fault rupture.

Liquefaction effects increased notably in severity and spatial extent toward the east end of the rupture zone (Fig. 1). On the north side of the Alaska Range in the Tanana River valley (Fig. 1), at 50–120 km from the zone of fault rupture, we saw extensive evidence of liquefaction where fluvial deposits of sand and silt were capped by a thin (<0.3 m) frozen surface layer. Liquefaction within the Tanana River valley was widespread from Fairbanks on the west to at least several hundred kilometers eastward. Liquefaction damage became increasingly severe to the east of Delta Junction, even as distance from the fault increased. In the Tok area, nearly every river bar contained extensive liquefaction effects. Farther east, for many kilometers around the towns of Northway and Slana, large continuous lowland areas of liquefaction and lateral-spread failures were observed. Two measured transects along the Tanana River at Tetlin Bridge, west of Tok, showed 3%–4% of lateral spreading of sand bars across

Figure 5. Polygonal cracks in frozen surface of floodplain deposits of Tanana River. For several hundred kilometers along the Tanana River (here near the town of Tetlin Junction), a pattern of polygonal surface fractures defined liquefaction-induced laterally deforming ground. The polygons formed when the frozen crust (≤0.3 m thick) above liquefied ground fractured and displaced.

distances of 200 m (21 fissures) and 400 m (48 fissures). In some places separate lateral spreads collided and their frozen crusts buckled and thrust over one another, resulting in contraction of as much as 4.5 m. Parallel fissures formed locally where the ground spread laterally toward the river. More commonly, the frozen ground surface displayed randomly oriented sublinear fissures, which formed polygon networks that could be traced for several kilometers (Fig. 5).

In the Northway area, a region of lowlands with swamps, liquefaction-related ground failures were ubiquitous. The Northway area is 130–180 km from the section of maximum displacement on the Denali Fault and ~80 km from the closest point on the Totschunda Fault rupture. Lateral spreading rendered the airport at Northway unusable. The frozen surface layer and paved runway at Northway were cut by fissures, many 10–30 cm wide with some 1 m wide or greater, spaced meters to tens of meters apart. Fractures as wide as 1 m and as long as 10 m opened along the perimeter of the runway and vented silt, coarse to fine sand, and pebbles. Associated with the sand boils were sinkholes as much as 4 m in diameter and 1 m deep. Anecdotal reports from residents describe water and soil spewing 2–4 m into the air. Parallel and polygonal patterns of lateral spreads similar to those observed in the Tanana River bars were observed at Northway, both in the paved runways and in the surrounding undeveloped areas. Away from the runway, houses and structures were unseated and tilted on their foundations, and road settlement bent and crushed drainage culverts.

The flood plain of the Nabesna River, 10–15 km from the eastern end of the

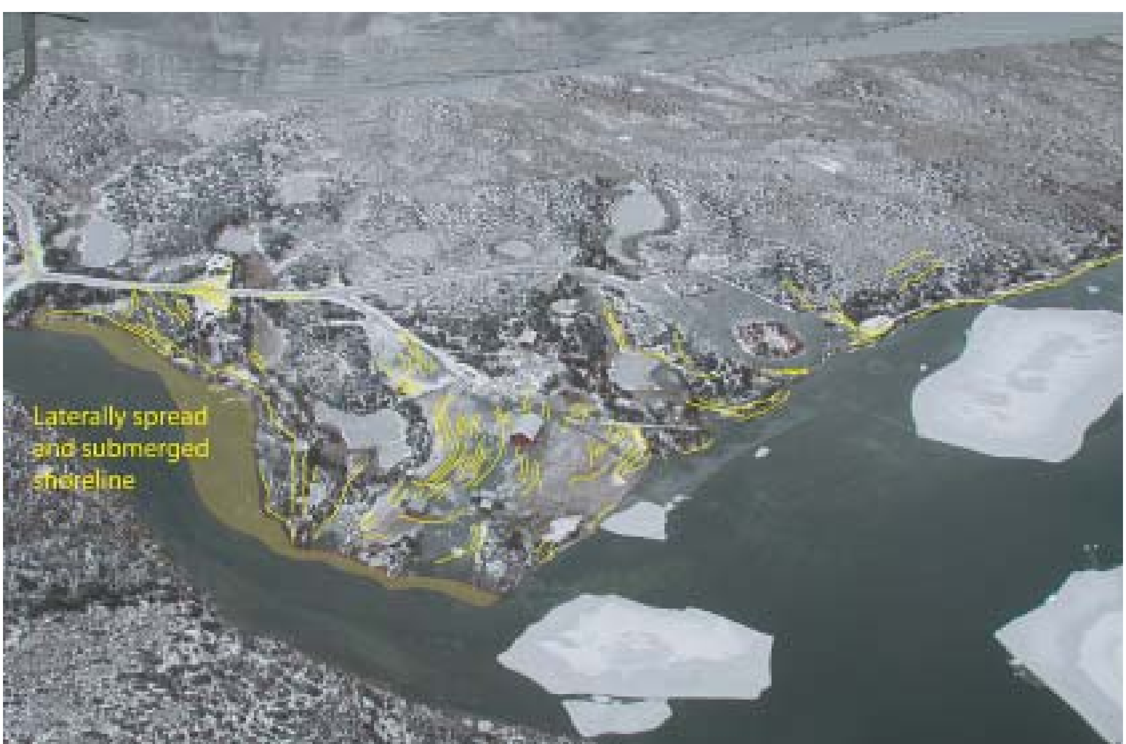

Figure 6. Lateral spreads and sand vents above liquefied ground at Fielding Lake Park was observed from the air and later mapped. The pattern of fissures (yellow lines) are generally across slope as ground slid toward low land areas and the lakeshore.

Totschunda Fault rupture, was cut by numerous fissures, most with sand boils. In contrast to the finer-grained sediment (silty sand) in the Tanana River and Northway regions, the liquefaction at the Nabesna River valley was in gravelly sand.

Widespread liquefaction, lateral spreading, sand boils, and submerged ground were observed at Fielding Lake, where the upper soil crust was not frozen at the time of the earthquake (Fig. 6). Structures on the spreading ground were deformed and displaced, including an underground septic tank that was buoyed to the surface, lifting an outhouse.

Approximately 11 km north of Fielding Lake and ~500 m south of the fault rupture, minor damage was done to the Alaska pipeline where the pipeline and a regulator valve sank 75 cm into artificial fill that liquefied during the shaking. About 300 m south of this point, there were isolated sand boils and lateral-spreading cracks in the alluvium of the Delta River.

Concentrations and severity of liquefaction effects were especially high over a large region near the eastern end of the ruptured Denali Fault and the Totschunda Fault, where the fault displacement was greatest (Fig. 1).

In addition to liquefaction, cracking of ice on lakes is another measure of ground shaking. A number of lakes dot the region, many of which were partially frozen at the time of the earthquake. Cracking of lake ice due to ground shaking was prevalent over the entire region. Cracked lake ice was observed within 30–40 km of the fault along the western part of the rupture, whereas to the east, lake-ice cracking extended ~100 km away from the fault. This eastward increase resembles the regional pattern of liquefaction.

COMPARISON OF LANDSLIDE AND LIQUEFACTION DISTRIBUTION WITH STRONG-MOTION CHARACTERISTICS OF THE EARTHQUAKE

Both landslides and liquefaction effects from the Denali Fault earthquake occur within the 30-km-wide zone that parallels the fault rupture, but liquefaction effects also extend significantly outside this zone, a relationship that is unusual for ground-failure distributions in earthquakes. Keefer's (1984) data from 40 worldwide earthquakes show that the distance limits from both epicenter and fault-rupture zone for landslides and liquefaction-induced failures are close to each other at earthquake magnitudes of 7.5–8.5, but that landslide limits are still greater than limits of liquefaction. Further, the concentration of the large rock avalanches near the first two subevents is also in contrast with the broad eastward distribution and concentration of liquefaction effects in the area of the third subevent of the earthquake. In the eastern part of the area, liquefaction effects were much more extensive and deformation more severe than in areas to the west near the first and second subevents. Because the earthquake was recorded by only one strong-motion instrument in the near field (Pump Station #10 near the fault rupture along the Richardson Highway, PS-10), it is impossible to completely resolve these apparent inconsistencies in the two distributions of ground failure. However, preliminary analysis of teleseismic data has allowed some insight into the problem and some tentative explanations.

Landslide Distribution

The narrow concentration of rock falls, rock slides, and large rock avalanches along the fault-rupture zone suggests that the highest accelerations generated from this earthquake did not extend far from the fault zone. Failures in brittle rock are sensitive to high accelerations commonly within the higher frequencies of ground motion. Relative to other earthquakes of comparable or lower magnitudes (1987 Ecuador M 6.9; 1970 New Guinea M 7.1; 1976 Darien, Panama M 7.0; 1977 San Juan, Argentina M 7.4; 1970 Peru M 7.9) for which landslide concentrations have been measured or estimated (Keefer, 1993) the Denali earthquake had significantly lower concentrations of rock falls and rock slides. Lower concentrations of rock falls and rock slides suggest that the earthquake shaking was deficient in high-frequency energy and high peak accelerations. The maximum recorded acceleration (which is still being confirmed; C. Stephens, 2003, personal commun.) of 0.34–0.40 *g* (PS-10) 3 km north of the fault rupture along the Richardson Highway is a fairly modest peak acceleration for an earthquake of this magnitude. During the 1994 Northridge, California, earthquake (**M** 6.7), accelerations exceeded 1.0 *g* and triggered more than 11,000 landslides with concentrations of hundreds of slides per square kilometer (Harp and Jibson, 1995). Because the first subevent of the Denali Fault earthquake was a **M** 7.2 thrust in the epicentral area, we would have expected to see similar landslide concentrations there as we saw from the Northridge earthquake. Although large rock avalanches were triggered in this area, we were surprised that the overall concentrations of landslides were significantly lower than those triggered by the Northridge earthquake.

Keefer's (2002) relationship between areas affected by landslides and earthquake magnitude shows that the mean area affected by a **M** 7.9 earthquake is ~28,000 km^2. Based on the landslide distribution shown in Figure 1, the area affected by the November 3 earthquake measures only 10,000 km^2. In contrast, the area affected by landslides triggered by the 1964 Alaska earthquake of **M** 9.2 was ~200,000 km^2, and the farthest landslides were triggered 700 km from the epicenter (Keefer, 1984, 2002).

