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High-Resolution Lidar Topography of the Puget Lowland, Washington —A Bonanza for Earth Science

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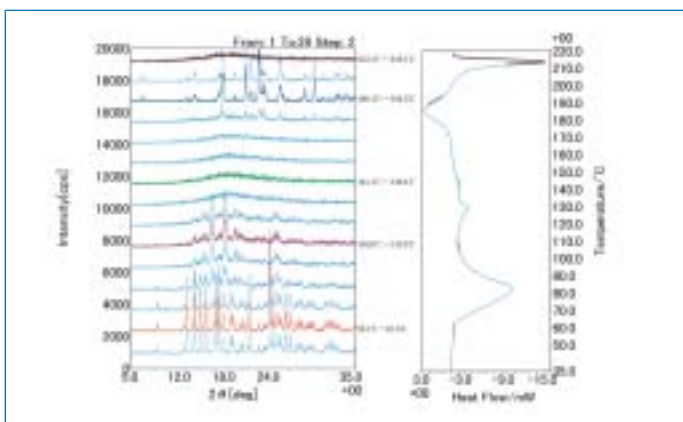
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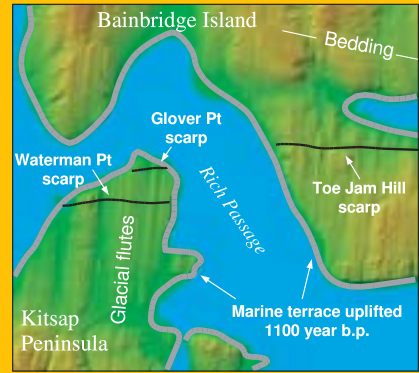
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ON THE COVER: Shaded relief image calculated from lidar topography of part of the Seattle fault zone, 15 km west of Seattle, site of the 2003 GSA Annual Meeting. Scene is 4.5 km across. For location, see Figure 3 of "High-resolution lidar topography of the Puget Lowland—A bonanza for earth science," by R.A. Haugerud, D.J. Harding, S.Y. Johnson, J.L. Harless, C.S. Weaver, and B.L. Sherrod, p. 4–10.

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High-Resolution Lidar Topography of the Puget Lowland, Washington

—A Bonanza for Earth Science

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ABSTRACT

More than 10,000 km² of high-resolution, public-domain topography acquired by the Puget Sound Lidar Consortium is revolutionizing investigations of active faulting, continental glaciation, landslides, and surficial processes in the seismically active Puget Lowland. The Lowland—the population and economic center of the Pacific Northwest—presents special problems for hazards investigations, with its young glacial topography, dense forest cover, and urbanization. Lidar mapping during leaf-off conditions has led to a detailed digital model of the landscape beneath the forest canopy. The surface thus revealed contains a rich and diverse record of previously unknown surface-rupturing faults, deep-seated landslides, uplifted Holocene and Pleistocene beaches, and subglacial and periglacial features. More than half a dozen suspected postglacial fault scarps have been identified to date. Five scarps that have been trenched show evidence of large, Holocene, surface-rupturing earthquakes.

INTRODUCTION

Whether looking for active faults, modeling flood inundation, inventorying landslides, or mapping bedrock geology, earth scientists depend on topographic data. In 1997, geologists in the Puget Lowland got their first look at a detailed lidar (light detection and ranging, also known as ALSM or airborne laser swath mapping) topographic survey. Using a narrow laser beam to probe through the trees, lidar can produce accurate terrain maps even where

forest cover stymies traditional photogrammetry. The survey was commissioned by Kitsap Public Utility District to map groundwater infiltration and runoff on Bainbridge Island, just west of Seattle (Harding and Berghoff, 2000). Among the landforms portrayed was a 1–5-m-high, east-trending scarp that offsets north-south glacial grooves at the south end of the island, within the Seattle fault zone (Fig. 1). Previous routine topographic mapping, geologic mapping, and examination of aerial photographs had failed to identify this scarp concealed beneath dense second- and third-growth forest. Subsequent trenching of the scarp confirmed that it formed during one or more large, Holocene, surface-rupturing earthquakes (Nelson et al., 2002). This discovery quickly led to the realization that other fault scarps might be revealed with lidar.

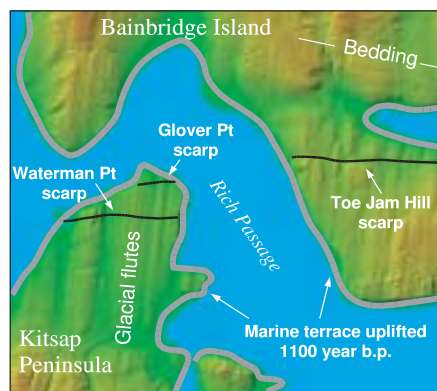


Figure 1. Image calculated from lidar topography of part of the Seattle fault zone, 15 km west of Seattle. Scene is 4.5 km across. See Figure 3 for location.

In 1999, geographic information system (GIS) specialists, planners, and earth scientists working for local government agencies, the U.S. Geological Survey (USGS), and the National Aeronautics and Space Administration (NASA) formed the Puget Sound Lidar Consortium (PSLC) and began an experiment to purchase cooperatively high-resolution, public-domain lidar topographic survey data. The initial impetus behind this effort was to find fault scarps for seismic hazards studies. To date, the PSLC has acquired over 10,000 km² of high-resolution digital elevation models (DEMs) of the heavily forested Puget Lowland of western Washington, and we have discovered more than half a dozen scarps of possible tectonic origin. The experiment has been a success.

In this report, we describe some of the hazards facing the Puget Lowland, lidar mapping technology, the PSLC data collection effort, and our use of these data for identifying seismic hazards and for geomorphic mapping.

THE PUGET LOWLAND

Seattle and the surrounding Puget Lowland lie in the forearc of the Cascadia subduction zone (Fig. 2). Two hundred kilometers to the west, off the Pacific coast, the Juan de Fuca plate subducts northeast beneath the North American plate at ~4 cm/yr. To the east of Seattle rise active volcanoes—Mount Rainier, Glacier Peak, and Mount Baker—of the Cascade volcanic arc. The Olympic Mountains to the west of Seattle are a rapidly uplifting forearc high. Between the Cascades and the Olympics lies the Puget Lowland (Fig. 3), part of a broad forearc depression that extends from southern British Columbia to west-central Oregon.

The Puget Lowland is subject to seismic shaking from great megathrust subduction earthquakes, most recently in 1700 A.D.

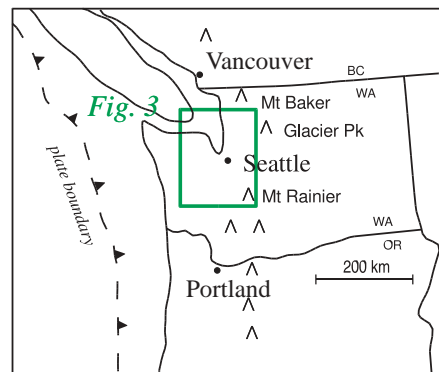


Figure 2. Location of Puget Lowland.

(Satake et al., 1996), and from Wadati-Benioff zone intra-slab earthquakes, 30–80 km deep, such as the M 6.8 February 2001 Nisqually earthquake. Faults in the continental crust pose an additional seismic hazard. These faults accommodate deformation of the forearc as it migrates north and is compressed against the older, relatively immobile crust of the Canadian Cordillera (e.g., Wells et al., 1998; McCaffrey et al., 2000). Geodetic studies (Mazzotti et al., 2002; Miller et al., 2001) indicate western Washington is shortening north-south at 3–7 mm/yr. Bucknam et al. (1992) described evidence for a shallow earthquake within the east-west Seattle fault zone (Blakely et al., 2002) about 1100 years ago. As much as 7 m uplift near Seattle accompanied this ~M 7 event. Were such an earthquake to occur today, the damage would be immense. Estimating the frequency of such crustal events is critical to assessing Seattle's seismic hazard.

Repeated, extensive, Pleistocene glaciation has obscured tectonic features in the Puget Lowland. The most recent ice sheet to flow south from British Columbia reached Olympia, 80 km south of Seattle, about 16,400 calendar years ago, then retreated rapidly, leaving the Lowland ice-free by 15,000 years ago (Porter and Swanson, 1998). The landscape of the Lowland still largely reflects glaciation: Much of the Lowland is a low-relief plain at an elevation of 100–150 m, formed as the floor of a broad outwash valley in front of the advancing ice sheet (Booth, 1994). Elongate, mostly north-south flutes (Figs. 1 and 3) decorate this surface, recording the direction of ice flow for the 1–4 k.y. duration of glaciation. Large troughs that now contain Puget Sound, Hood Canal, Lake Washington, and other waterways are attributed to erosion by subglacial drainage (Booth, 1994).

Regional geophysical studies (Danes et al., 1965; Blakely et al., 1999; Brocher et al., 2001) have outlined major possible fault zones beneath the glacial deposits, but are typically unable to provide direct evidence for the existence of a fault or the history of recent faulting necessary to estimate seismic hazard. One way to obtain such history is to trench fault scarps and date offset soils and scarp colluvium. However, the observed strain rate suggests postglacial fault scarps may be no more than a few meters high. Finding such scarps beneath the dense forest canopy

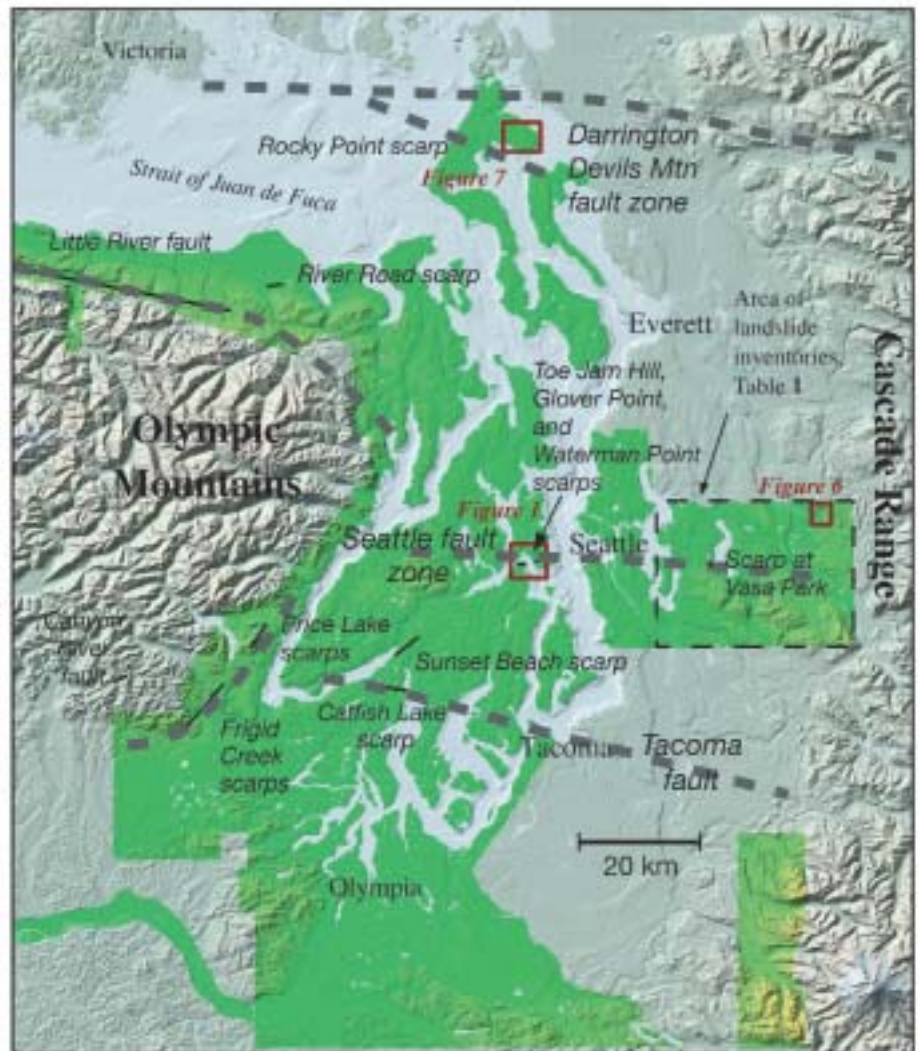


Figure 3. Map of Puget Lowland with extent of Puget Sound Lidar Consortium data as of April 2003 (darker green).

has been almost impossible using traditional photographic and photogrammetric methods. Marine shallow seismic-reflection surveys (Johnson et al., 1999, 2001a, 2001b) have identified faults with probable Quaternary offsets, but tracing these faults onshore has been difficult. The only Holocene fault scarps recognized in the Lowland prior to 1997 are at Price Lake, 70 km southwest of Seattle (Wilson et al., 1979).

Lidar can find these postglacial fault scarps hidden beneath the trees.

ABOUT LIDAR

Essential elements of a lidar mapping system are a scanning laser rangefinder mounted in an aircraft, differential Global Positioning System (GPS) to locate the aircraft, and an inertial measurement unit (IMU) to measure aircraft orientation (e.g.,

Carter et al., 2001). The rangefinder determines distance to a target by timing the round-trip travel of a short-duration laser pulse. The reflected pulse may produce more than one return if the laser beam—with an on-ground diameter of 0.2–1 m—hits more than one vertically distinct target, as in a forest. Initial processing reduces data from the three subsystems to XYZ coordinates for each discrete return. Further, largely automatic, processing—commonly referred to as post-processing—is necessary to separate ground returns from canopy returns in forested areas (Fig. 4; Haugerud and Harding, 2001).

Lidar is an attractive topographic mapping tool for three reasons. First is accuracy, with routine 10–20 cm height (Z) errors in unvegetated low-slope terrain. The error associated with range measure-

ments is small: most of the Z error typically associated with lidar systems is GPS and orientation error. Position (XY) errors, primarily due to errors in laser beam orientation, can be a factor of 10 larger, and on steep slopes these errors translate into larger Z errors. In densely vegetated terrain, Z errors of lidar digital elevation models (DEMs) can be large (although less than that of photogrammetric DEMs) where the density of ground returns is low and vegetation returns are misclassified as ground returns. Over the next few years, advances in detection of low-energy ground returns, GPS and IMU calibration procedures, and return classification should significantly reduce errors. The second reason is productivity: measurements are made at rates of 10,000–80,000 laser pulses per second. Finally, lidar is monoscopic and provides its own illumination. These characteristics overcome the major liabilities of photogrammetry in forested terrain.

There is a growing lidar mapping industry, with more than 30 commercial instruments active in North America (see <http://airbornelasermapping.com> for a summary). NASA operates several research instruments (Krabill et al., 1995; Blair et al., 1999; Wright and Brock, 2002; Degnan et al., 2002), and the University of Texas and University of Florida operate lidar mapping instruments (Gutierrez et al., 1998; Carter et al., 2001). Earth-science applications of lidar mapping include coastal change studies (Sallenger et al., 1999), landslide analysis (Dietrich et al., 2001), and fault mapping (Hudnut et al., 2002).

PUGET SOUND LIDAR CONSORTIUM

The Puget Sound Lidar Consortium came together in response to (1) the discovery of a Holocene fault scarp on the initial Bainbridge Island lidar survey; (2) appreciation by local planners, GIS professionals, and earth scientists of the utility of high-resolution topography; (3) the ability of the USGS, founded on relationships built in the course of operating the regional seismograph network, to provide a common focus that enabled local agencies to work together; and (4) a grant from NASA to purchase lidar data for investigation of earthquake hazards. Kitsap County has since received federal community assistance grants to support lidar data acquisition. Local and state governments and NASA have provided additional funds for a total to date of ~\$2.5 million.

Some PSLC members are planners and GIS staff with local government; others are federal research scientists. Our organizational structure is no more than a volunteer coordinator, an e-mail list, and a purchase contract. This flat structure has encouraged technical awareness on our part (e.g., Haugerud and Harding, 2001) and insight by the vendor into our needs. A shared high level of GIS expertise, few management constraints, lack of conflicting agency mandates, and a strong sense of cooperative purpose have all contributed to our ability to work together.

We have contracted for surveys with a nominal pulse density of 1/m². We purchase four data layers: (1) all lidar returns, with XYZ coordinates, GPS time, return number, and off-nadir angle for each return; (2) XYZ coordinates for all returns identified as from the ground; (3) a 6-ft DEM of the lidar 1st-return surface (essentially a canopy-top model); and (4) a 6-ft DEM of the bare-earth surface (vegetation and buildings removed). Independent ground control points in open areas show vertical accuracy of 13–17 cm root mean square error. Limited tests in forested areas show increased vertical errors, with the DEM locally biased upward. All data are in the public domain. (For access to PSLC data, contact Diana Martinez at the Puget Sound Regional Council, dmartinez@psrc.org. Sample data, images, and further information on the PSLC are online at <http://pugetsoundlidar.org>.)

SEISMIC HAZARDS STUDIES

Finding Faults

To date, lidar topographic data have revealed surface ruptures along five known fault zones: the Seattle fault zone, Tacoma fault, Darrington–Devils Mountain fault zone, the northern margin of the Olympic Mountains, and the southeastern Olympic Mountains (Fig. 3).

The Toe Jam Hill scarp revealed by the initial Bainbridge survey is north-side-up, opposite the vergence suggested for the Seattle fault (Johnson et al., 1994; Blakely et al., 2002). The scarp may have formed along a backthrust within the Seattle fault zone. Trenching across the scarp in 1998 and 1999 revealed a north-dipping thrust fault that disrupts late Holocene soils. Soil stratigraphy and radiocarbon ages suggest as many as three surface-rupturing earthquakes in the past 2500 years (Nelson et al., 2002). Southwest of the Toe Jam Hill

scarp, across Rich Passage, we found the en echelon, west-trending Waterman Point scarp and Glover Point scarp. Both are north-side-up. Three trenches excavated across the Waterman Point scarp in August 2001 exposed a north-dipping fault, on which Oligocene bedrock is thrust south over late Holocene soil. Radiocarbon ages from these soils indicate that faulting occurred ~1100 years ago, perhaps in the same event as rupture on the Toe Jam Hill scarp. It is interesting to note that lidar topography suggests that the Toe Jam Hill scarp does not offset an 1100-year-old uplifted wave-cut platform, while the Waterman Point and Glover Point scarps clearly offset the same 1100-year-old uplifted platform. This implies at least two closely spaced events about 1100 years ago. A north-side-up scarp is also evident in West Seattle, where it cuts the 1100-year-old platform.

Several en echelon north-side-up scarps that are collectively called the Catfish Lake scarp lie along the trace of the Tacoma fault. Existence of the Tacoma fault was previously hypothesized on the basis of large-amplitude gravity, aeromagnetic, and seismic-velocity anomalies (Brocher et al., 2001), shallow marine seismic reflection surveys (Johnson et al., 2001a), glaciolacustrine strandlines (Thorson, 1989), and coastal marsh stratigraphy (Bucknam et al., 1992). Preliminary work, including a trench excavated in October 2002, suggests that the Catfish Lake scarp formed during an earthquake on the Tacoma fault ~1100 years ago. North of the Catfish Lake scarp, en echelon segments of the southeast-side-up Sunset Beach scarp extend ~4 km along a northeast trend. The scarp is as high as 8 m. To the southwest, this feature merges with the head scarp of a large, previously undescribed landslide. Possibly the entire feature is the head scarp of an unusual, even larger landslide that rotated clockwise about a vertical axis, though this appears unlikely. Planned excavations across the scarp may resolve this uncertainty.

On northern Whidbey Island, at the south margin of the broad Darrington–Devils Mountain fault zone, we found the west-northwest-trending Rocky Point scarp. It lies along a fault strand previously defined on the basis of marine seismic reflection data (Johnson et al., 2001b). Two trenches excavated across the Rocky Point scarp in August 2002 exposed evidence for late Holocene vertical and left-lateral offset.

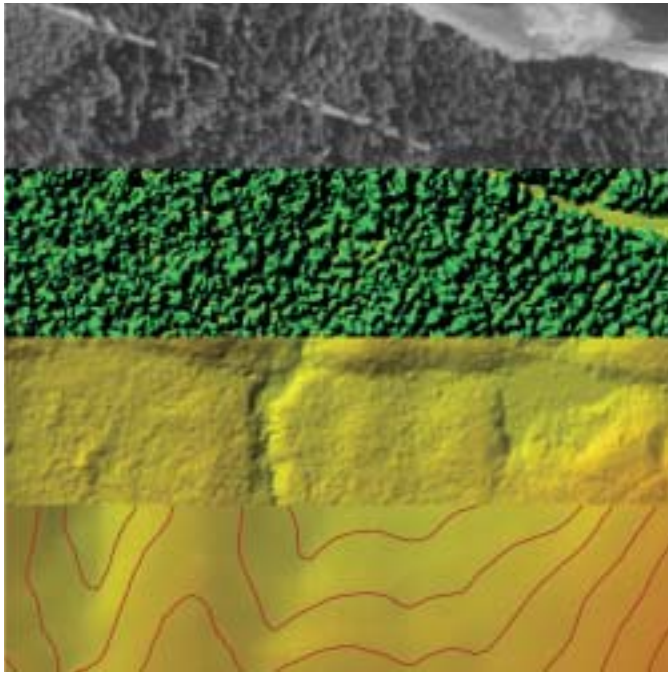


Figure 4. Contiguous image-maps, from N to S: digital orthophoto (3 ft pixels); lidar 1st-return surface (6-ft postings); lidar bare-earth model after post-processing to segregate ground returns (6-ft postings); U.S. Geological Survey 10-m digital elevation model with 10-ft 1:24,000-scale contours. East-west features are shoreline (upper right), a county road (upper left to mid-right), and Toe Jam Hill fault scarp (lower middle). Note disagreement on stream location. View is 600 m wide.

At the north margin of the Olympic Mountains, scarps along the Little River fault extend over 30 km east-west (Haugerud, 2002). At its west end, topographic features are ambiguous: a 10–20 m high south-side-up scarp in bedrock suggests this is a fault-line scarp eroded along an older weakness, although surface offset within a Holocene landslide suggests young deformation. At the east end of the Little River scarp, a 1–2 m north-side-up offset of the late Pleistocene glacially fluted surface almost certainly records postglacial faulting. Farther east, the River Road scarp is a minor north-side-up warp of a latest Pleistocene or early Holocene fluvial surface.

At the southeast corner of the Olympic Mountains, lidar topography images the previously recognized (Wilson et al., 1979) southeast-side-up scarps at Price Lake, and shows that the scarps are longer and more numerous. The ~10-km-long, en echelon Frigid Creek scarps cut across Holocene alluvial fans in a zone that extends southwest from Price Lake. Beyond the extent of our lidar data, the Canyon River fault has ~2 m of Holocene offset (Walsh et al., 1999). Scarp geometry suggests reverse and strike-slip motion on the Price Lake,

Frigid Creek, and Canyon River structures.

Not all scarps are obvious on the lidar images. A postglacial scarp found by field investigations near Vasa Park east of Seattle (Sherrod et al., 2001; Sherrod, 2002) is poorly defined by the lidar topography. This scarp may be older than the others—possibly ~10,000 years old—and hence degraded and less distinct. Human modification of the landscape has obscured a possible extension of this scarp to the west. Most importantly, dense understory vegetation at this locale prevented the laser from imaging the ground surface. At other locales, the lidar topography is ambiguous and further investigation is required. Lidar topography is, however, localizing these investigations.

The fault scarps we are discovering with lidar strongly support a tectonic model in which reverse and oblique-slip movements along multiple faults accommodate north-south shortening of the Puget Lowland (Wells et al., 1998).

Uplifted Marine Platforms

Harding et al. (2002) used lidar topography to delineate and measure the elevation of the back edge—the “shoreline

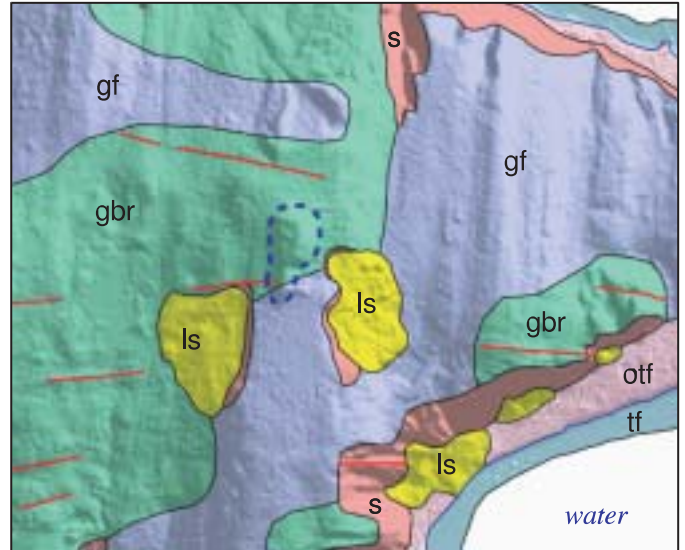


Figure 5. Geomorphic map of part of Bainbridge Island. Base is detailed lidar topography. Map units: s—scarp; ls—landslide; tf—tideflat; otf—old tideflat; gf—fluted glaciated surface; gbr—glaciated bedrock surface. Red lines are bedding traces; blue dashed line is relict shoreline from late-glacial lake. View is 1.5 km wide.

angle”—of an uplifted, wave-cut marine platform associated with uplift on the Seattle fault zone 1100 years ago (see Figure 1). Extensive north-south shorelines of Puget Sound yield a record of the spatial pattern of uplift across the zone. There is significant structure within the uplift pattern: elevations of the shoreline angle describe en echelon, east-west anticlines 2–5 km wide with limbs that dip 0.1°–0.8°. Anticlines are located above the blind, basal thrust of the Seattle fault zone, with hinges uplifted by as much as 9 m. Inflections in elevation of the shoreline angle on the south limbs suggest deformation also occurred above structurally higher blind thrusts that have been imaged in seismic reflection profiles (Johnson et al., 1999). The Waterman Point and Glover Point backthrusts, which rupture the platform, are parallel to the anticline axes.

GEOMORPHIC MAPPING

Geomorphic mapping can help in reading geologic history, inferring the properties of earth materials, and analyzing landscape evolution. High-resolution lidar topography is ideal for detailed geomorphic mapping, as the resolution of 1–2 m

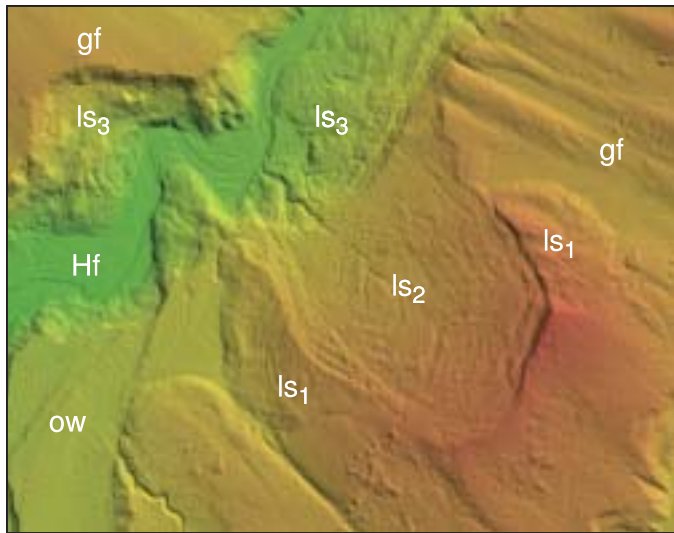


Figure 6. Lidar topography of landslides along Tolt River, east of Seattle; see Figure 3 for location. View is 3.5 km wide. Geomorphic units are gf—glacially fluted surface; ow—glacial outwash surface; ls—landslide, 1 (oldest) to 3 (youngest); Hf—Holocene fluvial surface. Faceting along some ridges and bluff edges reflects absence of ground returns from laser because of thick forest canopy or deletion during post-processing.

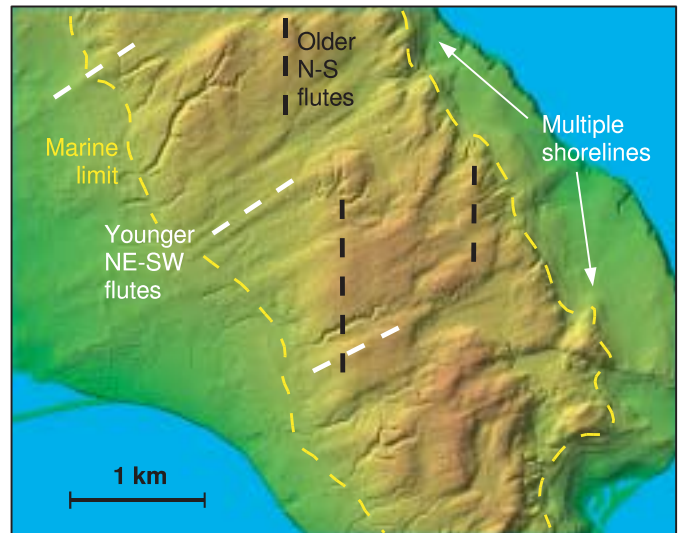


Figure 7. Lidar topography of part of Whidbey Island. Superimposed flutes record change in ice-flow direction late in Vashon glacial cycle. Note subdued surface below upper limit of marine inundation and multiple shorelines formed during postglacial isostatic rebound. See Figure 3 for location.

lidar DEMs appears close to that needed to capture all of the fluvial channels in the Puget Lowland landscape. Geomorphic mapping of Bainbridge Island (Fig. 5; Haugerud, 2001) and the county in which it sits is providing an improved landslide inventory, a refined analysis of ice-marginal lake history and elevations, and an enhanced appreciation of glacial process.

