2009 GSA Annual Meeting & Exposition ✸ Portland, Oregon, USA

GSA TODAY

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The Portland Basin: A (big) river runs through it

Inside:

- ▲ Position Statement Revision Draft: Climate Change, p. 36
- ▲ Call for Geological Papers: 2010 GSA Section Meetings, p. 44
- ▲ Groundwork: Late Holocene relative land- and sea-level changes: Providing information for stakeholders, p. 52

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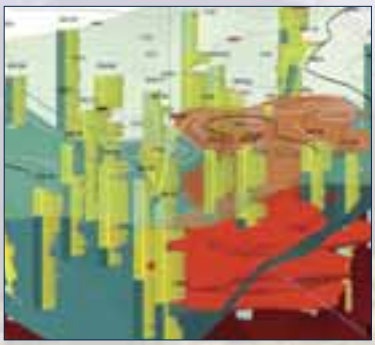

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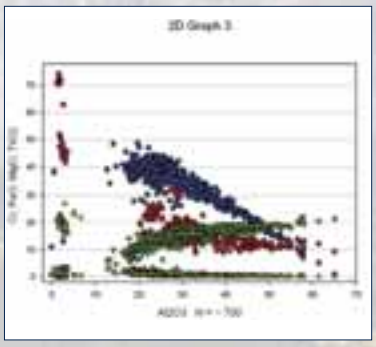

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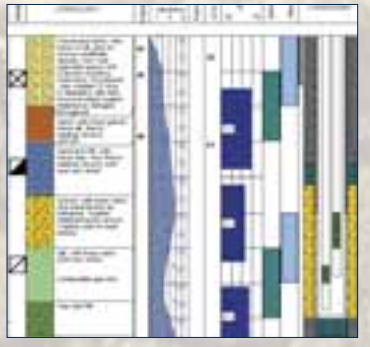

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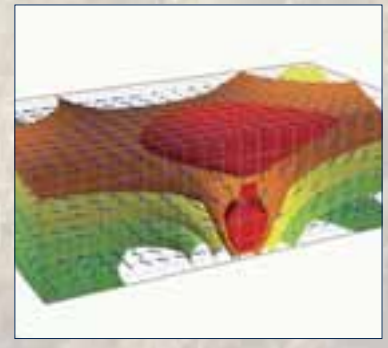

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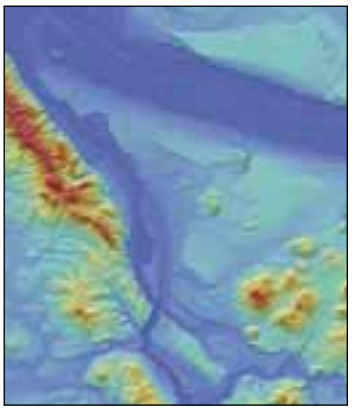
GSA TODAY

VOLUME 19, NUMBER 9 ▲ SEPTEMBER 2009

SCIENCE ARTICLE

4 **The Portland Basin: A (big) river runs through it.** Russell C. Evarts, Jim E. O'Connor, Ray E. Wells, and Ian P. Madin



Cover: LiDAR image of Portland area, ~35 km × 35 km, including confluence of NW-flowing Willamette River and W-flowing Columbia River. The Portland Basin's SW margin is bounded by the Portland Hills escarpment, a folded-faulted ridge of Miocene Columbia River Basalt. Small Quaternary volcanoes pepper the basin; basin fill (center) was sculpted as late Pleistocene Missoula floods. Source topographic data courtesy Oregon LiDAR consortium and Clark County, Washington. See "The Portland Basin: A (big) river runs through it" by R.C. Evarts et al., p. 4–10.

2009 GSA Annual Meeting & Exposition

From Volcanoes to Vineyards: Living with Dynamic Landscapes

12 **Pardee Keynote Symposia**
14 **Gold Medal Lectures and Presidential Address & Awards Ceremony**
15 **Registration**
16 **Hotel Map: Portland, Oregon, USA**
16 **Personal Scheduler**
17 **Housing Information and Travel & Transportation**
18 **Portland City Center and Fareless Square Light Rail Map**
19 **MAX Light Rail**
20–24 **Annual Meeting Events, Lectures & Extras!**
25 **Darwin Day**
26 **Mentor Program**
28 **Presenter Information and Poster Printing Service**
29 **Educator Events**
30 **Guest Program**
31 **GSA Foundation Silent Auction**
32 **Exhibitors**
33 **Thanks to Our Sponsors**
34 **Graduate School Information Forum**
35 **Session Cosponsor Organizations**

36 **Position Statement Revision DRAFT: Climate Change**
38 **Call for Applications:** 2010–2011 GSA-USGS Congressional Science Fellowship
40 ***GSA Today* Notices**
42 **GSA Foundation Update**
44 **Call for Papers:** 2010 GSA Section Meetings
44 **Call for Proposals:** 2010 GSA Annual Meeting
46 **Classified Advertising**
49 **Journal Highlights**
52 **Groundwork:** Late Holocene relative land- and sea-level changes: Providing information for stakeholders

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The Portland Basin: A (big) river runs through it

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ABSTRACT

Metropolitan Portland, Oregon, USA, lies within a small Neogene to Holocene basin in the forearc of the Cascadia subduction system. Although the basin owes its existence and structural development to its convergent-margin tectonic setting, the stratigraphic architecture of basin-fill deposits chiefly reflects its physiographic position along the lower reaches of the continental-scale Columbia River system. As a result of this globally unique setting, the basin preserves a complex record of aggradation and incision in response to distant as well as local tectonic, volcanic, and climatic events. Voluminous flood basalts, continental and locally derived sediment and volcanic debris, and catastrophic flood deposits all accumulated in an area influenced by contemporaneous tectonic deformation and variations in regional and local base level.

INTRODUCTION

The Portland Basin is one of several topographic and structural depressions that collectively constitute the Puget-Willamette forearc trough of the Cascadia subduction system (Fig. 1). Bisected by the lowermost reaches of the Columbia River—one of the few major world rivers cutting through an active volcanic arc—and located within a monogenetic volcanic field, the Portland Basin records not only local tectonic and volcanic activity, but also major North American geologic events, including emplacement of huge flood-basalt flows and inundation by colossal glacier-outburst floods. We provide a synopsis of Portland Basin evolution based on recent detailed geologic mapping, light detection and ranging (LiDAR) surveys, potential-field geophysics, and paleomagnetic and geochronologic investigations.

A FOREARC BASIN: GEOGRAPHY AND TECTONIC SETTING

The modern 30 × 80 km topographic basin is rectangular and northwest-elongated (Fig. 1) and originated as an early Neogene structure superimposed on the Paleogene strandline. Uplands flanking the basin are underlain by late Eocene and Oligocene subaerial volcanogenic rocks of the Cascade arc to the east and coeval uplifted marine sedimentary strata above accreted oceanic crust to the west. Geologic mapping and subsurface data show the present basin to be a wide, faulted, asymmetric syncline, bounded on the southwest by the Portland Hills, a faulted anticline of Miocene Columbia River Basalt (Fig. 1). The basin is filled with Miocene to Holocene sediments (Fig. 2). Isolated wells (Swanson et al., 1993; Mabey and Madin, 1995) and seismic reflection (Liberty, 2002) and gravity (Morin et al., 2007) data indicate that the floor of the sedimentary basin extends to ~400 m below sea level (bsl) and is deepest along its southwest edge.

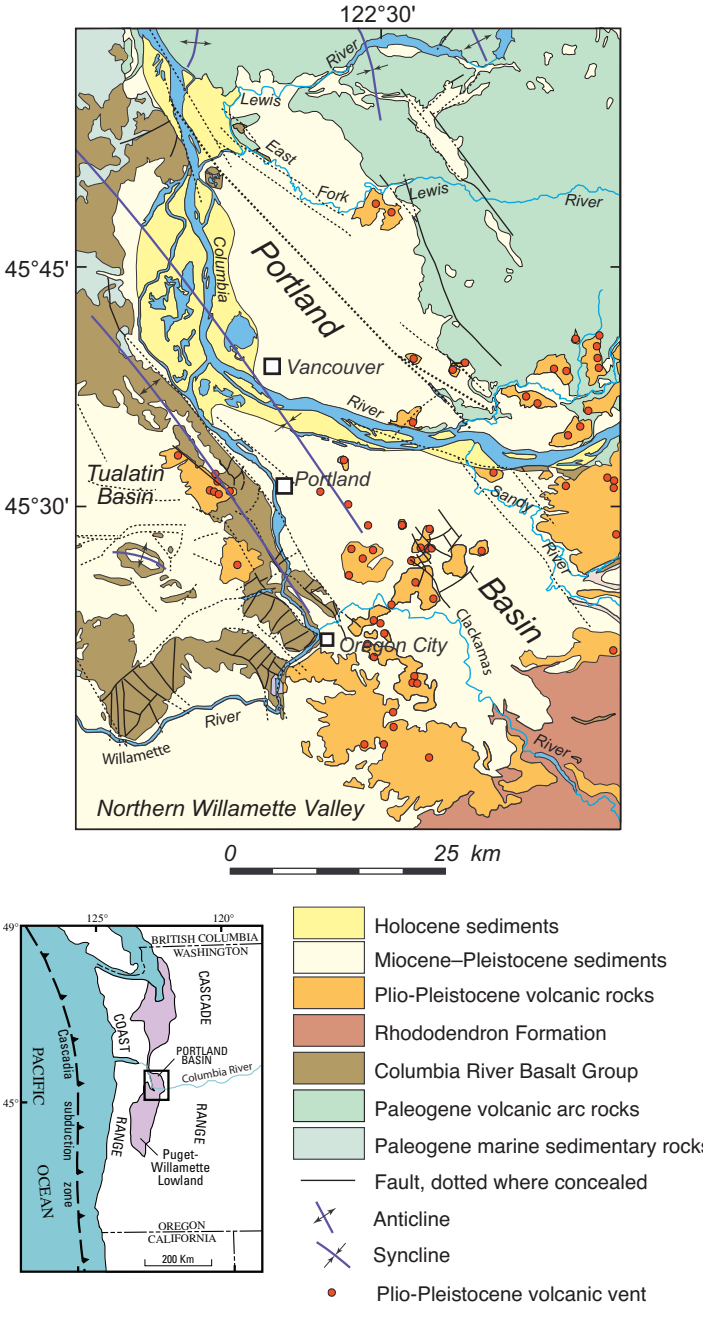

Figure 1. Generalized geology of Portland Basin and vicinity, modified from Blakely et al. (2000). Inset shows location of Portland Basin in forearc trough between Coast Range forearc high and Cascade Range volcanic arc.

GSA Today, v. 19, no. 9, doi: 10.1130/GSATG58A.1

Seismic activity in the Portland area is diffuse, and basin-margin structures are obscure. Focal mechanisms, well-bore breakouts, and GPS (Werner et al., 1991; Lewis et al., 2003; McCaffrey et al., 2007) indicate that the basin lies within a region of north-south margin-parallel compression related to the rotation and northward transport of an Oregon Coast Range microplate (Wells et al., 1998). Geologic, geophysical, and paleomagnetic data suggest that a dextral shear component of northward motion is accommodated by oblique slip on northwest-striking fault zones (Thomas et al., 1996; Blakely et al., 1995, 2000; Hagstrum et al., 2007). The Portland Basin exhibits some aspects of a pull-apart basin (Beeson et al., 1985, 1989; Yelin and Patton, 1991), but recent mapping and geophysical analysis indicate a more complex, poorly understood transpressional structure.

BASIN INCEPTION, BASALT FLOODING, AND EARLY SEDIMENTATION

The Portland Basin began to form after 20 Ma, probably as a broad syncline parallel to the Portland Hills anticline (Fig. 3A), as indicated by basinward-dipping attitudes of Paleogene strata along the basin margins (Evarts, 2004a, 2004b, 2004c, 2006). This fold developed contemporaneously with uplift of Paleogene strata to form the Coast Range forearc high (Snavely and Wells, 1996; Evarts and Swanson, 1994; McNeill et al., 2000).

At 16–15 Ma, flood-basalt flows of the Columbia River Basalt Group entered northwestern Oregon via a broad Columbia River valley transecting the Cascade Range (Beeson et al., 1989). The distribution of Grande Ronde Basalt flows delimits a basin between the western Cascade Range and a nascent Portland Hills anticlinal ridge (Fig. 3A) (Beeson et al., 1989). Sparse sub-basalt fluvial sediments (Van Atta and Kelty, 1985; Evarts, 2002, 2004a) attest to the prior existence of the ancestral Columbia River along the synclinal axis. Later Grande Ronde Basalt flows overwhelmed the Portland Hills anticline, but this structure continued to rise and by ca. 14 Ma was established as a permanent barrier that deflected the ancestral Columbia River northward (Beeson et al., 1989; Wilson, 2000).

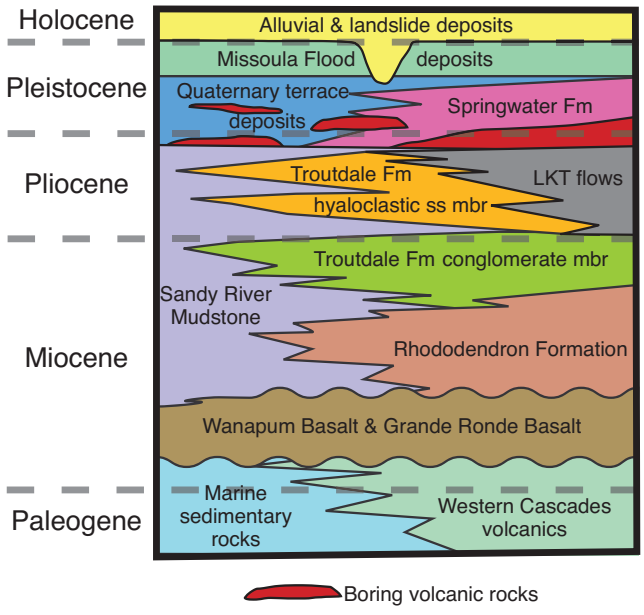

Figure 2. Schematic stratigraphic relations in the Portland Basin. LKT—low-potassium tholeiite.

During the last half of the Miocene, the Columbia River continued to pour sediment into the subsiding Portland Basin, including as much as 200 m of fine-grained fluvial and lacustrine sediments of the lower Sandy River Mudstone (Trimble, 1963) (Figs. 2 and 3B). This formation consists of thin-bedded micaceous and tuffaceous sandstone and siltstone, carbonaceous claystone, lignite, minor pumiceous tuff, and local gravel lenses (Trimble, 1963; Mundorff, 1964; Howard, 2002; Evarts, 2004a, 2004b). Most of this detritus originated in pre-Tertiary terranes east of the volcanic arc. The Sandy River Mudstone records a Columbia River similar in character to the low-gradient modern river. Like today, these beds were probably deposited near sea level, but there is no evidence that the Portland Basin was a marine estuary. Similar sediments beneath the northern Willamette Valley indicate that the basin receiving Columbia River sediments extended southward around the southeastern end of the Portland Hills anticlinal ridge (Yeats et al., 1996).

The paucity of volcanogenic material in these fine-grained beds is consistent with weak volcanic activity in the southern Washington segment of the Cascade arc during this time (Evarts and Swanson, 1994). To the southeast, however, eruptions of andesitic volcanoes in the northern Oregon Cascades fed debris flows and related fluvial deposits of the Rhododendron Formation (Trimble, 1963) into the southernmost part of the basin to construct a thick, northward-sloping volcaniclastic apron (Figs. 2 and 3B).

AN ENERGIZED RIVER

Near the end of the Miocene, the Columbia River transformed into a gravel-bed stream depositing coarse sandstone and conglomerate of the lower Troutdale Formation (Figs. 2 and 4A). A narrow paleocanyon cut into Grande Ronde Basalt flows and Paleogene bedrock east of the Portland Basin contains >200 m of conglomerate (Tolan and Beeson, 1984). This latest Miocene channel entered the eastern Portland Basin north of the modern river (Fig. 3C), building a broad braidplain westward across the basin and burying the lower Sandy River Mudstone with >70 m of gravel. The conglomerate is composed mainly of rounded cobbles and pebbles of Columbia River Basalt, but nearly ubiquitous clasts of quartzite and coarse-grained metamorphic and granitic rocks, as well as interbedded arkosic to quartzose micaceous sands, point to an extrabasinal source in pre-Tertiary terranes of eastern Washington and Idaho. Massive to crudely stratified beds, clast-support, openwork and sand-matrix textures, moderate to good sorting, and clast imbrication indicate deposition by a high-energy braided river. The far-traveled gravel and paucity of locally derived material indicate that the sudden influx of coarse sediment resulted from events far upstream, likely due to deformation and consequent erosion in and around the Columbia Plateau east of the Cascade Range.

Following deposition of the Troutdale Formation conglomerate, the Columbia River reincised through the thick gravel braidplain and uplifting western Cascade Range, entering the still-subsiding Portland Basin through a canyon south of the present Columbia River Gorge (Tolan and Beeson, 1984).