Few landslides were triggered west of the epicenter; most of the landslides, including the large rock avalanches, were located east of the epicenter. This pattern is clearly consistent with the propagation of the second and third subevents of the earthquake, which were directed to the east (A. Frankel, 2003, personal commun.). To the west of the epicenter, areas of concentrated rock falls and rock slides disappear within 30 km of the epicenter, whereas to the southeast, the zone of concentrated rock falls and rock slides extends more than 300 km.

All of the largest landslides clustered near the first two subevents, suggesting that this was the area of strongest shaking. These two subevents contained the largest accelerations of the earthquake record (Frankel et al., 2002). The **M** 7.2 thrust that formed the first subevent may have played a major role in the triggering of large rock avalanches, because thrust events generally have higher-frequency ground motion and higher accelerations than strike-slip events of similar magnitudes. Farther to the east, the absence of large avalanches of rock or snow near where the third subevent began suggests that shaking levels were too low.

Distribution of Liquefaction Effects

The increase in liquefaction effects to the east stands in contrast to the pattern of landslides. We attribute this contrast to the fact that landslides and liquefaction effects are sensitive to different ground-shaking parameters. Failures in brittle rock are sensitive to high accelerations commonly within the higher frequencies of ground motion. Small rock failures can be created with extremely short durations of high accelerations. Liquefaction-induced failure of saturated sediments is often more responsive to shaking duration than to short pulses of high acceleration. The liquefaction process is highly sensitive to repetitive cycles of shear strain (Seed and Lee, 1966). To liquefy, saturated sand, silt, or gravel requires multiple cycles of shear strain to move the grains with respect to each other so that densification can occur and pressurize the interstitial water. Thus, it is not surprising that the effects of liquefaction are more severe and concentrated in areas near the third subevent, because the rupture from this subevent is much longer than that of the second subevent (48 km vs. 27 km), and the rupture took longer, giving an expected longer duration for shaking than either the first or second subevents (A. Frankel, 2003, personal commun.).

SUMMARY OF LANDSLIDE AND LIQUEFACTION DISTRIBUTION

The distributions of landslide and liquefaction effects triggered by the Denali Fault earthquake of 3 November 2002 were unusual in many aspects. Preliminary analysis of the strong-motion characteristics of the earthquake suggest that the distribution of landslides is consistent with the patterns of strong shaking. Duration of shaking, rather than acceleration levels, may have largely determined the distribution and severity of liquefaction effects.

Only one strong-motion instrument (PS-10) was present to record shaking in the near field, so these distributions may provide useful insights into the spatial variations of shaking. Several preliminary conclusions can be drawn from the distribution of landslides and liquefaction effects.

- The accelerations generated by the earthquake were only moderate in amplitude for a magnitude 7.9 event. The maximum recorded acceleration was 0.33–0.40 *g*.
- Acceleration levels high enough to trigger concentrated rock falls and rock slides extended relatively short distances, ~15 km, from the zone of fault rupture.
- The lack of extreme concentrations of rock falls and rock slides within the epicentral area and the near field of the earthquake suggest that high frequencies and attendant high accelerations were missing from this earthquake.
- The clustering of large rock avalanches within the area of the first two subevents of the earthquake is consistent with these subevents containing the highest accelerations of the earthquake record. No large avalanches were present in the area of the third subevent, which generated high displacements associated with it but relatively lower accelerations (Frankel et al., 2002).
- Landslides extended only short distances to the west of the epicentral area of the earthquake, whereas to the east, they extended for over 300 km along the zone of fault rupture, presumably because of the eastward extension of shaking that attended the eastward propagation of fault rupture.
- Liquefaction features were observed well beyond the zone of concentrated landslides, an unusual situation suggesting that minimum shaking levels and duration requirements for liquefaction extended well beyond the zone of acceleration levels high enough to trigger rock falls and rock slides.
- The higher concentrations and severity of liquefaction effects to the east, in the area of the third subevent of the earthquake, suggest that ground-motion durations were longer in that area during the earthquake, resulting from a longer slip event.

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Manuscript submitted February 20, 2003; accepted May 28, 2003. ▲

Call for Geological Papers:
2004 GSA Section Meetings

South-Central Section
March 15–16, 2004
Texas A&M University, College Station, Texas
Abstract deadline: December 16, 2003
Information: Christopher Mathewson, Texas A&M University, Department of Geology & Geophysics, 3115 TAMU, College Station, TX 77843-3115, (979) 845-2488, mathewson@geo.tamu.edu

Northeastern–Southeastern Sections Joint Meeting
March 25–27, 2004
Hilton McLean Tyson's Corner, Washington, D.C.
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Information: George Stephens, George Washington University, Department of Earth & Environmental Sciences, 2029 G St., NW, Washington, D.C. 20052-0001, (202) 994-6189, geoice@gwu.edu; Rick Diecchio, George Mason University, Department of Environmental Science & Policy, MS 572, 4400 University Dr., Fairfax, VA 22030-4444, (703) 993-1208, rdiecchi@gmu.edu

North-Central Section
April 1–2, 2004
Millennium Hotel, St. Louis, Missouri
Abstract deadline: January 6, 2004
Information: Joachim O. Dorsch, Saint Louis University, Department of Earth & Atmospheric Science, 3507 Laclede Ave., St. Louis, MO 63103-2010, (314) 977-3124, dorsch@eas.slu.edu

Rocky Mountain–Cordilleran Sections Joint Meeting
May 3–5, 2004
Center on the Grove, Boise, Idaho
Abstract deadline: January 27, 2004
Information: C.J. Northrup, Boise State University, Department of Geosciences, 1910 University Dr., Boise, ID 83725, (208) 426-1009, cjnorth@boisestate.edu

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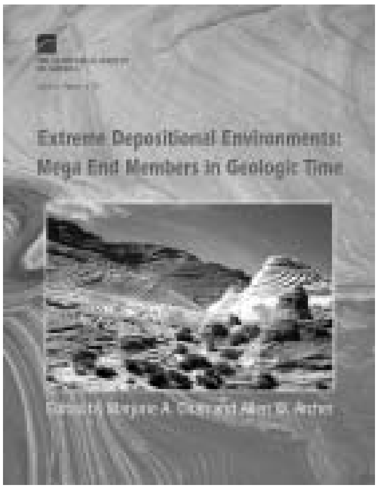

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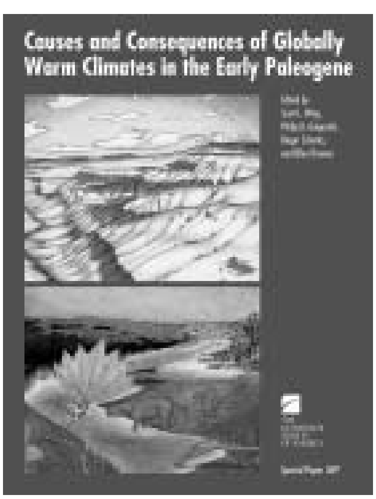

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PREMEETING

1. **Island and Coastal Hydrogeology of Hawaii [401]**

Sun.–Fri., Oct. 26–31. Stephen B. Gingerich, U.S. Geological Survey, 677 Ala Moana Blvd., #415, Honolulu, HI 96813, (808) 587-2411, fax 808-587-2401, sbginger@usgs.gov; Stephen Wheatcraft. Min.: 10; max.: 20. Cost: $690. (1L, R, 5ON, vans). *Begins on the Big Island of Hawaii and ends on Oahu.*

2. **Glacial Lake Missoula, Clark Fork Ice Dam, and the Floods Outburst Area: Northern Idaho and Western Montana [402]**

Wed.–Fri., Oct. 29–31. Norman Smyers, USDA–Forest Service, Lolo National Forest, Bldg. 24, Fort Missoula, Missoula, MT 59804, (406) 329-3775, fax 406-329-3795, nsmyers@fs.fed.us; Roy Breckenridge. Min.: 12; max.: 42. Cost: $290. (3L, R, 3ON, bus). *Begins and ends in Spokane, Washington.*

3. **Sequence Stratigraphy of the Sauk Sequence: 40th Anniversary Field Trip in Western Utah [403]**

Wed.–Sat., Oct. 29–Nov. 1. Cosponsored by *GSA Sedimentary Geology Division.* Kevin Evans, Dept. of Geography, Geology, and Planning, Southwest Missouri State University, Springfield, MO 65804, (417) 836-5590, fax 417-836-6006, kre787f@smsu.edu; Jim Miller, Ben Dattilo. Min.: 10; max.: 30. Cost: $295. (3B, 3L, R, 4ON, vans). *Begins and ends in Salt Lake City, Utah.*

4. **Tectonic Geomorphology and the Record of Quaternary Plate Boundary Deformation in the Olympic Mountains [404]**

Wed.–Sat., Oct. 29–Nov. 1. Frank J. Pazzaglia, Dept. of Earth and Environmental Sciences, Lehigh University, 31 Williams, Bethlehem, PA 18015, (610) 758-3677, fax 610-758-3667, fjp3@lehigh.edu; Glenn Thackray; Mark T. Brandon; Eric McDonald; John Gosse; Karl Wegmann. Min.: 8; max.: 24. Cost: $525. (3B, 4L, 3D, R, 3ON, vans).

5. **Wine and Geology—The Terroir of Washington State [405]**

Thurs.–Fri., Oct. 30–31. Cosponsored by *Society of Economic Geologists.* Lawrence D. Meinert, Dept. of Geology, Washington State University, Pullman, WA 99164-2812, (509) 335-2261, fax 509-335-7816, meinert@wsu.edu; Alan J. Busacca. Min.: 12; max.: 44. Cost: $315. (2L, 2D, R, 1ON, bus).

6. **Coastal Evolution, Dynamic Shoreline Processes, and Beach Management Controversies of the Columbia River Littoral Cell, Southwest Washington and Northern Oregon [406]**

Thurs.–Sat., Oct. 30–Nov. 1. Cosponsored by *GSA Sedimentary Geology Division.* Sandy Vanderburgh, Dept. of Geography, University College of the Fraser Valley, 33844 King Road, Abbotsford, British Columbia V2S 7M8, (604) 504-7441, ext. 4336, fax 604-855-7558, vanderburghs@ucfv.bc.ca; Guy Gelfenbaum; Curt Peterson; Harry Jol; Jim Phipps. Min.: 12; max.: 40. Cost: $415 (3L, 1D, R, 2ON, bus).

7. **Columbia River Basalt and Yakima Fold Belt [407]**

Thurs.–Sat., Oct. 30–Nov. 1. Stephen Reidel, Pacific Northwest National Laboratory, K6-81, P.O. Box 999, Richland, WA 99352, (509) 376-9932, fax 509-376-5368, sp.reidel@pnl.gov; Bart Martin; Heather Petcovic. Min.: 12; max.: 22. Cost: $290 (2L, R, 2ON, vans).