Comparison with landslide inventories from conventional mapping shows that with lidar topography we are finding over twice as many deep-seated landslides (Fig. 6)—and in some cases, we are able to see that certain features are not landslides (Table 1). The difference reflects the inability of air-photo-based methods to see through the forest canopy, the difficulty faced by the geologist on the ground seeking to synthesize impressions of the vegetated landscape, and our ability to enhance digital topography to improve the visibility of subtle features. Our lidar topography is not detailed enough to map the small debris flows (<100 m³) that comprise the majority of landslides in the Puget Lowland, but it does allow better identification of the steep slopes on which almost all such debris flows occur.

Retreating glacial ice dammed short-lived ice-marginal lakes, the largest of which extended across much of the Puget Lowland. Shorelines of such lakes are potential markers to identify young deformation, though the late-glacial lakes were

short-lived and rapid isostatic rebound caused their shorelines to move rapidly across the landscape. Limited by forest cover and the resolution of available topographic maps, Thorson (1989) was able to identify strandlines only at widely spaced large deltas formed where streams emptied into these lakes. Delta-top elevations increase northward at about 1 m/km, recording postglacial isostatic recovery of the Lowland. A kink in the delta elevation/latitude curve reflects postglacial movement in the Seattle fault zone (Thorson, 1993). With lidar topography, we see subtle nicks in some hillsides that correspond to the main recessional water levels (e.g., dashed blue line on Fig. 5). The feasibility of closely defining lake levels over large areas is uncertain until more geomorphic mapping is completed, but the possibility of defining such features throughout the Puget Lowland is exciting; we could not only thus identify Holocene faults, but we could place an upper limit on possible Holocene vertical offsets.

Detailed topography informs our understanding of glacial processes in this landscape. It reinforces the distinction between sub-parallel flutes, with meter to decameter amplitudes and spacing of hundreds of meters, and much larger anastomosing troughs (e.g., Rich Passage on cover image). Booth's (1994; Booth and Hallet, 1993) conclusion that the large troughs were eroded by subglacial melt water has

not convinced all observers. The clear contrast in form between flutes, which almost certainly were molded by flowing ice, and large troughs that must have been made by another process, supports Booth's conclusion.

Thorson (1980) hypothesized that the ice front in the Strait of Juan de Fuca retreated earlier than that in Puget Sound, inducing a local change in flow direction. At the north end of Whidbey Island, lidar topography shows a change in ice-flow direction that was even more profound and more extensive than Thorson figured. Late during the last glaciation, ice flowed to the west-southwest and modified flutes formed during earlier southwards flow (Fig. 7). A result of this overprinting was general smoothing that other observers have attributed to a blanket of glaciomarine drift or widespread end moraine. Note also, in Figure 7, the flights of relict shorelines that record postglacial isostatic rebound.

CONCLUSIONS

Lidar is capable of high-resolution topographic mapping in the heavily forested terrain of the Puget Lowland, producing better results than airborne interferometric synthetic aperture radar (InSAR) (Norheim et al., 2002) and photogrammetry. We have found the consortium approach to be very successful. Lidar costs drop significantly as the surveyed area increases be-

TABLE 1. COMPARISON OF LIDAR-BASED AND CONVENTIONAL LANDSLIDE INVENTORIES, CENTRAL KING COUNTY

	Area (km ²)
Identified as landslide in both lidar and conventional inventories	31
Identified as landslide in lidar inventory, not identified conventionally	123
Identified as landslide on conventional inventory, not identified in lidar inventory*	39

Note: From geologic map compilation in preparation by D.B. Booth, R.A. Haugerud, and J. Sackett, and analysis of lidar topography by Haugerud. See Figure 3 for area of comparison.
*Includes shallow debris flows on steep slopes in conventional inventory; lidar inventory is largely restricted to deep-seated features. Lidar topography suggests some landslides in conventional inventory do not exist.

cause of reduced mobilization expenses. By cooperatively contracting to map large areas across agency boundaries, we save money and produce a more uniform product. With lidar topography, we have more than succeeded in our goal of finding fault scarps for paleoseismic studies, we are improving our landslide inventory, and we are increasing our understanding of landscape evolution.

There is more to learn about the use of lidar mapping technology. From our experience, we see the need for better calibration procedures to increase accuracy by modeling and removing systematic errors. We need improved techniques for assessing the quality of bare-earth DEMs in forested areas. High-relief areas pose logistical difficulties; we are exploring these with a second NASA grant to survey of the west Mount Rainier seismic zone that includes over 1200 m of local relief. The best post-processing results are still obtained with substantial manual intervention, which raises the cost of lidar topography and, in some areas, leaves nagging concerns about the reproducibility of the resulting bare-earth DEM. Full automation is desirable. Pulse density is the prime determinant of survey cost, yet we lack the experience and tools to estimate the optimum pulse density in different landscapes.

Much work remains to be done to turn our new information on fault scarp locations into knowledge of the frequency of large crustal earthquakes in the Puget Lowland. Our present earthquake prehistory suggests that there was an unusual cluster of activity about 1100 years ago. If this clustering is real, what does it tell us about crustal deformation, the role of ice sheet unloading, and earthquake hazards (Thorson, 1996)? Or is the clustering only apparent, perhaps in part due to better preservation of younger scarps? We need research into scarp degradation rates in

this setting. Work is also needed to use the improved landslide inventory to model landslide processes and improve prediction of future slope failures.

Beyond the specific knowledge we are gaining about seismic and landslide hazards and landscape evolution in the Puget Lowland, the lessons gained from this successful lidar mapping experiment should enable improved earth-science investigations in forested landscapes elsewhere in the world.

ACKNOWLEDGMENTS

It continues to be a pleasure to work with our partners in the Puget Sound Lidar Consortium. We have benefited greatly from their skills and experience. We are grateful for continuing support from the Solid Earth and Natural Hazards Program at NASA. We thank William Dietrich, Keith Howard, Robert Thorson, and Ray Wells for constructive reviews of this article.

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CORRECTION

Reactivation, trishear modeling, and folded basement in Laramide uplifts: Implications for the origins of intra-continental faults *GSA Today*, v. 13, no. 3, p. 4–10 (March 2003)

An incorrect Table 1 was published. The corrected Table 1 is shown here. *GSA Today* regrets the error.

TABLE 1. EXAMPLES OF FOLDED BASEMENT-COVER CONTACT

Structure	Location (see Fig. 1)	Basement fold half wavelength (km)	Interlimb angle (degrees)	Maximum dip of basement surface (degrees)	Source	Reference
Uinta-Sparks fault	1	1.1	145	40	cross section ^{1,2}	Stone, 1993b
Island Park fault	2	0.8	90	23	cross section ^{1,2}	Stone, 1993b
Uinta Basin Boudary fault	3	5.0	140	40	cross section ^{1,2}	Stone, 1993b
North flank, Uinta Mountains	4	2.3	115	85	cross section ^{1,2}	Gries, 1983
Anticline in North McCallum field	5	0.6	160	10	seismic line ⁴	Lange and Wellborn, 1985
Anticline in Battleship field	6	0.3	165	10	seismic line ⁴	Lange and Wellborn, 1985
Rangely anticline	7	0.7	80	75	cross section ^{1,2}	Mitra and Mount, 1998
Twin Mountain anticline	8	0.1	70	85*	cross section ⁵	Schmidt et al., 1993
Big Thompson anticline	9	0.5	75	90	cross section ^{5,7}	Narr and Suppe, 1994
Willow Creek anticline	10	1.0	100	80	cross section ¹	Narr and Suppe, 1994
Laramie basin	11	0.8	145	21	seismic line ³	Stone, 1993a
Oregon Basin thrust	12	4.0	130	50	seismic line ³	Stone, 1993a
Pitchfork anticline	13	0.3	115	35	cross section ^{1,2}	Stone, 1993a
Elk Basin anticline	14	0.4	100	50	cross section ^{1,2}	Stone, 1993a
Maverick Springs anticline	15	4.0	60	40	cross section ^{2,0}	Stone, 1993a
Small anticline on Casper Mountain	16	0.1	105	90	cross section ⁶	Narr, 1993
Five Springs thrust, Bighorn Mountains	17	0.7	85	65	cross section ⁶	Narr and Suppe, 1994; Wise and Obi, 1992
Rawlins uplift	18	>1.3	70	75*	cross section	Gries, 1983
Granite Mountains	19	2.5	150	34	cross section	Gries, 1983
LaPrele anticline	20	0.6	70	90	cross section ⁶	Schmidt et al., 1993
Sheephead Mountain anticline	21	0.1	60	75*	cross section ⁵	Chase et al., 1993
Madden anticline	22	5.0	160	10	cross section ^{1,2}	Ray and Keefer, 1985
London Hills anticline	23	0.5	110	90	cross section ⁵	Chase et al., 1993

Note: Asterisk indicates overturned; 1—seismic control; 2—well control; 3—time section; 4—depth section; 5—down-plunge projection; 6—surface control only; 7—gravity control.

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Greetings!

The Annual Meeting is not far away—now is a good time to contemplate the state of your calendar for early November. This year's meeting in the Pacific Northwest has a remarkable line-up of talks, poster sessions, and field trips. It will also be held in the heart of downtown Seattle, where there is always lots to do!

The programming for this year's meeting emphasizes a particularly wide range of topics. It's tough to highlight the "most interesting" sessions because there are so many to choose from; however, some candidates include:

- His View of Life: Reflections on the Scientific Legacy of Stephen J. Gould (P2)
- Global Climate Changes: Abrupt Late Pleistocene Climatic Reversals and Modern Global Warming (T152)
- Preservation of Random Mega-scale Events on Mars and Earth: Influence on Geologic History (P5)
- The Paleoenvironmental and Paleoclimatic Framework of Human Evolution (P6)
- Impending Disaster—The Impact of Population Growth on Water Availability and Quality (T3)
- Geology of Salmon (T6)
- Geological Mapping: Key to Successful Management of Water and Land Resources (T102)
- The Peopling of the New World: Geology, Archaeology, and Paleoenvironments (T1)
- Tectonics of the Circum-Pacific Rim in Space and Time: Alaska, Central and South America, and the Western Pacific (T144)
- Mega-Events on Earth and Mars: Record, Recognition, and Consequences (T10)
- Revolutionizing Ocean Science: Cabled Observatories on the North American Pacific Coast (T74)
- Wetland Science: Intersection of Hydrogeology, Geomorphology, Ecology, and Computer Modeling (T100)
- The Washington Cascades: An Integrated Perspective on 100 Million Years of Orogenesis, Magmatism, and Surface Processes (T145)

Because GSA's membership is as diverse as the study of geology itself, *any* excerpt from the list of planned sessions is like showing you only the tip of the iceberg: you can only begin to get a feel for the impact of the meeting and all that will be available. So, I invite you to come to the Seattle meeting. You'll find plenty to engage you, and you'll also have a great opportunity to meet with your friends and colleagues.

Derek Booth

General Chair, Seattle Local Committee

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K–16 Workshops:	Sat.–Sun., Nov. 1–2
Presidential Address & Awards Ceremony:	Sun., Nov. 2, 4–6 p.m.
Welcoming Party & Exhibits Opening:	Sun., Nov. 2, 6–8 p.m.
Technical Program:	Sun., Nov. 2, 8 a.m.–noon & 1–3:45 p.m. Mon.–Wed., Nov. 3–5, 8 a.m.–noon & 1:30–5:30 p.m.
Pardee Keynote Symposia:	Sun., Nov. 2, 8 a.m.–noon Mon.–Wed., Nov. 3–5, 8 a.m.–noon & 1:30–5:30 p.m.
Private Alumni Receptions:	Mon., Nov. 3, 5:30 p.m.–1 a.m.
Group Alumni Party:	Mon., Nov. 3, 7–9:30 p.m.
Exhibits Open:	Mon.–Tue., Nov. 3–4, 9 a.m.–5:30 p.m.; Wed., Nov. 5, 9 a.m.–2 p.m.
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Hot Topics:	Sun.–Wed., Nov. 2–5, over lunchtime
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GSA PRESIDENTIAL ADDRESS & AWARDS CEREMONY

Sun., Nov. 2, 4–6 p.m.,
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Join us Sunday when President Clark Burchfiel gives his Presidential Address and distributes the 2003 Awards and Medals. Recipients of the Penrose Medal, the Arthur L. Day Medal, the Young Scientist Award (Donath Medal), the GSA Public Service Award, the Doris M. Curtis Women in Science Award, and the GSA Distinguished Service Award, as well as the newly elected Honorary Fellows, will be announced in an upcoming issue of *GSA Today*.

Come honor your fellow geoscientists, the award recipients, and the Honorary Fellows at the Presidential Address and Awards Ceremony. Also, be sure to stick around for great networking opportunities at the Welcoming Party in the Exhibit Hall from 6 to 8 p.m.

EXHIBITS OPENING & WELCOMING PARTY

Sun., Nov. 2, 6–8 p.m.,
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Come enjoy the Grand Opening of the 2003 GSA Annual Meeting & Exposition. This kickoff event will be in the Exhibit Hall following the Presidential Address. You'll find the Welcoming Party to be a great time for networking with colleagues and friends, as well as a good opportunity to view the exhibits and enjoy a beverage.

AWARD LUNCHEONS & OTHER TICKETED GROUP FUNCTIONS

GSA Associated Societies and GSA Divisions invite their members and other interested guests to join them for their annual meal functions, special addresses, and awards ceremonies. Only a few tickets will be available on-site, so please register early for ticketed functions online or with your preregistration form. The location and time of the event will appear on your ticket and in the 2003 Annual Meeting Program. Please note: Some luncheon dates have changed from previous years because of the new meeting schedule. Please double-check the preregistration form when you sign up.

GROUP ALUMNI PARTY

Mon., Nov. 3, 7–9:30 p.m., Sheraton Seattle, Grand Ballroom

Join your former classmates and colleagues at this year's Group Alumni Party at the Sheraton Seattle.

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Plan to join your fellow alumni for an evening of memories and renewed connections. Please check the 2003 Annual Meeting Program for a listing of schools holding individual alumni receptions and for reception locations.

If you would like to hold a private alumni reception, check with your department head, who may have already arranged this with GSA, or e-mail mcummmiskey@geosociety.org.

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GSA President Clark Burchfiel invites all students registered for the meeting to attend a free breakfast buffet sponsored by ExxonMobil Corporation. Clark and members of the GSA leadership, as well as ExxonMobil staff members, will be on hand to answer questions and address student issues. Each student registered for the meeting will receive a complimentary ticket for the breakfast buffet. This is one of the most popular events at the meeting for students, and with good reason! Take this opportunity to network with fellow students and meet the officers of GSA.

(by category—as of 5/1/03)

Join a community of dedicated exhibitors who will be meeting over 6,100 geoscientists in Seattle this November!

Opportunities to meet these geoscientists face to face are limited so take advantage of this important event. To select space now, contact GSA Exhibit Management Services, (303) 914-0694, or view the prospectus online at www.geosociety.org/meetings/2003.

Note the new hours on Wednesday!

EXHIBIT HALL HOURS

Sun., Nov. 2—Exhibits Opening & Welcoming Party 6–8 p.m.
 Mon., Nov. 3 9 a.m.–5:30 p.m.
 Tues., Nov. 4 9 a.m.–5:30 p.m.
 Wed., Nov. 5 9 a.m.–2 p.m.

NEW! Exhibits Close on Wed., Nov. 5 at 2 p.m.

National Ground Water Association
 Paleontological Research Institution
 Paleontological Society
 Society for Sedimentary Geology
 Society for Economic Geologists

PUBLICATIONS, MAPS, FILMS, & TEACHING AIDS

Academia Book Exhibits
 Blackwell Publishing
 Brooks/Cole, Thomson
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 National Association of Geoscience Teachers



Mount Adams volcano, Washington.
 Photo by John Karachewski.

Graduate School Information Forum

Sun.–Wed., Nov. 2–5, 8 a.m.–5:30 p.m.

Washington State Convention and Trade Center, Exhibit Hall 4DF

Draw the best students to your institution by prominently displaying your school in the Graduate School Information Forum! Reserve space now for the 2003 GSA Annual Meeting in Seattle.

The Graduate School Information Forum is an effective way to attract graduate students to your program. GSA student members are enthusiastic and serious about geology—that's why 1,900 of them attended GSA's 2002 Annual Meeting, and we expect even more in Seattle. It's no wonder more than 50 universities and colleges in the United States send representatives to the forum year after year. The four-day forum will be located in a high-traffic area adjacent to the Exhibit Hall, in the poster session hall, and the corridor leading to it.

Take advantage of outstanding visibility for your institution, and reserve space for one, two, three, or all four days. Space is extremely limited; Sunday and Monday will be the first to sell out. *Those schools reserving multiple days will be assigned first and will be given the most visible booths.*

When you reserve space in the forum, your school and program will also be promoted in three additional places at no additional charge:

- October issue of *GSA Today*
- 2003 Annual Meeting Program
- New this year: GSA's Web site (with live e-mail link)

A new online graduate school program posting opportunity may be available later this year that will help enhance visibility during the meeting and throughout the year. Participating GSIF schools will be eligible for significant discounts. Stay tuned for further details.

WOULD YOU LIKE TO PARTICIPATE IN THE GSIF?

Contact Kevin Ricker,
(800) 472-1988, ext. 1090
(303) 357-1090, fax 303-357-1072
or kricker@geosociety.org.

Student Volunteer Program

Free registration! Free abstracts volume! These are a couple of the benefits to working as a student volunteer at the GSA Annual Meeting.

To learn more about the Student Volunteer Program and other student opportunities, visit our Web site: www.geosociety.org/meetings/2003/students.htm.

If you have additional questions about the Student Volunteer Program, contact Kevin Ricker kricker@geosociety.org 1-800-472-1988, ext. 1090.

GSA Employment Services

EMPLOYMENT INTERVIEW SERVICE

Sun., Nov. 2, noon–5 p.m.

Mon.–Wed., Nov. 3–5, 8 a.m.–5 p.m.

Do you need qualified scientists to fill staff needs?

Are you looking for employment in the earth sciences?

If so, you are invited to participate in the GSA Employment Interview Service. All organizations seeking qualified earth scientists at any level are urged to submit notices of vacancies and requests for access to applicant profiles in advance of the meeting. Interview booths at the meeting may be reserved in half-day increments for a nominal fee, and GSA staff will handle all interview scheduling. Many job seekers have found the Employment Interview Service critical to their successful search for positions.

The registration fee for applicants is \$35 for GSA members and associates and \$65 for nonmembers (\$30 goes toward GSA membership) and includes not only interviewing at the annual meeting but year-round service as well. To register, applicants may post their own résumé-style profile online. Be sure to set up your profile early to receive maximum exposure prior to the meeting! Profile posting for applicants and forms for employers are available in the Employment Opportunities section of GSA's Web site, www.geosociety.org. Applicants and employers may also register at the meeting.

EMPLOYMENT OPPORTUNITIES IN THE GEOLOGICAL SCIENCES

Tentatively scheduled for Sun., Nov. 2, 1–3 p.m.

This annual forum on employment opportunities in the geosciences allows valuable one-on-one interaction between panel members and individuals or small groups. Experts in each of the areas listed here will conduct his or her own mini-roundtable discussion, designed to provide a better opportunity to field both general and specific questions on a more personal, individualized basis. These roundtable discussions will be in the Employment Service area during the interview registration time; *however, you do not have to be signed up for either the annual meeting or the Employment Matching Service to participate in these discussions.* Everyone—professionals and students—is encouraged to attend. Join as many of the discussions as you like. Roundtable discussion leaders from the following areas will be featured this year: academic and education; mining; federal government; state and local government; consulting; petroleum; and résumé review.

For additional information, contact Nancy Williams, Membership, GSA Headquarters, membership@geosociety.org, (303) 357-1017.



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We extend a warm welcome to all guests at the 2003 GSA Annual Meeting & Exposition in Seattle, Washington!

To register as a guest, please complete the preregistration form online at www.geosociety.org, or send the preregistration form in this issue (p. 33) to GSA, P.O. Box 9140, Boulder, CO 80301-9140, fax 303-357-1072.

The guest registration fee of \$80 per person is for non-geologist spouses, family members, or friends of a professional and/or student registrant. The guest registration fee is required for those attending all guest activities, tours, seminars, access to the Exhibit Hall, and for refreshments in the Guest Hospitality Suite. The guest registration fee will not provide technical session access; however, guests can sign in with the hostess in the Guest Hospitality Suite to get a visitor badge, allowing entrance to a specific presentation. Formal guest tours, listed in the following section, are at an additional cost and include professional tour guides, round-trip transportation, admission fees, and gratuities. *The price of lunch is only included with the full-day tours.*

TOURS

All GSA Annual Meeting guests are welcome to register for the following guest program tours. Reservations for all tours will be accepted on a first-come, first-served basis. The tour operator requires a final guarantee weeks in advance. Most tours have attendance minimums as well as maximums. Tours may be canceled if minimum attendance is not met. Please register early to guarantee your spot.

Plan to arrive at the departure location 15 minutes before the scheduled departure time to make sure you don't miss the bus. Guests should meet in the Convention Center on Level One at Convention Place near the escalators. Guest tours and field trips will depart from this same location—look for directional signs.

The Seattle area has a great deal to offer, and the formal tours can only cover a small portion of what is available for you to see and do. You may enjoy visiting other area attractions with fellow guests or go it alone on a self-guided

tour. The Guest Hospitality Suite hostess can provide you with more information and activity suggestions.

1. Bird Watching [101]

Sat., Nov. 1, 7 a.m.–noon

Back by popular demand, this bird watching tour of the Pacific Northwest begins with a stop at the Mercer Slough Nature Park. Mercer Slough has more than 300 acres of wetlands around Lake Washington and is one of the most diverse ecosystems in the urban Puget Sound region. Marshes, meadows, and forests provide critical habitat for wildlife and ample opportunities for discovering nature. It's a birdwatcher's paradise, with more than 100 species of birds. You'll also visit the 144-acre Juanita Bay Park in Kirkland, where you'll see songbirds, waterfowl, raptors, shorebirds, turtles, beavers, and other small mammals. Cost: \$35. Maximum: 25.

2. Seattle City Highlights—Deluxe Tour (Full-Day Tour) [102]

Mon., Nov. 3, 8 a.m.–2 p.m.

Find out why Seattle has been named one of America's most livable cities! This tour provides an overview of what Seattle has to offer. A friendly and informative tour guide will tell you about the city's historical background, point out interesting landmarks, and give insider sightseeing and shopping tips. Visit Pioneer Square, one of Seattle's oldest areas, featuring 1900s architecture, art galleries, and specialty shops. The tour also includes a drive over one of Seattle's floating bridges on beautiful Lake Washington, past the University of Washington campus, and a stop at the Hiram M. Chittenden Locks and Salmon Ladder. The locks connect saltwater Puget Sound with freshwater Lake Union and feature the seasonal migration of salmon returning to their parent streams to spawn. Last stop: Seattle's world famous Pike Place Market, an exciting array of color, aroma, sounds, and lunch. Guests will enjoy a delicious luncheon at Salty's on Alki Beach, which has a fabulous view of the Seattle sky-

line. Cost: \$68. Minimum: 35 people. Maximum: 45 per bus.

3. Experience Music Project and the Space Needle [103]

Mon., Nov. 3, 9 a.m.–noon

The day begins with transportation to the Seattle Center—home of the Space Needle, Experience Music Project (EMP), and a host of theatrical and cultural experiences—onboard the Seattle Monorail, the nation's first full-scale commercial monorail system. First stop: EMP, a technologically advanced interactive museum, takes you on a journey into the power and history of American popular music. The museum captures and reflects the past, present, and future of the world of music and includes interactive exhibits on jazz, rock 'n' roll, soul, gospel, country, and the blues. You'll find almost 80,000 music history artifacts on display, including musical instruments, an extensive recorded sound archive, film, photographs, stage costumes, handwritten song lyrics, and rare song sheets. Next, visit Seattle's most recognizable and world-famous landmark: the Space Needle. You'll be taken to the top of the 605-foot Space Needle, where you'll have the whole Northwest at your feet—and one of the best views in the world! The 360-degree panorama includes such awe-inspiring sites as Mount Rainier, Puget Sound, the University of Washington, beautiful Lake Union, and much more. Cost: \$45. Minimum: 25 people. Maximum: 35.

4. Seattle City Highlights [104]

Mon., Nov. 3, 1–5 p.m.

This is a shorter version of the full-day tour, and does not include the luncheon. Cost: \$27. Minimum: 35 people. Maximum: 45 per bus.

5. Snoqualmie Falls and Wine Tasting (Full Day Tour) [105]

Tues., Nov. 4, 10 a.m.–4 p.m.

Travel just 25 miles east of Seattle, through the foothills of the Cascade Mountains, to breathtaking Snoqualmie Falls. The Snoqualmie River cascades 270 feet through a spectacular rock gorge into a 65-foot-deep pool. You can choose to view the falls from the observation platform above the drop, where the view is amazing and you can actually feel the spray, or you may wander through the lush, tree-lined park at the bottom of the falls. Guests will enjoy a fabulous lun-

cheon above the falls at Salish Lodge, a four-diamond retreat and one of Seattle's most romantic getaways. To conclude the afternoon, you'll be transported to the lovely Chateau Ste. Michelle winery, Washington's oldest and most famous winery. During your private guided tour, you'll witness the marvel of the winemaking process and have the opportunity to sample world-famous wines, stroll the grounds, and visit the extensive wine and accessory gift shop. Cost: \$65. Minimum/maximum: 25 people.

6. The Art of Glassblowing: Seattle Art and Gallery Tour [106]

Tues., Nov. 4, 2-5 p.m.

Seattle has become the glass art capital of the U.S.—some say, of the world. Seattle is recognized for many glass art galleries and private collections worth millions. Public buildings throughout the city serve as galleries as well; the city government allocates 1% of its expenses toward the purchase of public art. Your guide for this tour will escort you through some of Seattle's glass art studios so you can see how the artists work to create their world-renowned pieces. You'll enjoy a fascinating visit to the Glasshouse Studio in Pioneer Square, where you'll have the opportunity to see a glassblowing demonstration—glass art created right before your eyes! Glass will never be the same again; you'll appreciate the art form as never before. Cost: \$38. Minimum: 20 people. Maximum: 25.

7. Seattle Aquarium and Pacific Science Center [107]

Wed., Nov. 5, 11 a.m.-3:30 p.m.

Enjoy the last day of the meeting by taking a short motor-coach ride to the bustling Seattle waterfront, home of the Pacific Science Center and the Seattle Aquarium. The aquarium has an underwater dome, offering an ideal spot for you to observe some of the sea life of Puget Sound, including salmon, sharks, and perhaps even some marine mammals. Special exhibits feature a Pacific coral reef, a tide pool, hands-on displays, and a "touch tank." Next, explore the magic and mysteries of the Pacific Science Center, where any adult is sure to become a kid again! The center has more than 200 hands-on exhibits for guests to explore science, technology, and the secrets of the universe. With robotic dinosaurs, a planetarium, informative traveling science exhibits, and a wide array of virtual displays, there is certain to be something there for you! Cost: \$52. Minimum: 35 people. Maximum: 45.

SEMINARS

Payment of the guest registration fee entitles you to attend the guest seminars offered below at no extra charge. Seminar locations will be listed in the October issue of *GSA Today* and in the Annual Meeting Program.

Welcome to Seattle

Mon., Nov. 3, 10-11 a.m.

This entertaining seminar will educate you on (almost) everything you need to know about Seattle. Topics will include the history of the great metropolis, the famous Pike Place Market, the amazing underground city, and the 1962 World's Fair, which brought the world (and the Space Needle) to Seattle. You will get a blend of history, current information, and many other little tidbits you never would have known. This is a must-attend seminar for any curious visitor!

Earth Scientists on Capitol Hill

Report from Raphael D. Sagarin, GSA-USGS
2002-2003 Congressional Science Fellow

Tuesday, November 4, 2003

Noon-1 p.m.