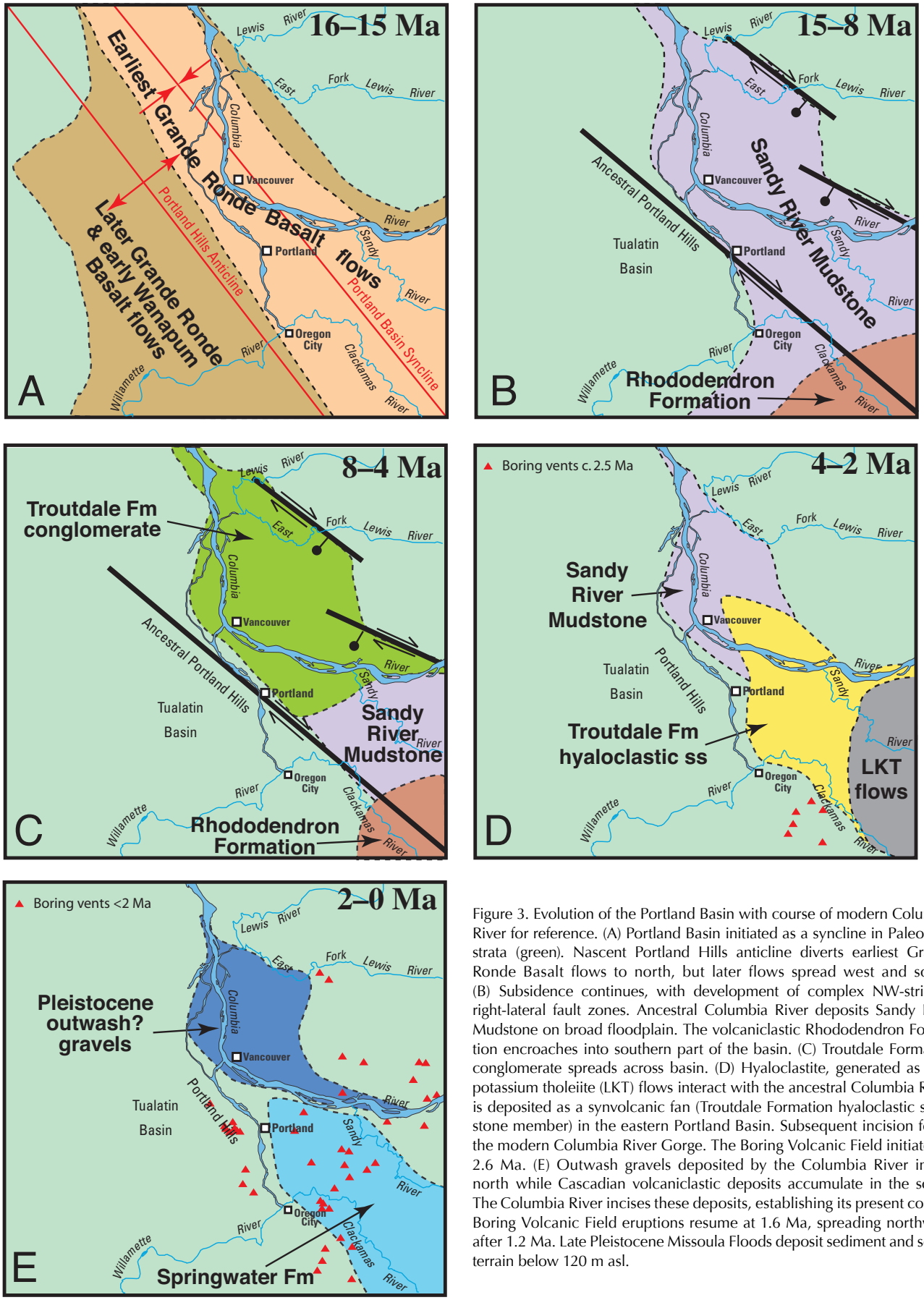

Figure 3. Evolution of the Portland Basin with course of modern Columbia River for reference. (A) Portland Basin initiated as a syncline in Paleogene strata (green). Nascent Portland Hills anticline diverts earliest Grande Ronde Basalt flows to north, but later flows spread west and south. (B) Subsidence continues, with development of complex NW-striking, right-lateral fault zones. Ancestral Columbia River deposits Sandy River Mudstone on broad floodplain. The volcaniclastic Rhododendron Formation encroaches into southern part of the basin. (C) Troutdale Formation conglomerate spreads across basin. (D) Hyaloclastite, generated as low-potassium tholeiite (LKT) flows interact with the ancestral Columbia River, is deposited as a synvolcanic fan (Troutdale Formation hyaloclastic sandstone member) in the eastern Portland Basin. Subsequent incision forms the modern Columbia River Gorge. The Boring Volcanic Field initiated at 2.6 Ma. (E) Outwash gravels deposited by the Columbia River in the north while Cascadian volcaniclastic deposits accumulate in the south. The Columbia River incises these deposits, establishing its present course. Boring Volcanic Field eruptions resume at 1.6 Ma, spreading northward after 1.2 Ma. Late Pleistocene Missoula Floods deposit sediment and sculpt terrain below 120 m asl.

Eventually, the river reverted to a low-gradient, near–sea level stream similar to its earlier character , depositing fine-grained beds of the upper Sandy River Mudstone, which locally contains early Pliocene fossil floras (Treasher, 1942; Chaney, 1944; Trimble, 1963; Tolan and Beeson, 1984).

MAFIC VOLCANISM IN THE CASCADE RANGE AND INFLUX OF HYALOCLASTIC SEDIMENT

At ca. 3.5 Ma, eruption of voluminous low-potassium tholeiite (LKT) flows in the Cascade Range to the east interrupted deposition of fine-grained Columbia River fluvial sediment in the Portland Basin. Some of these lavas entered the Columbia River—or possibly erupted from vents directly beneath the river—generating large quantities of hyaloclastite that flushed downstream, filling the Columbia River canyon within the western Cascade Range and building a large fan where the river entered the Portland Basin (Fig. 3D) (Tolan and Beeson, 1984). These beds crop out extensively in the eastern Portland Basin, where this unit is >100 m thick (Trimble, 1963; Madin, 1994; Evarts and O'Connor , 2007) and pinch out northwestward in the subsurface (Swanson et al., 1993). The crudely stratified coarse sandstone is intercalated with poorly sorted, foreset-bedded conglomerate containing cobbles and boulders of LKT. The sandstones are composed of angular , partially palagonitized sideromelane fragments (Fig. 4B) of LKT (Swanson, 1986). The poor sorting and monolithologic character of many hyaloclastic beds suggest rapid transport over short distances. East of the Portland Basin, the hyaloclastic sediment becomes interbedded with LKT flows with ages of 3.0–3.5 Ma (Conrey et al., 1996a, 1996b; R.J. Fleck, 2008, personal commun.). These lava flows and hyaloclastic deposits completely filled the Columbia River canyon where it passed through the western Cascade Range, resulting in northward diversion of the river and Quaternary incision of the present western Columbia River Gorge (Tolan and Beeson, 1984).

VOLCANOES AND FLOODS: QUATERNARY LANDFORMS AND DEPOSITS

Volcanism and the indirect effects of Quaternary glaciation have formed most of the present topography of the Portland Basin.

Local Mafic Volcanism of the Boring Volcanic Field

The Portland Basin is peppered with isolated hills and hill clusters rising up to 200 m above the surrounding landscape. Many of these hills are monogenetic volcanoes (Treasher, 1942; Allen, 1975) that erupted west of the Cascade arc axis beginning in latest Pliocene time to form the Boring Volcanic Field (Fig. 1) (Conrey et al., 1996b; Evarts et al., 2009). Boring centers consist of cinder cones (Fig. 4C) and associated lava flows, small shields, and lava cones. Like the many small, contemporaneous volcanoes in the arc, Boring lavas are predominantly geochemically diverse basalt and basaltic andesite (Conrey et al., 2003).

Isotopic age determinations (Madin, 1994; Conrey et al., 1996a; Fleck et al., 2002; R.J. Fleck, 2008, personal commun.) show that the earliest Boring eruptions were at 2.6 Ma in the southern part of the Portland Basin (Fig. 3D), but most activity is younger than 1.8 Ma (Fig. 3E); (Evarts et al., 2009) and has continued at a low but constant level throughout the Quaternary.

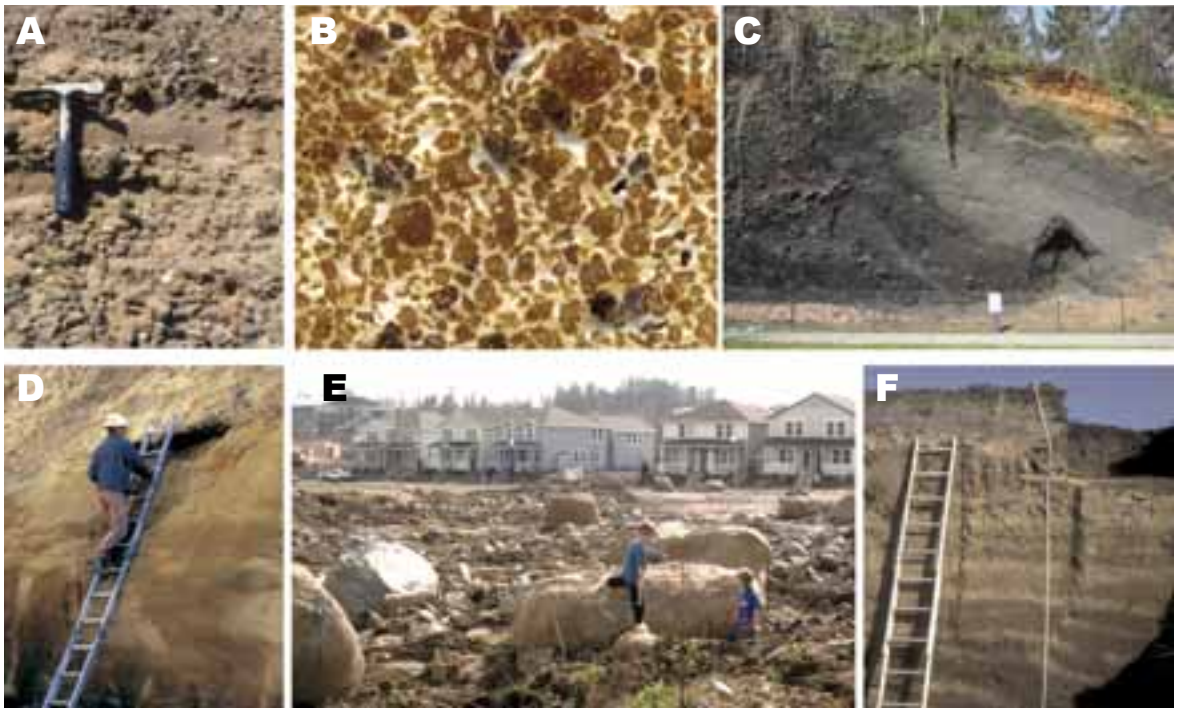

Figure 4. Selected deposits in the Portland Basin. (A) Conglomerate and micaceous sandstone in the lower part of the Troutdale Formation. (B) Photomicrograph of hyaloclastic sandstone from the upper part of the Troutdale Formation. (C) Cinder-cone beds on Mount Tabor (203 ± 5 ka). Outcrop is ~6 m high. (D) Pleistocene Columbia River terrace gravel deposits, northern Portland Basin. (E) Missoula flood boulders hindering development, eastern Portland Basin. (F) Sand (light) and silt (dark) couplets deposited by overbank flooding on the late Holocene Columbia River floodplain, northern Portland Basin.

Effects of Quaternary Glaciation

While glaciers never directly impinged upon the Portland Basin, Quaternary climate change has affected base level regionally and locally, changed the character of sediment transported and deposited within the basin, and led to the colossal Missoula Floods.

Quaternary Terrace Gravels

Episodic influxes of Columbia River sand and gravel into the Portland Basin in latest Pliocene to late Pleistocene time (Figs. 2 and 3E) are recorded by broad fill terraces flanking the present river. These sediments (Fig. 4D) resemble the Miocene Troutdale Formation conglomerates but are more poorly sorted and contain a higher proportion of clasts (including LKT basalt) derived from the Cascade Range. A prominent surface at 140 m above sea level (asl) in the eastern part of the basin may grade to a 75 m asl surface at the northwest margin. A distinctly lower surface (15–20 m asl) is preserved along the northwestern margin of the basin. Drillers' logs and quarry exposures indicate that these deposits underlie much of the Portland Basin marginal to the present floodplain of the Columbia River, perhaps locally to a depth of 100 m bsl—the approximate elevation of the Columbia River in the Portland Basin at low sea-level stands during major glaciations.

The presence and position of these terrace deposits are somewhat enigmatic, and their ages are poorly constrained. They pre-date the 16,000–12,000 ^{14}C yr B.P. Missoula Flood deposits that overlie them, and the higher deposits are overlain by Boring volcanic rocks as young as 575 ka (Evarts, 2006; Evarts and O'Connor, 2007). The coarse textures and sedimentary facies (Fig. 4D) indicate deposition by a large braided river system. The textures are as expected for sediment delivered during glacial episodes, but those would also be times of depressed sea level, with the Columbia River >100 m below its present position, as it was during the last glacial period (Gates, 1994; Baker, 2002). One plausible scenario is that these deposits formed at times of advanced glaciations, when deposition of voluminous outwash from the Lewis River at the north end of the Portland Basin forced upstream Columbia River aggradation (O'Connor and Evarts, 2007). Partly contemporaneous fan and terrace deposits flanking the Sandy and Clackamas rivers along the east and southeast margins of the basin, including the volcaniclastic Springwater Formation (Figs. 2 and 3E) (Trimble, 1963), indicate that volcanism and mountain glaciation in northern Oregon were also contributing sediment near the time of terrace formation.

Missoula Floods

Much of the modern land surface in the Portland Basin below 120 m asl is underlain by silt, sand, and gravel deposited by the cataclysmic late Pleistocene Missoula Floods (Figs. 2 and 4E). These floods occurred when a lobe of the Cordilleran Ice Sheet blocked the Clark Fork River in northwestern Montana, forming Glacial Lake Missoula, a lake 525 m deep at its maximum, with a volume of 2200 km^3. The ice-dam ruptured multiple times between 16,000 and 12,000 ^{14}C yr B.P., sending floods as large as 10^7 m^3 across eastern Washington, through the Columbia River Gorge, and into the Portland Basin (Bretz, 1925, 1928; Baker, 1973; Waitt, 1980, 1985; Benito and O'Connor, 2003). The largest of these floods entered the Portland Basin with velocities of 35 m^3/s and depths approaching 300 m (Benito and O'Connor, 2003). Flow velocity diminished rapidly westward as the floodwaters ponded behind the constricted Columbia River valley at the northwestern basin exit.

First described by Bretz (1928) and now beautifully revealed by high-resolution topographic data, the Missoula floods carved immense channels on the uplands and around Boring volcanic centers, built large bars along the main current threads, and blanketed backwater areas below 100 m asl with silt and sand. The colossal gravel bars are thickest and coarsest in the eastern Portland Basin, where bedload clasts attain diameters exceeding 5 m (Fig. 4E), and in the lee of flow-protruding uplands, where bars are formed of up to 70 m of festoon-bedded boulder sand and gravel. In backwater areas and up tributary valleys, rhythmically layered fine-grained deposits show that at least 40 such floods achieved stages of 35–50 m asl in the Portland Basin and Willamette Valley (Glenn, 1965; O'Connor et al., 2001; James, 2002).

Loess

Massive, micaceous, quartzofeldspathic eolian silt, known as the Portland Hills Silt (Lentz, 1981), blankets most upland surfaces above areas affected by the Missoula Floods but is especially thick on the uplands close to the Columbia River and in the Portland Hills. The Portland Hills Silt contains paleosols that indicate episodic accumulation separated by periods of relative surface stability enabling soil development. The distribution of the loess indicates deposition by easterly winds (Lentz, 1981), which regularly enter the Portland Basin during winter, when atmospheric high pressure in the interior drives easterly airflow down the Columbia River Gorge. Such winds were probably more prevalent during Quaternary glacial ages when high-pressure cells were entrenched over the Cordilleran Ice Sheet.

Holocene Sea-Level Rise and the Modern Columbia River Floodplain

Since the end of the last glacial epoch, sea level has been rising, and the Columbia River has aggraded its channel and floodplain. Borehole data from near the modern mouth of the Columbia River show that river level was 113 m below present sea level ca. 13,000 ^{14}C yr B.P. (Baker, 2002). Consistent with this, well records and seismic-reflection profiles in the Portland Basin indicate that 100 m of sand and silt fill a buried late Pleistocene paleochannel below the modern Columbia River floodplain (Fig. 2) (Hoffstetter, 1984; Hartford and McFarland, 1989; Gates, 1994; Madin, 1998; Pratt et al., 2001; Rapp, 2005). The present Columbia River floodplain (Fig. 4F), which caps this aggradational sequence and is everywhere <10 m asl, historically aggraded by overbank deposition and bar accretion, primarily during snowmelt floods that inundated the floodplain each summer before twentieth-century construction of dams and floodplain levees.

Holocene Cascade Range Volcanism

Cascade Range volcanism has affected the Portland Basin throughout the Quaternary. Although Pleistocene deposits contain tephra layers and fluvially reworked volcanogenic materials, it is late Holocene volcanic activity that has left the clearest mark on the present topography. At the eastern margin of the Portland Basin, the Sandy River has served as a conduit for

lahars and large quantities of volcaniclastic sand and gravel derived from Mount Hood. At least three lahars reached the Columbia River during the Mount Hood Timberline eruptive period of ca. 1500 ^{14}C yr B.P., followed by another pulse of aggradation during the Old Maid eruptive episode ~200 years ago. The Mount Hood lahars and up to 5 m of related aggradation built out the Sandy River delta, pushing the Columbia River 2 km northward (Rapp, 2005). Similarly, Mount St. Helens eruptions have shed lahars and sediment down the Lewis River and into the northern part of the Portland Basin, where extensive bottomlands at the mouth of the Lewis River were formed during the Pine Creek (ca. 2500 ^{14}C yr B.P.) and Kalama (ca. 500 ^{14}C yr B.P.) eruptive periods at Mount St. Helens (Vogel, 2005). At least one similar but larger episode of Pleistocene aggradation from Mount St. Helens apparently blocked the Columbia River to at least 25 m asl (Evarts, 2002).

CONCLUSIONS

The Portland Basin occupies the globally exceptional situation of a forearc basin bisected by a large continental river—a unique juxtaposition of local and regional geologic processes. Although the convergent margin setting is responsible for the structural development of the Portland Basin and flanking Coast and Cascade Ranges, basin sedimentation is dominated by distant tectonic, volcanic, and environmental events, which introduced a variety of materials into the basin. Quaternary climate change influenced basin sedimentation and erosion by controlling Columbia River base level as well as through the cataclysmic Missoula Floods, which shaped many of the present landforms of the Portland Basin.

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PARDEE KEYNOTE SYMPOSIA

Invited Papers

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

These Pardee Keynote Symposia are special events of interest to the wider geoscience community, representing leading-edge science or public policy and addressing broad, fundamental issues. The following symposia (which will take place at the Oregon Convention Center) were reviewed and accepted by this year's Annual Program Committee, and all speakers are invited.

SUNDAY, 18 OCT.

P8. The Evolution of Basaltic Landscapes: Time and the River and Lava Flowing

8 a.m.–noon, Portland Ballroom 252

This session will focus on the life and death of basaltic landscapes around the world, from lava-flow emplacement and dynamics to soil and hydrologic development, biological colonization, and channel incision and landscape evolution.

P6. Google Earth to Geoblogs: Digital Innovations in the Geosciences

1:30–5 p.m., Portland Ballroom 251/258

Digital technologies, such as Web 2.0 services, virtual globes, and new applications of digital photography, can enhance the understanding of geology at all levels and across disciplines. This symposium will showcase practical applications of new digital tools, including the OneGeology project, geoblogging, Google Earth for education, and site surveys with panoramic high-resolution photography. A focal presentation will involve creation of a virtual field trip using the tools discussed here. The session will also feature interactive small group demonstrations designed to give attendees the opportunity to discuss projects with speakers.

Cosponsored by *GSA's Geoinformatics and Education Divisions; Google, Inc.; National Association of Geoscience Teachers (NAGT).*

MONDAY, 19 OCT.

P7. Hazards and Health: Preventing Disaster and Building Resilience on the Ring of Fire

8 a.m.–noon, Portland Ballroom 252

Uniting the efforts of natural and social scientists is vital to the well-being of disaster-prone communities. This session highlights new interdisciplinary directions for managing risk at the emerging crossroads of hazards, health, and emergency management.

Cosponsored by *GSA's Geology and Health, Engineering Geology, Geoinformatics, Limnogeology, Quaternary Geology and Geomorphology, and International Divisions; GSA Geology & Public Policy Committee; Geological Society of New Zealand; International Medical Geology Association; International Union of Geological Sciences; International Union for Quaternary Research (INQUA).*

P2. Crustal Tectonic Deformation as Revealed by Seismic Anisotropy

1:30–5:30 p.m., Portland Ballroom 252

Crustal seismic anisotropy data are becoming more widely collected, but their meaningful interpretations rely on multidisciplinary ties between tectonics, microtextural analysis, seismic wave theory, and non-traditional field experiments. This symposium focuses on material anisotropy associated with tectonic processes, their resulting rock fabrics, and what characteristics might produce a seismically anisotropic signature. Factors include intensity and continuity of textures, structural geometry and internal configurations, and lateral and vertical scales of features relative to seismic wave resolvability. Presentations will examine tectonic processes that form anisotropic fabrics, potential differences that could be used as discriminants if detected by seismic waves, and some key terranes where such studies have been or might be applied.