8. **Cretaceous to Paleogene Cascades Arc: Structure, Metamorphism, and Timescales of Magmatism, Burial, and Exhumation of a Crustal Section [408]**

Thurs.–Sat., Oct. 30–Nov. 1. Cosponsored by *GSA Structural Geology and Tectonics Division.* Robert Miller, Dept. of Geology, San Jose State University, San Jose, CA 95192-0102, (408) 924-5025, fax 408-924-5053, rmiller@geosun.sjsu.edu; Jennifer Matzel; Scott Paterson; Harold Stowell. Min.: 12; max.: 35. Cost: $305 (3L, 2D, R, 2ON, vans).

9. **Late Pleistocene Fluctuations of the Puget and Okanogan Lobes of the Cordilleran Ice Sheet: Alpine Glaciation of the North Cascades, Washington [409]**

Thurs.–Sat., Oct. 30–Nov. 1. Don J. Easterbrook, Dept. of Geology, Western Washington University, Bellingham, WA 98225, (360) 650-3583, fax 360-650-7302, dbunny@cc.wwu.edu. Min.: 12; max.: 24. Cost: $340 (3L, R, 2ON, mini-bus).

10. **Engineering Geology in the Central Columbia Valley [410]**

Fri.–Sat., Oct. 31–Nov. 1. Cosponsored by *GSA Engineering Geology Division. Tom Badger, Washington State* Department of Transportation, P.O. Box 47365, Olympia, WA 98504-7365, (360) 709-5461, fax 360-709-5585, badgert@wsdot.wa.gov; Dick Galster. Min.: 12; max.: 24. Cost: $200 (2L, R, 1ON, vans).

11. **Regional Tertiary Sequence Stratigraphy and Regional Structure on the Eastern Flank of the Central Cascade Range, Washington [411]**

Fri.–Sat., Oct. 31–Nov. 1. Cosponsored by *GSA Sedimentary Geology Division; Northwest Geological Society.* Eric S. Cheney, Dept. of Earth and Space Sciences, University of Washington, Box 351310, Seattle, WA 98195-1310, (206) 543-1190, fax 206-543-0489, vaalbara@u.washington.edu. Min.: 7; max.: 21. Cost: $245 (2L, R, 1ON, vans).

12. Biogeochemical Processes at Ancient Methane Seeps: The Bear River Site in Southwestern Washington [412]

Sat., Nov. 1. Steven R. Benham, Dept. of Geosciences, Pacific Lutheran University, Tacoma, WA 98447, (253) 535-7378, fax 253-536-5055, benhamsr@plu.edu; James Goedert. Min.: 12; max.: 20. Cost: $125 (1L, R, vans).

13. Holocene Lahars along the White River Between Mount Rainier and Seattle [413]

Sat., Nov. 1. Cosponsored by *GSA Sedimentary Geology Division.* Paul Zehfuss, Dept. of Earth and Space Sciences, University of Washington, Box 351310, Seattle, WA 98195-1310, (206) 543-6229, fax 206-685-2379, pzehfuss@u.washington.edu; Brian Atwater; James Vallance. Min.: 7; max.: 20. Cost: $140 (1L, R, vans).

14. Late Pleistocene Glacial History of Whidbey Island, Washington [414]

Sat., Nov. 1. Terry W. Swanson, Quaternary Research Center and Department of Earth and Space Sciences, University of Washington, Box 351310, Seattle, WA 98195-1310, (206) 543-1923, fax 206-543-3836, tswanson@u.washington.edu. Min. 12; max.: 44. Cost: $95 (1L, R, vans, ferry).

15. Pleistocene Tephrostratigraphy and Paleogeography of Southern Puget Sound Near Olympia, Washington [415]

Sat., Nov. 1. Cosponsored by *GSA Sedimentary Geology Division.* Timothy J. Walsh, Washington DNR, Division of Geology and Earth Resources, P.O. Box 47007, Olympia, WA 98504-7007, (360) 902-1432, fax 360-902-1432, tim.walsh@wadnr.gov; Robert L. Logan; Michael Polenz; Marvin A. Lanphere; Thomas W. Sisson. Min.: 7; max.: 20. Cost: $210 (1L, R, vans).

16. Recent Geoarchaeological Discoveries in Central Washington [416]

Sat., Nov. 1. Cosponsored by *GSA Archaeological Geology Division.* Gary Huckleberry, Dept. of Anthropology, Washington State University, Pullman, WA 99164-4910, (509) 335-4807, fax 509-335-3999, ghuck@wsu.edu; Jerry Galm; Stan Gough; Brett Lenz. Min.: 12; max.: 38. Cost: $80 (1L, R, vans).

POSTMEETING

17. Evolution of a Polygenetic Ophiolite: The Jurassic Ingalls Ophiolite, Washington Cascades [417]

Wed.–Fri., Nov. 5–7. Gregory Harper, Dept. Earth and Atmospheric Sciences, SUNY, Albany, NY 12222, (518) 442-4476, fax 518-442-5825, gdh@albany.edu; Robert Miller; Jonathan Miller. Min.: 12; max.: 30. Cost: $250 (2L, R, 2ON, vans).

18. Geohydrology of the Hanford Nuclear Waste Site in the South-Central Columbia Plateau [418]

Wed.–Fri., Nov. 5–7. Roy E. Gephart, Pacific Northwest National Laboratory, P.O. Box 999, MS K8-88, Richland, WA 99352, (509) 376-1421, fax 509-376-0846, roy.gephart@pnl.gov; Steve Reidel; Frank Spane; Karl Fecht. Min.: 7; max.: 20. Cost: $240 (2L, R, 2 ON, vans). *Due to security restrictions, only U.S. citizens can enter the Hanford Site on this tour.*

19. Puget Sound Paleoseismology [419]

Thurs.–Fri., Nov. 6–7. Brian Sherrod, U.S. Geological Survey, Dept. of Earth and Space Sciences, Box 351310, University of Washington, Seattle, WA 98195, (206) 553-0153, fax 206-553-8350, bsherrod@ess.washington.edu; Alan Nelson; Harvey Kelsey; Carrie Garrison-Laney. Min.: 12; max.: 45. Cost: $170 (2L, R, vans).

20. Hydrogeology of Cascade Range Volcanoes: Mount St. Helens, Mount Hood, and Central Oregon [420]

Thurs.–Sat., Nov. 6–8. Cosponsored by *GSA Hydrogeology Division.* Steve Ingebritsen, U.S. Geological Survey, MS 439, 345 Middlefield Road, Menlo Park, CA 94025, (650) 329-4422, fax 650-329-4463, seingebr@usgs.gov; Terry Keith; Michael Manga; Larry Mastin. Min.: 12; max.: 40. Cost: $370 (2B, 3L, 2D, R, 2ON, vans).

21. Quaternary Geology of Seattle [421]

Thurs., Nov. 6. Cosponsored by *GSA Quaternary Geology and Geomorphology Division.* Kathy Goetz Troost, Dept. of Earth and Space Sciences, University of Washington, Box 351310, Seattle, WA 98195-1310, (206) 616-9769, fax 206-543-8954, ktroost@u.washington.edu; Derek Booth; Bill Laprade. Min.: 12; max.: 45. Cost: $105 (1L, R, bus).

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Paleontological Society Short Course

Bridging the Gap: Trends in Ostracode Biological and Geological Sciences

Sat., Nov. 1, 8 a.m.–5 p.m. Sponsored by *Paleontological Society.*

This short course is designed to bring together scientists working with ostracodes and ostracode specialists who do not usually interact on a regular basis. An international group of 13 scientists will present different approaches and new techniques used in ostracode studies. The goals are (1) to focus on establishing or strengthening methodological and conceptual links between studies of living ostracodes and studies of fossil ostracodes of Cenozoic age, and (2) to provide an avenue for further collaborative efforts and interdisciplinary research and education to graduate students and established scientists.

Faculty: Lisa Park and Alison Smith. No fee or registration required. Information: Lisa Park, Department of Geology, University of Akron, 252 Buchtel Commons, Akron, OH 44325-4101, (330) 972-7630, fax 330-972-7611, lepark@uakron.edu.

PS Members Take Note!

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Mon., Nov. 3, 11:30 a.m.–5:30 p.m. See on-site program for location. Cost: $38 for professionals; $15 for students.

ROCK STARS

Raymond Cecil Moore: A Great 20th Century Geological Synthesizer

Daniel F. Merriam, *Kansas Geological Survey, University of Kansas, Lawrence, Kansas 66047, USA*

R.C. Moore (1892–1974), administrator, researcher, teacher, world-class stratigrapher and paleontologist, linguist, and artist—a man of many talents—was born 20 February 1892 in Roslyn, Washington, in the Wenatchee Mountains. The eldest of four children born to Bernard Harding Moore, a Baptist minister of Irish descent, and Winifred Denney of Elk Falls, Kansas, Moore was educated at Denison University (Ohio) and granted an A.B. degree with honors in the classics in 1913. At Denison, he was introduced to geology by the learned geologist Frank Carney and was such a good student that he was hired to teach geology his senior year while Carney was on leave.

Moore continued his studies in geology at the University of Chicago and was awarded a doctorate (summa cum laude) three years later for his dissertation on the Early Mississippian formations of Missouri, supervised by Stuart Weller. His education at Chicago included instruction from the giants of the day—Weller, Thomas C. Chamberlain, Samuel W. Williston, and Rollin D. Salisbury. On completion of his studies at Chicago in 1916, he was hired as an assistant professor of geology at the University of Kansas and also state geologist and director of the State Geological Survey of Kansas. Moore replaced W.H. Twenhofel, who left for the University of Wisconsin after having been state geologist for just one year. Twenhofel had replaced the retiring Erasmus "Daddy" Haworth, although Haworth continued as chairman of the department (Merriam, 1975, 2002; Maples and Buchanan, 1989).

R.C. Moore dressed for fieldwork in the early 1930s.