Washington State Convention & Trade Center
FREE. Registration not required.

Plan to attend this FREE presentation by Raphael D. Sagarin, the 2002-2003 Congressional Science Fellow. Sagarin will share information about his experiences this past year in Washington, D.C. If you have questions about this Fellowship opportunity or about how YOU, as a geoscientist, can impact actions on Capitol Hill, Sagarin has answers.



Laughter—Good Medicine for the Soul

Tues., Nov. 4, 10-11 a.m.

According to Lesley Holdcroft of the *Seattle Times*, laughing became a formal discipline—a defined form of yoga—in India in 1995, after Dr. Madan Kataria, now known as the "Guru of Giggles," gathered five of his patients in a city park "to experiment with the healing qualities of laughter." Kataria noted that "the effect on the patients' spirits and health was striking." This 60-minute seminar will include a demonstration of eight silly laughs, from snorts to guffaws to the secret-weapon silent laugh and the ice-cube-down-the-shirt laugh.

The World of Washington State Wines

Wed., Nov. 5, 9-10 a.m.

Washington State is known for producing a wonderful variety of wine. This seminar will feature local wine expert David LeClaire, wine director at the Library Bistro at Seattle's exclusive Alexis Hotel. Come learn more about the brilliant world of Washington wines!

GUEST HOSPITALITY SUITE HOURS

Sun.-Wed., Nov. 2-5, 2003, 8 a.m.-5:30 p.m.

Washington State Convention & Trade Center, Room 201

Beginning Sunday, November 2, guests are invited to visit the Guest Hospitality Suite on Level Two at the Convention Center, Room 201. A hostess will provide a resource center with abundant information about Seattle and its various attractions and sightseeing opportunities, and light refreshments will be served throughout the day. Please remember to wear your GSA badge; it will be required for admission to the Hospitality Suite and Exhibit Hall.

STUDENTS, SPOUSES, & INTERESTED GUESTS are cordially encouraged to attend any of the field trips. Trips are technical in nature, and some can be physically rigorous. Participants should be prepared for cold, wet weather. Trips are one to five days in duration and are led by active field researchers. The minimum number of registrations for field trips is 12 unless otherwise stated.

If you register for *only* a field trip, you must pay a \$40 nonregistrant fee in addition to the field trip fee. The \$40 may be applied toward meeting registration if

Attention Students!

The **GSA HYDROGEOLOGY DIVISION** will subsidize the first student registrant who is a valid division member. The student must pay the full field trip fee when registering, but will be reimbursed \$50 after the GSA meeting by the Hydrogeology Division.

The **GSA SEDIMENTARY GEOLOGY DIVISION** is cosponsoring a few field trips and will subsidize all students who are valid division members (see individual trip descriptions for sponsorship information). Students must pay the full field trip fee when registering but will be reimbursed \$100 after the GSA meeting by the Sedimentary Geology Division. To be reimbursed, students must apply in writing to Paul K. Link, Dept. of Geology, Box 8072, Idaho State University, Pocatello, ID 83209-8072, (208) 282-3365, linkpaul@isu.edu.

The **GSA STRUCTURAL GEOLOGY AND TECTONICS DIVISION** offers up to five \$100 scholarships to division-affiliated student members for division-sponsored field trips. Apply in writing (by e-mail only), giving your name, institution, class, specialty, poster or talk title, field trip title, and a one-paragraph rationale to Martha Oliver Withjack, drmeow3@yahoo.com. Application deadline is Sept. 1. See the Structural Geology and Tectonics newsletter for more information.

you decide to attend the meeting. Trip fees include transportation during the trip and a guidebook. Other services, such as meals and lodging, are noted by the following symbols: B—breakfast, L—lunch, R—refreshments, D—dinner, ON—overnight lodging.

Most trips begin and end in Seattle at the Washington State Convention and Trade Center, *unless otherwise indicated*. Upon return, some postmeeting trips can stop at the Seattle-Tacoma International Airport to drop off participants who have evening flights or who would prefer to spend the night in a hotel closer to the airport. Participants are cautioned against scheduling any tight travel connections with field trip return times as those times are estimates and delays in the field can occur. For a list of hotels near the airport, contact Edna Collis, Program Officer, GSA Headquarters, (303) 357-1034, ecollis@geosociety.org.

CANCELLATION DEADLINE IS OCTOBER 3.

No refunds will be given after this date. If GSA must cancel a field trip because of logistics or if minimum registration requirements are not met, a full refund will be issued to you after the meeting. Be aware of flight-change penalties imposed by the airlines. Plan alternatives in advance should the trip you are registered for be cancelled.

FOR MORE INFORMATION

Contact the field trip leader or the 2003 field trip chair: Terry Swanson, Dept. of Earth and Space Sciences, University of Washington, Seattle, WA 98195, (206) 543-1923, fax 206-543-0489, tswanson@u.washington.edu.

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. Minimum: 10. Maximum: 20. Cost: \$690. (1L, R, 5ON, vans). *Begins on the Big Island of Hawaii and ends on Oahu.*

This field trip will consist of four field days: two on the Big Island (Island of Hawaii) and two on Oahu. Stops include

current eruption sites at Kilauea, geothermal drilling sites, a dike water collection tunnel, a Maui-type well, the top of Diamond Head Crater, fresh water springs at Pearl Harbor, and rejuvenation-stage volcanic craters such as Punch Bowl and Hanauma Bay.

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. Minimum: 12. Maximum: 42. Cost: \$290. (3L, R, 2ON, bus). *Begins and ends in Spokane, Washington.*

In 1923, J Harlan Bretz introduced his concept that Washington's Channeled Scabland owed its origins to catastrophic flooding, and in 1940 Joseph Pardee offered ice-dammed Glacial Lake Missoula as the floodwater source. Visit the source area, study the Clark Fork ice dam, and observe outburst features in northern Idaho and western Montana.

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. Minimum: 10. Maximum: 30. Cost: \$295. (3B, 3L, R, 3ON, vans). *Begins and ends in Salt Lake City, Utah.*

In 1963, Larry Sloss named the Sauk Sequence for a stratigraphic interval bounded by interregional unconformities; today, we recognize that this interval comprises many depositional sequences. During this field trip, we will examine key exposures in the House and Confusion ranges and discuss the processes and models for tectonic and sedimentological evolution of the western miogeocline.

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) 758-3667, fax 610-758-3677, fjp3@lehigh.edu; Glenn Thackray; Mark T. Brandon; Eric McDonald; John Gosse; Karl Wegmann. Minimum: 8. Maximum: 24. Cost: \$525. (3B, 4L, 3D, R, 3ON, vans).

This field trip is designed to exhibit the geology, geomorphology, and active tectonics of the Olympic Peninsula. We will generate lively discourse on how to use and interpret basic field relationships in tectonic geomorphology research, such as defining a river terrace and how it is used in active tectonics; whether margin parallel or margin orthogonal shortening is driving orogenesis for the Olympic Mountains; and how these different types of uplift influence landscape evolution. We will visit a wide array of glacial, glaciofluvial, and fluvial deposits, their soils, numeric constraints on their ages—including cosmogenics, in addition to tectonic and structural geology overviews at scenic locations like Hurricane Ridge and the coast near Kalaloch.

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. Minimum: 12. Maximum: 44. Cost: \$315. (2L, 2D, R, 1ON, bus).

The topic is the geologic setting of some of Washington's best vineyards and wineries, including the Red Mountain, Walla Walla, and Yakima Valley appellations. We will examine some of the world's better exposures of glacial slackwater sediments (which underlie most of the vineyards), flood basalts, and one of the world's largest wind turbine farms, ending the day with dinner at a beautiful winery.

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, BC V2S 7M8, (604) 504-7441, ext. 4336, fax 604-855-7558, vanderburghs@ucfv.bc.ca; Guy Gelfenbaum; Curt Peterson; Harry Jol; Jim Phipps. Minimum: 12. Maximum: 40. Cost: \$415 (3L, 1D, R, 2ON, bus).

Participants will tour one of the most dynamic coastal systems in the world. Numerous sites throughout the Columbia River Littoral Cell of the United State's Pacific Northwest coast between Point Grenville, Washington, and Tillamook Head, Oregon, will be visited. Aspects of barrier beach plain evolution, regional scale coastal processes, and tectonics will be examined and related to resource management and land-use planning.

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

Thurs.–Sat., Oct. 30–Nov. 1. Stephen Reidel, Pacific Northwest National

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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. Minimum: 12. Maximum: 22. Cost: \$290 (2L, R, 2ON, vans).

The Columbia River Basalt Group is the youngest and best-studied flood-basalt province on Earth. This trip provides an overview of the principal features of the flood-basalt lavas and the related Yakima Fold Belt. Topics include the nature and extent of the lavas, how the flows were erupted and emplaced, and how deformation of the basalt produced the geometry and structure of the fold belt.

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. Minimum: 12. Maximum: 35. Cost: \$305 (3L, 2D, R, 2ON, vans).

The southeast part of the Cascades core preserves a ~40 km thick crustal section through a 96 to 45 Ma continental magmatic arc. This trip will integrate structure, metamorphism, igneous petrology, and geochronology to evaluate processes over a wide range of crustal levels. Topics to be examined include strain, kinematic, and metamorphic patterns during major Cretaceous shortening and Eocene extension; mechanisms and timescales of pluton construction and magmatic fabric development; rapid lateral and vertical movements during arc construction and exhumation; and the rheology of the crustal section.

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.wvu.edu. Minimum: 12. Maximum: 24. Cost: \$340 (3L, R, 2ON, mini-bus).

Topics for this trip include ¹⁴C chronology of the Cordilleran Ice Sheet; morphologic, stratigraphic, and chronologic evidence for four Allerød and YD readvances; Glaciomarine drift, sea-level changes, and ¹⁴C marine reservoir changes; isostatic rebound rates; North Cascade Pleistocene alpine glaciation; Okanogan lobe moraines, drumlins, eskers, kames, and outwash fans; coulees, scablands, giant bars, dry falls, and cataracts of Missoula floods.

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. Minimum: 12. Maximum: 24. Cost: \$200 (2L, R, 1ON).

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This field trip is set within the dramatic semi-arid landscape of the Cascades' eastern slope and mid-Columbia River valley. In addition to the fascinating Tertiary and Quaternary history, the trip focuses on the geologic hazards and human development within the region, highlighting the enormous landslides, fault hazards, hydroelectric dams, and transportation corridors.

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. Minimum: 7. Maximum: 21. Cost: \$245 (2L, R, 1ON).

During this field trip we will examine the formerly enigmatic stratigraphy of the few km-thick, Eocene, nonmarine arkosic rocks of the Swauk Formation and other Eocene, Miocene, and Pliocene formations. These are parts of four interregional unconformity-bounded sequences. The sequences reveal a northeasterly verging fold and thrust belt that extends from Yakima to Seattle and the late Neogene Cascade Range anticline.

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. Minimum: 12. Maximum: 20. Cost: \$125 (1L, R, vans).

The main objective of this field trip will be to visit the Late Eocene Bear River cold-methane-seep deposit in southwestern Washington. There will be ample opportunity to collect samples from the richly fossiliferous deep-water limestone. We will traverse marine Tertiary basalts and volcanoclastic and siliciclastic strata as we travel to and from the Bear River deposit. If weather and road conditions permit, we intend to make brief stops at other

seep deposits, rock outcrops, and sites of local historic importance.

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. Minimum: 7. Maximum: 20. Cost: \$140 (1L, R, vans).

Sandy lahars from Mount Rainier and sediments derived from them have filled an arm of Puget Sound in the 5000–6000 years since the Osceola mudflow. The filling occurred episodically, as shown by facies and ages of terrace deposits along the White River, channel fills in Kent, and a delta that prograded across the Seattle fault.

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. Maximum: 44; minimum 12. Cost: \$95 (1L, R, vans, ferry).

We will ferry over to pastoral Whidbey Island to visit some of the classic exposures that define Puget Lowland glaciation. The advance and retreat history of the last glaciation is well-exposed in spectacular wave-cut bluffs surrounding Whidbey Island. Some of the more interesting questions surrounding the nature and timing of this advance and retreat history, including post-glacial sea-level reconstructions, will be addressed. Hiking will consist mainly of beach walks, and lunch will be at the historic Loganberry Farm Winery.

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. Minimum: 7. Maximum: 20. Cost: \$210 (1L, R, vans).

Southern Puget Sound has more than 1000 feet of Quaternary sediment, most of which is radiocarbon-infinite. Travel by boat to visit 200-foot coastal bluff exposures, where interbedded tephros from Mount Rainier and Mount St. Helens are critical to unraveling a glacial and interglacial stratigraphy and paleogeography quite different from what is exposed farther north.

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. Minimum: 12. Maximum: 38. Cost: \$80 (1L, R, vans).

We will visit recently studied geoarchaeological sites that provide insight into late Quaternary environments and early human prehistory. These include Columbia Park in Kennewick, where the controversial Kennewick Man skeletal remains were found, and Pleistocene-Holocene transition sites adjacent to the Columbia River, including the recently excavated Sentinel Gap site that contains a stratigraphic record complete with Paleoindian cultural material, paleosols and volcanic tephra.

Postmeeting

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

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

We will examine a high-T mantle shear zone (fracture zone?), intrusive and extrusive mafic rocks, argillite containing ophiolite breccias, and post(?)-ophiolite dikes. We will discuss tectonic

models in light of new stratigraphic, structural, geochemical, paleontologic, and radiometric age data, including the hypothesis that the ophiolite consists of older oceanic basement that was rifted in a Middle-to-Late Jurassic suprasubduction zone setting.

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. Minimum: 7. Maximum: 20. Cost: \$240 (2L, R, 2 ON, vans). *Due to security restrictions, only U.S. citizens can enter the Hanford Site on this tour.*



Association for Women Geoscientists:

GEOLOGY OF THE SEATTLE AREA

Sat., Nov. 1, 8 a.m.-5:30 p.m.

Sponsored by the *Association of Women Geoscientists*. Leader: Kathy Goetz Troost, University of Washington. Preregistration is required; preference will be given to AWG Convention attendees. Registration deadline: Sept. 30. For trip description, cost, information, and registration: Carla Whittington, (206) 878-3710, ext. 6183 or cwhittin@attbi.com. Also see the AWG Convention web site at www.scn.org/psawg/Convention.html.

ASSOCIATION OF EARTH SCIENCE EDITORS

Shaking, Baking, Slipping, and Sliding in Seattle

Sat., Nov. 1, 8 a.m.-9 p.m. Sponsored by *Association of Earth Science Editors*. Maximum: 90. Cost: Professional: \$120; student: \$75. Preregistration required. Registration deadline is September 30, 2003. Information and registration: Marla Adkins-Heljeson, (785) 864-2114 or marla@kgs.ku.edu.

This geologist-led field trip will include an overview of the geology of the Seattle area, with particular emphasis on hazards. With some world-class volcanoes, plate boundaries and associated earthquakes, debris flows, and flood potential in the area, there is no shortage of challenges for geologists in assessing the threats. Communicating these potential hazards to the public is the second major challenge facing geologists. We will leave the hotel in the morning, have box lunches on the bus or at a stop, and travel on to Mt. Rainier, where we will end our day with dinner at a rustic lodge before our two-hour trip back to Seattle.

This field trip provides an overview of the geohydrologic setting of the Hanford Site and its impact on contamination and waste cleanup at the former U.S. Department of Energy weapons site in south-central Washington State.

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. Minimum: 12. Maximum: 45. Cost: \$170 (2L, R, vans).

On this Seattle-based two-day trip, we will view geologic evidence for Holocene earthquakes on shallow faults in the Puget Sound Lowland. Evidence includes terraces recording coastal uplift along the Seattle and Tacoma faults and scarps from surface faulting recently discovered on LIDAR maps. Some evidence suggests that a large earthquake about 1100 years ago was shortly preceded by other large earthquakes.

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. Minimum: 12. Maximum: 40. Cost: \$370 (2B, 3L, 2D, R, 2ON, vans).

This scenic field trip will explore the hydrogeology of the Cascade Range volcanic arc in southern Washington and north-central Oregon. We will depart from Seattle early Thursday morning and spend much of the day at Mount St. Helens, lodging in northern Oregon near Estacada. On Friday, we will investigate the north-central Oregon Cascades and lodge at Sisters, Oregon. Saturday, we will visit Mt. Hood and return to Seattle in time to catch late evening return flights.

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. Minimum: 12. Maximum: 45. Cost: \$105 (1L, R, bus).

On this field trip, we will visit representative sites to view the Quaternary geology of Seattle. The city lies in a unique geologic setting near a subducting plate, having been glaciated more than six times in the last two million years. The area is geologically very young and very complex. Because of this setting, the area is subject to abundant geologic hazards, such as volcanic activity, earthquakes, faulting, landslides, liquefaction, and other ground failures. Even though an urban center may seem an improbable place to find any geologic exposures, much less a rich geologic story, examples abound here.

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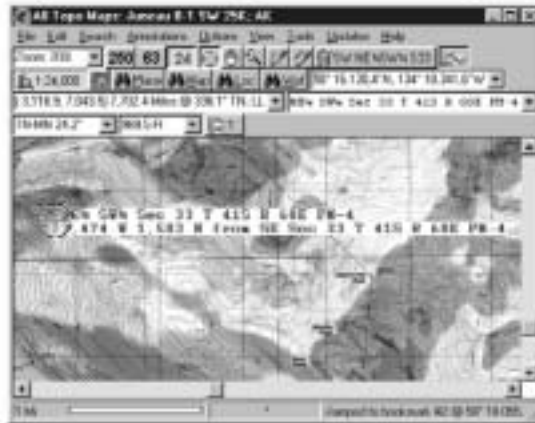
Hydrothermal Alteration in Ancient and Modern Volcanoes, Mount Rainier Area: Applications to Ore Genesis and Volcanic Hazards

Thurs., Nov. 6. Sponsored by *Society of Economic Geologists*. Leaders: David John, Roger Ashley, James Vallance, and James Rytuba, U.S. Geological Survey; Grant Newport, Weyerhaeuser Corp. Maximum: 35. Cost: Before October 3, \$95 SEG members, \$125 nonmembers, \$45 students; after October 3, \$125 SEG members, \$155 nonmembers, \$55 students. Includes transportation, lunch, refreshments, and a guidebook. Preregistration required—download registration form and pay by credit card at www.segweb.org/GSAFieldTripReg.pdf, or send a check, payable to Society of Economic Geologists, 7811 Shaffer Parkway, Littleton, CO 80127; (720) 981-7882, fax 720-981-7874, seg@segweb.org, www.segweb.org/GSAFieldTrip.htm.

Hydrothermal alteration is widespread in Tertiary and Quaternary igneous rocks of the Cascades arcs of Washington. Most alteration in the Tertiary Western Cascades arc resulted from hydrothermal systems related to small plutons, some of which formed porphyry copper and related deposits. Hydrothermal alteration of several Quaternary stratovolcanoes resulted in severely weakened volcanic edifices that were susceptible to failure and catastrophic landslides. Most notable is the 5600 yr B.P. clay-rich Osceola Mudflow that traveled 120 km down-valley from Mount Rainier to Puget Sound, covering about 200 km². In the morning, we will examine high-level alteration related to a large, early Miocene magmatic-hydrothermal system exposed near Enumclaw, Washington, where advanced argillic alteration is being quarried for silica. The afternoon will be spent examining the Osceola Mudflow and other Holocene lahars from Mount Rainier that contain abundant clasts and matrix material of hydrothermally altered Quaternary rocks from Mount Rainier.

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GSA-SPONSORED SHORT COURSES

GSA short courses will be held immediately before the Annual Meeting and are open to members and nonmembers. If you register for *only* a short course, you must pay a \$40 nonregistrant fee in addition to the course fee. The \$40 may be applied toward meeting registration if you decide to attend the meeting. Preregistration is recommended; on-site registration is an additional \$30. Cancellation Deadline: October 3, 2003.

Attention Students!

The **GSA HYDROGEOLOGY DIVISION** will subsidize the first student registrant who is a valid division member. The student *must pay the full course fee* when registering, but will be reimbursed \$50 after the GSA meeting by the Hydrogeology Division.

The **GSA GEOSCIENCE EDUCATION DIVISION** will subsidize the first five student registrants who are valid division members. The student *must pay the full course fee* when registering, but will be reimbursed \$50 after the GSA meeting by the Geoscience Education Division.

The **GSA STRUCTURAL GEOLOGY AND TECTONICS DIVISION** offers up to five \$100 scholarships to division-affiliated student members for division-sponsored short courses. Apply in writing (by e-mail only), giving name, institution, class, specialty, poster or talk title, short-course title, and a one-paragraph rationale, to Martha Oliver Withjack, drmeow3@yahoo.com. The deadline to apply is September 1. See the Structural Geology and Tectonics newsletter for more information.

For more information, contact Edna Collis, GSA Program Officer for Professional Development, (303) 357-1034, or ecollis@geosociety.org. For a more detailed course description, please visit GSA's Web site, www.geosociety.org/meetings/2003/cw.htm.

Continuing Education Unit (CEU) Service

All courses sponsored by GSA offer CEUs. A CEU is defined as 10 contact hours of participation in an organized continuing education experience under responsible sponsorship, capable direction, and qualified instruction. A contact hour is defined as a typical 60-minute classroom instructional session or its equivalent. Ten instructional hours are required for one CEU. For CEU record-keeping purposes, please be sure to include your social security number on the registration form.

1. Applications of Environmental Isotopes for Tracing Anthropogenic Contaminants in Groundwaters and Surface Waters [501]

Sat., Nov. 1, 8 a.m.–5 p.m. Washington State Convention and Trade Center. Cosponsored by *GSA Hydrogeology Division*.

This course will focus on practical applications of environmental isotopes for tracing contaminants in hydrological systems. The systematics of isotope fractionation and the distributions of selected isotopes in natural systems will be discussed briefly. However, the main focus of the class will be on examples of how isotope techniques can be used to determine sources and sinks of nitrate, metals and semi-metals, or organics in surface waters and groundwaters.

Faculty: Carol Kendall, Water Resources Division, U.S. Geological Survey, Menlo Park, CA; Ph.D., University of Maryland; Tom Bullen, Water Resources Division, U.S. Geological Survey, Menlo Park, CA; Ph.D., University of California, Santa Cruz. Limit: 40. Fee: \$550; includes course manual and lunch. CEU: 0.8.

2. DEMs: The Topographic Dimension for Visualizing Geology, Geomorphology, and Active Tectonics [502]

Sat., Nov. 1, 8 a.m.–5 p.m. University of Washington. Cosponsored by *GSA Geoscience Education Division; GSA Structural Geology and Tectonics Division*.

This course familiarizes participants with detailed digital topography for education and research. Topics include DEM properties, evaluating topography, DEM tools, and comparison of coextensive data sets. The course highlights (1) detailed lidar topography for mapping fault scarps, marine terraces, landslides,

and geomorphology; and (2) draping maps, satellite imagery, and aerial photography over DEMs to visualize the results in 3D. Faculty: Peter L. Guth, U.S. Naval Academy, Annapolis, MD; Ph.D., Massachusetts Institute of Technology; Ralph Haugerud, U.S. Geological Survey, Seattle, WA; Ph.D., University of Washington; Stephen J. Reynolds, Arizona State University; Ph.D., University of Arizona; Paul Morin, University of Minnesota, National Center for Earth-surface Dynamics. Limit: 30. Fee: \$650; includes course manual, CD, and lunch. CEU: 0.8.

3. Managing Environmental Projects [503]

Sat., Nov. 1, 8 a.m.–5 p.m. Washington State Convention and Trade Center. Cosponsored by *GSA Engineering Geology Division*.

This course will present an overview of all aspects of environmental project management. We will cover applicable federal and state environmental laws and regulations and discuss how they are applied to ensure regulatory compliance and protection of human health and the environment. The science of project management, including applications of chemistry, biology, toxicology, geology, and hydrology, will be presented. We will also discuss in detail pollution prevention, emergency preparedness, health and safety issues, regulatory permitting, risk assessments, sampling and monitoring protocols, remediation options, professional liability and ethics, and project management skills. An optional exam will be offered following the course for those interested in Registered Environmental Management (REM) certification through the National Registry of Environmental Professionals (NREP). Contact the instructor for more information about the NREP test and certification. Faculty: Raymond C. Kimbrough, P.E. LaMoreaux & Associates, Inc., Tuscaloosa, Alabama; B.A., University of Alabama. Limit: 30. Fee: \$500; includes course manual and lunch. CEU: 0.8.

4. New Satellite Data and Processing [504]

Sat., Nov. 1, 8 a.m.–5 p.m. Washington State Convention and Trade Center. Cosponsored by *GSA Quaternary Geology and Geomorphology Division*.

This short course is an introduction to new satellite data sets and interactive

computer processing techniques useful to the field geologist for mapping and analyses. The course will describe the characteristics of new visible-near IR, thermal IR, radar, and digital topographic data sets. Processing techniques will focus on interactive image processing using desktop workstations and inexpensive software. Faculty: Tom G. Farr, Jet Propulsion Lab, Pasadena, CA; Ph.D., University of Washington; John C. Dohrenwend, Southwest Satellite Imaging, Teasdale, UT; Ph.D., Stanford University. Limit: 50. Fee: \$525; includes course manual and lunch. CEU: 0.8.

OTHER COURSES AND PANELS

Registration and information can be obtained from the contact person listed.

Sequence Stratigraphy for Graduate Students

Fri. and Sat., Oct. 31–Nov. 1, 8 a.m.–5 p.m. both days. Cosponsored by *ExxonMobil Exploration Company; British Petroleum*.

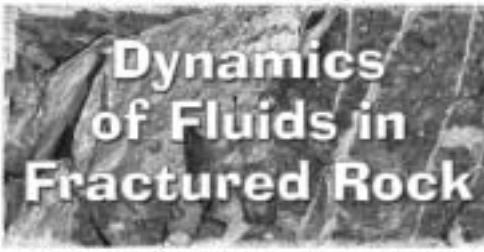
This two-day short course is designed to teach graduate students the principles, concepts, and methods of sequence stratigraphy. Sequence stratigraphy is an informal chronostratigraphic methodology that uses stratal surfaces to subdivide the stratigraphic record. This methodology allows the identification of coeval facies, documents the time-transgressive nature of classic lithostratigraphic units, and provides geoscientists with an additional way to analyze and subdivide the stratigraphic record. Using exercises that utilize outcrop, core, well-log and seismic data, the course provides a hands-on experience for learning sequence stratigraphy. The exercises include classic case studies from which many sequence stratigraphic concepts were originally developed. Instructors: Art Donovan, BP; Kirt Campion, ExxonMobil. Limit: 40. No fee. Preregistration required. Information and registration: Kirt Campion, kirt.m.campion@exxonmobil.com.

Bridging the Gap: Trends in Ostracode Biological and Geological Sciences


Sat., Nov. 1. Sponsored by *Paleontological Society*.

This short course is designed to bring together ostracode specialists and scientists working with ostracodes who do

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A closing session will discuss emerging issues in recent fluid flow and transport studies. Several participants in the Symposium will be asked to present their views on 'hot' issues of the day and suggest directions for future research.

For detailed information, including submitting and formatting your extended abstracts (up to 4-5 pages, including figures) in electronic form, please visit the Symposium website:

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Deadline for submitting the abstracts is September 30, 2003. Published proceedings of extended abstracts (including a CD) will be available at the Symposium.

Participants can register through the Symposium website. Registration fee is \$250, due on January 10, 2004 (\$300 thereafter). Student registration is \$125 (\$150 thereafter). Space is limited to 230 people.

If you have any questions regarding the Symposium, please contact Boris Faybisenko at bfaybi@lbl.gov.

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, Dept. of Geology, University of Akron, 252 Buchtel Commons, Akron, OH 44325-4101, (330) 972-7630, fax 330-972-7611, lepark@uakron.edu.

Diversity Issues in Geoscience Fields—A Panel Discussion

Mon., Nov. 3, 1:30–3:30 p.m. Sponsored by *National Association of Black Geologists and Geophysicists*.

This NABGG-sponsored event is a two-hour panel discussion among experts knowledgeable in the issues that face mi-

norities as they work in the different geoscience fields. There will be an in-depth discussion of the challenges and solutions for various minorities and women as they navigate their careers through the different geoscience companies including, but not limited to, academia, the oil industry, the environmental industry, and government agencies. Audience members are encouraged to ask questions and participate in the discussion. The audience will leave the session with a better understanding of the challenges that minorities and women face in the industry and some solutions on how to mitigate the problems both at the personal interaction level and the company policy level. This session will be useful to both managers and technical personnel and will help students prepare for the geoscience work environment. Information: Conrad K. Allen, ExxonMobil, 396 West Greens Road, P.O. Box 4697, Houston, TX 77210-4697, (713) 431-1365, conradallen@msn.com; Patricia Hall, BP, 501 Westlake Park Blvd., Houston, TX 77079, (281) 366-6877, pat.hall@bp.com.