Cosponsored by *GSA's Structural Geology and Tectonics and Geophysics Divisions.*

TUESDAY, 20 OCT.

P3. Earth et al.—Our Planets from the Hadean to Today

8 a.m.–noon, Portland Ballroom 252

This session spans the evolution of life and its paleoenvironmental context from the Hadean to the modern on Earth and beyond.

Cosponsored by *GSA's International, Sedimentary Geology, and Planetary Geology Divisions; Society for Sedimentary Geology (SEPM); Paleontological Society; American Geological Institute; NASA Astrobiology Institute; Mineralogical Society of America; Geochemical Society of America.*

P4. First Global View of the Geology of Mercury: Dynamic Landscapes on the Innermost Planet

1:30–5:30 p.m., Portland Ballroom 252

MESSENGER's two flybys of Mercury in 2008 provided the first detailed views of the planet in three decades and revealed a rich geological history marked by widespread volcanism, prolonged contractional tectonics, and pervasive impact cratering.

Cosponsored by *GSA's Planetary Geology Division.*

WEDNESDAY, 21 OCT.

P5. Intraplate Magmatic Growth and Tectonic Modification of a Continent: Case Study in the Pacific Northwest

8 a.m.–noon, Portland Ballroom 252

This symposium is dedicated to understanding the geodynamic evolution of the Cascadia margin and High Lava Plains, from the Miocene (18 Ma) to the present, and will synthesize geological, geophysical, and geochemical research addressing modification of the lithosphere through tectonism and magmatism.

Cosponsored by *GSA's Geophysics and Structural Geology and Tectonics Divisions.*

WEDNESDAY, 21 OCT. continued

P1. Crisis in the Cryosphere: Impacts of Planetary Meltdown
1:30–5:30 p.m., Portland Ballroom 252

Anthropogenic warming is rapidly destabilizing the global climate system. All components of the cryosphere—our planetary ther mometer—are in decline: ice sheets and outlet glaciers, ice caps and mountain glaciers, ice shelves and sea ice, and permanently frozen ground (permafrost). This worldwide meltdown forewarns humanity of dramatic changes in all Earth systems, including potentially catastrophic impacts on water supplies, sea level, and coastlines. Because of the vital importance of cryosphere monitoring, this symposium convenes leading researchers to document cur - rent behavior and provide impact projections for geoscientists, educators, and policy makers.

Cosponsored by *GSA's Geology and Health, Geology and Society, and Quaternary Geology and Geomorphology Divisions; American Quaternary Association (AMQUA); International Union for Quaternary Research (INQUA); National Association of Geoscience Teachers (NAGT).*

Les Collines Vineyard. Photo courtesy Kevin Pogue.

PLEASE JOIN US FOR *TWO* AWARD EVENTS!

2009 GSA GOLD MEDAL LECTURES

Sunday, 18 Oct., 5–7 p.m.
Location TBA

Please join us for the inaugural Gold Medal Lectures, a special public event hosted by GSA to honor its awardees. Penrose Medalist B. Clark Burchfiel of MIT, a specialist in continental tectonics; Day Medalist T. Mark Harrison of UCLA, a specialist in dynamic thermochronology; and Donath Medalist Cin-Ty Lee of Rice University, a multidisciplinary geologist studying the formation and stability of continents, are scheduled to speak and reflect on their scientific careers. Questions from the audience are encouraged. GSA President Jean Bahr will chair the program.

PRESIDENTIAL ADDRESS & AWARDS CEREMONY

Jean M. Bahr,
GSA President

Joaquin S. Ruiz, GSA Vice President
Master of Ceremony

Saturday, 17 Oct., 7–9 p.m., *with reception to follow*
Oregon Convention Center, Portland Ballroom 251/258

Please join us Saturday evening for GSA President Jean M. Bahr's Presidential Address, "O Brave New World—Geoscientists in an Emerging Green Economy." Following the address: presentations, citations, and responses recognizing the 2009 recipients of GSA's top medals and awards.GSA's newly elected Honorary Fellows, the Subaru Outstanding Woman in Science and John C. Frye Environmental Geology awardees, and the newly elected GSA Fellows will also be announced.

AWARD RECIPIENTS









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PENROSE MEDAL
B. Clark Burchfiel, Massachusetts Institute of Technology

ARTHUR L. DAY MEDAL
T. Mark Harrison, University of California at Los Angeles

YOUNG SCIENTIST AWARD (DONATH MEDAL)
Cin-Ty A. Lee, Rice University

PRESIDENT'S MEDAL OF THE GEOLOGICAL SOCIETY OF AMERICA
Judge John E. Jones III, federal judge, U.S. District Court for the Middle District of Pennsylvania

GSA PUBLIC SERVICE AWARD
Bruce F. Molnia, U.S. Geological Survey–Reston

GSA DISTINGUISHED SERVICE AWARD
Karl E. Karlstrom, University of New Mexico

HONORARY FELLOW
Xavier Le Pichon, Collège de France, Aix-en-Provence

SUBARU OUTSTANDING WOMAN IN SCIENCE AWARD
(Sponsored by Subaru America Inc.)
Jaime D. Barnes, The University of Texas at Austin

RANDOLPH W. "BILL" AND CECILE T. BROMERY AWARD FOR THE MINORITIES
John T. Leftwich, Jr., Halliburton Co.

AGI MEDAL IN MEMORY OF IAN CAMPBELL
Jonathan G. Price, Nevada Bureau of Mines & Geology

JOHN C. FRYE ENVIRONMENTAL GEOLOGY AWARD
Jonathan L. White and **Celia Greenman** *for* 2008 Colorado Geological Survey, Engineering Geology 14, "Collapsible Soils in Colorado"

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Oregon Convention Center. Photo by Bruce Forster/Viewfinders courtesy the Portland Oregon Visitors Association.

Save $$ by registering online before 14 September.

Online registration will be open throughout the meeting, but at an additional cost. Go to **www.geosociety.org/meetings/2009/reg.htm** for complete fee infor mation, to register , or to download a hard-copy registration form.

We'll need your mailed* or faxed** hard-copy registration form by **16 October.** Beginning at 7 a.m. PST on Saturday, 17 October, you'll be able to register on-site at the Oregon Convention Center, Lobby C.

Mount Hood in summer. Photo courtesy Travel Portland/Jeff Krausse and the Portland Oregon Visitors Association.

Registration Desk Hours (17–21 October)

Saturday: 7 a.m.–6 p.m.

Sunday: 6:30 a.m.–8 p.m.

Monday & Tuesday: 7 a.m.–4:30 p.m.

Wednesday: 7 a.m.–11 a.m.

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When you get to the convention center , please check in at the advanced registration desk in Lobby C to pick up your badge. Badges are required for entrance to all annual meeting events.

Heceta Head Lighthouse. Photo courtesy Travel Portland/Larry Geddis and the Portland Oregon Visitors Association.

May we assist you?

GSA is committed to making the annual meeting accessible to everyone. If you need auxiliary aids or service because of a disability, please check the appropriate box on the registration form. If you have suggestions or need further information, contact William Cox, wcox@geosociety.or g, +1-303-357-1013. It's best if you let us know your needs by 14 September 2009.

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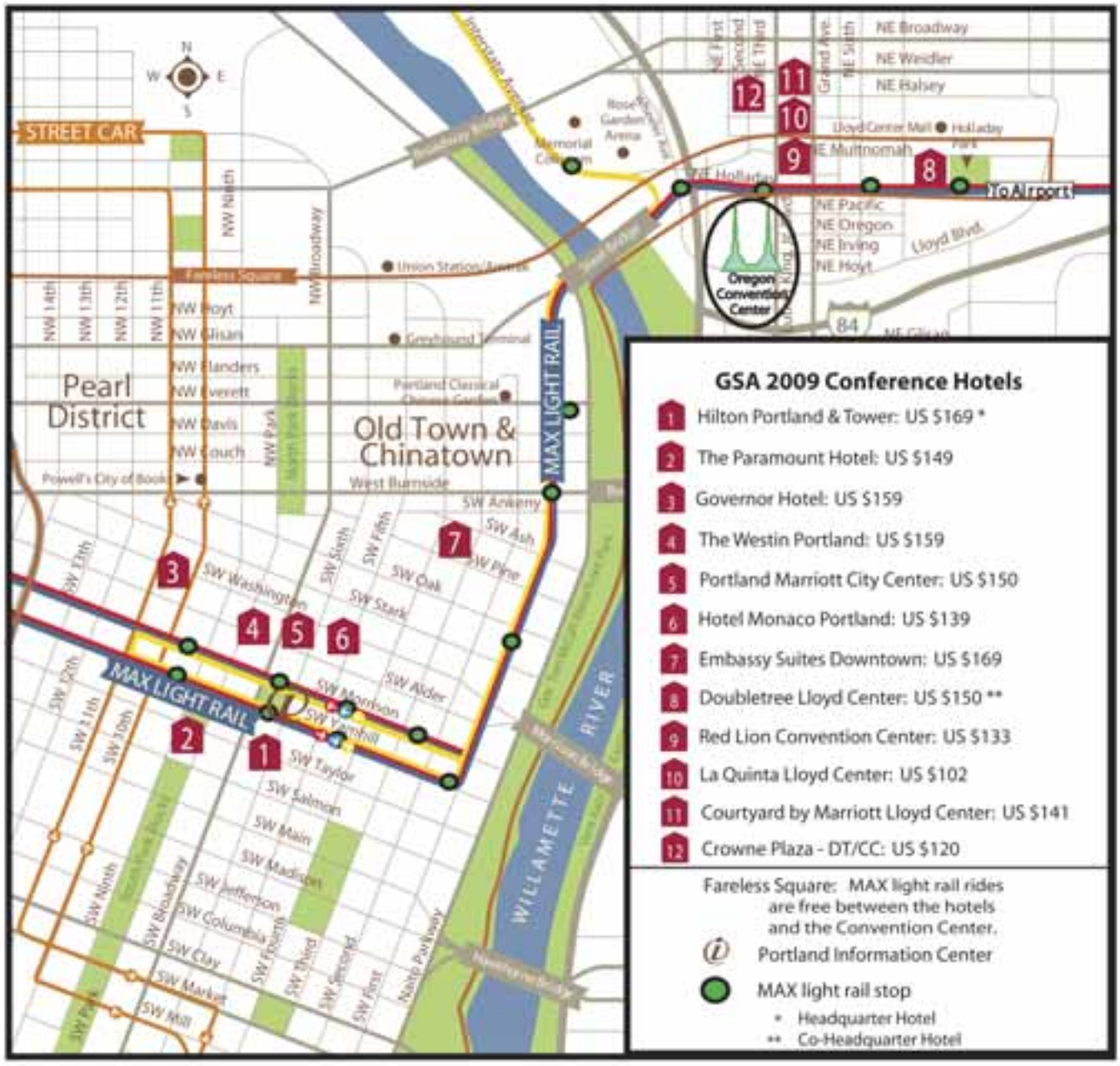

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1. Hilton Portland & Tower: US $169 *
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6. Hotel Monaco Portland: US $139
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8. Doubletree Lloyd Center: US $150 **
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10. La Quinta Lloyd Center: US $102
11. Courtyard by Marriott Lloyd Center: US $141
12. Crowne Plaza - DT/CC: US $120

Fareless Square: MAX light rail rides are free between the hotels and the Convention Center.

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MAX light rail stop

* Headquarter Hotel

** Co-Headquarter Hotel

Personal Scheduler

http://gsa.confex.com/gsa/2009AM/scheduler/index.epl

Search or browse meeting events, including exhibits you want to visit or a presentation you don't want to miss, create your own memos, reminders, and schedule of events, check it for confl icts, record notes, and download to your computer , PDA, or iPhone. If you download to a portable device, it's best to wait until the day before you travel to ensure you have the latest updates.

The Personal Scheduler—a simple, effective planning tool available to you at no charge.

HOUSING INFORMATION

Making Your Reservation

To take advantage of the special GSA convention rates, please book your reservation by **14 September.** After this date, room blocks will be released and hotels may charge higher rates.

Please make your reservations with Travel Portland using only *one* of the following four options:

- Reserve your room online via link at www.geosociety.org/meetings/2009/;
- Fax the downloaded form to +1-503-275-9782;
- Mail the downloaded form to GSA–Travel Portland Housing, 1000 SW Broadway, Suite 2300, Portland, OR 97205, USA; or
- Phone GSA–Travel Portland Housing at +1-877-678-5263 #2 or +1-503-275-9293, Mon.–Fri. between 8:30 a.m. and 5 p.m.

To make a NEW reservation after the 14 Sept. deadline, contact the Travel Portland Housing Bureau via e-mail at **housing@travelportland.com** or by phone at one of the numbers above. Group rates may not be available after this date, but Travel Portland can still assist you in finding a hotel.

Changes & Cancellations

Before 9 October: Changes to name, stay dates, address, or special requests can be made online via www.geosociety.org/meetings/2009/ – OR – by contacting the Travel Portland Housing Bureau at +1-877-678-5263 or +1-503-275-9293, Mon.–Fri., 8:30 a.m.–5 p.m.

After 9 October: All changes and cancellations must be made directly with your assigned hotel, but please DO NOT contact the hotel directly *until after this date.*

Cancellation requests received after 14 Sept. 2009 will be subject to a US$25 fee. Cancellations made within 72-hours of the scheduled arrival date are subject to a fee equal to one night's room rate plus tax. These fees will be charged to the credit card used to make the reservation.

Hotels

The annual meeting hotels (see map, opposite page) are in the "Fareless Square" area for the MAX light rail, streetcar, and bus systems. Trips that begin and end within the Fareless Square are free all day, every day. *All hotel rates are in U.S. dollars; prices listed are for singles and doubles.* For more hotel information, see the June *GSA Today,* p. 34–37, or go to **www.geosociety.org/meetings/2009/hotels.htm.**

TRAVEL & TRANSPORTATION

TRANSPORTATION TO/FROM THE AIRPORT

Go to **www.portofportland.com/PDX_Grnd_Trnsprtn.aspx,** Portland International Airport's Web site, for detailed information on ground transportation.

Trimet's MAX Light Rail

http://www.trimet.org/max, +1-503-238-7433

At Portland International Airport, go to the lower level, baggage claim area, and follow the signs to the MAX Light Rail red line (see map, next page). The trip from the airport to downtown takes ~38 minutes and requires an all-zone fare (one-way cost only US$2.30). MAX Light Rail hours are 5 a.m.–11:56 p.m., and trains run every 15 minutes. (See p. 18–19.)

Car Rental

Enterprise Rent-a-Car, www.enterprise.com, +1-800-593-0505

For the meeting discount, enter the group code **46W2750** in the optional account box online. On the next screen, enter the first three letters of the event name, "GEO," and press enter. You may also make reservations by phone.

Taxis

The pick-up area for taxis is located in the center section of the airport terminal's lower roadway on the baggage claim and departure level. Downtown Portland is about 20–40 minutes from Portland International Airport. Average taxi fare: US$35 one-way, not including gratuity.

Shuttles

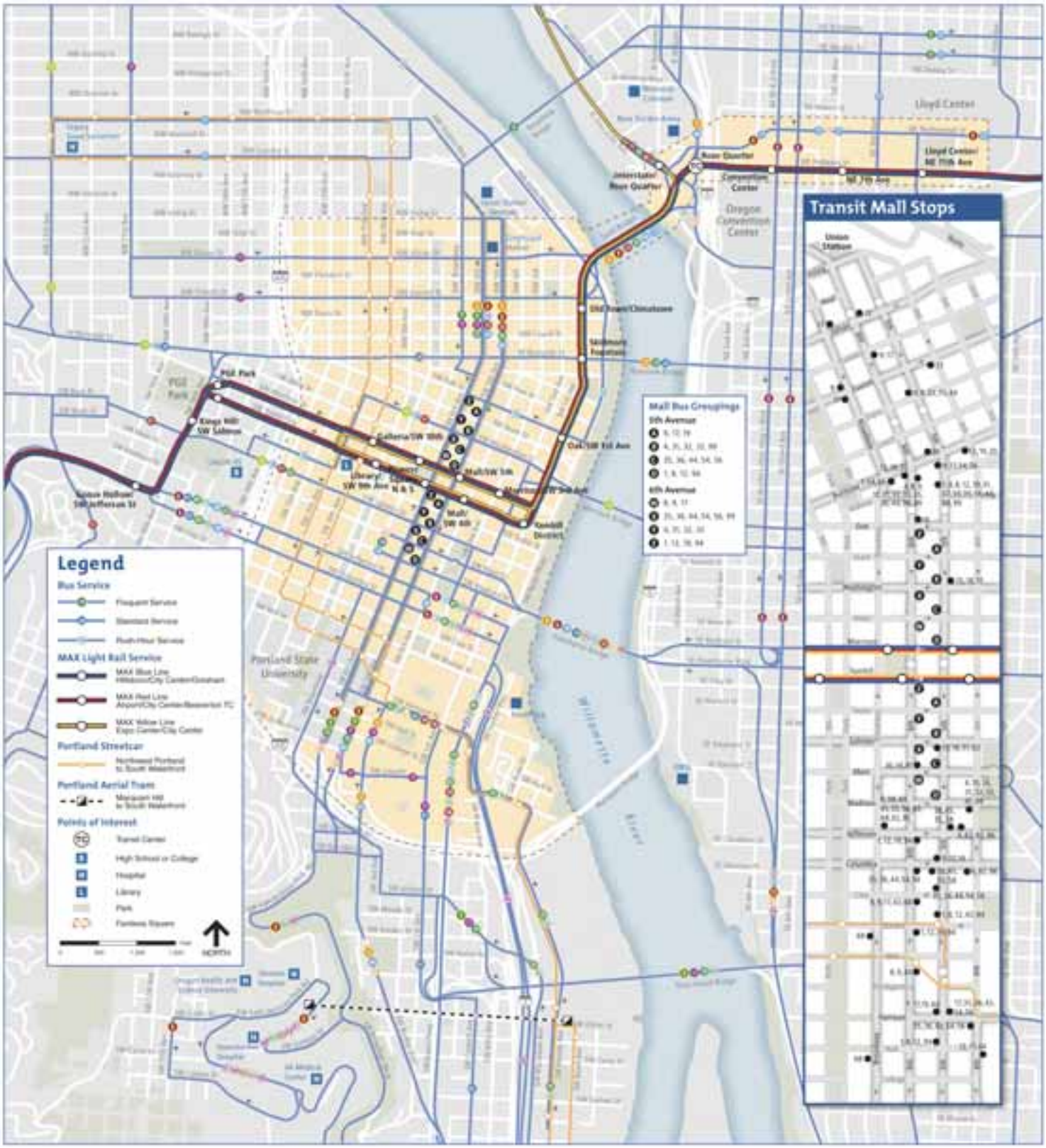
Shuttles depart from the center section of the airport terminal's lower roadway on the baggage claim level. Average shuttle fare: is about US$15–20 one-way. Some shuttle services require advance reservations.