Almost immediately, Moore turned his attention to refining the Permo-Pennsylvanian stratigraphy of the Midcontinent. His attention to detail allowed him to correlate individual beds as thin as 5 cm from Nebraska southward to Oklahoma; his measured sections are impeccable. From this detail, he was able to formulate his ideas on cyclic sedimentation and "genetic stratigraphy," as he phrased it, a forerunner of what we know today as sequence stratigraphy. He was particularly interested in the succession of depositional environments and he defined them by unique fossil assemblages. Many of these studies were the basis for a series of Kansas Geological Society field conferences in the 1930s, a summary publication on the Pennsylvanian of Kansas in 1936, and the revised and updated geological map of Kansas, published in 1937 with co-author Kenneth K. Landes. His flair for organization and technicalities was evident with these activities as he coerced and cajoled his colleagues into a uniform stratigraphic code for the Midcontinent. (He later showed these same abilities as chairman of the U.S. Committee on Stratigraphic Nomenclature and the Committee on Zoological Nomenclature.)

Moore envisioned individual cyclothems to consist of genetically related units, that is, a succession of sediment types deposited in a shallow epicontinental sea by a single advance and retreat of the sea. He extended the original concepts of J.A. Udden and J.M. Weller on cyclothems to a bundle of related cyclothems (usually five, each represented by the culminating marine limestone separated by thick nonmarine clastics), which he termed a "megacyclothem." Moore noted testily:

> The notion that any geologist seriously challenges the existence of many orderly successions of lithologically (and paleontologically) differing sorts of rock layers in the Pennsylvanian-Permian part of the geologic column of Kansas and other regions seems preposterous, unless excuse is made for such a geologist that he is grossly uninformed of field facts. (Moore and Merriam, 1959, p. 46)

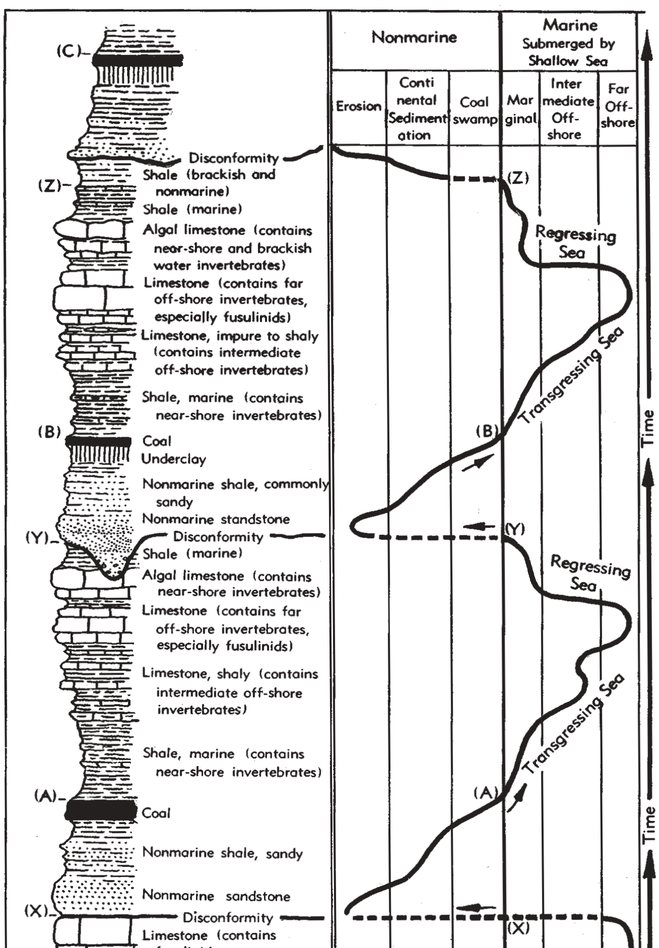
Moore used a rather elaborate classification for the genetic units based on a decimal-type system. He believed this classification was necessary because the genetic units (cyclothems) could not be mapped easily and there would be no ambiguity with rock units using such a dual classification. He envisioned a similar scheme for his megacyclothems, but neither scheme was adopted by other field geologists.

Using his extensive background in Permo-Pennsylvanian stratigraphy of the Midcontinent and Kansas in particular, Moore took an integral part in the discussions of the 1940s concerning rock cycles and facies as did L.L. Sloss, W.C. Krumbein, E.C. Dapples, H.R. Wanless, and J.M. Weller. In 1949, Sloss, Krumbein, and Dapples defined sequence in its modern sense as the rock sequence or operational unit between operational datum horizons (unconformities) in the Paleozoic of the mid-American craton and named the intervals. These sequences correspond approximately timewise (in a stratigraphic sense) to Joseph Barrell's major depositional cycle (1917), M.K. Elias' grand cycle (1936), and P.D. Krynine's tectonic cycle (1941). Moore suggested the term "magnacycle" to describe these large cycles, but it was never accepted, and sequence prevailed.

Moore entered the arena on facies in 1949 with his defining paper "Meaning of Facies" as an introduction to the Geological Society of America's Memoir 39. In this paper, he sought to clarify the use of terms and classification for the description of variations that characterize cyclic sediments, especially in Permo-Pennsylvanian units of the Midcontinent. He later pioneered the use of ecological communities (ecosystems) to help understand cyclothems. Based on his extensive field work in the Kansas Permo-Pennsylvanian section, he identified and described 20 representative ecologic communities (Moore, 1964). He concluded that (1) many different paleobiotopes could be distinguished, and (2) these communities could be used to test the paleoecological interpretation of cyclically arranged sedimentary deposits. This was Moore's last contribution to the subject, albeit an important one.

Moore had a steel-trap mind and total recall so that he never forgot a person, detail, or place. He could identify a person from his past with complete confidence, recall an event, or locate an outcrop measured decades before; he had an uncanny sense of time and place. The thoroughness and orderliness of his legalistic mind with which he outlined the stratigraphy of Kansas is obvious, as his

R.C. Moore in the field in 1962.



Advancing sea at Lawrence, Kansas, in Pennsylvanian time (sketch by R.C. Moore).

classification stands today—essentially unchanged—as he proposed it. As the stratigraphic and sedimentological framework took form, he focused his attention on invertebrate paleontology. He showed his versatility in the subject by working with flora as well as fauna, particularly with corals, crinoids, gastropods, and bryozoans. His paleontological work culminated in the classic and yet-used textbook *Invertebrate Fossils* published in 1952 with co-authors C.G. Lalicker and A.G. Fischer. His lasting contribution was in the conception, organization, and implementation of the *Treatise on Invertebrate Paleontology.* This gigantic undertaking was envisioned by Moore as early as 1948, with the first volume appearing in 1953. This ongoing synthesis rivals in scope Alexander von Humboldt's nineteenth century *Cosmos*, Carl Linnaeus' eighteenth century *Systema Naturae,* and Count de Buffon's *Histoire Naturelle.*

The list of services to Moore's chosen profession is almost endless as are his contributions to the Kansas Geological Survey, University of Kansas, and State of Kansas. He served as state geologist and director of the State Geological Survey of Kansas from 1916 to 1954 and as principal geologist thereafter. He was chairman of the Department of Geology on three separate occasions (1920–1939, 1940–1941, 1952–1954) and was named one of the first four distinguished professors of the university in 1958; he was accorded emeritus status in 1962.

Of the many honors and awards he received during his career, Moore was most proud that in 1973, the new Kansas Geological Survey building on (KU's) Campus West was named in his honor. He was recognized by many organizations, including his alma mater (Denison), the Philadelphia Academy of Natural Sciences, American Association of Petroleum Geologists, Paleontological Society, Academie Royale de Belgique, Geological Society of London, National Academy of

Sciences, and SEPM (Society for Sedimentary Geology). He served as an officer or on committees for many of these organizations. Two honors that he would have cherished but that eluded him were election to the National Academy of Sciences and the Penrose Medal from the Geological Society of America.

"Ol' Professor Ray Moore" was immortalized in a Pogo comic strip telling about the mythical bird, *Jayhawkornis kansasensis*. He lived to read his obituary after an incident on the Colorado River in which the famous 1923 Birdseye River mapping expedition was assumed lost after a flash flood. At 51, he volunteered for active military service in WWII and later served as a consultant to General Douglas MacArthur in Japan. He was fluent in French, German, and Dutch and conversant in several other languages; he was also a talented artist. Without doubt, he could have been successful in any field he chose.

Moore was an ambitious person with definite objectives. Outwardly, he was a cold and demanding person. In his younger days, he treated colleagues with indifference, and he had zero tolerance for incompetence. He was astringent and, as a result, perhaps unknowingly, made many professional enemies. This gruff treatment of friends and colleagues alike was, in his opinion, for their own good and was meant to correct their deficiencies. W.W. Hambleton described Moore in these words: "He possessed a large ego or, perhaps more appropriately, was comfortable in his knowledge of his own worth." But Moore did have a wily sense of humor, and as an example, named the Aarde Shale in 1932 for a farm in east-central Kansas just to assure that his proposed name was the first term in the stratigraphic lexicon—and it is. Inwardly, he was a good and caring person but, unfortunately, he did not know how to show affection. He mellowed considerably in his later years and to some, at least, he was a valued friend and ally.

Although his personal life remained private, it probably was not a very happy one, and family contacts were minimal. He was married twice and had a daughter by his first wife. He died in Lawrence, Kansas, on 16 April 1974 at the age of 82 while editing his beloved *Treatise*. He willed his estate to the University of Kansas and the Geological Society of America for continued support of the *Treatise*—his lasting legacy. Raymond Cecil Moore was the consummate and committed scholar.

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"Rock Stars" is produced by the GSA History of Geology Division. Editorial Committee: Robert Dott, Robert Ginsburg (editor of this profile), Gerard Middleton, Peter von Bitter, and E.L. (Jerry) Winterer.

Last Chance to Vote!

ATTENTION

Voting Members:

Vote by: Sept. 4, 2003

The success of GSA depends on the work of the elected officers who serve on its Executive Committee and Council. Make your wishes for GSA known by voting.

You should have received a postcard in July with instructions on how to access a secure Web site and your electronic ballot listing officer nominees for 2004 and councilor nominees for the term 2004 to June 2007. Biographical information on each candidate also is available on the site.

If you did not receive these instructions, or if you need paper copies of the ballot or candidate information, contact

GSA Sales & Service, (303) 447-2020, option 3, 1-888-443-4472, or gsaservice@geosociety.org.

Your vote is vital to GSA! Please take a few minutes and vote today. Ballots must be submitted electronically or postmarked by **September 4, 2003.**

GSA Fellows Elected by Council on May 3, 2003

Teofilo A. (Jun) Abrajano Jr.
Professor, Rensselaer Polytechnic Institute

Teofilo (Jun) Abrajano Jr. was elected to GSA Fellowship for his sustained contributions to research and education in geology and geochemistry. He has conducted innovative research on a wide range of topics, including mantle petrology, noble metal sulfide ore paragenesis, nuclear waste glass corrosion, low-temperature geochemistry, isotope biogeochemistry, and environmental geochemistry. He also has developed interdisciplinary degree programs in environmental science at two major universities.