COLLEGE AND UNIVERSITY FACULTY, K-12 TEACHERS, UNDERGRADUATE & GRADUATE STUDENTS, INFORMAL EDUCATORS: Please join us for an exciting and diverse series of workshops for educators at all levels. Annual Meeting registration and payment of the workshop fee are both required in order to participate in the K-16 workshops; Annual Meeting registration is \$40 for K-12 teachers or for those who will only participate in the weekend workshops. Preregister to ensure your spot.

EDUCATORS' SOCIAL HOUR & SHARE-A-THON BOOTH

Attend the Educators' Social Hour from 5-7 p.m. on Saturday, Nov. 1. The location will be announced on the GSA Web site in September and in the Annual Meeting Program. Network with other educators, and participate in demonstrations of education lesson plans. You can also meet other educators when you visit the Education Share-a-thon at the GSA Headquarters' Education & Outreach Booth. While there, you can pick up FREE lesson plans and materials. The materials are donated by formal and informal educators. Sponsored by the GSA Education Committee, GSA Geoscience Education Division, and the GSA Education & Outreach Department.

If you have questions about the workshops, Educators' Social Hour, or the Share-a-thon, or if you or your organization would like to donate educational materials for the Share-a-thon, please contact Julie Sexton, (303) 357-1005, jsexton@geosociety.org.

Saturday Workshops

1. Using Constructivism to Introduce Historical Geology [601]

Sat., Nov. 1, 8 a.m.-4 p.m. Cosponsored by *National Association of Geoscience Teachers; GSA Education Division; West Virginia University; Fairmont State College; West Virginia Geological Survey.*

INTENDED AUDIENCE: Middle and high school teachers, informal educators, graduate students, and any educator looking for hands-on methods of introducing basic historical geology concepts to children and adult nongeologists. Fee: \$35.

This workshop will appeal to K-16 educators looking for inquiry-based, national standards-oriented methods that entice students to construct a solid understanding of introductory historical geology concepts. Participants will learn how to engage students in the ongoing process of comparing, contrasting, and connecting. Participants will also learn how to encourage students to make their own scientific observations and construct understandings of geologic time, depositional environments, plate tectonics, fossils, and more. This workshop will focus on teaching methodology, not content. Workshop instructors will use the "4C" process, derived from 12 years of teacher professional development experiences through the West Virginia RockCamp Program.

INFORMATION: Tom Repine, repine@geosrv.wvnet.edu, or Deb Hemler, dhemler@mail.fscwv.edu.

2. Practical Tips for Proposal Writing [602]

Sat., Nov. 1, 8:30 a.m.-4 p.m. Cosponsored by *Council on Undergraduate Research.*

INTENDED AUDIENCE: College and university faculty. Fee: \$25.

This workshop will present strategies and approaches for writing grant proposals. It is open to all, but is aimed at college and university faculty who have never prepared a proposal or have not been successful with past proposal submissions. The workshop will focus on proposal writing for research, laboratory, and curriculum development at primarily undergraduate institutions. Presentations will include the rhetoric of the grant proposal, budget preparation, the review process, and expressing the role of undergraduates in a project. Presenters include former and current National Science Foundation program officers and representatives from the American Chemical Society—Petroleum Research Fund. **INFORMATION:** Lori Bettison-Varga, lbettison@acs.wooster.edu, or Jill Singer, singerjk@buffalostate.edu.

3. Integrating Important Advances in Planetary Geoscience into Undergraduate Courses [603]

Sat., Nov. 1, 8:30 a.m.-5 p.m. Cosponsored by *GSA Planetary Geology Division; National Association of Geoscience Teachers/Digital Library for Earth System Education On the Cutting Edge Professional Development Program.*

INTENDED AUDIENCE: College and university faculty. Fee: \$40.

Planetary science is an exciting way to teach fundamental geologic principles in a variety of different undergraduate courses. The workshop will: (1) give participants an overview of recent advances in planetary geoscience by experts in different aspects of extraterrestrial geology; (2) present model examples for effectively integrating advances into undergraduate courses at both the introductory and upper level; and (3) provide opportunities for participants to work with conveners and presenters to develop ideas for their own courses. More information about the workshop can be found at <http://serc.carleton.edu/NAGTWorkshops/index.html>. Co-conveners: Tracy Gregg and Barbara Tewksbury.

Leaders: TBA. **INFORMATION:** Tracy Gregg, tgregg@geology.buffalo.edu, or Barbara Tewksbury, btewksbu@hamilton.edu.

4. What did T. Rex Taste Like?—or—Dinosaurs: The Science behind the Stories [604]

Sat., Nov. 1, 9 a.m.-5 p.m. Cosponsored by the *Paleontological Society* and the *Society of Vertebrate Paleontology.*

INTENDED AUDIENCE: Middle and high school teachers, college and university faculty, and informal educators. Fee: \$40.

Using dinosaurs as a focus, this workshop emphasizes the process of science—how we know what we know. Participants will enjoy a series of hands-on activities focusing on the science that provides a visual portrayal of the past. Topics include evolution, phylogenetics, paleoecology, behavior, form, and function. All participants will receive a complimentary copy of the new book *Dinosaurs: The Science behind the Stories*. **INFORMATION:** Judy Scotchmoor, jscotch@uclink4.berkeley.edu, or Dale Springer, dspringe@husky.bloomu.edu.

5. Monitor Global Seismograph Stations in Real-Time from the Science Classroom [605]

Sat., Nov. 1, 9 a.m.-5 p.m. Cosponsored by *GSA Geophysics Division.*

INTENDED AUDIENCE: K-12 teachers and college and university faculty. Fee: \$50.

Advances in computer technology, Internet communications, and the integration of real-time earthquake monitoring bring live data from throughout the world into the classroom. This new technology also allows K-12 science educators to establish their own local seismograph system, which contributes to national and global monitoring efforts. New PC-based software provides real-time connectivity to national and global seismograph stations. In this hands-on workshop, participants interact with live seismic data on easy to use Windows software. The workshop will cover the basics of regional and global earthquake monitoring networks, digital data acquisition systems, Internet communications for seismology, seismic waveforms, phase identification and earthquake location on the computer, and setting up and operating a local seismograph. **INFORMATION:** Catherine Snelson, csnelson@unlv.edu, or Ken Smith, ken@seismo.unr.edu.

6. Addressing Environmental Problems to Stimulate Undergraduate Learning [606]

Sat. and Sun., Nov. 1-2, 9 a.m.-5 p.m. (two-day workshop; see also Sunday) Cosponsored by *National Science Foundation; GSA Geoscience Education Division.*

INTENDED AUDIENCE: College and university faculty, graduate students, and informal educators. Fee: \$15

Workshop presenters will model a multidisciplinary environmental problem-solving approach to teaching science. In this model, students use environmental impact analysis as a vehicle to learn relevant science disciplines. Presenters will provide easily adaptable sample exercises of the teaching methods and curricula, work with participants to develop ways to integrate this approach into their own courses and/or curricula, and provide strategies and methods to write successful proposals to external agencies for funding to help participants implement these techniques in their classes. To defray costs of room and board for the 2-day workshop, stipends of up to \$400 are available to any participant who needs assistance. **INFORMATION** about the stipends or workshop: Michele Hluchy, fhluca@alfred.edu, or James Haynes, jhaynes@brockport.edu.

Sunday Workshops

6. Addressing Environmental Problems to Stimulate Undergraduate Learning (Day Two) [606]

Sun., Nov. 2, 9 a.m.-5 p.m. (two-day workshop)

See description for workshop #6, above.

7. An Introduction to EarthEd Online: A New Online Instruction Resource for the Earth Sciences [607]

Sun., Nov. 2, 8 a.m.-noon Cosponsored by *National Association of Geoscience Teachers; National Science Foundation.*

INTENDED AUDIENCE: College and university faculty and producers and developers of online materials. Fee: \$52.

Workshop presenters will introduce participants to new learning management software and data browsing tools that support live and online earth science courses. The software has been designed to support a modern pedagogy that includes

online group projects, online writing and grading, automatic and teacher graded homework assignments, and on-demand student grade calculation. Instructor support software includes an expandable, shared library of problems, images, and learning activities. Modular design and its open-source availability allow expansion by other developers. The presenter has used the EarthEd Online software in a large general education oceanography course at University of California, Santa Barbara, for several years. **INFORMATION:** William Prothero, prothero@geol.ucsb.edu, or Dorothy Pak, pak@geol.ucsb.edu.

8. Earthquakes—A One-Day Workshop for College and University Faculty [608]

Sun., Nov. 2, 8 a.m.-5 p.m. Cosponsored by *Incorporated Research Institutions for Seismology Consortium; National Science Foundation; University of Arizona; Purdue University.*

INTENDED AUDIENCE: College and university faculty. Fee: \$20.

This workshop is intended for faculty at 2- and 4-year colleges and universities who are teaching introductory earth science courses and who want to learn more about earthquakes, seismology, and plate tectonics. Topics will include causes of earthquakes, plate tectonics, propagation of seismic waves, seismographs, statistics and data, Earth's structure, and earthquake hazards. Activities that emphasize hands-on and inquiry-based learning will be used to deliver content to participants, and they will be encouraged to reflect on how these activities can be used in their classrooms. Participants will receive \$120 in materials (hands-on activities, maps, earthquake book, posters, software, and other teaching aids).

INFORMATION: Michael Hubenthal, hubenth@iris.edu, or John Taber, taber@iris.edu.

9. K-16 Teaching Strategies and Methods that Encourage ALL Students (Especially Students with Disabilities) to Participate in the Geosciences [609]

Sun., Nov. 2, 9 a.m.-4 p.m. Cosponsored by *National Science Foundation.*

INTENDED AUDIENCE: College and university faculty, middle and high school teachers, and undergraduate and graduate students. Fee: \$20.

This workshop will focus on teaching strategies and methods that make the geosciences inclusive for *all* K-16 students (especially students with disabilities). The C.L.A.S.S. Project and the DO-IT Project are joining forces to share what they have learned about using technology, inquiry-based learning, and physical adaptations to make science education meaningful for students with a variety of disabilities. The number of students seeking science careers is increasing because of their efforts. By adopting the strategies presented in the workshop, participants will be able to encourage *all* students to learn the basic concepts of geoscience. **INFORMATION:** Roderic Brame, roderic.brame@wright.edu, or Mary Ellen Bargerhuff, mary.bargerhuff@wright.edu.

10. Effective Use of Web-Based Resources in an Interdisciplinary Science Classroom [610]

Sun., Nov. 2, 1 p.m.–5 p.m.

INTENDED AUDIENCE: College and university faculty, high school teachers, graduate students, and informal educators. Fee: \$35.

Web-based teaching materials can avoid the weaknesses of traditional science textbooks by offering low-cost resources that integrate concise content, interactive exercises, news stories, biographies, and other options. Finding and using these resources effectively can be a challenge, however. In this workshop, participants will learn about the advantages of using Web-based materials, especially in an interdisciplinary science classroom for which no textbook is appropriate. Participants will have the opportunity to fully explore the resources available at Visionlearning.com, a National Science Foundation-funded undergraduate education Web site, and use the site to set up their own MyClassroom. **INFORMATION:** Anne E. Egger, eggera@sanjuancollege.edu.

11. In-depth Exploration of the Juan de Fuca Plate, Northeast Pacific Ocean, with the REVEL Project [611]

Sun., Nov. 2, 1–5 p.m. Cosponsored by *University of Washington's School of Oceanography; National Science Foundation; ChevronTexaco Corporation*.

INTENDED AUDIENCE: K–12 teachers and informal educators. Fee: \$20.

Since the discovery of “black smokers” on the Galapagos Ridge in 1977, many hydrothermal vent systems have been explored on the mid-ocean ridges circling our planet, including the Juan de Fuca Ridge. Some of the largest venting sulfide edifices are located just 200 miles off the coast of Washington. This workshop will highlight the multidisciplinary studies that take place in this remote environment, and how researchers envision the use of a permanent, underwater observatory to monitor the entire Juan de Fuca Plate so they can study the processes that form and recycle the oceanic crust from a spreading center to a subduction zone. Participants will study the links between the geological, geochemical, and physical processes that control the evolution of a tectonic plate.

INFORMATION: Véronique Robigou, vero@ocean.washington.edu.

12. Building the EarthScope Education & Outreach Network [612]

Sun., Nov. 2, 1–5 p.m. Cosponsored by *National Association of Geoscience Teachers*.

INTENDED AUDIENCE: K–12 teachers, college and university faculty, undergraduate and graduate students, and informal educators. Fee: \$15.

EarthScope is a decade-long experiment to understand the formation and evolution of the North American continent. It will provide educators with a unique opportunity to teach about Earth in a holistic, data-rich way. The effort to bring EarthScope data and discoveries to educators will center on a grassroots EarthScope Education & Outreach Network (EON). This workshop introduces EON and offers entry for those who would like to work with EON. Members of the EON planning group will present topics such as new technology for data analysis and partnering with diverse groups of educators. Participants will form discussion groups and plan EON Alliances.

INFORMATION: Steven Semken, semken@dinecollege.edu, or Michelle Hall-Wallace, hall@geo.arizona.edu.

13. Strategies for Effective Testing & Grading in Introductory College Science Courses [613]

Sun., Nov. 2, 8 a.m.–noon Cosponsored by *National Science Foundation DUE CCLI (ND) Award 998115: National Dissemination of Field-Tested Classroom Assessment Techniques in Science, Mathematics, Engineering, and Technology for Postsecondary Faculty*.

INTENDED AUDIENCE: College and university faculty and graduate students. Fee: \$25.

One of the most difficult challenges in teaching at the college level is accurately determining the extent to which students really understand the concepts. This interactive workshop will help participants improve student learning in their courses by focusing on effective testing and grading strategies, implementing these successful strategies even in large enrollment courses, and introducing participants to innovative assessment approaches that focus on engendering meaningful understanding. **INFORMATION:** Tim Slater, tslater@u.arizona.edu, or Ed Prather, eprather@as.arizona.edu.

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- Register by fax at 303-357-1071 or 303-357-1072 if using a credit card. If you register by fax, please do not send another copy in the mail.

PREREGISTRATION DEADLINE: September 26

CANCELLATION DEADLINE: October 3

LATE REGISTRATION DEADLINE: October 24

The member fees apply to members of both GSA and Associated Societies (listed on the form). Registrations will not be processed unless full payment is received. Unpaid purchase orders are NOT accepted as valid registration. The confirmation sent by GSA will be your only receipt. You should receive it within two weeks after your registration is submitted. Badges are needed for access to ALL activities, 8 a.m. Sunday through 5:30 p.m. Wednesday.

A guest registration fee of \$80 per person is available for non-geologist spouses or family members and friends of a professional and/or student registrant and is required for those attending all guest activities, tours, seminars, refreshments in the Guest Hospitality Suite, and access to the Exhibit Hall. Formal guest tours are at an additional cost and include professional tour guides, round-trip transportation, admission fees, and gratuities. *Lunch is only included in the price of full-day tours.* The guest registration fee does NOT allow access to technical sessions. However, guests can sign in with the hostess in the Guest Hospitality Suite and get a Visitor Badge allowing them to attend a specific presentation.

STUDENTS: A CURRENT student ID is required to obtain student rates. You will have to pay the professional fee unless you have the ID. Please register only one professional or student per form and retain a copy for yourself. All registrations received after September 26 will be considered LATE registrations and charged accordingly. Online registration will remain open until October 24. Absolutely no registrations should be mailed or faxed after October 24. After this date we will handle registrations at the Convention Center during normal registration hours. On-site fees for Continuing Education Courses are an additional \$30. As a special consideration, GSA is offering a discount rate to our members who are 70 years of age and older. Please write your membership number in the space provided and be sure to bring a picture I.D. to ensure your discount.

CANCELLATIONS, CHANGES, AND REFUNDS

All requests for additions, changes, and cancellations must be made in writing and received by October 3, 2003. Faxes are accepted. A \$30 processing fee will be charged for cancellation of a full- or one-day professional registration received in writing prior to October 3. **NO REFUNDS WILL BE MADE ON CANCELLATION NOTICES RECEIVED AFTER THIS DATE.** Refunds will be mailed from GSA after the meeting. Refunds for fees paid by credit card will be credited according to the card number on the preregistration form. There will be NO refunds for on-site registration, *Abstracts with Programs* volumes, and ticket sales.

BADGES? YES, YOU NEED THEM!

Badges are needed for access to ALL activities, 8 a.m. Sunday through 5:30 p.m. Wednesday. If your registration form is received at GSA by September 26, your badge will be mailed to you

two weeks before the meeting. If you register after September 26, pick up your badge at the GSA Registration Desk, Washington State Convention & Trade Center, South Lobby, Level 4.

HOW TO SAVE \$

GSA and **ASSOCIATED SOCIETY** members SAVE \$80 (professional) and \$30 (student) by preregistering.

NONMEMBERS SAVE additional money by joining GSA now. See section below on how to join.

GSA MEMBERS PAY LESS! JOIN NOW OR AT THE MEETING!

If you are not yet a GSA member, isn't it time you joined? There are two ways to join, and both save you money! If you pay the nonmember registration rate for the full meeting AND complete your membership application at the meeting, you will receive complimentary membership for 2004. To receive the free membership, you must fill out an application and turn it in at our Membership booth onsite in the Exhibit Hall. OR

Join now, pay the lower member registration rate for the meeting, and take advantage of member benefits for the rest of 2003. Professionals and students who join GSA save a substantial amount on their registration fee by paying the member rate. It's like joining GSA for free! Please note, though, that membership is on the calendar year (January through December), so later in the year, it may be to your advantage to join using the first option mentioned above. To join before the meeting, complete the application form available in the Membership section on GSA's Web site at www.geosociety.org, or contact GSA Services at gsaservices@geosociety.org or 1-888-443-4472 or (303) 447-2020, option 3. It pays to be a GSA member!

REGISTRATION HOURS (ONSITE)

WASHINGTON STATE CONVENTION & TRADE CENTER —SOUTH LOBBY, LEVEL 4

Sat., Nov. 1	7 a.m.–4:30 p.m.
Sun., Nov. 2	7 a.m.–7:30 p.m.
Mon.–Tues., Nov. 3–4	7 a.m.–4:30 p.m.
Wed., Nov. 5	7–11 a.m.

REGISTRATION FEES

	ADVANCE (by 9/26/03)		LATE/ON-SITE (after 9/26/03)	
	FULL MEETING	ONE DAY	FULL MEETING	ONE DAY
Professional Member	\$295	\$190	\$375	\$200
Professional Member 70 or older	\$240	\$135	\$315	\$145
Professional Nonmember	\$375	\$215	\$465	\$225
Student Member or Student Associate	\$90	\$60	\$120	\$60
Student Nonmember	\$120	\$75	\$150	\$75
Guest or Spouse	\$80	N/A	\$80	N/A
K–12 Professional	\$40	N/A	\$40	N/A
Short Course or Field Trip Only	\$40	N/A	\$40	N/A



PREREGISTRATION FORM

GSA ANNUAL MEETING ■ SEATTLE, WASHINGTON ■ NOVEMBER 2-5, 2003
 Preregistration Deadline: September 26, 2003 ■ Cancellation Deadline: October 3, 2003
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BADGE INFORMATION

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School/Company _____ City/State/Prov. _____

Spouse/Guest First Name/Nickname _____ Last Name _____ City/State/Prov. _____

Do you or your guest require any special considerations? Yes No Will you be working in the exhibit hall? Yes No

PREREGISTRATION FEES	FULL MEETING	ONE DAY	Qty.	U.S. \$ Amt.
Professional Member*	(10) \$295	(11) \$190	1	\$
Professional GSA Member (70 and older)	(12) \$240	(13) \$135	1	\$
Professional Nonmember	(14) \$375	(15) \$215	1	\$
Student Member or Student Associate*	(30) \$ 90	(31) \$ 60	1	\$
Student Nonmember	(32) \$120	(33) \$ 75	1	\$
K-12 Professional	(60) \$ 40	N/A	1	\$
Guest or Spouse**	(90) \$ 80	N/A	1	\$
Field Trip or Short Course Only	(95) \$ 40	N/A	1	\$

PREREGISTRATION FEES SUBTOTAL \$

Check member affiliation(s) (to qualify for member registration discount):
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*Member fee applies to any current Professional OR Student Member of GSA or Associated Societies listed above. Discount does not apply to guest registrants. **Guest or Spouse registration fee does NOT allow access to technical sessions. A \$30 processing fee will be charged for cancellation of a full- or one-day professional registration received in writing prior to Oct. 3. No refunds will be made after Oct. 3.

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GUEST PROGRAM (P. 18)	Qty.	U.S. \$ Amt.
1. Bird Watching, Sat.	(101)	\$35
2. Seattle City Tour, Full Day, Mon.	(102)	\$68
3. EMP & Space Needle, Mon.	(103)	\$45
4. Seattle City Tour, Half Day, Mon.	(104)	\$27
5. Snoqualmie Falls and Winery, Tues.	(105)	\$65
6. Glassblowing and Art Gallery, Tues.	(106)	\$38
7. Aquarium & Pacific Sci. Ctr., Wed.	(107)	\$52

SPECIAL EVENTS (P. 14)

1. Seattle Symphony & Dinner, Sat.	(201)	\$95
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TICKETED FUNCTIONS (SEE WEB SITE)

1. G&PP Committee Breakfast, Sat.	(301)	\$24
2. AESE Ann. Bus. Mtg. Lunch, Sun.	(302)	\$38
3. History of Geology Lunch, Sun.	(303)	\$38
4. NAGT & GSA Geosci. Div. Lunch, Sun.	(304)	\$38
5. NABGG Lunch, Sun.	(305)	\$38
6. MSA Recep. for G. Ernst, D. Lindsley, & C. Prewitt, Sun.	(306)	\$25
7. AESE Breakfast Meeting, Mon.	(307)	\$23
8. AWG Breakfast, Mon.	(308A)	\$23
Professional	(308B)	\$10
Student	(309)	\$38
9. Hydrogeology Div. Lunch, Mon.	(310)	\$38
10. Paleo Society Lunch, Mon.	(311A)	\$60
11. AESE Awards Banquet, Mon.	(311B)	\$45
Professional	(312)	\$23
Student	(313)	\$38
12. NAS Geo. Sec. Breakfast Mtg., Tues.	(314)	\$38
13. Eng. Geology Div. Lunch, Tues.	(315)	\$38
14. GSIIS Lunch, Tues.	(316)	\$38
15. MSA Lunch, Tues.	(317A)	\$10
16. SEG Lunch, Tues.	(317B)	\$5
17. MSA/GS Reception, Tues.	(318)	FREE
Professional	(319)	FREE
Student	(401)	\$690

FIELD TRIPS (P. 20)

1. Hydrogeology of Hawaii	(402)	\$290
2. Glacial Lake Miss., Clark Fork Dam, Floods Outburst Area	(403)	\$295
3. Sequence Stratigraphy, Sauk Seq.	(404)	\$525
4. Tectonic Geomorphology, Olympic Mtns.	(405)	\$315
5. Wire & Geology	(406)	\$415
6. Coastal Evolution, Dynamic Shoreline	(407)	\$290
7. Columbia R. Basalt, Yakima Fold Belt	(408)	\$305
8. Cret. to Paleogene Cascades-Arc		

Qty. U.S. \$ Amt.

9. Alpine Glaciation, North Cascades	(409)	\$340
10. Eng. Geology, Columbia Valley	(410)	\$200
11. Regional Tertiary Sequence Strat.	(411)	\$245
12. Biogeochemical Proc., Ancient Methane Seeps	(412)	\$125
13. Holocene Lahars Along White R.	(413)	\$140
14. Late Pleist. Glacial Hist., Whidbey I.	(414)	\$95
15. Pleist. Tephrostratigraphy, Puget Sound	(415)	\$210
16. Geochronological Discoveries	(416)	\$80
17. Evolution of a Polygenetic Ophiolite	(417)	\$250
18. Geohydrology of Hanford Nuclear Waste Site	(418)	\$240
19. Puget Sound Paleoseismology	(419)	\$170
20. Hydrogeology, Cascade Range Volcanoes	(420)	\$370
21. Quaternary Geology of Seattle	(421)	\$105

SHORT COURSES (P. 26)

1. App. of Environmental Isotopes	(501)	\$550
2. DEMs: Visualizing Geology	(502)	\$650
3. Managing Environmental Projects	(503)	\$500
4. New Satellite Data and Processing	(504)	\$525

E&O SPONSORED WORKSHOP (P. 25)

1. Effective presentation Workshop	(601)	\$35
Professional	(600A)	\$20
Student	(600B)	\$10

K-16 WORKSHOPS (P. 28)

1. Using Constructivism	(601)	\$35
2. Practical Tips for Proposal Writing	(602)	\$25
3. Advances in Planetary Geoscience	(603)	\$40
4. Dinosaurs: Science Behind Stories	(604)	\$40
5. Monitor Global Seismo. Stations	(605)	\$50
6. Addressing Environmental Problems	(606)	\$15
7. Intro to EarthEd Online	(607)	\$52
8. Earthquakes for College Faculty	(608)	\$20
9. K-16 Teaching Strategies	(609)	\$20
10. Eff. Use of Web Resources	(610)	\$35
11. Exploration of Juan de Fuca Plate	(611)	\$20
12. EarthScope Network	(612)	\$15
13. Effective Testing & Grading	(613)	\$25

ABSTRACTS WITH PROGRAM

1. AWP Book	(901)	\$33
2. AWP CD-ROM*	(902)	\$15

* Includes 2003 Section Meetings abstracts; pick up on-site only.

SUBTOTAL

\$

PREREGISTRATION FEES SUBTOTAL

\$

TOTAL OF ALL FEES REMITTED

\$

Seattle Hotels



GSA 2003 Annual Meeting & Exposition

SEATTLE HOTELS

Rates (single/double)

Distance to Washington State Convention & Trade Center

- | | |
|--|--|
| <p>1 Sheraton Seattle
(Headquarters hotel)
\$190/\$210
1 block</p> <p>2 Crowne Plaza
\$140/\$150
3 blocks</p> <p>3 Days Inn Town Center
\$69/\$79
7 blocks</p> <p>4 Executive Pacific Plaza
\$99/\$99
6 blocks</p> <p>5 Hilton Seattle
\$156/\$176
2 blocks</p> <p>6 Renaissance Seattle Hotel
(formerly Renaissance Madison)
\$139/\$149
5 blocks</p> | <p>7 The Roosevelt
\$122/\$122
1 block</p> <p>8 Sixth Avenue Inn
\$69/\$79
5 blocks</p> <p>9 Summerfield Suites by Wyndham
\$142/\$142
1 block</p> <p>10 Red Lion Hotel on Fifth Avenue
(formerly WestCoast Grand)
\$158/\$168
2 blocks</p> <p>11 WestCoast Vance
\$105/\$105
3 blocks</p> |
|--|--|

For more information and to view the hotels, go to the online Hotel Reservation form at www.geosociety.org.



2003 GSA Annual Meeting & Exposition NOVEMBER 2-5, 2003 ■ SEATTLE, WASHINGTON

INSTRUCTIONS

The deadline date for new reservations is **Friday, October 3, 2003**. For best availability and immediate confirmation, make your reservation via the Internet.

INTERNET: Visit GSA's Web site, www.geosociety.org.

PHONE: Call the Seattle Housing Bureau at (888) 877-0255 or (206) 461-5881.

FAX: Only fully completed forms will be accepted at the Seattle Housing Bureau at **206-461-5853**.

Use one form per room, make copies as needed.

MAIL: Only fully completed forms will be accepted at the Seattle Housing Bureau, **One Convention Place, 701 Pike Street, Suite 800, Seattle, WA 98101**.

ACKNOWLEDGMENTS

The Seattle Housing Bureau will send you an acknowledgement of your reservation. Please review all information for accuracy. If you do not receive your acknowledgement within 10 to 14 days or have questions regarding your reservation, please contact the Seattle Housing Bureau by phone at: 888-877-0255 or by e-mail at hotelres@seeseattle.org.

You will not receive a confirmation from the hotel.

ROOM RATES/TAXES

To take advantage of the special Seattle rates, please book your reservation by **October 3, 2003**. After that date, the Seattle room blocks will be released and rooms may only be available at higher rates. All rates are per room and are subject to **15.6%** tax, (subject to change). Special requests cannot be guaranteed, however hotels will do their best to honor all requests. Hotels will assign specific room types upon check-in, based on availability.

DEPOSITS

All reservations must be guaranteed with a credit card or check. Credit cards will not be charged a deposit. Checks are only accepted with mailed forms in the amount of \$200 for deposit made out to Seattle Housing Bureau and sent to the address listed above.