AIRLINES

Alaska Airlines, www.alaskaair.com: Use meeting code **ECCMB0852** for a discount on all roundtrip tickets to the meeting. The discount is applicable for travel 15 Oct.–23 Oct. 2009 only and is valid *only* for reservations made online (phone reservations will incur a US$15 ticketing fee). Be sure to input the meeting discount code when filling out the Flights Quick Search box.

United Airlines, +1-800-521-4041: Use meeting code **585KH** for an up to 5% discount on domestic and international roundtrip flights to the meeting when you call the United MeetingsPlus reservation line. Discounts are applicable for travel 14 Oct.–25 Oct. 2009 only, and reservations must be made by phone.

PORTLAND CITY CENTER & FARELESS SQUARE



MAX LIGHT RAIL

http://trimet.org/max/

MAX Light Rail Rider Information and Customer Service: +1-503-238-7433

Hotels: All meeting hotels are in the "Fareless Square" area for the MAX light rail, streetcar, and bus system. Check with your hotel for specific instructions on where to board the MAX light rail for transportation to the Convention Center or other locations.

Convention Center: Take the red or blue lines and exit at the Oregon Convention Center MAX Station on NE Holladay. You can also take the yellow line train to the Rose Quarter and walk the additional three to four blocks to the Oregon Convention Center.

General Information

- Trips that begin and end within the Fareless Square are free, all day, every day.
- Trains run every 5–15 minutes every day between 4:30 a.m. and midnight.
- If you are traveling in an area outside of the Fareless Square area, you must have a validated ticket, bus transfer receipt, or pass before boarding MAX. Ticket machines are located at each station.
- Signs at the station indicate where to wait and when the next train is due. Signs on the front of each train identify the line (blue, red, or yellow) and destination.
- As MAX approaches, stay behind the white bumpy tiles and wait for the train to come to a complete stop. The doors will open automatically so you may board the train.
- The station name is announced before each stop and appears on a reader board overhead.

Accessibility Features on MAX

- MAX has ramps that extend onto the sidewalk for easy boarding.
- Priority seating spaces for people with limited mobility and people using mobility devices are near the door.
- To board the MAX, wait in the middle of the boarding platform where the MAX operator can see you. That way the operator can deploy the boarding ramp as soon as the train stops, which helps save time.
- Look for the door equipped with a ramp, which will be marked with the blue accessibility symbol. The boarding ramps are located at the two doors in the center of each low-floor car.

MAX light rail in downtown Portland. Image courtesy Travel Portland.

NSF

TOWN HALL MEETING

NATIONAL SCIENCE FOUNDATION
DIVISION OF EARTH SCIENCES

Tuesday, October 20
5:30 PM – 7:00 PM

Oregon Convention Center
Room TBA

FOR DETAILS SEE
Conference Program &
NSF Booth # 759

FREE REFRESHMENTS
CASH BAR

NSF-CCLI SPONSORED WORKSHOP

Google Earth in Undergraduate Geoscience Education

PRESENTERS
Declan De Paor (ODU)*
Steven Whitmeyer (JMU)
Assessor: Janice Gobert (WPI)

Saturday October 17, 2009
8:30 a.m. to 4:30 p.m.
Room F150
Oregon Convention Center
Cost: $25; Limit 25; CEU 0.7

Learn new ways to use Google Earth for teaching undergraduate geology with our interactive 3D Collada models. Create your own instructions materials without any programming. The workshop manual will include lesson plans and outcomes assessment instruments.

For more details:
www.odu.edu/~ddepaor

2008 winner in Google's KML in research competition

Annual Meeting Events & Extras

President's Student Breakfast Reception

Sunday, 18 Oct., 7–8:30 a.m.

Oregon Convention Center, Oregon Ballroom 201/202

Enjoy a free breakfast buffet with GSA President Jean M. Bahr, members of GSA's leadership team, and ExxonMobil staff members.

Each student registered for the meeting will receive a complimentary ticket for the breakfast buf fet. This is one of the most popular student events at the meeting, so be a part of the action!

Sponsored by ExxonMobil

Hosted by GSA

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Coffee and Beer BREAKS

Oregon Convention Center

Coffee

Sunday, 9 a.m., in Poster Hall A

Monday–Wednesday, 9 a.m., in Poster Hall A and Exhibit Hall C/D

Beer

Monday–Wednesday, 5 p.m., in Poster Hall A and Exhibit Hall C/D

All registered attendees will receive a complimentary drink ticket for each day.

PHOTO CONTEST EXHIBIT

Theme: *Visions of the Dynamic Landscape: How Geology Tells the Stories of Planetary Change*

Geologic processes have sculpted this planet for more than 4.5 billion years. Volcanoes erupt, magma chambers seethe, rivers erode, hillslopes fail, and faults shift the planetary playing field. This exhibit will feature the top submitted images important to understanding and witnessing the changing landscape, especially in the Pacific Northwest. A jury of three (a photographer, an artist, and a geologist) will have selected the images for the show. *Then it's your chance!* Stop by during the meeting and vote for your favorite's. The top two images in each category will receive an award.

Exhibit Categories

Pacific Northwest geology: The Pacific Northwest features one of Earth's most dynamic landscapes, and images in this category will depict some aspect of present or past geologic activity in the area.

Abstract images: This category includes maps, photomicrographs, and images from scanning electron microscopy.

Active geologic processes across the planet: Erupting volcanoes, floodwaters, active landslides, and more!

Past processes and events found in the geologic r ecord: This includes images specifi c to processes or that depict a feature resulting from a specific process.

Iconic landscapes of change and time: Iconic, commonly visited landscapes in national parks, monuments, or other public places that represent, or are part of, an important process.

Oregon Sesquicentennial Celebrations at the GSA Annual Meeting

Oregon's official 150th birthday as a U.S. state was on 14 February 2009, but the celebrations continue throughout the year. GSA will help commemorate this event with several displays—including a new Oregon geological map—throughout the Oregon Convention Center.

MOVIE THEATER

Oregon Convention Center, Room D132

Need a break from the hustle and bustle of the annual meeting? Be sure to visit the movie theater, kick back, and enjoy the videos we'll have running throughout each day.

Publish with GSA

GSA's top-rated journals—*GSA Bulletin*, *Geology*, *Geosphere*, and *Lithosphere*—publish scientific papers on all aspects of earth science, with science editors at the forefront of their fields overseeing a rigorous peer-review process for all manuscripts.

GSA Bulletin has published definitive geoscience works since 1890—and it's as timely, relevant, and whip-smart as ever. Join a top-notch roster of international contributors: submit a paper to *GSA Bulletin*. 5-year impact factor: 3.482; cited half-life: >10 years. Submit online: http://www.editorialmanager.com/gsabulletin/

Geology articles are innovative, provocative, and timely. Of interest to a broad audience, papers in *Geology* often describe a significant advance in the field. 5-year impact factor: 4.212; cited half-life: 9 years. Submit online: http://www.editorialmanager.com/geology/

Geosphere targets an international audience with its high-quality research results from all geosciences fields. An online format encourages extensive use of color, animations, and interactivity. Impact factor: 1.627. Submit online: http://www.editorialmanager.com/geosphere/

Lithosphere, launched in February, highlights research that addresses how the surface, crust, and mantle interact to shape the physical and chemical evolution of the lithosphere at all spatial and temporal scales. Submit online: http://www.editorialmanager.com/lithosphere/

Take a Free Peek at GSA's Online Journals

Click on the "Free Sample Issue" link at the following pages:

http://geology.geoscienceworld.org/
http://bulletin.geoscienceworld.org/
http://geosphere.geoscienceworld.org/
http://lithosphere.geoscienceworld.org/

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Have an idea for a book or a whole session's worth of papers? Consider making a permanent record of this work by publishing a GSA Special Paper organized and edited by you and your colleagues. GSA Special Papers are carefully prepared, are published quickly after acceptance, and have a worldwide distribution in print and online. Please communicate your interest by submitting a proposal to Don Siegel or Pat Bickford (GSA Books Editorial Office, Department of Earth Sciences, Syracuse University, 204 Heroy Geology Lab, Syracuse, NY 13244-1070, USA, +1-315-443-7300, gsabooks@syr.edu).

Annual Meeting Events & Extras

SCIENCE PUB—MISSION THEATER

Serial Crimes of Subduction: Giant Earthquakes and Tsunamis in Oregon's Past and Future with Brian Atwater and Yumei Wang

Mission Theater & Pub, 1624 NW Glisan, Portland, Oregon, USA

Tuesday, 20 October, 7–9 p.m.

Science Pub—Mission Theater is open to everyone; no reservations necessary. Doors open at 5 p.m., and there is a US$2 suggested cover charge. Come early for food and drinks!

On a calm night in 1700, a tsunami ran ashore in Japan without an advance-warning earthquake. Samurai, merchants, and peasants wrote of the mystery, which would remain unsolved for nearly three centuries. Today, there is little doubt that the tsunami originated from North America during a giant earthquake at the Cascadia subduction zone, an active fault that slants beneath southern British Columbia, Washington, Oregon, and northern California.

The next giant Cascadia earthquake will shake large parts of the Pacific Northwest. Its tsunami will likely take more lives than the shaking, which in Oregon alone may damage more than 1,000 schools and emergency facilities. In Portland, rebuilding and economic recovery will depend largely on the seismic resilience of electrical, oil, and gas facilities along the lower Willamette River.

Come to this Science Pub to find out more about our earthquakes and tsunamis, just how much risk we face, and what is being done to prepare.

Brian Atwater is a USGS geologist based at the University of Washington. He is lead author of *The Orphan Tsunami of 1700*, describing North American and Japanese clues to the 1700 Cascadia earthquake. His current earthquake and tsunami research focuses on Indonesia and the Caribbean.

Yumei Wang is a geotechnical engineer at the Oregon Dept. of Geology and Mineral Industries who seeks to reduce future losses from earthquakes, landslides, and tsunamis. She made the nation's first statewide estimates of future earthquake damage, and her influence on public policy includes improvements to the seismic safety of schools and the reliability of energy facilities.

Learn more about Science Pub Portland at **www.omsi.edu/sciencepubportland** or e-mail sciencepub@omsi.edu.

SUBARU

SUBARU OUTDOOR LIFE LECTURE

Yvon Chouinard

Oregon Convention Center, Monday, 19 Oct., 6–7 p.m.

Yvon Chouinard published *Climbing Ice* in 1978, and has been extraordinarily influential in ushering in the "clean climbing" movement in North America. Chouinard was one of the leading climbers of the Golden Age of Yosemite Climbing, participating in the second ascent of The Nose on El Capitan in 1960 and, using no fixed ropes, the ascent of the North American Wall in 1964.

Chouinard is founder and owner of Patagonia Inc., which followed from his initial interest in the 1950s in designing, manufacturing, and distributing high-quality rock-climbing equipment. As Patagonia gained popularity and expanded in the 1980s, Chouinard turned his vision toward finding solutions to environmental crises. In 1985, Patagonia instituted an "Earth Tax," pledging 1% of sales to aid the preservation and restoration of the natural environment. Patagonia is also a leader in using pesticide-free cottons. Other environmental organizations supported by Chouinard and Patagonia include One Percent for the Planet, the Common Threads Garment Recycling Program, and the World Trout Initiative.

Chouinard is an inveterate outdoorsman, spending much of his time outdoors or, if he has to be indoors, talking about the outdoors with environmental groups and businesses around the world.

Yvon Chouinard; photo courtesy of Patagonia.

Social Media:

A Fresh Twist on an Old Idea

One thing we consistently hear from members who attend the GSA Annual Meeting is that it is one of their favorite networking events each year. Today, as new media present new avenues for connecting professionally, GSA continues to lead in building the community that our members and friends have enjoyed for decades and have come to expect.

By all means, attend your alumni reunion, meet colleagues at the welcoming party, catch up with friends over dinner, and discuss a new idea over a poster session and a beer. And this year, you can also plan to join in the online conversations via the world of social media. Even if you haven't participated before, you might discover that folks are on to something!

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Join the online excitement during GSA's Annual Meeting on Twitter, Facebook, and LinkedIn.

Learn more at **www.geosociety.org/meetings/2009/fusion.htm.**

twitter Find us on Facebook LinkedIn

2009 GSA Annual Meeting
Portland, Oregon, USA

Lunchtime Keynote Lectures

Oregon Convention Center, 12:15–1:15 p.m.

Bring your lunch, relax, and be informed by GSA's new Lunchtime Keynote Lectures.

Lucile M. Jones

Lunchtime Keynote Lecture 3: The Great Southern California ShakeOut: A Successful Experiment in Communicating Science and Policy

Lucile M. Jones

Tuesday, 20 Oct. 2009

Lucy Jones has been a U.S. Geological Survey (USGS) seismologist and visiting research associate at the Seismological Laboratory of Caltech since 1983. She is currently chief scientist for the Southern California Multi Hazards Initiative, integrating hazards science in urban areas with economic analysis and emergency response for increased community resiliency. This includes leading the Great Southern California ShakeOut. Jones serves on both the California Seismic Safety Commission and the California Earthquake Prediction Evaluation Council. She has received numerous awards, including the Alquist Award from the California Earthquake Safety Foundation and the USGS Shoemaker Award for Lifetime Achievements in Science Communication.

Jones will discuss "The Great Southern California ShakeOut," a week of special events featuring the largest earthquake drill in U.S. history on 13 November 2008. More than five million participants, including schools and businesses, engaged in a mock-M7.8 earthquake scenario, as described at **www.shakeout.org.** The next "ShakeOut" is scheduled to take place on 15 October 2009, just days before Jones' talk.

The primary message of the ShakeOut, according to Jones and the USGS, is that what we do now, before a big earthquake, will determine what our lives will be like after. Benefits derived from the ShakeOut include improved communication with the general public as well as groups and organizations; strengthening of partnerships within the southern California emergency response, engineering, and science community; and clear lessons for scientists interested in policy communication.

Jones will outline four elements of successful policy communications identified during the Great ShakeOut. GSA members interested in conveying policy to decision makers and the public are invited to use the new GSA policy networking Web site, PolicyComNet (policycomnet.wikidot.com), to rally with colleagues and organize communications employing these four elements.

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Check next month's* GSA Today *to learn the name of the final lecturer in this series.

DARWIN DAY

Monday, 19 Oct. 2009

Oregon Convention Center, Portland Ballroom 251/258

This day of activities celebrating the 200th birthday of Charles Darwin is brought to you by The Geological Society of America and The Paleontological Society.

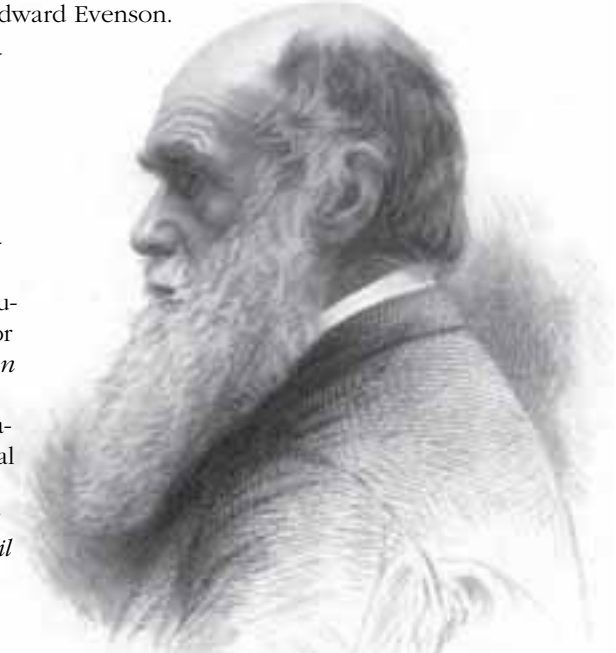
9–11:15 a.m.

Session T92: "In the footsteps of Darwin the geologist: Celebrating Darwin's 200th birthday." Cosponsored by the Darwin Society; convened by Gregory S. Baker, Yildirim Dilek, Patrick A. Burkhart, and Edward Evenson.

11:30 a.m.–1:30 p.m.

Panel Discussion: "Overcoming resistance to the reality of evolutionary change in nature."

- Jeremy Jackson, Director , Center for Marine Biodiversity & Conservation, Scripps Institution of Oceanography, and a leading authority on human impacts on the oceans;
- Judge John E. Jones, well known for his presiding role in the landmark Kitzmiller v. Dover Area School District case bearing on teaching of "intelligent design";
- Randy Olson, marine biologist, independent filmmaker known for his documentary *Flock of Dodos: the Evolution-Intelligent Design Circus*, and author of the forthcoming book *Don't Be Such a Scientist: Talking Substance in an Age of Style*; and
- Kevin Padian, Professor of Integrative Biology and Curator, Museum of Paleontology, University of California, Berkeley, and President of the National Center for Science Education.
- Ray Troll, artist incorporating sound science and focusing on evolutionary themes whose posters and books include *Planet Ocean, Cruisin' the Fossil Freeway,* and *Raptors Fossils, Fins & Fangs.*



1:30–3:45 p.m.

Session T120: "Darwin, geology, and evolution: Impact of Darwinian views on scientific theory-making." Cosponsored by GSA's Geology and Society, Geoscience Education, History of Geology, International, Quaternary Geology and Geomorphology, Sedimentary Geology, and Structural Geology and Tectonics Divisions; the National Association of Geoscience Teachers; and the Paleontological Society. Convened by Yildirim Dilek, Gregory S. Baker, Michael Roberts, and Léo F. Laporte.

4–6 p.m.

Showing of *Flock of Dodos: the Evolution-Intelligent Design Circus* followed by a Q&A with filmmaker Randy Olson.

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Brought to you on behalf of The Geological Society of America

SUBARU

Sponsored by Subaru of America, Inc.

7:30–10 p.m.

GSA-Subaru of America Inc. Public Forum: L.A. Theater Works: *The Great Tennessee Monkey Trial.* Newmark Theater, Portland Center for the Performing Arts. US$25; tickets can be purchased at registration.

The Great Tennessee Monkey Trial by Peter Goodchild is taken from original sources and trial transcripts. The Scopes Trial, about the right to teach evolution in public schools, reaffirmed the importance of intellectual freedom as codified in the Bill of Rights. The trial, which took place in a small-town Tennessee courtroom in 1925, set the stage for debate over the separation of church and state in a democratic society—a debate that continues to this day.

MENTOR PROGRAM SCHEDULE

SUNDAY: WOMEN IN GEOLOGY

SUBARU

Sun., 18 Oct., noon–1:30 p.m.

This mentor program, sponsored by Subaru of America, Inc., addresses issues faced by women in geology. This informal gathering begins with remarks from a few key women speakers, followed by time for networking, sharing ideas, and getting to know other women geoscientists and geoscience educators. *Appetizers provided.*

MONDAY: GEOLOGY IN GOVERNMENT

Mon., 19 Oct., 11:30 a.m.–1 p.m.

This popular program, sponsored by the GSA Foundation, features a FREE lunch for undergraduate and graduate students with a panel of mentors representing a variety of government agencies. These mentors will answer questions, offer advice about preparing for a career in government, and comment on the prospects for current and future job opportunities with their agencies.