Ariel Anbar
Assistant Professor, University of Rochester

Elected to Fellowship as the 2002 Young Scientist (Donath) Medalist.

Asish R. Basu
Professor, University of Rochester

Elected for fundamental contributions to our understanding of the geochemistry and isotopic composition of mantle peridotites, mantle plumes, and flood basalts.

Victoria C. Bennett
Fellow, Australian National University

Elected for her innovative contributions to understanding the nature of early Earth, evolution of crust-mantle systems, lithospheric structure, and the geochemistry of mantle plumes.

Marcia G. Bjornerud
Professor and Chair, Lawrence University

Elected for contributions to structural geology, in the field and in theory.

Kenneth R. Bradbury
Research Hydrogeologist and Professor, Wisconsin Geological and Natural History Survey

In addition to his more than 20 years of professional experience, Ken Bradbury has contributed substantially to our understanding of the hydrogeology of fractured rock, glacial deposits, and groundwater recharge through a combination of field research and numerical modeling. He has mentored numerous graduate students, successfully administered hydrogeology research programs at the Wisconsin Geological and Natural History Survey, and contributed to public service through public presentations, editorial responsibilities, and service to the GSA Hydrogeology Division.

John H. Calder
Geologist, Nova Scotia Department of Natural Resources

John Calder has made, and continues to make, tremendous contributions to the science of coal geology through his professional activities, teaching, publications, and organization of scientific meetings and field excursions. The Society has benefited greatly from his active participation in the GSA Coal Geology Division.

James L. Carew
Professor, College of Charleston

Elected in recognition of his 30-year career as a college-level educator of geologists, his outstanding publication record in carbonate geology, and his dedicated service to the profession in a wide variety of ways.

Donald R. Chesnut Jr.
Geologist and Paleontologist, Kentucky Geological Survey

Donald Chesnut was a research geologist at the Kentucky Geological Survey for 20 years and currently teaches paleontology at the University of Kentucky. He published 22 reports for the Kentucky Geological Survey, including one bulletin on the stratigraphy of the eastern Kentucky Coal Field that is considered a milestone. While at the survey, he made a number of discoveries in paleontology, including a rare Pennsylvanian insect wing, tetrapod trackway, and previously unknown plant fossils. He made significant contributions to the stratigraphic nomenclature for the Pennsylvanian of eastern Kentucky and the deposition of coal-bearing rocks.

Vincent S. Cronin
Associate Professor, Baylor University

Elected for outstanding effort at promoting ethical behavior in our profession through example, teaching, and work with GSA divisions.

Ralph K. Davis
Professor, University of Arkansas

Elected for contributions to the science and profession, Ralph Davis has served the public in scientific management of the water resource and has enhanced the science of the water resource. He has, more uniquely, contributed to the understanding and management of tribal water resources by working with tribal leaders over several decades. His publication record reflects the dual nature of his scientific research with traditional journal articles and refereed reports prepared for proprietary agencies on research under contract. He has contributed to the training of students by teaching, and supervision and funding of student research. He has been active in the profession, serving in elected positions and on committees.

Joseph J. Donovan
Associate Professor, West Virginia University

Elected for significant contributions to the field of hydrogeology through his applied research with the Montana Bureau of Mines and Geology, as a hydrogeology consultant, and in the last decade, with his research as an associate professor of geology at West Virginia University. He has published significant research papers, mentored and taught a large number of students, and is currently in charge of hydrology for the West Virginia Water Research Institute. Recently, he has worked with underground flow in manmade aquifers that are a result of coal mining and produce and discharge acid drainage. These include aquifers developed within both "spoil" deposits of waste rock and subsided underground mines. He is one of few workers in the field of hydraulics and flow/transport processes of such aquifers. His primary research focus is to understand the relationship between subsurface flow and geochemical phenomena that operate at relatively slow rates.

Robert F. Dymek
Professor, Washington University

Robert Dymek is an outstanding and highly productive scientist who has made important contributions to mineralogy and petrology as a professor and as an editor of a premier journal.

Lucy E. Edwards
Research Geologist, U.S. Geological Survey

Elected for her research contributions in quantitative biostratigraphy and graphic correlation, dinoflagellate biostratigraphy and biostratigraphy of aquifer systems; for her commitment to the teaching of stratigraphy; and for her dedicated and inspirational service to the professional organizations of the American Association of Stratigraphic Palynologists and of the North American Commission of Stratigraphic Nomenclature.

Graham E. Fogg
Professor, University of California at Davis

Elected for his contributions to developing our understanding of groundwater flow, dispersion and transport heterogeneous hydrogeological systems; for his studies developing methodologies to quantify heterogeneous systems; for his services in higher education; and for his public outreach, including presenting GSA's 2002 Birdsall-Dreiss lectures.

Jay M. Gregg
Gulf Oil Foundation Professor and Chair, University of Missouri—Rolla

Elected for his outstanding and continuing research contributions to the understanding of the origin of Dolomite, fluid-flow in the crust, and the formation of Mississippi Valley Type lead zinc deposits worldwide.

Mary C. Hill
Research Scientist, U.S. Geological Survey

Elected for significant contributions to the field of hydrogeology. With collaborators, she has written several codes that enhance or are incorporated into the current version of MODFLOW to overcome problems of parameter estimation and sensitivity analysis. MODFLOW is the most widely used computer code for modeling groundwater systems today. Hill has an outstanding publication record that documents her model development and her expertise in the application of groundwater models to understand complex systems. She has contributed to the training of students through teaching, mentoring, and lecturing activities. In addition, she has been active in professional societies, serving as the Darcy Lecturer of the Association of Ground Water Scientists and Engineers.

Russell J. Jacobson
Geologist and Acting Head, Coal Section, Illinois State Geological Survey

Russell Jacobson has expanded geologic knowledge by authoring or co-authoring more than 35 peer-reviewed articles and maps on the geology, stratigraphy, and coal resources of Illinois. In cooperation with representatives of the Indiana and Kentucky Geological Surveys, he has helped the three surveys agree on a common set of stratigraphic terms for the Pennsylvanian rocks of the Illinois Basin. He has contributed extensively to the ISGS's programs to expand the awareness of teachers and the general public about the influences of geology and geological processes in their daily lives by leading geology field trips for the general public, participating in workshops for teachers in Illinois, and, during his vacations, organizing and leading expeditions in which public participants excavate dinosaur bones and other fossils.

Jiu Jimmy Jiao
Assistant Professor, University of Hong Kong

Elected for his significant contributions to many aspects of hydrogeology, engineering geology, and their intersection. His work in quantitative analysis of coastal groundwater systems is particularly noteworthy.

William C. Johnson
Professor, University of Kansas

Elected for his seminal research on the Quaternary stratigraphy of the central Great Plains and for his service to the public and profession.

Timothy F. Lawton
Professor, New Mexico State University

Tim Lawton is an intellectual leader in studies of foreland sedimentation and inversion tectonics, and his recognition of an exposed salt weld in Mexico has provided an outcrop example of structural relations otherwise only imaged in the subsurface by seismic reflection. He is past chair of the GSA Sedimentary Geology Division.

Daniel R. Lux
Professor, University of Maine

Daniel Lux is elected for his outstanding contributions to understanding the thermal and compositional evolution of the continental crust through research into the timing of deformation and metamorphism, as well as the petrogenesis

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of igneous rocks. In addition, his impact on geology extends to his classes, where many Saturdays are spent bringing introductory students into the field where they can appreciate the importance of our science firsthand.

Harmon D. Maher Jr.
Professor, University of Nebraska—Omaha

Elected for contributions to southern Appalachian and Spitsbergen geology.

Rolfe D. Mandel
Project Coordinator, Geoarchaeology Research Program, Kansas Geological Survey

Rolfe Mandel has published a number of papers in respected journals on topics ranging from landscape evolution to geoarchaeology. His papers form the foundation for current understanding of stream behavior in the central Great Plains, and he is a recognized international authority on the geoarchaeology of caves and river valleys.

Royal H. Mapes
Professor, Ohio University

Royal Mapes' paleontological research and his world-class paleontological collections are significant scientific achievements. He has instructed and trained hundreds of students and has been a key factor for bringing many of them into the field of geology. He has an extensive record of administration, service, and editorial endeavors both within Ohio University where he has taught since 1978 as well as within the geological community at large.

Stephen J. Martel
Associate Professor, University of Hawai'i

Elected in recognition of his contributions to understanding how fractures and faults grow, and for public service to the earth sciences and general community.

John H. McBride
Professor, Brigham Young University

John McBride is an internationally known geologist and geophysicist and an authority in the field of seismic reflection geophysics. He is frequently asked to convene and/or participate in national and international symposia on basement tectonics and has a solid record of publishing in world-class journals. The significant impact of his research has been recognized and featured in articles in *GSA Today* and *Geotimes*.

William F. McDonough
Associate Professor, University of Maryland

William McDonough is an outstanding petrologist and geochemist who has made, and continues to make, strong contributions to our knowledge of continental lithosphere and upper mantle.

E. Donald McKay
Principal Scientist, Illinois State Geological Survey

Elected for his 28-year geological career, mainly managing an interdisciplinary geological research and service group, his admirable publication record, but most notably for implementing GIS technology into the field of geology.

James F. Miller
Professor, Southwest Missouri State University

Elected for his pioneering studies on the systematics and biostratigraphy of Upper Cambrian and Lower Ordovician conodonts, for his long-term involvement and leadership of the International Working Group on the Cambrian-Ordovician Boundary, sponsored by the Commission on Stratigraphy, and for his dedication and commitment to undergraduate geology education.

Isabel P. Montanez
Professor, University of California at Davis

Elected for her outstanding and continuing contributions to understanding the history of the atmosphere and oceans through geochemical studies.

Donald W. Neal
Associate Professor, East Carolina University

Donald Neal has a distinguished career as an educator and has provided much service to geological professional organizations. He has trained many geology students since 1979 and has a long history of service to professional societies starting with NAGT in 1979. He also has been and/or is currently an officer in GSA, SEPM, and Sigma Gamma Epsilon. He is current National President of SGE.

W. John Nelson
Senior Geologist, Illinois State Geological Survey

W. John Nelson is an outstanding field geologist and a recognized authority on the structural and stratigraphic framework of the Midcontinent U.S. He is often called upon to apply his expertise to help solve geologic problems in Illinois and surrounding states. His productivity and thoroughness are exceptional as is well illustrated by his publication record.