CHANGES/CANCELLATIONS

Reservations may be changed or cancelled via the web site or through the Seattle Housing Bureau until October 17, 2003. Cancellations received after the form cutoff date, October 17, 2003, will be assessed a \$25.00 processing fee. Do not contact the hotels directly until after October 17, 2003.

Hotel Reservation Form

For best availability, make your reservation via the internet www.geosociety.org

Arrival Date		Departure Date	
First Name	M.I.	Last Name	
E-mail Address:			
Daytime Phone:		Fax:	
Company			
Address			
Address 2			
City/State/Province		Zip/Postal Code	Country

HOTEL SELECTION

Please list four choices in order of preference.

First	Second
Third	Fourth

If all requested hotels are unavailable, a reservation will be made at the next available hotel. Please indicate criteria for choices:

- Comparable room rate Proximity to conference site

of occupants _____ # of beds requested _____

To request a suite, please contact the Housing Manager at (206) 461-5894

List all room occupants:



- Check here if you have a disability requiring special services
 Non smoking room request

Special requests:

DEPOSIT INFORMATION

All reservation requests must be guaranteed. Credit cards will not be charged prior to the arrival date. Hotel Reservation Forms received without a valid credit card will not be processed. Please be advised that the credit card must be valid through the dates of the convention or your reservation will not be processed. Checks are only accepted with a mailed Hotel Reservation Form, in the amount of \$200 for deposit and made out to the Seattle Housing Bureau.

- American Express Discover Diner's Club MasterCard Visa

Card Number	Exp. Date
Name on Credit Card	
Cardholder's Signature*	*Necessary to process reservation

Air Travel

Seattle-Tacoma International Airport (Sea-Tac) is about 30 minutes (or more, depending on traffic) from downtown Seattle.

The following airlines have been contracted to provide convention rates to and from Seattle for the GSA Annual Meeting & Exposition. You can save up to 15% on published airfares by booking through the group reservation desks at the numbers listed below.

ALASKA AIRLINES

1-800-445-4435

Meeting ID #CMR6375

Alaska Airlines is offering discounts of 10% off published excursion fares, except companion and other promotional fares. Call the Alaska Airlines Meeting Department at 1-800-445-4435 and reference meeting ID number CMR6375 to book your discounted travel.

SOUTHWEST AIRLINES

1-800-433-5368

Meeting ID #U0216

Southwest Airlines offers up to 10% off most fares for air travel to and from the event, with the convenience of Ticketless Travel. To qualify, call Southwest Airlines Group and Meetings Reservations at 1-800-433-5368 and reference meeting ID number U0216. Reservations sales agents are available 7 a.m.–8 p.m., Monday–Friday, or 8:30 a.m.–5:30 p.m., Saturday and Sunday, Central Standard Time.

UNITED AIRLINES

1-800-521-4041

Meeting ID #516BG

United is offering a 10% discount off the unrestricted, fully refundable coach fare or a 5% discount off the lowest applicable fares, including first class, to all attendees of the GSA Annual Meeting. An additional 5% discount will apply when tickets are purchased at least 30 days in advance of travel. This special offer applies to travel on domestic segments of all United Airlines and United Express flights. United's schedule and discounted fares are available through United's Meeting Desk or your travel agent. Call 1-800-521-4041 and reference meeting ID number 516BG. Dedicated reservationists are on duty seven days a week, 8 a.m.–10 p.m. Eastern Standard Time.

Transportation Options to & from Sea-Tac

CAR RENTAL

Alamo Rent-A-Car

1-800-732-3232 or www.alamo.com

Group ID # 699477

Plan Code: GR

Alamo Rent-A-Car will provide convention rates from \$33 per day to \$149 per week (and up), with no charge for an additional driver. Attendees can call or book online. Reference group ID number 699477 and plan code GR.



SHUTTLE SERVICE

Grayline Airport Express

Grayline Airporter bus service offers daily door-to-door service from Sea-Tac Airport to the following downtown hotels: Sheraton, Hilton, Renaissance, Crowne Plaza, Four Seasons, Roosevelt, Cavanaugh's, Paramount, Warwick, Westin, and the Greyhound Depot. Departs twice an hour. Boarding locations at Sea-Tac: North Booth—outside the United Airlines baggage claim area, and South Booth—outside the International baggage claim area (covers Northwest and TWA).

Current prices are \$8.50 one-way for adults and \$14.00 round-trip for adults. These prices are subject to change. For more information, please call (206) 626-6088.

Shuttle Express

Shuttle Express offers the following transportation options:

Execucar—Private, nonstop services to and from Sea-Tac Airport. Execucar's spacious Lincoln Town Cars offer "Meet and Greet" services at the Sea-Tac baggage claim area for arriving guests (with advanced reservations), as well as baggage service—your driver will take care of everything, and will arrive at your requested time. The fare is \$45.00 to downtown Seattle for up to four people.

Charters—Private, nonstop service to and from Sea-Tac airport. After collecting your luggage, please proceed to the nearest Traveler's Information Center (adjacent to the escalators). Pick up the phone and press 48. You will be connected to a Shuttle Express reservationist who will direct you to an inside waiting area. The driver will arrive in less than 30 minutes, call you by your last name, and escort you to a seven-passenger Dodge van. The fare to downtown Seattle is \$44.00 for up to seven people.

Door-to-Door—After collecting your luggage, please proceed to the nearest Traveler's Information Center. Pick up the phone and press 48. You will be connected to a Shuttle Express reservationist who will direct you to an inside waiting area. The driver will arrive in less than 30 minutes, call you by your last name, and escort you to a share-a-ride van. Vans leave Sea-Tac on demand; therefore, an advanced reservation is not necessary. The fare is \$20.00 for the first person, and \$4.00 for each additional person.

TAXI

Average rate: \$30–\$40 one-way

Transportation Options in Seattle

GSA will NOT be providing shuttle service from the hotels to the convention center this year, but Seattle does have the following inexpensive—or free—options for getting around downtown.

DOWNTOWN BUSES

Metro buses are free from 6 a.m. to 7 p.m. in the downtown Ride Free zone that extends from First Avenue to Sixth Avenue off the I-5 Freeway, between Jackson on the south and Bell on the north. You can also purchase a one-day pass for only \$2.50 for travel anywhere on the system. For additional Metro bus information, please call (206) 553-3000.

MONORAIL

The Monorail departs every 10 minutes for a two-minute ride between Seattle Center and Westlake Center. The cost is \$1.50 one-way or \$3.00 round-trip for adults. Hours of operation are Monday–Friday, 7:30 a.m.–11 p.m., and Saturday and Sunday, 9 a.m.–11 p.m. For additional information, please check the Seattle Center Monorail Web site at www.seattlemonorail.com.

General Meeting Information

ACCESSIBILITY FOR REGISTRANTS WITH SPECIAL NEEDS

GSA is committed to making the Annual Meeting accessible to all people interested in attending. If you need auxiliary aids or services because of a disability, check the appropriate box on the registration form. If you have suggestions or need further information, contact Kevin Ricker, kricker@geosociety.org, (303) 357-1090. Please let us know your needs by October 3.

TOURIST INFORMATION

For general information about sightseeing, accommodations, restaurants, and shopping in Seattle, visit www.seeseattle.org, or see the GSA Meeting Web site for additional area information.

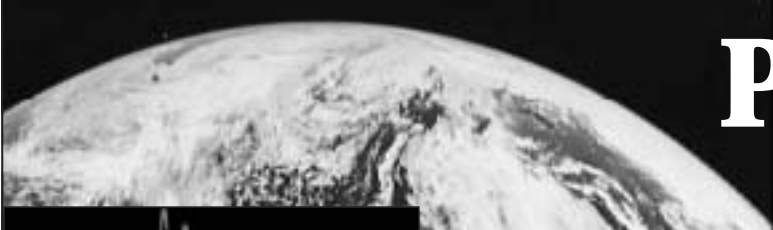
WEATHER & CLIMATE

Because two mountain ranges flank the city of Seattle, the climate is temperate year-round, and gardens thrive even in mid-winter. The average daily temperature in November is 51° Fahrenheit, with an expected 5.08 inches of precipitation for the month.

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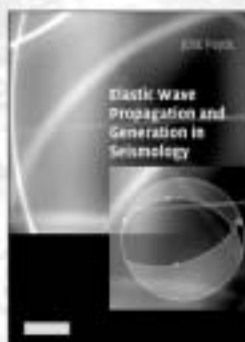
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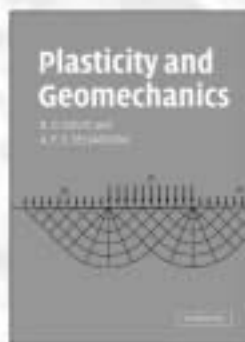


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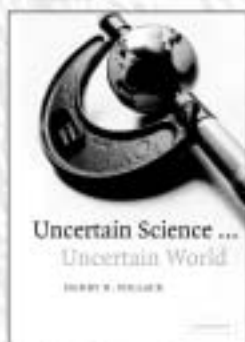
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INVITED PAPERS

The Pardee Keynote Symposia are made possible by a grant from The Joseph T. Pardee Memorial Fund.

These Pardee Keynote sessions are *special events* of broad interest to the geoscience community. They represent hot issue topics on the leading edge in a scientific discipline or area of public policy, address broad fundamental issues and are interdisciplinary. Selection was on a competitive basis. This year's seven Pardee Keynote sessions were reviewed and accepted by the Annual Program Committee. *(All speakers are invited.)*

P1. Global Climate Changes: Abrupt Late Pleistocene Climatic Reversals and Modern Global Warming

.....
GSA Quaternary Geology and
Geomorphology Division

Don J. Easterbrook, Western Washington University, Bellingham, WA; Ed Evenson, Lehigh University, Bethlehem, PA; John Gosse, Dalhousie University, Halifax, NS. Tuesday, November 4, 8 a.m.–noon.

This session will explore global, late Pleistocene, rapid climatic changes, focusing on the Younger Dryas and Intra-Allerod Cold Period, and aspects of global warming during the past century and earlier natural climatic changes.

P2. His View of Life: Reflections on the Scientific Legacy of Stephen J. Gould

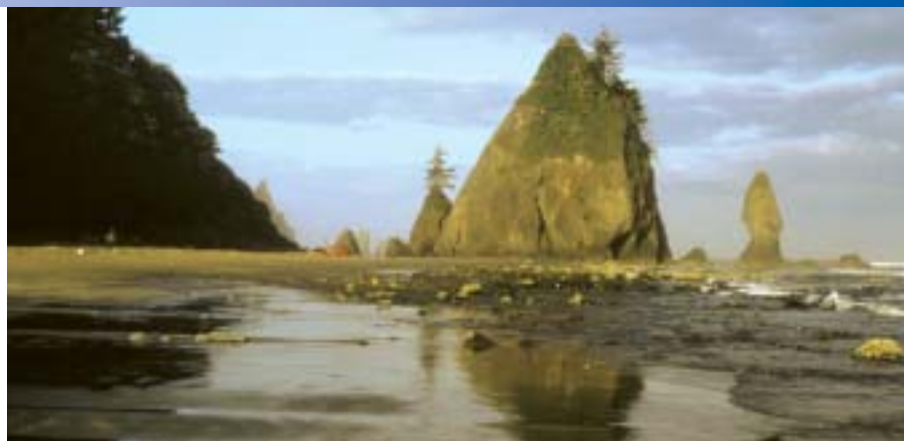
.....
Paleontological Society

Warren D. Allmon, Paleontological Research Institution, Ithaca, NY; Patricia Kelley, University of North Carolina, Wilmington, NC; Robert M. Ross, Paleontological Research Institution, Ithaca, NY. Sunday, November 2, 8 a.m.–noon.

This session will explore the legacy of Stephen Jay Gould. Speakers will reflect upon and attempt to clarify Gould's views, some of which were widely misunderstood, and explicate interrelationships among his views in disparate subjects.

P3. Modeling Metamorphism: Petrology, Geochemistry, and Tectonics

.....
Mineralogical Society of America;
Geochemical Society; GSA Structural



Seastacks Point of Arches Olympia N.P., Washington. Photo by John Karachewski.

Geology and Tectonics Division

Michael Brown, University of Maryland, College Park, MD; Barbara L. Dutrow, Louisiana State University, Baton Rouge, LA. Monday, November 3, 1:30–5:30 p.m.

Metamorphism involves the study of global-scale cycles, for example, from diagenesis to exhumation of metamorphic rocks, and from ocean floor sedimentation to formation of mountain belts and global climate change. This session addresses a broad theme that is fundamental for mineralogy, petrology, geochemistry, tectonics, and earth system science.

P4. Neoproterozoic Geobiology: Fossils, Clocks, Isotopes, and Rocks

.....
GSA Geobiology and Geomicrobiology
Division; Paleontological Society;
Geochemical Society; Precambrian (at
large); GSA Sedimentary Geology Division

Shuhai Xiao, Tulane University, New Orleans, LA; Alan J. Kaufman, University of Maryland, College Park, MD. Wednesday, November 5, 8 a.m.–noon.

Sedimentologists, paleontologists, geochemists, and earth system modelers are brought together to present new data and models (stimulated by the “snowball Earth” hypothesis) on the Neoproterozoic Earth, in order to better understand the relationship between tectonic, climatic, and biological change at the end of the Proterozoic Eon.

P5. Preservation of Random Mega-scale Events on Mars and Earth: Influence on Geologic History

.....
GSA Planetary Geology Division

Mary G. Chapman, U.S. Geological Survey, Flagstaff, AZ; Lawrence H. Tanner, Bloomsburg University, Bloomsburg, PA. Tuesday, November 4, 1:30–5:30 p.m.

This session presents the state of our understanding of large-scale, rapid-acting geologic processes, such as bolide impact, superplume eruption, catastrophic flood, and edifice collapse that are obvious on Mars yet scarcely recognized on Earth.

P6. The Paleoenvironmental and Paleoclimatic Framework of Human Evolution

.....
GSA Archaeological Geology Division;
GSA Quaternary Geology and
Geomorphology Division; GSA
Sedimentary Geology Division; Society for
Sedimentary Geology (SEPM)

Gail M. Ashley, Rutgers University, Piscataway, NJ; Craig S. Feibel, Rutgers State University, New Brunswick, NJ. Monday, November 3, 8 a.m.–noon.

Recent discoveries and established facts regarding the paleoenvironment and paleoclimatic context of human evolution will be examined with the goal of shedding some light on the puzzle of human origins.

P7. The Science of Lewis and Clark: Historical Observations and Modern Interpretations

.....
GSA Engineering Geology Division; U.S.
Geological Survey; U.S. Department of the
Interior; GSA History of Geology Division;
History of Earth Science Society

Paul M. Santi, Colorado School of Mines, Golden, CO. Wednesday, November 5, 1:30–5:30 p.m.

The year 2003 is the 200th anniversary of the initiation of the Lewis and Clark Expedition. This session will gather scientists, historians, and science policy makers to explore the scientific impacts of the expedition as well as the changes in scientific interpretations and government support of science since the expedition.

(Invited and Volunteered Papers)

TOPICAL SESSIONS

Below is a listing of all approved topical sessions. These sessions are topically focused with a mix of invited and volunteered papers. Sessions are designed to promote the exchange of interdisciplinary, state-of-the-art information. Papers can be submitted to a specific topical session, and you may choose up to three scientific categories. After each topical description below, the categories are identified as they appear on the abstract form. PLEASE SUBMIT ONLY IN THE MODE (oral or poster) AND CATEGORIES INDICATED in the description. An abstract submitted in the incorrect mode will be transferred automatically to a discipline session.

ABSTRACTS DEADLINE: JULY 15

Please use the online electronic abstract form found on the GSA Web site. An abstract submission fee will be charged. The fee is \$18 for all students; \$30 for all others. If you cannot submit your abstract electronically, contact Nancy Carlson, (303) 357-1061, ncarlson@geosociety.org.

DISCIPLINE SESSIONS

From the list found on the electronic abstract form, you may choose up to three discipline categories you feel your abstract would fit best. Joint Technical Program Committee representatives organize the papers in sessions focused on disciplines (e.g., environmental geoscience or mineralogy).

TOPICAL SESSIONS

T1. The Peopling of the New World: Geology, Archaeology, and Paleoenvironments

.....
GSA Archaeological Geology Division;
GSA Quaternary Geology and Geomorphology Division; *Society for American Archaeology*

Archaeological Geology; Quaternary Geology/Geomorphology; Paleoclimatology/Paleoceanography

Vance T. Holliday, University of Arizona, Tucson, AZ. ORAL

T2. Geoarchaeology of Historic and Urban Sites

.....
GSA Archaeological Geology Division
 Archaeological Geology; Quaternary Geology/Geomorphology; Engineering Geology

David L. Cremeens, GAI Consultants, Inc., Monroeville, PA; Julie K. Stein, University of Washington, Seattle, WA. ORAL

T3. Impending Disaster—The Impact of Population Growth on Water Availability and Quality

.....
U.S. National Committee for the Geological Sciences; *U.S. National Committee for Geodesy and Geophysics;* *GSA Geology and Public Policy Committee;* *GSA Hydrogeology Division*

Environmental Geoscience; Engineering Geology; Hydrogeology

Grant Heiken, Los Alamos National Lab, Los Alamos, NM; Patrick Leahy, U.S. Geological Survey, Reston, VA; Farouk El-Baz, Boston University, Boston, MA. ORAL

T4. Mathematical Modeling of Earth Surface Processes: The Good, the Bad, and the Ugly

.....
Environmental Geoscience; Engineering Geology; Public Policy

Robert S. Young, Western Carolina University, Cullowhee, NC; Orrin H. Pilkey, Duke University, Durham, NC. ORAL

T5. Terroir, Geology, and Wine: A Tribute to Simon J. Haynes

.....
Society of Economic Geologists

Economic Geology; Quaternary Geology/Geomorphology; Remote Sensing/Geographic Info System
 Lawrence D. Meinert, Washington State University, Pullman, WA. ORAL

T6. Geology of Salmon

.....
 Environmental Geoscience; Quaternary Geology/Geomorphology; Paleontology/Paleobotany

David R. Montgomery, University of Washington, Seattle, WA. ORAL

T7. Geologists in the U.S. Peace Corps: The Contribution of Peace Corps Geologists to

International Development and the Contribution of the Peace Corps Experience to the Development of the Geosciences in America

.....
GSA International Division, Association of Geoscientists for International Development; *U.S. Peace Corps;* *Ghana Geological Survey;* *U.S. Geological Survey*
 Public Policy

Robert A. Levich, Las Vegas, NV; R. Stephen Saunders, NASA, Arlington, VA; Ernest W. Kendall, Seabrook, TX. ORAL

T8. The Role of Geology in the Management of Public and Private Western Temperate Forest Lands

.....
GSA Quaternary Geology and Geomorphology Division; *GSA Engineering Geology Division*

Quaternary Geology/Geomorphology; Engineering Geology; Environmental Geoscience

Wendy J. Gerstel, Washington State Department of Natural Resources, Olympia, WA; Matthew J. Brunengo, Portland, OR. ORAL and POSTER

T9. The Proposed Deep Geologic Repository for High-Level Radioactive Waste at Yucca Mountain, Nevada: Attributes of the Natural System

.....
U.S. Department of Energy

Public Policy; Environmental Geoscience
 Ronald M. Linden, Las Vegas, NV; Robert A. Levich, Las Vegas, NV; Ardyth Simmons, Lawrence Berkeley National Lab, Berkeley, CA. ORAL

T10. Mega-Events on Earth and Mars: Record, Recognition, and Consequences (Posters)

.....
GSA Structural Geology and Tectonics Division

Planetary Geology; Volcanology; Quaternary Geology/Geomorphology
 Lawrence H. Tanner, Bloomsburg University, Bloomsburg, PA; Thorvaldur Thordarson, University of Hawaii, Honolulu, HI. POSTER

T11. Expanding Extraterrestrial Geoscience Horizons: Planetary Remote Sensing

.....
GSA Planetary Geology Division

Planetary Geology; Remote Sensing/Geographic Info System; Geochemistry, Other

Michael S. Kelley, Georgia Southern University, Statesboro, GA. ORAL

T12. Advances in Analytical Techniques and New Approaches to the Study of Ore Deposits

Society of Economic Geologists

Economic Geology; Geochemistry, Aqueous; Geochemistry, Other

Werner Halter, ETH Zurich, Zurich, Switzerland; Thomas Pettke, ETH Zurich, Zurich, Switzerland. ORAL and POSTER

T13. Cathodoluminescence of Quartz in Hydrothermal Ore Deposits

Society of Economic Geologists

Economic Geology; Geochemistry, Aqueous; Geochemistry, Other

Brian Rusk, University of Oregon, Eugene, OR. ORAL and POSTER

T14. Modern and Ancient Mineralizing Seafloor Hydrothermal Systems

Society of Economic Geologists

Economic Geology; Marine/Coastal Science; Geochemistry, Other

J. Bruce Gemmell, University of Tasmania, Tasmania, Australia; Cornel E.J. de Ronde, Institute of Geological and Nuclear Sciences, Lower Hutt, New Zealand. ORAL

T15. Characterizing Complexity in Geomechanics, Engineering Geology, and Hydrogeology

GSA Engineering Geology Division

Engineering Geology; Hydrogeology; Structural Geology

William C. Haneberg, Haneberg Geoscience, Port Orchard, WA; Edmund Medley, Exponent® Failure Analysis Associates, Menlo Park, CA. ORAL

T16. Deep Rock Slope Deformation: Mechanics, Processes, and Timing

GSA Engineering Geology Division

Engineering Geology; Quaternary Geology/Geomorphology

James P. McCalpin, Crestone, CO; Stephen G. Evans, Geological Survey of Canada, Ottawa, ON. ORAL and POSTER

T17. Advances and Applications of 3-D Fracture Analysis to Rock Mechanics and Engineering Geology

GSA Engineering Geology Division;

American Rock Mechanics Association; GSA Structural Geology and Tectonics Division

Engineering Geology; Structural Geology; Hydrogeology

Judy Ehlen, USA Engineer Research and Development Center, Alexandria, VA; Paul La Pointe, Golder Associates, Inc., Redmond, WA. ORAL

T18. Impacts of Hydrostratigraphy on Engineering and Civil Works Projects in the Pacific Northwest

GSA Hydrogeology Division; GSA Engineering Geology Division

Hydrogeology; Stratigraphy

Richard J. Martin, Shannon & Wilson, Inc., Seattle, WA; Scott W. Gaulke, Shannon & Wilson, Inc., Seattle, WA. ORAL

T19. Biogeochemical and Physical Processes in Mine Pit Lakes

GSA Limnogeology Division

Geochemistry, Aqueous; Environmental Geoscience; Hydrogeology

Laurie Balistrieri, Seattle, WA; Gina Tempel, Reno, NV; John Crusius, Woods Hole, MA. ORAL and POSTER

T20. Widespread Importance of Immiscible H₂O-CO₂ Fluids for Petrologic and Geochemical Processes in Low-to-Moderate Temperature Crustal Environments

Geochemical Society

Geochemistry, Aqueous; Petrology, Metamorphic; Geochemistry, Other

John P. Kaszuba, Los Alamos National Lab, Los Alamos, NM; David R. Janecky, Los Alamos National Lab, Los Alamos, NM. ORAL and POSTER

T21. Geochemistry for Technogenesis

Environmental Geoscience; Geochemistry, Aqueous; Geochemistry, Organic

Viktor V. Dolin, Institute for Environmental Geochemistry, Kyiv, Ukraine; Reto Gieré, Purdue University, West Lafayette, IN; James Morris, University of South Carolina, Columbia, SC. ORAL

T22. Working at the Interface of Isotope Geochemistry and Ecology: A Rapidly Growing Discipline (Posters)

GSA Geobiology and Geomicrobiology Division; U.S. Geological Survey

Environmental Geoscience; Geochemistry, Organic; Geoscience Information/Communication

Adrian Farmer, U.S. Geological Survey, Fort Collins, CO; Elisabeth Brouwers, U.S. Geological Survey, Denver, CO. POSTER

T23. Ecological Stoichiometry: Elemental Cycling and Biogeochemical Interactions in Ecosystem Processes

GSA Geobiology and Geomicrobiology Division; U.S. Geological Survey

Environmental Geoscience; Geochemistry, Other; Geomicrobiology

Elisabeth Brouwers, U.S. Geological Survey, Denver, CO; Jill Baron, U.S. Geological Survey, Fort Collins, CO; Ann Kinsinger, U.S. Geological Survey, Seattle, WA. ORAL

T24. On the Forefront of Terrestrial and Marine Organic Geochemistry: A Tribute to John I. Hedges

Geochemical Society; American Chemical Society; Geochemical Division

Geochemistry, Organic; Geochemistry, Other; Paleoclimatology/Paleoceanography

Stephen A. Macko, University of Virginia, Charlottesville, VA; Peggy Ostrom, Michigan State University, East Lansing, MI. ORAL

T25. Hydrogen in Biogeochemical Systems

Geochemical Society; Organic Geochemistry Division

Geochemistry, Organic; Geomicrobiology; Geochemistry, Aqueous

Michael J. Whiticar, University of Victoria, Victoria, BC; Alex L. Sessions, Woods Hole Oceanographic Institution, Woods Hole, MA. ORAL

T26. Quantitative Modeling of Petroleum Systems and Basin Processes

Geochemical Society; GSA Sedimentary Geology Division; Society for Sedimentary Geology

Geochemistry, Organic; Hydrogeology; Geochemistry, Aqueous

Kenneth E. Peters, U.S. Geological Survey, Menlo Park, CA; Martin B. Goldhaber, U.S. Geological Survey, Denver, CO. ORAL

T27. Cutting Edge and “Vintage” Geochemistry: Celebrating the Science and Life of Glenn Goodfriend

.....
GSA Quaternary Geology and Geomorphology Division; GSA Archaeological Geology Division; Geochemical Society; Paleontological Society

Geochemistry, Organic; Quaternary Geology/Geomorphology; Marine/Coastal Science

Bonnie A.B. Blackwell, Williams College, Williamstown, MA; Paul Goldberg, Boston University, Boston, MA; Julie Brigham-Grette, University of Massachusetts, Amherst, MA. ORAL and POSTER

T28. Great Ideas for Problem-Based Instruction and Assessment in the Undergraduate Geosciences (Posters)

.....
National Association of Geoscience Teachers; GSA Geoscience Education Division

Geoscience Education

Thomas J. Hollis, Cuesta College and Atascadero High School, San Luis Obispo, CA. POSTER

T29 In Our Own Backyards: Undergraduate Research in a Local Context (Posters)

.....
Council on Undergraduate Research; Geosciences Division

Geoscience Education

Edward C. Hansen, Hope College, Holland, MI; Karen H. Fryer, Ohio Wesleyan University, Delaware, OH. POSTER

T30. Large Intro Courses That Work: Sharing Exciting and Effective Teaching Strategies (Posters)

.....
National Association of Geoscience Teachers; GSA Geoscience Education Division

Geoscience Education

Eric Butler, University of Vermont, Burlington, VT; Paul Bierman, University of Vermont, Burlington, VT. POSTER

T31. Subliminal and Intentional Outreach: Educating the General Public about Geological Sciences Through Novels, Film, TV, and Other Public Media

.....
GSA Geoscience Education Division;

National Association of Geoscience Teachers

Geoscience Education

Bonnie A.B. Blackwell, Williams College, Williamstown, MA. ORAL

T32. Using Global Datasets to Teach Earth Processes: An Illustrated Community Discussion (Posters). Special Session in Support of the NAGT/DLESE “On the Cutting Edge” Program

.....
National Association of Geoscience Teachers

Geoscience Education

David W. Mogk, Montana State University, Bozeman, MT; Cathryn A. Manduca, Carleton College. POSTER

T33. Beyond Google: Strategies for Developing Information-Literate Geoscience Students (Posters)

.....
National Association of Geoscience Teachers

Geoscience Education; Geoscience Information/Communication

R. Heather Macdonald, College of William and Mary, Williamsburg, VA; Barbara J. DeFelice, Dartmouth College, Hanover, NH; Karen K. Berquist, College of William and Mary, Williamsburg, VA. POSTER

T34. Building the Digital Library for Earth System Education (DLESE): New Opportunities for Collaboration

.....
National Association of Geoscience Teachers

Geoscience Education; Geoscience Information/Communication

Ed Geary, Colorado State University, Fort Collins, CO; Rajul Pandya, DLESE Program Center, Boulder, CO. ORAL

T35. Geoscience Innovation Fostering the Achievement of All Students: Curriculum and Pedagogy Methods Reform, Universal Design Principles, and Applications

.....
GSA Geoscience Education Division; Council on Undergraduate Research; National Association of Geoscience Teachers

Geoscience Education; Geoscience Information/Communication; Public Policy

Wendi J.W. Williams, University of Arkansas, Little Rock, AR; Roderic Brane, Wright State University, Dayton, OH; Pranoti M. Asher, Georgia Southern University, Statesboro, GA. ORAL

T36. Overcoming Obstacles to Incorporating Experiential Learning into the Undergraduate Geoscience Curriculum

.....
Geoscience Education; Geoscience Information/Communication; Public Policy

Robert C. Thomas, University of Montana—Western, Dillon, MT; Sheila M. Roberts, University of Montana—Western, Dillon, MT. ORAL

T37. Teaching Local Geology: A NAGT Session In Honor of Robert Christman

.....
National Association of Geoscience Teachers

Geoscience Education; Geoscience Information/Communication; Public Policy

Andrew Buddington, Spokane Community College, Spokane, WA; Rob Viens, Bellevue Community College, Bellevue, WA. ORAL

T38. Volunteering in K-12 Settings

.....
GSA Geoscience Education Division; National Association of Geoscience Teachers

Geoscience Education; Geoscience Information/Communication; Public Policy

Elizabeth Wright, School of the Art Institute of Chicago, Chicago, IL; William Slattery, Wright State University, Dayton, OH. ORAL

T39. History and Future of the Relationship Between the Geosciences and Religion: Litigation, Education, Reconciliation?