TUESDAY: GEOLOGY IN INDUSTRY

Chevron · Alpha Natural Resources · ExxonMobil

Tues., 20 Oct., 11:30 a.m.–1 p.m.

Chevron, Alpha Natural Resources, and ExxonMobil cosponsor this mentor program, which features a FREE lunch for undergraduate and graduate students with a panel of mentors representing various industries. These mentors will answer questions, offer advice about preparing for a career in industry, and comment on the prospects for current and future job opportunities with their companies.

INVITATION ONLY: JOHN MANN MENTORS IN APPLIED HYDROGEOLOGY

This program underwrites the cost for up to 25 students to attend the Hydrogeology Division Luncheon and Awards Presentation and meet some of geoscience's most distinguished hydrogeologists. Students eligible for this honor are those who have (1) indicated a professional interest in hydrology/hydrogeology on their GSA membership application, and (2) registered for the annual meeting by 14 September. The first 25 students who respond to an e-mail invitation based on these criteria will receive FREE tickets for the luncheon.

Full program descriptions are available at **www.geosociety.org/mentors/.**

Questions? Contact Jennifer Nocerino jnocerino@geosociety.org.

PRESENTER INFORMATION

All presenters must register for the meeting. Please check your abstract acceptance e-mail for your assigned mode of presentation (ORAL or POSTER), as well as for the time and location of your presentation. **If your presentation is designated as a talk, please pay close attention to the following information:**

- **For presentation submission prior to the meeting,** please upload to the Conference Exchange Web site at **http://gsa.confex.com/gsa/extra.cgi.** You can also withdraw your presentation from this site. **Upload deadline:** 11:59 p.m. Eastern Time, 15 Oct. 2009.
- **GSA provides the following equipment in each presentation room:** A laptop computer (MS Office 2003) compatible with all MS PowerPoint XP and Mac presentations saved in PC format; speaker timer; LCD projector and screen; laser pointer; a podium with light and microphone; and a wireless lavaliere microphone. **We highly recommend that you test your presentation in the Speaker Ready Room well before your talk.**
- **If you did not submit your presentation via the Conference Exchange Web site prior to the meeting,** please submit it at the Speaker Ready Room the day before your presentation.
- **If you have a Sunday presentation** and are unable to get to the Speaker Ready Room on Saturday, please go directly to your session room **at least 30 minutes before the beginning of the session.**
- **Presentation files may be in the following formats:** PowerPoint (.ppt or .pps), Microsoft Word (.doc), or portable document format (.pdf). Presentations created using PowerPoint 2007 should be saved as PowerPoint 2003 or as a .pdf and tested on Windows XP prior to the meeting. Presentations may be saved on a USB hard drive (Pocket Drive, iPod), USB flash drive, CD-ROM, CD-R, or DVD.

SPEAKER READY ROOM HOURS

Oregon Convention Center

Room A103/A104

Fri., 16 Oct., 3–6 p.m.
Sat., 17 Oct., 8 a.m.–8 p.m.
Sun.–Tues., 18–20 Oct., 6:30 a.m.–6:30 p.m.
Wed., 21 Oct., 6:30 a.m.–1:30 p.m.

- **If your graphics or video clips are not embedded in your presentation, please be sure that you bring those files as well.** We again highly recommend that you visit the Speaker Ready Room to practice your presentation and get comfortable with the equipment. Technicians will be available to assist you.
- **If your presentation was created on a Mac and converted to run on a PC,** please test it *before you come to the meeting.* Make sure that the hyperlinks still function, and avoid using a rewritable CD (CD-RW), as we've encountered compatibility problems with them. If the presentation includes embedded video, your video will most likely NOT play automatically on the PC platform. You will need to either convert your .mov files to .avi format or create a link in your slide show to an external .mov file. If you choose the latter, your animation will play in a separate QuickTime window outside of your PowerPoint presentation. **Again, we strongly recommend that you test your Mac-produced presentation on a Windows-based system before arriving at the meeting.**

Questions? Contact Nancy Wright, nwright@geosociety.org, +1-303-357-1061.

POSTER PRINTING SERVICE

GSA and DP$_i$ Printing offer presenters the option of having their posters printed in advance and available for pick up in Exhibit/Poster Hall A at the Oregon Convention Center. The approximate cost for a 4' × 8' poster is US$100.

Submit poster files in PDF format to **http://ftp.dpi.sf.com,** using login name **GSA** and password **dpisf. All orders must be pre-paid and received on or before 14 October.** Valid ID is required for pick up. Questions? Contact DP$_i$ at +1-415-216-0031.

EDUCATOR EVENTS

Annual Geoscience Social Educators' Reception

Saturday, 17 Oct., 5–7 p.m., Doubletree Lloyd Center , Mount Hood and Mount Bachelor Rooms

The GSA Education Committee, National Association of Geoscience Teachers (NAGT), GSA Geoscience Education Division, Cutting Edge, Deep Earth Academy, IRIS Consortium, American Geological Institute (AGI), EarthScope, National Earth Science Teachers Association (NESTA), and UNAVCO invite all educators to this annual reception. Join other educators and the GSA Education & Outreach staff at this relaxing forum for socializing, sharing ideas, and meeting other geoscience community members interested in education. *Appetizers and cash bar provided.*

Darwin Day

Monday, 19 Oct.

We're celebrating Darwin's 200th birthday with a variety of events, including a discussion panel, free lectures, and the L.A. Theater Works presentation of the "Great Tennessee Monkey Trial." All Darwin Day participants will receive a free pass to the GSA Exhibit Hall.

Field Trips

GSA is offering a large variety of field trips this year, and teachers are encouraged to participate. Go to www.geosociety.org/meetings/2009/fieldtrips.htm for details.

Short Courses

The following short courses are designed especially for teachers. Go to www.geosociety.org/meetings/2009/courses.htm for details.

507. Helping your Students Investigate Plate Tectonics Just Like Scientists. Sat., 17 Oct., 8 a.m.–noon. US$90. Limit: 50. CEU: 0.4.

514. Pacific Northwest Earthquakes and Tsunamis for Middle School Teachers. Sat., 17 Oct., 8 a.m.–5 p.m. US$10, includes refreshments. Limit: 30. CEU: 0.8.

518. Watch Faults Grow Before Your Very Eyes! Using a Deformational Sandbox in High School and Middle School Earth Science Classrooms. Sun., 18 Oct., 8 a.m.–5 p.m. FREE. Limit: 20. CEU: 0.8.

520. Using and Developing Historical Image Archives to Investigate Landscape Change. Sun., 18 Oct., noon–3 p.m. US$10; includes lunch. Limit: 40. CEU: 0.4.

GUEST PROGRAM

Guest Hospitality Suite

Oregon Convention Center, Room F151-F152
Sun.–Wed., 8 a.m.–5:30 p.m.

We extend a warm welcome to all our guests! Registered guests* are invited to spend time in the Guest Hospitality Suite, a resource center with abundant information on Portland and its surroundings. We will provide light snacks and refreshments, special giveaways and drawings, and have local experts on hand to answer your questions.

President's Guest Breakfast
Monday, 19 Oct., 8:30–9:15 a.m.

Consider this your invitation… GSA's president and executive director are looking forward to meeting you during this complimentary breakfast just for registered guests!

FREE SEMINARS

The following seminars are especially for our registered guests. See the August *GSA Today* or www.geosociety.org/meetings/2009/guestSeminars.htm for seminar descriptions.

School Days
Sunday, 18 Oct., 10–11 a.m.

Lewis and Clark: The Science of Discovery
Monday, 19 Oct., 10–11 a.m.

Chinook: Master Traders of the Northwest
Tuesday, 20 Oct., 10–11 a.m.

On the Oregon Trail & Pioneer Life
Wednesday, 21 Oct., 10–11 a.m.

LOW-COST TOURS

All annual meeting attendees and guests are welcome to participate in the following tours. Tour fees offset the cost of guides, transportation, admission, and gratuities. Tours may be cancelled if minimum attendance is not met, so please register early; on the other hand, some tours may still have spots available at the start of the meeting—please check with the registration desk in Pre-function area C at the Oregon Convention Center for ticket availability.

Tours will depart from and return to the Oregon Convention Center. Please plan to arrive in the Guest Hospitality Suite at least 15 minutes early so that you don't miss the bus. GSA is unable to refund tour costs if you miss the scheduled departure time.

101. City Tour—Weird and Wonderful! Sun., 18 Oct., 9 a.m.–1 p.m. Cost: US$79; min.: 20. The "city of roses" trip would not be complete without this tour of its highlights—both the beautiful and the unusual!

102. Seashells at the Seashore and Rogue Ale Too! Mon., 19 Oct., 8 a.m.–5 p.m. Cost: US$125, lunch included; min.: 20. Your journey will take you to the "blue Pacific" and the central Oregon fishing village of Newport.

103. Birds of a Feather—Including the Eagles! Mon., 19 Oct., 8 a.m.–4 p.m. Cost: US$140, includes box lunch; min.: 10. This 8-hour driving and walking tour will visit one of the Pacific Northwest's most significant winter waterfowl and raptor refuges.

104. Mighty Mount Hood. Tues., 20 Oct., 9 a.m.–3 p.m. Cost: US$97, lunch included; min.: 20. Visit Mount Hood (elev. 11,235 ft)—just a 90-min drive from Portland.

105. Magnificent Columbia Gorge. Wed., 21 Oct., 9 a.m.–3 p.m. Cost: US$62; min.: 20. Enjoy a motor coach ride and breathtaking views from the Crown Point Vista House located on an historic scenic highway ~700 ft above the mighty Columbia River.

***Fine print:** The guest/spouse registration fee of US$90 per person is for nongeologists accompanying professional or student meeting registrants. This fee does not include access to technical sessions. Any guest wishing to see a specific presentation should make a request with the hostess in the Guest Hospitality Suite. **Badges:** Be sure to wear your meeting badge for access to the Oregon Convention Center, the Guest Hospitality Suite, and the Exhibit Hall.

Warrior Rock Lighthouse, Sauvie Island, Oregon. Photo by Tim Jewett courtesy the Portland Oregon Visitors Association.

What's Happening in GSA's Foundation Booth at the Portland Meeting?

THE GSAF'S ANNUAL SILENT AUCTION

18–20 October 2009
Oregon Convention Center Exhibit Halls C/D

You are invited to the GSA Foundation's 10th Silent Auction! We will have a new assortment of interesting and intriguing items on which you may place your bid(s).

All auction proceeds will go to our "Greatest Needs" Fund, which supports Research Grants, Student Travel Grants, Mentor Programs, International Travel, Field Forums, and other Education & Outreach Programs.

Want to donate to the Silent Auction?

You can help support these programs by donating fossils, mineral specimens, jewelry, rare geologic books or maps, wine, field supplies, antiques, time shares, gift certificates, and more. All donations are tax-deductible; your tax-deduction is based upon the retail value of the donated item.

Questions?

Please contact Donna Russell, +1-303-357-1054, drussell@geosociety.org. You may mail donations directly to Donna Russell at the GSA Foundation, 3300 Penrose Place, P.O. Box 9140, Boulder, CO 80301, USA. The Foundation's Tax I.D. number is 74-2156871, and your name will be listed in the Foundation Booth as a donor.

If you don't have any items, we're happy to accept a cash donation. You may send your check directly to the Foundation office, or go to the Foundation's Web site—gsafweb.org—click on the "Make a Donation" tab, and follow the instructions. Be sure to note in the comment field that your gift is for the Silent Auction.

Thanks to all for your support!

Childcare at the GSA Annual Meeting & Exposition

THE GEOLOGICAL SOCIETY OF AMERICA®

Sat.–Wed., 17–21 October ✷ Oregon Convention Center

For the fourth consecutive year, GSA is proud to offer KiddieCorp's professional childcare services for children ages 6 months to 12 years. Children enjoy games, story time, arts and crafts, and other activities planned around the program hours and ages of the children. Fees are US$7 per hour, per child, with a two-hour minimum.

Register at www.kiddiecorp.com/gsakids.htm by 14 Sept. 2009 to secure your child's spot!

For more information, contact the Meetings Department at meetings@geosociety.org. Childcare services are a contractual agreement between each individual and the childcare company. GSA assumes no responsibility for the services rendered.

What parents are saying:

"Excellent! I am very grateful for this service and will use it again."

"This was great—thank you very much. I hope to see them at all meetings."

EXHIBITORS*

EXHIBIT HALL

Oregon Convention Center
Exhibit Halls C/D

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Trimble

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ESRI
GEON 2.0

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Delight's Earthly Delights
Evogeneao
Finesilver Designs/Jewelry
Gems & Crystals Unlimited
IKON Mining & Exploration
Komodo Dragon
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In-Situ Inc.
Innov-X Systems
Leica Microsystems Inc.
Los Gatos Research
MALÅ Geoscience USA Inc.
Meiji Techno America
Ocean Optics
Optech Inc.
Rigaku Americas Corp.
Sensors & Software Inc.
Thermo Scientific

Geological Society of America
GSA Engineering Geology Division
GSA Geoinformatics Division
GSA Geology & Society Division
GSA Geology and Public Policy Committee
GSA Geoscience Educator Division
GSA History of Geology Division & the History of Earth Sciences Society (HESS)
GSA Hydrogeology Division
GSA Limnogeology Division
GSA Planetary Geology Division

Government Agencies (Federal, State, Local, International)
Minerals Management Service
NASA
National Mine Map Repository
National Park Service
National Science Foundation
Office of Surface Mining
Oregon Dept. of Geology and Mineral Industries
U.S. Bureau of Land Management
U.S. Forest Service (USDA)
U.S. Geological Survey
U.S. National Geologic Map Database
USDA–NRCS National Water & Climate Center

Other
British Geological Survey
Consortium for Ocean Leadership
Consortium of Universities for the Advancement of Hydrologic Science Inc. (CUAHSI)
Decagon Devices
Happy Feet
Ice Age Floods Institute
International Union of Geological Sciences & 34th International Geological Congress
International Year of Planet Earth (IYPE)
IRIS Consortium
MAPCIS Research Project
Oregon Paleo Lands Institute
Research Partnership to Secure Energy for America (RPSEA)
Subaru of America Inc.
Zanfel Laboratories Inc.

Professional Societies and Associations
AAPG Bookstore and Student Programs
AASP - The Palynological Society
American Geological Institute
American Geophysical Union
American Institute of Professional Geologists
American Meteorological Society
American Quaternary Association
Association for Women Geoscientists
Association of American State Geologists
Association of Earth Science Editors
Association of Environmental & Engineering Geologists
Clay Minerals Society, The
Council on Undergraduate Research (CUR) Geosciences Division
Cushman Foundation
Environmental and Engineering Geophysical Society
European Geosciences Union
Geochemical Society
Geological Society of London
Geoscience Information Society
GeoScienceWorld
International Association of GeoChemistry
Mineralogical Association of Canada
Mineralogical Society of America
National Association of Black Geologists and Geophysicists
National Association of Geoscience Teachers (NAGT)
National Cave and Karst Research Institute
National Earth Science Teachers Assoc. (NESTA)
Paleobiology Database
The Paleontological Society
SEPM Society for Sedimentary Geology
Sigma Gamma Epsilon
Society of Economic Geologists (SEG)

Publications, Maps, Films
Allen Press Inc.
Cambridge University Press
Columbia University Press
Elsevier

*As of press time for this issue.

EXHIBITORS* continued

Geological Association of Canada
McGraw-Hill Publishers
Micropaleontology Project
Mountain Press Publishing Co.
Nature Publishing Group
Paleontological Research Institution
Pearson
Taylor & Francis
University of California Press
W.H. Freeman
W.W. Norton & Company
Wiley-Blackwell

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Activation Laboratories Ltd.
Aeroquest Surveys
Beta Analytic Inc.
DOSECC
Environmental Isotope Lab
Gerace Research Centre
GNS Science–National Isotope Centre/Rafter Radiocarbon
Inflatable Packers International
Ruen Drilling Inc.

Universities/Schools
Baylor University Dept. of Geology
Desert Research Institute
Geocognition Research Laboratory
Geoinformatics for the Geosciences
King Fahd University of Petroleum and Minerals (KFUPM)
Louisiana State University Geology & Geophysics
Mississippi State University
Missouri University of Science and Technology
Oregon State University Dept. of Geosciences
Rutgers, The State of New Jersey, Earth & Planetary Sciences
School of Earth and Environmental Sciences, Washington State University
University of Houston Dept. of Earth and Atmospheric Sciences
University of Nevada–Las Vegas
University of Nevada–Reno
University of Texas at Austin Jackson School of Geosciences
University of Texas at San Antonio Dept. of Geological Sciences
University of Wyoming Geology & Geophysics Dept.
Utah State University

Exhibit Hall Hours & Information

Exhibits office: Oregon Convention Center, Exhibit Hall C, +1-503-963-5704
Exhibits location: Oregon Convention Center Exhibit Halls C/D

OPEN

Sunday, 7–9 p.m.
Monday–Tuesday, 9 a.m.–6 p.m.
Wednesday, 9 a.m.–2 p.m.

GSA invites you to visit these exhibitors—They're here for you!

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GRADUATE SCHOOL INFORMATION FORUM

Oregon Convention Center, Exhibit Hall B

Sun., 18 Oct., 8 a.m.–5:30 p.m. (optional 7–9 p.m.) • Mon.–Wed., 19–21 Oct., 8 a.m.–5:30 p.m.

Institution	Sunday	Monday	Tuesday	Wednesday
Central Washington University	X	X		
Clemson University		X		
Colorado School of Mines	X	X		
Colorado State University		X		
Dartmouth College	X	X		
Duke University	X	X	X	X
East Carolina University	X			
Indiana State University		X	X	
Iowa State University	X			
Miami University	X	X		
Missouri State University	X	X		
Ohio State University	X	X	X	
Oklahoma State University	X	X		
Penn State University	X	X		
Purdue University	X	X		
Rice University	X	X		
San Diego State University		X		
South Dakota School of Mines & Technology		X	X	
Syracuse University	X	X		
University at Buffalo	X	X	X	X
University of Alabama		X		
University of California at Davis	X	X		
University of California at Riverside	X	X		
University of Florida	X	X		

Institution	Sunday	Monday	Tuesday	Wednesday
University of Idaho	X	X		
University of Illinois		X		
University of Kansas	X	X	X	
University of Massachusetts–Amherst	X	X		
University of Memphis	X	X	X	
University of Michigan	X	X	X	X
University of Minnesota–Duluth	X	X		
University of Montana	X	X		
University of Notre Dame	X	X	X	
University of Oklahoma	X	X	X	
University of Southern California	X	X	X	
University of Texas at El Paso	X	X	X	X
University of Tulsa	X	X		
University of Utah		X		
Utah State University	X	X	X	X
Vanderbilt University	X	X		
Virginia Tech	X	X	X	
Western Michigan University	X	X		
Yale University	X	X	X	X

Searching for the right graduate school? Meet with university representatives from across the nation at GSA's Graduate School Information Forum. The participating schools (as of press time) are listed above. To check if a school has a booth, go to **http://rock.geosociety.org/gsif/.**

Session Cosponsor Organizations

American Geological Institute (AGI)

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Geothermal Resources Council

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International Society of Groundwater for Sustainable Development (ISGSD)

Mineralogical Society of America (MSA)

National Aeronautics and Space Administration (NASA)

National Association of Geoscience Teachers (NAGT)

National Cave and Karst Research Institute (NCKRI)

On the Cutting Edge Leadership Development in the Geosciences

Paleontological Society

Precambrian (at large)

Sigma Gamma Epsilon

Smithsonian Institution

Society for Sedimentary Geology (SEPM)

Society of Economic Geologists (SEG)

The Association of Environmental and Engineering Geologists (AEG)

U.S. Geological Survey (USGS)

U.S. Geological Survey Earth Surface Processes Team–Denver

U.S. National Chapter of the International Association of Hydrogeologists

USDA Forest Service, Minerals & Geology Management and Watershed, Fish, Wildlife, Air & Rare Plants Programs

University Alaska Fairbanks Geophysical Institute

Geological Society of America Divisions

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Geoscience Education

History of Geology

Hydrogeology*

International

Limnogeology

Planetary Geology

Quaternary Geology and Geomorphology

Sedimentary Geology

Structural Geology and Tectonics

*Congratulations to the Hydrogeology Division on their 50th anniversary!