D. Kirk Nordstrom
Research Scientist, U.S. Geological Survey

D. Kirk Nordstrom has made significant contributions to the field of aqueous geochemistry and hydrology through his research on interdisciplinary problems and mentoring and advising students. He is well known for using field, laboratory, and modeling approaches to understand the fate and transport of toxic metals in the environment. His contributions to understanding the problems associated with acid mine drainage have provided the science to support decisions that state and federal agencies make for remedial actions. His expertise is sought nationally and internationally on issues related to radioactive waste disposal and evaluating mine-impacted sites.

Brenda Pierce
Program Coordinator,
Energy Resources Program, U.S. Geological Survey

Elected for contributions to coal geology, including important landmark research, management of projects both nationally and internationally, and the development and coordination of energy-related research. Pierce has organized and participated in a number of GSA Coal Geology Division activities including symposia, workshops, and fieldtrips, and has served as division chair.

André Pugin
Geologist, Illinois State Geological Survey

André Pugin is an outstanding scientist who possesses an extremely rare, if not unique, combination of skills that include field seismic data acquisition and design, data processing applications and design, and skillful geological interpretation. He has applied training and experience in glacial sedimentology and geophysics from his research in Europe, Asia, and Canada to acquiring shallow high-resolution seismic reflection profiles that have provided important new insights on Quaternary and groundwater geology in Illinois and on neotectonic structures in the Mississippian Embayment region of southern Illinois and western Kentucky.

Larry R. Rhodes
President, Rhodes Incorporated

Larry Rhodes is a registered professional geologist in several states and has worked diligently for professional recognition of the geology profession. He is well known in Kentucky for his support of geology and the outstanding geologic work he has done professionally. Kentucky Governor Paul Patton appointed him to the Board of Registration for Professional Geologists because of his stature in the state with regard to geology. He has held national and sectional offices in the American Institute of Professional Geologists, and contributes his time and talents for the benefit of the science.

John W. Robinson
Geologic Consultant

John Robinson has 28 years of successful petroleum industry experience and is a recognized leader in petroleum geology and stratigraphy of the Rocky Mountain region. He has been involved in exploration and development of several giant gas fields, and is regarded as an expert on gas-productive fluvial reservoirs. The quality of his research has been recognized by best paper awards, both verbal and written, and by leadership rolls in election as RMAG president (2002), and SEPM (RMS) president (1997).

Donald T. Rodbell
Associate Professor, Union College

Don Rodbell has contributed substantially to our understanding of glacial geology and climate change in South America, including late Quaternary variation in El Niño Southern oscillation. As an associate professor, he is training the next generation of geoscientists involved in Quaternary studies.

Roberta L. Rudnick
Professor, University of Maryland

Roberta Rudnick is a star in research on the composition and evolution of continental lithosphere. She integrates diverse observations from geology, geophysics, and geochemistry to create coherent models of the formation of continental lithosphere and the generation and flow of heat from the crust and mantle. Her work is characterized by intensive collaboration with students and other colleagues; nevertheless, her leadership, independence, and originality are clear.

Leslie F. Ruppert
Geologist, U.S. Geological Survey

Leslie Ruppert has contributed a great deal to our current understanding of coal formation and coal properties. This contribution has come in the form of very excellent individual and collaborative research and also from a project managerial standpoint. Her dedication and commitment to GSA has been nothing short of exemplary.

Ira D. Sasowsky
Associate Professor, University of Akron

Ira Sasowsky has made broad-based contributions to the hydrogeology profession and the science. With extensive experience in applied and basic science, he has published his results in many major journals. His students have followed his lead and, in many cases, his passion for speleology, as demonstrated by their publications and careers. He has been

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heavily involved in professional work including editing of books and symposium proceedings, serving on committees, and was responsible for converting *The Hydrogeologist* to an electronic format, making the GSA Hydrogeology Division an innovator and saving thousands of dollars in publishing costs. He continues his broad contributions as represented by his active involvement in GSA, AAPG, AGWSE, AGU, IUS, NSS, BCRA, and other professional organizations while continuing an active research program and teaching students.

Jane Selverstone
Professor, University of New Mexico

Elected in recognition of important scientific contributions to the fields of metamorphic petrology, tectonics, and the application of petrology and geochemistry to tectonic problems, excellence in teaching, and service to the profession.

William W. Shilts
Chief, Illinois State Geological Survey

William Shilts is elected based on his long career and significant contributions, primarily in environmental geochemistry, glacial sedimentology and stratigraphy, geological mapping, drift mineralogy, and mineral prospecting in glaciated terrain. Since becoming chief of the Illinois State Geological Survey in 1995, he has had a large impact on the direction, operations, and philosophy of the organization, particularly increasing awareness by state and federal lawmakers that geological mapping is needed to address critical water and mineral resource, environmental, and earth-hazard issues.

Bruce M. Simonson
Professor, Oberlin College

Bruce Simonson started as an igneous petrologist, and he has made significant contributions in advancing geological sciences in Precambrian iron formations as well as impact ejecta of large extraterrestrial bodies. He is a dedicated scientist, both in research and in teaching. He is eager to help other researchers by providing samples and professional comments. Through his guidance over the years he has produced many excellent students, either pursuing their advanced degrees in prestigious universities or continuing to make contributions in the geological profession. Through his leadership as department chair, the geology department at Oberlin College has secured funding for and has received numerous useful pieces of equipment for research and for student training.

Stephen A. Sonnenberg
Team Leader, Denver Basin Sub Business, EnCana Oil & Gas

Stephen Sonnenberg's extensive publications describe the application and integration of new science and technology in the broad subjects of petroleum geology and geophysics, mainly in the Rocky Mountains and Midcontinent, but also with work in the former USSR. He taught at Colorado School of Mines as an adjunct professor for 10 years and has taught short courses for professionals in many venues, including Indonesia. He has been appointed to the Colorado Oil and Gas Conservation Commission since 1997, and has been chair since 1999. He is currently president-elect of AAPG.

Howard J. Spero
Professor, University of California at Davis

Elected for significant contributions toward understanding the geochemistry and biology of foraminifera and resulting advances in paleoceanography, paleobiology, and Earth history.

Pål (Paul) Wessel
Professor, University of Hawai'i

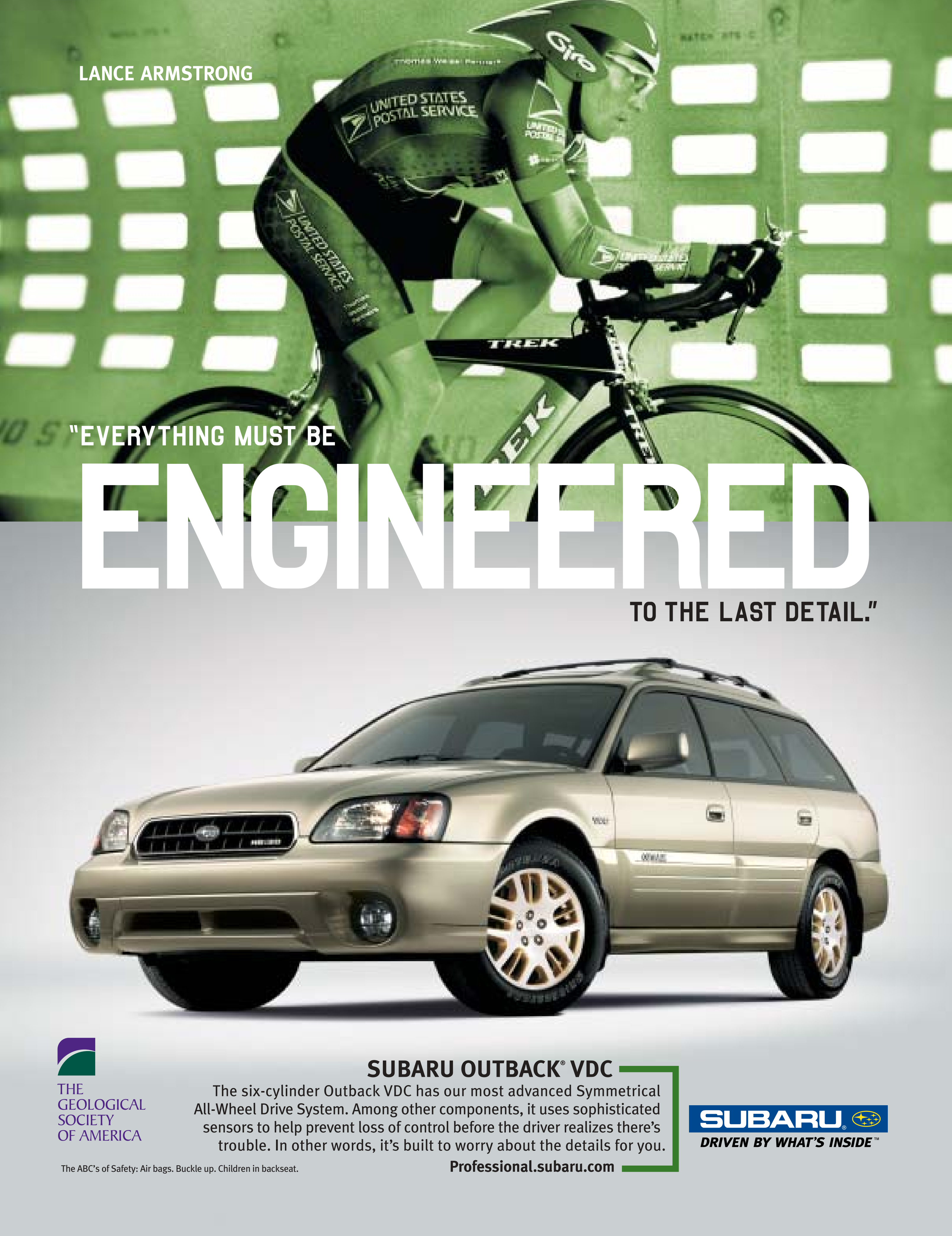
Elected in recognition for his contributions to the earth sciences in using gravity and topography data to determine and refine plate motion models and for the development and maintenance of free software for map making and data analysis.

Donna L. Whitney
Associate Professor, University of Minnesota

Donna Whitney has established herself as one of the most prominent metamorphic geologists in the U.S. through her high-quality research and innovative approaches ranging from advances in the determination of *P-T-t* paths to analysis of garnet microcracking. Her publication record is large and broad and demonstrates her scientific qualities and talents. She has received several important honors, including a Distinguished Lectureship from the Mineralogical Society of America and the association of Women Geoscientists. She also received the prestigious McKnight Professorship from the University of Minnesota for her research achievements and potential.