.....
Geoscience Education; History of Geology; Paleontology/Paleobotany

John F. Bratton, U.S. Geological Survey, Woods Hole, MA. ORAL and POSTER

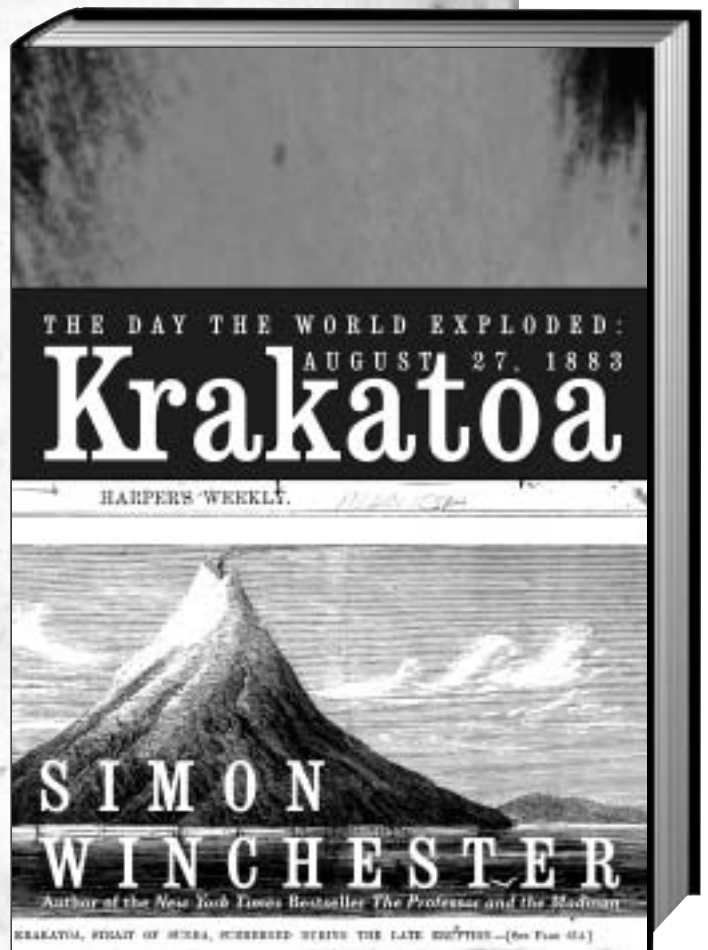
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T40. Workforce and Education: Building the Industry-Academia Connection in Developing a Capable and Sufficient Science and Technology Workforce

Geoscience Education; Public Policy; Geoscience Information/Communication

Marilyn J. Suiter, National Science Foundation, Arlington, VA; Richard M. Taber, National Science Foundation, Arlington, VA. ORAL

T41. Innovative Approaches to Teaching Sedimentary Geology Courses

GSA Geoscience Education Division; GSA Sedimentary Geology Division; National Association of Geoscience Teachers

Geoscience Education; Sediments, Clastic; Sediments, Carbonates

Karen Grove, San Francisco State University, San Francisco, CA; Marjorie A. Chan, University of Utah, Salt Lake City, UT; R. Heather Macdonald, College of William and Mary, Williamsburg, VA. ORAL and POSTER

T42. Enhancing the Earth Science Content Knowledge of Elementary School Teachers

National Association of Geoscience Teachers

Geoscience Education

Barbara M. Manner, Duquesne University, Pittsburgh, PA. ORAL

T43. Field and Research Experiences for Students at Two-Year Colleges

National Association of Geoscience Teachers

Geoscience Education

Laura Guertin, Penn State University, Delaware County, Media, PA; Prajukti Bhattacharyya, Saint Louis Community College, Meramec, Saint Louis, MO. ORAL

T44. Sigma Gamma Epsilon Student Research (Posters)

Sigma Gamma Epsilon

Environmental Geoscience

Donald W. Neal, East Carolina University, Greenville, NC; Charles J. Mankin, Oklahoma Geological Survey, Norman, OK. POSTER

T45. Geological and Geophysical Databases: What We Have and What We Need

GSA Geophysics Division; GSA Structure and Tectonics Division

Geoscience Information/Communication; Geophysics/Tectonophysics/Seismology; Remote Sensing/Geographic Info System

G. Randy Keller, University of Texas, El Paso, TX; J. Douglas Walker, University of Kansas, Lawrence, KS. ORAL

T46. Challenges in Geoscience Publishing: The Insiders' Perspectives

Association of Earth Science Editors (AESE)

Geoscience Information/Communication; Geoscience Education; Public Policy

Monica G. Easton, Ontario Geological Survey, Sudbury, ON; Carol L. Ruthven, Kentucky Geological Survey, Lexington, KY. ORAL

T47. Design and Development of XML-based, Discipline-Specific, Geological Markup Languages, and Development of Applications (with Object-oriented Languages) and Databases to Process, Store, and Interchange Geological Data over the Web

Geoscience Information/Communication; Remote Sensing/Geographic Info System; Structural Geology

Hassan A. Babaie, Georgia State University, Atlanta, GA; Rahul Ramchandran, University of Alabama, Huntsville, AL. ORAL and POSTER

T48. Geoscience Information Horizons: Challenges, Choices, and Decisions

Geoscience Information Society

Geoscience Information/Communication

Lura E. Joseph, University of Illinois at Champaign-Urbana, Urbana, IL; Joanne Lerud-Heck, Colorado School of Mines, Golden, CO. ORAL and POSTER

T49. The National Geologic Map Database (Posters)

U.S. Geological Survey; Association of American State Geologists

Geoscience Information/Communication

David R. Soller, U.S. Geological Survey, Reston, VA; Thomas M. Berg, Ohio

Geological Survey, Columbus, OH. POSTER

T50. Henry Darcy's 200th Birthday: Fundamental Advancements Through Observation and Analysis

GSA Hydrogeology Division; National Ground Water Association; GSA History of Geology Division; History of Earth Science Society (HESS)

Hydrogeology; Engineering Geology; History of Geology

Vicki J. Kretsinger Grabert, Luhdorff and Scalmanini, Consulting Engineers/AG-WSE (NGWA), Woodland, CA; Graham E. Fogg, University California, Davis, CA. ORAL

T51. M. King Hubbert at 100: The Enduring Contributions of Twentieth-Century Geology's Renaissance Man

GSA Hydrogeology Division; National Ground Water Association; U.S. National Chapter of the International Association of Hydrogeologists; GSA Geophysics Division; GSA Sedimentary Geology Division; GSA Structural Geology and Tectonics Division; GSA History of Geology Division

Hydrogeology; Structural Geology; History of Geology

Alan E. Fryar, University of Kentucky, Lexington, KY; T.N. Narasimhan. ORAL

T52. Twenty Years of Exploration and Innovation in Quantitative Hydrogeology: In Honor of Ed Sudicky

GSA Hydrogeology Division

Hydrogeology

Rene Therrien, Universite Laval, Quebec, QC; Motomu Ibaraki, Ohio State University, Columbus, OH. ORAL

T53. Watershed-Based Research and Education: The State of the Science

GSA Hydrogeology Division; GSA Geoscience Education Division; GSA Quaternary Geology and Geomorphology Division; Geochemical Society

Hydrogeology; Environmental Geoscience; Quaternary Geology/Glomorphology

Rachel O'Brien, Allegheny College, Meadville, PA; Christopher J. Woltemade, Shippensburg University of Pennsylvania, Shippensburg, PA. ORAL

T54. Geochemical Modeling of Arsenic Speciation, Transformation, and Reactive Transport in Groundwater

GSA Hydrogeology Division

Hydrogeology; Geochemistry, Aqueous; Geomicrobiology

Chen Zhu, University of Pittsburgh, Pittsburgh, PA; Robert Ford, U.S. Environmental Protection Agency, Ada, OK. ORAL

T55. Groundwater and Watershed Analysis Across Political Boundaries

GSA Hydrogeology Division

Hydrogeology; Public Policy; Environmental Geoscience

Barry J. Hibbs, California State University, Los Angeles, CA; Dave Rudolph. ORAL

T56. Recent Advances in Outcrop-Aquifer Analog Studies: Insights from Geophysical, Geostatistical, and Modeling Techniques

GSA Hydrogeology Division

Hydrogeology; Stratigraphy; Environmental Geoscience

Andrew C. Muller, Millersville University, Millersville, PA. ORAL and POSTER

T57. The Role of Diffusion in Groundwater Contaminant Behavior

GSA Hydrogeology Division

Hydrogeology; Environmental Geoscience

Matthew W. Becker, University at Buffalo, Buffalo, NY; Beth Parker, University of Waterloo, Waterloo, ON. ORAL and POSTER

T58. Saturated and Vadose Zone Hydrogeology, Environmental Geology, and Biogeochemistry of the Department of Energy Hanford Site in Southeastern Washington State

GSA Hydrogeology Division

Hydrogeology; Environmental Geoscience; Engineering Geology

Timothy D. Scheibe, Pacific Northwest National Lab, Richland, WA; Christopher J. Murray, Battelle Pacific Northwest National Lab, Richland, WA; Andy L. Ward, Pacific Northwest National Lab, Richland, WA. ORAL and POSTER

T59. Pharmaceuticals and Emerging

Organic Contaminants in the Hydrologic Environment: Progressing from Occurrence to Fate and Effects

GSA Hydrogeology Division; Toxic Substances Hydrology Program, Water Resources Discipline, U.S. Geological Survey

Hydrogeology; Environmental Geoscience; Limnogeology

Edward T. Furlong, U.S. Geological Survey, Denver, CO; Dana W. Kolpin, U.S. Geological Survey, Iowa City, IA. ORAL

T60. Transport and Remediation of Organic Compounds in the Saturated Zone

GSA Hydrogeology Division

Hydrogeology; Geochemistry, Organic; Environmental Geoscience

Thomas B. Boving, University of Rhode Island, Kingston, RI; John E. McCray, Colorado School of Mines, Golden, CO. ORAL and POSTER

T61. Springs: Interactions of Physical, Chemical, Biological, and Cultural Systems

GSA Hydrogeology Division

Hydrogeology; Environmental Geoscience; Engineering Geology

Abe Springer, Northern Arizona University, Flagstaff, AZ; Susan Swanson, Beloit College, Beloit, WI. ORAL and POSTER

T62. Flow and Biogeochemical Processes at the Interface Between Surface Water and Groundwater

GSA Hydrogeology Division

Hydrogeology; Geochemistry, Aqueous; Marine/Coastal Science

Donald O. Rosenberry, U.S. Geological Survey, Lakewood, CO; Masaki Hayashi, University of Calgary, Calgary, AB. ORAL

T63. Exploring the Linkages Between the Geochemistry, Biology, and Hydrology of the Hyporheic Zone (Posters)

GSA Hydrogeology Division

Hydrogeology; Geochemistry, Aqueous; Quaternary Geology/Geomorphology

Eric W. Peterson, Illinois State University, Normal, IL; Toby Dogwiler, Winona State University, Winona, MN. POSTER

T64. How Subsurface Properties Determine Microbial Habitats:

The Role of Groundwater Flow and Subsurface Chemistry in Supplying Energy and Nutrients to the Subsurface Biosphere

GSA Hydrogeology Division; International Association of Hydrogeologists, U.S. National Chapter; GSA Geobiology and Geomicrobiology Division

Hydrogeology; Geomicrobiology; Geochemistry, Aqueous

Barbara Bekins, U.S. Geological Survey, Menlo Park, CA; Phillip Bennett, University of Texas, Austin, TX. ORAL and POSTER

T65. Evolution and Migration of Brines in Sedimentary Basins

GSA Hydrogeology Division; Society of Economic Geologists; GSA Sedimentary Geology Division; Society for Sedimentary Geology

Hydrogeology; Geochemistry, Aqueous; Economic Geology

Alicia M. Wilson, University of South Carolina, Columbia, SC; Benjamin J. Rostron, University of Alberta, Edmonton, AB. ORAL and POSTER

T66. Karst Hydrology and Geomorphology in North America Over the Past Half Century: In Honor of Derek Ford and William White

GSA Hydrogeology Division; GSA Quaternary Geology and Geomorphology Division; Karst Waters Institute

Hydrogeology; Quaternary Geology/Geomorphology

Carol M. Wicks, University of Missouri, Columbia, MO; Russell S. Harmon, U.S. Army Research Office, Durham, NC. ORAL and POSTER

T67. Hydrogeologic Analysis of Glaciated Terrains

GSA Hydrogeology Division; GSA Engineering Geology Division

Hydrogeology; Quaternary Geology/Geomorphology; Engineering Geology

John J. Quinn, Argonne National Lab, Argonne, IL; M. Jim Hendry, University of Saskatchewan, Saskatoon, SK. ORAL

T68. Quaternary Stratigraphy and Implications for Water Resources in the Pacific Northwest

U.S. Geological Survey; Washington Water Science Center; GSA Hydrogeology Division

Hydrogeology; Quaternary
Geology/Geomorphology;
Environmental Geoscience

Sue Culton Kahle, U.S. Geological Survey,
Tacoma, WA; Christopher P. Konrad, U.S.
Geological Survey, Tacoma, WA. ORAL
and POSTER

T69. Characterization of Brackish and Saline Aquifer Systems

*GSA Hydrogeology Division; U.S.
Geological Survey*

Geochemistry, Aqueous; Hydrogeology
Norman Grannemann, U.S. Geological
Survey, Lansing, MI; Alan Burns, U.S.
Geological Survey, Lakewood, CO. ORAL

T70. Heterogeneity in Sedimentary Aquifers: Challenges for Characterization and Flow Modeling

GSA Hydrogeology Division

Hydrogeology; Sediments, Carbonates;
Sediments, Clastic

Timothy T. Eaton, Wisconsin Geological
and Natural History Survey, Madison,
WI; Kenneth R. Bradbury, Wisconsin
Geological and Natural History Survey,
Madison, WI. ORAL

T71. Hydrogeology of Volcanic Arcs

GSA Hydrogeology Division

Hydrogeology; Volcanology

Michael Manga, University of California,
Berkeley, CA; Timothy Rose, Lawrence
Livermore National Lab, Livermore, CA.
ORAL and POSTER

T72. A Century of Hydrogeologic Investigations and Groundwater Modeling in the Great Basin: What Have We Learned?

*GSA Hydrogeology Division; U.S.
Geological Survey*

Hydrogeology; Structural Geology;
Tectonics

Wayne R. Belcher, U.S. Geological
Survey, Henderson, NV; Donald S.
Sweetkind, U.S. Geological Survey,
Denver, CO. ORAL

T73. The Integration of Measurements and Modeling in the Hydrological Sciences

GSA Hydrogeology Division

Hydrogeology; Engineering Geology;
Remote Sensing/Geographic Info System
Kellie B. Vache, Oregon State University,
Corvallis, OR; Jeffrey J. McDonnell,

Oregon State University, Corvallis, OR.
ORAL and POSTER

T74. Revolutionizing Ocean Science: Cabled Observatories on the North American Pacific Coast

Marine/Coastal Science

John Delaney, University of Washington,
Seattle, WA; Christopher Barnes,
University of Victoria, Victoria, BC.
ORAL

T75. Human Versus Natural Influences on Holocene Sedimentation in Estuaries, Harbors, and Marginal Marine Ecosystems

*Society for Sedimentary Geology; GSA
Sedimentary Geology Division*

Marine/Coastal Science; Quaternary
Geology/Geomorphology;
Paleoclimatology/Paleoceanography

Douglas W. Haywick, University of
South Alabama, Mobile, AL; Miriam L.
Fearn, University of South Alabama,
Mobile, AL. ORAL and POSTER

T76. Present Posture and Future Status of Pacific Atoll Research

GSA International Division

Sediments, Carbonates; Environmental
Geoscience; Marine/Coastal Science

John D. Collen, Victoria University of
Wellington, Wellington, New Zealand;
Douglas Edsall, U.S. Naval Academy,
Annapolis, MD. ORAL and POSTER

T77. Coastal Processes and Hazards Along Active Margin and Low Latitude Coasts

GSA Engineering Geology Division

Marine/Coastal Science; Quaternary
Geology/Geomorphology;
Environmental Geoscience

Cheryl J. Hapke, U.S. Geological Survey,
Santa Cruz, CA; Laura J. Moore, Oberlin
College, Oberlin, OH. ORAL and
POSTER

T78. Gas Hydrate in the Natural Environment and Implications for Energy Resources, Seafloor Stability, Climate, and the Biology of the Deep Sea

*Marine/Coastal Science; Environmental
Geoscience; Engineering Geology*

William P. Dillon, U.S. Geological
Survey, Woods Hole, MA; Timothy S.
Collett, U.S. Geological Survey, Denver,
CO; Deborah R. Hutchinson, U.S.

Geological Survey, Woods Hole, MA.
ORAL

T79. Biogeochemical Processes at Ancient and Modern Methane Seeps

*Burke Museum of Natural History and
Culture*

Marine/Coastal Science;
Paleoclimatology/Paleoceanography;
Paleontology/Paleobotany

Joern Peckmann, University of Bremen,
Bremen, Germany; James L. Goedert.
ORAL

T80. The Impact of Crystal Chemistry in the Earth Sciences: A Tribute to Charles T. Prewitt, Recipient of the 2003 Roebbling Medal of the Mineralogical Society of America

Mineralogical Society of America

Mineralogy/Crystallography

Nancy L. Ross, Virginia Tech, Blacksburg,
VA; Russell J. Hemley, Carnegie
Institution of Washington, Washington,
DC; Ross J. Angel, Virginia Tech,
Blacksburg, VA. ORAL and POSTER

T81. Multi-Proxy Terrestrial Records and the Ocean-Climate System: Links and Perturbations in the Cretaceous

GSA Sedimentary Geology Division

Paleoclimatology/Paleoceanography;
Geochemistry, Other;
Paleontology/Paleobotany

David B. Finkelstein, Indiana University,
Bloomington, IN; Darren R. Gröcke,
Royal Holloway University of London,
Egham, Surrey, UK; Lisa M. Pratt,
Indiana University, Bloomington, IN.
ORAL and POSTER

T82. Ocean Chemistry Through the Mesozoic and Cenozoic

Geochemical Society

Paleoclimatology/Paleoceanography;
Geochemistry, Other; Geochemistry,
Other

Adina Paytan, Stanford University,
Stanford, CA. ORAL and POSTER

T83. Reevaluating the Equatorial Temperature Paradox for Mesozoic and Cenozoic Warm Episodes

*Paleoclimatology/Paleoceanography;
Geochemistry, Other; Stratigraphy*

Timothy S. White, U.S. Geological Survey, Anchorage, AK; David Pollard, Pennsylvania State University, University Park, PA; Chris Poulsen, University of Southern California Earth Sciences, Los Angeles, CA. ORAL and POSTER

T84. Pliocene Climates—Sea Levels and Ice Volumes (Posters)

Paleoclimatology/Paleoceanography
Detlef A. Warnke, California State University, Hayward, CA; Lloyd Burckle, Lamont-Doherty Earth Observatory, Palisades, NY. POSTER

T85. Signs of Life: the Role of Paleobiology in the History of Evolutionary Theory and Our Attempts to Understand the Changing Nature of the Biosphere

GSA History of Geology Division; Paleontological Society; Society of Vertebrate Paleontology; Cushman Foundation; History of Earth Science Society (HESS)

History of Geology; Paleontology/Paleobotany; Geomicrobiology
Roger D.K. Thomas, Franklin & Marshall College, Lancaster, PA; Gary D. Rosenberg, Indiana University–Purdue University, Indianapolis, IN. ORAL

T86. Fossil Decapod Crustacean Paleobiogeography, Systematics, and Evolution Over the Past 20 Years: In Honor of Ross and Marion Berglund (Posters)

Paleontological Society
Paleontology/Paleobotany
Elizabeth Nesbitt, Burke Museum, Seattle, WA; Torrey G. Nyborg, Loma Linda University, Loma Linda, CA. POSTER

T87. Paleo-Plant Ecophysiology

Paleontological Society
Paleontology/Paleobotany; Paleoclimatology/Paleoceanography; Environmental Geoscience
Dana L. Royer, Pennsylvania State University, University Park, PA; Christopher J. Williams, University of Pennsylvania, Philadelphia, PA. ORAL

T88. The Hunt for Precambrian Life: An Integrated Approach

Paleontological Society; GSA Geobiology

and Geomicrobiology Division; Precambrian (At Large)
Paleontology/Paleobotany; Geomicrobiology; Precambrian Geology
David J. Bottjer, University of Southern California, Los Angeles, CA; J. William Schopf, University of California, Los Angeles, CA. ORAL and POSTER

T89. Evolutionary and Ecological Links Between Terrestrial and Marine Ecosystems in the Phanerozoic

Paleontological Society; GSA Sedimentary Geology Division
Paleontology/Paleobotany; Paleoclimatology/Paleoceanography; Geochemistry, Other
Wolfgang Kiessling, Humboldt University, Berlin, Germany; Allister Rees, University of Chicago, Chicago, IL. ORAL

T90. Terrestrial Paleobiology of South America, Cretaceous through Neogene

Paleontological Society
Paleontology/Paleobotany; Paleoclimatology/Paleoceanography; Sediments, Clastic
Peter Wilf, Pennsylvania State University, University Park, PA; Robyn J. Burnham, University of Michigan, Ann Arbor, MI; Maria A. Gandolfo, Cornell University, Ithaca, NY; Kirk R. Johnson, Denver Museum of Nature & Science, Denver, CO. ORAL and POSTER

T91. Understanding Late Devonian Biotic, Climatic, and Oceanographic Events: Toward an Integrated Approach

Paleontological Society
Paleontology/Paleobotany; Geochemistry, Other; Paleoclimatology/Paleoceanography
Jared R. Morrow, University of Northern Colorado, Greeley, CO; Paul B. Wignall, University of Leeds, Leeds, United Kingdom; D. Jeffrey Over, State University of New York at Geneseo, Geneseo, NY. ORAL

T92. Advances in the Fossil Record of Insects and Other Terrestrial Arthropods

GSA Geobiology and Geomicrobiology Division; Paleontological Society; Paleontological Research Institute
Paleontology/Paleobotany; Coal

Geology; Paleoclimatology/Paleoceanography
Cary Easterday, Ohio State University, Columbus, OH; Conrad Labandeira, Smithsonian Institution, Washington, DC. ORAL and POSTER

T93. Micropaleontological Proxies of Ocean Gateway Paleoceanography

Cushman Foundation
Paleontology/Paleobotany; Paleoclimatology/Paleoceanography; Geochemistry, Other
Stephen A. Nathan, University of Massachusetts, Amherst, MA; R. Mark Leckie, University of Massachusetts, Amherst, MA. ORAL and POSTER

T94 Bridging the Gap: Ostracodes in the Earth Sciences

Paleontological Society; GSA Limnogeology Division
Paleontology/Paleobotany; Quaternary Geology/Geomorphology; Hydrogeology
Gene Hunt, University of Chicago, Chicago, IL; Lisa E. Park, University of Akron, Akron, OH. ORAL

T95. Organic Carbon in Lake Systems: From Primary Production to Oil Production

GSA Limnogeology Division
Limnogeology; Geochemistry, Organic; Quaternary Geology/Geomorphology
Kevin Bohacs, ExxonMobil Upstream Research Co., Houston, TX; Thomas C. Johnson, University of Minnesota, Duluth, MN. ORAL

T96. Lakes and Holocene Environmental Change: The Use of Multiproxy Lake Records for Paleoclimate Reconstructions

GSA Limnogeology Division
Limnogeology; Paleoclimatology/Paleoceanography; Quaternary Geology/Geomorphology
Mark Abbott, University of Pittsburgh, Pittsburgh, PA; Andrea Lini, University of Vermont, Burlington, VT. ORAL and POSTER

T97. Who Needs Carbon: Innovative Applications of Alternative Quaternary Geochronology Methods (Posters)

Quaternary Geology/Geomorphology;

Archaeological Geology

Kenneth Lepper, Los Alamos National Lab, Los Alamos, NM; Andrew Ivester, State University of West Georgia, Carrollton, GA. POSTER

T98. Interhemispheric Records of Paleoclimate Change: Low Latitude Influences on the High Latitudes, or the Other Way Around, in Pole-Equator-Pole Syntheses

GSA Quaternary Geology and Geomorphology Division; International Geosphere/Biosphere Program—Past Global Changes

Quaternary Geology/Geomorphology; Paleoclimatology/Paleoceanography; Limnogeology

Vera Markgraf, University of Colorado, Boulder, CO; Julie Brigham-Grette, University of Massachusetts, Amherst, MA. ORAL and POSTER

T99. Soils and a Sustainable Future—The Neglected Challenge in Geology: A Tribute to the Many Contributions and Challenges of Aldo Leopold

GSA Geology and Public Policy Committee; U.S. National Committee for the Geological Sciences; Geological Association of Canada; Canadian Society of Soil Science; GSA Sedimentary Geology Division

Public Policy; Environmental Geoscience; Quaternary Geology/Geomorphology

Paul H. Reitan, University at Buffalo, Buffalo, NY; Ward Chesworth, University of Guelph, Guelph, Ontario. ORAL

T100. Wetland Science: Intersection of Hydrogeology, Geomorphology, Ecology, and Computer Modeling

GSA Hydrogeology Division; USDI—Geological Survey; Montana State University

Hydrogeology; Quaternary Geology/Geomorphology; Environmental Geoscience

Richard S. Sojda, USDI—Geological Survey, Bozeman, MT; Brian L. McGlynn, Montana State University, Bozeman, MT; Donald O. Rosenberry, U.S. Geological Survey, Lakewood, CO. ORAL

T101. Erosion, Exhumation, and Uplift: Complex Interactions

and Feedback Mechanisms Between Tectonics and Geomorphology

GSA Quaternary Geology and Geomorphology Division; GSA Structural Geology and Tectonics Division

Quaternary Geology/Geomorphology; Tectonics; Remote Sensing/Geographic Info System

Kurt L. Frankel, University of California, Los Angeles, CA; Bernard Guest, University of California, Los Angeles, CA. ORAL and POSTER

T102. Geological Mapping: Key to Successful Management of Water and Land Resources (Posters)

GSA Quaternary Geology and Geomorphology Division; GSA Hydrogeology Division; GSA Engineering Geology Division; U.S. Geological Survey; Association of American State Geologists

Quaternary Geology/Geomorphology; Hydrogeology; Environmental Geoscience

Richard C. Berg, Illinois State Geological Survey, Champaign, IL; Peter T. Lyttle, U.S. Geological Survey, Reston, VA; Harvey Thorleifson, Geological Survey of Canada, Ottawa, ON. POSTER

T103. Comprehensive Landscape Analysis—A Predictive Tool for Mapping Surficial Deposits and Their Environmental Attributes

GSA Sedimentary Geology Division

Quaternary Geology/Geomorphology; Stratigraphy; Environmental Geoscience

Kathleen M. Farrell, Raleigh, NC; C. William Zanner, University of Nebraska, Lincoln, NE. ORAL and POSTER

T104. “Noah’s Flood” and the Late Quaternary Geological and Archaeological History of the Black Sea and Adjacent Basins

Avalon Institute of Applied Science

Quaternary Geology/Geomorphology; Paleoclimatology/Paleoceanography; Archaeological Geology

Valentina Yanko-Hombach, Avalon Institute of Applied Science, Winnipeg, MB; Jim Teller, University of Manitoba, Winnipeg, MB. ORAL

T105. Ecological Implications of Headwater Channel Processes

Environmental Geoscience; Quaternary

Geology/Geomorphology

Michael K. Liquori, University of Washington, Seattle, WA. ORAL and POSTER

T106. Quaternary History and Stratigraphy of the Pacific Northwest

GSA Sedimentary Geology Division

Quaternary Geology/Geomorphology

Kathy Goetz Troost, University of Washington, Seattle, WA; Tim Walsh, Washington Division of Geology, Olympia, WA; Ralph Haugerud, University of Washington, Seattle, WA. ORAL and POSTER

T107. Records of Quaternary Landscape Change in the Rocky Mountains

GSA Quaternary Geology and Geomorphology Division

Quaternary Geology/Geomorphology

Benjamin J.C. Laabs, University of Wisconsin, Madison, WI; Jeffrey S. Munroe, Middlebury College, Middlebury, VT. ORAL

T108. Sedimentary Records of Rapid Ice Sheet Decay and Intensive Ice-Calving Events

GSA Sedimentary Geology Division

Quaternary Geology/Geomorphology; Sediments, Clastic; Stratigraphy

Amir Mokhtari Fard, American University of Beirut, Beirut, Lebanon. ORAL

T109. New Insights into the Origins of Glacial Landscapes

Quaternary Geology/Geomorphology

Staci L. Goetz-Ensminger, Northwest Missouri State University, Maryville, MO; Nelson R. Ham, St. Norbert College, De Pere, WI; Jeffrey C. Strasser, Augustana College, Rock Island, IL. ORAL and POSTER

T110. Assessing the Deglacial Record of Quaternary Ice Sheets

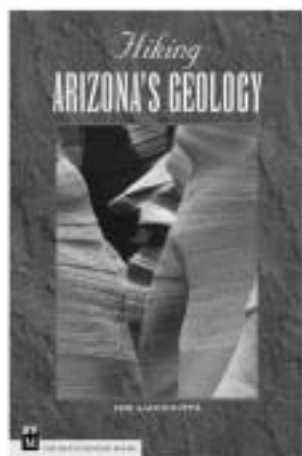
GSA Quaternary Geology and Geomorphology Division

Quaternary Geology/Geomorphology; Paleoclimatology/Paleoceanography

Tracy A. Brennand, Simon Fraser University, Burnaby, BC; Jerome-Etienne Lesemann, Simon Fraser University, Burnaby, BC. ORAL

HAPPY TRAILS FROM THE MOUNTAINEERS BOOKS

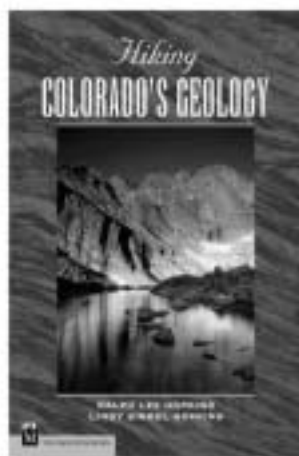
"These fascinating books prove that learning about geology is anything but boring."
—Sunset magazine



Hiking Arizona's Geology
Ivo Lucchitta

"Vibrant photographs illustrate the hiking trails, while simple diagrams aid readers' understanding of basic principles of geology."
—Sunset magazine

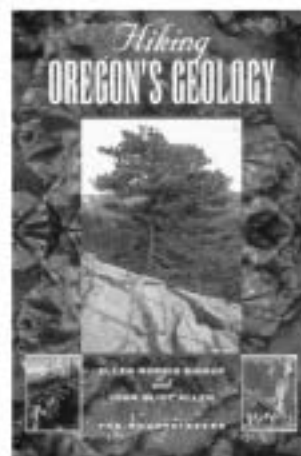
\$16.95, ISBN 0-89886-730-4



Hiking Colorado's Geology
Ralph Hopkins and Lindy Hopkins

"A well-researched compendium that is more than an engaging narration of interesting hikes (although it certainly is that) but also an easy-to-read account of the state's fascinating geology and how it got that way."
—The Daily Sentinel, Grand Junction, Colo.