GSA thanks all these groups and organizations for their tremendous effort and contribution to the vigor, diversity, appeal, and scientific excellence of the 2009 GSA Annual Meeting in Portland, Oregon, USA.

Panel Seeks Input on GSA Position Statement Draft

CLIMATE CHANGE

GSA members are invited to submit comments and suggestions regarding the following *position statement draft* by **21 Sept. 2009** at **www.geosociety.org/geopolicy/**. This draft would replace GSA's current position statement on global climate change, which expires this year. Go to **www.geosociety.org/positions/** to learn more.

POSITION STATEMENT

The Geological Society of America concurs with key elements of recent assessments by the National Academies and the Intergovernmental Panel on Climate Change (IPCC). Global climate has warmed by ~0.7 °C since the middle to late 1800s, and human activities (mainly greenhouse-gas emissions) account for most of the warming since the middle 1900s. If current trends continue, the projected increase in global temperature by the end of the twenty-first century will result in large negative impacts on humans and other life forms. Addressing the challenges posed by future anthropogenic warming will require a combination of national and international emissions reductions and adaptations to those changes that occur.

Purpose

This position statement (1) summarizes the recently strengthened basis for the conclusion that humans are the primary factor responsible for recent global warming; (2) describes the large effects on humans and ecosystems if greenhouse-gas concentrations and global climate reach projected levels; and (3) provides information for policy decisions guiding mitigation and adaptation strategies designed to address the future impacts of anthropogenic warming.

Rationale

Recent scientific advances have eliminated or greatly reduced previous uncertainties about the size and causes of recent global warming. Ground-station measurements have shown a rapid warming trend of ~0.7 °C since the mid-1800s, and this trend is consistent with (1) retreat of northern hemisphere snow and Arctic sea ice in the last 40 years; (2) greater heat storage in the ocean over the last 50 years; (3) retreat of most mountain glaciers since 1850; (4) an ongoing rise of global sea level for more than a century; and (5) proxy reconstructions of temperature change over past centuries from ice cores, tree rings, and corals. Both instrumental records and proxy indices from geologic sources show a temperature rise since 1850 that is far more rapid than any in records extending back at least half a millennium.

Measurements from satellites beginning in 1979 initially did not show a warming trend, but later studies (Mears and Wentz, 2005; Santer et al., 2008) found that the satellite data had not been fully adjusted for losses of satellite elevation through time, differences in time of arrival over a given location, and removal of higher-elevation effects on the lower tropospheric signal. With these factors taken into account, the satellite data are now in basic agreement with ground-station data and confirm a warming trend since 1979. In a related study, Sherwood et al. (2005) found problems with corrections of tropical daytime radiosonde measurements and largely resolved a previous discrepancy with ground-station trends. As a result, the warming of Earth's surface by ~0.7 °C since 1850 is no longer open to serious challenge.

Several potential causes of this warming trend can be eliminated. Long-term changes driven by changes in Earth's orbit or its tectonism are far too slow to have played a significant role in a 150-year trend. Large volcanic eruptions cooled global climate for a year or two, and El Niño episodes warmed it for about a year, but neither factor dominates multi-decadal trends.

As a result, human influences and solar fluctuations are the only factors that could have changed rapidly enough and lasted long enough to explain the observed changes in global temperature. Although the 3rd (2001) IPCC report allowed that solar fluctuations might have contributed as much as 30% of the warming since 1850, subsequent observations of Sun-like stars (Foukal et al., 2004) and new simulations of the evolution of solar sources of irradiance variations (Wang et al., 2005) have reduced these estimates. The 4th IPCC report concluded that changes in solar irradiance, continuously measured by satellites since 1979, account for less than 10% of the recent warming.

Greenhouse gases remain as the major explanation. Climate model assessments of the natural and anthropogenic factors responsible for this warming conclude that rising anthropogenic emissions of greenhouse gases have been an important contributor since the mid-1800s and the major factor since the mid-1900s. The CO_2 concentration in the atmosphere is now ~30% higher than peak levels measured in ice cores for the last 800,000 years, and the methane concentration is 2.5 times higher. Half of Earth's warming has occurred through the basic heat-trapping effect of the gases in the absence of any feedback processes. This "clear-sky" part of the response to climate is known with high certainty. The other half of the estimated warming results from the net effect of feedbacks in the climate system: a very large positive feedback from water vapor; a smaller positive feedback from snow and ice albedo; and sizeable, but still uncertain, negative feedbacks from clouds and aerosols. The vertical structure of observed changes in temperature and water vapor in the troposphere is consistent with the anthropogenic greenhouse-gas "fingerprint" simulated by climate models (Santer et al., 2008). Considered in isolation, the greenhouse-gas increases during the last 150 years would have caused a warming larger than the one actually measured, but negative feedback from clouds and aerosols has offset part of the warming. In addition, because the oceans take decades to respond fully to climatic forcing, the climate system has yet to register the complete effect of gas increases in recent decades.

These advances in scientific understanding of recent warming form the basis for projections of future changes. If greenhouse-gas emissions follow the current trajectory beyond the twenty-first century, CO_2 levels will reach two to four times pre-industrial levels, for a total warming of 2.4–4.6 °C compared to 1850. This range of changes would substantially alter the functioning of the planet in both positive and negative ways. Several negative changes involve risk to humans and other life forms: (1) continued shrinking of Arctic sea ice with effects on native cultures and ice-dependent biota; (2) less snow accumulation and earlier melt in mountains, with reductions in spring and summer runoff for agricultural and municipal water; (3) disappearance of mountain glaciers and their late-summer runoff; (4) increased evaporation from farmland soils and stress on crops; (5) greater soil erosion due to increases in heavy convective summer rainfall; (6) longer fire seasons and increases in fire frequency; (7) severe insect outbreaks in vulnerable forest stands; (8) acidification of the global ocean; and (9) fundamental changes in the composition, functioning, and biodiversity of many terrestrial and marine ecosystems. Melting of Greenland and West Antarctic ice (still highly uncertain as to amount), along with thermal expansion of seawater and melting of mountain glaciers, will cause substantial future sea-level rise along densely populated coastal regions, inundating farmland and dislocating people. Because Earth's history shows past examples of large and abrupt changes occurring within decades, the possibility exists for rapid future changes in response to increased greenhouse-gas concentrations. Carbon-climate model simulations indicate that 10–20% of the anthropogenic CO_2 "pulse" could stay in the atmosphere for thousands of years, extending the duration of fossil-fuel warming and its effects on humans and other life forms. The acidification of the global ocean, and its effect on ocean life, will last for tens of thousands of years.

Public Policy Aspects

Recent scientific investigations have strengthened the case for policy action to reduce greenhouse gas emissions and to adapt to unavoidable climate change. To strengthen the consensus for action, this statement from the Geological Society of America is intended to inform policymakers about improved knowledge of Earth's climate systems based on recent advances in climate science. Geoscientific investigations have contributed to this improved understanding of the climate system and strengthened the case for human-caused global warming, providing policymakers with a unique perspective on which to base mitigation and adaptation strategies. Future climate change will pose societal, biological, economic, and strategic challenges that will require a combination of national and international emissions reductions and adaptations. These challenges will also require balanced and thoughtful national and international discussions leading to careful long-term planning and sustained policy actions.

Recommendations

- *Public investment is needed to improve our understanding of how climate change impacts society, including on local and regional scales, and to formulate adaptation measures.* Sustained support of climate-related research to advance understanding of the past and present operation of the climate system is needed, with particular focus on the major remaining uncertainties in understanding and predicting Earth's future climate at regional and global scales. Focused research is needed to improve our ability to assess the response and resilience of natural and human systems to past, present, and future changes in the climate system.
- *National and international planning is needed to address challenges posed by future climate change.* Near-, mid-, and long-term strategies for climate-change evolution, adaptation, and mitigation, based in part on knowledge gained from studies of previous environmental changes, should be developed.
- *Public policy should include effective strategies for the reduction of greenhouse-gas emissions.* Earth has a virtually unlimited supply of low-carbon energy. Cost-effective investments to improve the efficiency of these natural resources can reduce the economic impacts of the needed changes.

Opportunities for GSA and GSA Members to Help Implement Recommendations

To facilitate implementation of the goals of this position statement, the Geological Society of America recommends that its members take the following actions:

- *Actively participate in professional education and discussion activities so as to be technically well informed about the latest advances in climate science.* GSA should encourage symposia at national and regional meetings to educate members on mainstream understanding among geoscientists and climate scientists of the causes and future effects of global warming within the broader context of natural variability. These symposia should seek to actively engage members in hosted discussions that clarify issues, possibly utilizing educational formats other than the traditional presentation and Q&A session.
- *Engage in public education activities in the community, including at the local level.* Public education is a critical element of a proactive response to the challenges presented by global climate change. GSA members are encouraged to take an active part in outreach activities to educate the public at all levels (local, regional, and national) about the science of global warming and the importance of geological research in framing policy development. Such activities can include organizing and participating in community school activities; leading discussion groups in churches or other civic organizations; meeting with local and state community leaders and congressional staffs; participating in GSA's Congressional Visits Day; writing opinion pieces and letters to the editor for local and regional newspapers; contributing to online forums; and volunteering for organizations that support efforts to effectively mitigate and adapt to global climate change.
- *Collaborate with a wide range of stakeholders to help educate and inform them about the causes and impacts of global climate change from the geosciences perspective.*

continued on p. 38

continued from p. 37

GSA members are encouraged to discuss with businesses and policymakers the science of global war ming, as well as the opportunities for transitioning from our predominant dependence on fossil fuels to greater use of low-carbon energies and energy efficiencies.

- *Work interactively with other science and policy societies to help inform the public and ensure that policymakers have access to scientifi cally r eliable infor mation.* GSA should actively engage and collaborate with other earth-science organizations in recommending and for mulating national and international strategies to address impending impacts of anthropogenic climate change.
- *Take advantage of the following list of references for a current scientific assessment of global climate change.*

SELECTED REFERENCES

Foukal, P.G., et al., 2004, A stellar view on solar variations and climate: Science, v. 306, p. 68–69.

IPCC (Intergovernmental Panel on Climate Change), 2007, Summary for policymakers, *in* Climate Change 2007: The physical science basis: Cambridge, United Kingdom, Cambridge University Press, 18 p.

Mears, C.A., and Wentz, F.J., 2005, The effect of diurnal correction on satellite-derived lower tropospheric temperature: Science online, doi: 10.1126/science.1114772.

National Research Council, 2006, Surface temperature reconstructions for the last 2000 years: Washington, D.C., National Academy Press, 146 p.

Oerlemans, J., 2005, Extracting a climate signal from 169 glacier records: Science, v. 308, p. 675–677.

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Sherwood, S., Lanzante, J., and Meyer, C., 2005, Radiosonde biases and late-20th century warming: Science online, doi: 10/1126/science.1115640.

Solomon, S., Plattner, G-K., Knutti, R., and Friedlingstein, P., 2009, Irreversible climate change due to carbon dioxide emissions: Proceedings of the National Academy of Sciences, v. 106, no. 6, p. 1704–1709.

Wang, Y.-M., Lean, J.L., and Sheeley, N.R., Jr., 2005, Modeling the Sun's magnetic fi eld and irradiance since 1713: Astrophysical Journal, v. 625, p. 522–538.

SELECTED WEB SITES

Intergovernmental Panel on Climate Change
IPCC reports: www.ipcc.ch/

U.S. National Academies
Climate Change at the National Academies: http://dels.nas.edu/climatechange/

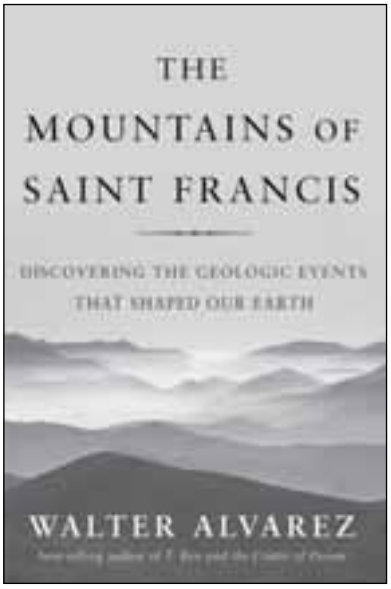
Surface temperature reconstructions: http://www.nap.edu/catalog.php?record_id=11676#toc

U.S. Global Change Research Program
Home page: http://www.globalchange.gov/

Satellite issue: http://www.climatescience.gov/Library/sap/sap1-1/finalreport/default.htm

Geologic record of abrupt changes: http://www.climatescience.gov/Library/sap/sap3-4/final-report/

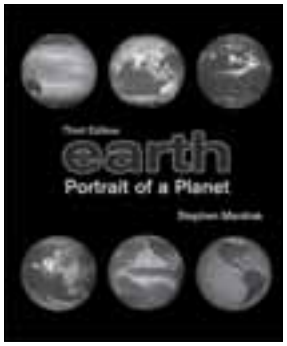
Global climate change impacts in the United States: http://www.globalchange.gov/publications/reports/scientific-assessments/us-impacts

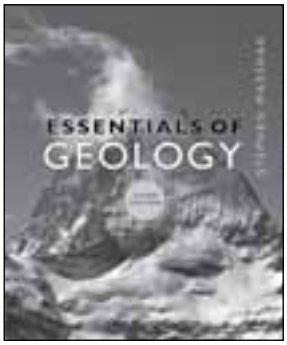


The Apennine Mountains of Italy, the nearby Alps, and the surrounding Mediterranean have given to science a long stream of great discoveries about the Earth—thrust faults, turbidites, ophiolites, mountain glaciers, collisional tectonics, foraminiferal biostratigraphy, olistostromes, magnetic-reversal stratigraphy, the Cenozoic time scale, the KT impact, cyclostratigraphy, microplate tectonics, carbonate-platform geology, the Messinian salinity crisis, and even Nicholas Steno's invention of stratigraphy itself—so much so that this could be considered the heartland of geology.

In *The Mountains of Saint Francis*, Walter Alvarez tells the saga of how geologists learned all these remarkable things from this unique part of the world. Based on 40 years of research experience, this book recounts not only the geological discoveries, but also the stories of the scientists who made the discoveries, setting it all in an account of the pleasures of doing geological research in a lovely and historical land. Profusely illustrated and written in a non-technical way that does not skimp on the science, *The Mountains of Saint Francis* is a book for geologists, their students, and their friends.

Keep in mind . . .





ABOUT PEOPLE

News about GSA's Members

GSA Fellow and Foundation Trustee **Farouk El-Baz** was presented with an honorary doctorate of science degree by the American University of Beirut for his outstanding contributions to geology and a better understanding of Earth and its environments.

GSA Fellow **Sharon Mosher** has been named Dean of the Jackson School of Earth Sciences at The University of Texas at Austin.

GSA Fellow **Marcia McNutt** was nominated by President Obama to serve as Director of the United States Geological Survey and Science Advisor to the Secretary of the Interior.

GSA member **Robert S. Kuhlman,** professor of earth science at Montgomery County Community College since 1977, was awarded the 2009 Christian R. and Mary F. Lindback Distinguished Teaching Award at the college's 42nd commencement ceremony. The Lindback Award recognizes academic excellence and a commitment to the life of the mind along with the well-being of students that extends beyond the classroom.

View the member news archive at **www.geosociety.org/news/memberNews.htm.**

IN MEMORIAM

GSA received notice between 26 April 2009 and 26 July 2009 of the deaths of the following members.

Rhesa M. Allen Jr.
Dallas, Tex., USA
4 January 2009

Ewart M. Baldwin
Eugene, Ore., USA
2 May 2009

Reginald Peter Briggs
Pittsburgh, Pa., USA
29 April 2009

Daniel R. Croswell
Brooklyn Park, Minn., USA
notified 13 May 2009

Richard J. Deuerling Jr.
South Bend, Ind., USA
notified 1 June 2009

Donald F. Eschman
Ann Arbor, Mich., USA
1 November 2008

David M. Gilbert
Fort Collins, Colo., USA
notified 11 June 2009

Richard J. Gleason
Mansfield, Mass., USA
notified 1 June 2009

Gregg Lamorey
Reno, Nev., USA
notified 28 May 2009

J. Stewart Lowther
Tacoma, Wash., USA
notified 4 May 2009

Joe Madison
Lanesboro, Mass., USA
notified 29 May 2009

Paul W. Ollila
Rutland, Mass., USA
notified 10 July 2009

Marcia Romero
Centennial, Colo., USA
notified 3 June 2009

George G. Shor Jr.
La Jolla, Calif., USA
3 July 2009

Alice E. Weis
Spokane, Wash., USA
21 April 2009

C. William Zanner
Saint Paul, Minn., USA
1 February 2008

To honor one of these colleagues with a memorial, please go to **www.geosociety.org/pubs/memorials/.** This page also lists the memorials already completed and available as PDFs. If you would like to contribute to the GSA Memorial Fund, please contact the GSA Foundation, +1-303-357-1054, drussell@geosociety.org, www.gsafweb.org.

New *GSA Today* **Comment** & **Reply** Posted Online

The February 2009 *GSA Today* science article, "A shift from lithostratigraphic to allostratigraphic classification of Quaternary glacial deposits" (Räsänen et al., v. 19, no. 2, p. 4–11, doi: 10.1130/GSATG20A.1), received a Comment and subsequent Reply, which can be read on *GSA Today*'s new Web site, **www.geosociety.org/GSAToday/.**

Comment

Lithostratigraphy for Quaternary glacial deposits: "If it ain't broke, don't fix it!"

Mark D. Johnson, Carrie Jennings, and **Howard Hobbs** (*GSA Today,* v. 19, no. 9, p. e13, doi: 10.1130/GSAT52C).

Reply

Lithostratigraphy for Quaternary glacial deposits: "If it ain't broke, don't fix it!"

M.E. Räsänen, J.M. Auri, J.V. Huitti, A.K. Klap, and **J.J. Virtasalo** (*GSA Today,* v. 19, no. 9, p. e14, doi: 10.1130/GSATG60Y).