Mark A. Wilson
Professor, The College of Wooster

Mark A. Wilson is internationally recognized for his research on early marine diagenesis of marine substrata, the organisms that encrust hardgrounds, and the dynamics of sea level during the Pleistocene. He is an outstanding educator in his faculty position at The College of Wooster. Wilson also has an exemplary record of professional service to GSA, the Paleontological Society, and other organizations. He is truly a distinguished scholar who has made a significant impact in the geological sciences.



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2004 Birdsall-Dreiss Lecturer Named

***Barbara Bekins** of the U.S. Geological Survey (USGS) has been selected as the 2004 Birdsall-Dreiss Distinguished Lecturer, sponsored by the GSA Hydrogeology Division and funded by the GSA Foundation.*

After studying both geology and mathematics, Bekins received a B.A. in mathematics from the University of California at Los Angeles. She worked for eight years as a computer specialist in the Seismology Branch of the USGS, and studied part-time to earn an M.S. in mathematics from San Jose State University. She then left the USGS to pursue Ph.D. studies at University of California at Santa Cruz under the direction of Shirley Dreiss. Dreiss was the 1992 GSA Birdsall lecturer, and the lectureship was renamed "Birdsall-Dreiss" after her untimely death in 1993.

Bekins' thesis research focused on numerical modeling of groundwater flow and solute transport in the Barbados subduction zone. After completing her Ph.D., she obtained a postdoctoral position at the USGS, modeling the biodegradation of groundwater contaminants with funding from the Environmental Protection Agency. In 1997, she joined the USGS staff as a research hydrologist in Menlo Park, California. From 1998 to 2000, she was a member of the National Research Council's Committee on Intrinsic Remediation. The committee's report, "Natural Attenuation for Groundwater Remediation," describes the capabilities of natural attenuation and the adequacy of the published guidelines for demonstrating its effectiveness. Bekins has also sailed as a shipboard scientist on Ocean Drilling Program Leg 171A to the Barbados subduction zone in 1997 and Leg 201 to the Peru Margin in 2002. More recently, she has been working with the USGS National Water Quality Assessment Program on the fate of agricultural chemicals in the subsurface.

Bekins' current research interests encompass two broad areas. The first is the role of groundwater along plate-boundary faults, including effects of pore pressure on fault strength and the use of natural tracers to understand regional flow systems. The second involves the effects of groundwater flow and aquifer properties on subsurface microbial activities including natural attenuation of contaminants.

To request a visit to your institution, contact Barbara Bekins, U.S. Geological Survey, 345 Middlefield Road, Menlo Park, CA 94025, (650) 329-4691, babekins@usgs.gov. The Hydrogeology Division is particularly interested in including liberal arts colleges in the itinerary. The division will pay transportation expenses and the host institution will provide local accommodations. Bekins will present either or both of the lectures below.

Lecture Topics

"Hydrogeology and the Weak Nature of Plate Boundary Faults"

There is evidence for low frictional strength along many plate-boundary faults, including the San Andreas and the Cascadia subduction megathrust. High pore pressure is a leading hypothesis to explain this behavior. Proposed mechanisms for generating excess pore pressures include consolidation, tectonic strain, metamorphic dehydration, mantle degassing, hydrocarbon generation, thermal expansion, and pressure solution. Regional-scale flow and transport models constrained by observations of fluid chemistry, heat flow, and pore pressure data can be used to test various pressure generation hypotheses. Ultimately, these results may be coupled to models of other processes such as frictional heating or strain to understand the importance of fluids.

In subduction zones, very high pressures result from rapid loading of saturated seafloor sediments during accretion and subduction. Evidence for excess fluid pressure includes direct measurements, mud volcanism, and dilated faults. The Ocean Drilling Program has installed seven seafloor wells in subduction zones. Data from the Cascadia margin off central Oregon show that flow is both transient and focused along faults. In the Barbados complex, pore water chloride anomalies indicate that clay dehydration fluids flow from deep in the complex to the seafloor along the plate-boundary thrust. Model results constrain the duration of flow and the distance of transport. Future models will quantify deeper fluid sources, evaluate mechanisms for transient flow, and changes in pore pressure through the earthquake cycle.

"The Influence of Hydrogeology on 25 Years of Natural Attenuation at a Crude Oil Spill Site"

Natural attenuation has been used as a practical method to dispose of wastes throughout human history. It is now clear that the subsurface environment has a limited ability to assimilate wastes and that this ability depends on the nature and quantity of the wastes and the characteristics of the subsurface. To increase our knowledge of the capabilities and limitations of natural attenuation, the USGS Toxic Substances Hydrology Program conducts studies on the fate of contaminants in the natural environment. Results from the research have documented the effectiveness of a variety of individual processes that together contribute to natural attenuation of several classes of contaminants.

This talk will illustrate important principles using examples from research at a crude-oil spill site located near Bemidji, Minnesota. The Bemidji results show that groundwater flow plays a central role in regulating subsurface microbial activity during natural attenuation. Microbial populations and reaction rates are inextricably linked to recharge, permeability, and hydraulic gradient. At the Bemidji site, degradation rates for constituents of non-aqueous crude oil vary strongly with recharge rates. In addition, the temporal evolution of microbial populations and associated benzene degradation capabilities vary with permeability. The Bemidji results show that thorough characterization of the hydrogeology of a site is essential for understanding the subsurface microbial populations, their activities, and the associated effects on water quality.

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ASSISTANT/ASSOCIATE PROFESSOR
ENVIRONMENTAL GEOPHYSICS
WRIGHT STATE UNIVERSITY

Applications are invited for the position of tenure track Assistant/Associate Professor, Wright State University, Dayton, Ohio. The candidate should be suitable for joint appointment in the Departments of Geological Sciences and of Physics. These Departments each have undergraduate and masters degree programs, including a Master of Science in Teaching, and both support an interdisciplinary Environmental Sciences Ph.D. program. For additional information visit http://www.wright.edu/cosm/pages/business/geophysics.htm.

Applicants must hold a Ph.D. in geophysics or a closely related discipline and have a record of excellence in teaching and research appropriate to their ranks; prior funded research is required for appointment at Associate level. Experience with mathematical modeling of physical systems, with advising Ph.D. candidates, and with outreach programs to K–12 schools are also desirable. The candidate will be expected to develop a program of externally funded research and contribute to undergraduate and graduate teaching. Applicants should send a curriculum vitae; a statement of capabilities and qualifications; and the names, addresses, telephone numbers, and email addresses of at least three professional references to: Geophysics Search Committee, Institute for Environmental Quality, Wright State University, Dayton, OH 45435. Review of applications will begin September 1, 2003, but applications will be accepted until the position is filled. Wright State University is committed to a policy of equal opportunity and affirmative action, and specifically encourages applications from members of underrepresented groups.

GEOCHEMISTRY; UNIVERSITY OF OREGON

The Department of Geological Sciences invites applications for a tenure track faculty position at the assistant professor level to begin in fall 2004. We seek an individual who applies geochemical measurements to the solution of fundamental problems in the Earths crust or surficial environment. The ideal applicant will complement existing departmental strengths in hydrothermal geochemistry, paleopedology, volcanology, neotectonics, and/or geomorphology. Applicants with expertise in light stable, or cosmogenic isotope geochemistry are particularly encouraged to apply.

The successful candidate will be expected to establish a laboratory appropriate for her or his research focus, develop an externally funded, academically-oriented research program, and contribute to teaching at both the undergraduate and graduate levels.

Completion of the Ph.D. is required and postdoctoral research experience is desirable. Applicants should send a curriculum vitae, statements of teaching and research interests, and the names, postal and email addresses, and telephone numbers of three referees to Geochemistry Search Committee, Department of Geological Sciences, 1272 University of Oregon, Eugene, OR 97403-1272. We will begin reviewing completed applications October 20, 2003 and will continue until the position is filled.

The University of Oregon is an equal opportunity/affirmative action institution committed to cultural diversity and compliance with the Americans with Disabilities Act.

GEOPHYSICS/FLUID DYNAMICS
UNIVERSITY OF OREGON

The Department of Geological Sciences invites applications for a tenure track faculty position at the assistant professor level to begin in fall 2004. We seek an individual working in the general field of continuum mechanics, including fluid dynamics, who integrates data of diverse type and scale with the use of computer-based models. Specific applications may include geohydrologic processes, earthquake and fault physics, and/or visco-elastic problems related to magma transport, tectonics, or the earthquake cycle.

The successful candidate will be expected to develop an externally funded, academically-oriented research program and contribute to teaching undergraduates, graduate-level fluid dynamics, and other courses in his or her specialty.

Completion of the Ph.D. is required and postdoctoral experience is desirable. Applicants should send a curriculum vitae, statements of teaching and research interests, and the names, postal and email addresses, and telephone numbers of three referees to Geophysics Search Committee, Department of Geological Sciences, 1272 University of Oregon, Eugene, OR 97403. We will begin reviewing completed applications October 20, 2003 and will continue until the position is filled.

The University of Oregon is an equal opportunity/affirmative action institution committed to cultural diversity and compliance with the Americans with Disabilities Act.

GEOPHYSICS: LITHOSPHERIC DEFORMATION
UNIVERSITY OF CALIFORNIA AT SANTA BARBARA

The Department of Geological Sciences at the University of California at Santa Barbara seeks a broadly educated geophysicist who conducts creative research in quantitative analysis of deformation processes within the lithosphere. Individuals who utilize recent advances in geodesy, numerical modeling, inversion methods, or geoinformatics are particularly encouraged to apply. This tenure-track appointment will be as an Assistant Professor to begin July 1, 2004. The appointee is expected to develop a vigorous, externally funded research program (for example, by participating in EarthScope) and will teach both undergraduate and graduate courses in geophysics and tectonics.

A Ph. D. is required at the time of appointment. Review of applications will begin October 15, 2003. Applicants should request that three referees send letters of evaluation directly to the search committee by October 15. Applicants should submit a letter of application, curriculum vita, a description of teaching and research objectives and accomplishments, and provide the names, email addresses and contact information of the three referees. All materials should be sent to: Doug Burbank, Chairperson, Geophysics Search Committee, Department of Geological Sciences, University of California, Santa Barbara, CA 93106-9630.

The department is especially interested in candidates who can contribute to the diversity and excellence of the academic community through research, teaching and service. UCSB is an Equal Opportunity/Affirmative Action employer.