\$16.95, ISBN 0-89886-708-8



Hiking Oregon's Geology
Ellen Bishop and John Allen

"Hiking Oregon's Geology should be in every hiker's backpack—and in the bookshelf or glovebox of anyone interested in the marvels of Oregon's diverse, colorful landscape."
—The Oregonian

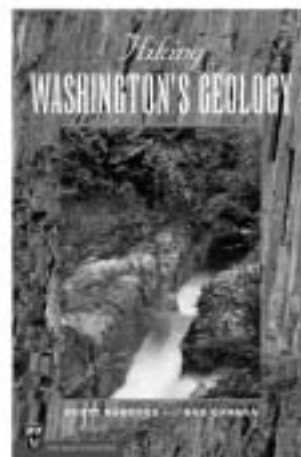
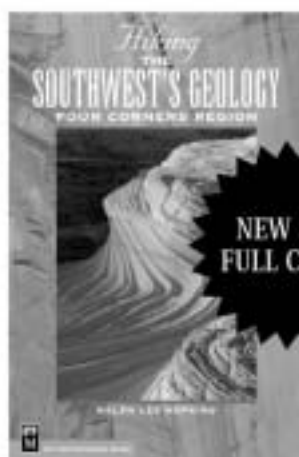
\$16.95, ISBN 0-89886-485-4

**Hiking the Southwest's Geology:
Four Corners Region**
Ralph Hopkins

"Just when you don't think there's room for another new hiking book in the West, another good one comes along . . . even hikes you've done are likely to seem different with some of the scientific details the author includes. An expert photographer, the author took some magnificent pictures."

—Deseret News

\$16.95, ISBN 0-89886-856-4



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Scott Babcock and Bob Carson

"A cover-to-cover read will add to any hiking experience, telling of dunes flooded over, ice ages, volcanic eruptions and lava flows. This gem of a book helps you appreciate the eye candy of each hike as you explore Washington's surface territory."

—Metropolitan Living

\$16.95, ISBN 0-89886-548-4

The Mountaineers Books are available at all bookstores and outdoor retailers or at www.mountaineersbooks.org

T111. McMurdo Dry Valleys, Antarctica, 1903–2003: A Celebration of a Century of Science

GSA Limnogeology Division

Quaternary Geology/Geomorphology; Paleoclimatology/Paleoceanography; Geomicrobiology

W. Berry Lyons, Ohio State University, Columbus, OH; Andrew G. Fountain, Portland State University, Portland, OR. ORAL

T112. Tills We Meet Again: Terrestrial Records of Pre-Wisconsinan Glaciations, Their Relationship to Other Pleistocene Climate Records, and Their Paleoclimatic Significance

Quaternary Geology/Geomorphology; Paleoclimatology/Paleoceanography; Stratigraphy

Greg Balco, University of Washington, Seattle, WA; Carrie Jennings Patterson, University of Minnesota, St. Paul, MN. ORAL

T113. Glaciers, Glacial Geology, and Glacial Ecosystems in the National Parks

National Park Service

Environmental Geoscience; Quaternary Geology/Geomorphology; Geoscience Information/Communication

Harold S. Pranger, Denver, CO. ORAL

T114. Isotopic Determination of Sediment Provenance: Techniques and Applications

GSA Sedimentary Geology Division; Society for Sedimentary Geology

Sediments, Clastic; Geochemistry, Other; Tectonics

Paul Karl Link, Idaho State University, Pocatello, ID; Mark Fanning, Australian National University, Canberra, Australia; J. Brian Mahoney, University of Wisconsin, Eau Claire, WI. ORAL and POSTER

T115. New Applications of Provenance Analysis to Landscape Evolution and Sediment Transport Systems

GSA Sedimentary Geology Division; Society for Sedimentary Geology

Sediments, Clastic; Stratigraphy; Tectonics

Matthias Bernet, University of

Canterbury, Christchurch, New Zealand; Kari Bassett, University of Canterbury, Christchurch, New Zealand. ORAL and POSTER

T116. Sabkha Environments, Recent Insights

GSA Hydrogeology Division; GSA Sedimentary Geology Division; Society for Sedimentary Geology

Hydrogeology; Sediments, Carbonates; Paleoclimatology/Paleoceanography

Warren W. Wood, U.S. Geological Survey, Reston, VA; Abdulrahman S. Alsharhan, U.A.E. University, Al-Ain, United Arab Emirates; Peter T. Kolesar, Utah State University, Logan, UT. ORAL

T117. Influence of Tsunamis in the Geological Record

GSA Sedimentary Geology Division

Sediments, Clastic; Marine/Coastal Science; Neotectonics/Paleoseismology

Frank R. Ethensohn, University of Kentucky, Lexington, KY; Kevin G. Stewart, University of North Carolina, Chapel Hill, NC. ORAL

T118. From the Abyss to the Beach: In Honor of Orrin H. Pilkey

GSA Sedimentary Geology Division

Sediments, Clastic; Marine/Coastal Science; Geoscience Education

David M. Bush, State University of West Georgia, Carrollton, GA; Bruce F. Molnia, U.S. Geological Survey, Reston, VA. ORAL

T119. Revisiting the Biogeochemistry of Black Shales and Oxygen-Deficient Marine Environments

Geochemical Society; GSA Sedimentary Geology Division; Society for Sedimentary Geology

Geochemistry, Organic; Paleoclimatology/Paleoceanography; Sediments, Clastic

Richard B. Schultz, Elmhurst College, Elmhurst, IL; Timothy W. Lyons, University of Missouri, Columbia, MO. ORAL and POSTER

T120. Sedimentology and Oceanography of Phosphogenic Systems

GSA Sedimentary Geology Division; Society for Sedimentary Geology

Sediments, Carbonates; Sediments, Clastic; Paleoclimatology/

Paleoceanography

Peir K. Pufahl, Queen's University, Kingston, ON; Eric E. Hiatt, University of Wisconsin, Oshkosh, WI. ORAL and POSTER

T121. Fortieth Anniversary of Sloss's Cratonic Sequences: Sequence Stratigraphy of the Sauk Sequence

GSA Sedimentary Geology Division

Stratigraphy; Sediments, Carbonates; Paleontology/Paleobotany

Kevin R. Evans, Southwest Missouri State University, Springfield, MO; James F. Miller, Southwest Missouri State University, Springfield, MO. ORAL and POSTER

T122. Clinofolds: Past, Present, and Modeled

GSA Sedimentary Geology Division; Society for Sedimentary Geology

Stratigraphy; Sediments, Clastic; Marine/Coastal Science

Charles A. Nittrouer, University of Washington, Seattle, WA; Lincoln F. Pratson, Duke University, Durham, NC; David Mohrig, Massachusetts Institute of Technology, Cambridge, MA. ORAL and POSTER

T123. Advances in Stratigraphic Analyses Using Ground Penetrating Radar

GSA Geophysics Division; GSA Engineering Geology Division; GSA Sedimentary Geology Division

Geophysics/Tectonophysics/Seismology; Quaternary Geology/Geomorphology; Hydrogeology

Gregory S. Baker, University at Buffalo (SUNY), Buffalo, NY; Harry M. Jol, University of Wisconsin, Eau Claire, WI. ORAL and POSTER

T124. The Geologic Record of Biosphere Dynamics—The Key to Understanding the Biotic Effects of Future Environmental Change

GSA Geobiology and Geomicrobiology Division

Geomicrobiology

Karl W. Flessa, University of Arizona, Tucson, AZ; David A. Feary, National Research Council, Washington, DC. ORAL

T125. Geology and Paleogeology of the Beringian Subcontinent:

To Honor the Career of David M. Hopkins

Alaska Quaternary Center (AQC)

Quaternary Geology/Geomorphology;
Paleoclimatology/Paleoceanography;
Archaeological Geology

Sarah J. Fowell, University of Alaska, Fairbanks, AK; Patricia Heiser, University of Alaska, Anchorage, AK. ORAL and POSTER

T126. Testing Rodinia Using New Maps Compiled for Each Craton through IGCP 440

GSA Structural Geology and Tectonics Division; International Geologic Correlation Project; Tectonics Special Research Center

Tectonics; Precambrian Geology

Karl E. Karlstrom, University of New Mexico, Albuquerque, NM; Svetlana V. Bogdanova, University of Lund, Lund, Sweden. ORAL

T127. New Perspectives on Neoproterozoic–Early Paleozoic Development of Western Laurentia: In Honor of John Cooper

GSA Sedimentary Geology Division

Stratigraphy; Sediments, Carbonates; Sediments, Clastic

Mike Pope, Washington State University, Pullman, WA; Chris Fedo, George Washington University, Washington, DC. ORAL and POSTER

T128. Barremian to Turonian Carbonate Platform Facies in Northeastern Mexico, their Paleogeographic, Paleocenic, and Paleoclimatic Implications: Comparison with Coeval Facies Elsewhere in the Tethys (Posters)

GSA Sedimentary Geology Division; Society for Sedimentary Geology

Stratigraphy; Paleoclimatology/
Paleoceanography; Sediments,
Carbonates

Florentin J. Maurrasse, Florida International University, Miami, FL. POSTER

T129. The Jurassic System of North America: Stratigraphy, Tectonics, and Depositional History (Posters)

GSA Structural Geology and Tectonics Division; GSA Sedimentary Geology

Division; Society for Sedimentary Geology
Stratigraphy; Tectonics; Sediments,
Clastic

William C. Parcell, Wichita State University, Wichita, KS. POSTER

T130. Advances in Understanding Fault Mechanics: Beyond Mohr-Coulomb

GSA Structural Geology and Tectonics Division

Structural Geology; Geophysics/Tectonophysics/Seismology; Neotectonics/
Paleoseismology

Juliet G. Crider, Western Washington University, Bellingham, WA. ORAL

T131. Seismogenic Friction and Pseudotachylites

GSA Structural Geology and Tectonics Division; GSA Geophysics Division

Structural Geology; Geophysics/Tectonophysics/Seismology; Tectonics

Eric C. Ferre, Southern Illinois University, Carbondale, IL; Joseph L. Allen, Concord College, Athens, WV; Kieran O'Hara, University of Kentucky, Lexington, KY. ORAL and POSTER

T132. Understanding Coupled Metamorphic and Deformational Processes: Advances in Integrated Textural, Chemical, and Microstructural Analysis

GSA Structural Geology and Tectonics Division; Mineralogical Society of America

Structural Geology; Petrology,
Metamorphic; Tectonics

Gary S. Solar, SUNY College, Buffalo, NY; Aaron Stallard, University of Canterbury, Christchurch, New Zealand. ORAL and POSTER

T133. Exhumation Along Major Continental Strike-Slip Fault Systems

GSA Structural Geology and Tectonics Division

Tectonics; Structural Geology; Petrology,
Metamorphic

Sarah Roeske, University of California, Davis, CA; Alison Till, U.S. Geological Survey, Anchorage, AK; Dwight Bradley, U.S. Geological Survey, Anchorage, AK. ORAL and POSTER

T134. The Columbia River Flood Basalts: New Insights into the Volcanism, Petrology, and

Tectonism of a Large Igneous Province

GSA Structural Geology and Tectonics Division

Volcanology; Petrology, Igneous;
Tectonics

Heather L. Petcovic, Oregon State University, Corvallis, OR; Bart S. Martin, Ohio Wesleyan University, Delaware, OH; Stephen P. Reidel, Pacific Northwest National Lab and Battelle Memorial Institute, Richland, WA. ORAL and POSTER

T135. Hydrothermal Alteration on Active Volcanoes: Processes, Rates, and Applications to Hazards and Resources

Society of Economic Geologists

Economic Geology; Volcanology;
Geochemistry, Other

David A. John, U.S. Geological Survey, Menlo Park, CA; Thomas W. Sisson, U.S. Geological Survey, Menlo Park, CA. ORAL

T136. Shallow Submarine Hydrothermal Vents: Geology, Geochemistry, and Biota

Marine/Coastal Science

Rosa Ma. Prol-Ledesma, Universidad Nacional Autónoma de México, México D.F. Mexico; Carles Canet, Universidad Nacional Autónoma de México, México D.F. Mexico; Matthew J. Forrest, Moss Landing Marine Labs, Moss Landing, CA. ORAL and POSTER

T137. Submarine Hydrothermal Systems: The Emergence of Geobiology

Geomicrobiology; Volcanology; Geochemistry, Other

Deborah S. Kelley, University of Washington, Seattle, WA; John Baross, University of Washington, Seattle, WA. ORAL and POSTER

T138. From Oxides to Anorthosites: A Tribute to D.H. Lindsley

Mineralogical Society of America; Geochemical Society

Petrology, Experimental; Petrology,
Igneous; Mineralogy/Crystallography
Hanna Nekvasil, State University of New York, Stony Brook, NY; B. Ronald Frost, University of Wyoming, Laramie, WY. ORAL and POSTER

T139. Granites at Convergent Margins: Physical and Chemical Constraints on Processes and Petrogenesis

Mineralogical Society of America

Petrology, Igneous; Structural Geology; Geochemistry, Other

Paul B. Tomascak, University of Maryland, College Park, MD; Scott Paterson, University of Southern California, Los Angeles, CA. ORAL and POSTER

T140. Modeling Metamorphism: Petrology, Geochemistry, and Tectonics

Mineralogical Society of America; Geochemical Society; GSA Structural Geology and Tectonics Division

Petrology, Metamorphic; Geochemistry, Other; Tectonics

Michael Brown, University of Maryland, College Park, MD; Barbara L. Dutrow, Louisiana State University, Baton Rouge, LA. ORAL and POSTER

T141. Phase Relations, High P-T Terrains, P-Tometry and Plate Pushing: A Tribute to W.G. Ernst

Mineralogical Society of America

Petrology, Metamorphic; Petrology, Igneous; Tectonics

Sorena S. Sorensen, Washington, DC; Mark Cloos, University of Texas at Austin, Austin, TX; M. Charles Gilbert, University of Oklahoma, Norman, OK. ORAL and POSTER

T142. Structure and Stratigraphy: New Perspectives on Lithotectonic Processes

GSA Structural Geology and Tectonics Division; GSA Sedimentary Geology Division

Structural Geology; Stratigraphy

Mark P. Fischer, Northern Illinois University, De Kalb, IL; David Anastasio, Lehigh University, Bethlehem, PA. ORAL and POSTER

T143. Earthquake Geology in Reverse-Faulting Terrains

GSA Quaternary Geology and Geomorphology Division

Neotectonics/Paleoseismology; Quaternary Geology/Geomorphology; Structural Geology

Alan R. Nelson, U.S. Geological Survey, Denver, CO; Brian L. Sherron, U.S.

Geological Survey, Seattle, WA. ORAL and POSTER

T144. Tectonics of the Circum-Pacific Rim in Space and Time: Focus on Alaska, Central and South America, and the Western Pacific

GSA International Division; U.S. National Committee on the Geological Sciences; Circum-Pacific Council; GSA Structural Geology and Tectonics Division

Tectonics; Petrology, Igneous; Geophysics/Tectonophysics/Seismology

Suzanne Mahlburg Kay, Cornell University, Ithaca, NY; Mark Cloos, University of Texas, Austin, TX. ORAL and POSTER

T145. The Washington Cascades: An Integrated Perspective on 100 Million Years of Orogenesis, Magmatism, and Surface Processes

GSA Geophysics Division; GSA Structural Geology and Tectonics Division

Tectonics; Quaternary Geology/Geomorphology; Petrology, Igneous

Peter W. Reiners, Yale University, New Haven, CT; Donna L. Whitney, University of Minnesota, Minneapolis, MN. ORAL and POSTER

T146. Collisional Tectonics of the Northwest Cordillera: Integration of New Data in Basin Development, Magma Petrogenesis, Geophysics, Structural, and Metamorphic Analysis (Posters)

GSA Structural Geology and Tectonics Division

Tectonics; Stratigraphy; Petrology, Igneous

Ronald B. Cole, Allegheny College, Meadville, PA; Kenneth D. Ridgway, Purdue University, West Lafayette, IN. POSTER

T147. Crustal Character of the Northwestern Cordilleran Continental Margin

GSA Geophysics Division; GSA Structural Geology and Tectonics Division

Geophysics/Tectonophysics/Seismology; Tectonics

R.W. Saltus, U.S. Geological Survey, Denver, CO; T.L. Hudson, Applied Geology, Sequim, WA; D.B. Snyder, Geological Survey of Canada, Ottawa, ON. ORAL and POSTER

T148. The Cascade Volcanic Arc System

Volcanology; Geophysics/Tectonophysics/Seismology; Tectonics

Patrick Muffler, U.S. Geological Survey, Menlo Park, CA; Richard J. Blakely, U.S. Geological Survey, Menlo Park, CA. ORAL and POSTER

T149. Seismic Hazards and Neotectonics in Southern Nevada (Posters)

GSA Geophysics Division

Tectonics; Geophysics/Tectonophysics/Seismology; Neotectonics/Paleoseismology

Catherine M. Snelson, University of Nevada, Las Vegas, NV; Wanda J. Taylor, University of Nevada, Las Vegas, NV. POSTER

T150. New Views of Seismic Hazard in Cascadia I: Seismology and Seismotectonics

GSA Geophysics Division

Geophysics/Tectonophysics/Seismology; Neotectonics/Paleoseismology; Structural Geology

Thomas M. Brocher, U.S. Geological Survey, Menlo Park, CA; Kate C. Miller, University of Texas, El Paso, TX; Thomas L. Pratt, U.S. Geological Survey, Seattle, WA. ORAL and POSTER

T151. New Views of Seismic Hazard in Cascadia II: Neotectonics of the Cascadia Forearc

GSA Structural Geology and Tectonics Division

Neotectonics/Paleoseismology; Tectonics; Quaternary Geology/Geomorphology

Samuel Y. Johnson, U.S. Geological Survey, Lakewood, CO; Ray E. Wells, U.S. Geological Survey, Menlo Park, CA. ORAL

T152. Global Climate Changes: Abrupt Late Pleistocene Climatic Reversals and Modern Global Warming

GSA Quaternary Geology and Geomorphology Division

Quaternary Geology/Geomorphology; Paleoclimatology/Paleoceanography; Environmental Geoscience

Don J. Easterbrook, Western Washington University, Bellingham, WA; Edward B. Evenson, Lehigh University, Bethlehem, PA; John Gosse, Dalhousie University, Halifax, NS. ORAL

Please use the online abstract form found on the GSA Web site, www.geosociety.org. An abstract submission fee of \$18 for all students and \$30 for all others will be charged. If you cannot submit your abstract electronically, contact Nancy Carlson, (303) 357-1061, ncarlson@geosociety.org.

From the home page of www.geosociety.org, click on "Submit an Abstract" and follow the steps given. If you lose your Internet connection before you are finished, you can resume making a submission when you log back on.

You and your coauthors will be provided (by e-mail) with a record of the abstract identification number and password, and you can access your abstract and revise it as necessary from any Internet connection up until the published abstract submission deadline date (July 15).

The system supports the submission of complex abstracts that contain subscripts, superscripts, italic and boldface type, tables, Greek letters, and equations.

SCIENTIFIC CATEGORIES

Determine if your paper would fit neatly under one of the topical sessions. If it doesn't, please submit your abstract for inclusion in the general discipline sessions. The available choices are:

Archaeological Geology
 Coal Geology
 Economic Geology
 Engineering Geology
 Environmental Geoscience
 Geochemistry, Aqueous
 Geochemistry, Organic
 Geochemistry, Other
 Geomicrobiology
 Geophysics/Tectonophysics/
 Seismology
 Geoscience Education
 Geoscience Information/
 Communication
 History of Geology
 Hydrogeology
 Limnogeology
 Marine/Coastal Science
 Mineralogy/Crystallography
 Neotectonics/Paleoseismology
 Paleoclimatology/
 Paleoceanography
 Paleontology/Paleobotany
 Petrology, Experimental
 Petrology, Igneous
 Petrology, Metamorphic
 Planetary Geology
 Precambrian Geology
 Public Policy
 Quaternary Geology/
 Geomorphology
 Remote Sensing/Geographic
 Info System
 Sediments, Carbonates

Sediments, Clastic
 Stratigraphy
 Structural Geology
 Tectonics
 Volcanology

PRESENTATION MODES

Select your preferred mode of presentation: Oral, Poster, or Either (no preference). *Please Note:* The program organizers will do their best to fit you into your preferred mode. However, they will override your original mode selection if they feel your paper would fit well in a particular session with other compatible abstracts. The decision of the program organizers is final.

Oral Mode. This is a verbal presentation before a seated audience. The normal length of an oral presentation is 12 minutes, plus three minutes for discussion.

Poster Mode. Each poster session presenter is provided with one horizontal, free-standing display board approximately 8' wide and 4' high. Precise measurements will appear in the Speaker Guide, which will be posted on the GSA Web site in September. The speaker must be in the poster booth for at least two of the four presentation hours.

Papers for discipline sessions may be submitted in either oral or poster mode. Papers for topical sessions are to be submitted *only* in the mode noted in the session description. If a topical abstract is submitted in the incorrect mode, the abstract will be transferred automatically to a discipline session.

ABSTRACT BODY

Please keep it to 2,000 characters or fewer. The online abstract system will reject it if it exceeds this limit.

If you want to include a table with your abstract, you may. But understand that the table might reduce the number of words allowed in your abstract. Taken together, the body of the abstract should take up no more space than would be occupied by roughly 2,000 characters alone.

Check the spelling of the abstract's body and title using your own word processor. Then read it again and make sure that it is something the whole world should see. (We won't check or edit it for you.)

For typing and pasting, add an extra line between paragraphs or they will run together when displayed (you can do this before copying or after pasting, or while typing).

ABSTRACT FEE

Once the abstract is in place, a window to submit payment will appear. The non-refundable submission fee is \$18 for all students; \$30 for all others.

You May Present Only One Volunteered Abstract

- Please submit only one *volunteered* abstract as speaker or poster presenter in topical and/or discipline sessions. This helps avoid speaker-scheduling conflicts and gives everyone an equal opportunity to be heard. Multiple submissions as speaker-presenter will result in rejection of all abstracts.
- This limitation does not apply to, nor does it include, *invited* contributions to keynote symposia or topical sessions.

JTPC TO FINALIZE PROGRAM IN MID-AUGUST

The Joint Technical Program Committee (JTPC) selects abstracts and determines the final session schedule. All authors will be notified in August. The JTPC includes representatives from those GSA Associated Societies and Divisions participating in the technical program. GSA Council approved the JTPC technical program chairs.

FIELD FORUM SCHEDULED

Processes on the Early Earth

July 4-9, 2004

Barberton Mountain Land, the Vredefort Dome, and Kaapvaal Craton, South Africa

Cosponsored by Geological Society of America and Geological Society of South Africa

Conveners:

W.U. Reimold, *University of the Witwatersrand, Department of Geology, Impact Cratering Research Group, Johannesburg, South Africa.*

C.R. Anhaeusser, *University of the Witwatersrand, Schonland Research Centre, Economic Geology Research Unit, Johannesburg, South Africa.*

Roger L. Gibson, *University of the Witwatersrand, Department of Geology, Impact Cratering Research Group, Johannesburg, South Africa.*

Kenneth A. Eriksson, *Virginia Polytechnic Institute and State University, Department of Geological Sciences, Blacksburg, Virginia, USA.*

Christian Koeberl, *Institut für Geochemie, University of Vienna, Austria.*

Bruce M. Simonson, *Department of Geology, Oberlin College, Oberlin, Ohio, USA.*

Frances Westall, *Centre de Biophysique Moléculaire, CNRS, Orléans, France.*

You are invited to participate in "Processes on the Early Earth" to examine critical exposures in the Archean terranes of the Barberton Mountain Land and the Vredefort Dome, South Africa. This field forum has an explicit format that favors field studies and discussion at outcrops. The Barberton Mountain Land represents one of the best exposed Archean greenstone belts in the world; the Vredefort Dome is the erosional remnant of the world's largest and oldest known impact structure that exposes a unique section through the Archean crust of the Kaapvaal craton. The 6-day forum will provide opportunities to investigate critical outcrops and debate issues on the exposure, including:

- accretionary processes;
- age of Earth and oldest rocks on Earth;
- early, intense impact on Earth and the Moon;
- Archean crust formation and tectonics;
- impact flux through time;
- formation of large impact structures, traces of impact in the limited Archean rock record, and significance of large impact for formation of life and evolution of life;
- when life first appeared on Earth and the evidence for life in Archean rocks;

- earliest sedimentary processes;
- transfer of material from space to Earth;
- rise and evolution of the early atmosphere; and
- Archean oceans.

If you would be interested in presenting your specialized and relevant expertise during this workshop, please indicate this

prior to **June 30, 2003**. Invited speakers will set the scene, to be followed by other short oral presentations, with poster sessions being held in the evenings. You can inform the organizing committee of your interest by sending an e-mail to Uwe Reimold, reimoldw@geosciences.wits.ac.za, about your expertise (subject area) and the type of contribution you plan to make. Poster presentation is encouraged, and short (3-5 minute) slots will be available for oral introduction of posters. If, in your opinion, it is vital that a specific outcrop be visited, please provide all necessary detail about its location and the duration and requirements to access it. When responding, please indicate your level of interest (i.e., definitely wish to participate, likely participant, possible participant). Space for the forum is limited to 50 participants.