Comments and Replies on *GSA Today* science and Groundwork articles must be 900 words or fewer and can be submitted to the *GSA Today* science editors via the online manuscript tracking system (http://gsa-today.allentrack.net/cgi-bin/main.plex). The 900-word limit includes author names, affiliations, and references. If you would like to use a figure in your comment, please reduce the text by at least 200 words to allow space for the figure and caption. Comments and Replies are no longer printed in *GSA Today,* but are posted online at **www.geosociety.org/GSAToday/comment-reply/.**

Did Westward Subduction Cause Cretaceous–Tertiary Orogeny in the North American Cordillera?

by Robert S. Hildebrand

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Special Paper 457

This volume describes an iconoclastic model for the Cretaceous–Tertiary development of the Cordilleran orogen. Hildebrand argues that the orogeny was collisional in origin, caused by westerly-dipping subduction beneath an exotic ribbon continent named Rubia, and followed by development of an eastward-dipping subduction zone outboard of the collision zone. This model explains the origin of Laramide thick-skinned deformation, Cordilleran-type batholiths, early Tertiary metamorphic core complexes, Basin and Range extension, porphyry copper deposits, and the Pelona-Orocopia-Rand schists, and it helps resolve the longstanding Baja–British Columbia controversy.

SPE457, 71 p.,
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Donna L. Russell, *Director of Operations*

An Overview of GSA's Mentor Programs

GSA runs five programs devoted to the ideals of mentorship, designed to facilitate mentoring relationships between professionals in applied geology and university students.

Students seeking career advice will find it by attending one of these programs, and professionals can play a key role in these students' lives by becoming a mentor. No matter where you are in your career, there will always be someone with less experience than you who could benefit from your advice. Your experience and advice are especially invaluable to students contemplating their future.

ROY J. SHLEMON MENTORS IN APPLIED GEOLOGY

The Shlemon Program extends the mentoring reach of applied geoscience professionals to undergraduates and graduate students attending GSA Section Meetings. Over a free lunch, mentors and students discuss professional opportunities and challenges the students may face after graduation. Over the course of a season, 350+ students will have been mentored by 80+ professionals.

Student Comment:

These mentor programs are extremely helpful and informative. Thank you for providing this great program (and others like it) for students!

JOHN MANN MENTORS IN APPLIED HYDROGEOLOGY

Mann Program sessions are held at GSA sectional and annual meetings. They provide opportunities for students interested in hydrogeology to meet, connect with, and learn from professionals employed in the field. Informal, focused career sessions are held over a light meal at GSA's Section Meetings. During the annual meeting, the Mann Program underwrites the cost for up to 25 students to attend GSA's prestigious Hydrogeology Division Business and Awards Banquet. These programs impact about 250 students every year.

Student Comment:

All the mentors were great. I will definitely attend this program in the future.
Excellent program. Very beneficial.

GEOLOGY IN GOVERNMENT

The Geology in Government mentor luncheon is an interactive event that connects geoscience professionals working in local, state, regional, and federal government sectors with GSA's student members. The Q&A panel platform for this career information exchange includes a free lunch for both students and mentors. Approximately 350 students attend this event.

Student Comment:

It is always good to hear new perspectives and opinions on what we can do as geologists, and it is great to know we have lots of options available to us.

GEOLOGY IN INDUSTRY

This mentor luncheon is held at GSA's Annual Meeting and features a select panel of mentors representing various industries. These mentors invite questions from the students (more

than 300 every year), offer advice about preparing for a career, and comment on the prospects for current and future job opportunities within their organizations.

Student Comment:
The panel opened my eyes to the opportunities in industry; it's something I haven't considered before.

WOMEN IN GEOLOGY

This mentoring program, sponsored by Subaru of America, Inc., addresses the issues faced by women in geology. This event begins with remarks from a few key women speakers, followed by a relaxing forum for socializing, sharing ideas, and meeting other women (about 100 every year) in geology.

Student Comment:
The speakers all had good things to say and I appreciated the career and age diversity between them. Please make this a regular feature at GSA.

To learn more, go to **www.geosociety.org/mentors/.**
Questions?
Contact Jennifer Nocerino
jnocerino@geosociety.org
+1-303-357-1036.

Most memorable early geologic experience:

Visiting Devils Tower and realizing that it once was the site of an active volcano.

—Gail Ashley

Call for Proposals:

2010
GSA Annual Meeting
Field Trips *and* Short Courses

2010 Field Trips

Next year, we'll be back in Denver. Know of a great geoscience excursion in or near Colorado? We invite you to bring your local expertise to your colleagues and peers! Submit your field-trip idea at **http://gsa.confex.com/gsa/2010AM/fieldtrip.htm.** Trips can be anywhere from a half day to 5 days long. Questions? Contact Eric Nocerino, +1-303-357-1060, enocerino@geosociety.org.

2010 Short Courses

Share your unique knowledge and experience with your peers, students, or earth science teachers in our dynamic annual meeting setting. Learn more about submitting a short course proposal at **www.geosociety.org/meetings/2010/scProposals/.** Questions? Contact Jennifer Nocerino, +1-303-357-1036, jnocerino @geosociety.org.

2010 GSA Annual Meeting & Exposition

31 October–3 November • Denver, Colorado, USA
Field Trip and Short Course proposals deadline: 1 December 2009

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Call for Papers

2010 GSA Section Meetings CALENDAR

13–16 March
Northeastern-Southeastern Joint Meeting, Baltimore, Maryland, USA.
Abstract submission opens 1 Oct.; deadline: 8 Dec. 2009.

11–13 April
North-Central–South-Central Joint Meeting, Branson, Missouri, USA.
Abstract submission opens 1 Nov.; deadline: 19 Jan. 2010.

21–23 April
Rocky Mountain, Rapid City, South Dakota, USA.
Abstract submission opens 1 Nov.; deadline: 26 Jan. 2010.

27–29 May
Cordilleran, Anaheim, California, USA.
Abstract submission opens 1 Dec.; deadline: 9 Mar. 2010.

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Plan your 2010 Section Meeting attendance today!

Photo by Mr. Janis Miglavs courtesy the Portland Oregon Visitors Association.

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As a member of the Geological Society of America, you may be eligible for the Subaru VIP Purchase Program.

No haggling, no negotiation, no pressure - just a great deal on a brand new Subaru!

Save between $1,300 - $3,300 off the Manufacturer's Suggested Retail Price (depending on model and accessories) plus any applicable incentives on the purchase or lease of a new Subaru from participating dealers. With each purchase, Subaru of America will donate $100 to the GSA Foundation.

- You must be a GSA member in good standing for at least six (6) consecutive months prior to participating in this program.
- The Subaru VIP Program is available on vehicles purchased in the United States. Not applicable in Hawaii.
- This benefit cannot be applied if you have already taken delivery of your new Subaru.
- Before shopping or contacting Subaru, please contact GSA Sales and Service at +1-888-443-4472 (toll free in the U.S.) or +1-303-357-1000, option 3, or gsaservice@geosociety.org, to request a dealer visit authorization form. Please know, at this time, the name of the Subaru dealership you intend to use.
- Subaru of America will send a confirmation to you and the Subaru dealer of your choice. Present this confirmation upon entering the Subaru dealership.

Subject to change without notice. Terms and conditions apply. Savings depend upon model and accessories selected. MSRP does not include tax, title, and registration fees. Certain models may be excluded subject to dealer availability.

CLASSIFIED ADVERTISING

Classified Rates—2009

Ads (or cancellations) must reach the GSA advertising office no later than the first of the month, one month prior to the issue in which they are to be published. Contact advertising@geosociety.org, +1.800.472.1988 ext. 1053, or +1.303.357.1053. All correspondence must include complete contact information, including e-mail and mailing addresses. To estimate cost, count 54 characters per line, including punctuation and spaces. Actual cost may differ if you use capitals, boldface type, or special characters. Rates are in U.S. dollars.

Classification	Per Line for 1st month	Per line each addt'l month (same ad)
Positions Open	$8.50	$8.25
Opportunities for Students		
First 25 lines	$0.00	$4.50
Additional lines	$4.50	$4.50
Fellowship Opportunities	$8.50	$8.25

Positions Open

HYDROGEOLOGIST–GEOHYDROLOGY SECTION
KANSAS GEOLOGICAL SURVEY
THE UNIVERSITY OF KANSAS, LAWRENCE

Full-time position to lead KGS High Plains aquifer activities. Position can be an unclassified-professional rank of research associate or a faculty-equiv. rank of assistant or associate scientist. Requires M.S. with experience in regional-scale hydrogeology and project management or leadership of research programs, and strong communication skills. Ph.D. and experience with hydrogeologic processes of relevance for the High Plains aquifer are desirable. Individual expected to develop research program of national stature and relevance to Kansas. The Geohydrology Section has 9 full-time professionals with additional support personnel. Emphasis on state-of-the-science field studies and complementary theoretical research. Scientist-rank positions are sabbatical-eligible. Complete announcement at www.kgs.ku.edu/General/jobs.html. Apply online at jobs.ku.edu, search by position number 00008386. First consideration deadline: 8 Jan. 2010. For further information contact Jim Butler (jbutler@kgs.ku.edu) or Brownie Wilson (bwilson@kgs.ku.edu). KU is an EO/AA employer.

STAFF POSITION IN MASS SPECTROMETRY
BAYLOR UNIVERSITY

The Department of Geology at Baylor University is pleased to announce a search for a new staff position for hire beginning on or before 1 Jan. 2010 as Instrumentation Specialist in Stable Isotope Mass Spectrometry. The Department currently consists of 15 geoscientists, including geologists, geophysicists and geographers (please see the Department Web site at: www.baylor.edu/Geology/ for further information).

INSTRUMENTATION SPECIALIST POSITION. The Department of Geology at Baylor University invites applications for a staff position managing the new stable isotope mass spectrometry laboratory at Baylor University, beginning as early as August 2010. A Ph.D. in Geology or Geochemistry is required at the time of appointment. The Department seeks an individual with a strong background in applications of stable isotope mass spectrometry to geological systems, who will manage a new laboratory containing a Thermo-Electron Delta V Advantage isotope ratio mass spectrometer with the following peripherals: Gas Bench II, combustion EA, TCEA, and a dual inlet. The instrumentation specialist is expected to support ongoing research programs that include geology, biology and environmental sciences. The position carries appointment as 90% staff and 10% research scientist, and we especially encourage collaboration with Geology faculty and students currently engaged in research focusing on terrestrial paleoclimatology. The successful candidate should also be capable of managing use of the instrument by faculty and students, be able to instruct new users, and conduct routine maintenance and repairs, assisted by a Baylor Sciences Building instrumentation Specialist. Baylor University also supports an annual service contract for the instrument.

Send letter of application, including statement of research interests, curriculum vitae, transcripts, and the names and contact information for three references to: Dr. Stephen I. Dworkin, Instrumentation Specialist Search Committee Chair, Department of Geology, Baylor University, One Bear Place #97354, Waco, TX 76798-7354; +1-254-710-2361; Steve_Dworkin@baylor.edu). The review of applications will begin 1 Oct. 2009 and applications will be accepted until the position is filled. To ensure full consideration, application must be completed by 15 Dec. 2009. Baylor is a Baptist university affiliated with the Baptist General Convention of Texas. As an Affirmative Action/Equal Opportunity employer, Baylor encourages minorities, women, veterans and persons with disabilities to apply.

TENURE-TRACK FACULTY POSITION
ORGANIC GEOCHEMISTRY OR
PALEOCLIMATOLOGY
BAYLOR UNIVERSITY

The Department of Geology at Baylor University is pleased to announce a search for a new faculty position for hire beginning in August of 2010 in Organic Geochemistry or Paleoclimatology. The Department currently consists of 15 geoscientists, including geologists, geophysicists and geographers (please see the department Web site at www.baylor.edu/Geology/ for further information).

ORGANIC GEOCHEMISTRY/PALEOCLIMATOLOGY. The Department of Geology at Baylor University invites applications for a tenure-track Assistant or Associate Professor in the general areas of organic geochemistry and/or paleoclimatology, beginning August 2010.

A Ph.D. in Geology, Geochemistry, or related field is required at the time of appointment. The Geology Department seeks an individual with a strong research agenda that possibly includes compound-specific organic geochemistry, paleoclimate modeling, or palynology applied to field and laboratory studies of terrestrial climate records archived within fluvial (river and floodplain), eolian (loess and sand dune), lacustrine (lake), and coastal systems. The individual must be able to communicate and collaborate with a subset of six Geology faculty members that are currently engaged in studies in the general area of paleoclimatology, and to carry out a vigorous externally funded research program that involves both undergraduate and graduate students. A strong commitment to excellence in teaching is essential, with both undergraduate and graduate courses that might include organic geochemistry, paleoclimate modeling or palynology, as well as other courses in his/her area of specialization. Research space for terrestrial paleoclimatology is available in the five-year-old, 500,000 ft^2 "state-of-the-art" Baylor Sciences Building, and startup funds associated with this position are highly competitive. Construction of a new stable isotope laboratory was completed in the spring of 2009, which currently includes a new 600 ft2 laboratory containing a Thermo-Electron Delta V Advantage isotope ratio mass spectrometer with the following peripherals: Gas Bench II, combustion EA, TCEA, and a dual inlet, supporting ongoing research programs that include geology, biology and environmental sciences. The laboratory will be managed by a dedicated instrumentation specialist.

Send letter of application, including statement of teaching and research interests, curriculum vitae, transcripts, and the names and contact information for three references to: Dr. Steven G. Driese, Paleoclimatology Search Committee Chair, Department of Geology, Baylor University, One Bear Place #97354, Waco, TX 76798-7354; +1-254-710-2361; applications sent by e-mail to Steven_Driese@baylor.edu. The review of applications will begin 1 Dec. 2009 and applications will be accepted until the position is filled. To ensure full consideration, application must be completed by 15 Dec. 2009. Baylor is a Baptist university affiliated with the Baptist General Convention of Texas. As an Affirmative Action/Equal Opportunity employer, Baylor encourages minorities, women, veterans and persons with disabilities to apply.

TENURE-TRACK ASSISTANT PROFESSOR
GEOSCIENCES, UNIVERSITY OF ARKANSAS

The Department of Geosciences, University of Arkansas-Fayetteville invites applications for a 9-month appointment as a tenure-track assistant professor with an anticipated start date of August 2010. We are seeking an outstanding individual with expertise in broad areas of structural geology and tectonics. Applicants must demonstrate ability and commitment to develop an independent externally funded research program as well as the potential for collaboration and synergism with ongoing research in the Department of Geosciences (http://geosciences.uark.edu). The successful applicant will be an integrated scholar with a strong commitment to teaching at all levels, including possible participation in our required summer field course, in concert with supervision of graduate research.

Review of applications will begin 1 October 2009 and will continue until the position is filled. Applicants should submit their curriculum vitae, brief statements of research and teaching interests, and the names, addresses and contact information for at least three professional references to: Dr. Ralph Davis, Chair, Department of Geosciences, 113 Ozark Hall, Fayetteville, AR 72701.

The University of Arkansas is a nationally competitive student-centered research university located in Fayetteville, Arkansas. It is the flagship campus of the University of Arkansas system. The Department of Geosciences offers bachelors and masters degrees in geology and geography, and participates in two interdisciplinary graduate programs, Space and Planetary Sciences and Environmental Dynamics, providing opportunity for supervision of Ph.D. students.

Fayetteville, nestled in the Ozarks of Northwest Arkansas, is part of a metropolitan area of about 420,000 people that retains its small college town atmosphere. It is the sixth fastest growing metropolitan area in the U.S. spurred by opportunities with national companies including Wal-Mart, Tyson, Inc., and J.B. Hunt. The quality of life is high and it's a great place to work, play, and raise a family.

The University of Arkansas is an Affirmative Action/Equal Opportunity Employer and applications will be accepted without regard to age, race, color, sex, or national origin. Applicants must have proof of legal authority to work in the United States as well as all Ph.D. requirements completed at the time of the appointment. Women and minorities are encouraged to apply.

DEPARTMENT OF GEOLOGY & GEOPHYSICS
TENURE TRACK POSITION
EARTH SYSTEM SCIENTIST–GEOCHEMISTRY
BOSTON COLLEGE

The Department of Geology and Geophysics at Boston College seeks to hire an Assistant Professor in the broad area of Earth System Science with a focus in Geochemistry to start in Fall 2010. Areas of expertise might include (but are not limited to) biogeochemistry, organic geochemistry, isotope geochemistry, and paleoclimatology. The successful candidate will be expected to develop a vigorous externally funded research program integrated with excellence in teaching within the earth and environmental geoscience curriculum at both the undergraduate and graduate levels, including teaching a course related to climate change, an introductory geochemistry or environmental geochemistry course, and upper level electives in the area of the successful candidate's expertise. The appointment is expected to be made at the Assistant Professor level, but applications from outstanding candidates at a higher level will also be considered. Information on the department, faculty, and research strengths can be viewed at www.bc.edu/geosciences. Applicants should send a curriculum vita, statements of teaching and research interests, and the names and contact information of at least three references as a single PDF-file e-mail attachment to geochem_position@bc.edu. Review of applications will begin on 6 Nov. 2009. Department faculty will be available at the GSA and AGU fall meetings to meet with applicants. Boston College is an academic community whose doors are open to all students and employees without regard to race, religion, age, sex, marital or parental status, national origin, veteran status, or handicap.

SURFICIAL GEOLOGY, MINOT STATE UNIVERSITY

The Department of Geosciences at Minot State University invites applications for a tenure-track faculty position in surficial geology. This appointment will be at the assistant professor level starting fall 2010. A Ph.D. in geological sciences or related field by time of appointment is expected. We seek someone with a broad, field-based background in surficial processes. Teaching expectations include upper-level courses in geomorphology, soils, and global climate change; introductory GIS; and contribution to introductory courses (environmental geology and physical geology).

Applicants for the position should demonstrate potential for excellence in undergraduate teaching, active engagement in research and scholarship, and enthusiasm for developing the geology curriculum and growing the major. Research expectations include development of an active research program that would ideally include local field-based studies involving undergraduate students. The department is well equipped for material characterization (XRD, SEM-EDS), water analysis (ICP, GFAA, GCMS), and geospatial investigations (Topcon total station, ESRI 9.2 ArcEditor Suite, Trimble GeoXT). More information about this position can be found at www.minotstateu.edu/hr/jobs_01.shtml.

Applicants should send a cover letter, CV, copies of transcripts, statement of research interests, and statement of teaching interests/philosophy to Dr. Allen Kihm, Geoscience Search Committee Chair, Division of Science, Minot State University, Minot, ND 58707. Applicants should arrange to have three letters of reference sent directly to the search committee. Review of applications will begin on 30 Sept. 2009. However, applications will be accepted and considered until the position is filled. Minot State University is an equal opportunity employer and actively seeks diversity among its employees.

DIRECTOR
Enhanced Oil Recovery Institute
University of Wyoming

The University of Wyoming invites nominations and applications for the position of director of the Enhanced Oil Recovery Institute (EORI). As the only public baccalaureate and graduate degree-granting institution in Wyoming, UW plays a prominent role in the state, through its involvement in energy-related issues and as a national research university. Wyoming's geology and oil producing history, together with a record of strong support from state officials, make EORI an extraordinary vehicle for internationally visible research and outreach.