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GEOLOGY/EARTH SCIENCE
UNIVERSITY OF VIRGINIA COLLEGE AT WISE

The University of Virginia's College at Wise seeks a tenure track assistant professor of geology or earth science for fall term 2003. The appointment begins August 15, 2003. The college is a nationally ranked four-year public liberal arts college located in the mountains of southwestern Virginia and is the only college branch of the University of Virginia. The successful candidate is expected to have a doctorate in geology or other closely related earth science field and have a commitment to teaching undergraduate students in a liberal arts institution. The candidate will be expected to teach introductory courses in physical and historical geology, physical geography, and courses of interest in earth science. Review of applications will begin in mid July and continue until the position is filled. Candidates who are ABD will be considered for a one year appointment as an instructor of geology. Please send a resume including a statement of teaching philosophy, letters of reference, and transcripts to Geology Search Committee, The University of Virginia's College at Wise, Office of Human Resources, 1 College Avenue, Wise, VA 24293. The University of Virginia's College at Wise is an equal opportunity/affirmative action employer.

CARBONATE RESERVOIR GEOLOGIST and
WELL-LOG PETROPHYSICIST
THE PETROLEUM INSTITUTE, ABU DHABI

The Petroleum Geosciences Program of The Petroleum Institute, Abu Dhabi, is seeking a carbonate reservoir sedimentologist-stratigrapher and a well-logging petrophysicist, although other specializations will be considered.

Applicants should possess a Ph.D. in Geology or Geophysics and experience in the petroleum industry is desirable. Appointments probably will be at the Assistant Professor rank, although senior appointments will be considered for strong candidates. Faculty in Petroleum Geosciences will teach undergraduate and graduate courses, develop an active research program that impacts the UAE petroleum industry, and engage in service work. Opportunities exist to work with PI industry stakeholders in research.

The Petroleum Institute is a small, highly focused, new teaching and research institute that offers educational programs that will lead to B.Sc., M.Sc., and Ph.D. degrees in engineering and petroleum geosciences. Staff will have the resources to equip laboratories with up-to-date analytical equipment and computer software and hardware to support teaching and research. The Colorado School of Mines is the PI's academic advisor.

The compensation package for staff includes a 12-month salary and benefits that include housing, utilities, home furnishings, an automobile purchase loan, health insurance, and annual leave travel.

This is an unusual opportunity for self-motivated geoscientists to help build a world-class teaching and research institution. Additional information is at www.pi.ac.ae/. Interested candidates should send an application letter and their résumé by 31 September 2003, although late applications may be considered, to: Human Relations, Geoscience positions, Petroleum Institute, P.O. Box 2533, Abu Dhabi, United Arab Emirates; with an email copy to: Dr. Robert Winn, Petroleum Geosciences, rwinn@pi.ac.ae.

CRUSTAL EVOLUTION/TECTONICS/GEOPHYSICS
SYRACUSE UNIVERSITY

The Department of Earth Sciences invites applications for an Associate or Full Professor in the field of crustal evolution/tectonics and geophysics to start in August, 2004. We seek an innovative geoscientist to join a faculty with two concentrated research foci: crustal evolution/tectonics (including geochronology/thermochronology, reflection seismology, radiogenic isotope geochemistry, and basin analysis) and Quaternary studies/environmental geology (including paleoclimatology, hydrogeology, stable isotope geochemistry, paleobiology/ paleoecology). Desirable research areas for this position include, but are not restricted to, structure and evolution of the continental lithosphere, reflection/refraction seismology, plate boundary geodynamics, and quantitative modeling of lithospheric deformation. The department houses a UNIX computer network hosting PROMAX and SEISWORKS seismic processing and interpretation software, a 48-channel seismic acquisition system, portable marine multichannel and high-resolution seismic acquisition systems. Additional pertinent facilities include a thermal ionization mass spectrometry and ultra clean-lab (U-Pb geochronology and Nd-Hf-Sr-Pb isotope geochemistry), a new noble gas thermochronology laboratory ($^{40}Ar/^{39}Ar$, (U-Th)/He), a fission-track thermochronology laboratory, a stable isotope laboratory, and sediment cold storage facilities. The successful candidate will have a distinguished publication record, an externally funded research program, and will be expected to contribute to the department's teaching mission at the advanced and introductory levels (e.g., physical geology, geophysics, structural geology/tectonics). To apply, send a curriculum vitae, statement of research and teaching interests, and names/e-mail addresses of three referees to: Search Committee Chair, Department of Earth Sciences, 204 Heroy Geology Laboratory, Syracuse University, Syracuse, NY 13244-1070. The search committee will begin reviewing applications October 15, 2003. The search will remain open until the position is filled. Syracuse University is an equal opportunity employer. Minorities and women are encouraged to apply.

FACULTY POSITION
QUANTITATIVE GEOMORPHOLOGY/SURFICIAL PROCESSES/QUATERNARY GEOLOGY
UNIVERSITY AT BUFFALO
THE STATE UNIVERSITY OF NEW YORK

The Department of Geology, University at Buffalo (http://www.geology.buffalo.edu) is accepting applications for a tenure-track Assistant Professor position, to begin in August 2004. The successful candidate will demonstrate a potential for research and teaching that will complement and integrate with our existing programs in Environmental Geology and Volcanology. We seek a person with primary interest in quantitative sedimentology and landform development, Quaternary geochronology, or surficial geostatistics. Preference will be given to candidates who use techniques applicable to the understanding of the age, disposition and development of geological materials in the shallow subsurface. Teaching duties will involve undergraduate introductory courses and graduate level courses in the candidate's specialties, including advanced geomorphology or Quaternary geochronology. Minimum qualifications include: Ph.D. degree at the time of appointment, demonstrated potential to start and maintain an active research program through the securing of external grants, demonstrated potential to publish and otherwise disseminate results of research, and demonstrated potential to perform teaching duties. To apply, please submit a letter explaining research and teaching interests, a curriculum vitae, and names and contact information for at least three references to: Professor Marcus Bursik Department of Geology, University at Buffalo, 876 Natural Sciences Complex, Buffalo, NY 14260. Review of the material will begin on October 1, 2003, and will continue until the position is filled. The University at Buffalo is an Equal Opportunity Employer/Recruiter.

Opportunities for Students

Graduate Assistantships in Ground-water Biogeochemistry/Hydrogeology. MS and PhD assistantships are available for projects in biogeochemical and hydrological interactions related to N transport in karst. Assistantships are available January 2004 in Biological Sciences, Geosciences, or the Environmental Dynamics programs at the University of Arkansas in Fayetteville. One project will define hydrological flow paths and hydrologic budget in karst systems using stable isotopic tracers. A complementary study element will focus on biogeochemical cycling of N; dissolved organic matter, NO_3-concentration, and stable isotopic compositions will be assessed to link immobilization and denitrification to hydrologic controls. Results will be applied to field-scale experiments testing impact of common agricultural practices on hydrology and biogeochemistry in karst. Students will gain experience in hydrology and stable isotope techniques, including direct training in the U of A Stable Isotope Lab. Ideal candidates will have analytical and field skills and at least a BS in some field of biology or geology. Contact Dr. Phil Hays (Geosciences: pdhays@usgs.gov; 479-575-7342) or Dr. Sue Ziegler (Biological Sciences; susanz@uark.edu; 479-575-6944) for information. Applications (http://biology.uark.edu/bisc.html or http://www.uark.edu/depts/geology/) due October 1, 2003.

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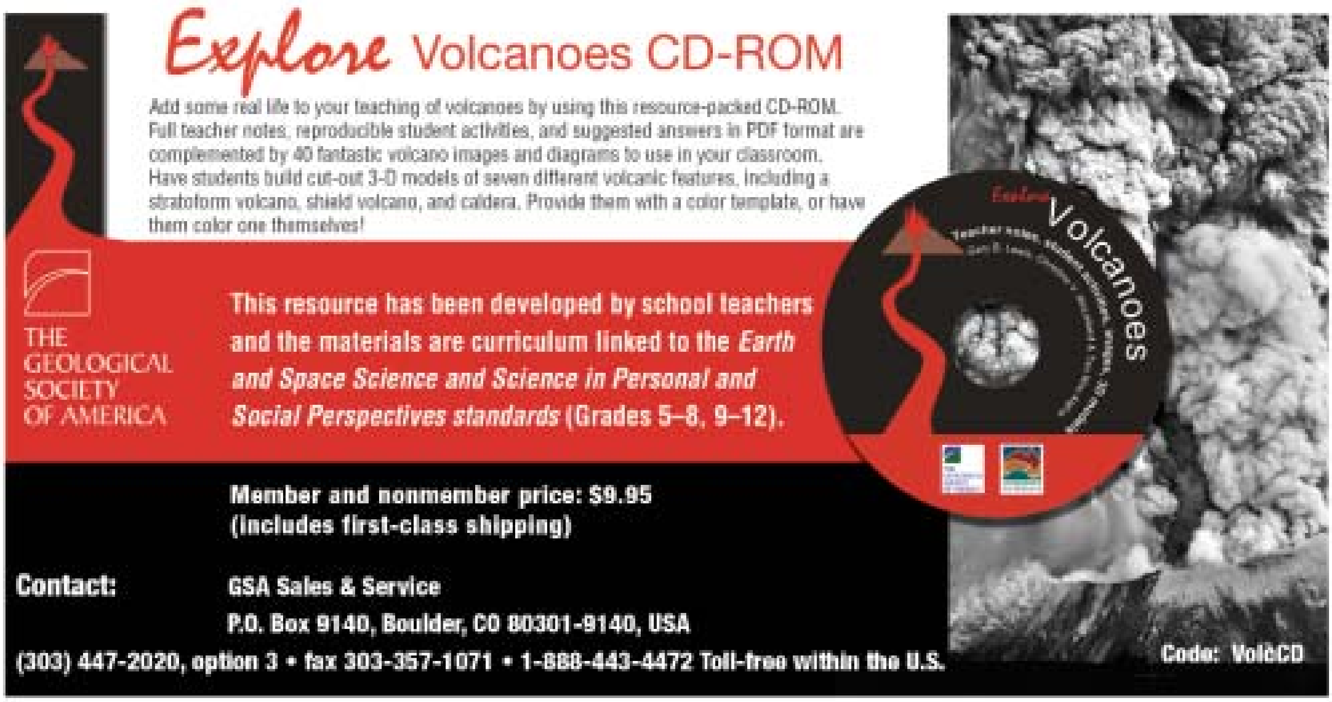

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