SOME EXCURSION HIGHLIGHTS

Most field stops will be easily accessible, involving only short hikes, but several longer walks ought to be anticipated. The preliminary program includes the following:

Day 1 (Sun., July 4). Morning: travel from Johannesburg to Badplaas.

Afternoon: first field visits, followed by introductory and keynote presentations.

Evening: poster exhibit to be set up and viewed.

Day 2 (Mon., July 5). Main sites to be visited are in the Komati River valley.



3400 Ma pillow lava in Songimvelo game reserve, southern Barberton Mountain Land. Photo courtesy of Carl Anhaeusser.

Morning: Visit the lower Onverwacht Group type locality to examine the predominantly komatiitic volcanic rocks of the lower, ca. 3500 Ma Onverwacht volcanic pile. **Afternoon:** Visit the Middle Marker locality in the Steynsdorp valley; a traverse across part of the Kromberg Formation (upper Onverwacht–Geluk Subgroup) along the Komati River in the eastern part of the Songimvelo Game Reserve—sites where primitive microfossils (ca. 3400 Ma) have been reported from carbonaceous cherts.

Day 3 (Tues., July 6). Morning: See rocks of the Fig Tree and Moodies Groups in the area near the historic gold-mining town of Barberton. A spectacular tidal sandwave deposit will be examined in the bed of the Sheba River for evidence of Archean neap-spring cyclicity. **Afternoon:** Depending upon access, time will be spent examining sites of impact-related spherule layers.

Day 4 (Wed., July 7). Morning: Travel from Badplaas to the Johannesburg region. En route stops will include stromatolitic megadomal structures. **Afternoon:** A selection of exposures on the Johannesburg Dome to display various aspects of crustal development in the central Kaapvaal craton. **Evening:** Arrive at Vredefort and set up and discuss posters.

Day 5 (Thurs., July 8). The Vredefort Dome exposes a 20–25 km thick crustal section through the central Kaapvaal craton, involving a 10–15 km thick Late Archean to Paleoproterozoic (ca. 3080–2100 Ma) supracrustal succession and a pre–3080 Ma Basement Complex. This day examines the Basement Complex (main rock types and the pre-impact structural and metamorphic evolution).

Day 6 (Fri., July 9). Examine the extensive Late Archean sedimentary and volcanic deposits formed on the craton from 3080 Ma and the impact-related metamorphic and deformation phenomena (shatter cones, pseudotachylitic breccias, impact melt breccias).

All information about the field forum is posted at www.geosociety.org/fieldforums/04earlyearth.htm. Information can also be found on the Web site of the Geological Society of South Africa (www.gssa.org.za). Also, please note that the field forum will be immediately followed by the Geoscience Africa conference (University of the Witwatersrand, Johannesburg, July 11–16,

2004). This incorporates the 3rd Annual Meeting of the Geological Society of South Africa as well as the centenary celebration of the Geology Department at the University of the Witwatersrand. Details can be found at the conference Web site, www.wits.ac.za/geoscienceafrica.

Registration and Fees

The registration fee is \$690 (U.S. dollars) if received before March 1, 2004, and covers all cost items, including all bus/combi transport from and to Johannesburg, accommodation in 2- or 4-bed cottages, all meals, two guidebooks and an abstracts volume. Registration between March 1 and April 30, 2004, is \$730 (U.S. dollars). No registration or payments will be allowed after April 30, 2004, due to the organizers' obligation to make full payments to service providers. A late cancellation fee of 50% will be levied. Should you wish to apply for a student participation grant, you must furnish proof of full-time registration with a university (confirmed by a letter of support from a supervisor). Register early: The forum is limited to 50 participants.

Field Forum Proceedings

The proceedings of this field forum will be published as a Special Paper of the Geological Society of America (to be edited by W.U. Reimold and R.L. Gibson). The deadline for submission of manuscripts is set for September 15, 2004. While contributions by field forum participants will form the core of this publication, other submissions dealing with the field forum topics not presented at the meeting itself will also be considered for publication in this volume.

Important Deadlines:

June 30, 2003: Indication of interest to be received. Invitations to participants will be sent off together with a request to complete the official registration form, then posted on the GSSA Web site.

November 15, 2003: Program to be finalized and second circular to be posted.

March 1, 2004: Deadline for submission of abstracts and payment of registration fee.

July 4–9, 2004: Field Forum.

September 15, 2004: Final deadline for submission of manuscripts to the Field Forum Proceedings Special Paper.

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ANNOUNCEMENTS

Meetings Calendar

2003

- September 2–6 The Fifth Hutton Symposium on the Origin of Granites and Related Rocks, Toyohashi, Japan. Information: <http://www.gsj.jp/Info/event/hutton>.
- September 15–21 Association of Engineering Geologists 46th Annual Meeting: AEG 2003—Engineering Geology with an Altitude, Vail, Colorado. Information: Michael Hattel, Chair, mhattel@msn.com, www.aegweb.org.
- October 4–9 AIPG's 40th Annual Meeting, Glenwood Springs, Colorado. Information: Susan Landon, susanlandon@worldnet.att.net, (303) 436-1930, fax 303-322-2288; Tom Fails, thomgeol@aol.com (303) 759-9733, fax 303-759-9731.
- October 15–17 16th World LP Gas Forum, Conference and Exhibition, Santiago, Chile. Information: worldlpgas@colloquium.fr, www.worldlpgas.com/mainpages/newsevents/forum.php.
- November 1–5 Association of Earth Science Editors' Annual Meeting, Seattle, Washington, USA. Information: www.aese.org. (*Held in conjunction with GSA Annual Meeting. Abstracts deadline, session T46, Challenges in Geoscience Publishing: The Insiders' Perspectives: July 15, 2003.*)

2004

- January 15–18 The Hawaii International Conference on Sciences, Honolulu, Hawaii. Information: Hawaii International Conference on Sciences, P.O. Box 75036, Honolulu, HI, 96836, USA, (808) 949-1542, fax 808-947-2420, sciences@hicsciences.org.
- May 3–7 International Congress on the Application of Recent Advances in Underwater Detection and Survey Techniques to Underwater Archeology, Bodrum, Turkey. Information: secretary@uw-detection-for-archeology.org, www.uw-detection-for-archeology.org.

2005

- September 5–9 7th International Symposium on the Cretaceous, Neuchâtel, Switzerland. Information: Karl B. Föllmi, karl.foellmi@unine.ch, Thierry Adatte, thierry.adatte@unine.ch, Institut de Géologie, Université de Neuchâtel, case postale 2, CH-2007 Neuchâtel, Switzerland, 0041-718 26 00 (secretary), 26 55 (Karl Föllmi), 26 07 (Thierry Adatte), fax 0041-718 26 01, www-geol.unine.ch/.

Visit www.geosociety.org/calendar/ for a complete list of upcoming geoscience meetings.

BSSA Special Issue on the 2002 Denali Fault Earthquakes

The *Bulletin of the Seismological Society of America* (BSSA) will publish a special issue on the October 23, 2002, Mw 6.7 Nenana Mountain and November 3, 2002, Denali Fault, Alaska, earthquakes. The November 3, Mw 7.9 event ruptured over 300 km of the Denali Fault and was the largest strike-slip earthquake to occur in the United States since 1857. The October 23 occurrence of the Mw 6.7 Nenana Mountain event, a foreshock for the Denali Fault earthquake, prompted deployment of seismic and geodetic monitoring networks that should yield important coseismic and post-seismic information for the mainshock and its aftershock sequence. Teleseismic analysis has already confirmed the complex nature of the Mw 7.9 Denali Fault rupture, which was predominantly right-lateral but began with a thrusting component. The far-field effects, spectacularly evidenced in places such as Yellowstone and Long Valley, should provide important insights into remote dynamic triggering effects. Field studies of fault offset,

liquefaction, landslides, and effects on engineered structures such as the Trans-Alaska pipeline will enhance work on hazard mitigation and design considerations for the future.

This BSSA special issue will focus on results of investigations into all seismological, geodetic, other geophysical, geological, and earthquake engineering aspects of the Nenana Mountain and Denali Fault earthquakes and aftershocks. All authors working in this area are encouraged to submit research papers for consideration as part of this special issue. (Contact one of the guest editors, Charlotte Rowe, char@lanl.gov, Doug Christensen, doug@giseis.alaska.edu, or Gary Carver, woak@ptialaska.net, to discuss your intentions.)

Submission deadline: December 31, 2003.

BSSA anticipates that the special issue will be published in December 2004.

Vadose Zone Journal Highlights GSA Symposium

The May issue of the Soil Science Society of America's (SSSA) *Vadose Zone Journal* includes a Special Submissions section—Contaminant Characterization, Transport, and Remediation in Complex Multiphase Systems—that features work by presenters at the Geological Society of America Annual Meeting in Denver 2002.

The papers originated from two sessions titled "Characterization, Attenuation, and Remediation of Subsurface Contaminants in Heterogeneous Chemical or Physical Settings" at the GSA Annual Meeting in Denver (October 29–30, 2002).

Guest Editors John McCray and Geoffrey Thyne (Colorado School of Mines, Golden, Colorado) and Thomas Boving (University of Rhode Island) describe the special section as taking on "some of the most challenging problems facing scientists and engineers dealing with the subsurface environment." Topics covered include DNAPL architecture based on data collected at several field sites, characteri-

zation of DNAPL contamination in the vadose zone, surfactant behavior in multiphase systems, and issues related to metal transport and remediation. Three of the articles are review papers.

Published by the SSSA, with GSA as a cooperator, *Vadose Zone Journal* is an international peer-reviewed electronic journal for multidisciplinary research of the vadose zone. Rien van Genuchten (USDA, ARS, George E. Brown, Jr. Salinity Laboratory, Riverside, California) is leading this new publication as editor.

Persons interested in the journal can preview free sample issues from www.vadosezonejournal.org. As members of the cooperator organization, GSA members may subscribe at the member rate of \$50.00 per year. To subscribe, call SSSA Headquarters at (608) 273-8095 or e-mail your request to journals@agronomy.org. Be sure to let the customer representative know that you are a GSA member.

In Memoriam

J. Robert Berg

Andover, Kansas
March 7, 2003

Harmon Craig

La Jolla, California
March 14, 2003

Steven N. Daviess

Denver, Colorado
March 7, 2003

Jack G. Elam

Midland, Texas
February 27, 2003

John P. Gries (joined GSA in 1944)

White Lake, Michigan
March 28, 2003

Richard Hamburger

Germantown, Maryland
April 8, 2003

Robert B. Hargraves

Princeton, New Jersey
March 21, 2003

Walter D. Keller (joined GSA in 1939)

Columbia, Missouri
March 23, 2001

Robert T. Littleton

Boulder City, Nevada
February 27, 2003

Hans H. Renz

Bern, Switzerland
January 2003

Kenneth O. Stanley

The Woodlands, Texas
December 30, 2002

Michael A. Tolley

Pekin, Illinois
May 2003

William R. Walton

Evanston, Illinois
April 23, 2001

Please contact the GSA Foundation
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on contributing to the Memorial Fund.

GEON: Developing the Cyberinfrastructure for the Earth Sciences—A Workshop Report on Intrusive Igneous Rocks, Wilson Cycle and Concept Spaces

Co-Conveners:

A.K. Sinha, B. Ludäscher, B. Brodaric, C. Baru, D. Seber, A. Snoke, and C. Barnes

GEON (GEOscience Network) is a new National Science Foundation-sponsored research initiative designed to create a cyberinfrastructure for the earth sciences through information management. Its fundamental objective is to facilitate interlinking the four-dimensional data of earth science by establishing an interoperable and scalable geoscience network. The network will consist of digital resources and an integrated set of software tools for access, analysis, visualization, and modeling.

In keeping with the research goals of GEON, a workshop was held at the San Diego Supercomputer Center. The goal of the workshop was to explore ways to forge a link between *data* that we possess and the *knowledge* that exists in the igneous petrology community. This was done within the context of the Wilson cycle and igneous rocks. The workshop participants recognized that one of the principal difficulties lies in the vast differences of information contained in databases and the lack of explicit linkages between them. However, these disparate databases may be linked using the knowledge and conventions of the earth sciences and the formalisms of knowledge representation. An explicit, logical linkage of such knowledge is referred to as a *concept space* or *ontology*.

The workshop participants began to lay out the logical relationships between knowledge and data pertaining to igneous rocks and situated these data within the Wilson cycle. Preliminary concept-space maps for both igneous rocks and the Wilson cycle were developed. Although such concept space development may remain transparent to most users, its development will be critical in the establishment of a cyberinfrastructure for the geosciences. The full workshop report is posted at www.geongrid.org/workshops/conceptspace/igneous_rocks.



Homeland and Climatic Security at the Crossroads of Science and Policy

Raphael D. Sagarin, 2002–2003 GSA–U.S. Geological Survey Congressional Science Fellow

Every morning, I pass through security at the Longworth House Office Building. Connected to the Capitol building through a series of labyrinth-like tunnels, my building should be one of the most secure places on Earth. Yet for the six months I've been working there, security has been exactly the same. The Capitol police check cars by opening their trunks and glancing in before waving them into the underground garage. People pass through a metal detector that has not once beeped about the keys in my pocket. This "standing target" approach to homeland security is a good example of the failure of science to penetrate deeply into the political world.

Specifically, it is a failure of evolutionary scientists to get involved in the homeland security debate. In his 1993 book, *Evolution and Escalation*, evolutionary biologist Gary Vermeij wrote that when faced with an adaptable enemy, you may either adapt yourself, move away, or go extinct. Vermeij was talking about the evolutionary dance between snails and crabs in the fossil record, but he might as well have been talking about the U.S. and Al Qaeda. Unfortunately, I have seen almost no discussion on Capitol Hill of how our security systems should evolve, or of whether consolidating all of our security apparatus under one giant Office of Homeland Security will make us more or less *adaptable* to terrorist threats.

The failings and occasional successes of infusing science into public policy are evident every day on Capitol Hill. Nowhere is this better illustrated than in the issue of global climate change. Success can be seen in the rapid change in the publicly stated attitudes about climate change among political leaders and politically powerful business interests. Both success, and more often, failure, can be seen in the plans of action proposed to deal with climate change.

The Bush Administration's initial tone on climate change reflected the view that there was insufficient evidence to support the theory of climate change or to link human activity to climate change. Accordingly, President Bush announced early in his term that he would not ratify the Kyoto Protocol on curbing greenhouse gas emissions. But this view was soon rebuked by two widely publicized scientific reviews of climate change science: the Intergovernmental Panel on Climate Change's (IPCC) "Third Assessment Report" of 2001, and a follow-up report by the National Academies that was commissioned by the Bush administration. Both reports stated that observed and predicted future climate change can be attributed in part to human activity.

In the six months I have spent in Washington, I have heard several high-level administrators announce that climate change is indeed occurring and is likely to be in part due to human causes. Even ExxonMobil, which has held out longer than its

competitors in acknowledging the threat of climate change, has discussed its product's role in climate change in briefings on the Hill. I believe that it is the willingness of the thousands of scientific contributors to the IPCC and National Academies reports to put their findings in a highly publicized forum that has caused this radical shift in attitudes of powerful political players.

Nonetheless, success has been limited in scientists' ability to shape policy responses to climate change. The main plan of action proposed by the Bush administration to reduce greenhouse gas emissions is to voluntarily reduce greenhouse gas "intensity" (the ratio of emissions to economic output) by 18% in 10 years. I consider this plan a voluntary plan to do nothing. Consider that with no plan in place, greenhouse gas intensity declined 16% from 1990 to 2000, but overall emissions of greenhouse gases increased. Additionally, at least some of the reduction in emissions due to our intensity reduction will be transferred to another country because of a shift from manufacturing to service based economy. If manufacturing is shifted to a greenhouse gas intensive economy, such as China's, global intensity *and* emissions could increase.

On the scientific frontier, administration actions have shifted from positive, to negative, to uncertain. On the positive side, the administration proposed in fall 2002 a broad expansion of current scientific efforts known as the Climate Change Strategic Plan (CCSP). Over 1,200 people, including some of the country's leading climate change scientists, attended a public meeting to comment on the plan in December 2002, and the National Academies were asked to review the plan.

The National Academies' report on the CCSP, released in late February 2003, echoed the sentiments of many of the scientists I talked with during the December CCSP meeting. The academies noted that the plan lacked clear goals and priorities, standards for measuring progress, timetables for completion, or realistic assessments of the feasibility of proposed actions. Most damning of all was the finding that no new funding for climate change science was provided in the president's 2004 budget proposal.

Scientists should watch carefully to see if the recommendations of the National Academies and the hundreds of public comments (all published at climatescience.gov) are incorporated into the final CCSP, due in the end of April 2003. Equally important, Congress must approve a budget that includes significant increases from the president's proposal for climate change science. This will be a difficult feat in times of war, tax cuts, and massive budget deficits.

March 17, 2003

This manuscript is submitted for publication by Raphael Sagarin, 2002–2003 GSA–U.S. Geological Survey Congressional Science Fellow, with the understanding that the U.S. government is authorized to reproduce and distribute reprints for governmental use. The one-year fellowship is supported by GSA and by the U.S. Geological Survey, Department of the Interior, under Assistance Award No. 02HQGR0141. The views and conclusions contained in this document are those of the author and should not be interpreted as necessarily representing the official policies, either expressed or implied, of the U.S. government. Raphael Sagarin can be reached at rafe.sagarin@mail.house.gov.



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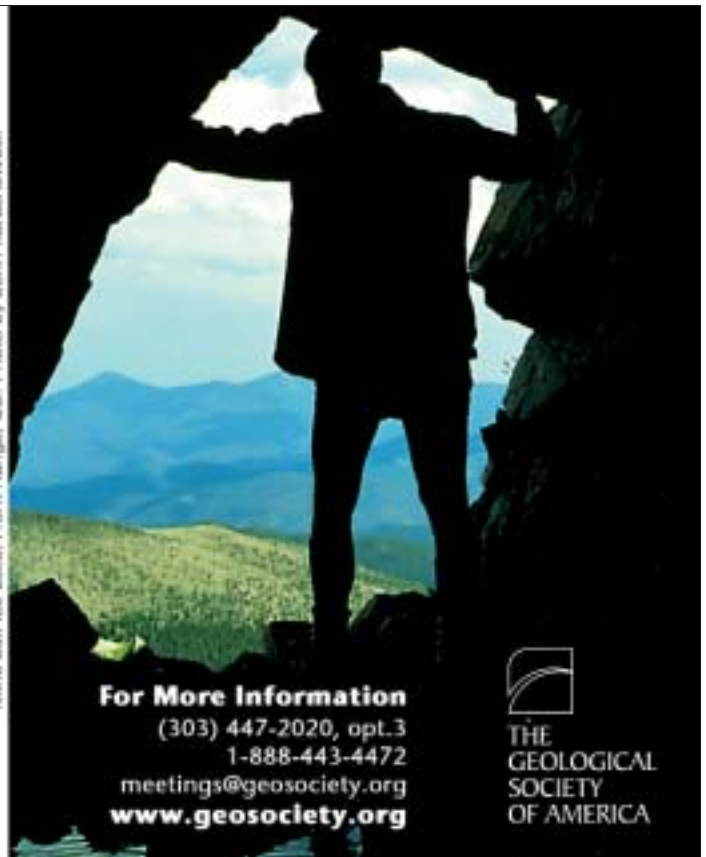
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We seek an individual who can develop a forward-looking, externally funded research program and whose research experience involves integrating geological, geophysical, and petrophysical data in the investigation of subsurface geology and petroleum systems. The successful candidate also should complement existing departmental strengths in reservoir characterization, stratigraphic analysis, basin studies, seismic interpretation, tectonics, and sedimentary geochemistry. The successful candidate is expected to advise graduate students and teach undergraduate and graduate courses in petroleum geology.

Faculty in our department have opportunities to collaborate with colleagues in Petroleum Engineering, Chemical Engineering, Oceanography, the Ocean Drilling Program, and the Geochemical and Environmental Research Group. Departmental facilities and programs can be reviewed at our web site (<http://geoweb.tamu.edu>).

Applicants should submit a curriculum vita, recent reprints, a statement of research and teaching interests, and the names, postal and e-mail addresses, and fax numbers of three references to: Dr. Steven L. Dorobek,



Simon Fraser University

**ASSISTANT PROFESSORSHIP IN STRUCTURAL GEOLOGY
Department of Earth Sciences**

The Department of Earth Sciences at Simon Fraser University invites applications for a tenure track Assistant Professorship in Structural Geology commencing January 1st, 2004. A PhD is required and previous research, teaching or industry experience is desirable. It is expected that the research activities of the successful candidate will complement some aspect of our existing research interests within the Department. The successful candidate will develop a field-oriented research program, and supervise both graduate and undergraduate students. Teaching responsibilities will include structural geology, field camps and advanced courses in the appointee's field of expertise. Eligibility for registration as a professional geoscientist (P.Geo) with the Association of Professional Engineers and Geoscientists of British Columbia (APEGBC) is desirable.

For additional information about this position, see <http://www.sfu.ca/earth-sciences/>

All qualified candidates are encouraged to apply; however, Canadian Citizens and permanent residents will be given priority. Simon Fraser University is committed to employment equity and encourages applications from all qualified women and men, including visible minorities, aboriginal people and persons with disabilities.

Applicants are requested to submit curriculum vitae, a statement of research and teaching interests, and the names, addresses, phone numbers and/or fax numbers, and email addresses of three referees. Applications or requests for further information should be directed to: **Dr. Doug Stead, Chair, Department of Earth Sciences, Simon Fraser University, 8888 University Drive, Burnaby, BC V5A 1S6. Phone: 604-291-4657; Fax: 604-291-5481; E-mail: dstead@sfu.ca.**

Review of applications will begin July 18, 2003. The search will remain open until the position is filled.



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Chair, Petroleum Geoscientist Search Committee, Department of Geology and Geophysics, Texas A&M University, College Station, TX 77843-3115. We will interview candidates until a qualified applicant is found. A Ph.D. is required at the time employment begins.

Texas A&M University, a land-, sea-, and space-grant university, is located in College Station, Texas, a dynamic and international community of 140,000 people. Texas A&M University is an affirmative action/equal opportunity employer committed to excellence through diversity and compliance with the Americans with Disabilities Act.

**UNIVERSITY OF SASKATCHEWAN
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Tenure Track Position—Palaeontology-Stratigraphy. The University of Saskatchewan is accepting applications for a tenure-track position in the area of palaeontology and stratigraphy. We seek a versatile, field-oriented candidate who takes an integrative approach to elucidating past environments using palaeobiological, palaeoecological, biostratigraphic, and geochemical methods in a stratigraphic context.

The successful candidate will be expected to develop a vigorous and innovative research program, and participate broadly in undergraduate and graduate student teaching and research, including field school. Candidates must hold a Ph.D. when appointed. Appointment will be at the Assistant Professor level.

The Department has 13 full-time faculty. The geochronological analytical infrastructure is one of the finest in North America, and the University of Saskatchewan is home to the Canadian Light Source, the first synchrotron in the country (under construction). Applications, including

résumé, statement of research intent and three letters of reference, should be addressed to: Paleontology Search Committee, Department of Geological Sciences, University of Saskatchewan, Saskatoon, SK S7N 5E2, Canada, Email: brian.pratt@usask.ca, Fax: 306-966-8593, Website: www.usask.ca/geology/.

We will begin reviewing applications after 15 September 2003.

All qualified candidates are encouraged to apply; however, Canadians and permanent residents will be given priority. The University of Saskatchewan is committed to increasing representation of equity groups (women, people of Aboriginal ancestry, visible minorities and/or people with disabilities). Applicants from these groups are encouraged to self-identify in their applications.

STATE OF IOWA—STATE GEOLOGIST

The Iowa Department of Natural Resources is seeking a State Geologist for the Iowa Geological Survey (IGS) in Iowa City, Iowa. The State Geologist will serve as the state's lead geological scientist, and will manage the IGS worksite. Applications must be submitted by June 30, 2003. For more information, including duties, salary range, and instructions for applying go to: www.igsb.uiowa.edu.

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tantship and year two is a teaching assistantship. Research assistantships are then provided by the student's major professor for the remainder of their degree study period. The program provides a strong interdisciplinary focus both in the course work and dissertation research, with a focus on contaminant fate and effects in three areas of faculty expertise: environmental toxicology and chemistry, environmental stressors, and environmental geophysics and hydrogeology. There are over two dozen ES program faculty from the departments of Biology, Chemistry, Geology and Physics. For more information on the curriculum, faculty research areas and application materials see <http://www.wright.edu/academics/ieq>.

The Yellow Springs Instruments Environmental Sciences Ph.D. Fellowship. Wright State University is pleased to announce a new YSI Environmental Sciences Ph.D. Fellowship. The Research Fellowship is for \$25,000 with tuition and fee waivers. This prestigious award will be given to a qualified applicant accepted into the new Environmental Sciences Ph.D. program at WSU. Students may apply with either a B.S. or M.S. degree from a relevant major (e.g., biology, chemistry, geology, physics, toxicology, environmental health sciences). The program provides a strong interdisciplinary focus both in the course work and dissertation research, with a focus on contaminant fate and effects in three areas of faculty expertise: environmental toxicology and chemistry, environmental stressors, and environmental geophysics and hydrogeology. Review of applications for the 2003-2004 Academic Year will begin in June, 2003, and continue until the position is filled. For more information on the curriculum, faculty research areas and application materials see <http://www.wright.edu/academics/ieq>.



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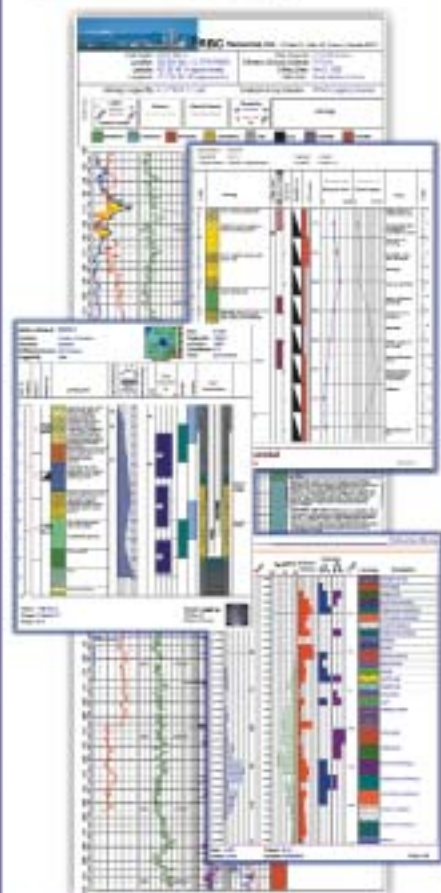
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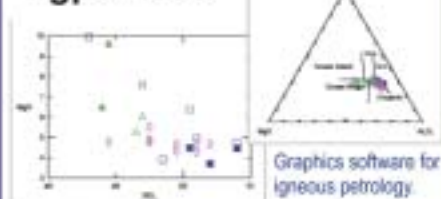
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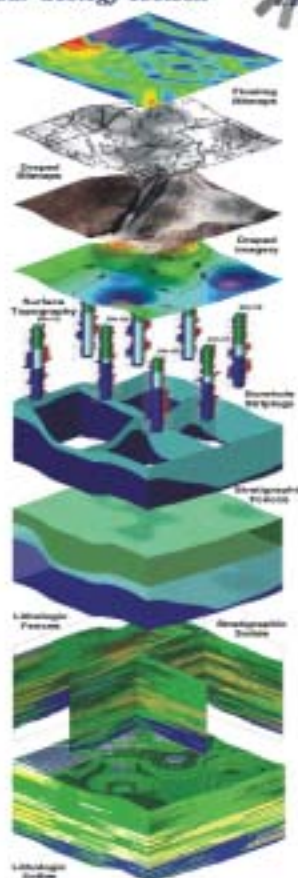
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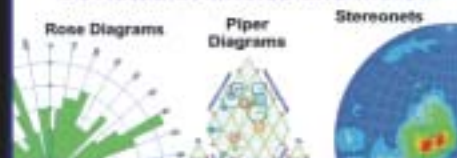
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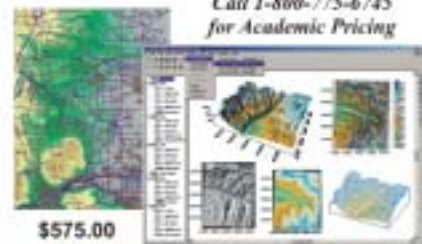
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