The director of EORI is responsible for promoting research and service that advance the viability of enhanced oil recovery (EOR). Reporting to the director are 15 full- and part-time staff members, funded through Wyoming's Enhanced Oil Recovery Commission, appointed by the Governor of Wyoming and confirmed by the Legislature. With funding from the commission, totaling about $3 million/year, the institute facilitates research and outreach by affiliated faculty from several UW departments, including Chemical and Petroleum Engineering, Geology and Geophysics, and Economics and Finance. The director reports to the director of UW's School of Energy Resources. The mission and other information are available at the institute's web site, http://eori.gg.uwyo.edu/.

We welcome applicants and nominations from industry, academia, and government. Preferred qualifications include an earned doctorate or commensurate professional credentials, a distinguished record of contributions to a field related to EOR, demonstrated understanding of the challenges in implementing EOR, sensitivity to the mission of a research university, and evidence of strong leadership skills. We also encourage candidates with industry experience and/or a positive industry working experience and relationship.

The director is housed in EORI's offices on UW's main campus in Laramie, a city of 28,000 in a scenic valley between the Laramie and Medicine Bow Mountains. Laramie is a two-hour drive from Denver, Colorado. For more information about the university and its setting, see http://www.uwyo.edu.

Complete applications include a cover letter, curriculum vitae, names and contact data for at least three professional references, and a brief narrative summarizing the candidate's leadership experience and interest in the position. The search committee will begin screening in September, 2009; however, applications will be accepted until the position is filled. Please send nominations and applications to Dr. Myron B. Allen, Provost and Vice President for Academic Affairs, University of Wyoming, Dept. 3302, 1000 E. University Avenue, Laramie, WY 82071. We encourage electronic applications, sent to Ms. Wilma Varga at wilmav@uwyo.edu.

The university adheres to principles of affirmative action and welcomes applications from qualified individuals of any race, color, religion, sex, national origin, disability, age, veteran status, sexual orientation or political belief. We welcome applications from underrepresented groups, including women and people of color.

INTERNATIONAL SYMPOSIUM ON TERMINUS LAKES

Preserving Endangered Lakes Through Research

October 26–29, 2009
University of Nevada, Reno, USA

Learn about current research on closed-basin lakes in the western United States and around the globe.

- Hear from Wallace S. Broecker, Ph.D., a renowned geochemist at Columbia University's Lamont-Doherty Earth Observatory and winner of many of the highest awards in science, and Berry Lyons, Ph.D., director of the Byrd Polar Research Center and professor at The Ohio State University who has conducted research on all continents.
- Hear about a comprehensive project that explored the best means to get additional water to Nevada's Walker Lake while maintaining the region's economy and ecosystem.
- Visit Nevada's Pyramid Lake, following its waters from the point of origin at Lake Tahoe through the Truckee River.

Learn more or register at www.nevada.edu/symposium.

University of Nevada, Reno

DRI

Sponsored by the Walker Basin Project

USGS
science for a changing world

USGS Mendenhall Research Fellowship Program (Fiscal Year 2011)

The U.S. Geological Survey (USGS) invites applications for the Mendenhall Research Fellowship Program for Fiscal Year 2011. The Mendenhall Program provides opportunities to conduct postdoctoral research in association with selected members of the USGS professional staff. Through Mendenhall appointments the USGS will acquire current expertise in science to assist in implementation of the scientific goals of its programs. Fiscal Year 2011 begins in October 2010.

Opportunities for research are available in a wide range of topics including: global and climate change; continental margin processes; ambient seismic noise analysis; karst geomorphology and hydrology; seismic hazard and risk modeling; coastal change; carbon sequestration; environmental effects of mineral mining; gas hydrates; applications of airborne gravity gradient measurements; vegetation phenology and ecosystem health; reducing risk from damaging earthquakes; integrated geologic and habitat mapping; sediment cycling in estuarine habitats; applied remote sensing; effects of metals on human health; applications of real-time and high data rate GPS; development of joint inverse methods; risk and vulnerability of communities to natural hazards; methane oxidation in terrestrial systems; valuating landscape and ecological services; microbial methanogenesis; streambank erosion and sediment transport; socio-economic induced alterations in land-use, projected climate models, and biological diversity.

The postdoctoral fellowships are 2-year appointments. The closing date for applications is November 9, 2009. Appointments will start October 2010 or later, depending on availability of funds. A description of the program, research opportunities, and the application process are available at http://geology.usgs.gov/postdoc. The U.S. Geological Survey is an equal opportunity employer.

Program Contacts: Dr. Rama K. Kotra, rkotra@usgs.gov, 703-648-6271; Ms. Kimberly Reed, kbreed@usgs.gov, 703-648-7436

U.S. Department of the Interior
U.S. Geological Survey

Coming to *GSA Today* in October

- **Science article:** "Did natural fission reactors form as a consequence of the emergence of oxygenic photosynthesis during the Archean?" by L.A. Coogan and J.T. Cullen
- **Preliminary Announcement and Call for Papers:** Joint Meeting: Northeastern Section–Southeastern Section
- **Article:** International Activities of the Geological Society of America and Results of the International Survey

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GSA Today articles from 1995 on are open access via link at **www.geosociety.org/pubs/.**

Journal Highlights

New Impact Factors

Thomson Reuters released their 2008 impact factors and, as usual, GSA's journals rank at the top:

Geology is the #1 rated geology journal (of 42). Its impact factor, which is currently 3.887, has increased five years in a row.

Geological Society of America Bulletin is the #12 ranked multidisciplinary geosciences journal (of 143) with an impact factor of 3.032.

Geosphere, which earned its first impact factor this year, is the #51 rated multidisciplinary geosciences journal (of 143). It has an impact factor of 1.627.

GSA Journals online:

www.gsapubs.org

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BACKBONE OF THE AMERICAS:
Shallow Subduction, Plateau Uplift, and Ridge and Terrane Collision

edited by Suzanne Mahlburg Kay, Víctor A. Ramos, and William R. Dickinson

The American Cordilleras form a continuous orogen that extends for 12,500 km along the eastern flank of the Pacific Ocean from Arctic to Antarctic latitudes as an integral part of the circum-Pacific orogenic belt. Following two summary articles on the overall anatomy and evolution of North and South American segments of the orogenic system, this volume includes ten seminal articles dealing with salient aspects of the key geodynamic processes that have accompanied Cordilleran geotectonic evolution: forearc terrane accretion, arc magmatism, shallow subduction, and backarc intracontinental deformation. The papers in the volume were selected from those presented at the 2005 international conference of the same name sponsored jointly by multiple North and South American geological societies in Mendoza, Argentina.

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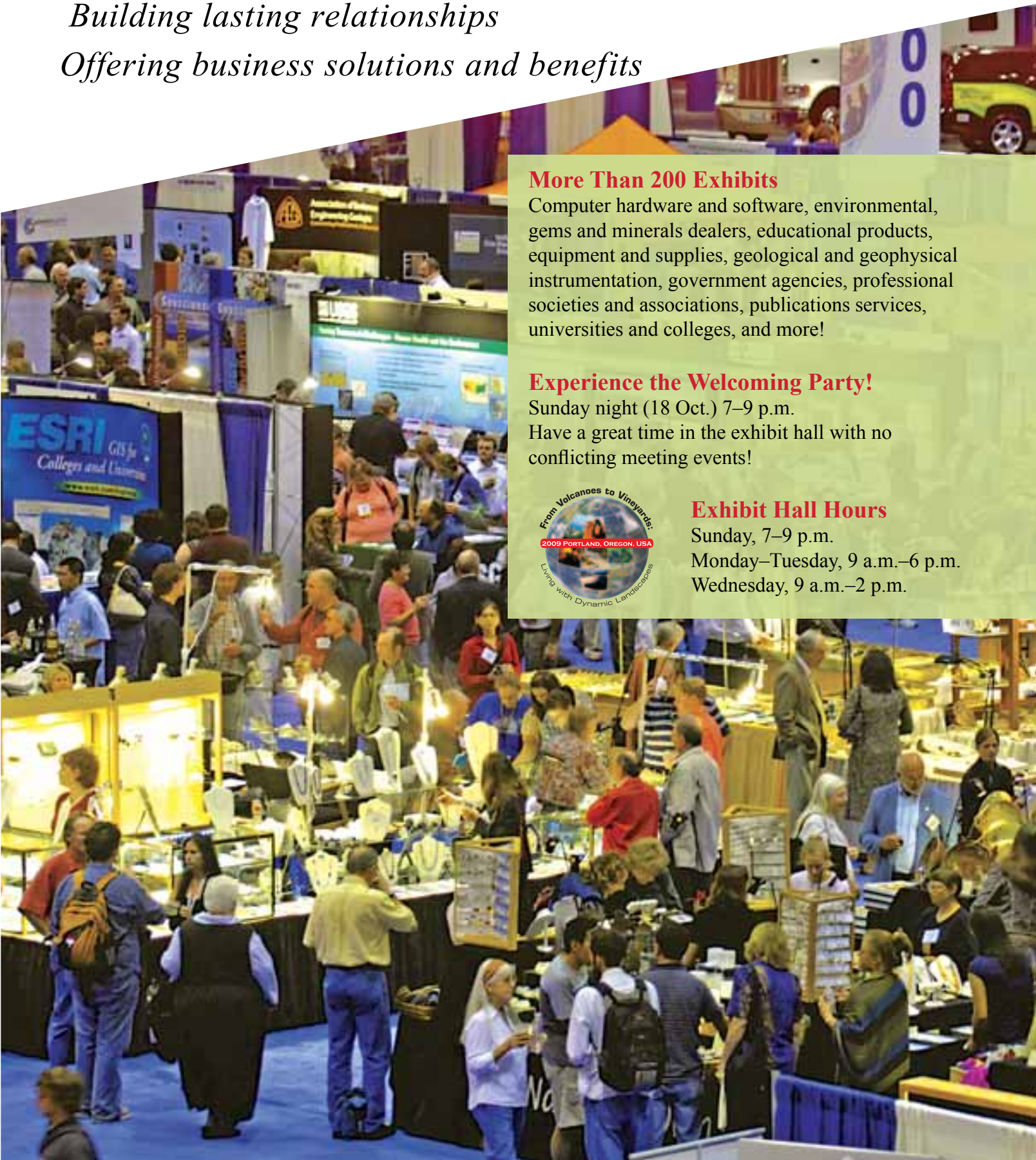

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GROUNDWORK
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Late Holocene relative land- and sea-level changes: Providing information for stakeholders

Ian Shennan, *Sea Level Research Unit, Dept. of Geography, Durham University, Durham DH1 3LE, UK;* ***Glenn Milne,*** *Dept. of Earth Sciences, University of Ottawa, Ottawa K1N 6N5, Canada; and* ***Sarah Bradley,*** *Dept. of Earth Sciences, Durham University, Durham DH1 3LE, UK*

INTRODUCTION

Throughout history, human societies dependent upon coastal environments have adapted to changes in sea level. Drowned peat layers on the North Sea continental shelf contain artifacts of Mesolithic communities that had no alternative than to migrate or drown as sea level rose up to 10 mm a^{-1}. At the same time, those in western Scotland prospered, as illustrated by analyses of Mesolithic shell middens, when the rate of sea-level rise declined to zero at a mid-Holocene highstand (Shennan et al., 2006). We can explain these contrasts by the process of glacial isostatic adjustment (GIA), which results in variable relative sea-level change around the British Isles. This geological process, driven by the build-up and retreat of the last great ice sheets, continues in and around previously glaciated regions.

The combination of contrasting relative sea-level changes around the British Isles and a large database of paleo–sea-level reconstructions provides a rigorous test for quantitative GIA models. These models offer a spatial picture not easily inferred from field research at individual sites. Two studies demonstrate the recent advances: Brooks et al. (2008) and Shennan et al. (2006). Their model predictions show good agreement with the majority of the geological evidence of relative sea-level change since 16 ka B.P., but unlike Shennan and Horton (2002), did not include a map summarizing current rates.

The approaches outlined here are applicable to the coastlines of other previously glaciated countries where the processes controlling long-term coastal change, ranging from glacial isostatic adjustment to localized sediment consolidation, are similar to the British Isles (Peltier, 1998; Törnqvist et al., 2008). We also present a map showing our best estimates of current relative sea-level change around the British Isles.

MODEL PREDICTIONS AND RECONSTRUCTIONS OF PAST SEA LEVEL

Our GIA model has three key inputs: a model of the Late Pleistocene ice history, an Earth model to reproduce the solid-earth deformation resulting from surface mass redistribution between ice sheets and oceans, and a model of sea-level change to calculate the redistribution of ocean mass (Bradley et al., 2009). For each geographical location, φ, relative sea-level change ($\Delta\xi_{rsl}$) at time, τ, results from these and other factors:

$$\Delta\xi_{rsl}(\tau,\varphi) = \Delta\xi_{eus}(\tau) + \Delta\xi_{iso}(\tau,\varphi) + \Delta\xi_{tect}(\tau,\varphi) + \Delta\xi_{local}(\tau,\varphi), \quad (1)$$

where $\Delta\xi_{eus}(\tau)$ is the eustatic sea-level function derived from the model of ice history, and $\Delta\xi_{iso}(\tau,\varphi)$ is the total isostatic effect, including the glacio-isostatic and hydro-isostatic load contributions and the redistribution of ocean mass. In contrast to areas adjacent to active plate boundaries, we consider the tectonic effect, $\Delta\xi_{tect}(\tau,\varphi)$, negligible over Holocene time scales.

We express local processes as

$$\Delta\xi_{local}(\tau,\varphi) = \Delta\xi_{tide}(\tau,\varphi) + \Delta\xi_{sed}(\tau,\varphi), \quad (2)$$

where $\Delta\xi_{tide}(\tau,\varphi)$ is the total effect of tidal regime changes and the elevation of the sediment with reference to tide levels at the time of deposition (Shennan and Horton, 2002), and $\Delta\xi_{sed}(\tau,\varphi)$ is the total effect of sediment consolidation since the time of deposition.

Sediment consolidation can be both a major process in coastal evolution (Long et al., 2006; Törnqvist et al., 2008) and a key variable in relative sea-level change (van de Plassche, 1982). The net effect for each site is determined by plotting data as either basal or intercalated data points. Basal data points come from samples at the base of the Holocene sequence and have suffered minimal consolidation, whereas intercalated data points, from within the Holocene sediment sequence, are likely to be at a lower elevation than at the time of deposition due to sediment consolidation.

Comparison of model predictions and reconstructions of Holocene relative sea levels at 80 sites shows good agreement (Brooks et al., 2008; Shennan et al., 2006). All meter-scale differences have data points below model predictions, consistent with showing the net effect of sediment consolidation, which lowers the elevation of a data point. Net effects of 3–5 m are not unusual, either in our study or others (Törnqvist et al., 2008; van de Plassche, 1982).

DISCUSSION

Policymakers use estimates of late-Holocene relative sea-level change to modify predictions of sea-level rise according to geographical location (DEFRA, 2006; UKCIP, 2005). We follow their convention and show relative uplift as a positive value and relative subsidence as a negative value (Fig. 1). The

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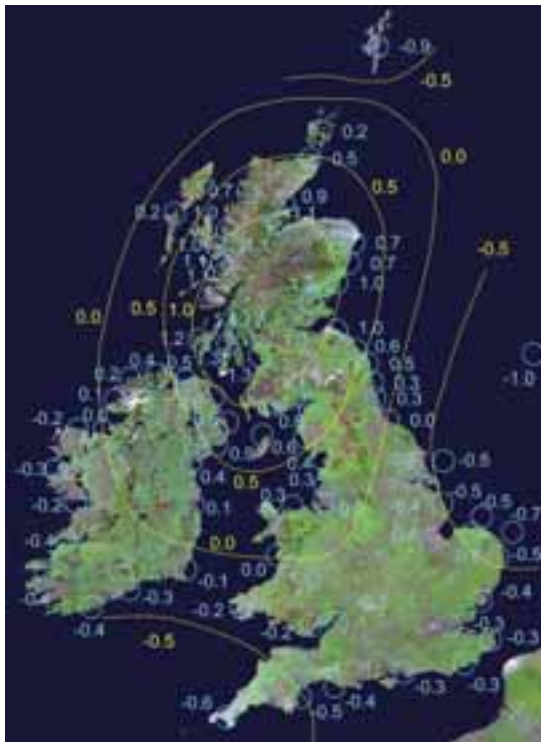

Figure 1. Current rate of relative land- and sea-level change in the British Isles in mm a^{-1}, showing relative land uplift as positive and relative subsidence as negative. Image is ~900 × 1300 km, courtesy of the NASA Scientific Data Purchase Program.

center of relative uplift over central Scotland reflects the continuing impact of glacial isostatic adjustment. Rather than a simple elliptical pattern, three foci of relative subsidence over southwest England, the southern North Sea, and the Shetland Isles show that other factors are important. These include the ocean load on the Atlantic basin and on the continental shelf and the glacial isostatic signal from far-field ice sheets (predominantly Fennoscandinavia).

Our model shows important differences with the 2002 study (Shennan and Horton, 2002). The 2002 study showed greater relative uplift in Scotland and greater relative subsidence in southwest England. We attribute the differences to (1) the availability of more data to test models; (2) model improvements; (3) calculating late Holocene rates for the past 1 ka rather than 4 ka; and (4) greater consideration of sediment consolidation. The 1-ka time frame is important where the relative sea-level trend is distinctly nonlinear. The benefit of our adopted approach to sediment consolidation is borne out by new data from southwest England (Massey et al., 2008). The new data, basal peat data points, fit better with our model, −0.6 mm a^{-1}, compared to intercalated peat data points that gave the 2002 estimate of −1.2 mm a^{-1}.

Figure 1 provides a practical baseline for considering climate-driven sea-level change in different locations. Our calculations use calibrated radiocarbon ages B.P., with A.D. 1950 as 0 B.P., so are independent of debates over any late–twentieth-century acceleration of sea-level rise. Tide gauge–derived trends show a regional sea-level rise of climate change origin on the order of 1.4 mm a^{-1} (Woodworth et al., 2009). The spatial pattern of relative uplift and subsidence is similar to that derived from GPS observations (Bradley et al., 2009) but not identical since they measure different parameters (Eq. 1).

How stakeholders use the baseline rates must be determined by their individual needs. If we consider flood defenses, whether a structure has foundations in Holocene sediment or in basement rock determines the net effect of all components in Equation (1). Many hundreds of kilometers of sea defenses around the world are made up of dirt levees or concrete and steel structures with shallow foundations in Holocene sequences. Their failure or overtopping can cause widespread flooding. Whether in nineteenth-century rural England (Skertchly, 1877) or twenty-first century New Orleans, our understanding of and adaptation to relative land and sea-level change remains intrinsically linked to Holocene geology.

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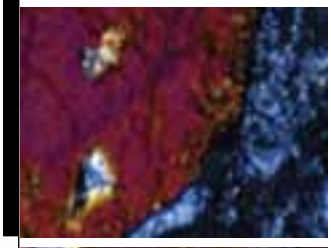

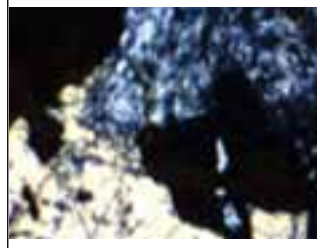

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